

Upcycle post-WWII housing in Germany, case study: prototype design in Frankfurt-Mainz Region

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Abstract

This article examines postwar social housing rehabilitation in Germany, where current policies primarily address construction quality and energy efficiency. Beyond these technical concerns, the research emphasizes the need to reconsider the inherited domestic spaces and programs of the *siedlungen*. Despite their architectural, social, and urban value, nearly a third of these estates face not only physical and energetic deficiencies but also programmatic obsolescence and limited adaptability, hindering alternative forms of dwelling. Minor projects and small-scale interventions can act as catalysts for new spatial practices, as advocated by Eleb and Bendimerad, and Avermaete and van den Heuvel, challenging the typological and urban rigidity of the modernist legacy. Within this framework, the article explores an experimental design strategy in postwar estates by Ernst May's office in the Rhine-Main region. Coordinated interventions by professionals, associations, and administrations may enable emancipatory processes, fostering collective reconfiguration of housing through simple spatial tools.

Keywords

Social housing, postwar *siedlungen*, upcycle, research by design, Germany.

Introduction

Between 1950 and 1970, the Federal Republic of Germany constructed approximately 4.9 million social housing units following the *siedlung model*—planned residential estates that today represent around 43% of the national housing stock (Walberg et al. 2022, 10). These initiatives were initially developed by the *Arbeitsgemeinschaft für zeitgemässes Bauen e.V.* (Association for Contemporary Building), founded in Kiel in 1946. As economic recovery advanced, gaining access to these suburban housing estates became a strong sociocultural marker for the postwar generation. The large-scale production and access to standardized housing were presented as mechanisms of social welfare within a supposedly secure and democratic society, in line with what Harvey (2010, 125) describes as a broader *sociocultural contract* extended beyond Central Europe. Despite their architectural, social, and urban value, nearly a third of these estates face not only physical and energetic deficiencies but also programmatic obsolescence and limited adaptability, hindering alternative forms of dwelling.

This article summarises the research project on upcycling solutions for post-war social housing in Germany, using a research-by-design methodology. Through the Research Project “Home and Office? Prototype for sustainable upcycling of post-WWII housing 1950-1970, Mainz”, abbreviated “H&O?”, approaches housing projects and the domestic space do not function in isolation but acquire meaning through the processes by which they are conceived, occupied, and transformed. When housing is examined beyond its role as an object of market exchange—shifting the perspective from exchange and use value toward social and cultural value—it becomes clear that both the processes of production and appropriation, together with the physical spaces, define the potential for identity formation and social integration, whether in new constructions or in the existing housing stock.

The first part of this article outlines the context of mass social housing production in postwar Germany, understood as a built framework tied to a broader social contract, regulated by political and economic structures. The second part explores the possibility of upcycle the blocks through a “small intervention”, focusing on how architectural strategies may act as mediating and diversifying mechanisms, integrating various stakeholders and domestic programs at both the unit and collective scales.

The research project underlying this article critically examines the tendencies often present in rehabilitation policies for postwar social housing in Germany that are frequently reduced to energy-efficiency optimization, and accessibility improvements, serving as responses to pressing demands but leaving aside the spatial and programmatic conditions of the residents. Within the context of the Rhine-Main region—Frankfurt, Mainz, Wiesbaden—the research

project sums up the collaborative processes between universities, local communities, and institutions, to find out operational tools that advance interdisciplinary innovative proposals on sustainable upcycling of the housing stock of post-WWII housing 1950-1970.

Frankfurt–Rhine–Main Region *Siedlungen* post war urban production

The research project hypothesis focuses on the possibility of improving the spatial relationship and domestic space facilities in a group of standardised housing estates built in post-war Germany, in order to provide more space and update their use. This would be achieved through a small-scale, modular and serialised architectural intervention that meets the technical requirements for energy efficiency and comfort, and diversifies the existing domestic programme.

To understand the context of housing complexes in Germany, it is interesting to note that the interplay of architecture, politics, and propaganda was especially visible in the housing projects of *Neue Heimat*, a corporation founded by labour union that became the largest non-state housing developer in Europe during the postwar period. Within the Frankfurt–Rhine–Main region, the return of architect Ernst May after years in the Soviet Union and East Africa—was particularly influential. Between 1954 and 1963, E. May served as planning director in several municipalities, including Frankfurt, Wiesbaden, Mainz, and Darmstadt. Together with his team, he produced housing projects on a scale unmatched by most twentieth-century architects, reinforcing the ideal of access to green suburban estates equipped with services and amenities as a symbol of social progress.

The legacy of these developments has been subject to critical examination not only from architectural and urban perspectives (Harnak, Wechs, and Glunde 2019, 20) but also with regard to the centralization of power, the neglect of shifting demographics, and the lack of innovative governance or participatory mechanisms (Quiring and Barr 2011, 32). The economic adjustments following the 1973 oil crisis, coupled with the rise of neoliberal policies in the 1980s, further dismantled the notion of a shared cultural and political framework. Over time, the social reality within the *siedlungen* grew increasingly diverse and fragmented. Common spaces, once conceived as collective assets, became restrictive, deteriorated, or were commercialized—leading to more individualistic and consumer-oriented patterns of living (Lipovetsky and Sébastien, 2006).

