Analysing Legal and Policy Frameworks for Integrating Circular Economy Principles in Affordable Housing Development in India

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Research Project Report

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LIST OF ABBREVIATIONS

Abbreviation	Full Form
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
AHP	Affordable Housing in Partnership (vertical under PMAY-U)
ARHCs	Affordable Rental Housing Complexes
BIS	Bureau of Indian Standards
BLC	Beneficiary-Led Construction (vertical under PMAY-U)
BRSR	Business Responsibility and Sustainability Report
C&D	Construction and Demolition
CE	Circular Economy (principles)
CLSS	Credit-Linked Subsidy Scheme (vertical under PMAY-U)
CPHEEO	Central Public Health & Environmental Engineering Organisation
CPWD	Central Public Works Department
CPCB	Central Pollution Control Board
DPR	Detailed Project Report
ECBC	Energy Conservation Building Code
EIA	Environmental Impact Assessment (regulations)
EMI	Equated Monthly Instalment (housing finance context)
ENS	Eco-Niwas Samhita (residential energy code)
EWS	Economically Weaker Sections
FAR	Floor Area Ratio
GHG	Greenhouse Gas
GHTC-India	Global Housing Technology Challenge - India
GRIHA	Green Rating for Integrated Habitat Assessment
IS (e.g., IS 383:2016)	Indian Standard (BIS)
ISSR	In-Situ Slum Redevelopment (vertical under PMAY-U)
LEED	Leadership in Energy and Environmental Design
LIG	Low Income Group
MBBL	Model Building Bye-Laws, 2016
MNREGA/MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Act/Scheme
MoEFCC	Ministry of Environment, Forest and Climate Change (Fly Ash notifications)
MoHUA	Ministry of Housing and Urban Affairs
MoRTH	Ministry of Road Transport and Highways (inter-ministerial reference)
NAPCC	National Action Plan on Climate Change
NBC	National Building Code, 2016
NHB	National Housing Bank (report sponsor)
NITI Aayog (CE-RE)	Circular Economy & Resource Efficiency series (NITI)
NMSH	National Mission for Sustainable Habitat
NUHHP	National Urban Housing & Habitat Policy, 2007
PMAY-G	Pradhan Mantri Awas Yojana – Gramin
PMAY-U	Pradhan Mantri Awas Yojana – Urban
PPP	Public–Private Partnership
RBI	Reserve Bank of India

RERA	Real Estate (Regulation and Development) Act
SBM-U	Swachh Bharat Mission – Urban
SCM	Smart Cities Mission
SEBI	Securities and Exchange Board of India
SPCB	State Pollution Control Board
TIG	Technology Innovation Grant (PMAY-U)
TISM	Technology & Innovation Sub-Mission (PMAY-U)
TSM	Technology Sub-Mission (PMAY-U)
ULB	Urban Local Body
URDPFI	Urban & Regional Development Plans Formulation & Implementation (Guidelines)

EXECUTIVE SUMMARY

This report, *"Analysing Legal and Policy Frameworks for Integrating Circular Economy Principles in Affordable Housing Development in India"*, explores how circular economy (CE) concepts can transform India's affordable housing sector into a more sustainable, resource-efficient system. It maps the legal–policy landscape (missions, model codes, standards), diagnoses implementation gaps, derive lessons from international comparators, and proposes an integrated reform pathway so housing delivered "at scale" is also durable, resource-efficient, and affordable to live in over time.

Across national schemes (PMAY-U/G), building regulations, resource rules (C&D Waste), and finance/governance levers, India already has many enabling provisions—but they sit in silos. The report finds circularity remains largely advisory; material circularity is the weakest link; lifecycle durability and maintenance are under-specified; and procurement/monitoring rarely reward CE performance. The core opportunity is integration: make CE measures measurable, mandatory, and financeable within existing missions and codes.

International practice (Australia, Netherlands, Singapore, North America) shows that clear recycled-content norms, lifecycle costing, long-horizon planning, and joined-up incentives can deliver housing that is environmentally sound, economically prudent, and socially inclusive. These experiences inform India-specific levers and sequencing.

The recommendations chapter operationalises the above findings by recommending revision of PMAY guidelines e to mandate C&D plans and recycled-content thresholds; updation /adoption Model Building Bye-Laws / National Building Code with explicit CE features; integrate housing with urban missions (SCM, AMRUT, SBM-U) for water–waste–energy loops; tie funding and finance to verified green performance; and empower ULBs and regulators to enforce and audit outcomes. The thrust is to connect approvals, procurement, standards, and finance into one accountability chain so savings in utilities, maintenance, and longevity translate into affordability for households.

Chapter 1 - Design of the Research**:** Explains the objectives, scope, and doctrinal methodology for evaluating how circular economy (CE) principles can be embedded into India's affordable housing framework. Chapter 2 - Mapping India's Legal & Policy Architecture**:** Reviews key policies, laws, and codes and highlights how they partially address circularity while leaving significant gaps .Chapter 3 - Alignment with CE Principles: **A**nalyses current schemes and regulations against five CE dimensions—resource efficiency, material circularity, lifecycle integration, local synergy, and community embeddedness—revealing that most provisions remain advisory and under-enforced .Chapter 4 - Systemic Gaps & Institutional Limits: Diagnoses the operational and governance reasons circularity intentions do not translate into outcomes, such as fragmented mandates, weak enforcement, and limited technical capacity. Chapter 5 - Comparative Analysis (Australia, Netherlands, Singapore, North America): Explores how international jurisdictions integrate CE principles in affordable housing through clear regulations, lifecycle planning, and incentives, offering lessons for India. Chapter 6 - Policy-Embedded Levers & Pathways: Proposes practical levers within existing schemes, standards, and financial frameworks to make circularity measurable, mandatory, and financeable. Chapter 7 - Mapping Barriers: Identifies persistent barriers - structural, financial, spatial, market, institutional, and socio-cultural - and suggests how to target interventions to bridge the policy-practice gap. Chapter 8 - Conclusion & Recommendations**:** Summarizes findings and presents a reform roadmap for embedding CE in affordable housing delivery, emphasizing integration, accountability, and lifecycle resilience

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CHAPTER 1: Design of the Research

1.1. Introduction

Affordable housing development in India is an imperative socio-economic necessity, catalysed by the rapid urbanization and growth in population with an imperative for inclusive housing solutions. However, the traditional approaches to housing development are based on linear economic models characterized by "take, make, dispose" cycles. This approach not only depletes natural resources but also exacerbates environmental challenges such as waste generation and carbon emissions[1]. The concept of circular economy in the built environment has gained significant attention globally, with various studies advocating its integration into housing sectors[2]. Circularity in affordable housing not only addresses resource depletion but also promotes social and economic benefits by ensuring the long-term sustainability of housing projects[3]. In India, policies like the National Mission on Sustainable Habitat, 2010 and the Smart Cities Mission, 2015 emphasize the need for sustainable construction practices. The integration of circular economy principles into affordable housing development will unlock a transformative space to address two of India's dual challenges pertaining to housing scarcity and environmental sustainability. The tenets of the circular economy approach emphasize resource efficiency, waste reduction, and the regenerative capacities of such production systems. Still, its applications in affordable housing require a supportive legal and policy framework. This study critically reviews the existing legal and policy frameworks governing affordable housing and environmental sustainability in India. It aims at identifying regulatory gaps, evaluating global best practices, and proposing actionable recommendations for embedding CE principles into India's housing policies. The doctrinal research method will be adopted, where primary sources include statutes, policies, and judicial decisions and secondary sources such as academic literature and reports of international organizations. Through aligning these principles with affordable housing initiatives such as the Pradhan Mantri Awas Yojana and the Smart Cities Mission, this research aims to contribute to the achievement of inclusive growth and sustainable urban futures.

1.2. Research objectives

1: To examine existing legal and policy frameworks related to affordable housing development in India from the perspective of circular economy principles.

Methodology:

- Conduct a comprehensive review of Indian policies, acts, and regulations governing affordable housing, including Pradhan Mantri Awas Yojana, the National Urban Housing and Habitat Policy, and State Housing Policies.
- Assess these policies against core circular economy principles such as resource efficiency, waste management, and life cycle thinking.
- Identify areas where existing frameworks fall short in integrating circular economy principles.

[1] See Keena, N. and Friedman, A., 2024. *Sustainable Housing in a Circular Economy*. Taylor & Francis.
[2]Geissdoerfer, M., Savaget, P., Bocken, N.M. and Hultink, E.J., 2017. The Circular Economy–A new sustainability paradigm?. Journal of cleaner production, 143, pp.757-768.
[3] See, Marchesi, M., Tweed, C. and Gerber, D., 2020, November. Applying circular economy principles to urban housing. In *IOP Conference Series: Earth and Environmental Science* (Vol. 588, No. 5, p. 052065). IOP Publishing.

2: To undertake comparative analysis of best practices in affordable housing development in the perspective of circular economy principles from international jurisdictions.

Methodology:

- Identify and select international jurisdictions with exemplary circular economy integration in affordable housing, such as the Netherlands, North America, Australia and Singapore.

The choice of Australia, North America, the Netherlands, and Singapore is informed by their documented policy frameworks, regulatory instruments, financial models, and implementation strategies that collectively position them as leaders in operationalising circularity within the housing sector. The inclusion of these jurisdictions is further guided by their demonstrable success in integrating CE principles at both policy and operational levels, their availability of robust, verifiable data, and their relevance to the Indian context. Collectively, they represent a spectrum of governance models - from federal to centralised - offering rich comparative insights. This diversity allows the research to distil adaptable strategies for embedding circularity in India's affordable housing ecosystem, ensuring that recommendations are both globally informed and locally grounded.

