Case Study Report

Making wood cities happen:

New urban policies for a sustainable and carbon-neutral future

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Abstract

In the context of global accelerating urbanisation, the total floor area of buildings is expected to double by 2060, with significant impact on the environment. Reducing embodied emissions for new and renovated construction represents one of the critical priorities for mitigating this impact and reaching true carbon neutrality but faces the challenge of an immature urban development policy framework. The challenge remains translating pilots and promising practices, such as the Horizon 2020 "Build-in-Wood" project, into policy. In this project, we worked on understanding the real needs of cities and territories, the drivers and the key entry points for new local, regional, and national policies supporting multi-storey wood buildings both explicitly, as well as implicitly. We achieved this by performing a multi-criterial analysis and applying co-design processes in seven Early Adopter Cities (EACs) in Europe, while concomitantly researching different best practice policy instruments at global level which incentivize building with wood, offering coordinated for improving policy, governance, and the decision-making process for subnational governments. Presented in a form of a Policy Catalogue, it documents more than 40 policies at national, regional, and local level, focusing on both the implementation process and the impact, with main findings included in this report, which focuses on the case of Trondheim, Norway.

Keywords

embodied carbon, wood cities, sustainable urban development, carbon-neutral policy

1. Introduction

1.1. Global and European context

An intense political focus on cutting energy consumption from the use phase of buildings has dominated the global sustainable urban development agenda for the past several decades. The building sector is, however, still responsible for nearly 50% of the annual global CO2 emissions (UNEP, 2018), while consuming about 40% of the materials in the economy, of which an estimated fifth are recycled or reused after the lifetime of the buildings (Pomponi and Moncaster, 2017). While the policy and practice focus has so far been centred on cutting energy consumption for the use phase of buildings, reducing embodied emissions for new and renovated construction represents one of the critical, high-impact priorities for reaching the Paris Agreement (2015) targets.

In the context of future urban growth, the substitution of regular concrete buildings with wood constructions (multi-storey buildings), that act as carbon sinks, can significantly offset emissions and contribute to achieving climate goals, while reinforcing urban-rural and regional bio-based economies and promoting regenerative urban systems (FAO, 2020). However, the policy framework to support built environment decarbonisation is still in its early stages at both international and national levels, specifically

in what concerns material substitution and support to bio-based solutions such as tall (multi-storey) wood buildings (Wiegand and Ramage, 2022). Europe witnesses only a few front-runners leading the change through new laws, standards and regulations on whole-life carbon emissions, in lieu of a revised Energy Performance of Buildings Directive (EC, 2021). The mismatch between progress in lowering in-use operational energy consumption and embodied carbon is a critical policy issue and may lead to the latter representing over 90% of a new building's emissions between 2022 and 2050 (CaGBC, 2021). The main vectors of change are under the direct responsibility of city administrations: zoning and land use, regulation, procurement, waste management and circularity, investments in municipal buildings and financial incentives (CNCA, 2020).

1.2. The "Build-in-Wood" project

The Horizon 2020 "Build-in-Wood" project (2019-2023, www.build-in-wood.eu) is taking a whole-life carbon perspective on the potential of using timber and promoting multi-storey wood buildings as long-term carbon storages and compensators of CO2 emissions from human activities. The project is being implemented by an international consortium led by the Danish Technological Institute and brings together seven Early Adopter City (EAC) affiliates across Europe, under the coordination of URBASOFIA: Metropolitan Region of Amsterdam (NL), Brașov Metropolitan Area (RO), Copenhagen (DK), Haringey Borough of London (UK), Innsbruck (AT), Trento (IT) and Trondheim (NO),. The main outputs of "Build-in-Wood" are:

- A fully documented, demonstrated, and cost-effective building system suitable for residential, commercial and public functions, and fit for both new construction and retrofitting. The solution, tested via 7 digital pilots in the EACs, is considering environmental and socio-economic benefits, as well as the benefits for cities and regions, in future-thinking scenarios.
- Research, case studies and recommendations for multi-storey wood building support policies.
- An International Community of wood construction, connecting timber professionals and stakeholders, including urban and regional planners across the world, providing resources and decision-making evidence to support wood construction and retrofitting.

The designed multi-storey wood building system can be used for both new construction and retrofitting needs. The elaborated model takes into consideration a wide range of stakeholder requirements, urban contexts, technical and regulatory limitations. The challenge remains, however, to translate pilots and practices into policy, overcoming baked-in biases towards concrete in public tenders and "building as usual" practices, and creating an enabling framework that supports wood construction at a wider scale.

