



Scaling up retrofit: regional challenges and opportunities for MMC

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SPECIAL COLLECTION:
MMC AND THE FUTURE
OF HOUSING

RESEARCH

ubiquity press

ABSTRACT

Increasing energy retrofit rates is considered essential for reducing housing-related greenhouse gas emissions, particularly in Central and Northern Europe. In Germany, despite ambitious and costly policies, annual retrofit rates have remained largely stagnant at around 1% of the housing stock. The current trend of modern methods of construction (MMC) and digitisation have renewed hope that serial retrofit and service platforms could enable the scaling up of energy retrofits by reducing costs, disruptions and management burdens, especially for non-professional property owners. While a growing literature explores this potential, empirical research on the region-specific conditions to scale up serial retrofit remains limited. To address this gap, this study interviewed intermediaries and professionals who organise retrofits in the Freiburg region in south-west Germany. Their views were sought on the challenges and opportunities for serial (prefabricated) retrofit facilitated by digitised planning, platform thinking, and collaboration among trades and other partners. Applying the challenge-oriented regional innovation systems (CORIS) framework revealed an early-stage reorientation pathway in the region, providing entry points for scaling up MMC.

PRACTICE RELEVANCE

There is leeway for practitioners to deepen existing and create new networks across sectors and trades, and to experiment with collaborative methods, working towards serial approaches. The early adoption of innovative methods and the use of regional and renewable resources is recommended to strengthen both ecological sustainability and the regional economy. As for governance, the provision of digital tools and legal bases for data collection is essential to promote a transformation pathway for MMC and platforms. Institutional innovations such as publicly funded one-stop shops and database can contribute to a comprehensive housing transition.

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KEYWORDS:

retrofit; housing transition;
modern methods of
construction (MMC); service
platforms; challenge-oriented
regional innovation system
(CORIS); governance; Germany

TO CITE THIS ARTICLE:

Dörr, H., Späth, P., & Goñi, I.
(2026). Scaling up retrofit:
regional challenges and
opportunities for MMC. *Buildings
and Cities*, 7(1), pp. 1199–1214.
DOI: [https://doi.org/10.5334/
bc.819](https://doi.org/10.5334/bc.819)

Tackling the housing transition is one major objective in post-industrialised countries for achieving decarbonisation. Incentivising retrofit is therefore a political priority, particularly in Germany, where the housing sector contributes about 30% of the country's anthropogenic CO₂ emissions (BuVEG n.d.; BVGeM n.d.). Even though the state of Baden-Württemberg holds a pioneer status in energy transition policy, its yearly retrofit quota stagnates around 1%, despite the 2% needed to reach climate neutrality goals by 2040 (Schmidt et al. 2023). This is due to the estimated €8.75 billion/year of investments and 100,000 additional professional workers that are needed for the housing transition (DIW ECON 2023). Simultaneously, accommodation is becoming increasingly unaffordable, calling for cost-efficient solutions that prevent further increases of rent burdens while addressing the renovation backlog effectively. This combination of decarbonisation goals and a housing (affordability) crisis has generated growing interest in industrial, 'modern' or 'modular' methods of construction (MMC) and serial approaches (Köhler et al. 2025; Soltani et al. 2025).

Serial retrofit refers to prefabrication and serial production with on-site assembly, emphasising repeatability and standardisation, whereas *modular* construction involves prefabrication of larger entities with electrical, sanitary and heating installations integrated beforehand (BAU n.d.). Two serial retrofit models elucidate this potential. First, the *Energiesprong* principle, which combines digitised planning, high prefabrication, renewable materials and energy technology strategies, has been able to achieve net zero standards within weeks of project inception (Energiesprong n.d.-b). Second, Germany's *retrofit sprint*, focusing on single- and double-family homes, coordinates trades under a retrofit coach and cut construction time to 22 days—illustrating how streamlined processes can reduce barriers (Agora Energiewende et al. 2024; Schmidt et al. 2023). Multiple policy instruments aim to foster MMC approaches in Germany. The European Union's (EU) Energy Performance of Buildings Directive (EPBD) emphasises digital and platform tools (European Commission n.d.), the German Building Energy Act sets energy efficiency standards (BMWSB n.d.), and federal funding programmes increasingly incorporate modular approaches and municipality-coordinated programmes with 'renovation managers' (BAFA n.d.; KfW n.d.-a, n.d.-b). Yet, none has moved the needle on annual retrofit rates (BuVEG n.d.).

The present research explores whether leeway exists at a regional level by drawing on 14 in-depth interviews and one workshop with intermediaries and practitioners active in the region of Freiburg in south-west Germany. The aim is to identify signs of scaling up MMC methods, particularly serial retrofit, platforms and digital tools, when answering the following two research questions:

- What preconditions, challenges and opportunities for (serial) energy retrofit using MMC shape the regional innovation system in Freiburg?
- How do actors currently orchestrate innovative methods for energy retrofits and what solutions emerge for scaling up MMC regionally?

The conceptual model of challenge-oriented regional innovation systems (CORIS) (Trippel et al. 2024) is used to assess the contributions of this framework to support socio-technical transitions in an early-stage context.

The paper is structured as follows. After an overview of the literature on serial approaches to retrofits and service platforms in theory and practice, the CORIS conceptual model and methods are introduced. The findings start with a contextualisation of the case study region. The regional developments regarding serial retrofits and platforms, based on intermediaries and professionals' perspectives, are then presented. These findings are contrasted with the prescriptions found in the literature on system building around service platforms. Recommendations for practitioners and policymakers in search of innovative approaches for promoting energy retrofits are then given.