3: To identify opportunities and challenges in integrating Circular Economy principles into affordable housing development policies.

Methodology:

- Review relevant policies and theoretical frameworks to identify potential opportunities for circular economy integration, such as leveraging existing sustainability mandates or urban renewal schemes.

4: To propose actionable recommendations for enhancing legal and policy support for Circular Economy integration in affordable housing.

1.3. Relevance of the research:

This research addresses a critical gap in the intersection of sustainability and affordable housing policy in India. By integrating CE principles into housing development, the study aims to:

- Enhance resource efficiency and reduce construction waste.
- Promote long-term environmental sustainability in urban planning.
- Provide cost-effective and resilient housing solutions for low-income communities

CHAPTER 2: Aligning "Housing for All" with Circularity: Mapping India's Legal–Policy Architecture for Affordable, Sustainable Housing

2.1. Introduction

Affordable housing holds a crucial place in India's development agenda. With rapid urbanization and population growth, the country faces a massive housing shortage, especially for low-income groups. An official technical assessment estimated an urban housing deficit of 18.78 million units in 2012, over 95% of which was in the Economically Weaker Sections (EWS) and Low-Income Group (LIG) categories. By 2018, the urban housing shortage was projected to have risen to roughly 29 million units, indicating the enduring scale of the problem. Millions of urban residents live in slums or in inadequate conditions[4], lacking secure and decent homes. Ensuring access to affordable housing is a basic human need and essential for inclusive growth and social stability. Adequate housing contributes to better health, education, and economic outcomes for families[5], reinforcing broader development goals. Recognizing this, the Government of India launched initiatives like the "*Housing for All*"[6] mission (notably Pradhan Mantri Awas Yojana – Urban, PMAY-U, in 2015) to address the gap, aiming to provide millions of affordable homes to EWS and LIG households by 2022. PMAY-U set a target of constructing about 1.12 crore (11.2 million) new urban housing units within seven years and rolled out multiple support verticals to reach this goal. The importance of affordable housing thus goes beyond shelter – it is about building inclusive, liveable cities and improving quality of life for the urban poor.

Parallel to the focus on "housing for all," there is a growing recognition of the need for sustainability in the housing sector. Traditional approaches to construction and housing development have followed a linear "take-make-dispose" model that consumes large quantities of raw materials and generates significant waste[7]. The building and construction industry is one of the world's largest users of natural resources and energy, and it produces a substantial share of solid waste and greenhouse gas (GHG) emissions[8]. Globally, buildings account for roughly 40% of raw material consumption and 30–40% of all waste and GHG emissions across their life cycle. This linear model is increasingly unsustainable in India, where construction is booming to meet housing demand. Introducing circular economy (CE) principles into housing can help break this pattern. A circular economy approach emphasizes reducing resource

[4] Technical Group on Urban Housing Shortage (2012–17). (2012). Report of the Technical Group on Urban Housing Shortage (TG-12). Ministry of Housing & Urban Poverty Alleviation, Government of India. https://mohua.gov.in/

[5] World Health Organization. (2018). Housing and health guidelines. WHO. https://www.who.int/publications/i/item/9789241550376

[6] Ministry of Housing & Urban Affairs. (n.d.). PMAY-Urban: About the Mission (extension to 31-12-2025). Government of India. https://pmay-urban.gov.in/about

[7] Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy. Resources, Conservation & Recycling, 127, 221–232. Elsevier. https://doi.org/10.1016/j.resconrec.2017.09.005

[8] Global Alliance for Buildings and Construction / UNEP. (2023). Global Status Report for Buildings and Construction 2023. https://globalabc.org/resources/publications

consumption, reusing materials, and recycling waste[9], thereby minimizing environmental impact. In the context of affordable housing, adopting CE principles means homes can be built and maintained using materials more efficiently, generate less construction and demolition waste, and lower the overall carbon footprint of development. Embracing a circular approach is not just an environmental imperative; it can also lower construction costs over time, reduce dependency on scarce virgin materials, and create new economic opportunities[10] (such as jobs in recycling industries and in producing innovative building materials). Thus, there is a clear need to infuse circular economy thinking into India's housing sector so that the push for affordable homes aligns with long-term sustainability.

This chapter introduces the conceptual and regulatory foundations of integrating circular economy principles into India's affordable housing sector. The discussion progresses to the key laws, policies, and guidelines shaping India's affordable housing landscape. It then unpacks the core principles of the circular economy, emphasizing how concepts like resource efficiency, reuse, modularity, and regenerative design are directly relevant to the built environment. By mapping this policy ecosystem, the chapter establishes the groundwork for subsequent analysis of how circularity metrics can be mainstreamed across housing lifecycles with a view to align the "*Housing for All*" agenda with a regenerative, resource-conscious future.

2.2. Conceptual framework

2.2.1. Affordable housing in the Indian policy and law context

In India, "affordable housing" generally refers to housing within the financial means of lower- or middle-income households, particularly the EWS and LIG segments. Government policies and schemes define these categories by income thresholds and housing unit size. For example, EWS households are commonly defined as those with annual incomes up to around ₹3 lakh, and LIG up to around ₹6 lakh, with corresponding guidelines on the maximum size of the housing unit (such as 30 or 60 square meters)[11] to qualify under schemes. These definitions ensure that programs target the intended beneficiaries. Affordable housing can include a range of solutions: ownership housing provided at subsidized rates, rental housing, or upgraded slum dwellings through in-situ redevelopment.

In terms of the legal and institutional framework, housing is a subject that involves multiple levels of governance. Through the Ministry of Housing and Urban Affairs (MoHUA), the central government sets national policies and flagship missions (like Pradhan Mantri Awas Yojana mentioned above) and provides financial support. State governments have their own housing agencies and policies (such as state housing boards or development authorities) responsible for implementing projects and regulating housing development within their jurisdiction. Urban local bodies (*city municipal corporations and urban development*

[9] Ellen MacArthur Foundation. (n.d.). What is a circular economy? https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview
[10] World Economic Forum. (2021). Circular economy in the built environment: Opportunities for resilient cities. WEF. https://www.weforum.org/whitepapers/
[11] Ministry of Housing & Urban Affairs. (2024). PMAY-U 2.0: Housing for All — Operational Guidelines (income & carpet-area limits). Government of India. https://pmay-urban.gov.in/uploads/guidelines/Operational-Guidelines-of-PMAY-U-2.pdf

authorities) play a critical role[12] in land-use planning, granting building permissions, and providing local infrastructure and services for housing projects. Thus, the affordable housing framework in India is a patchwork of central schemes, state-level policies, and local regulations, all aimed at increasing the housing supply that low-income households can afford.

The socio-economic objectives behind India's affordable housing efforts are fundamentally about inclusion and equity. Affordable housing policies are designed to ensure that urban growth and economic development benefits extend to the poorer segments of society. By enabling low-income families to access formal housing, the government seeks to curb the proliferation of slums and informal settlements and to improve living conditions for millions of citizens. These programs often include provisions for social inclusion[13], such as reserving housing units for marginalized groups (*e.g., scheduled castes, scheduled tribes, or other disadvantaged communities*) and for vulnerable populations like women or persons with disabilities. The broader goals of affordable housing initiatives include providing shelter and enhancing quality of life through access to basic services like clean water, sanitation, and electricity that formal housing can facilitate. Moreover, affordable housing is seen as a driver of economic empowerment: secure housing can improve children's health outcomes and educational attainment, and support adult livelihood opportunities. It also generates employment through construction and allied industries and can stimulate the local economy. In policy discourse, affordable housing is closely linked with "*inclusive cities*" – cities where all residents, regardless of income, have a place and a voice. Overall, the Indian legal and policy context treats affordable housing as a key strategy for social development, poverty alleviation, and urban inclusivity, embedding it within various schemes and laws that aim to make housing accessible to those who need it most.

2.2.2. Circular economy principles and their relevance to the built environment

The circular economy is an economic model that contrasts the traditional linear model of "take, make, dispose." At its core, a circular economy seeks to eliminate waste and keep resources in use for as long as possible. Several key principles define a circular economy: First, it emphasizes resource efficiency, meaning reducing virgin raw materials through more innovative design, improved processes, and substituting renewable or abundant resources for finite ones. Second, it prioritizes reuse and recycling, ensuring that products and materials are kept in circulation rather than thrown away – for instance, repurposing materials at the end of a product's life into new products, or finding secondary uses for what would otherwise be waste. Third, CE principles include design for longevity, reparability, and modularity[14], which means creating products (or buildings) that last longer, can be easily maintained and repaired, and can eventually be disassembled to recover and recycle their components. Another principle is the idea of regenerating natural systems, which involves returning valuable nutrients to the environment and using processes that have a net positive impact (for example, composting organic waste to improve soils, or using nature-based solutions to manage water and waste). In summary, the CE approach aims to create a closed-loop system of production and consumption:

[12] Ministry of Housing & Urban Affairs. (n.d.). *Institutional framework of PMAY-U.* Government of India. https://pmayuclap.gov.in/content/html/pmay-u.html
[13] Ministry of Housing & Urban Affairs. (2024). PMAY-U 2.0 Operational Guidelines (beneficiary prioritization for SC/ST, women, PwD) https://pmay-urban.gov.in/uploads/guidelines/Operational-Guidelines-of-PMAY-U-2.pdf
[14] Ellen MacArthur Foundation. (2013). Towards the Circular Economy, Vol. 1. EMF. https://ellenmacarthurfoundation.org/

extracting maximum value from resources, minimizing waste and pollution, and ultimately reducing the strain on the environment.