In order to provide orientations for this change, the main objective of our work was to analyse the needs, local development preconditions and trends in seven European major cities, corroborating them with drivers, key entry points and stakeholder perceptions with respect to opportunities of introducing new decarbonisation policies and supporting multi-storey wood buildings (both explicitly, as well as implicitly). Supplemented by research on global best practices in wood support policies and local co-design processes through sets of three workshops in each of the Early Adopter Cities, our purpose was to inform the definition of measures, strategies, procurement instruments and local policies for the built environment. In this paper, we focus on the case of one of the Early Adopter Cities, Trondheim (Norway).

2. Project and case study methodology

The first step of Build-in-Wood planning research analysed provisions and connections between different post-2020 legislative and regulatory layers impacting the construction sector, in order to understand the strategic directions informing local EU city policies for climate neutrality by 2050 and the prerequisites of adopting the prescriptive measures of Fit for 55. This high-level analysis was supplemented by a review national, regional and local-level policies and regulations for the built environment and their impact on multi-storey wood building adoption (explicit support, implicit support, neutral or restrictive).

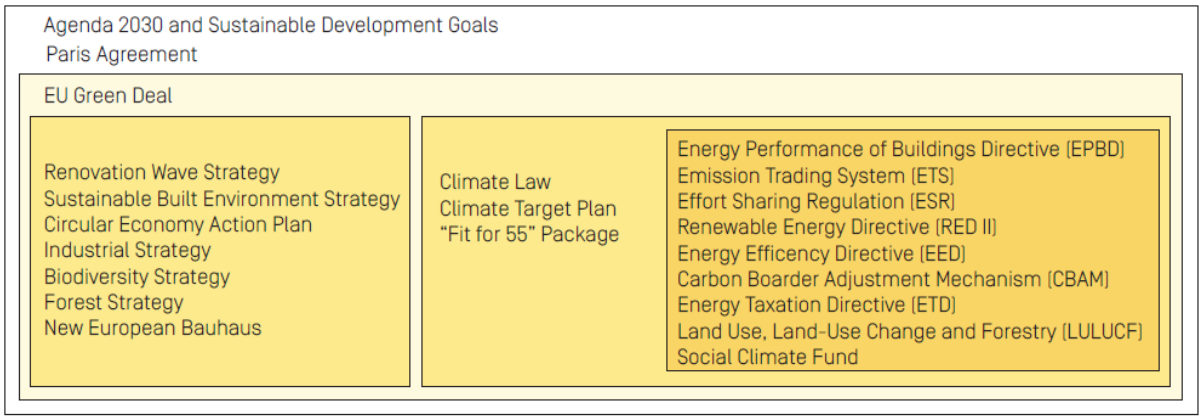

Figure 1. EU policy framework and legislative layers pertaining to building in wood. Source: URBASOFIA (2022)

Secondly, key quadruple helix stakeholders in each city have been involved in surveys and a first round of workshops (180 total participants) to analyse perceptions on barriers and opportunities for the sector, including implications and priorities for future planning and development. In parallel, a multi-criterial analysis of the Early Adopter Cities has been performed to analyse and understand the main drivers and preconditions, and to produce evidence for new policymaking. The analysis was based on 73 quantitative indicators over three evaluative dimensions (socio-demographic, environmental, and economic and market context), synthesized in individual city SWOT analyses and a comparative trend assessment (currently being updated to include Haringey and Amsterdam, onboarded at a later stage in the EAC process).

In a third step, specific pathways for lowering embodied carbon through planning and new urban policies are explored in two subsequent rounds of workshops (1 - solutions and scenario-building; 2 - policy options and roadmaps), supported by a global best practice Policy Catalogue including (to date) 20 national, 10 regional / metropolitan and 10 local pro-wood policies.

3. Results of EAC research and co-design

For the most part, sustainable wood value chains, multi-storey wood buildings, wood retrofitting and related concepts are not explicitly mentioned or openly supported in the national, regional or local plans and policies of the analysed cities. However, there is implicit support through e,g, Energy and Climate plans, Environmental strategies and low embodied carbon provisions of Municipal General Plans (e.g. Trento). The city of Trondheim (Building sector roadmap for 2050 "Bygg og anlegg", "Trebyen Trondheim") and the Metropolitan Region of Amsterdam ("Green Deal Timber Construction" 2021) distinguish themselves through a robust planning framework supporting wood projects. Furthermore, new laws at higher territorial scales, such as the Fit for 55 package and Denmark's new embodied carbon targets, set to enter

into force on January 1st, 2023 (IM Denmark, 2021) create significant urgency and opportunity for designing "wood first" urban development policies.