The evolution of housing policy during this decades was shaped by two key directions. The first centred on the principle *Urbanität durch Dichte* (“Urbanity through Density”), which emerged from the 1963 congress of the *Bund Deutscher Architekten* in Gelsenkirchen. This approach emphasized large-scale residential projects as an alternative to extensive suburban

sprawl, resulting in megastructures such as Frankfurt's Sonnenring Ost, completed in 1974. Parallel research initiatives, such as those at HBK University in Braunschweig, drew on the Dutch *Stichting Architecten Research* (S.A.R.) system. Their focus on adaptable residential design demonstrated how technical flexibility could respond to demands for cultural individuality and spatial identity.

The second direction involved widespread campaigns for training, participation, and dissemination in housing projects. These efforts aimed to strengthen social cohesion, echoing sociologist Edgar Salin's call for a "real urbanity" in his 1960 Augsburg conference (Salin 1960, 35). He emphasized integrating architects, administrations, and residents in shared processes of design and management, recognizing the need for housing policies that incorporated identity-building dimensions into residential projects.

Decay and evolution of the housing policy in the region

In the Frankfurt–Rhine–Main region, the research Labor Forschungslabor nachkriegsmoderne FraUAS have illustrated that the strong opposition from the intellectual left to the *siedlung* model played a decisive role in dismantling the social and housing ideals that had shaped the extensive postwar suburban peripheries of German cities (Harnak & Schlögl, 2023; Bahrtdt, 1970). Publications like *The Inhospitability of Our Cities* (Mitscherlich, 1969) further amplified the critique, framing large-scale estates as spaces of alienation, which coincided with processes of resident segregation. What had once been embraced as a symbol of middle-class integration became, by the late 1960s, increasingly stigmatized. Moving into social housing came to be perceived as a sign of failure and as acceptance of a Fordist model of mass housing production, bound to rigid social, familial, and gender roles (Durán Heras & Hernández Pezzi 1998).

The resulting degradation of common spaces prompted discussions as early as the 1980s about the partial demolition of some estates (Gibbins 1988, 125; Großböhtling 1990, 15). The most acute dysfunctions emerged in large estates such as Neuperlach in Munich, Sandow in Cottbus, Südliche Neustadt in Halle, and Neu-Zippendorf and Mueßer Holz in Schwerin. Reduced public expenditure led to declining investment in maintenance, infrastructure, and amenities (Zupan, 2019, 20). These cases highlighted the vulnerability of architectural projects when not accompanied by sustained social and cultural frameworks capable of reinforcing residential cohesion and identity.

From the 1980s onward, liberal housing policies accelerated this transformation. Housing was no longer protected as a public good, and subsidies shifted from supply-side support to demand-side mechanisms. By 1990, the nonprofit status of public-interest housing

companies was abolished, and tax incentives were extended to private developers. Rising housing prices made access increasingly difficult, especially in metropolitan areas.

The need for a conceptual and practical update

As previously discussed, postwar German social housing constitutes a relatively homogeneous legacy that embodied the ambitions of the era: to provide secure housing for the middle classes, which in much of Europe became a symbol of prosperity and social advancement. In the early twenty-first century, however, research and academic debate have increasingly focused on the obsolescence of these estates and the strategies for their renewal. Comparative studies have catalogued best practices, particularly in Anglo-Saxon and French contexts (García-Vázquez 2015), while highlighting the potential of cross-regional analyses for identifying alternative operational tools to update and adapt this housing stock.

The collection, analysis, and critique of strategies for intervening in postwar housing estates have fostered an interdisciplinary and transnational debate. A recent milestone was the *Do.Co.Mo.Mo. 2023* conference *European Middle Class Mass Housing*, held in Frankfurt. The proceedings stressed a recurring European-wide challenge: “the successful middle class struggles, if not fails, to imagine a better future for itself and its descendants. The decline of residential estates reflects, and at times accelerates, the decline of democracy itself” (Caramellino, Tsiambaos & Vaz-Milheiro 2023, 3).

This consensus underscores the urgency of developing new conceptual and practical frameworks to reassess the urban and architectural legacy of postwar housing. Beyond the issue of affordability, these estates remain deeply embedded in the social, political, and cultural fabric of European cities (Harnak et al. 2022, 98). Updating them requires tools capable of addressing changing demographic and programmatic demands while safeguarding their historical and symbolic weight.

The urban quality in *Siedlungen* revisited

Within this context, the debate in the Rhine–Main region has increasingly turned toward the question of whether large-scale redensification can serve as an appropriate strategy for renewal—or whether such interventions risk overlooking more fundamental concerns about quality of life in the *Siedlungen*. Today, more than 80% of the postwar social housing stock in the Rhine–Main area is dedicated to rental use and is managed by large housing corporations such as ABG Frankfurt Holding GmbH, Wohnbau Mainz, and Nassauische Heimstätte.

Most rehabilitation policies and subsidies are tied to regulations on accessibility, insulation, and energy consumption, a framework that has remained largely consistent since 1977, albeit with periodic updates. According to recent estimates, around 36% of these buildings have already undergone technical improvements, with another third currently under renovation (Walberg et al. 2022, 16–21). Yet these measures primarily address construction standards, leaving unresolved the programmatic mismatch between standardized typologies and contemporary residential realities. Current housing layouts often fail to accommodate diverse forms of domestic life—such as single-parent families, migrant households, elderly residents under assisted care, or younger professionals working from home (Eleb & Bendimerad 2011, 26).

A second group of policies has emphasized redensification, supported in the early 2000s by low-interest bank financing backed by state guarantees. While these large-scale interventions have contributed to updating the housing stock, they have been criticized for their lack of social policy integration (Hopfner & Simon-Philipp 2013). Concerns also arise regarding the scale of intervention—sometimes exceeding 20% increases in density—the disruption of established community networks, and the erosion of inherited urban and architectural identity, as well as broader reductions in environmental and spatial quality.