These principles have gained global prominence as a pathway to sustainability, especially in resource-intensive sectors. Applying circular economy principles to the built environment – particularly housing – means rethinking how we design, construct, use, and dispose of buildings. The construction sector traditionally consumes vast quantities of materials like cement, steel, bricks, and timber, and generates significant waste (*notably construction and demolition debris*)[15]. The housing sector can drastically reduce its environmental footprint by adopting a circular approach. In practice, this could involve using sustainable or recycled building materials (for example, incorporating industrial by-products such as fly ash into bricks and cement, using recycled steel or wood alternatives, and reusing aggregates from demolished structures in new construction)[16]. It also means designing houses for durability and adaptability – homes that can be easily maintained, upgraded, or modified over time rather than prematurely demolished. Construction techniques like modular prefabrication[17], for instance, allow components to be standardized and later reused or replaced with minimal waste. Another aspect of circularity in housing is efficient resource use during the building's occupancy life: implementing systems for water conservation and recycling (like rainwater harvesting and greywater reuse) and for energy efficiency (such as *better insulation, passive cooling design, and solar panels*)[18] aligns with the principle of using resources wisely and reducing ongoing consumption. Moreover, at the end of a building's life, a circular perspective would encourage salvaging and repurposing as much as possible – reusing elements like doors, windows, and fixtures, and recycling materials like metal, glass, and concrete – rather than sending them to landfills. These practices not only reduce waste and save raw materials, but can also lower costs in the long run and create new markets and jobs (for example, in the recycling of construction materials, development of eco-products, or services for retrofitting buildings[19]).

In the context of urban housing development – exceptionally affordable housing – integrating circular economy principles ensures that the urgent push to build more homes does not come at the expense of environmental sustainability. Instead, it offers a pathway to create housing stock accessible to low-income populations and aligned with India's goals for sustainable, resilient cities. A circular economy lens on housing emphasizes that growth in housing supply and improvement in living conditions can be achieved while conserving resources, reducing waste, and innovating for a greener economy.

2.3. Law and policy frameworks governing affordable housing in India

Real Estate (Regulation and Development) Act, 2016 (RERA): The Real Estate (Regulation and Development) Act, 2016 – commonly known as RERA – marked a watershed in India's

[15] GlobalABC/UNEP. (2023). Global Status Report for Buildings and Construction 2023.
[16] MoEFCC. (2016, amended 2021). Fly Ash Utilisation Notifications (mandates use within a specified distance from coal TPPs). Gazette of India. https://moefcc.gov.in/
[17] MoHUA. (2019). Global Housing Technology Challenge (GHTC-India): Emerging technologies & Lighthouse Projects. https://ghtc-india.gov.in/
[18] Ministry of Urban Development/TCPO. (2016). Model Building Bye-Laws 2016 (Ch. 9 & Ch. 10: RWH, wastewater reuse; rooftop solar norms) https://mohua.gov.in/upload/uploadfiles/files/MBBL.pdf; BEE. (2017). ECBC 2017. https://beeindia.gov.in/
[19] World Economic Forum. (2021). Circular economy in the built environment (design for disassembly/adaptability).

housing sector by introducing a robust regulatory framework aimed at transparency, accountability, and financial discipline in real estate projects. Enacted in 2016, RERA requires the registration of housing projects (above a specific size) with a state Real Estate Regulatory Authority and mandates full disclosure of project details (including land title status, approvals, timelines, etc.) before any sale. Notably, the Act compels compliance with sanctioned plans and prevailing laws and establishes grievance redressal mechanisms for homebuyers through the Authority and specialized tribunals. One key provision is the escrow rule[20] – Developers must deposit 70% of project funds received from buyers into a dedicated escrow account and use those funds only for that project's construction and land costs. This prevents the common abuse of diverting money from one project to another, a practice that led to delays, stalled projects, and resource wastage in the past. By enforcing financial discipline and project timeline accountability, RERA has improved governance in the housing sector and reduced instances of half-built buildings languishing due to cashflow problems. The Act also prescribes defect liability on developers for five years, meaning they must repair structural or service issues that arise in a new building, incentivizing better build quality.

While RERA's primary intent is consumer protection and market orderliness, it indirectly benefits sustainability. By compelling timely completion of projects, RERA helps avoid prolonged construction periods that can lead to material deterioration and wastage on site. Mandating adherence to approved plans and building standards reinforces compliance with safety and environmental norms (e.g., requirements for fire safety, structural soundness, and possibly energy/water provisions specified in local building codes). Section 32 of the Act explicitly mentions that the regulatory authorities should encourage environmentally sustainable and affordable housing, and promote the use of appropriate construction materials, systems, and technologies. This indicates that RERA recognizes sustainability as part of its mandate, although it stops short of imposing specific green building requirements. Implementation of RERA varies across states, and some state-level authorities have begun to link RERA compliance with quality and sustainability initiatives. For example, the Andhra Pradesh RERA has taken initiatives under Section 32 to improve construction quality and promote better building materials, even setting up an engineering unit to vet material quality and encouraging builders to use higher-grade, warranty-backed materials[13]. Such measures support circular economy ideals (like longevity and standards in construction) by ensuring buildings are made to last and discouraging the use of subpar materials needing early replacement.

In summary, RERA is a foundational instrument for a well-regulated housing market. Its contribution to circularity is mostly indirect – through improved governance, reduced irresponsible practices, and mention of sustainability in its advisory scope. With targeted policies and incentives layered onto RERA (for instance, making certain green practices a condition of registration or fast-track approval), this legal framework could significantly accelerate the mainstreaming of circular economy principles in affordable housing.

Pradhan Mantri Awas Yojana – Urban (PMAY-U): Pradhan Mantri Awas Yojana (PMAY), launched in 2015, is the flagship national mission to achieve "Housing for All." Focused on urban areas (there is a parallel PMAY-Gramin for rural housing), PMAY-U aims to provide affordable housing to the urban poor by constructing millions of new housing units and upgrading existing informal housing by 2022. PMAY-U operates through several verticals: *In-Situ Slum Redevelopment (ISSR)*, which rehabilitates slum dwellers into formal housing on the same land (often via public-private partnerships where developers get incentives to build new flats for slum residents in exchange for development rights); *Affordable Housing in*

[20] *Real Estate (Regulation and Development) Act, 2016*, Section 2(l)(D)

Partnership (AHP), which provides financial grants to public or private developers to include EWS/LIG units in their projects; *Credit-Linked Subsidy Scheme[21] (CLSS)*, which offers interest subsidies on housing loans for EWS, LIG, and also middle-income households to enable them to buy or build homes; and *Beneficiary-Led Construction (BLC)*, which supports individual EWS families to build or enhance their own house on their own land through a direct subsidy. Under PMAY-U, the central government provides funding assistance (grants or subsidies) to states, urban local bodies, or beneficiaries, while state-level housing agencies and city authorities carry out implementation.

This mission also launched a **Technology Sub-Mission** to encourage modern construction technology for faster and cost-effective building of mass housing[22]. For example, through initiatives like the Global Housing Technology Challenge, PMAY-U promoted the adoption of alternative building techniques (such as precast concrete construction, monolithic construction, or other innovative methods) that can speed up delivery and improve quality. While PMAY's primary focus is quantitative – reducing the housing shortage in a time-bound manner – it has some implicit sustainability angles. Modern construction technologies can improve resource efficiency (many new methods generate less waste on site and allow for more precise use of materials). PMAY-U guidelines also emphasize quality and durability; houses constructed should have basic services and a design life as per standards, so that they provide long-term shelter. By the end of its initial target year 2022, the mission had sanctioned about 1.1 crore houses in urban areas, although fewer (around 50-60 lakh) had been fully built and occupied by that time, reflecting implementation challenges[15]. (The program has since been extended beyond 2022 to meet the unmet demand.) PMAY-U has become the cornerstone of India's affordable housing policy, creating an overarching framework that also dovetails with other government programs – for instance, cities are encouraged to coordinate PMAY housing projects with infrastructure schemes like the Smart Cities Mission and with sanitation and water supply programs[23] to ensure new housing has holistic amenities. However, in terms of circular economy principles, PMAY-U does not mandate green design or construction waste recycling, beyond what local building codes require. The large-scale construction under PMAY makes it a crucial arena for integrating sustainability – any improvements in materials or design standards here could significantly impact it. In later sections, we will analyze to what extent PMAY-U projects have embraced (or could embrace) circular practices such as using recycled content, incorporating solar energy or rainwater systems, or planning for future maintenance. Parallelly,

Pradhan Mantri Awas Yojana – Gramin (PMAY-G)[24]This flagship policy, launched in April 2016 under the Ministry of Rural Development, embodies India's commitment to "Housing for All" by providing pucca houses with a minimum carpet area of 25 square meters, featuring a hygienic cooking space, to rural families residing in kutcha or dilapidated shelters. The Pradhan Mantri Awaas Yojana – Gramin (PMAY-G), launched in 2016 as part of the Government of India's vision of "Housing for All", is more than just a rural housing scheme; it represents a transformative approach to rural development and dignity. At its core, PMAY-G seeks to provide every eligible rural household with a pucca home with basic amenities such as a hygienic cooking space, sanitation facilities, electricity, and clean water. What distinguishes the programme is its beneficiary-driven design. Instead of a centrally imposed model, households are empowered to plan and construct their homes, often using locally

[21] Credit-Linked Subsidy Scheme (CLSS) Guidelines. (2016, as amended). MoHUA. https://pmaymis.gov.in/
[22] MoHUA. (2019). GHTC-India: Technology Sub-Mission & Lighthouse Projects. https://ghtc-india.gov.in/
[23] MoHUA. (2021). AMRUT 2.0 Guidelines. Government of India. https://mohua.gov.in/
[24] Government of India. (2021). Framework for Implementation of Pradhan Mantri Awaas Yojana-Gramin (PMAY-G). Ministry of Rural Development, https://pmayg.dord.gov.in/netiayHome/Uploaded/Guidelines-English_Book_Final.pdf

available materials and labour supported by the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), fostering economic participation and territorial circularity.