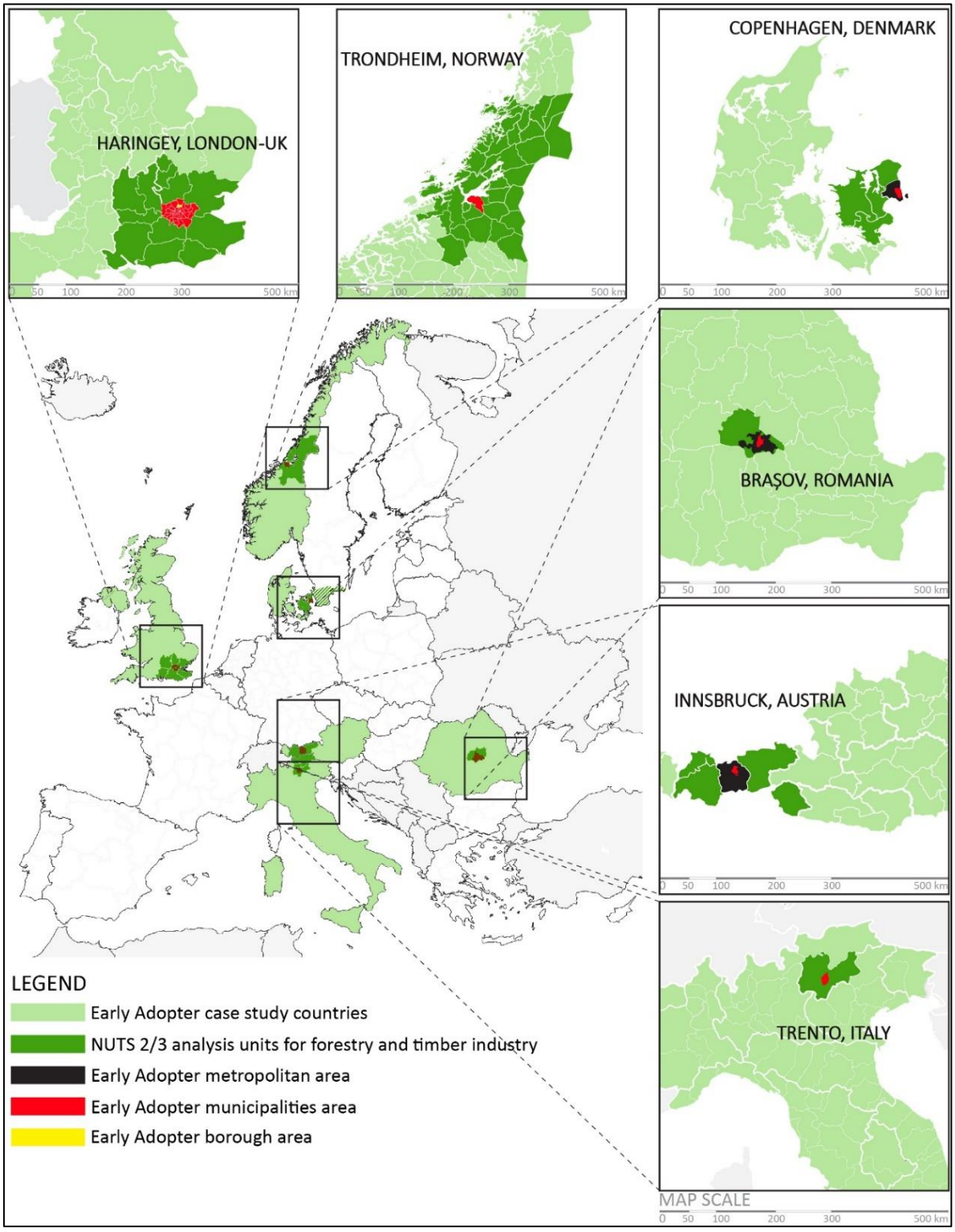

Figure 2. Build-in-Wood Early Adopter Cities: territorial scope of analysis. Source: URBASOFIA (2020).

