Off-site construction

to simplify the energy transition in social housing

Handbook of Good Practices

A project by

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Handbook of Good Practices

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Abstract

The contemporary era is characterised by an increasing scarcity of resources in all forms, prompting a profound reflection on the way in which we live.

In light of the increasing necessity to reduce the environmental impact of the construction industry, European legislation is requiring the implementation of new environmentally-friendly technologies and approaches to reduce the energy consumption and environmental impact of the building stock.
Furthermore, the progressive impoverishment of families and the scarce supply of affordable housing on the market have led to a real social emergency and crisis of living that is affecting numerous countries across Europe and beyond.
These phenomena are significantly influencing the construction sector, as the majority of European buildings must be renovated in the near future, particularly social housing due to its pervasive energy poverty.

Climate change and the housing crisis are two issues that are well-known, but how can architecture provide with innovative and sustainable responses?
The twofold reflection on the future of living and the ecological transition is encountered along this path, through a research project that analyses the potential of off-site architecture for collective housing retrofit and new construction.
The project proposes a turnaround to innovate the construction sector by establishing new professions, skills and roles to cope with a constant scarcity of resources and demographic issues such as the ageing population and the increasing life expectancy.

Mission & Vision

Looking at the ecological transition: the European context

The European legislation (2020 'Renovation Wave' and the newest 2023-24 European Performance of Buildings Directive) requires new environmentally-friendly technologies and approaches to reduce the environmental impact and energy consumption of buildings, also setting the goal of having zero-emission EU building stock by 2050. This will impact the construction sector, as the majority of European buildings must be renovated in the years to come, in particular social housing due to its widespread energy poverty.

The progressive impoverishment of families and the scarce supply of affordable housing on the market bring us to a real social emergency and crisis of living.
In addition, recent evidence has shown that low-income individuals and households tend to dedicate a larger share of their budget to fundamental goods such as energy and food, and they are the ones experiencing the highest rates of inflation with consequences in terms of poverty and inequality. Housing costs are part of this concern on the increasing cost of living. Expenditure on housing costs represents the highest share of household budgets in the vast majority of EU countries with an average 32.7% of total consumption expenditure.[1]
Moreover households account for 27% of final energy consumption in the EU and contribute to 21% of total greenhouse gas emissions.[2] Buildings are therefore the largest consumer of energy in Europe: heating, cooling and domestic hot water account for 80% of citizens' consumption.
The construction sector contributes significantly to global climate

1 Eurostat, "Housing, food & transport: 61% of households' budgets". Data referring to 2020.

2 Eurostat, "Greenhouse gas emission statistics - air emissions accounts". Data referring to 2021.

change, accounting for about 23% of global greenhouse gas emissions and 37% of energy and process-related carbon dioxide (CO2) emissions.

Off-site construction is the only technique that makes building projects' delivery faster, cheaper, safer and greener (less waste and emissions), delivering low-carbon prefabricated buildings and reducing the embodied energy of a building by up to 30%.
Promoting off-site since the first step of the construction chain is important to reverse this trend and create a network of skilled professionals that look at green and inclusive alternatives in architecture.

The increasing impoverishment of families and the scarcity of affordable housing on the market are creating a real social emergency and housing crisis. More and more households are exposed to energy poverty, especially low-income households living in energy-inefficient dwellings. This is compounded by other factors such as the loss of effectiveness of housing support policies due to a lack of public funding and inefficiencies in the management of existing assets.

One of the consequences of this is a progressive reduction in the supply of public housing, which has to contend with some critical factors such as the high percentage of owner-occupied homes that has always characterized the Italian property market.
However, the vast majority of houses, around 7 out of 10, are owner-occupied, which in Italy is considered a safe investment.
Nationally, public rental housing (Edilizia Residenziale Pubblica or ERP) is estimated to represent about 3.5% of the total housing stock in the country and is a permanent feature of our housing system.[3]

It includes about 900.000 units managed by public housing companies and municipalities. There is no centralized information on the energy performance of public housing, but the need to renovate public housing units is widespread - to the extent that an estimated 10% of the stock is currently vacant. In fact, more than half of the available EPCs are in classes F and G, indicating that the energy efficiency of housing in Italy is relatively low. [4]

Turin's social housing stock, most of which was built between the 1950s and 1980s (68% of the housing stock was built before 1981 and 14% after 1991), is spread over a large part of the urban

3 Istat, Population and Housing Census 2021.

4 Sistema informativo sugli Attestati di Prestazione Energetica (SIAPE).

area, with varying densities. There are 17.435 housing units, 63% of which are owned by ATC, 34.4% by the Municipality of Turin and the rest by the State Property Office, the Local Health Authority and the Ministry of Justice.[5]
This data confirms that around 35% of EU buildings are over 50 years old and almost 75% of the building stock is energy inefficient.

In terms of the labour market, construction remains one of the most vulnerable sectors in Italy. In 2022, construction is the sector with the highest number of fatal accidents, with 110 fatalities. Even for non-fatal accidents, the sector remains one of the most exposed, as confirmed by Inail[6] data.

In this context, it is clear how an innovative process could control the risk associated with work phases, drastically reducing work-related injuries and fatalities.
Inevitably, the need for human resources, which are increasingly scarce in the sector, would be reduced or redesigned.

The Italian off-site project landscape is mainly developed on new construction projects (both single-family and multi-storey buildings). The most commonly used technologies are timber or hybrid timber-reinforced concrete-steel, while retrofit technologies are still almost unexplored. Off-site architecture offers various possibilities for innovation in the construction chain, which in Italy is currently static and rooted in traditional technologies and methods.

The green and digital transitions are an opportunity to address the shortcomings of the construction industry and make social housing projects more inclusive, effective, safer, faster and more environmentally friendly. What's more, off-site techniques, with their lower costs, can help to reduce the financial burden on the beneficiaries of social housing refurbishment, who typically cannot afford large investments.

In Poland, the construction industry is experiencing a gradual shift towards the use of prefabrication methods.
Prefabrication involves the manufacture of building components in a factory and then transporting these components to the construction site for assembly. One of the most promising developments in this area is modular construction. This

5 Città di Torino, Osservatorio Condizione Abitativa XIX Rapporto - anno 2022.

6 National Institute for Insurance against Accidents at Work.

innovative approach involves the production of entire modules of a building in a factory, which are then transported and assembled on site. The potential of modular construction in Poland is considerable, as it can lead to faster project completion, cost savings and a reduction in environmental impact. However, despite its potential, the widespread adoption of modular construction in Poland faces several challenges. One of the main obstacles is the existing regulatory framework, which has not been fully adapted to this modern construction method. Regulations often lag behind technological advances, creating hurdles in the approval process and increasing the complexity of compliance. In addition, traditional construction practices are deeply ingrained in the industry, making it difficult to move towards a more modular approach.

On the other hand, in Poland, factories have sprung up near Toruń and Kraków to produce modular housing elements from wood or steel. Although their production is mostly exported to other Western markets, their location could be seen as a beacon and driver for change. With the right attention, they could be brought more into the domestic market, where they are not as widely used as in other countries where their customers are located.

In Poland, the use of prefabrication in construction is still somewhat limited and most prefabricated buildings are based on concrete wall systems rather than fully modular components. Projects that typically involve the use of prefabricated concrete walls, which are assembled on site to form the structure of the building, are being used in various residential and commercial buildings across Poland.
Although these methods improve durability, efficiency and quality compared to traditional construction techniques, they fall short of the full potential of modular construction. Unfortunately, there are currently restrictions in the law and building regulations that are very much in line with what is considered good practice. These are mainly related to adequate fire protection and the need to build lower structures, for example in timber. This is set to change in the coming years, as the government has recently launched a wider debate on the subject.
In summary, while Poland is making progress in integrating prefabrication into its construction industry, there is still a long way to go before the full potential of modular construction is realised.

Project objectives

The main objective of the project is to engage a group of Polish and Italian architects to stimulate debate, deepen their knowledge and develop innovative project ideas for off-site construction to facilitate the energy transition in social housing and to enable architects to adapt their professional profile to the changing skills arising from the renovation wave in Europe.
The architects will improve their professional practices and pave the way for a widespread greening and digitalisation of their work, comparing and learning from the experiences of Poland and Italy within the framework of best practices in the European context.
Building knowledge of off-site techniques will support its use in the partner countries, contributing to a faster green transition in social housing, where decarbonization and energy efficiency are more urgent given the higher obsolescence of building stock.

Site and company visits will allow participants to discuss with policy makers, contractors and professionals the off-site solutions used in the renovation and new construction of social housing and their strategic contribution to achieving inclusiveness, aesthetics and sustainability.

Starting from the analysis of different good practices, the project will identify and design new transnational training content and professional tools to empower architects in off-site design for social housing. In this way, their work will respond to the environmental and social challenges of the social housing context, combining digital and collaborative technologies with innovative and high-performance materials. At the design stage, equal access to housing will be improved through cheaper and higher quality solutions that meet people's diverse needs. Off-site design will allow architects to escape conventional methods and adopt more flexible techniques. Buildings that respond to housing shortages can be adapted to different needs and the use of modular/prefabricated components can help reduce costs and materials.

Following these statements, the project aims to build a community of professionals who will able to:

- Exchange good practices on off-site architecture for social housing as a first step towards its wider adoption;

- Promote the use of off-site construction among European architects;

- Increase the digitalisation of the construction process thanks to a better use of digital tools (BIM, 3D printing, drones and robots) in off-site practices for social housing;

- Support the digital and green transition in the construction sector by promoting off-site construction as a sustainable and inclusive approach to the construction and the retrofit of social housing projects.