Another defining feature is its integrated convergence framework, where housing delivery is paired with complementary welfare schemes like the Swachh Bharat Mission for toilets, Ujjwala Yojana for clean cooking fuel, and Saubhagya for electricity connections. This approach ensures the house becomes a foundation for holistic well-being, not just a physical structure. Moreover, the scheme promotes gender equity by mandating ownership—solely or jointly—in the name of women, enhancing their social and economic agency. Together, these design and delivery features make PMAY-G a rich, living case for how rural housing policy can serve as an entry point to circular economy strategies.

National Urban Housing and Habitat Policy (NUHHP), 2007: The National Urban Housing and Habitat Policy of 2007 is a comprehensive policy framework that guides housing development in India's cities. NUHHP 2007 was formulated to promote *"sustainable development of habitat"* with a focus on ensuring affordable housing for all. It was a successor to earlier national housing policies (from 1988 to 1994) and notably expanded the concept of *"habitat"* – recognizing that housing policy must integrate with basic services and livelihood opportunities provisions. Key features of NUHHP 2007 include an emphasis on the government's role as a facilitator rather than merely a provider of housing, and a strong encouragement of Public-Private Partnerships (PPPs)[25] to mobilize private sector investment in affordable housing[16]. The policy advocated various incentives to stimulate the supply of EWS/LIG housing: for instance, making more land available through relaxed zoning or land-use norms, offering higher Floor Area Ratio (FAR) or density allowances for projects that include affordable units, simplifying approval processes for affordable housing projects, and fiscal incentives like tax and fee concessions for such projects. NUHHP also underscored the promotion of rental housing (*acknowledging that homeownership is not feasible or desirable for all*), including mechanisms like rental vouchers or encouraging institutional rental housing operators.

NUHHP 2007 recognized the need to *"promote sustainable construction and affordable technologies."* It called for the use of cost-effective, eco-friendly building materials and techniques, urging research and development in alternative building materials (such as fly-ash bricks, precast components, and materials using industrial/agricultural waste) and broader dissemination of proven innovations from organizations like the Building Materials and Technology Promotion Council (BMTPC). The policy highlighted that building designs should incorporate energy-efficient and environmentally benign features[26] (for example, optimal use of natural light and ventilation, rainwater harvesting, and so on). On the legal side, NUHHP 2007 recommended reforms to outdated laws that hampered housing supply – such as rent control acts (to make renting viable for landlords and attractive for tenants) and land tenure/legal title issues – and it stressed *reservations of land for EWS/LIG housing* in all new developments (suggesting that *10–15% of land in every new public or private housing project or 20–25% of FAR be earmarked for EWS/LIG housing to ensure inclusivity*[17]). The policy also promoted balanced regional development to reduce pressure on big cities, and the use of microfinance and other financing innovations to expand credit to low-income homebuyers.

Although NUHHP 2007 is not a law, it has significantly influenced central and state housing initiatives. Many elements of subsequent schemes like PMAY-U (2015) or the Rajiv Awas

[25] Ministry of Housing & Urban Poverty Alleviation (2007) National Urban Housing & Habitat Policy 2007 Government of India. https://mohua.gov.in/

[26] Bureau of Energy Efficiency. (2017). Energy Conservation Building Code (ECBC) 2017 https://beeindia.gov.in/

Yojana (2013) drew from this policy's recommendations (e.g., the emphasis on PPP, slum redevelopment, and service-rich housing). For circular economy considerations, NUHHP's importance lies in the fact that it explicitly links habitat development with sustainability and encourages the mainstreaming of green building practices at a policy level. It created an early impetus (in 2007) for thinking about how to increase housing stock in environmentally sustainable and resource-conscious ways, setting the stage for later missions and building code revisions that incorporated these concerns.

National Mission for Sustainable Habitat (NMSH): The National Mission for Sustainable Habitat was introduced in 2010 as one of the eight missions under India's National Action Plan on Climate Change (NAPCC)[27]. While not a housing program per se, the NMSH provides a policy umbrella for promoting sustainability in urban development, including housing. It covers broad areas such as energy efficiency in buildings, sustainable urban transport, and solid waste management[28]. Within the housing sphere, NMSH has been influential in pushing for greener construction and operation of buildings. A notable outcome of NMSH was the promotion and adoption of the Energy Conservation Building Code (ECBC) for new commercial buildings, and its residential variant, the Eco-Niwas Samhita, which set minimum energy performance standards[29] for building design (insulation, glazing, lighting, etc.). Cities and states, under NMSH guidance, were encouraged to modify local building bylaws to incorporate these energy efficiency provisions. The mission also stressed better management of municipal solid waste and specifically construction and demolition (C&D) waste, recognizing that urban construction activity contributes large volumes of debris that typically end up in landfills or illegal dumps[30]. It advocated measures like setting up C&D waste recycling facilities and using recycled materials in construction[31]. Furthermore, NMSH underscored the importance of public transport-oriented urban planning for housing, which means locating affordable housing so that residents can access public transit and do not rely solely on personal vehicles, thereby reducing emissions.

Though NMSH did not build houses, it shaped the regulatory environment in which houses are built. For example, following NMSH, many cities made it compulsory for large buildings to include rainwater harvesting systems, solar water heaters, and segregated waste storage space, through changes in bye-laws[18]. The mission also influenced the creation of new national regulations like the C&D Waste Management Rules, 2016, which mandate that cities above a specific size set up facilities to process and recycle construction waste and that large generators of such waste (including housing developers) dispose of it properly. NMSH complements housing policies by infusing environmental objectives into urban development. Affordable housing projects funded by central schemes are now often expected (or required) to incorporate some green features. For instance, housing built under PMAY-U in many cities includes LED lighting, solar-powered lights in common areas, or provisions for rainwater harvesting, which are in line with sustainable habitat guidelines. However, NMSH's principles for integrating into affordable housing are still evolving and can vary widely by city. Overall, the National Mission for Sustainable Habitat established a strategic direction for making housing and habitat development more climate-friendly and resource-efficient, aligning India's shelter goals with its climate change commitments.

[27] MoHUA. (n.d.). National Mission on Sustainable Habitat (overview). https://mohua.gov.in/
[28] Ministry of Environment, Forest & Climate Change (2016) Construction & Demolition Waste Management Rules, 2016. Gazette of India. https://moefcc.gov.in/
[29] Eco-Niwas Samhita (ENS) 2018 — Residential energy code (BEE). https://www.beepindia.org/eco-niwas-samhita
[30] MoEFCC. (2016). C&D Waste Management Rules, 2016. Gazette of India
[31] MoEFCC. (2016). C&D Waste Management Rules, 2016 (schedules on processing/recycled products). Gazette of India. https://moefcc.gov.in/

Model Building Bye-Laws, 2016: The Model Building Bye-Laws (MBBL) 2016, published by the Ministry of Urban Development (now MoHUA), serve as a template for state governments and urban local bodies to frame or update their building regulations. These model bye-laws incorporated various modern provisions to ensure safety, efficiency, and sustainability in building construction and use. Several clauses in the 2016 MBBL are particularly relevant to promoting circular economy principles and sustainability in housing. For example, the bye-laws mandate that all buildings above a specific plot size or number of dwelling units must include rainwater harvesting structures and provisions for wastewater recycling[19]. They also require significant developments (such as group housing colonies) to allocate space for waste segregation at source and, in some cases, to provide on-site composting for biodegradable waste – measures that encourage recycling and reduce the burden on municipal waste systems. Additionally, the 2016 guidelines introduced requirements or incentives for the use of renewable energy: for instance, they stipulate installation of solar water heating systems in specific categories of new buildings (like *multifamily residential buildings above a size threshold, hospitals, hotels, etc*.), and encourage rooftop solar photovoltaic panels by streamlining permissions.

Regarding construction materials and methods, the Model Bye-Laws promote using environmentally friendly materials and innovative techniques. There are references to utilizing fly-ash-based bricks or blocks (*which recycle coal power plant waste*) in construction, using wood alternatives (*to reduce timber use*), and adopting new technologies that minimize resource use (such as *prefab systems*). To support inclusive housing, the bye-laws suggest planning norms like allowing higher FAR or other development incentives if developers include EWS/LIG housing units within larger projects – this ties social sustainability objectives with regulatory incentives. The 2016 MBBL also took into account the "*Ease of Doing Business*" initiative, introducing single-window clearance systems and digitization of approval processes, which, while primarily administrative, can indirectly benefit sustainability by reducing construction delays (and thus reducing time-based resource wastage) and by making it easier to enforce compliance (*through standardized processes*).

Though the Model Bye-Laws are advisory and each state/city adapts them to local context, they have been quite influential. Many states updated their building regulations in line with the 2016 model, raising the baseline for green building practices across India. For affordable housing projects, especially those undertaken by public agencies or under schemes like PMAY-U, compliance with the latest building bye-laws means that features like rainwater harvesting, energy-efficient lighting, etc., are increasingly becoming standard. The model regulations also implicitly encourage circular practices such as water reuse (*through greywater systems*), use of local materials, and designing for natural ventilation/light to reduce energy use. In summary, the Model Building Bye-Laws 2016 integrate sustainability considerations into the legal framework of construction. They support a more circular approach in the housing sector by setting norms that reduce resource consumption and waste generation at the building level, and by encouraging integrated planning for services (*water, waste, energy*) within housing developments. Other national-level instruments, such as the Smart Cities Mission, AMRUT (*urban renewal scheme*), and various state housing policies, also intersect with the affordable housing and sustainability agenda. However, the abovementioned ones are among the most significant ones in our analysis.