	Indicator	BRASOV	COPENHAGEN	INNSBRUCK	TRENTO	TRONDHEIM
SOCIO-DEMOGRAPHY	number of inhabitants	C ↗	C ↗	C ↗	C ↗	C ↗
	population density	C ↗	C ↗	C ↗	C ↗	
	number of migrants	C ↗	C ↘	C ↘	C ↘	C →
	material deprivation rate	C ↘	C →	C ↘	C ↘	C ↘
	revenues by households	C ↗	C ↗	C ↗	C ↘	C ↗
	work intensity	C ↗	C ↗	C ↗	C ↗	C ↗
	incidences of cardio respiratory desease	yes	C ↗	●	●	↗
	level of education	R ↗	●	●	high	high
ECONOMY & MARKET	GDP per capita	R ↗	N ↘	C ↗	R ↗	R ↗
	number of industrial companies	R →	R ↗	R ↗	C →	●
	number of real estate companies	R ↗	N ↗	C ↗	C →	●
	employment rate	R ↗	R ↗	C ↗	R →	R ↗
	unemployment rate	R ↘	R ↘	R ↗	R ↗	R →
	forestry sector turnover	R ↗	↗	N ↗	R ↗	R ↗
	no. of enterprises in forestry sector	●	●	●	R ↗	R →
	no.of personnel occupied forestry sector	R ↘	R ↗	N ↗	R ↗	R ↗
	construction sector turnover	●	●	C ↗	●	R ↗
	number of construction companies	R ↗	R ↗	R ↗	C ↘	R ↗
	no. of personnel occupied in construction sector	R ↘	C ↗	C ↗	C ↘	R ↗
	construction sector wages	R ↗	N ↗	R ↗	C ↗	R ↗
	number of dwellings	●	C ↗	●	●	C ↗
	homeownership rate	C ↗	●	●	high	C ↘
	no. of crowded dwellings	●	●	●	●	C ↗
	average annual rent	C ↘	C ↗	R ↗	C ↗	C ↗
	average property sale value	C ↗	C ↗	R ↗	C ↘	C ↗
	number of new building permits(residential)	C ↗	C ↘	C ↘	C ↘	C ↘
	commercial rental price index	C ↘	C ↗	●	●	C ↗
	number of new building permits(office)	C ↘	C ↘	C ↘	●	●
	presence of regional facilitating institutions	yes	yes	yes	●	yes
	level of innovation	low	high	high	moderate	high
ENVIRONMENT	Co2 emissions	C ↘	C ↗	N ↗	C ↗	C ↗
	incidence of earhquakes	low	low	low	low	moderate-low
	incidence of landslides	low	moderate	moderate	low-moderate	moderate
	incidence of forest fires	low	●	●	low	low
	availability of wood resources	yes	yes	yes	yes	yes
	availability of wood processing industry	yes	yes	yes	●	yes
	rate of deforestation	C ↗	C ↗	N ↗	C ↗	C ↗
	rate of reforestation	low	C ↗	N ↗	C ↗	C ↗
	relative humidity	high	high	moderate	high	high
	magnitude of earhquakes	low	low	low	low	low

LEGEND OF CROSS-CITY COMPARASION TABLE

DIRECTION AND INTENSITY OF DEVELOPMENT

↗ ↘ clear significant increase/decrease

↗ ↘ moderate/slight increase/decrease

→ nearly no change over time/fluctuating

SPATIAL COVERAGE OF DEVELOPMENT

N national level trend
R regional level trend
C city level trend

INTENSITY OF DEVELOPMENT

low - moderate - high

● no data found

Figure 3. Cross-cutting comparative analysis of development trends in 5 EACs. Source: URBASOFIA (2020)

The built environment and socio-economic analysis indicated that, while cities have their own specificities in terms of development trends, there are three common factors which represent favourable conditions

to support further development through the Build-in-Wood project: 1) increased urbanization, 2) population growth and 3) a high resulting demand for new buildings, generating: increased regulatory focus on sustainable construction and decreasing the GHG emissions of the construction sector; trends to build more vertically; openness to innovation; competent trainable workforce; availability of wood resources; availability of wood processing industries; lastly, other positive trends in construction and regional forestry, such as: increased wages, employment rate, turnover, number of personnel and number of companies.

The overall perception of EAC stakeholders (76 questionnaires) is that there are strong premises for adoption of wood-based materials in construction, albeit there are missing and weak links, such as the awareness of end-users and contractors and the adaptation of regulations to permit the use of wood-based materials in structural design of tall buildings. Across the board, the main legislative barrier is the regulation regarding fire hazards and earthquakes, which in most cases favour the use of concrete/steel structures. The institutions issuing these types of permits in most cases are willing to work together with stakeholders and local authorities in order to better understand the behaviour of new wood-based materials (especially structural and façade elements) in fire hazard and earthquake scenarios and to support safe practical solutions for use of such materials in tall buildings.

As a result of the first rounds of workshops in EACs, five core planning and policy challenges have been identified by the cities, together with their stakeholders:

1. Supporting a dedicated building in wood policy (stand-alone or integrated a larger embodied carbon policy) and passing specific timber policies (quota, CO_2 and energy requirements);
2. Supporting a retrofit-first approach in planning policy that is low-carbon and circularity-oriented
3. Setting targets for embodied energy in planning policy, prioritizing low carbon materials and “true pricing” of materials;
4. Ensuring carbon offsetting, circular economy principles & performance-oriented heritage building refurbishment
5. Updating outdated regulatory frameworks in the context of high retrofitting and new housing needs, with a focus on material use and design for disassembly.