To attend the social, urban and architectural, analysis at the Rhein Main region the *Forschungslabor Nachkriegsmoderne* at the Frankfurt University of Applied Sciences set of parameters (Fig. 1) designed to evaluate quality of life in large housing estates of the Rhine–Main region (Harnack, Heger & Schlögl, 2022). These parameters combine technical and architectural criteria with residents’ subjective perceptions of their neighborhoods, including building condition, services, collective life, and access to care and health facilities. The lab’s work exemplifies a broader approach to upcycling postwar *Siedlungen*—linking academic research with practical interventions in estates such as the Platensiedlung Frankfurt, where renovation, energy upgrades, and selective densification are implemented alongside community engagement and preservation of historic spatial qualities. These subjective and qualitative aspects, often overlooked in conventional policy frameworks, provide essential insights for fostering collaboration between administrators, designers, and inhabitants in shaping the future of the *Siedlungen*.



Fig. 1. Diagram for evaluating quality of life in the Brückenhof, Kassel Siedlung . Source: Harnack, Heger & Schlögl, 2022

Based on this analysis, the ongoing experimental research in Mainz extends the Frankfurt approach by testing small-scale, flexible interventions directly within existing residential units. While the Frankfurt research provides tools for assessing quality of life and guiding estate-wide planning, the Mainz project operationalizes these insights at the level of individual dwellings and blocks, combining energy retrofits, modular interior devices, and participatory reprogramming of spaces.

The research by design project (Frayling, 1993) focuses on several case studies within postwar Siedlungen in the city of Mainz constructed in the 1950s–1970s under similar planning and typological restrictions, including the Lerchenberg Siedlung, Mombach Siedlung (West and East), and Neustadt Siedlung (Fig2.). These estates feature linear blocks of 2–4-bedroom apartments, 4–7 stories high, and share spatial and programmatic characteristics with Frankfurt’s postwar developments, making them ideal for testing modular, adaptable interventions. By evaluating not only technical upgrades but also programmatic adaptability, user engagement, and social interaction, these case studies allow researchers to examine how small-scale interventions can enhance daily life, foster community, and integrate multiple forms of housing use—including co-working, assisted living, and home-office setups.



Fig. 2 Location plan (1:10,000) of five housing estates built between 1950–1970 on the outskirts of Mainz.

In contrast to policies that emphasize re-densification as a response to land value pressures and regulatory compliance, this research highlights the need to account for factors that are not easily quantified: residents' sense of well-being, the adaptability of daily routines, and programmatic flexibility within existing housing. These subjective and qualitative aspects, often overlooked in conventional policy frameworks, provide essential insights for fostering collaboration between administrators, designers, and inhabitants in shaping the future of the *siedlungen*.

Academic background and references

As state of arts in this research focus on Upcycle Social housing in MiddleEurope , particular attention should be given to the collaborative work of the TU Delft research laboratory (Prof. Tom Avermaete), the Institut für Architektur, Design, Kunst und Theorie at KIT Karlsruhe (Walter Nägeli and Niloufar Tajeri), and the KTH School of Architecture in Stockholm. Over the past decade, these groups have collectively articulated—around the concept of *Small Interventions*—a potential conceptual and practical framework that responds to the concerns raised during the Do.Co.Mo.Mo. sessions. T. Avermaete argues that the grand consensual discourses of the modern movement, as crystallized in the CIAM meetings, not only produced a progressive ideological shift but also entailed a necessary shift in scale that links

post WWII middle class mass housing productions: between 1928 and 1956, CIAM emphasized the modern project's capacity to facilitate the *socialization of space*, but the rise of Team 10 after 1956, however, attention moved toward architecture's autonomy in shaping the *spatialization of the social*. The research project to upcycle Siedlungen in Rhein Main Region develops this idea up to the architectural design inside the Siedlungen blocks, to gain space for the new grouping and families, work and care, and social diversity.

The design based research has focused on revaluing small-scale architectural interventions within postwar housing contexts. These are framed as alternatives capable of demonstrating both the proximity of architectural tools at the small scale and the possible individual and collective involvement that such processes enable.

Looking backwards, the relationship between small-scale design and the production of domestic space finds historical precedents in early twentieth-century modernist architects engaged in domestic experimentation (Espiegel 2006). These precedents are themselves contradictory: on the one hand, consolidating family and gender roles—as in Margarete Schütte-Lihotzky's well-known *Frankfurt Kitchen* (1926)—and on the other, projecting alternative domesticities that opened new ways of living both individually and collectively. Notable examples include Lillie Reich's work for the Deutscher Werkbund (1920–1928) and Charlotte Perriand's designs presented at the *Salon d'Automne* (1927–1929).

Key precedents include Habraken's 1972 concept of the separable unit or infill, Joe Colombo's "Habitat of the Future" (1969–1970), and the 1972 MoMA exhibition *Italy: The New Domestic Landscape*, which collectively influenced approaches to modularity, domestic equipment, and spatial experimentation.

At ETH Zürich Prof. Dr. Elli Mosayebi has developed the research project *Performatives Haus* (Mosayebi 2022), which evaluates the uses and transformations enacted by residents within a 54 m² apartment equipped with a mobile wall. This project draws upon both modernist precedents—such as Richard Neutra's Onkel-Tom-Strasse development in Berlin (1924) and El Lissitzky's "mobile wall for a communal house" (1929). Using presence and motion sensors, the study compares the behaviours of residents by age and usage, demonstrating the relevance of foldable, flexible elements that allow inhabitants to redefine their domestic space.