The programme is organised by macro areas and will cover the following topics:

- **Political and socio-cultural context**

In light of the European housing crisis, the debate aims to explore and propose public policy solutions for public heritage to be upgraded and renovated. It will also explore the potential of collective and shared housing as architectural typologies and the benefits they can bring to urban management;

- **Environmental and socio-cultural context**

It focuses on energy poverty in the social housing stock and analyses the new trend of energy retrofitting according to the rules of the recent European Green Deal. Special attention is given to circularity in construction processes, material reuse and bio-construction;

- **Off-site design & processes**

Starting from the current state of the art, we will explore innovative construction technologies, materials and processes in off-site architecture and site management in the context of European best practice;

- **Digital design and industrialization**

What is process innovation?
The topic covers the role of process industrialisation and how established and emerging technologies in off-site construction, such as BIM technologies, 3D printing and robotics, can help to rapidly innovate the system.

Project partners

"Off-site Construction to Simplify the Energy Transition in Social Housing" is a project by Fondazione per l'architettura / Torino and Stowarzyszenie Laboratory for Urban Research & Education, funded by the European Union within the framework of the Vocational Training Partnership KA210-VET (Erasmus+).

Fondazione per l'architettura / Torino

Fondazione per l'architettura / Torino was founded in 2002 on the initiative of the Association of Architects of Turin, and it promotes architecture as a discipline at the service of the quality of life.

The organisation promotes interdisciplinary relations and acts as a bridge between the worlds of design, construction, technology and culture. Its aim is to investigate current and future social needs, to study innovative responses and to implement concrete actions in the field, stimulating change and seeking tools to face the challenges of the future with awareness and responsibility.
The foundation works in various fields: vocational training, social projects, cultural projects and architectural competitions.

Fondazione per l'architettura / Torino is a member of the New European Bauhaus Community and of Torino Social Impact, the platform that aims to experiment, together with companies and institutions, a new development strategy with a high social impact and technological intensity.

Social media:
Sito web

Laboratory for Urban Research & Education

LURE is an urban think tank focused on research, education and development to provide answers to the challenges facing cities and the Green Deal agenda. Its team consists of architects and researchers working on innovative projects for cities.
The group focuses on promoting susta inable urban development through innovative architecture and interdisciplinary perspectives in all urban dimensions.

LURE has experience in unleashing a new wave of innovative buildings and urban infrastructure focused on sustainable building materials, renewable energy solutions and water challenges.
LURE is part of the New European Bauhaus and a supporter of the Covenant of Mayors for Climate and Energy and has offices in 4 countries (Poland, Belgium, Romania and Spain).

Social media:
Sito web

Calendar activities

18–19 October 2024	Vocational training with conferences, construction site visits and workshop scenario TURIN (ITALY)
21–22–23 February 2025	Vocational training with conferences, construction and factory visits, and workshop WARSAW AND TORUŃ (POLAND)
3 April 2025	Public dissemination event with local experts and stakeholders TURIN (ITALY)
30 May 2025	Public dissemination event with local experts and stakeholders WARSAW (POLAND)

Project impact

Over **350** architects empowered thanks to project events

2 major events featuring conferences and workshops

2 dissemination events for broader outreach

40 speeches from sector experts

10 public and private stakeholders actively engaged in the debate

20 partners, both technical and technological

3 media partners

Introduction

The energy transition represents one of Europe's most pressing and complex challenges, particularly in the social housing sector, which is often marked by outdated building stock, high energy consumption, and limited resources for large-scale renovations.
Moreover, the increasing impoverishment of families and the scarcity of affordable housing on the market are creating a real social emergency and housing crisis. More and more households are exposed to energy poverty, especially low-income households living in energy-inefficient dwellings. This is compounded by other factors such as the loss of effectiveness of housing support policies due to a lack of public funding and inefficiencies in the management of existing assets. One of the consequences of this is a progressive reduction in the supply of public housing, which has to contend with some critical factors such as the high percentage of owner-occupied homes.

Renovations are also crucial to help reduce the energy poverty that is a significant issue in Europe, affecting millions of households, especially those with low incomes, poorly insulated homes, and high energy costs. In fact, energy poverty is a widespread issue across Europe where buildings are the largest consumer of energy where heating, cooling and domestic hot water have a significant impact on citizens' consumption, accounting for a large part of household expenditure. The latest data from 2023 shows that 10.6% of the European population (around 48 million people) faced inadequate heating in their

homes or lived in a state of energy poverty.[1] This issue is especially acute in Eastern and Southern European countries which Italy and Poland are part of.

Rising energy prices, inflation, and the impacts of climate change are further exacerbating this condition, deepening existing inequalities. Energy poverty not only has an impact on the cost of living, but also has an impact on health, social inclusion, and family well-being. In addition, it is a disproportionate phenomenon that affects vulnerable groups, including low-income households, the elderly, and residents of poorly insulated buildings, many of whom live in social housing. Addressing energy poverty requires not only financial support but also structural interventions aimed at improving the energy performance of buildings and demonstrating the public interest. In this context, innovative and scalable solutions such as off-site construction and deep renovation strategies play an important role in reducing energy demand and ensuring that the energy transition is inclusive and just for all.

The *Handbook of Good Practices in Off-site Construction for Social Housing* is not meant to be an exhaustive list of European case studies. Instead, it is based on comparative research conducted in Italy and Poland, aiming to provide an overview of what has already been achieved and what still needs to be implemented in both countries. Within the broader framework of European territory, the handbook seeks to support the wider adoption of off-site construction methods as a way to simplify the energy transition in social housing and shift the mindset of architects, developers, and clients toward more innovative, efficient, and sustainable building practices.

The document presents a selection of European best practices that demonstrate how innovative off-site construction approaches can effectively support the decarbonisation of the building sector, with a particular focus on social housing renovation.
By highlighting replicable models, technological solutions, and organisational strategies, the aim is to offer valuable insights into how off-site methods can contribute to a more inclusive, efficient, and sustainable energy and social transition within the built environment.

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1 Eurostat

Why does off-site matter for social housing?

The role of social housing in times of uncertainty

In a period marked by increasing global inequality, housing insecurity, and economic volatility, social housing have, in many European countries, an important role in safeguarding the fundamental right to adequate housing access. As housing prices and rental costs continue to rise often outpacing incomes, access to affordable and decent living conditions is becoming increasingly difficult for large segments of the population.

Public investment in maintaining social housing is therefore not just a matter of welfare policy, but a strategic response to structural inequalities and social fragmentation. It ensures long-term stability, prevents the marginalisation of vulnerable communities, and strengthens social cohesion. Especially nowadays, when private markets fail to meet the growing demand for affordable housing, a strong and sustained public commitment becomes essential to guarantee dignity, security, and equal opportunity for all.

Off-site construction as a response to housing emergencies

Off-site construction is well known for significantly reducing both construction time and costs, making it a highly effective solution to meet the growing demand for housing during crises. In a context marked by social, economic, and geopolitical uncertainty exacerbated by factors such as rising migration flows, increasing homelessness, and climate-related displacement, flexible and rapid response building solutions are essential for the resilience of urban areas. Off-site methods permit the rapid deployment of housing units, even in rural or remote contexts, offering a scalable and cost-effective response to emergency housing needs. By minimizing on-site disruptions and accelerating delivery timelines, this approach could help local authorities and social housing providers respond promptly to urgent situations while maintaining long-term sustainability goals.

As a public development strategy, off-site construction offers an efficient and adaptable solution to meet evolving community needs.
In fact, off-site constructions are characterized by a temporary nature, making them an ideal solution for projects that require quick assembly and adaptability in the future. One of their key advantages is that they can be dismantled, relocated, or modified according to changing needs, without compromising on structural integrity or quality. This makes them particularly valuable for large-scale urban planning and construction strategies, such as temporary housing, emergency shelters, educational facilities, or healthcare infrastructure.

Gaps and opportunities in off-site retrofit for social housing

Identifying case studies that successfully combine both off-site construction practices and the retrofit of existing social housing has proven to be particularly challenging. While off-site methods are gaining traction in new-build projects and large-scale developments, their application in the context of social housing renovation remains limited and uneven across Europe. This gap reflects not only technical and logistical challenges, such as operating within dense urban areas or dealing with outdated building stock, but also a broader absence of cohesive policy frameworks and targeted investment.

Europe today: stories and innovations

Within this framework, it is valuable to examine the specific contexts in which Italy and Poland, along with the broader European perspective, are addressing this issue and advancing innovation in off-site construction for the retrofit of public and social housing stock.

The Netherlands

The *Stroomversnelling* association originated from an earlier government-funded Dutch innovation programme called *Energiesprong*, which aimed to create net zero energy buildings on a large scale. In 2013, Stroomversnelling brokered a deal to refurbish 111,000 homes to reach NZE standards. Two years later, this became a market initiative to further advance the project. The network comprises contractors, suppliers, housing providers and other stakeholders, and focuses on reducing renovation costs, increasing occupant acceptance and accelerating the NZE housing market. To date, 1.300 NZE refurbishments have been completed, with a further 500 under construction. The network has developed practical NZE solutions for terraced houses and is working on concepts for apartment buildings, which present challenges such as limited roof space for solar panels. The programme is also seeking financial solutions to help private homeowners fund NZE refurbishments.