2. MMC, PLATFORM THINKING AND ONE-STOP SHOPS

MMC and serial retrofit have potential to catalyse the net-zero transition, especially when combined with principles of platform thinking and digital tools to navigate complexity (Thuesen et al. 2023). However, techno-optimistic narratives of this potential often overemphasise productivity

and overlook socio-political and governance dimensions (Green 2022). Thus, it is essential to examine this nexus by understanding adoption challenges and possible solutions for effective implementation. Specifically, knowledge-oriented systems, which most closely resemble the concept of service platforms, focus on information-sharing, transparency, and capacity-building to reduce administrative burdens for public and private entities (Köhler et al. 2024, 2025). Due to the extensive information required for their usefulness, municipal or regional scales represent a promising scale for deployment where collaboration and resource pooling could be facilitated.

2.1 ONE-STOP SHOPS: FACTORS FOR SUCCESS

‘One-stop shops’ (OSS) represent the existing initiatives closest to the concept of a service platform for energy retrofits. An OSS functions as a platform that centralises information about funding sources, technical options and retrofit processes, effectively acting as a single point of contact for a homeowner (Volt et al. 2021). It can function as a guiding resource, streamlining the retrofit steps and leading to a greater willingness to undertake more extensive renovation work (Panakaduwa et al. 2025b), while also reducing information asymmetry and fragmentation of the energy retrofit market (Biere-Arenas et al. 2021).

Bertoldi et al.’s (2021) mapping of the European OSS market shows that models assuming direct responsibility for renovation perform more effectively and are most trusted, particularly when sustained by ongoing public or municipal funding. Municipal OSS oriented towards a broader public objective are more successful in expanding from a local pilot to a regional programme (Bertoldi et al. 2021). Indeed, publicly driven models tend to operate more smoothly and are held in higher regard by homeowners in terms of trustworthiness (Pardalis et al. 2022). In Germany, the ProRetro project (2020–23) piloted OSS models across five areas and recommended a standardised digital tool for data collection and funding applications (Riesenweber 2024), while the CO2COMPASS (n.d.) initiative proposed institutionalised municipal climate centres connecting residents, industry, energy agencies and city administrations. The ‘all-inclusive’ model—in which the OSS itself acts as the contractor rather than referring externally—is the most effective (Biere-Arenas et al. 2021).

According to the INNOVATE evaluation, pure digital platforms are outperformed by those with staff given barriers around usability, accessibility and engagement (Eisermann & Maraquin 2020). OSS models that utilise *case managers* from initial contact to completion generate the highest level of stakeholder trust and are therefore the most promising route to deliver retrofit at scale (Bertoldi et al. 2021). Rather than treating staffing and digitisation as opposed, a split-allocation approach can deliver initial cost estimates online while reserving formal assessment and contracting for staff, balancing capacity and financing concerns against the higher retrofit rates linked to all-inclusive OSS (Panakaduwa et al. 2025a, 2025b).

The current European OSS landscape demonstrates tangible success, managing around 100,000 projects per year. Service platforms such as OSS have significant benefits in catalysing retrofit rates through bridging the supply and demand sides of the industry (Bertoldi et al. 2021). Further, these models can democratise access to retrofit by providing smaller property owners and cooperatives with information, increase transparency around costs, options and performance, and improve regulatory compliance, standardised quality and efficiency (Köhler et al. 2024).

2.2 OSS: KEY CHALLENGES

Despite the benefits, the literature also reveals challenges to OSS success and expansion. Overall, both development and maintenance require high upfront investment as well as ongoing coordination (Köhler et al. 2025). This is compounded by ownership type, as publicly driven OSS face administrative budgetary constraints, while private models face greater upfront financial barriers (Biere-Arenas et al. 2021; Pardalis et al. 2022). Despite clear resource needs, a lack of long-term structural funding has been cited as the most impactful factor leading to OSS discontinuation (Biere-Arenas et al. 2021).

Accessibility presents an additional challenge. Physical OSS models are constrained by high set-up costs and skills shortages, whereas online OSS models are limited by digital literacy and services that lack sufficient functionality to be fully trusted (Panakaduwa et al. 2025b). A Portuguese digital

OSS pilot illustrates this risk, as uptake skewed toward educated, higher income users rather than the harder-to-reach households it aimed to serve (Sequeira & Gouveia 2022). If not addressed, there is a risk that platform-based approaches could reinforce existing inequities by sidelining smaller landlords, rural homeowners and smaller companies (Köhler et al. 2025).

Lastly, coordinating contractor networks that deliver retrofit work through OSS requires deliberate, ongoing effort (Pardalis et al. 2022). A study of the Turnkey Retrofit model recommends shared guidelines and funded contractor training to tackle the building of a reliable local network of professionals (Voll et al. 2021). The INNOVATE programme found that building trust and momentum with installers was one of the most demanding aspects of establishing an OSS in practice (Eisermann & Mara Quinn 2020). Therefore, an intentional focus on contractor networks and trade partnerships is essential as a precondition for implementation (Mlecnik et al. 2019).

2.3 TOWARD REGIONAL PLATFORM THINKING

Much of this evidence stems from OSS programmes operating at regional or national scales within Europe. Addressing the gap around service platforms requires examining the issue at increasingly more local scales, especially considering two directions: stakeholder perspectives on what types of information and services would be most useful; and governance analyses investigating key stakeholders, financing mechanisms and political considerations. Dixon & Eames (2013) argue that large-scale retrofit depends on city-regional governance arrangements, long-term strategic planning and public-private coordination to overcome institutional lock-in, integrating not only technologies but also implementation in cities. Soltani et al. (2025) highlight digital infrastructure as an emerging predictor of MMC implementation success, but emphasise the ongoing challenges of fragmentation and uneven stakeholder capacities. Given these complexities, regional stakeholders represent essential voices in understanding the existing preconditions and challenges, contributing to a more successful development and expansion of platform thinking in a specific locale.