In the professional Central European context, the most experimental re-densification and rehabilitation projects have been supported by programs such as the *Programme National pour la Rénovation Urbaine* (PNRU), with large-scale interventions like the *Grand Project*

de Renouveau Urbain in Paris, including the well-known *Bois-le-Père* project (Lacaton & Vassal, 2008–2012).

In Germany, interventions are more commonly tied to municipal agreements with housing management corporations. Regional examples include the already mentioned *Platensiedlung* (originally built 1956–1959; re-densified 2017–2024 by Stefan Forster Architekten) and the *Fritz-Kissel-Siedlung* (1951–1954; re-densified 2020–2021 by Menges Scheffler Architekten). In both cases, investments required for regulatory updating have been offset through the construction of additional housing units, with innovations in modular design, timber prefabrication, and housing typologies. However, these projects rarely incorporate critique on the housing standards, possibility of new domestic arrangements and new spatial programs.

In contrast to these large-scale operations, academic studies underscore the importance of small-scale transformations of existing housing—interventions in which both users and institutions actively participate. Such approaches are increasingly viewed as crucial within rehabilitation and accessibility policy frameworks (Gill 2016, 115).

Research by a designing a prototype for five *siedlungen* in Mainz

Initiated in 2022 at the Institut für Architektur of Hochschule Mainz, this research project explores how rehabilitation plans might integrate a process through which residents can actively imagine how they wish to live, inhabit, and cohabit. The project challenges the solutionist inertia embedded in both the original postwar designs and the subsequent re-densification strategies commonly employed in the region. In particular, it highlights the absence of reflection—within official housing rehabilitation policy—on how technical measures might also respond to the new modes of dwelling that have emerged in the twenty-first century. The objective is to test small-scale interventions that can be integrated within the broader framework of constructive and energy upgrades mandated by municipal housing policy. This involves a process of spatial and material interaction that is simultaneously reflective and productive, supporting local transformation from the level of the individual housing unit to the scale of the shared living environment. Following an analysis of potential practices (García-Vázquez 2016) and the academic precedents discussed above, the project aims to improve both the adaptability of spatial programs and interior comfort conditions.

STREETS PROPORTION: AVERAGE SITUATION

After the post-war residential development provided by the Wohnungsbaugesellschaft (WBG) research project, the average housing program of the year 1955-75, as defined by the urban development plan of 1957.

The average ratio of streets to green spaces (1:1) is a measure of the number of green spaces per building and a central characteristic of the post-war housing program.

The 3. development phase under state supervision (1955-1962) is characterized by a high degree of green spaces and a high degree of green spaces, as well as a high degree of green spaces and a high degree of green spaces.

The 4. development phase (1962-1975) is characterized by a high degree of green spaces and a high degree of green spaces.

IMPROVEMENTS IN URBAN CONDITIONS

As a result of the post-war development, the urban conditions have improved in many ways, including the quality of the housing and the quality of the urban environment.

The research on street characteristics, blocks, and housing conditions

- Degree of spatial integration
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TYPOLOGICAL CONDITIONS & OPPORTUNITIES

The research project also aims to provide a typological analysis of the housing units and to identify the most important typological characteristics of the housing units.

The typological analysis of the housing units is based on the following criteria:

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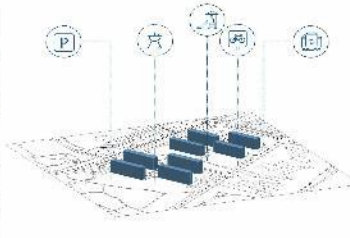
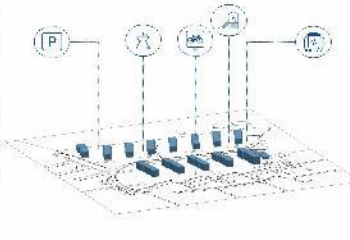
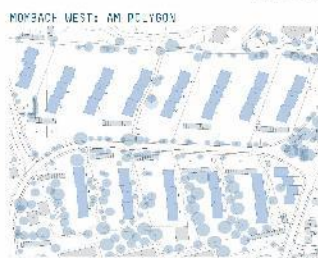
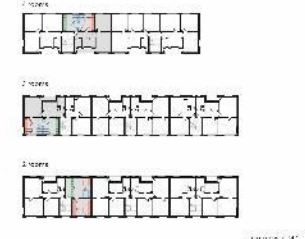
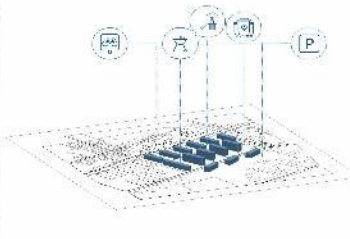
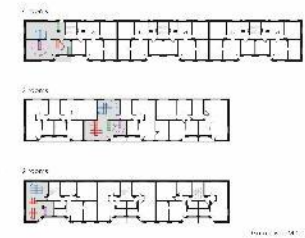
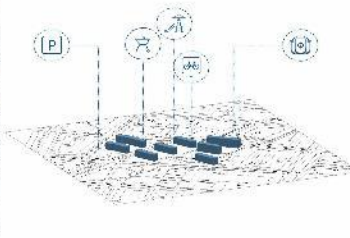
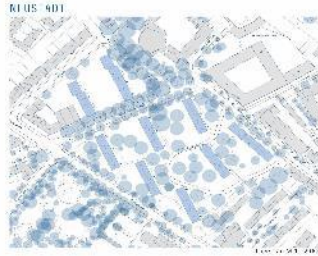