Following its initial success, the Energiesprong programme was extended to encompass other buildings and neighbourhoods, with the goal of renovating thousands of homes across the Netherlands. This model has since been adopted in other European countries, including the United Kingdom, France, Italy, and Germany, helping to spread sustainable and environmentally friendly housing solutions.

Germany

Germany also proposed policies in which the state's active role was important.
In 2016, within the coalition agreement between the SPD, Greens, and Liberals in Germany, a program point was introduced focused on "serial buildings renovation"'. Based on this initiative, the German Energy Agency, acting on behalf of the Federal Ministry of Economics and Climate Protection, launched the *Serielle Sanierungslösungen* project. The project aims to facilitate large-scale redevelopment of residential housing through the digitization of design processes and the industrialization of the renovation process. It has been implemented across several major German cities, including Berlin, Munich, and Stuttgart.

United Kingdom

An interesting initiative promoted by the local government appeared in 2018 in the UK. With the financial support of the Greater London Authority and the European Regional Development Fund, the *London Retrofit Accelerator* was created, a programme aimed at tackling climate emergency and energy poverty through off-site retrofits that make buildings more efficient, sustainable and comfortable.

France

In France, as part of the 2021-2022 Recovery Plan, the Ministry of Ecological Transition has allocated 40 million of euros to the *MAssiRenò* program, which funds social housing energy renovation projects following the Energiesprong approach. This approach is based on performance-based contracts, offering both economic sustainability and the potential for innovation and industrialization. Through its demand, the state plays an active and deliberate role in driving innovation within the supply system.

Italy

The Italian off-site project landscape is mainly developed on new construction projects (both single-family and multi-story buildings). The most commonly used technologies are timber or hybrid timber reinforced concrete-steel, while retrofit technologies are still almost unexplored. Off-site architecture offers various possibilities for innovation in the construction chain, which in Italy is currently static and rooted in traditional technologies and methods.

Nevertheless, in the last 10 years in Italy, practitioners have been experimenting and off-site construction is emerging nowadays as an innovative strategy for the renovation of public housing (social housing) and private houses, especially in the context of upgrading the existing housing stock, with a focus on small or medium-scale interventions.
Some companies are working to spread regeneration interventions on the territory, especially for residential buildings, targeting public and social housing and the suburbs.
Nationally, public rental housing (Edilizia Residenziale Pubblica o ERP) is estimated to represent about only 3.5% of the total housing stock in the country and is a permanent feature of our housing system[2]. It includes about 900.000 units managed by public housing companies and municipalities. There is no centralized information on the energy performance of public housing, but the need to renovate those units is widespread - to the extent that an estimated 10% of the stock is currently vacant. In fact, more than half of the available EPCs are in classes F and G, indicating that the energy efficiency of housing in Italy is relatively low[3]. The reason also lies in the fact that the vast majority of houses in Italy, around 7 out of 10, are owner-occupied. Homeownership is seen as a secure investment, which complicates the activation of public funding for maintenance.

Prominent among companies nowadays is the commitment of Edera, a social enterprise engaged in the redevelopment of urban suburbs that pushes towards deep regeneration.
Edera has imported the model, first Dutch, now European, of Energiesprong into our country.
Energiesprong proposes an innovative approach that radically improves redevelopment by combining new processes (digitisation, lean approaches and industrialisation with offsite construction technologies) with new models of economic-financial sustainability based on the concept of total cost of ownership[4] and the guarantee of long-term performance.
All Energiesprong projects have the common goal of transforming old energy-hungry buildings into decarbonised buildings, in line with energy and environmental targets, through safe interventions, both for workers and for users who see the improved earthquake safety of their home's comfort.

2 Istat, Population and Housing Census 2021.

3 Sistema informativo sugli Attestati di Prestazione Energetica (SIAPE).

4 Total Cost of Ownership (TCO) is the complete cost of acquiring, operating, and maintaining a product or system over its entire lifecycle.

Edera has carried out seven pilot projects over the years, in various Italian cities, including Milan, Vicenza, and Treviglio, to test innovative solutions on different building typologies including tower blocks, schools and urban suburbs.
Since the start of the project in March 2020, the work of Edera's team and market experts have focused on adapting this approach also to new constructions, immediately highlighting some differences from the Dutch context, as many experts in the sector have noticed. Whereas abroad the process was initiated from demand, in Italy the situation was different: the demand was present, but it was disaggregated, diffuse and of insufficient quality. Consequently, Edera chose to focus on the offer, selecting the most promising companies, able to propose ideas and solutions to realise industrialised energy upgrading.[5]
Thus, Edera works on two fronts to ensure the large-scale development of retrofit projects: selecting new pilot projects and developing an aggregate, homogeneous demand for retrofitting. This involves engaging with and raising awareness among those who manage large real estate assets, as this seems to be missing in Italy as a fundamental driver for growth in the sector.

Italy has put in place a number of policies and instruments to promote the energy requalification of social housing, using both national funds from the *Recovery and Resilience Plan* (PNRR, PINQuA) and tax incentives (Ecobonus, Superbonus), as well as local and regional projects. One of the big aims is to rehabilitate the existing building stock, and improving the quality of living to limit housing deprivation in deprived urban areas.
However, unlike what we have previously read, this Italian national funding does not force the use of off-site technologies but only encourages it, missing a great opportunity to push companies and designers towards the use of new construction models.
In some contexts, demand accelerators have been introduced, tools through which the government has demonstrated the possibility of adopting an alternative and more proactive approach. In these cases, demand was not seen as a passive market element, but as a strategic lever capable of stimulating innovation and transformation. This highlights the importance of viewing demand not just as an expression of need, but as a driver of change and development in the sector.

The role of the State in the Italian construction sector is a central

5 Edilizia off-site: «serve un cambio di paradigma»", interview with Thomas Miorin, in impreseedili, October 2022.

issue, particularly in light of the growing gap between the cost of construction projects and the actual financial resources available, both for public and private actors. Incentive tools, while useful, are insufficient to bridge this gap. It is therefore necessary to improve the productivity of the construction sector and fully leverage the potential of energy efficiency measures, through a system that ensures the expected performance.
In recent times, the Italian State has shown a certain degree of involvement in providing incentives; however, in terms of innovation and productivity in the construction process, no significant changes have yet been observed. This stagnation appears to contrast with the interest shown by various public administrations, which in some cases -such as the Municipality of Milan- have incorporated innovative solutions like off-site construction in their tender procedures.

To promote the widespread adoption of off-site construction, it is therefore essential to foster innovation and a consistent level of demand, with a particular focus on achieving results in the short term. This requires action on a large scale, ensuring significant volumes, replicability of the adopted solutions, and, at the same time, respect for local specificities. In this context, industrial partners play a key role, having risen to the challenge by making their long-standing know-how available and actively committing to accelerating innovation processes in the sector. In conclusion, it can be affirmed that at a systemic level, there remains a lack of a structured operational approach capable of defining concrete objectives for the widespread adoption of off-site construction methods.[6]

Poland

In Poland, prefabrication once played a central role in addressing urgent housing needs. During the 1960s and 1970s, faced with the necessity to construct several million dwellings in a short period of time, the country witnessed the rapid development of large-scale housing estates built using "large-panel" (*Wielka Płyta*) prefabricated systems. While the living conditions in these buildings were often suboptimal—characterized by small windows and limited floor areas—their urban layouts allowed for the emergence of generous green spaces between blocks, resulting in a form of planning that offered certain environmental and spatial outside benefits. Today, Poland once again faces a housing deficit estimated at 2–3 million units, with a significant portion needed in the social housing sector. Simultaneously,

6 Ibid.

the country now hosts a new generation of advanced prefabrication factories producing timber, steel, and concrete modular systems. Until recently (last 5 years), these facilities were oriented primarily toward export markets. However, a shift is underway: the proximity between production sites and domestic construction projects presents an opportunity to reduce both costs and environmental impact, particularly in terms of transportation. The availability of European funds under the National Recovery Plan (*Krajowy Plan Odbudowy*, KPO) offers a critical catalyst for the domestic uptake of modern prefabricated housing. Leading manufacturers see this as an opportunity to implement demonstrator projects that can overcome persistent public skepticism—rooted in outdated historical associations—and showcase the potential of prefabrication to rapidly deliver high-quality social housing in Poland.

However, an interesting opportunity already lies in the repurposing of the aforementioned buildings constructed during the communist era. These structures could play also a crucial role in addressing Poland's housing crisis, provided they are properly managed. While these buildings may not meet modern standards for energy efficiency or comfort, they could be revitalized through renovations and energy upgrades. By improving insulation and heating systems, and integrating modern technologies, these buildings could become more sustainable and better aligned with current housing needs. Adequate EU funding is accessible currently to groups of inhabitants of these housings to carry out thermal retrofitting in them.

Moreover, many of these buildings could be adapted for a variety of uses, such as temporary housing, social housing, or community support facilities. Their existing locations in urban and peripheral areas make them a cost-effective solution, eliminating the need for land acquisition. Additionally, these structures could be combined with new housing solutions, like prefabricated modules or off-site construction, to provide flexible responses to the growing demand for affordable housing.

Another potential benefit is the preservation of the historical and cultural heritage of these buildings, which could enhance urban identity and improve quality of life. With the right renovations and planning, these buildings could play a significant role in alleviating Poland's housing shortages while also contributing to sustainability and social inclusion goals.

Atlas of best practices

The Handbook of Good Practices in Off-site Construction for Social Housing is designed to serve both as a comprehensive overview and a practical reference guide.