3. CORIS FRAMEWORK AND TOOLBOX

Grounded in the multilevel perspective (Geels & Schot 2007), which analyses socio-technical transitions as structural change across landscape, regime and niche levels (Arentshorst & Peine 2018; El Bilali 2020; Loorbach 2010; Smith et al. 2010), a regional innovation systems (RIS) approach is adopted, with a focus on regional dynamics and solutions beyond a ‘one-size-fits-all’ logic (Tödtling et al. 2022). The elements of an RIS—actors, networks and institutions—are commonly clustered into knowledge, industrial and political subsystems whose interplay enables and steers socio-technical innovation (Hassink et al. 2020; Isaksen et al. 2022; Mattes et al. 2015).

Adding a normative position, the concept of CORIS (Tödtling et al. 2022) is used to understand the challenges and opportunities for scaling up MMC and platforms within the case study context. Acknowledging the importance of the regional policy level in tackling societal challenges (Isaksen et al. 2022), CORIS address regional challenges with their place-based assets and structures while being embedded in national and supranational conditions (Tödtling et al. 2022; Tripl et al. 2024). They include a variety of actors beyond industry and policy (adding civil society, public sector, municipalities, users and citizens) as well as their networks (Hug et al. 2025; Tödtling et al. 2022). Hence, they subscribe to a broad conception of innovation beyond technology, considering society, institutions and behaviours as relevant (Loorbach 2010). Observing innovative agents in and beyond the RIS makes visible the learning activities involved in scaling up solutions for challenges amidst institutional conditions (Tödtling et al. 2022).

Whether such reconfigurations result in a *reorientation* or *transformation* pathway depends on the regional preconditions and the nature of the challenge. Complex issues such as cross-sectoral transitions typically require transformative changes—including new actors, institutions and networks—as well as the replacement of existing regional assets. Reorientation of existing resources and organisations is more likely when innovative methods are adopted bottom-up, allowing actors and institutions to adapt gradually (Isaksen et al. 2022). Yet, such a strategy of ‘small wins’ (Bours et al. 2022) can fundamentally change the RIS configuration, especially when strengthened by coordinated policy efforts and networks (Isaksen et al. 2022).

For either route, governance is necessary to promote the diffusion of innovations and steer towards systemic change, especially when working in an early-stage context. Therefore, the term *scaling up* is mobilised to conceptualise respective governance initiatives (Naber et al. 2017; van Doren et al. 2018). Three dimensions hereof have been carved out: *scaling up* (quantitative increase of either the means or the output/outcome) and *scaling out* (geographical expansion) diffuse innovations horizontally, while *scaling deep* (transforming formal and informal institutions, values, and ideas) transfers and institutionalises them vertically (Meijer 2020; Moore et al. 2015; van Doren et al. 2018). In comparison with RIS approaches, scaling up strongly emphasises the importance and agency of actors and networks, operating in politics, industry and market areas to hinder as well as to support upscaling efforts (Meijer 2020; Petrovics & Giezen 2022). The combination of the two conceptual frameworks, CORIS and scaling up, thus provides a potent lens through which to analyse emerging developments at the regional scale with a focus on actors' perceptions and actions, as well as (potential) reconfiguration pathways—all based on the problem-driven quest (Flyvbjerg 2006) of contributing to a housing transition.

3.1 METHODS

The Freiburg region in Germany is shaped by a fast-growing city with a particularly tight housing market, making an acceleration of cost-efficient retrofits especially important. This case study region was chosen due to a high number of companies providing prefabricated, largely wood-based construction and for pragmatic reasons of proximity. The area is characterised by the absence of major serial retrofit initiatives to date (Energiesprong n.d.-a), constituting space for improvement. The existing landscape of regional energy consulting and public funding is a basis for potential innovations, supported by a robust knowledge network of actors. A single case study, applying qualitative, explorative methods, as a first step, allows for a thick description of place-based structures. Although the findings' external validity is limited, it provides rich evidence for practitioners (Flyvbjerg 2006; Sovacool et al. 2018) by unravelling emerging developments of scaling up MMC and conceptually prepares the ground for further studies.

To operationalise the CORIS framework, the first two steps of Tripl et al.'s (2024) *CORIS conceptual model* are applied to make the regional conditions, challenges and opportunities for scaling up MMC methods and platforms visible. First, an overview of the historically grown place-based structures and challenges (Tripl et al. 2024; Tödtling et al. 2022) sketches the preconditions for a reconfiguration of the regional socio-technical system (Isaksen et al. 2022), including the institutional regime and landscape settings. Second, actors' perceptions (and actions) regarding the core processes of RIS reconfiguration are disentangled by analysing (1) their perception and framing of challenges and opportunities; and (2) their (proposed) solutions and orchestration activities for developing and diffusing innovations. Since CORIS emergence is at an early stage in the case study region, the model's analytical aspects of unlocking-destabilisation processes and outcomes can only be hinted at, based on existing actions and opportunities (Hug et al. 2025; Tripl et al. 2024). To fill this gap in evaluating potential outcomes, the concept of *scaling up* with its three dimensions and six empirically derived success factors is mobilised (Meijer 2020; Moore et al. 2015; Petrovics & Giezen 2022; van Doren et al. 2018) (see Table S2 in the supplemental data online).