4. Informing policy design: Best practices

Based on the EAC policy challenges, a best practice Policy Catalogue has been developed to identify and review wood support policies and measures across the globe, currently comprising 40 entries (20 national, 10 regional or metropolitan and 10 local-level). Its purpose is to represent a working resource for Early Adopter Cities in their second and third-stage co-design workshops and further project-related decision making, and to provide knowledge and evidence for the public audience.

The final publication (2023) is intended to include the full experience and lessons learned working with “Build-in-Wood” EACs and to represent a Policy “Choice Catalogue” for other cities, at European level and beyond.

The Policy Catalogue maps out, research, assess and present different instruments, which have been documented according to a series of features in order to obtain an overview of policy practices:

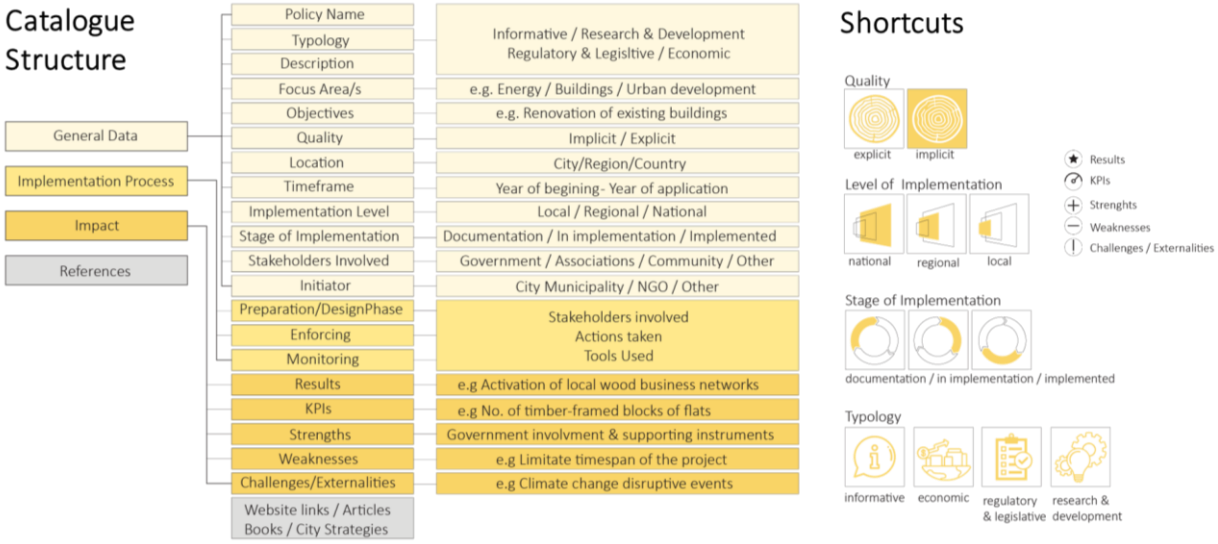

Figure 4. Structure of the "Build-in-Wood" policy catalogue. Source: URBASOFIA (2021)

22 out of the 40 policies reviewed and included in the catalogue are European (particularly Northern European), with the rest North American (10), Oceanian (4), Asian (3) and South American (1). While the oldest policies date to the 1990s ("Wood Works!", Canada, 1998; "Building of Tomorrow", Austria, 1999), they have been predominantly of an informative and research & development nature. Front-runners in developing regulatory and legislative policies, i.e. criteria have explicitly been introduced only in the mid-2000s, with pioneers such as Japan (The Act for Promotion of Use of Wood for Public Buildings, Law no. 36/2010) and Sweden ("Mer trä i byggandet / More Wood in Construction", 2004) and front-running cities Vaxjo, Sweden (Construction Strategy, 2005), Zurich, Switzerland ("the 2,000-Watt Society project, 2005) and Trondheim, Norway (Trebyen, 2004).

More recently, Wood Encouragement Policies (WEP) and new explicit regulations have been increasingly shaping the direction of planning, new urban development as well as regeneration: France is preparing legislation mandating that all new public buildings must be made at least 50% from wood or other sustainable materials from 2022, Denmark is introducing CO2 ceilings for building materials from 2023, while cities such as Helsinki in Finland introduce Carbon Footprint Criteria of their own. In the case of the Metropolitan Region of Amsterdam, the "Green Deal Timber Construction" (2021) represents a new historical accord of 32 municipalities mandating at least 20% of the planned MRA housing production annually to be constructed in wood or other bio-based materials, from 2025 (AMS Institute, 2021). These policies will produce significant impacts ranging beyond the form and function of the built environment, changing to the local economy and job market and challenging the status quo with respect to site planning, masterplanning and normative regulations.