It presents a curated selection of exemplary practices in off-site construction for social housing across Europe, exploring the diverse systems and methods available, including structural frameworks, prefabricated elements, wall assemblies, and modular units, and their application across various project typologies, such as new construction, building renovations, and partial additions.

In addition to showcasing built examples from contemporary architecture, the handbook provides an overview of the most commonly used building materials in off-site construction -wood, steel, and concrete- examining their potential, limitations, and suitability for different contexts.

The handbook encompasses a diverse range of public and private initiatives aimed at social impact, ranging from sustainable urban development and regeneration strategies in responses to social issues, such as housing, education and healthcare.

By outlining the strengths and limitations of each approach, the handbook aims to support informed, innovative decision-making, encouraging architects to design and renovate high-quality, efficient, and sustainable social housing, with the goal of fostering broader application across Europe.

Timber Prefabrication

Sustainability and Carbon Reduction

Timber modular construction significantly reduces the carbon footprint of buildings.

For example, wooden modular systems can lower CO_2e emissions by up to 96% compared to traditional methods, with some projects emitting as little as 8,085 kg CO_2e during construction. Off-site fabrication minimizes waste by up to 75%, while wood's natural insulation properties reduce long-term energy use. As a renewable material, timber naturally stores carbon, supporting climate-neutral construction and helping cities meet green building targets faster.

One of the reasons also why for us as authors timber prefabrication is important to highlight is one of its key advantages that lies in its alignment with the "design for disassembly" philosophy. Buildings designed specifically with this technology can be dismantled and reassembled elsewhere, allowing for full relocation. Thanks to the high degree of prefabrication—up to 95% of the building is completed off-site—mostly external elements such as façades, which represent roughly 5% of the entire building, are typically dismantled on-site. The remaining components can be almost entirely reused in a new location, making this approach both sustainable and adaptable to future needs.

Rigot Collective Dwelling Centre

© Marcel Kultscher
© acau architecture SA

Designers:	acau architecture sa
Company:	JPF Ducret (Main contractor for wood construction)
Location:	Genève, Swtizerland
Year:	2019
Category:	New construcion
Use:	Social housing
Size:	7,070 m²
Client:	Hospice Général - service immobilier
Cost:	-

Located in Rigot Park in Genève, the Rigot Collective Dwelling Centre is designed to accommodate 370 migrants as a temporary and emergency measure.
Developed in close collaboration with local stakeholders, the project embodies a proactive response to contemporary social challenges. At its heart lies a refugee sheltering program that not only addresses immediate humanitarian needs but also anticipates future demands for emergency housing.

The modular design of the apartments and their internal subdivisions also makes them suitable for alternative uses, such as student housing or accommodations within the hospitality industry. The configurable arrangement of prefabricated modules enables the creation of buildings with varied volumes, adaptable to future reconstructions or repurposings. Prefabrication and the delivery of fully finished modules played a key role in construction planning. By organizing the process into three parallel workstreams -foundations, module prefabrication, and on-site assembly and finishing- the project can be completed within a significantly shortened timeframe. The construction process engaged local timber manufacturers, utilizing wood sourced from Geneva's forests for both the foundations and the building envelope. Approximately 3.200 m^3 of certified "Label Bois Suisse" timber was used. The financial model includes provisions for both the assembly and disassembly of the structure, with anticipated savings from the durable, modular system contributing to a positive balance during the project's initial cycle.
The pursuit of a character that reflects the wooden structure underscores rational aesthetics as the core of the project. Beginning with a single dimension of raw-cut boards, this deliberate constraint positively shaped both the façade composition and aspects of the exterior installations. In the façade, the same construction element is articulated through two distinct details, one for the railings and another for the cladding.

This project is particularly interesting because it effectively articulates several key characteristics of off-site construction, such as its temporary use, technological reversibility (even when using wood as a foundation material), and high aesthetic quality. It demonstrates that, with the right aesthetic design and detailing, off-site construction can achieve high standards of architectural quality while meeting social needs.

Torri Risorsa

© Beatrice Arenella

Designers:	Ricehouse Srl sb - arch. Tiziana Monterisi, Arch Elia Sbaraini; ARPO studio Ing. Costante Bonacina, ING Srl Ing Gabriele Ghilardi
Company:	A2A Calore e Servizi, WoodBeton, RiceHouse
Location:	Milano, Italy
Year:	2023
Category:	Renovation
Use:	Social housing
Size:	16,120.22 m²
Client:	Aler Milano (Azienda Lombarda per l'Edilizia Residenziale)
Cost:	13 milions €

The residential complex, built in 1978, consists of four nine-storey towers above ground connected by a basement.
The complex was in need of a thorough redevelopment to bring it up to the required energy

performance standards, to optimise resources and energy use, to carry out an architectural and urban redevelopment of the context, to increase the value of the buildings and common areas, to guarantee the quality of life of the tenants, and to create liveable social spaces.

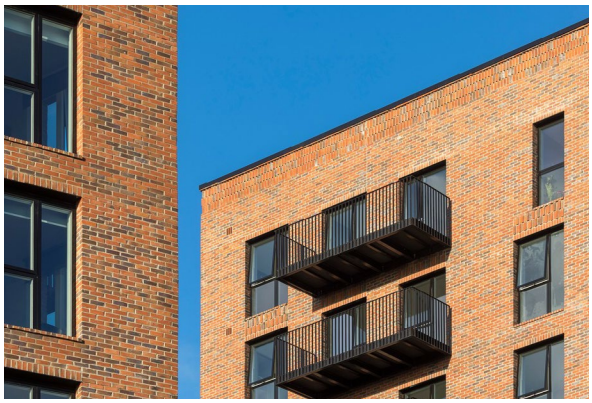
The project unfolds across multiple dimensions: environment, city, people, and sustainability. The energy retrofitting of the complex focuses on the use of prefabricated façades featuring thermal insulation made from bio-based materials—rice and straw husks—and finished with a windproof and fire-resistant layer of non-combustible gypsum fiber. These timber-frame façades were designed using BIM sofwares, which enabled the majority of the vertical surfaces to be prefabricated off-site.

A total of 5,935 m² of prefabricated walls have been installed, comprising 341 panels with a wooden structure. This approach optimizes resource use and leverages energy from the city's district heating system. Additionally, the vertical envelope was insulated through the replacement of windows and shutters, while green roofing solutions were incorporated to create new social spaces. The installation of the prefabricated façades was quick and efficient, with two workers able to install six panels per day. This process did not require scaffolding, further streamlining the construction and reducing time and costs while improving the safety of the construction site.

The interventions improved the building's energy efficiency, achieving energy class A4 and near-zero energy standards. The new envelope and heating system significantly reduce energy consumption, with heating provided by a centralized and district system. These upgrades increase the use of renewable energy, lower consumption and costs, and help combat energy poverty. As a result, the annual energy demand has been cut by over 90%.
The project includes intervention on the roofs, installing solar photovoltaic systems and creating roof gardens to enhance biodiversity, reduce the heat island effect, and provide communal spaces. The initiative positively impacted the environment and social aspects of the neighborhood, benefiting about 400 residents by promoting sustainability and improving quality of life. It fostered community integration, encouraged respect for public spaces, and restored a sense of neighborhood that was missing. The project involved extensive collaboration with various stakeholders, including universities, public institutions, and private companies, throughout all stages of design and implementation.
Achievements include a significant reduction in construction time on site as well as a reduction in inconvenience to residents and local traffic, thanks to the use of innovative off-site energy retrofit façades produced from bio-based materials and installed without the use of scaffolding.

In conclusion, this project is a noteworthy example of how public participation can play a crucial role in advancing sustainable energy solutions for social housing. By integrating off-site practices, bio-based materials, and actively engaging residents, it sets a precedent for a more inclusive and environmentally responsible approach to medium-small urban renewal. This innovative model not only demonstrates the potential for improving energy efficiency but also fosters a sense of shared responsibility, which could inspire similar initiatives in the future.

Dalston Works



© Waugh Thistleton Architects

Designers:	Waugh Thistleton Architects
Company:	Regal Homes
Location:	London, UK
Year:	2017
Category:	New construction
Use:	Housing
Size:	Residential surface: 12,500 m² Commercial surface: 3,500 m²
Client:	Regal Homes
Cost:	-

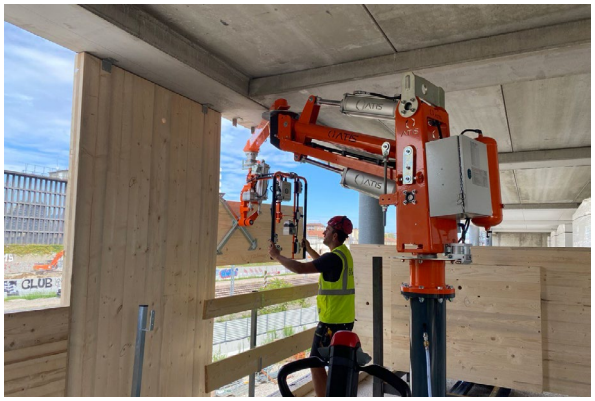
Completed in 2017, Dalston Works is a 10-storey residential development in east London that includes 121 apartments with balconies and a two ground-level shared courtyards, retail and restaurant space with an integrated workspace.
Upon its completion, the project became the world's largest cross-laminated timber (CLT) building at the time, standing 43 meters tall and using more CLT by volume than any other building. Dalston Works its representing also a landmark project in the use of timber construction in high-density urban housing. The building is made entirely out of CLT (4,650 m³ in total), including

the external, party and core walls, floors and stairs. The panels are characterised by structural rigidity in two directions thanks to the arrangement of the layers and are cut to size before being assembled on-site.
Thanks to the use of CLT technology, the building weighs just one-fifth of what a concrete structure of the same size would. This also reduces construction-related deliveries by 80 percent. Additionally, the timber serves as a carbon sink, locking in over 2,600 tonnes of CO_2, effectively making the building carbon-negative for the first several years of its use.
Creating a lighter core meant that the project could reach much higher than if it had been constructed in concrete, since the development sits on a neglected brownfield site and above the underground Elizabeth Line railway.
The use of timber technology not only addresses London's need for high-quality, high-density housing that provides a natural and healthy living environment, but also significantly reduces the building's carbon footprint in terms of material production, on-site time and energy consumption.
Moreover, the efficiency and lightweight nature of the scheme enabled client Regal Homes to increase the number of units by 25% and deliver the project quickly due to its reliance on prefabricated CLT panels. The CLT timber assembly took 52 weeks, and the entire construction took 130 weeks.
The new residential quarter makes up a large part of the new streetscape, and responds in scale with varied roof heights, undulating between five and ten storeys, each orientated to maximise daylight to the apartments' balconies and communal open spaces. The development is separated into several boxy volumes, while the CLT frame was clad in traditional bricks chosen to reference the Edwardian and Victorian architecture of nearby warehouses and terraced properties.