Following an explorative, qualitative research approach, 14 semi-structured interviews were conducted in the context of the preliminary research project 'Sustainable Housing Collab'¹ between January and April 2025. Using purposive sampling,² the participants include intermediaries and practitioners from industry, public institutions such as energy agencies, civil society, different property owner types and tenant representatives (see Table S1 in the supplemental data online). The reliance on *intermediaries* is justified by their role as key knowledge-transfer facilitators, building connections between innovation projects or between innovations and outside actors (Meijer 2020; Moore et al. 2015). By covering actors with expertise on energy retrofits (criterion) from all relevant subsystems of the RIS of housing and different governance levels (maximum variation), the sample provides an adequate diversity of perspectives (Ahmad & Wilkins 2025; Flick 2020; Hassink et al. 2020; Mattes et al. 2015; Zrineh 2026). Questions addressed serial retrofit projects and their preconditions that were part of a broader questionnaire on actors' perceptions of retrofit rate challenges and opportunities.

To further deepen the investigation into actors' understandings and ideas (Sovacool et al. 2018), a workshop was organised in December 2025 with three foci: single- and multi-family houses, and the preconditions of serial energy retrofit. Through an intensified group discussion format, the aim was to validate the interview results and further identify signs of a regional potential for upscaling serial retrofit. The authors enquired about their assessment of digitised planning, bundled or serial retrofit campaigns, and platform thinking. The participants (see Table S1 in the supplemental data online) included all interview perspectives except tenants' representatives, reducing the focus on housing affordability. The municipality, while absent from the interviews, participated in the workshop, allowing for a deeper discussion of public investments and measures.

The interviews and workshop were conducted and analysed in German, with results translated by the authors for publication. Using qualitative content analysis (Flick 2020), the transcribed and anonymised data were analysed by one author iteratively.³ Deductive codes drawn from the preliminary research focus on regional specifications, barriers and enablers and were translated into the CORIS categories of initial situation, challenges and opportunities. These were then filled with inductive codes for themes, practical examples, solutions and actors. This combination accounted for the coherence of the findings with the conceptual framework (Sovacool et al. 2018), while allowing a close relationship with the data and emergence of regional factors (Petrovics & Giezen 2022).

4. RESULTS

4.1 SITUATION IN THE FREIBURG REGION

The case study region's centre is Freiburg im Breisgau, a city of roughly 230,000 inhabitants. It is the fourth biggest city in the state of Baden-Württemberg, located in the southern Upper-Rhine Region near the Black Forest (City of Freiburg 2023). Rooted in the anti-nuclear movement of the 1970s–90s, Freiburg is known as a pioneer in energy transition and energy-efficient construction of buildings, and continues to position itself as a green city (City of Freiburg n.d.-b). Yet, most of its buildings predate 1970, and rely mainly on fossil energy sources, with renewable energies supplying heating for a quarter of the buildings and a third of the apartments (Destatis 2022). Building types are evenly distributed between single-/double- and multi-family houses (Statistik BW 2025).

As a university city, Freiburg and its region face high inward migration and a tight housing market with rent burdens reaching 37–48% of income across tenant groups (City of Freiburg 2022). Homeownership is low: over 70% of housing is leased. Historically, municipal social housing in the city of Freiburg has been reduced through privatisation which aggravated the housing crisis. Due to a referendum against privatisation in 2006, the municipality of Freiburg still holds a relatively high level of social housing, and cooperatives also play a significant role. The market is nonetheless dominated by individual property owners and their associations (85%). The average net rent in privately owned housing is higher than average, whereas housing cooperatives and the municipality lease apartments for lower (Destatis 2022). High rental price levels have led to a shortage of affordable housing in the region, creating social pressures (City of Freiburg 2025; Destatis 2022). The city of Freiburg put a funding scheme in place which considers social aspects to address the distributional effects of retrofits (City of Freiburg n.d.-a).

Medium-sized firms shape the economic structure of the region, with established pioneers in wood (fibre) construction and universities contributing to innovation in sustainable housing. This represents a starting point for scaling up serial retrofits supported by digital tools in the region (Figure 1). However, such approaches (e.g. *Energiesprong* principle) are not yet widespread, with a preference for small measures related to energy technologies as 'low hanging fruits' (dena n.d.). Against the backdrop of these preconditions, the following section sheds light on the perception of intermediaries and practitioners regarding the challenges and opportunities, and solutions for scaling up MMC methods are analysed and oriented towards CORIS pathways of orchestrating the regional housing transition.

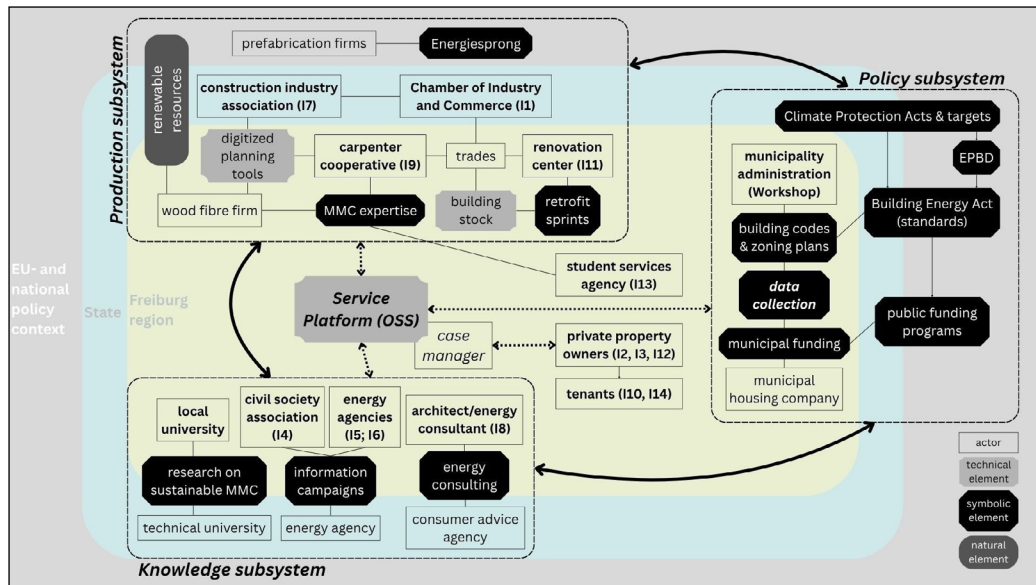


Figure 1: Constellation of the Freiburg challenge-oriented regional innovation systems (CORIS) (yellow) with its three subsystems embedded at landscape (grey) and state (blue) levels, including the potential solutions (*italics*) proposed by involved actors (**bold**).