Fig. 3. Overview of Mainz postwar Siedlungen selected as case studies for experimental interventions

Siedlung	Year Built	Number of Units	Block Typology	Stories	Key Features	Experimental Focus
Lerchenberg Siedlung	1952–1958	~450	Linear blocks	4–6	Large central courtyards, green areas	Energy retrofits, modular interior devices, participatory spatial reprogramming
Mombach West Siedlung	1955–1960	~350	Linear blocks	4–7	Playground areas, mixed-use edges	Home-office integration, communal spaces, flexible units
Mombach East Siedlung	1955–1962	~400	Linear + H-shaped	4–7	Proximity to schools and shops	Assisted-living spaces, modular interventions, co-working spaces
Neustadt Siedlung	1953–1959	~300	Linear blocks	4–5	Pedestrian pathways, limited parking	Social interaction enhancement, interior adaptability, energy upgrades

Siedlung	Year Built	Number of Units	Block Typology	Stories	Key Features	Experimental Focus
Berliner Siedlung*	1959–1963	~500	Linear + H-shaped	4–17	Central hub with school, church, and commercial areas	Pilot site: full modular device testing, participatory workshops

Five case studies in Mainz were selected, each comprising 300–550 dwellings in linear blocks of 4–7 stories with comparable typologies (2–4 rooms). Greater detail is devoted to one estate, the *Berliner Siedlung* designed by Ernst May’s office between 1959 and 1963 (Fig. 4). Its central layout combines four-story linear blocks with children’s play areas and pedestrian pathways, as well as H-shaped blocks of 10–17 stories adjacent to a school, social centre, churches, and a commercial zone.



Fig. 4. Aerial photograph of the Berliner Siedlung, Mainz, 1969. Author: Wolfgang Lemp. Source: Landeshauptarchiv Koblenz/LU15346.

The study integrates municipal housing data, official statistical data, and on-site surveys to evaluate both quality of life and residents’ own perceptions. Since 2018, interventions have improved energy systems, waste collection, and parking facilities. Findings reveal a broadly positive assessment of urban quality, including density, connectivity, vegetation, multifunctionality, social inclusion, safety, and appropriation.

Architectural analysis of the housing blocks highlights deficiencies in construction quality, energy performance, and accessibility. The limited diversity of dwelling typologies (mainly 2–4 bedrooms accessed via three stairwells without shared interior spaces) compounds these issues. Residents also request improved spaces for childcare, eldercare(gym or

physiotherapy), co-workings and home office. Since the current municipal rehabilitation program focuses solely on energy reduction, the proposal consists of integrating programmatic adaptability within selected units and ground-floor areas while initiating participatory processes through small-scale interventions.

At the block scale (Fig 5), standard construction measures are prescribed—improved insulation, waterproofing, energy-loss prevention, and accessibility upgrades, including elevators and façade access walkways. Yet residents also voice concerns about rising rents, imposed as compensation for rehabilitation costs, and the disruptive length of construction works. This emphasises the need for modular devices that can be installed while dwellings remain occupied, thereby accelerating the renovation process.