5. Trondheim, Norway: implicit wood building support through ambitious climate targets

5.1. Urban context

With a long-standing tradition of building in wood and green innovation, Trondheim is currently a growing city, with a population growth of 13.8% and a building stock increase of 12.8% from 2010 to 2020. As a low-rise, low-density city, it can still absorb population growth through densification of existing built-up areas. A tendency to build vertically is highlighted by the increased dwelling-to-permit ratio. Evidence of this trend

in the last years is showed also through the increase of the following indicators: number of constructions, real estate companies, average wages, number of personnel and turnover in construction at regional level (Trøndelag).

With falling ownership rates, the general market trend is leaning towards build-to-rent as opposed to build-to-sale, further supporting sustainable solutions like multi-storey wood, for which the cost is front-loaded, to become more attractive. This is further supported by soil structure typology of the region, where a lighter material like wood makes it possible to add more storeys to both new and existing buildings.

CO_2 emissions have fallen slightly in recent years in Trondheim (2.46 tonnes CO2/capita), reflecting progress in the city's actions towards sustainability. However, both emissions from energy industries and transport, as well as the incidence of respiratory disease within the population have increased (2015-2020). Using more wood in homes can be a solution to improve indoor air quality due to it's moisture buffering capacity, and Trøndelag makes up for 29.8% of the total forested area of Norway, which makes the resource accessible. The reforestation rate has always exceeded the one of deforestation, concluding that the wood sector relies on an ongoing circularity and continuity of raw material.

5.2. Existing wood policies and strategies

According to the **Climate and Energy Plan 2017-2030**, one of the current main goals of the city is to lower the carbon footprint of all major municipal investment projects by 30% (materials included), an option which makes wood the first construction material choice. The strategy's chapter on the built environment ("bygg og anlegg") also includes a target to develop more climate-friendly projects in Trondheim, including "zero emissions neighbourhoods", which are currently in the early stages of implementation.

The flagship initiative "**TREbyen Trondheim**", initiated by the City Council in 2004, has been an ongoing urban development project facilitating innovative wooden construction projects through municipal investment, initially through regulating a former industrial neighbourhood affected by fire in 2002 to a new urban ecological wood building trial area. The programme's main aim is to realize a wide range of different model projects characterized by high quality, proper use of wood with a focus on the environmental aspect, leveraging on: 1) Innovation (implementation of various new buildings and transformation projects); 2) Repair (repair of historic buildings and urban environments from different eras); and 3) Wood in urban spaces (an arena for art installations, interiors, furniture inside and out).

The model projects must meet specific quality criteria for each group and are provided advisory teams of skilled professionals, as well as access to various support schemes. The quality criteria are reviewed periodically, and if necessary calibrated. The working group assists with requirement mapping, project assessment and applications for grants from relevant actors.

Over 20 projects have been completed to date, such as kindergartens, schools, housing, commercial buildings, student housing and also in the ongoing projects like Moholt 50|50. In 2010, TREbyen Trondheim was included as a sub-project under the municipality's initiative within Cities of the Future.

5.3. Participatory development of new urban projects and policies in Build-in-Wood

As an Early Adopter City, Trondheim has participated together with partners Treteknisk and URBASOFIA in a process of co-design, over the course of three stakeholder workshops (2021-2022) with over 80 participants in total, exploring challenges and priorities, creating the scenarios for the Build-in-Wood digital pilot and the supporting framework to finance urban development and building innovation. Local survey of both governmental, as well as industry and planning stakeholders, revealed the following main challenges:

- An outdated tender and municipal building procurement system, which makes early decision making and wider adoption of multi-storey buildings difficult;
- A lack of focus on the re-use of building materials after end-of-life;
- Wood building logistics : the transportation of solid construction elements from the factory to the building site (panels, beams, columns, which have a specific design that makes it hard to manipulate);
- Resistance to change in the perception of the population and lack of knowledge and experience of developers and constructors;
- Optimisation of connection points between wood components and articulation of wood with existing construction (i.e. "building out", both vertically as well as horizontally, to address densification needs).

The last priority was tackled through the Trondheim digital pilot, developed in "Build-in-Wood" by Waugh Thistleton Architects (London, UK), who designed a model approach to increasing density of existing low-rise concrete buildings in the Vestlia neighbourhood of Trondheim through a wood vertical extension.