Note: A simplified version of constellation analysis was applied to visualise the Freiburg CORIS (Ohlhorst & Schön 2015: 263): “The element type ‘actors’ refers to persons and groups of actors (e.g. institutions or organizations); the symbol for ‘technical elements’ depicts artefacts (e.g. technical elements, procedures); ‘natural elements’ refers to materials, resources, environmental media, plants and animals, the landscape or a natural phenomenon; and the element type ‘symbolic elements’ stands for concepts, ideologies, standards, laws, discourses, as well as institutional, legal or economic factors. The relationships between the elements are [...] empirically determined.”

4.2 CHALLENGES AND OPPORTUNITIES OF SERIAL RETROFITS IN FREIBURG

In general, intermediaries of industry as well as homeowners and tenants acknowledge that retrofit projects should be executed comprehensively due to the energy inefficiency of singular measures. Yet, based on the experience of an architect, a housing cooperative and a company, systematic retrofitting tends to be complex, time-consuming and expensive. It also imposes heavy burdens on residents who ‘have to swallow a lot—literally swallow dust, dirt, noise’ (Q1, I8). Against this backdrop, the technical potentials of serial retrofits are evaluated by all—industry, private homeowners, housing companies and civil society—as sensible due to the efficiency in time, resources and material, as well as higher quality. Both aspects are enabled by the standardisation of production and possible modular approaches. The regional student services agency, which is responsible for student dorms, shares insights into its experience with serial approaches to new buildings that can be harnessed for retrofits as well:

For almost 20 years we’ve had concrete prefabrication plants that produce fully designed wall panels in the factory, which are then assembled on site like a Lego set. It’s efficient. Planning takes about half a year longer, but the construction progress and the onsite work have two advantages. First, quality is clearly better because the factory applies quality control during production. [...] On site, we can start on the concrete cellar slab and within, say, five [or] six weeks we have a complete building. That’s a huge advantage. It’s also more ecological—production is more efficient and thus more climate friendly than the conventional method.

(Q2, I13)

At the same time, scaffolding costs and project duration are reduced by coordinating with other building services and electrical work. From a tenants’ perspective, the benefits outweigh the short-term inconveniences:

We consider this highly sensible because we want [...] tenants [...] to be able to stay in place during the renovation. Serial retrofit means the work is much faster, the disturbance [...] is far reduced, and ultimately the costs (and any rent surcharges that might be passed on to tenants) are lower.

(Q3, I14)

However, the precondition of different building types and material conditions requiring individual solutions is emphasised as a barrier to large-scale prefabrication methods in interviews and workshop by industry, housing cooperative, company, homeowners, and civil society. According to the construction industry association, this is amplified by the societal context of (southern)

Germany, where cultural expectations regarding retrofits are highly individualised and hinder uniform measures. With regard to prioritising, a general focus on ‘worst performing buildings’, such as post-war constructions, is commonly recommended by industry intermediaries and energy agencies. While the renovation backlog persists across all types of buildings, ownership and utilisation, single-family homes, due to their high energy consumption per capita, hold the greatest potential for *effective* improvements through energy retrofits. But serial retrofit is not viable, as a carpenter underlines:

That can't work with a single-family house; we need a larger building with a simple geometry, uniform windows or large façades. A small single-family house with a balcony, bay window and side garage doesn't make sense.

(Q4, I9)

Hence, multi-family houses are considered more suitable for serial approaches by a majority of intermediaries from industry, energy agencies and property owners, as multistorey buildings are sufficiently large and of similar construction to enable *efficient* measures. From an architect's and an energy agency's perspective, they also allow for a low-effort achievement of a higher energy efficiency category, and larger blocks are therefore targeted by federal funding programmes. Homeowners' associations could pool buildings and distribute costs, but slow decision-making and a lack in service personnel works against quick success, as reported by the association, civil society, energy agency and industry intermediaries. In contrast, private and public housing companies, with similar buildings in comparable condition, type and age, present a more feasible opportunity.

The existing shortage in skilled labour in the construction sector causes demand to exceed supply, leading to delays, additional price increases and lower quality. Consequently, small projects are sidelined as trades prioritise bigger, more profitable projects, as a homeowners' association points out. An energy agency, architect and intermediary of the housing industry observe a lack of expertise, qualification and openness toward serial retrofit approaches in the relevant trades and companies. The low coordination intensity between trades is weakened due to lack of capacity, according to an industry intermediary. Moreover, limited personnel capacities in municipal administrations are a restricting factor that would need to be overcome to apply for federal funding schemes and implement projects on the neighborhood scale, as discussed during the workshop.

From a carpenter's point of view, there is no single ‘correct’ approach to retrofit; instead, conflicts of objectives arise between regulatory requirements, protective provisions, preferences of owners and technically feasible options. Serial retrofits especially are perceived as a management challenge by voices of civil society, homeowners, housing companies, a cooperative, an energy agency and industry. This is because of the involvement of multiple sectors requiring integration of trades and compliance with regulations. Relying on external planning reduces homeowner effort, but increases costs proportionally to project depth given the complexity of 3D laser modelling and calculations needed for prefabrication—though new technology and digitalisation may make this process increasingly feasible.