This point highlights the potential and flexibility of wood for structural purposes, and its ability to receive and incorporate finishes of a different nature that could completely hide its aesthetic and make it camouflage with the surroundings if necessary.

Dalston Works and projects of this entity are important not only for further developing wooden technologies, but also for pushing governments to prioritise carbon reduction and invest more in sustainable urban planning and architecture, even in high-density contexts where building is more challenging. In this context, architects have an important role to play in driving demand for timber design and creating a market that breaks away from the current one, which is often driven by lobbying from construction companies and the manufacturing industry.

Villaggio Olimpico Milano-Cortina 2026



© XLAM Dolomiti

Designers:	Studio SOM
Company:	Various. Xlam Dolomiti supplied and installed the exterior Xlam walls using a patented manipulator.
Location:	Milano, Italy
Year:	2024
Category:	New construction
Use:	Temporary housing and tourism
Size:	CLT panels: 15,500 m²
Client:	COIMA SGR
Cost:	-

Xlam Dolomiti is located in the heart of Trentino, where wood has always been a precious resource. Founded in 2012, the company is linked to the entrepreneurial tradition of the Paterno Group and is now one of the world leaders in the production of Xlam/CLT panels. Its success is based on a technologically advanced production cycle, an integrated approach to the construction project and a constant drive for innovation.
Among the company's numerous realisations, a recent project in Milan stands out: in sight of the Milan-Cortina 2026 Winter Olympics, the city is equipping itself with new infrastructure to accommodate athletes, staff and visitors, which will later be used for student housing. The Olympic Village project, designed by the U.S. Studio SOM, includes the redevelopment of two historic structures and six new residential buildings, as well as the green spaces specified in the masterplan.

In this context, Xlam Dolomiti has been involved in the construction of the buildings, facing the challenge of extremely tight deadlines for design and construction. The answer to this critical issue came in the form of a proposal that fuses technology and practicality: a manipulator was introduced at the laying stage with a procedure never before tried and tested on a building site, entirely developed and patented by Xlam Dolomiti.
This machine is already used in the automotive sector and has now been redesigned for a new task: handling and precisely positioning 9 cm-thick Xlam wood panels, even large ones. It uses a methodology that simplifies the installation process, making it safer and easier for workers.

Construction remains one of the most vulnerable sectors in the labour market, particularly in Italy, where it recorded the highest number of fatal accidents in 2022, with 110 fatalities.
Workers are no longer directly exposed to the lifting and positioning of the panels; instead, they manage the process in more controlled and protected conditions, thereby reducing the risk of injury and the physical impact of the work. The manipulator can be easily transported by an electric pallet truck and is equipped with safety sensors that prevent operation without complete stabilisation. Moreover, the manipulator is equipped with telescopic arms and a fixing plate for the panels. This allows the walls, even overhanging ones, to be lifted, rotated and precisely positioned, guaranteeing greater installation speed and efficiency.

Thanks to the use of the manipulator, the expected costs and construction times set out in the cronoprogramma were optimised, and the workers could be kept working at a positive and non-strenuous pace. Only three specialist technicians were needed instead of the planned 20, and the construction site was closed in eight months instead of ten.

The Milan-Cortina Olympic Village project is a source of pride for the company, and the value of this experience is not confined to the construction site itself. It shows how a critical operational issue can be turned into an opportunity for technological advancement. The ability to reinterpret existing tools has resulted in the creation of a patent that can now serve as a reference point for the entire timber construction sector. Thanks to this innovation, tight project deadlines have been met and clients have been offered a concrete, safe and sustainable solution.
This solution fully exploits the potential of off-site construction, where industrialisation allows for precise planning, reduced on-site times and improved overall safety. In the context of social housing and highly replicable public projects, solutions of this type represent a virtuous model for efficient, safe and accessible construction, reinterpreting the tradition of wood thanks to new technological solutions.

Camera Obscuradreef - Flat with a future

© Energiesprong

Designers:	Op ten Noort Blijdenstein (ONB)
Company:	NUP - Nieuw Utrechts Peil consortium (VIOS Bouwgroep BV + Op ten Noort Blijdenstein + Nieman Raadgevende Ingenieurs)
Location:	Utrecht, The Netherland
Year:	2016-2019
Category:	Renovation
Use:	Social housing
Size:	4,000 m² (per 48 flats)
Client:	Mitros Social Housing Organisation
Cost:	4.3 milions € (per 48 flats)

Originating in the Netherlands, Energiesprong is an innovative, industrial-scale renovation method designed to upgrade outdated housing stock with practical, cost-effective solutions that accelerate the transition to energy efficiency. Developed over a decade ago and primarily applied to social and public housing, the Energiesprong approach offers scalable models, technologies, and projects, achieving cost savings of 10 to 30% compared to traditional renovation methods.

One of the first major implementations of this approach was the *Camera Obscuradreef* project in Utrecht, which underwent a major energy redevelopment as part of the Dutch Energiesprong programme. The aim was to transform existing residential buildings into net-zero energy dwellings. After a successful pilot involving eight homes that were made net-zero within 10 weeks, construction company VIOS went on to refurbish several social housing units and build new homes, owned by housing organisation Mitros, in the same neighborhood to the same standard.

The project, titled *Flat met Toekomst* (Flat with a Future), unfolded over several years and aimed to revitalize aging housing stock. It began with the renovation of 48 flats, soon followed by an additional 80, all refurbished according to a consistent design approach. Building on this momentum, the project was later expanded to include the renovation of 252 flats from the 1960s in the same neighborhood, along with the construction of 15 brand-new units.
New prefabricated façade elements were installed, integrating heating, ventilation, thermal insulation, and solar energy systems. These off-site interventions enabled the buildings to reach net-zero energy status, significantly improving energy efficiency and reducing CO_2 emissions without compromising living comfort. The upgrades included photovoltaic panels, air-water heat pumps, ventilation systems with heat recovery, and a significant enhancement of thermal insulation. Interior spaces were also renovated, asbestos was removed, and sustainable materials were used throughout. Thanks to those interventions energy consumption was reduced by nearly fivefold, from 225 kWh/m² to 50 kWh/m² per year.

An innovative aspect of the project was its energy performance-based financing model, which enabled renovation costs to be covered by energy bill savings without increasing monthly expenses for tenants. Another key element was the decision to carry out a pilot test on an existing apartment before scaling up. This included installing advanced heating and ventilation systems, with continuous monitoring to optimize performance.

The project was significant not only for its technical achievements but also for its positive social impact. In fact, it was one of the first prefabrication projects dedicated to the deep retrofit of social housing, applied on a large scale and committed by the public administration. Moreover, residents were able to stay in their homes during construction, observing daily progress, and ultimately reported high satisfaction with the results and the implemented comfort. The work extended the building's life by 50 years and came with a 10-year performance guarantee.

Thanks to these interventions, the buildings met net-zero energy standards and earned multiple accolades, including the Sustainable Renovation Grand Prize at the Green Solutions Awards 2019. The success of this initiative helped replicate similar projects across the Netherlands and supported the expansion of the Energiesprong model into other European countries through the creation of the EnergieSprong Alliance, now active in the Netherlands, France, Germany, the UK, and Italy.

Shared accommodation Aubing-Lochhausen-Langwied

© MOD21

Designers:	MOD21
Company:	MOD21
Location:	Munich, Germany
Year:	Construction time: Jun. 2023 - Jan. 2024
Category:	New construction
Use:	Childcare infrastructure
Size:	Gross floor area: 3,636 m^2
Client:	City of Munich, Building Construction Department
Cost:	-

The modular accommodation facility at Freihamer Weg 69 in Munich exemplifies an efficient and sustainable approach to addressing urgent housing needs for refugees. Commissioned by the City of Munich and constructed by MOD21, this three-storey building was completed in early 2024 and is designed to accommodate up to 180 individuals. The project was developed in

direct response to the increasing demand for refugee housing, particularly following the arrival of displaced people from Ukraine. The facility comprises 78 double rooms, three family apartments with four beds each, two four-bed apartments, and two single-room apartments designed for wheelchair users. While only the family units are equipped with private kitchens and bathrooms, each floor features communal kitchens, lounges, sanitary facilities, cleaning rooms, and laundry areas. These shared amenities are designed to foster a sense of community while ensuring functionality and accessibility.