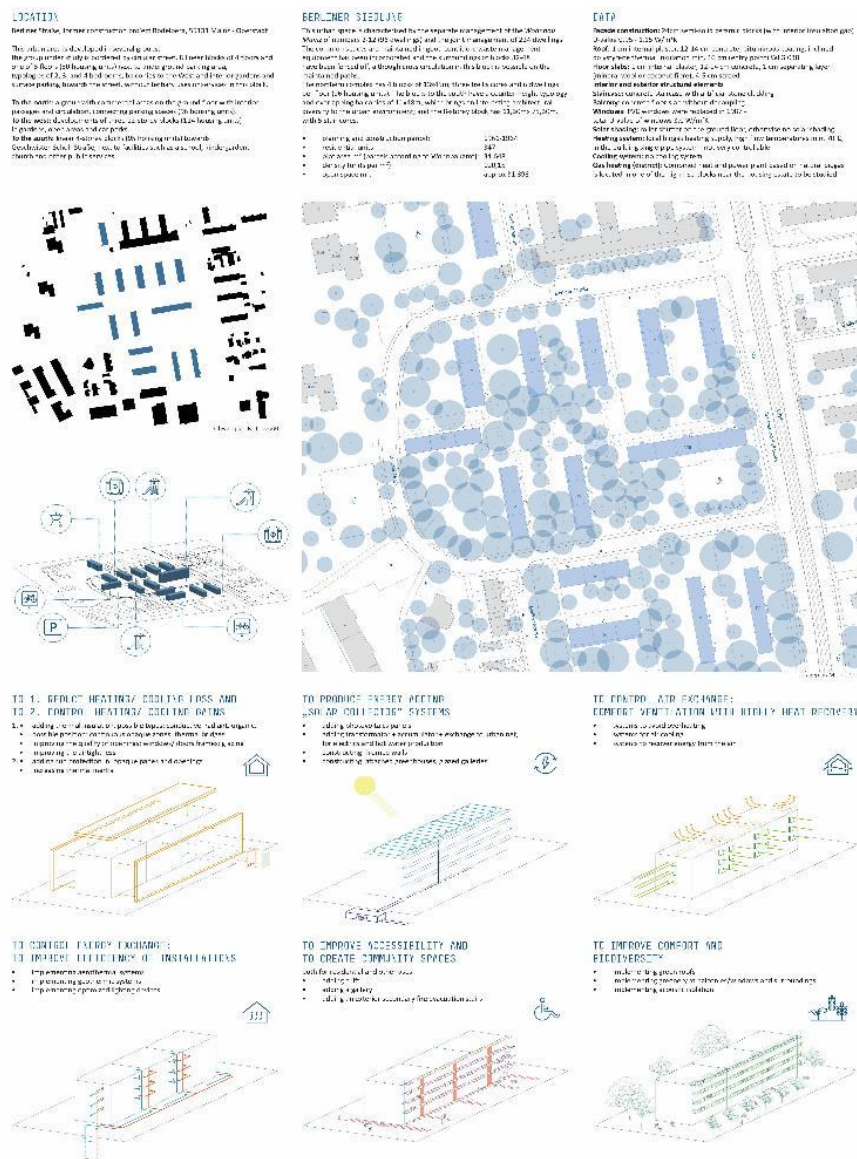



Fig.5. Standard retrofitting block. Berliner Strasse 28-32, Mainz. Source: Preliminary report on the research project 'H&O?'.




Fig.6. Model of the standard block. Berliner Strasse 28-32, Mainz. Study of spatialities with the insertion of devices (as prototypes) with different integrated functions. Model: D. Ercin. Photo: Ammenhauser., 2023. Source: Preliminary report on the research project ‘H&O?’.

Prototype device as a small-scale intervention

The research project “H&O?” addresses current debates on the design of tools that combine spatial and functional flexibility, while remaining manageable for both individuals and groups with shared domestic needs, such as care and work. The project aims to contribute to contemporary regeneration strategies for postwar housing built between 1950 and 1970, particularly in the Rhine-Main region, through the development of a modular, adaptable, and integrable device intended to enhance the functional flexibility and comfort of existing dwellings.

As an experimental prototype, the device supports multiple module configurations that accommodate home office use, rehabilitation, and small-scale food production, while also integrating systems designed to improve environmental performance across residential blocks (Fig 6). Its innovation lies in its ability to enhance domestic spatial programming while preserving the architectural and urban values characteristic of Ernst May’s postwar Siedlungen.

To explore how existing housing typologies can adapt to new functional demands—such as home-based work, shared care, and physical exercise—a modular, reconfigurable device was developed. Physical models have served as tools for testing these reorganizations, enabling dialogue with residents and municipal authorities by visualizing how ground-floor areas

could be repurposed for childcare, eldercare, and home office use (Fig. 7). These models illustrate typological transformations in 1-, 3-, and 4-room apartments within the Berliner Strasse blocks, highlighting reductions in spatial hierarchy, improvements in accessibility, and the expansion of exterior space.

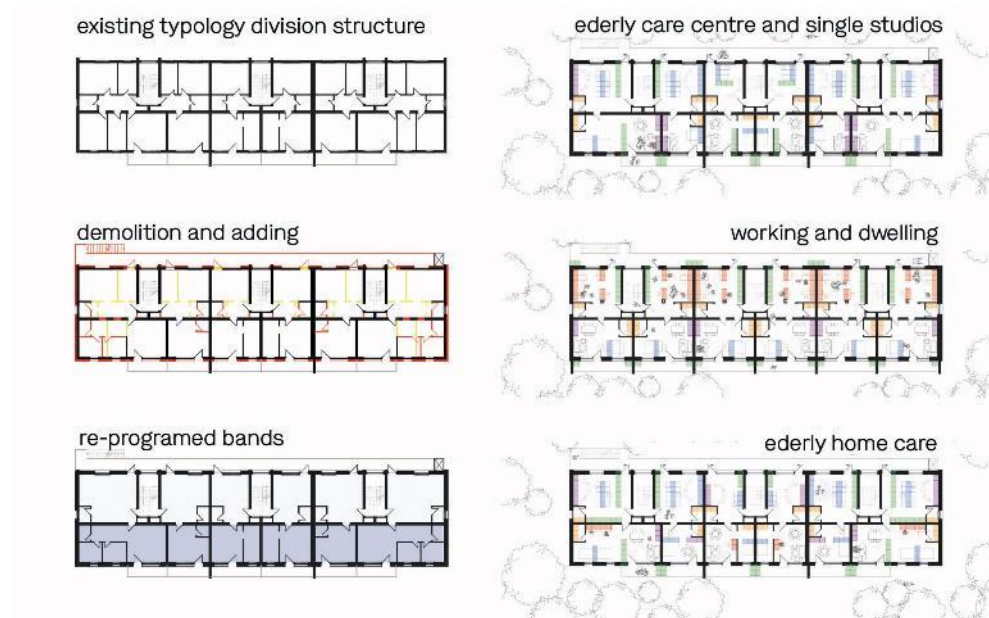


Fig. 7. Typological transformations of 1-, 3-, and 4-room apartments in the Berliner Strasse blocks, showing reduced hierarchy, improved accessibility, and expanded exterior space. Source: Preliminary report of the research project “H&O?”.