On the supply side, a lack of providers of prefabrication is diagnosed by an energy agency. This makes imports from other EU countries necessary, contributing to the logistical complexity. Here, the quantity of buildings plays a role for economic feasibility, as illustrated by an architect:

There is a big manufacturer who built a plant in Poland specifically for these timber frame refurbishment components. He said, ‘What, only three units? No, that doesn't pay off for us. Sure, we could produce the parts in Poland, truck them over the highway, we have installation crews and everything—but three dwellings just isn't viable.’

(Q5, I8)

Nevertheless, there is regional potential for transposing existing experiences from serial construction of new builds to serial energy retrofitting (see Q2). With the region shaped by wood construction, a majority of intermediaries see renewable building materials as a driver of sustainable, resource-efficient retrofits that also improve residential comfort. Beyond pioneer firms—which apply serial methods in timber construction according to a specialised carpenter—they are still not widely used.

In reporting this multitude of challenges and opportunities, intermediaries and practitioners also suggest several solutions to orchestrate the shift towards a serial retrofit CORIS. A focus lies on public institutions and municipalities' agency to activate relevant actors, since homeowners need support, as a civil society association responsible for administration of the city's retrofit funding programme points out:

Germany is still lagging behind on serial refurbishment. Still, I find it very interesting and a good solution because [...] it would, in my view, save huge amounts of time and money. The only question is organization. It's unlikely that neighbors will just step up and take care of it themselves.

(Q6, I4)

Due to the overload and fragmentation of information about retrofit, private homeowners tend to be overwhelmed and lack guidance. During the workshop participants emphasised that a tailored communication strategy involving multipliers and best-practice examples is necessary to reach those homeowners, who are often senior citizens, and provide an overview of counselling and subsidy offers, including serial options. Both municipality and energy agency put in place an online collection of sample retrofits in the region that could be extended to serial projects ([City of Freiburg n.d.-c](#); [Häfelinger 2024](#)). To incentivise homeowners' associations to access public funding for combined projects (given enough administrative capacity), an energy agency proposed a municipal premium. This scaling deep of serial approaches in municipal institutions would motivate the scaling up of retrofits in the private housing sector and beyond. From a civil society, tenants' and energy agency perspective, municipalities in particular should retain and invest in their real estate, providing social housing and support housing cooperatives.

Regarding knowledge transfer and capacity-building, housing cooperatives are considered pioneers whose experience with sustainable and affordable energy retrofits can be leveraged for scaling up innovative methods. Trades could be reached through intensified information and (peer-to-peer) training campaigns building on existing networks and institutions. For initiating investments in serial innovations within the construction sector, the workshop identified pilot projects with transparent cost analyses as essential—as initiated by a carpenter specialising in renewable materials in collaboration with a technical university.

4.3.1 Retrofit sprint solutions

The niche character of serial retrofits in the Freiburg region is reflected by a lack of common understanding of the term and its entailed techniques, as emphasised by a construction industry intermediary. Instead of high-level prefabrication, actors mainly associate serial retrofit with the retrofit sprint, a cooperation among trades. Aligned with the dominance of private property owners in Freiburg, it is evaluated as an advantageous approach that streamlines and coordinates retrofit processes. Minimal or no relocation of residents is required, while energy-cost savings are guaranteed—even when using local small contractors. The condition for success is the 'one source supply' of trades, acting as a single contractor. By purchasing and building collectively, projects and access to funding are simplified. This collaborative approach is part of a state-level programme for retrofits, 'Future of Old Buildings' ([Zukunft Altbau n.d.](#)). Supported by the chamber of industry and commerce, it enables energy retrofit of single buildings in less than a month. In Freiburg, a renovation centre already applies informal collaboration, coordinating trades for single projects and scheduling different projects complementarily. Thereby, the overall administrative effort is reduced for all actors.

4.3.2 OSS solutions

A central, reliable and neutral contact point for counselling and information was the focus of a discussion during the workshop. An OSS would institutionalise the existing innovation network of well-connected stakeholders. Such a service platform could channel and complement existing outreach campaigns of federal and state institutions, municipality, local energy agencies, and civil

society. Hence, it would improve the activation of property owners and exchange of practitioners, eventually scaling up retrofits. Yet, as emphasised by an energy agency, legal questions around state aid must be clarified to ensure neutrality while still meeting needs. While energy consulting already offers an entry point for technical questions and funding options, projects often stall or fail from lack of support during implementation. An identified solution is a case manager, to whom private property owners can delegate tasks—combining planning, tendering, contracting, overseeing construction and securing funding in one person. This is seen as a low-threshold service, providing ‘one-stop’ support and enabling contract bundling. By scaling deep service platforms as a public institution integrating all governance levels, private homeowners’ capacities to organise retrofits could be substantially strengthened.

4.3.3 Digitised planning solutions

To scale up digitised planning tools, data on building type, condition and size of, for example, homeowners’ associations’ building stock are needed to create targeted information campaigns. Such data are largely lacking due to both collection costs and legal obstacles such as data privacy regulations. A legal basis for systematic municipal data collection should be created, enabling the merging of existing datasets. One step further, (publicly funded) online tools could give homeowners and associations a low-barrier way to estimate project costs—potentially via artificial intelligence (AI)-supported calculation—and to evaluate buildings’ retrofit suitability. The generated data, covering construction plans and energy consumption, could be complemented by remote-sensing, utility, municipal data and publicly subsidised laser-scan measurements. These datasets could feed a data acquisition system that pools similar buildings, enabling retrofit sprints and serial retrofits. Moreover, building regulations and zoning plans could be updated to promote serial approaches on a micro scale, while enforcing standardisation.