2.4. Conclusion

India's affordable housing drive has rightly centered inclusion, expanding formal shelter for EWS and LIG households through instruments like PMAY-U, PMAY-G, and RERA, under a wider policy scaffold provided by NUHHP, NMSH, and the Model Building Bye-Laws.

Together, these measures have improved governance, accelerated delivery, and mainstreamed baseline sustainability features (rainwater harvesting, energy-efficiency norms, on-site segregation) into the regulatory fabric. To align "Housing for All" with a regenerative urban future, the legal–policy architecture needs a clearer through-line that embeds circular economy principles across the housing life-cycle—planning, design, procurement, construction, occupancy, and deconstruction. The following chapters operationalise this shift: first by clarifying concepts and metrics for circularity in housing; then by assessing how current national and state instruments perform within the identified metrics.

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CHAPTER 3: Alignment of India's Affordable Housing Policies with Circular Economy Principles

3.1. Introduction

This chapter assesses the formal alignment of India's affordable housing instruments with circular economy principles across four dimensions - Resource efficiency, Material circularity, Structural longevity and life-cycle thinking, Local resource synergy, and Community embeddedness. The unit of analysis spans core policies and delivery schemes (PMAY-Urban and PMAY-Gramin), model codes and rules (Model Building Bye-Laws, Construction & Demolition Waste Management Rules), performance standards (Eco-Niwas Samhita), technical manuals (CPHEEO), and overarching policy statements such as the National Urban Housing & Habitat Policy. Evidence is drawn directly from primary texts, specific clauses, guidelines, eligibility criteria, technical annexures, appraisal and compliance checklists, and design standards to determine CE-relevant provisions' presence, precision, and enforceability.

The idea of circularity in housing especially when tied to the demand for affordability has often remained a peripheral imagination in Indian policy spaces. It is not that the language is absent; terms like *"eco-friendly materials," "low-carbon construction,"* and *"green buildings*" increasingly surface in flagship programs like the Pradhan Mantri Awas Yojana (PMAY). However, what becomes painfully clear upon reading through the compiled set of landscape studies, technical research, and evaluative reports is that this invocation of sustainability remains largely rhetorical unless backed by an institutional readiness to embrace material reuse, spatial flexibility, and life-cycle thinking.

In India, where the need for rapid urban housing coincides with deep environmental constraints and chronic cost pressures, circularity should have been a natural partner of affordability. The CE idea in affordable housing has matured far beyond its material-science origins. It now touches deep ethical, spatial, and institutional questions about sustainability, affordability, justice, and state responsibility. While the rhetoric of CE - reuse, recycling, material innovation - has been enthusiastically embraced in high-level dialogues, the on-ground integration of these principles into actual affordable housing frameworks reveals a landscape marked by experimentation, contestation, and policy ambivalence.

India's engagement with CE in housing is not recent. Traditional settlement typologies often followed low-carbon principles of reuse and spatial efficiency. However, the contemporary turn toward circularity emerges from a distinctly modern need reducing construction waste, controlling life-cycle costs, and extending material longevity in the context of massive urban housing demand. What follows is an analysis of how policy papers, empirical research, and housing strategy documents speak to circularity not as a pre-set checklist of technical attributes, but as a constellation of ongoing concerns, many of which remain unaddressed by existing policy and legal regimes.

Thus, this chapter proposes a matrix not as an abstract conceptual tool but as a grounded diagnostic framework for testing the real embeddedness of circularity in India's affordable housing governance. The matrix is developed based on a comprehensive analysis of the literature on affordable housing and assessments of sustainability in housing systems from both Indian and comparative sources:

3.2. Circularity: From buzzword to design ethic

Circularity arrived in India's housing discourse through a swirl of global frameworks—SDGs, Paris goals, green-rating manuals, but the term often remains a decorative prefix: "*circular-ready*", "*circular-inspired*", "*circular-friendly*". The E4C-Habitat landscape analysis cuts through that veneer, documenting the promise and inertia on Indian ground. Its field interviews capture start-ups producing fly-ash bricks, agro-crete panels, and recycled-plastic roofing; yet most of these products stall at the tender gate because state schedules do not list them, and banks refuse to finance unlisted materials.[32]

The survey also confirms a yawning gap between pilot optimism and mass deployment. Large-scale schemes still default to time-tested (and *resource-intensive*) recipes. That finding echoes the World Green Building Council's global housing review, which applauds community-rooted prototypes but notes an "institutional hesitancy" once innovations demand changes in approval norms or cost ledgers.[33]

Meanwhile, scholarship such as Laura Lammert's design thesis insists that *design for disassembly*—bolting rather than casting, separable floor cassettes, reusable façades - should be the starting point, not a retrofit afterthought.[34] Moreover, the Australian AHURI inquiry on circular housing reminds us that life-cycle accounting is possible even in public rental stock, provided codes recognise residual value in components.[35]

3.3. Constructing a diagnostic matrix

Efforts to institutionalise circularity in affordable housing have consistently stumbled on a familiar contradiction. While there is no shortage of well-articulated goals across policy documents and sustainability reports, the absence of evaluative coherence makes it difficult to assess whether these intentions are genuinely being implemented. Thus, A diagnostic matrix becomes necessary—not as a rigid checklist but as a thinking tool that allows policy makers, housing authorities, and practitioners to interrogate their systems with clarity and consistency.

In reviewing various contemporary academic and policy literature on sustainable housing and circularity, five distinct outcome-oriented themes emerge with regularity. These are not arbitrarily chosen but reflect the cumulative consensus across technical studies, field evaluations, and global sustainability frameworks. Circular housing, when stripped of its rhetorical surplus, ultimately seeks to achieve: Resource efficiency, Material circularity, Structural longevity and life-cycle thinking, Local resource synergy, and Community embeddedness.

3.3.1. Resource efficiency

In a circular economy, resource efficiency means delivering the same or better service with fewer virgin inputs across the full life cycle, so design, business models, and maintenance all

[32] Engineering for Change & Habitat for Humanity, A Landscape Analysis of Sustainable, Circular Housing Solutions in India (2022) 7–12
[33] World Green Building Council, Sustainable and Affordable Housing (2023) 4–10.
[34] Laura Lammert, Circular Economy in Architecture: Sustainable Principles for Future Design (University of Oulu, 2018) 23–27
[35] R. Horne et al., Informing a Strategy for Circular Economy Housing in Australia (AHURI Final Report 403a, 2023) 34–38

work to lower new material and energy demand[36]. A shift in value toward durability, repair, remanufacturing, and high-quality recycling instead of one-way recycling is what research studies define as designing out waste and keeping products and materials in use. Stahel adds the performance economy lens, where extending service life and prioritising maintenance and reuse saves resources while creating local jobs[37]. Technically, resource efficiency shows up through material-efficiency strategies - *light-weighting, product life extension, yield improvements*, and substitution that deliver services with less primary production[38]. In practice, this translates into buildings and infrastructure specified for longevity and adaptability, components designed for repair and modular replacement, and procurement that privileges high-value secondary materials over new raw stock[39].

3.3.2. Material circularity

The narrative of circularity often begins, almost instinctively, with materials. If fly-ash bricks, plastic-composite lumber, or agro-waste panels are technically viable and environmentally superior, their adoption should follow naturally. This circular housing principle is straightforward, treating building materials as resources, not waste. This idea comes from the Cradle-to-Cradle concept developed by William McDonough and Michael Braungart, which argues that every product should be designed so its materials can be reused repeatedly, just like nature recycles nutrients.[40] In housing, this means using materials that can either return to nature (like bamboo, earth blocks, or lime plasters) or be recycled into new buildings (like steel, aluminium, or modular panels). Recent research by Pineda-Martos et al. (2025) demonstrates that considering materials at various levels - *building, component, and raw material* - facilitates resource retention in a closed loop, thereby minimizing waste and expenses.[41]

3.3.3. Structural longevity and life-cycle thinking

If material circularity is about what buildings are made of, design adaptability is about how they are built and, more importantly, how they are unbuilt. The underlying principle is simple yet powerful: a home should not be a sealed box but an open framework, capable of being adapted, repaired, or extended as lives evolve[42]. A circular house is not a box that fits everyone. It is a flexible framework that can change with a family's needs over the years. This principle comes from "Design for X (DfX)," when architects plan for inevitable future uses, like making it easy to expand, fix, or take apart. Tsoka (2024) calls this "*Design for Circularity*," which

[36] Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, conservation and recycling*, *127*, 221–232; Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hultink, E. J. (2017). The Circular Economy–A new sustainability paradigm?. *Journal of Cleaner Production*, *143*, 757–768.
[37] Stahel, W. R. (2019). *The circular economy: A user's guide*. Routledge.
[38] IPCC. (2022). Chapter 9: Buildings. In Climate Change 2022: Mitigation of Climate Change (AR6 WGIII). https://www.ipcc.ch/report/ar6/wg3/chapter/chapter-9/
[39] International Resource Panel. (2020). Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future. United Nations Environment Programme. https://www.unep.org/resources/report/resource-efficiency-and-climate-change-material-efficiency-strategies-low-carbon
[40] McDonough, W., & Braungart, M. (3). Remaking the way we make things: Creating a new definition of quality with cradle-to-cradle design. *The International handbook on environmental technology management*, *33*.
[41] Pineda-Martos, R., Kahraman, İ., Puma, G. C. C., Ungureanu, V., de Barros Gomide, F. P., & Buzatu, R. (2025). Circular Materials—A Multiscale Approach to Circularity at a Building, Components and Materials Level. *Circular Economy Design and Management in the Built Environment*, 25.
[42] See Schmidt III, R., & Austin, S. (2016). *Adaptable architecture: Theory and practice*. Routledge.

means that the design is made to be flexible and easy to take apart from the start.[43] For instance, a house might have a layout that allows movement of walls, add rooms, or replace parts without tearing down the whole thing. This keeps the helpful building, saves money, and stops the waste from tearing it down and building it again.