A major strength of this project lies in the use of prefabricated modular construction, which enabled rapid deployment without compromising on quality or comfort. The modules were manufactured off-site in a controlled factory environment, allowing for precise quality control, reduced material waste, and significantly shorter construction timelines. This method also gave the City of Munich greater oversight of the production process, with modules being inspected before on-site installation.

The ability to realize such a facility within a short timeframe proved critical in addressing the sudden and pressing housing needs caused by the war in Ukraine. Unlike traditional construction methods, which are often slow and heavily affected by weather or site logistics, modular construction offers the speed and predictability required during humanitarian crises. By minimizing on-site work and streamlining the building process, MOD21 was able to deliver a safe and dignified residential environment when it was most needed. This project demonstrates how modular construction can be a key tool in municipal strategies to provide rapid, scalable housing solutions during periods of acute demand.

The facility is managed by the City of Munich, with the AWO München-Stadt organization providing social services and support to residents. Their on-site team offers essential guidance and assistance to help individuals navigate their new environment and integrate into the local community.

The modular accommodation at Freihamer Weg is a compelling example of how innovative building methods can meet urgent social challenges. By combining speed, sustainability, and thoughtful design, the project delivers more than just shelter—it offers stability, community, and a foundation for new beginnings.

Reutlingen Children's Home

© MOD21

Designers:	MOD21
Company:	MOD21
Location:	Reutlingen, Germany
Year:	Construction time: Nov. 2023 - May 2024
Category:	New construction
Use:	Childcare infrastructure
Size:	Gross floor area 810 m^2
Client:	City of Reutlingen
Cost:	-

The Children's Center in Reutlingen, Germany, exemplifies a forward-thinking approach to early childhood education infrastructure through modular construction. Commissioned by the City of Reutlingen, this two-storey facility spans 810 square meters of gross floor area and is designed to accommodate children up to 6.5 years old, addressing the city's pressing need for additional childcare spaces. The project is being realized by MOD21, a company renowned for its expertise in modular building solutions.

The construction employs timber modular technology, with modules prefabricated in a controlled factory environment. This method ensures high-quality construction, reduces material waste, and significantly shortens the on-site assembly time. The modular approach also allows for flexibility in design, enabling the adaptation of spaces to meet the specific needs of young children and educational staff.

Sustainability is a core component of the Children's Center project. The use of certified timber and eco-friendly materials contributes to an environmentally responsible footprint. This aligns with Reutlingen's broader commitment to sustainable urban development and green building practices.

One of the key advantages of modular prefabrication, particularly for public-sector investors like cities and municipalities, is the enhanced ability to supervise and control the construction process. Unlike traditional on-site building methods, where quality checks are often limited by environmental conditions and time pressures, factory-based production provides a controlled environment where every phase—from structural assembly to interior finishes—can be precisely monitored. This centralized setting allows public project managers to inspect individual modules before they are delivered to the site, ensuring compliance with technical, safety, and sustainability standards well in advance of installation. In the case of the Reutlingen Children's Center, for instance, city representatives, including project manager Dieter Pross, visited the manufacturing facility to review progress and verify execution. This model of off-site quality assurance not only minimizes construction risks and rework but also fosters greater transparency and accountability—essential qualities in public infrastructure delivery. It enables municipalities to maintain stricter oversight, adhere to budgetary constraints, and accelerate timelines without compromising on quality or safety.

The Children's Center in Reutlingen stands as a testament to the efficacy of modular construction in delivering high-quality, sustainable, and adaptable educational facilities. By combining rapid deployment, environmental responsibility, and thoughtful design, it sets a precedent for future developments in the sector.

Steel Prefabrication

Mobility and Reusability

Steel modular buildings stand out for their durability and reusability. Thanks to concealed crane hooks integrated into their frames, individual modules can be disassembled and relocated quickly, offering a lifespan that extends beyond one site. In several urban student housing projects, entire steel modular buildings have been installed in just 3–5 days using pre-assembled units, reducing construction time by over 60%. This makes steel an ideal solution for rapidly deployable and mobile infrastructure in evolving urban areas.

Another key advantage of steel prefabrication is the configurability of the repeating module—particularly in terms of its shape. Unlike other technologies, steel allows for greater flexibility in customizing modular forms, enabling more varied and adaptive designs that are harder to achieve with concrete or timber systems.

Transformation of 530 dwellings

Designers:	Lacaton & Vassal architectes, Frédéric Druot Architecture e Christophe Hutin Architecture
Company:	-
Location:	Bordeaux, France
Year:	2017
Category:	Renovation
Use:	Social housing
Size:	68,000 m² (44,210 m² existing +23,500 m² winter garden)
Client:	Metropolis of Bordeaux (Aquitanis O.P.H. de la communauté Urbaine de Bordeaux (CUB)
Cost:	27.2 millions € for renovation and 1.2 million € for new construction

The project involves the transformation of three occupied social housing buildings, marking the first phase of a broader renovation program for the "Cité du Grand Parc", a residential district located close to the historic center of Bordeaux. Originally constructed in the early 1960s, this urban housing complex comprises more than 4,000 units. The three buildings (G, H, and I) range from 10 to 15 stories and contain a total of 530 apartments. These structures offer considerable potential for transformation into attractive, high-quality living spaces with enhanced comfort and architectural value.

This complex initiative includes the partial renovation of 530 existing apartments, as well as the addition of 8 new units on occupied sites. The renovation primarily focused on the facades, introducing spacious winter gardens and balconies, adding about 41.6 m² on average per dwelling. The extensions are made with a prefabricated external metal structure that anchors to the existing building without requiring internal structural modifications. The added balconies consist of a lightweight transparent facade structure made of corrugated transparent polycarbonate panels mounted on aluminum frames. These panels are equipped with reflective solar shades to improve energy efficiency.
A key aspect of the project's cost-efficiency lies in preserving the existing building structures, avoiding major interventions to core elements such as the structural framework, stairwells, and floors. This approach allows investment to be directed toward creating expansive and thoughtfully designed extensions, vital to improving the long-term livability and comfort of the apartments.

These new extensions significantly increase usable living space, allowing residents to enjoy both indoor and outdoor environments, much like in a traditional house. Apartments will open onto large winter gardens and balconies, offering generous outdoor spaces, each with a depth of 3.8 meters on the south-facing facades of buildings H and I, and on both facades of building G.
The integration of those elements enhances both the living experience and the aesthetic

presence of the buildings while keeping the residents in place throughout the renovation.
Additional interior upgrades include bathroom renovations and improvements to the surrounding gardens, enhancing accessibility and usability. The project also improves overall building performance by upgrading the envelope and reconfiguring vertical circulation and access areas. Through this initiative, social housing (often criticized for its lack of quality) demonstrates the potential for meaningful and cost-effective transformation. This project takes aging, underperforming structures and turns them into spacious, comfortable, and high-performing dwellings. It redefines residential living, enhancing comfort, enjoyment, and the urban landscape while renewing the housing typology.
This project exemplifies how thoughtful, resource-conscious architecture can redefine the future of social housing renovation with the use of off-site prefabrication techniques. By working with existing structures rather than replacing them or building from scratch, the intervention proves that sustainability and architectural quality are not mutually exclusive and can be a replicable model for the renovation of post-war housing stock across Europe.

APROP - Ciutat Vella

© Adrià Goula

Designers:	Straddle3, Eulia Arkitektura, Yaiza Terré Estudi d'Arquitectura
Company:	UTE Constècnia – Eurocatalana
Location:	Barcelona, Spain
Year:	2019
Category:	New construction
Use:	Social housing
Size:	816 m²
Client:	Ajuntament de Barcelona, Área de Derechos Sociales
Cost:	940,000 €

The municipal program *APROP* (Provisional Proximity Housing) from the municipality of Barcelona, aims to respond quickly, urgently, and pragmatically to emergencies caused by the lack of housing, helping to prevent the forced displacement of residents from gentrified neighborhoods. These programs see vacant plots, properties that have not exhausted their buildability, and even excessively large public spaces as opportunities to place residential units. By using modular prefabrication with criteria for urban, ecological, and social sustainability, they achieve faster, more economical, and fairer execution compared to conventional public housing developments. Through these residential facilities, the city council aims to temporarily rehouse (with a maximum stay of two years), in their own neighborhood, residents who have been displaced. The APROP provides not only temporary accommodation but also socio-educational support to individuals and families at risk of social exclusion, who are assisted by social services until they secure stable, permanent housing.

Following the success of similar projects in cities such as London, Copenhagen, and Vancouver, the project uses recycled shipping containers as housing units that are adapted into one- or two-bedroom units, ranging from 30 to 60 m². Both types are characterized by natural lighting and ventilation, private and shared exterior spaces (balconies and walkways), functional and versatile furniture, and ensure thermal, acoustic, and lighting comfort through the use of high-quality, efficient installation systems, insulation, and spatial features.

These modular buildings significantly reduce their ecological footprint. On one hand, they eliminate the energy consumption and greenhouse gas emissions typically associated with the extensive use of reinforced concrete or steel casting in traditional construction. On the other hand, they are fully dismantlable, transportable, and adaptable to other locations, which reduces energy consumption and waste generated during the demolition process. This approach also highlights the potential for incorporating reused components and materials in off-site construction practices.
The ground floor of the APROP Ciutat Vella houses the expansion spaces of the CAP Gòtic (Centre d'Atenció Primària Gòtic), a nearby public healthcare center. The building is characterized by its double-skin facade, which, on one hand, maintains the urban alignments and, on the other, functions as a passive thermal control system.