4.4 POTENTIAL PATHWAYS

Overall, serial retrofits fulfil many of the characteristics related to successful scaling up (see Table S2 in the supplemental data online) (Petrovics & Giezen 2022; van Doren et al. 2018). They can become a lever for affordability of energy retrofits and ecological sustainability in the CORIS shaped by the timber industry. As revealed, industry actors and property owners are already adapting practices through retrofit sprints, applying serial prefabrication and developing pilot projects using renewable materials in collaboration with knowledge institutions. Public actors support capacities with knowledge-transfer campaigns, accounting for a scaling deep (Meijer 2020; Moore et al. 2015; van Doren et al. 2018). However, the complex planning and coordination of serial and bundled projects remain a challenge in the region. Thus, potential improvements through digital platforms and OSS become apparent. They could shift the currently emerging reorientation pathway shaped by bottom-up activity (Bours et al. 2022; Isaksen et al. 2022) towards a transformation of the CORIS.

5. DISCUSSION

A beginning reconfiguration towards a CORIS addressing housing’s net-zero transition and affordability crisis through MMC is visible in Freiburg. This includes pioneer serial retrofit experiences and collaborative retrofit sprints across trades. The material shows a regional, cross-sectoral learning process in creating broad innovation, and a reorientation pathway in the retrofit CORIS similar to other construction sector cases (Hug et al. 2025; Loorbach 2010; Mühlenhoff & Herzig 2024; Soltani et al. 2025). Yet, place-based challenges must be considered to scale up serial retrofits: prefabrication remains limited to multi-family buildings (with retrofit sprints covering single-family homes), the dominance of private property owners is a structural barrier, and cultural expectations constrain public acceptance. Mirroring the empirical findings with literature on platform thinking and OSS surfaces leverage points for the future pathway of the Freiburg CORIS.

The centrality of governance for scaling up serial retrofits in the Freiburg region is apparent in the emphasis of organisational challenges, confirming calls for a stronger consideration of socio-political dimensions in the housing transition (Dixon & Eames 2013; Green 2022). The carved-out

service platform solutions—a public OSS and database—echo the literature’s assessment of their trust- and continuity-driven effectiveness, offering a transparent, accessible node strengthening regional governance (Bertoldi et al. 2021; Biere-Arenas et al. 2021; Dixon & Eames 2013; Köhler et al. 2025; Pardalis et al. 2022).

Nevertheless, their calibrated implementation requires attention to place-based conditions of the CORIS (Soltani et al. 2025; Tödtling et al. 2022; Trippl et al. 2024). The lack of capacities in municipalities is a prevalent limiting factor for a publicly driven OSS (Biere-Arenas et al. 2021; Pardalis et al. 2022). Despite that, regional actors still expect public leadership (van Doren et al. 2018) rather than a private model (Pardalis et al. 2022). They evaluate direct responsibility—via a case manager supporting property owners—as the most effective, confirming the literature’s claims (Bertoldi et al. 2021). The trust-factor of case managers (Bertoldi et al. 2021; Eisermann & Maraquinn 2020) positions digital platforms and databases as tools for initial information and professional planning rather than OSS substitutes due to constraints of data fragmentation (Soltani et al. 2025). Also, questions of data privacy must be clarified for comprehensive data collection and pooling at the municipal level. This endorses the split allocation model (Panakaduwa et al. 2025a, 2025b) in the context of Freiburg, combining digital information (potential project costs and technicalities) with a case manager supporting implementation.

A physical OSS set-up still needs to be designed, considering the necessary funding and staffing (Panakaduwa et al. 2025b), and ideally harnessing the expertise of energy agencies, consultants, trades and industry. Yet, an all-inclusive model (Biere-Arenas et al. 2021) can be dismissed based on the existing legal barrier of state aid issues. Existing European and German models could inform further developments, vertically scaling ‘down’ successful serial projects and municipal climate centres (CO2COMPASS n.d.; Energiesprong n.d.-b; Riesenweber 2024). Moreover, an OSS could formalise the retrofit sprint networks, ensuring their sustainability (Mlecnik et al. 2019) and inducing contractor network coordination. As the supply side is a major barrier in the Freiburg region with the shortage of skilled labour and capacities beyond pioneers in prefabrication, existing resources must be expanded through professional training, as outlined in the orchestration activities in the case study region as well as the literature (Pardalis et al. 2022; Volt et al. 2021).

While the bottom-up orchestration of CORIS developments (Hug et al. 2025; Isaksen et al. 2022) can create networks of knowledge transfer to scale up serial retrofits, the model risks underweighting the reliance on supra-regional policies and regulations. Another case study in the German construction sector has shown the strong influence of supra-national or federal policies and funding schemes on regional developments and underlined their suitability for standardisation processes (Mühlenhoff & Herzig 2024; Soltani et al. 2025). The context of the emerging CORIS in Freiburg shows that EU and federal regulation and funding have a driving function in providing the policy and legal framework for serial retrofits (Figure 1). Yet, funding schemes’ requirements are both beyond regional control and surpass private and municipal resources, therefore lacking the necessary flexibility and effectiveness.

Applying the CORIS framework proved valuable for surfacing the dynamics of regional retrofit governance. The focus on regional preconditions in the analysis of MMC pathways ensured the observation of existing resources, networks and capacities while avoiding a top-down, one-size-fits-all approach (Hug et al. 2025; Soltani et al. 2025). This limits transferability, since Freiburg’s pioneer status in energy policy, profiting from the presence of both the university and a wood construction cluster, is not readily generalisable. Due to the early-stage context, the application of the CORIS model (Trippl et al. 2024) is constrained to a preliminary investigation into intermediaries’ and practitioners’ perceptions and orchestrations of MMC and platform solutions. The supplementation with the concept of scaling up (van Doren et al. 2018) has proven useful in detecting early signs of MMC potential and governance pathways in the region. The interview and workshop data enabled the trends and discourses to be grasped at the intermediary level, but more insight is needed into the implementation level regarding technicalities and capacities of regional firms in adopting serial approaches (Soltani et al. 2025).