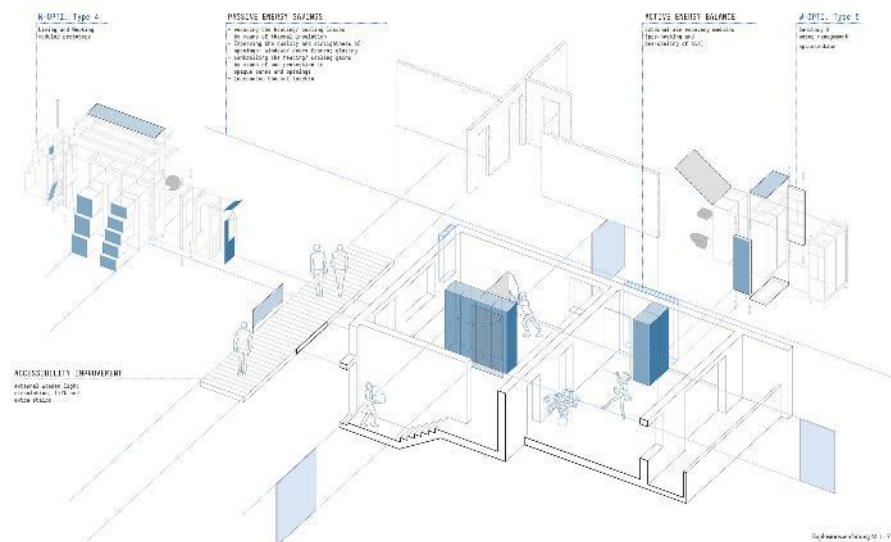


Fig. 8. Isometric view of device installations within existing typologies, expanding programmatic diversity.

Source: Preliminary report of the research project “H&O?”.

Designed as an industrially manufactured prototype, the device is installed alongside standard rehabilitation measures, including insulation upgrades, replacement of window frames, and the integration of new ventilation systems (Fig 8). It introduces alternative combinations of domestic space that residents can adapt to their evolving individual and collective needs. Constructed from a technical frame of solid wood profiles with a plywood shell, the device accommodates specialized modules that support various domestic functions—such as childcare, physiotherapy, information access, and flexible storage. It connects to the exterior façade through a climate-control unit equipped with filters and heat recovery, as well as integrated electrical and digital infrastructure (Fig.9).

The modular design, featuring simple joints and a quasi-do-it-yourself logic, allows residents to reconfigure the layout over time and across housing types. Moreover, to assess user engagement, behavior, and satisfaction, tools and indicators from related studies have been considered (Montaner & Muxí 2011; Cánovas, Espejel & Lapuerta 2021; Mosayebi 2021), and are being refined to the specificities of the present research.

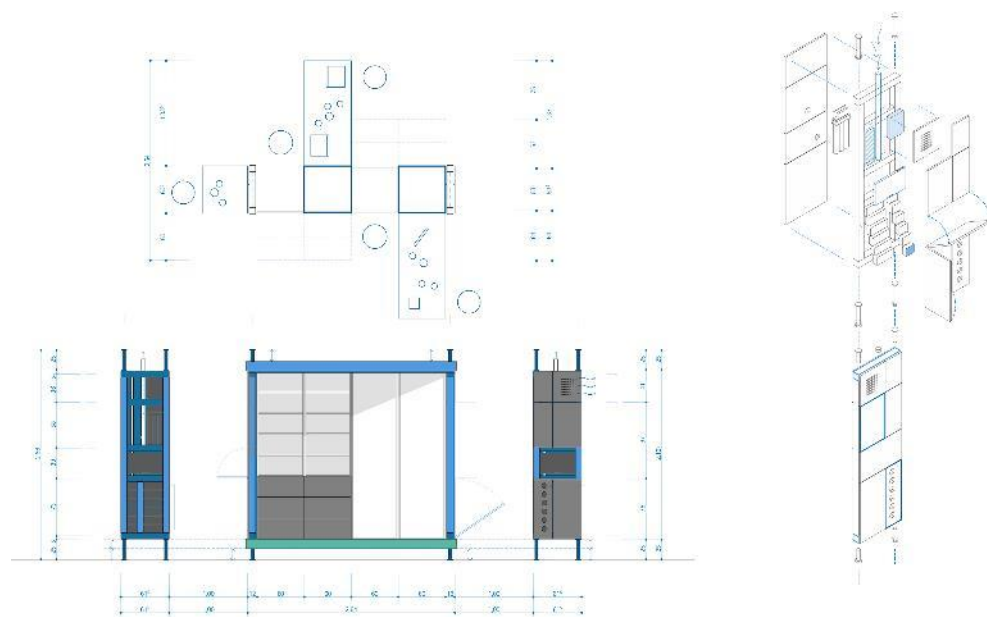


Fig. 9. Plans of prototype with equipped technical frame and interchangeable modules. Source: Preliminary report of the research project “H&O?”.

Functional hierarchy has been evaluated according to the percentage of mono-functional space relative to total habitable space: H (high) if greater than 30%; M (medium) if between 10–29%; and L (light) if below 9%. Spatial segregation has been assessed according to the percentage of habitable space with more than one entrance, door, or passageway: H (high segregation) above 30%; M (medium segregation) between 10–29%; and L (low segregation)

below 9%. Connection to the exterior has been measured by the percentage of openings relative to the surface of the exterior wall: H (high connection) above 30%; M (medium connection) 10–29%; and L (low connection) below 9%. Finally, potential growth of interior space—measured by the percentage of habitable surface adaptable for work or care functions—was defined as: H (high adaptability) above 30%; M (medium adaptability) 10–29%; and L (low adaptability) below 9%.



Fig. 10. Floor plan variations for the transformation of linear block typologies in the case study: adapting spaces to new domestic programs. M. Pelegrín, F. Pérez, D. Ercin, BIM Labor, 2023. Source: Preliminary report of the research project H&O?.