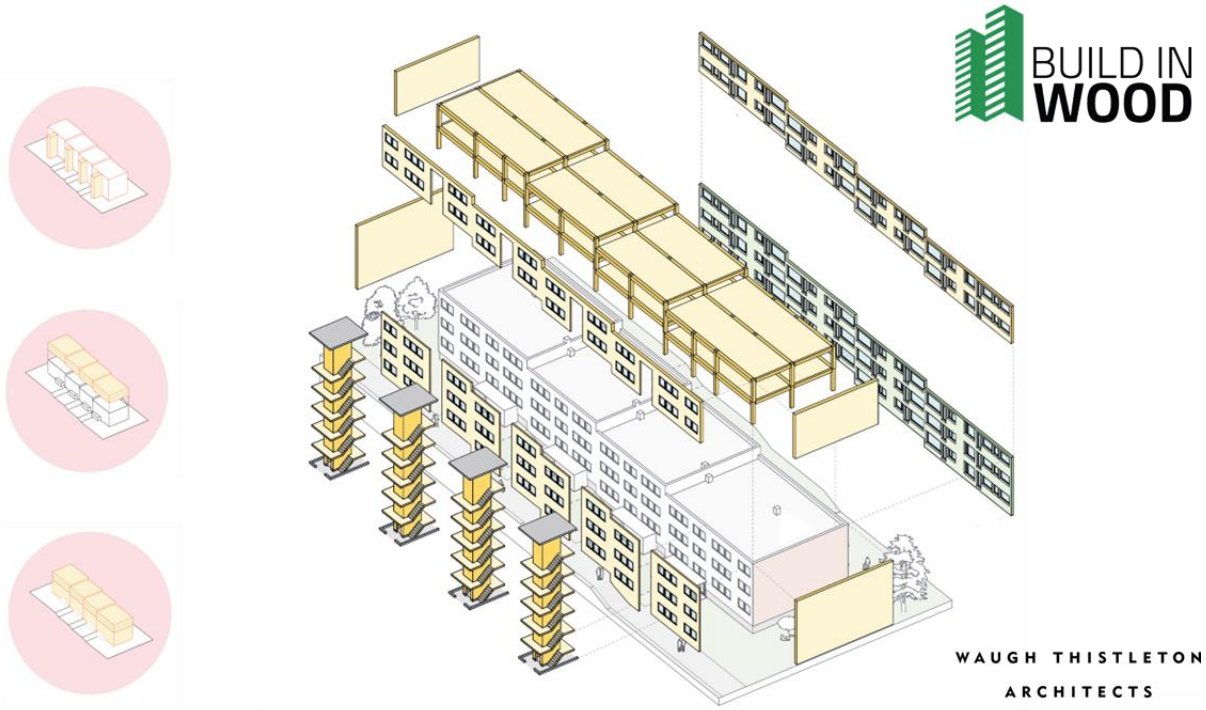

Figure 5. "Build-in-Wood" extension in Trondheim. Source: Waugh Thistleton Architects (2021)

Seven core policy-related challenges (1 - demonstrating measurable effects, 2 - circularity, 3 - ability to change and adapt, 4 - local value chains, 5 - tender process, 6 – vulnerability, and 7 - regulation adaptation to technical solution specificity) have been further explored in the second workshop (30 September 2022).

Working groups have been assigned the challenge of creating project ideas and further refining into pre-projects before submitting them into a local competition sponsored by the municipality and Kystskogbruket, an association of county authorities, governments, forestry and wood industry. After the evaluation process, two pilot projects have been selected to win 150.000 NOK each:

1. **Action menu for tender processes**: Reducing the number of tenders and investigating how higher involvement of local actors can be ensured through good tender processes (working group: Viken County Municipality, Green Advisors, Växjö Municipality, Trondheim Municipality and Ruralis)
2. **New local value chains:** A "living lab" approach focusing initially on the use of local hardwood (birch) resources as well as the reuse of the material and reuse of furniture and wooden interiors (working group Arkitre AS, Snekkeriet Verdal AS, Skjetne Design, Myhr Interiør, Green Advisers AS, Lium Møbelfabrikk, Næringshagen i Orkdalsregionen, Rallar arkitekter, Treteknisk, Ruralis).

The pilot projects delivered progress reports during the third workshop, organized as the first international **"Wood City Festival" in Trondheim** (21-22 June 2022) by the Build-in-Wood project in collaboration with the Trondheim Municipality and a volunteer community in neighbouring town of Orkanger. The scope of the last workshop was to explore next steps and actions for deliberate and increased use of wood in buildings and the built environment, as well as replication opportunities and knowledge transfer to other municipalities.