The results show that the regional preconditions are fertile ground for serial and OSS approaches. To go beyond technical fixes and ensure sustainable implementation, social and economic implications must be further investigated, especially pertaining to small firms' capacities to adapt (Green 2022; Soltani et al. 2025). Because tenants' perspectives were absent from the workshop (see Table S1 in the supplemental data online), proposed solutions are shaped mainly by industry, property owners and public institutions. Hence, they represent governance tools focused on operational challenges, while sidelining equity impacts. Tenant representatives' positive evaluation of serial approaches hints at possible acceptance, but effects on rent increases and gentrification must be factored into platform design for a socially equitable scaling up of MMC (Köhler et al. 2025; Sequeira & Gouveia 2022).

6. CONCLUSIONS AND OUTLOOK

In the face of climate change and housing crises, it is urgent to invest in the development and testing of innovative approaches for energy retrofits. The early scanning of preconditions, challenges and opportunities of modern methods of construction (MMC) in a regional context has proven timely, revealing actors' perceptions, activities and (proposed) solutions for orchestration of serial retrofits. The findings reveal the importance of public governance instruments for the regional scaling up of serial retrofits, such as a one-stop shop (OSS) with case managers and digital planning tools for data-based bundling of projects. Actors' call for public leadership synthesising the expertise of regional innovation system (RIS) subsystems and providing the necessary capacities and institutions to steer the Freiburg challenge-oriented regional innovation systems (CORIS) towards serial retrofits. Those approaches are in not a one-size-fits all method (Soltani et al. 2025), instead requiring careful consideration of the characteristics and resources of actors, networks and institutions in the respective RIS to drive meaningful change (Hug et al. 2025).

Fundamentally, the discourse of serial retrofits and platform approaches has reached the intermediary level in Freiburg, with a diversity of understandings of the respective concepts. Based on these findings, it is suggested that practitioners deepen existing and create new networks across sectors and trades to build capacities and experiment with collaborative methods of retrofit sprints and serial approaches. As exemplified by pioneers in cooperation with universities, the early adoption of innovative methods and the use of regional and renewable resources is recommended to strengthen both ecological sustainability and the regional economy (Hug et al. 2025). As for the legal framework, the provision of legal bases for data collection and OSS are essential to promote a 'steady adoption' path for MMC and platforms (Soltani et al. 2025). A future longitudinal study could capture future CORIS developments, while comparative case studies across German regions could crystallise systemic versus place-based factors.

In general, this case study has reiterated that the housing transition is a governance rather than a technical challenge (Dixon & Eames 2013; Green 2022). It is not yet clear whether regional efforts open a transformation pathway for the Freiburg CORIS including the necessary institutional framework (Isaksen et al. 2022) or if the actors must rely on a 'small wins' strategy (Bours et al. 2022) under political constraints. Nevertheless, several starting points for actors at the municipal scale have been identified—including public investments in OSS and data platforms to foster serial approaches—which could contribute to scaling up the retrofit rate as aligned with decarbonisation goals.

NOTES

- 1 Research project 'NaWo-Collab—Transdisciplinary Collaborations for Sustainable Housing and Retrofitting', 2024–25, as part of the 'Sustainability Innovation Campus' of Baden-Württemberg, <https://uni-freiburg.de/en/topics-in-focus/sustainability-at-the-university-of-freiburg/sustainability-innovation-campus/>.
- 2 The internet and regional newspapers have been systematically combed for a series of search terms to identify actors that expressed opinions on the need to increase retrofit rates regionally

(criterion) beyond the intuitive list of ‘usual suspects’ of decade-long observers of the regional retrofit ‘scene’, reducing selection bias (Zrineh 2026).

- 3 Due to limited capacity, intercoder testing could not be afforded, but reliability is ensured by transparent documentation of the coding process in MaxQDA and close supervision of the coding process.

ACKNOWLEDGEMENTS

The authors are grateful to the participants for their time and openness, to Janik Wischmeyer for very skilfully conducting many interviews, and to Teresa Döring for contributing to the literature review. The authors also thank the four anonymous reviewers for their constructive comments, and Rachel McCrorie, Richard Lorch and Andrew Karvonen for their editorial work, extraordinary engagement and friendly exchange.

AI DECLARATION

Claude was used in the revision process to extract outlines of the literature to be additionally considered, supporting the decision for substantive reading.

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COMPETING INTERESTS

The authors have no competing interests to declare.

DATA ACCESSIBILITY

The data have not been made accessible to provide confidentiality and anonymisation to the participants.

ETHICAL APPROVAL

Institutional ethical approval was not required, but informed consent was ensured by collecting written statements from all interviewees before the interviews.

FUNDING

The research on which this article is based was made possible through a seed money grant by the state of Baden-Württemberg (Ministry of Science, Research and the Arts) via the Sustainability Innovation Campus (grant number 8200126108).

Supplemental data for this article can be accessed at: <https://doi.org/10.5334/bc.819.s1>

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TO CITE THIS ARTICLE:

Dörr, H., Späth, P., & Goñi, I. (2026). Scaling up retrofit: regional challenges and opportunities for MMC. *Buildings and Cities*, 7(1), pp. 1199–1214. DOI: <https://doi.org/10.5334/bc.819>

Submitted: 15 March 2026

Accepted: 06 October 2026

Published: 30 October 2026

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