When the keys are handed over, traditional housing policy often thinks the project is "done." That is when the journey starts, according to circular thinking. Sim Van der Ryn and Stuart Cowan (1996), who were pioneers in ecological design, came up with this idea. They said that we need to think about a building's whole life, from when it is built to when it is used for decades, and then when it is renovated or torn down[44]. Recent research, such as dos Santos Gonçalves et al. (2025), demonstrates the availability of tools for measuring and monitoring the "circularity" of a home throughout its entire life-cycle[45]. By planning for maintenance, upgrades, and even the “unbuilding” process, housing becomes an asset that serves communities for generations rather than a liability[46].

3.3.4. Local resource synergy

Circularity is relational: the dwelling participates in a local material ecosystem, drawing inputs from proximate, traceable streams and returning recoverable outputs to the same. This idea comes from vernacular architecture, which is how people used to build with stone, earth, wood, or bamboo that was nearby. Vernacular traditions have long practised circularity out of necessity[47]. John T. Lyle and other regenerative design thinkers said that good design makes use of local resources in ways that help the environment instead of hurting it[48]. Researchers today, such as Castellano et al. (2023), are looking into bio-based materials like mycelium (from fungi), hemp, and wood that is harvested locally[49]. These materials lower carbon emissions and make homes that feel like they belong in their surroundings.

3.3.5. Community embeddedness

Lastly, circular housing is not only about technology but also about people. People in a community who build, fix, and even improve their homes take ownership of them and keep them functional for much longer. One of the most famous examples is Elemental's "half-a-house" model in Chile, where architects built only the basic structure and let families finish and change the inside over time. This simple idea gave families power and pride, and the improvements they made over the years kept the housing stock practical and lively for decades[50]. Scholars such as Bullinger and Schiller (2025) demonstrate that social innovation—

[43] Tsoka, S., & Tsikaloudaki, K. (2024). Design for Circularity, Design for Adaptability, Design for Disassembly. In *Circular Economy Design and Management in the Built Environment: A Critical Review of the State of the Art* (pp. 257-272). Cham: Springer Nature Switzerland.
[44] Vander Ryn, S., & Cowan, S. (1996). Ecological Design Island Press, Washington. *DC*
[45] dos Santos Gonçalves, J., Claes, S., & Ritzen, M. (2025). Measuring Circularity of Buildings: A Systematic Literature Review. *Buildings (2075-5309)*, *15*(4).
[46] Bullen, P. A., & Love, P. E. (2010). The rhetoric of adaptive reuse or reality of demolition: Views from the field. *Cities*, *27*(4), 215-224.
[47] Nguyen, A. T., Truong, N. S. H., Rockwood, D., & Le, A. D. T. (2019). Studies on sustainable features of vernacular architecture in different regions worldwide: A comprehensive synthesis and evaluation. *Frontiers of Architectural Research*, *8*(4), 535–548.
[48] Lyle, J. T. (1996). *Regenerative design for sustainable development*. John Wiley & Sons.
[49] Castellano, G., Paoletti, I. M., Malighetti, L. E., Carcassi, O. B., Pradella, F., & Pittau, F. (2023, June). Bio-based solutions for retrofitting the existing building stock: A systematic review. In *International Conference on Bio-Based Building Materials*(pp 399-419). Cham: Springer Nature Switzerland.
[50] Aravena, A., & Iacobelli, A. (2016). Elemental: Incremental housing and participatory design manual. Ostfildern.

exemplified by shared maintenance systems or participatory design—facilitates the closure of the circular loop by transforming residents into active partners rather than passive users[51].

3.4. Analytical assessment of policy alignment with circular economy principles

3.4.1. Resource efficiency

Resource efficiency in the context of housing means using fewer raw materials and less energy to construct and operate homes, without compromising quality or performance. It is a core tenet of the CE. Evaluating India's affordable housing policies, we find that explicit emphasis on resource efficiency is limited, though some indirect measures exist. On the positive side, a few policy instruments encourage alternative materials and methods that could improve material efficiency. For instance, the Model Building Bye-Laws 2016 take a forward-looking approach by encouraging eco-friendly materials like fly-ash bricks and recycled aggregates, while promoting solar energy and rainwater harvesting. These measures not only help conserve valuable natural resources but also pave the way for more sustainable and efficient building practices .[19]. Similarly, the PMAY-U's Technology Sub-Mission is implicitly a resource efficiency move: by advocating prefab and other modern techniques, it seeks faster construction with potentially less material waste. The National Urban Housing & Habitat Policy 2007 also touched on efficiency by promoting cost-effective building technologies and calling for research into locally available materials with lower embodied energy[16].

However, these sustainability-oriented measures tend to be optional, advisory, or marginal, rather than central requirements of affordable housing programs. The mainstream approach to delivering affordable housing in India has prioritized scale and speed (number of units built) over resource efficiency metrics. For example, PMAY-U's success is primarily measured in terms of houses sanctioned and completed[52]The scheme guidelines do not mandate any specific percentage of recycled content or any particular energy efficiency standard beyond the normal building codes. A typical mass housing project under PMAY-U or state programs might use conventional materials – cement, burnt clay bricks, steel reinforcement – in large quantities sourced through the usual supply chains, without incentives for greener alternatives. Construction often involves cast-in-situ concrete frames with infill brick/block walls, a proven method, but not particularly lean in material use. There are no explicit mandates saying that, for example, a certain proportion of building materials must be recycled or locally sourced, or that the design must be optimized for material reduction. Likewise, in public housing tenders, the eligibility criteria or design briefs rarely include points for resource-efficient design (such as thin-shell technology, high-strength materials that allow smaller sections, etc.). This absence of mandates means that adoption of resource-efficient practices is primarily left to the initiative of individual developers or state agencies, which in most cases stick to business-as-usual approaches due to familiarity and perceived lower risk. PMAY-G, aiming to deliver nearly 2.95 crore pucca houses by 2023–24, explicitly promotes the use of locally available construction materials to enhance cost-effectiveness and regional adaptability[53]. This

[51] Bullinger, K., & Schiller, G. (2025). Social innovations for a circular built environment: A heuristic framework based on a review. *PLOS Sustainability and Transformation*, *4*(3)
[52] Press Information Bureau. (2025, February 6). Cities covered under PMAY-U (*118.64 lakh sanctioned; 112.50 lakh grounded; 90.25 lakh completed*). https://pib.gov.in/PressReleseDetailm.aspx?PRID=2100339
[53] Government of India. (2021). Framework for Implementation of Pradhan Mantri Awaas Yojana-Gramin (PMAY-G). Ministry of Rural Development, https://pmayg.dord.gov.in/netiayHome/Uploaded/Guidelines-English_Book_Final.pdf

significantly reduces transportation energy, supports vernacular practices, and keeps resource procurement economically and environmentally lean[54]. The policy emphasizes basic amenities and hygienic cooking spaces within a compact footprint (*min. 25 m²*), aligning with efficient land and material use. These measures reflect thoughtful resource allocation and mitigate overconsumption of global or non-regional materials.

From an operational standpoint, many affordable housing projects are under cost pressures, and developers may not want to experiment with newer materials unless they are cheaper or required, which often leads to a "*minimum compliance*" mentality with little impetus for innovation in resource saving. Some pilot projects have used alternatives (e.g., bamboo-based structures for EWS housing or precast panels to reduce formwork and material wastage), but these are exceptions rather than the rule. Additionally, while building codes have energy-saving provisions (*like the Eco-Niwas Samhita for residential buildings*), enforcement in affordable housing is uneven, especially since many EWS housing projects might be under area thresholds that trigger full code compliance.

Going forward, there is considerable scope to tighten the alignment with resource efficiency. Policies could introduce clear criteria or incentives focusing on material and energy efficiency. For example, the housing scheme guidelines could award additional central subsidy per unit if a project demonstrably uses 20% recycled content in construction or achieves a 10% reduction in cement usage through design optimization. Urban local bodies could expedite building permissions, reduce permit fees for projects that meet green building certification, or incorporate certain eco-friendly technologies. At the building design level, promoting compact floor plans and space-efficient layouts for affordable housing can also be a resource-saving strategy (*smaller dwelling size means less material per unit*), but that has to be balanced with habitability. The concept of "affordable green housing"[55] needs to be mainstreamed: showing that incorporating things like better insulation (to reduce energy use for cooling) or using composite cement (*with fly ash or slag*) is not a costly add-on but a smart long-term move that aligns with affordability. Right now, that narrative is only starting to emerge in India's policy discussions.

In summary, while resource efficiency is acknowledged in high-level terms (e.g., *in NUHHP 2007 and missions like NMSH)*, it has not yet become a core performance metric for affordable housing delivery. The emphasis remains on quantity (how many houses, how fast) rather than the quality of resource input per house. Strengthening this aspect – making efficient use of materials and energy a trackable and rewarded part of housing programs – would bring India's affordable housing efforts more in line with CE ideals, ensuring that the drive to build millions of houses embodies a commitment to conserving key resources.