5. Conclusions and outlook

The "Build-in-Wood" project and the collaboration with Trondheim Municipality are still ongoing until the second part of 2023. Although results are still under development, they are promising – in particular with respect to the impact of local participatory processes leading the critical analysis, exploration and strategy-building for material and construction system substitution with more sustainable options, such as wood. The project experience shows that overcoming stakeholder fragmentation in the construction sector can significantly accelerate uptake of new building systems and technologies with a direct contribution to urban decarbonisation and the Paris Agreement targets.

The Trondheim collaborative approach represents an innovation policy in itself, building on an already-advanced experience in creating regulatory and planning preconditions for multi-storey wood buildings. Through an iterative involvement of stakeholders for the definition of challenges and city priorities, and through the provision of small grants and financial stimuli as an open competition for solutions, it has so far managed to accelerate the definition of evidence-based policies and instruments for the built environment. This lean approach to urban innovation can easily be replicated in other cities as well and will be further explored and monitored as the "Build-in-Wood" project progresses.

6. References

Abergel, T., Dean, B. and Dulac, J. (2018). 'Global Status Report 2017: Towards a Zero-emission, Efficient, and Resilient Buildings and Construction Sector'. UN Environment and International Energy Agency. Available at: https://globalabc.org/sites/default/ files/2020-09/2017%20GlobalABC%20GSR%20.pdf (Accessed: 29.08.2022)

Canada Green Building Council (2021). 'Embodied Carbon: A Primer for Buildings in Canada'. White Paper. Available at: https://www.cagbc.org/wp-content/uploads/2022/03/Embodied-carbon-white-paper-March-2022.pdf (Accessed: 29.08.2022)

Carbon Neutral Cities Alliance (2020). 'City Policy Framework for Dramatically Reducing Embodied Carbon'. Available at: http://carbonneutralcities.org/wp-content/uploads/2021/02/City-Policy-Framework-for-Dramatically-Reducing-Embodied-Carbon.pdf

Dimitriu, S., Rusen, M. and Zagaglioni, G. (2020). 'Socio-economic, planning and regulatory context in Early Adopter cities'. Technical Deliverable D7.3, Build-in-Wood project, GA no. 862820.

European Commission (2021). Proposal for a Directive of the European Parliament and of the Council on the Energy Performance of Buildings (recast). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0802&qid=1641802763889 (Accessed: 29.08.2022)

Hurmekoski, E., Jonsson, R. and Nord, T. (2015).'Context, drivers, and future potential for wood-frame multi-story construction in Europe'. Technological Forecasting and Social Change. 2015, 99, 181–196. DOI: 10.1016/j.techfore.2015.07.002

Maniak-Huesser, M., Tellnes, L.G.F. and Zea Escamilla, E. (2021). 'Mind the Gap: A Policy Gap Analysis of Programmes Promoting Timber Construction in Nordic Countries'. Sustainability 2021, 13, 11876. DOI: 10.3390/su132111876

Papadaki, D., Nikolaou, D.A. and Assimakopoulos, M.N. (2022). 'Circular Environmental Impact of Recycled Building Materials and Residential Renewable Energy'. Sustainability 2022, 14, 4039. DOI: 10.3390/su14074039

Pomponi, F. and Moncaster, A. (2017). 'Circular Economy for the Built Environment: A Research Framework'. J. Clean. Prod. 2017, 143, 710–718. DOI: 10.1016/j.jclepro.2016.12.055

Secretariat of the Advisory Committee on Sustainable Forest-based Industries, Food and Agriculture Organization (2020). 'Status of public policies encouraging wood use in construction – an overview'. Draft Background Paper prepared for the 61st Session of the FAO Advisory Committee on Sustainable Forest-based Industries. Available at: https://www.fao.org/forestry/49801-0cae892398185071321d397e2c1e0d520.pdf (Accessed: 29.08.2022).

Trondheim Kommune (2018). 'Kommunedelplan: energi og klima 2017-2030'. Available at: https://www.trondheim.kommune.no/globalassets/10-bilder-og-filer/10-byutvikling/miljoenheten/klima-og-energi/kommunedelplan-energi-og-klima130618.pdf (Accessed: 29.08.2022)

Trondheim Kommune (2015). 'Å bygge i tre er både tradisjonelt og framtidsrettet'. Available at: https://trondheim2030.no/2015/11/02/a-bygge-i-tre-er-bade-tradisjonelt-og-framtidsrettet/ (Accessed: 29.08.2022)

Wiegand, E. and Ramage, M. (2022). 'The impact of policy instruments on the first generation of Tall Wood Buildings', Building Research & Information, 50:3, 255-275, DOI: 10.1080/09613218.2021.1905501

World Business Council for Sustainable Development (2021). 'Net-zero Buildings: Where Do We Stand?' Geneva. Available at: https://www.wbcsd.org/contentwbc/download/12446/185553/1