The building offers features comparable to those of conventional constructions, such as elevators, and has received an AA energy certification thanks to the incorporation of sustainable systems, including the use of rooftop photovoltaic panels to generate electricity and the collection of rainwater for reuse.
Additionally, the industrialized construction system enables a large portion of the work to be completed in a workshop, which greatly shortens execution times. The entire construction process was completed in just 16 weeks, while also minimizing the environmental impact.

The Smallville Residence

© DMD Modular

Designers:	DMD modular
Company:	DMD Modular
Location:	Sion, Switzerland
Year:	2017
Category:	New construction
Use:	Housing
Size:	Building area: 695 m^2 Gross floor area: 1.488 m^2
Client:	Local Tempohousing company in Sion
Cost:	-

The Smallville Student Living project in Sion, Switzerland, is a compelling example of modern modular architecture that prioritizes efficiency, sustainability, and adaptability. Designed and delivered by DMDmodular, the three-storey residence consists of 42 prefabricated steel modules, creating 51 fully equipped student apartments over a gross area of 1,488 square meters.

At the core of the project is a steel-frame modular technology, allowing for precise fabrication under factory-controlled conditions. This off-site production process ensures consistent quality,

reduces construction waste, and minimizes the environmental footprint compared to traditional building methods. Each volumetric module—measuring 303×1090 cm or 303×1390 cm—is delivered to the construction site as a complete unit, fully fitted with essential elements such as kitchens and bathrooms.

Following production, the modules are transported to the site in Sion and assembled within a significantly shortened time frame. This rapid deployment not only limits disruption in the surrounding urban environment but also reduces the total construction timeline and associated costs. The controlled logistics and reduced need for on-site labor also contribute to improved safety and predictability.

What sets the Smallville project apart is its emphasis on long-term flexibility. The building has been designed for potential disassembly and relocation, which allows the structure to be reused in a different location or reconfigured for alternative purposes. This approach not only extends the life cycle of the materials used but also supports evolving urban planning needs without the environmental burden of demolition and reconstruction. Each steel module is equipped with specially engineered lifting hooks discreetly integrated into the structural frame. These hidden elements enable safe and efficient disassembly using a crane, making the relocation process both technically feasible and cost-effective.

Smallville reflects key principles of best practice in modular construction. Its efficient, factory-led process guarantees high standards of execution, while the speed of on-site assembly minimizes disruption. The use of durable steel modules enhances longevity, and the potential for disassembly underscores a commitment to circular construction models. As an integrated architectural solution, Smallville Student Living demonstrates how modular building systems can address the challenges of urban density, sustainability, and changing occupancy demands. It provides a valuable reference for future projects aiming to leverage the benefits of off-site construction, both on and beyond the building site.

Energy Efficient Housing

© DMD Modular

Designers:	DMD Modular
Company:	DMD Modular
Location:	Mysłowice, Poland
Year:	2023
Category:	New construction
Use:	Housing
Size:	Building gross area 656.5 m^2 Usable area: 2,109.4 m^2 Building height: 13.26 m
Client:	Public
Cost:	-

The Energy Efficient Housing project in Mysłowice, Poland, stands as a pioneering example of sustainable modular construction, addressing contemporary challenges in housing and environmental stewardship. Developed through a collaboration between DMDmodular, the Cracow University of Technology, and Lightoffo, under the DMD-M research and development consortium, this four-storey building comprises 29 apartments, ranging from 45 to over 60 square meters.

Central to the project's innovation is the use of volumetric steel modules, manufactured in a controlled factory environment. This method ensures precision, reduces construction waste, and shortens the building timeline. Each of the 56 modules arrived on-site fully equipped with interior installations, including doors, windows, finished floors, ceilings, and fitted bathrooms and kitchens, allowing for rapid assembly and immediate occupancy.

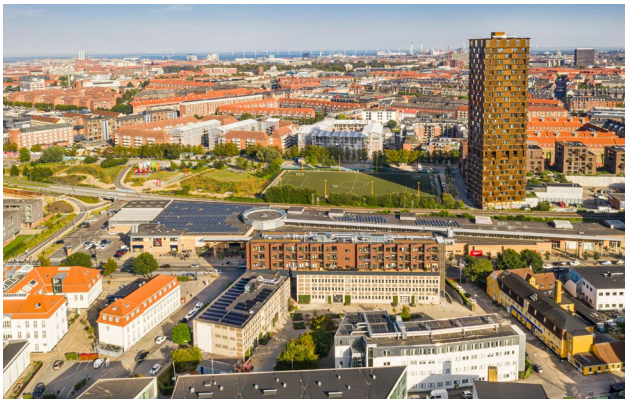
The building's design integrates advanced ecological technologies to achieve energy efficiency. It utilizes renewable energy sources such as ground source heat pumps, solar collectors, and photovoltaic panels installed on the roof and south-facing walls. These systems enable the building to produce more energy than it consumes, aligning with the principles of positive energy buildings. Additionally, the structure incorporates wastewater treatment, grey water recovery, and rainwater utilization systems, contributing to sustainable water management.

Beyond its environmental features, the project emphasizes social responsibility. As a municipal building managed by the Municipal Management Board, the apartments are designated for social housing, providing affordable living options for residents. The building's design also considers accessibility, with units adapted for wheelchair users, ensuring inclusivity.

The Energy Efficient Housing project exemplifies best practices in modular construction: efficient off-site fabrication, swift on-site assembly, integration of renewable energy systems, and adaptability to social needs. Its success demonstrates the potential of modular technology to deliver sustainable, affordable, and high-quality housing solutions in response to modern urban challenges.

The selected project was highlighted by us as authors also because it had previously been awarded through a national competition and grant program run by Poland's National Centre for Research and Development (NCBiR). Both the design phase and its implementation were co-financed with EU funds, further underscoring the project's uniqueness and strategic importance.

Danish Student Living



© DMD Modular

Designers:	DMDmodular
Company:	DMDmodular
Location:	Copenhagen, Denmark
Year:	2023
Category:	New construction on existing building
Use:	Student housing
Size:	Gross modular area: 2,464 m^2
Client:	Public
Cost:	-

The Danish Student Living project in Copenhagen exemplifies an innovative approach to urban development through modular architecture. DMDmodular undertook the challenge of adding three new storeys atop an existing 1980s office building, transforming it into a modern residential complex. This vertical extension comprises 84 prefabricated steel modules, resulting in 75 new apartments, technical rooms, two staircases, and an elevator shaft, collectively spanning approximately 2,464.8 square meters.

A distinctive feature of this project is the use of non-standard module shapes, diverging from typical rectangular forms commonly seen in modular construction. These varied geometries contribute to a unique architectural façade, enhancing the building's aesthetic appeal and integrating seamlessly with Copenhagen's urban landscape. The project not only reimagines the visual potential of modular systems but also demonstrates their capacity for architectural expression and contextual sensitivity.

The modules were manufactured off-site in a controlled factory environment, ensuring high-quality construction and efficient resource utilization. Each module was fully equipped with interior finishes, including kitchens and bathrooms, prior to transportation. The on-site assembly was completed in just four weeks, minimizing disruption to the surrounding community and demonstrating the efficiency of modular building techniques.

Structurally, the extension was facilitated by steel columns penetrating the existing reinforced concrete building, supporting a transfer beam system upon which the modular units were placed. This design allowed the new addition to maintain an independent structural system while coexisting with the original building, ensuring long-term stability and safety.

Moreover, the project aligns with key sustainability goals by optimizing the reuse of existing urban space rather than resorting to demolition and new construction. This adaptive reuse approach significantly reduces the environmental impact while responding to the high demand for student housing in a densely populated city. Danish Student Living is thus a benchmark in contemporary modular design, merging technical innovation, environmental responsibility, and architectural quality into one cohesive urban solution.

Concrete Prefabrication

Speed and Quality Assurance

Concrete prefab systems dramatically shorten construction timelines. In some office and residential projects, assembly of precast concrete elements took only 3 months—compared to 9–12 months for conventional builds—using over 1,000 m² of ready-to-install sandwich panels with integrated windows, blinds, and facade finishes. Hollow-core slabs and double walls speed up floor and wall assembly by 50–70%, while factory-controlled conditions ensure higher precision and lower defect rates, enabling earlier occupancy and cost certainty for investors.

Compared to other technologies such as steel and timber, concrete prefabrication typically involves a lower degree of off-site assembly — more components (walls and not entire living units) are put together on the construction site rather than in the factory. However, the overall construction process tends to be faster.

Leopoldau - Vienna

© GREENCODE

Designers:	feld72 Architekten ZT GmbH
Company:	GREENCODE
Location:	Wien, Austria
Year:	2017 - 2018
Category:	New construction
Use:	Social housing
Size:	GreenCode Thermo Wall: 2,228 m²
Client:	-
Cost:	-

The architectural intervention on the grounds of the former Leopoldau gasworks represents an innovative and socially responsive model of contemporary housing. It features an exceptionally high-quality exterior façade aesthetics, even though it is designed for standard residential use. Central to the design is the emphasis on communal living and interpersonal communication, positioning the project as a counter-model to the widespread phenomenon of urban anonymity, where social fragmentation and detachment from one's immediate neighbors prevail. From the level of spatial organization to material articulation, the building fosters encounters, mutual

visibility, and collective presence—evoking the social structure of a village embedded within a larger urban framework.