3.4.2. Material circularity

Circular economy principles demand that housing development minimize waste generation and maximize the reuse of materials. In the context of affordable housing, this relates mainly to construction and demolition (C&D) **waste** management and incorporating recycled

[54] Government of India. (2021). Framework for Implementation of Pradhan Mantri Awaas Yojana-Gramin (PMAY-G). Ministry of Rural Development, https://pmayg.dord.gov.in/netiayHome/Uploaded/Guidelines-English_Book_Final.pdf

[55] Indian Green Building Council. (2025). IGBC Green Affordable Housing v2.0 — Detailed reference guide. IGBC. https://igbc.in/frontend-assets/html_pdfs/IGBC%20Green%20Affordable%20Housing%20Ver%202.0.pdf

materials. At present, India's affordable housing drive only has rudimentary linkages to systematic waste management, which is a clear area of misalignment with CE principles.

During the construction phase of housing projects, considerable waste can be generated: concrete rubble, broken bricks or blocks, metal scraps, packaging, wood formwork, and excavated soil, among others. Typically, in the absence of enforcement, much of this waste is dumped on the outskirts of cities or landfills, representing a loss of potentially reusable material and causing environmental damage. Housing programs like PMAY-U do not include specific requirements or guidelines for C&D waste management on project sites. For example, when a slum is redeveloped under PMAY's ISSR vertical, old structures are demolished, but there is no mandate in the scheme that the debris must be recycled or that a certain percentage should be reused in the new construction. While India does have C&D Waste Management Rules, 2016 at the national level, enforcing these rules is left to urban local bodies and is still nascent in most cities. Thus, unless a city has particularly proactive waste regulations, affordable housing contractors often dispose of construction debris in the cheapest possible way, which is usually dumping (sometimes illegally). Some exceptions exist: a few metros like Delhi, Mumbai, and Bangalore have commissioned C&D waste recycling plants and require large projects to send waste there. However, compliance is uneven, and many smaller cities lack such facilities. While PMAY-G's core guidelines do not deeply elaborate on construction-stage waste management, convergence with sanitation and electrification schemes ensures comprehensive infrastructure rather than piecemeal construction[56].

Another aspect is designing to reduce waste – e.g., using modular components to minimize on-site cutting and wastage, or planning construction sequencing to reduce material spoilage. These circular practices are not commonly mandated or practiced in affordable housing construction, which often relies on conventional, labour-intensive methods with significant on-site material handling (*leading to breakage and wastage).* So far, the housing agencies have placed little focus on tracking or reducing the waste footprint of projects.

The policy environment has some encouraging signs: The Model Building Bye-Laws 2016, as mentioned, introduced requirements for waste segregation on-site[57] for large projects, which is a start. Additionally, some municipalities (like in Pune, Hyderabad, etc.) now ask builders to submit a waste management plan as part of building permission for big projects. However, these initiatives are general and not built explicitly into affordable housing programs. Moreover, compliance burden typically falls on the local enforcement capacity, which is often weak. Resource constraints in municipalities mean monitoring whether each housing site segregates and properly disposes of waste is challenging. As a result, many affordable housing sites may still discard valuable materials (like *steel scraps or broken concrete*) instead of recycling them.

At the end-of-life stage (though *the current concern is more on new construction than demolition, since we are adding housing stock*), there will eventually be a need to address demolition waste from old housing, including old public housing estates or redeveloped slums. Currently, the informal sector in India does achieve some level of material recovery (for instance, when a building is torn down, salvagers often reclaim steel rods, doors, window frames, etc., for resale). However, without formal integration, much material is still wasted.

[56] Government of India. (2021). Framework for Implementation of Pradhan Mantri Awaas Yojana-Gramin (PMAY-G). Ministry of Rural Development, https://pmayg.dord.gov.in/netiayHome/Uploaded/Guidelines-English_Book_Final.pdf

[57] Ministry of Urban Development. (2016). Model Building Bye-Laws 2016. Government of India. Chapter 10: Green Buildings and Sustainability Provisions

The policies do not yet account for "design for deconstruction" or future recyclability of housing components – an idea central to circular construction.

Significant improvements are needed to align affordable housing with CE principles. Firstly, explicit waste management guidelines should be integrated into housing scheme conditions. For instance, PMAY-U could require that any developer receiving subsidies segregate C&D waste and send it to an authorized recycling facility (if available), with an obligation to report the quantity of waste generated and recycled. There could also be an incentive system: additional payments or recognition for projects that demonstrate high rates of waste reuse on-site (like using crushed concrete from demolition as base material for roads or floors). Secondly, encouraging recycled building materials in new affordable houses can close the loop. Some possibilities are using recycled aggregate or sand from C&D waste in concrete (*up to a certain percentage*), or using products made from waste (*tiles from recycled glass, wood substitutes from agricultural residue, etc.*). Currently, developers may hesitate to use these due to a lack of familiarity or concern about quality, but if national or state housing authorities endorse and standardize some of these materials, it could boost confidence. Public housing projects could even set targets like "at least 20% of building materials (by volume or cost) should come from recycled or secondary sources[58]" – This would drive innovation and market development for such materials.

Additionally, capacity building and facilitation are needed. Contractors and site engineers might not know how to implement waste minimization practically[59]. Here, toolkits or training from bodies like BMTPC or CPWD (Central Public Works Department) on construction waste management for affordable housing would help translate policy intent into action. Some cities are experimenting with "eco bricks" (bricks made from recycled plastic or waste), and if proven, these could be integrated into housing schemes' supply chains.

3.4.3. Life-cycle thinking and structural longevity

Life-cycle thinking in housing means considering the entire lifespan of homes – from construction through decades of use to eventual repurposing or demolition – and aiming to optimize performance and minimize negative impacts at each stage[60]. Structural longevity is a related concept: ensuring buildings remain safe, functional, and comfortable for a long time, thus delaying the need for resource-intensive replacement[61]. Examining India's affordable housing initiatives through this lens reveals that current policies pay scant attention to long-term performance and maintenance, focusing overwhelmingly on the initial delivery of housing units.

The primary metric for schemes like PMAY-U has been the number of houses built or allocated. Little in the policy framework addresses how those houses will be maintained or how

[58] Ministry of Environment, Forest and Climate Change (MoEFCC). (2016, March 29). Environment Ministry notifies Construction and Demolition Waste Management Rules, 2016 [Press release]. Press Information Bureau.
[59] Centre for Science and Environment (CSE). (2020, August 25). *"....manages to recover and recycle only about 1 per cent of its construction and demolition (C&D) waste",* says new CSE analysis, https://www.cseindia.org/india-manages-to-recover-and-recycle-only-about-1-per-cent-of-its-construction-and-demolition-10326#:~:text=New%20Delhi%2C%20August%2025%2C%202020,just%20about%201%20per%20cent.
[60] Devi, P., & Palaniappan, S. (2014). A case study on life cycle energy use of residential buildings in Southern India. Energy and Buildings, 80, 247–259.
[61] Bansal, D., Byahut, S., & Bansal, Y. (2024). Optimization of Embodied Energy and Construction Cost of Low-Income Housing in Urban India. *Urban Science*, *8*(3), 146

they will perform 10, 20, or 50 years down the line. One consequence is that many affordable homes are built to minimum acceptable standards to keep costs low and meet urgent needs, but they may not age well without intervention[62]. For example, some EWS housing projects feature small single-room units with plastered finishes and simple fittings. While these meet the immediate goal of providing shelter, over time issues often emerge – water seepage in walls due to inadequate waterproofing, cracks because of modest structural margins, inefficient thermal performance making units too hot in summers (*tin or RCC roofs without insulation*), etc. Because the policies did not bake in quality standards beyond initial occupancy requirements, the durability depends mainly on the executing agency. There have been reports and case studies in different cities of government-built housing deteriorating a few years after construction due to poor construction quality or lack of upkeep (*paint peeling, plumbing failing, etc*.), which undermines the objective of a long-term housing solution[63].

Maintenance is a particularly under-addressed issue. Programs like PMAY-U do not allocate funds or create mechanisms to maintain the housing stock after it is handed over to beneficiaries or local bodies. Low-income homeowners or housing societies often lack the resources for regular maintenance. Unlike middle-class apartment complexes, which might have formal resident associations and maintenance funds, many EWS housing complexes disappear unless the government or an NGO steps in. This lack of a maintenance plan means the effective lifespan of buildings could be shortened. For instance, if water penetration is not fixed due to absent maintenance, concrete reinforcements may corrode faster, reducing structural life. Life-cycle thinking would require planning for maintenance costs and responsibilities at the outset – something not systematically done in the current framework. PMAY-G houses are expected to last decades, derived from "quality pucca construction" delivered through phased disbursal tied to construction milestones and integration with MGNREGS labour inputs for durability[64]. The policy's design offers full support for foundation to roof, including plastering, roofing, cooking, and sanitation systems, and suggests a life-cycle mindset where each structural stage is addressed for long-term performance. However, direct articulation of life-cycle assessments or embodied energy considerations remains absent; integrating such analyses would support better long-term sustainability.