In the case study block of the *Berliner Siedlung* in Mainz, the initial analysis revealed a high degree of spatial hierarchy and segregation, alongside medium levels of connection with the exterior and growth potential. As part of the experimental design for improving comfort and programmatic flexibility, one proposal includes transforming the ground floor into a shared co-working and day-care facility, while another converts one floor into assisted living units for older adults, complemented by exercise and rehabilitation spaces (Fig. 10).

The transformation of this residential block has been evaluated through the implementation of the modular device across two-, three-, and four-room typologies, integrating energy improvements with programmatic adaptation. The results demonstrate the possible potential for spatial reprogramming, both individually and collectively, which can be scaled based on the level of building management and resident agreement. Functional hierarchy and spatial segregation have been significantly reduced, with less than 9% of habitable space remaining

mono-functional or restricted by single points of access. The potential for spatial growth has increased markedly, with more than 30% of habitable space now adaptable for work-related functions. Connection to the exterior has also improved, facilitated by the installation of a walkway that enables direct access to new domestic programs within the block.

As part of the research timeline, a 1:1 mock-up was constructed (Fig. 11), consisting of two modules measuring 2.40×2.20 m in length and 0.70 m in depth, built with a wooden substructure braced with plywood panels and detachable joints. Its public exhibition in Mainz in February 2024 enables both residents and the Municipal Housing Service to visualize the prototype precisely within its real context, and to interact with and evaluate the feasibility of programmatic adaptation of standard *siedlungen* typologies.



Fig. 11. Full-scale (1:1) mock-up of the modular device exhibited at the university during public sessions involving the research team, municipal representatives, and residents. Photo: M. Pelegrín, 2023. Source: Preliminary report of the research project H&O?.

A digital model has also been developed: a virtual prototype in augmented and virtual reality that integrates the functional equipment required for adapting spaces for home-office use. This includes technical installations, heat-recovery ventilation, and photovoltaic solar louvers. Through this digital prototype, the necessary regulatory calculations and simulations have been conducted to secure municipal funding. Verification of parameters and prototypes is essential for integrating them into a joint experimental program of energy efficiency and programmatic adaptation.

Conclusions on the ongoing process

This research—grounded in the empirical investigation of five postwar *Siedlungen* in Mainz—proposes a complementary and critically engaged approach to housing transformation. The research project addresses the pressing need to reconsider and update the spatial and programmatic frameworks of domestic space in ways that reflect the increasing diversity of contemporary life, while building upon the architectural, urban, and social value embedded in the existing housing stock.

By initial testing experimental interventions within five representative housing estates—Lerchenberg, Mombach West, Mombach East, Neustadt, and Berliner Siedlung—the project demonstrates how standardized typologies built between 1950 and 1975 can be reactivated through small-scale, low-impact strategies. In particular, the *Berliner Siedlung*, selected as a pilot site, serves as a reference for in-depth experimentation with modular and programmatic adaptation. The analysis of its blocks—characterized by high spatial segregation and limited typological diversity—revealed both technical deficiencies and strong resident demand for shared and flexible spaces such as childcare facilities, eldercare units, and co-working areas.

As a specific contribution, the project introduces an experimental prototype device that operates across multiple levels. It has been tested through physical models, digital simulations, and a full-scale (1:1) mock-up exhibited in Mainz in early 2024. These tools have served as platforms for evaluating the feasibility and acceptability of spatial reprogramming strategies within the existing housing fabric. The device enables functional flexibility within domestic spaces by integrating technical elements for energy retrofitting—such as heat-recovery ventilation and photovoltaic louvers—with modular components for new programs, including home office setups, physiotherapy spaces, and shared care infrastructure.

Its application in the *Berliner Siedlung* allowed for significant reductions in spatial hierarchy and segregation, while increasing both adaptability and the degree of connection to exterior communal areas. Through targeted interventions—such as the transformation of ground-floor areas into shared facilities or the retrofitting of individual units with adaptable modules—the project reclaims underused or mono-functional areas, converting them into spaces that respond to evolving patterns of living, working, and caring. As drafted in the *Berliner Siedlung*, these transformations could be undertaken without requiring full vacancy or displacement, thereby reducing costs and minimizing social disruption

Furthermore, the replicability of the approach (prototyped design to be optimized by further research) has been tested across the five *Siedlungen*, each selected for their typological consistency and historical significance. These case studies validate the potential for a shared

yet site-specific methodology, whereby modular and attachable devices can be adapted to varying degrees of spatial and programmatic demand.

From the development of this process, it can be concluded that it is both feasible and necessary to introduce strategies of spatial and typological reprogramming within existing housing stock. The integration of modular interventions directly into the domestic environment has proven functionally effective, technically viable, and procedurally adaptable. Such interventions offer flexibility over time, accommodate diverse needs, and introduce reversible configurations that can be negotiated collectively or individually.

The potential for reconfiguring space not only enhances residential stability—allowing dwellings to respond to changing life conditions—but also promotes social inclusivity. By enabling the cohabitation of diverse user groups (e.g., students and elderly residents) and fostering the shared use of infrastructure, the project expands the functional capacity of each housing unit and block without increasing the physical footprint.

Ultimately, the experimental work conducted the research process uses architectural design as an active procedure in addressing contemporary challenges within the domestic realm. It contributes not only to academic discourse but also to the operational capacity of architecture, both as a technical practice and as a disciplinary field. For this reason, it is essential that such experiences be further disseminated, critically evaluated, and debated with all relevant stakeholders, so as to reanimate the domestic project through the adaptive reuse and enhancement of our shared architectural legacy.

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