A key element of this approach is the integration of compact, multifunctional studios or micro-workspaces into each dwelling unit. These semi-public spaces, visually and spatially connected to the expansive central staircase, function as liminal zones that blur the boundaries between the private and the collective. They are conceived as expressive platforms—enabling residents to showcase personal interests, engage in creative production, or establish a home office—while also allowing for optional retreat through the use of curtains or movable partitions. This architectural typology supports a dynamic interplay between self-presentation and privacy, reinforcing the project's broader commitment to social connectivity.

Beyond the mere provision of housing, the development adheres to a holistic vision of living that foregrounds spatial openness, ecological sensitivity, and dialogical engagement with the built and natural environment. The preservation and integration of the existing tree population not only enhance the site's ecological value but also contribute to a strong place identity. Equally, the project incorporates sustainable principles at every scale of detail, including in the specification of ecological materials for furnishings, flooring, lighting, plantings, and play areas.

The resulting residential environment is guided by principles of economic efficiency, resource-consciousness, and constructional optimization. Notably, the concept of "young living"—as applied here—is decoupled from chronological age, instead denoting a mode of inhabitation characterized by openness, adaptability, and a future-oriented ethos. The building is conceived as a responsive medium for personal and communal unfolding: modular in structure, temporally flexible, and capable of accommodating diverse and evolving modes of use.

Grieser Auen – Bolzano

© GREENCODE

Designers:	Work Architects Europe
Company:	GREENCODE
Location:	Bolzano, Italy
Year:	2017 - 2018
Category:	New construction
Use:	Housing
Size:	Gross floor area: 3,900 m² per building
Client:	-
Cost:	-

The Grieser Auen residential development in Bolzano, Italy, presents the potential of modular precast concrete technology in delivering sustainable, high-quality housing at scale. This example of a building using concrete prefabrication is particularly noteworthy due to its

height. Located in a newly developed, largely car-free and energy-optimized district, the project was designed to offer affordable, family-oriented homes with long-term replicability in mind. The use of prefabricated components played a critical role in achieving construction efficiency, environmental performance, and aesthetic integrity.

This development relied heavily on Green Code's modular concrete elements, including 5,165 m² of Thermo Walls, 9,184 m² of Twin Walls, 3,376 m² of Climatic Slabs, 160 m² of Thermo Slabs, 3,300 m² of biaxial hollow-core slabs, and 3,200 m² of prestressed hollow-core slabs, along with prefabricated columns, beams, and stairs. The modular nature of these elements allowed for faster assembly on-site and consistent production quality, helping reduce construction time and labor demands.

The integrated Climatic Slab system provides an energy-efficient solution for indoor climate control, leveraging embedded water-carrying pipes to deliver radiant heating and cooling. This enables the use of low-temperature heating sources such as heat pumps while maintaining a stable, comfortable thermal environment with minimal air movement and noise. It also significantly reduces energy loss through ventilation, a common inefficiency in conventional HVAC systems.

Complementing this system, the Thermo Wall combines structural strength with high-performance insulation by integrating thermal and load-bearing layers in a single unit. This design minimizes thermal bridges, enhancing overall insulation and energy retention. Furthermore, as the walls are pre-fabricated with integrated insulation, their production eliminates the need for additional on-site thermal treatment, streamlining the construction timeline and improving building envelope performance.

The synergy between Climatic Slabs and Thermo Walls significantly enhances both heating and cooling efficiency. Thermal inertia inherent in concrete contributes to peak load shifting and temperature stability, reducing reliance on mechanical systems. The walls' ability to manage internal moisture through radiant heating not only prevents mold growth but also improves thermal resistance, with only a small decrease in wall humidity dramatically boosting insulation values.

The modular approach taken in Grieser Auen was not only environmentally driven but also economically strategic. The prefabrication of all major structural and climate-regulating elements off-site allowed the public and private stakeholders to monitor production closely, ensure quality control, and minimize delays. While exact construction times were not specified, the volume and integration of modular units suggest a significantly faster build compared to conventional methods.

The Grieser Auen project demonstrates how modular concrete construction—when paired with intelligent climate systems—can offer a sustainable, replicable model for contemporary housing, achieving both architectural integrity and operational efficiency.

Mieszkanie Plus residential development

© Grzegorz Olkowski/PFR Nieruchomości

Designers:	S.A.M.I. Architekci, Sp. z o.o.
Company:	Pekabex
Location:	Toruń, Poland
Year:	2020
Category:	New construction
Use:	Housing
Size:	Gross floor area: 15,000 m²
Client:	Public
Cost:	-

The Mieszkanie Plus residential development on Okólna Street in Toruń represents Poland's first large-scale housing project under the national housing program to fully utilize precast concrete technology. This example stands out not primarily for its architectural aesthetics, but for the remarkable speed of construction, its scale, and—most importantly—the profile of the main client. The project was commissioned by PFR (Polish Development Fund), a state-owned national institution, as part of the government-led Mieszkanie Plus program. PFR played a central role in planning and implementing comprehensive residential masterplans across the country, making this project a significant case study in large-scale, state-backed prefabricated housing.

Designed by the Warsaw-based architectural firm S.A.M.I Architekci, with Pekabex BET S.A. as the general contractor, the complex consists of eight four-story buildings offering a total of 320 apartments across approximately 15,000 square meters of usable space. The development demonstrates how contemporary prefabrication methods can be implemented on a wide scale to deliver high-quality, affordable housing within a significantly shortened construction timeline.

The core of this project lies in its use of modern three-layer precast concrete wall panels. These elements were fabricated off-site in a controlled factory setting, where they were outfitted with insulation, façade finishes, window joinery, external blinds, and sills. As a result, the elements arrived on site nearly finished and were installed with minimal additional processing. Small assembly teams of just six workers were able to erect one floor per week, enabling the completion of an entire building in roughly one month. This approach allowed for a construction timeline up to 30% shorter than traditional methods while maintaining a consistent and high standard of quality.

Beyond speed and quality, the prefabricated construction also led to a measurable increase in usable living space. The thinner structural profile of precast wall panels compared to their masonry counterparts meant that each apartment gained between 5% and 7% more floor area. On a development of this scale, this translated to approximately 500 square meters of additional residential surface without increasing the building's footprint.

The project was also carefully designed to respond to the local urban context, both functionally and aesthetically. The façades maintain a clean and minimalist appearance, with visible panel seams emphasizing the modular construction. Interior circulation areas such as stairways and corridors were finished in exposed concrete, balanced with wooden details and subtle color accents. The ground floor units were enhanced with private gardens, and outdoor communal spaces included a playground and landscaped areas. Notably, a historic military route that once passed through the area has been preserved in the paving design as a cultural reference to the site's past.

This housing estate in Toruń illustrates how advanced precast concrete construction can contribute not only to faster, cost-effective housing solutions but also to well-integrated, livable urban environments. By shifting much of the construction process off-site, public-sector developers gained greater control over the quality and logistics of delivery, while minimizing disruption at the construction site. The project sets a strong precedent for future public housing initiatives, showcasing how modular, prefabricated building systems can meet growing residential demand with efficiency, resilience, and architectural sensitivity.

Conclusion

Off-site construction represents a transformative shift in policymaking and the building industry, offering diverse growth opportunities. In fact, designing and building off-site enables the integration of multiple key factors such as flexibility, sustainability, and resilience.

Many case studies proposed highlight the increasing need for reversible and temporary construction interventions in response to the rapidly evolving challenges of the built environment. Off-site construction marks a departure from conventional building methods, embracing practices that better address the urgent environmental demands of our time. As we reconsider the necessity of traditional construction and the changing needs of new interventions, the off-site approach offers valuable opportunities to reduce land consumption while providing resilient and adaptable solutions.
Furthermore, the study of reversibility and disassembly in off-site architecture aligns closely with other emerging sustainable concepts in contemporary design. Off-site construction is also well-suited to the integration of bio-based materials and waste reduction strategies. It could complement principles such as selective demolition and material reuse, approaches that have been widely adopted and supported by legislation in France and Belgium for almost a decade. Additionally, off-site construction allows for the seamless integration of installations and technological components during the building process, enhancing overall performance while reducing emissions and maintenance costs.

Architects play an interesting role in advancing the widespread adoption of off-site construction. By deepening their understanding of the technical and technological aspects of building processes and production, they can drive innovation and maintain high standards of quality in off-site construction. Moreover, collaboration among all stakeholders in the production chain -architects, engineers, construction companies, and workers- is vital for achieving both aesthetic satisfaction and attention to detail in the architecture. Without careful consideration by designers of construction methods and design possibilities, the outcome may differ significantly. In addition, the integration of advanced building components and digital tools further empowers architects to design more efficient, adaptable, and scalable solutions.

In conclusion, although widely replicable examples of off-site solutions for energy-efficient retrofits in social housing remain limited, this gap presents a significant opportunity.
By investing in innovation, fostering collaboration between public and private sectors, and scaling successful pilot projects, off-site construction has the potential to become a central component of future sustainable and inclusive housing policies. However, achieving this requires a shift in mindset and a strong commitment to change and innovation, particularly within public administration, which holds both the economic power and the responsibility for public housing stock. Instead of focusing solely on providing funding, the emphasis should shift toward cost-effective interventions that also contribute to broader urban transformation. This integrated approach can maximize impact and help incorporate social housing upgrades into larger strategies for sustainable urban development.

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