Energy and water efficiency over the building's life-cycle is another gap. Most affordable housing designs have not been optimized for reduced life-cycle costs (like energy bills). Simple climate-responsive design choices – such as proper orientation of buildings for sun and wind, shading devices over windows, reflective paint on roofs (cool roofs), or improved ventilation – are often missing, even though they could significantly cut cooling costs for residents and improve comfort. Since policies do not insist on these (except to the extent local codes might require basic natural ventilation and light), many affordable units end up with high operating costs relative to income (for example, requiring an electric fan or cooler running constantly in summer due to heat). This burdens low-income households financially and means higher energy consumption (often from fossil-fuel-based electricity) over the building's life, contrary to sustainability goals. A life-cycle approach would weigh slightly higher initial costs (for

[62] Kumar, D., Maurya, K. K., Mandal, S. K., Mir, B. A., Nurdiawati, A., & Al-Ghamdi, S. G. (2025). Life Cycle Assessment in the Early Design Phase of Buildings: Strategies, Tools, and Future Directions. *Buildings*, *15*(10), 1612.

[63] Moghayedi, A., Awuzie, B., Omotayo, T., Le Jeune, K., Massyn, M., Ekpo, C. O., ... & Byron, P. (2021). A critical success factor framework for implementing sustainable, innovative, and affordable housing: a systematic review and bibliometric analysis. *Buildings*, *11*(8), 317.

[64] Government of India. (2021). Framework for Implementation of Pradhan Mantri Awaas Yojana-Gramin (PMAY-G). Ministry of Rural Development, https://pmayg.dord.gov.in/netiayHome/Uploaded/Guidelines-English_Book_Final.pdf

better design or materials) against decades of savings and resilience, but the current short-term view and tight budgets impede this approach.

Another aspect is adaptability: Over a building's life, occupants' needs may change (family sizes grow or shrink, economic activities might be carried out from home, etc.). Circular thinking favors buildings that can be adapted rather than demolished. In affordable housing, units are typically minimal and tightly specified, leaving little flexibility. Extending or modifying them is often not structurally feasible (or not legally permitted). As a result, if a family outgrows a unit, they might resort to informal modifications or move out, potentially leaving units under-utilized. Some progressive housing designs (esp. in international examples or a few Indian pilots) have tried incremental housing – where the owner can expand an initial core house as resources allow. However, mainstream policy has not incorporated that idea widely.

There are early signs of change: The dialogue around *housing resilience* is emerging – for instance, after seeing damage to poorly built houses in disasters, there is emphasis that new housing (even affordable) should be disaster-resilient (e.g., compliant with seismic codes, etc.). This indirectly improves longevity. Some states have started programs for housing management societies or training residents on upkeep (e.g., under the Smart Cities Mission, a few cities did initiatives for maintenance of public housing). Green building rating systems in India (like GRIHA for affordable housing[65]) encourage life-cycle cost analysis, which is voluntary and not yet mainstream for government housing.

To truly embed life-cycle thinking, policies could include measures such as: requiring a maintenance fund to be set up for each affordable housing project (perhaps seeded by government for initial years), designing housing clusters with robust common areas that can be repurposed (like community halls that can serve as disaster shelters or be converted to additional housing if needed), and using materials that might cost more upfront but last significantly longer (for example, higher grade waterproofing, paints, etc., which could be encouraged by bulk procurement for many units together). Additionally, providing basic user education to beneficiaries about home maintenance and energy/water saving practices could prolong the life and efficiency of the housing.

3.4.4. Local resources synergy

India's PMAY-U and PMAY-G each contain foundational elements that promote Local Resource Efficiency, but neither fully realizes its potential without stronger, mandated provisions. PMAY-G explicitly encourages the use of locally available construction materials and beneficiary-driven building, with formal frameworks to map material sources and train rural masons, thus shortening supply chains, reducing embodied energy, and retaining value within villages in true circular-economy spirit[66]. Moreover, the "*Greening PMAY-G*" component provides optional incentives for eco-friendly materials and methods[67], though its discretionary nature limits systemic impact. Complementing this, PMAY-U's 2.0 iteration includes the Technology & Innovation Sub-Mission (TISM) and Technology Innovation Grant (TIG), which incentivize innovative, sustainable, green, and disaster-resilient building technologies, and climate-appropriate designs supporting resource-efficient construction

[65] GRIHA Council. (2018). GRIHA Affordable Housing — Abridged manual. https://www.grihaindia.org/
[66] Ministry of Rural Development. (2022). *Framework for Implementation of PMAY-G*. Government of India. https://pmayg.dord.gov.in/netiayHome/Uploaded/Guidelines-English_Book_Final.pdf
[67] Ministry of Rural Development. (2022). Greening PMAY-G (Chapter 14). https://pmayg.dord.gov.in/netiayHome/Uploaded/Guidelines-English_Book_Final.pdf

across urban geographies[68]. Additionally, appraisal checklists under PMAY-U require attention to solid-waste management, solar lighting, and compliance with CPHEEO/IS/NBC standards[69], offering entry points for resource-loop closure in urban settings. However, both schemes stop short of mandating the use of recycled content (e.g., fly-ash bricks, recycled aggregates), requiring C&D waste management plans, or incorporating decentralized water or energy reuse systems within housing clusters, measures already enabled by national rules and CPHEEO guidance[70]. To fully embrace local resource synergy, India could make "green material" use mandatory for a share of components in both schemes, require waste-management and life-cycle-cost-positive resource loops, and preferentially source these within a defined local radius, transforming existing incentives into standardized, enforceable circular practices.

3.4.5. Community embeddedness:

PMAY-U and PMAY-G each seek to embed housing solutions within local social, institutional, and cultural fabrics—but again, opportunities for deeper, systemic integration remain. PMAY-G's approach is deeply rooted in meaningful local participation: Gram Sabhas validate beneficiary selection, SECC-derived lists ensure transparent targeting of deprived rural households, and social audits provide community oversight[71]. Local training through Rural Mason Training (RMT) invests in village capacity, preserves traditional skills, and anchors livelihood within the built-environment delivery system[72]. These mechanisms reinforce community ownership and resilience, hallmarks of a place-based, embedded delivery model. PMAY-U embeds similarly through in-situ slum rehabilitation, which maintains community networks and proximity to livelihoods; credit-linked subsidies that empower individuals; and involvement of urban local bodies (ULBs) through Project Sanctioning Committees, ensuring local governance participation[73]. The inclusion of social infrastructure schools, health centres, Anganwadis, and transport nodes in project designs further physically and functionally integrates housing into the urban social fabric. Nonetheless, both schemes would benefit from more structured co-design processes, inviting beneficiaries to contribute to unit layouts, open-space planning, cultural architectural forms, and formalized roles for communities in operations and maintenance (O&M) of amenities and resource systems. For instance, neighbourhood-level committees or SHG-based maintenance groups could manage decentralized waste, rainwater, or sanitation systems, reinforcing stewardship and long-term viability. By elevating participation from verification to design and upkeep, PMAY-U and PMAY-G can move from enabling embeddedness to co-creation, a deeper circular-economy alignment that builds social and infrastructural capital.

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[68] Ministry of Housing & Urban Affairs. (2024). PMAY-U 2.0: Scheme Guidelines. https://pmay-urban.gov.in/uploads/guidelines/Operational-Guidelines-of-PMAY-U-2.pdf; Ministry of Housing & Urban Affairs. (2024). PMAY-U 2.0: Technology Innovation Grant provisions. https://pmay-urban.gov.in/uploads/guidelines/Operational-Guidelines-of-PMAY-U-2.pdf

[69] Ministry of Housing & Urban Affairs. (2024). PMAY-U 2.0: Appraisal checklists and compliance standards. https://pmay-urban.gov.in/uploads/guidelines/Operational-Guidelines-of-PMAY-U-2.pdf

[70] CPHEEO (MoHUA). (2020). Guidelines for Decentralized Wastewater Management. https://cpheeo.gov.in/upload/uploadfiles/files/Guidelines%20for%20Decentralized%20Wastewater%20Management.pdf

[71] Ministry of Rural Development. (2022). Framework for Implementation of PMAY-G (Beneficiary selection; Gram Sabha verification; social audits). https://pmayg.dord.gov.in/netiayHome/Uploaded/Guidelines-English_Book_Final.pdf

[72] Ministry of Rural Development. (2019). Guidelines on Rural Mason Training (RMT). https://pmayg.dord.gov.in/netiayHome/Document/Guidelines-on-RMT.pdf

[73] Ministry of Housing & Urban Affairs. (2024). PMAY-U 2.0: Scheme Guidelines. https://pmay-urban.gov.in/uploads/guidelines/Operational-Guidelines-of-PMAY-U-2.pdf

3.5. Conclusion

Taken together, India's affordable housing frameworks acknowledge, but do not yet operationalize, the CE. On resource efficiency, enabling references exist (e.g., alternative materials, solar, rainwater harvesting), yet these remain largely advisory; the dominant performance lens is still speed and scale of unit delivery rather than material and energy intensity per dwelling. Material circularity is the weakest link: national C&D Waste Rules provide a legal scaffold, but scheme conditions rarely require on-site segregation, verified off-take to authorized recyclers, or minimum recycled-content thresholds in public housing works, so most projects default to conventional, linear practices. Life-cycle thinking and structural longevity are similarly under-specified: design for durability, climate responsiveness, adaptability, and maintenance governance is seldom mandated or funded, shortening effective asset life and raising operating burdens for low-income residents. Finally, legal synchronization with environmental frameworks is partial rather than programmatic; housing guidelines reference standards and missions but do not consistently translate them into enforceable obligations, budget lines, procurement rules, or monitoring protocols. A circular turn is therefore less about inventing new schemes and more about tightening what already exists—by making circularity measurable, mandatory, and financeable. Reframing "affordable" as durable, efficient, and locally grounded closes the gap between intent and impact.

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CHAPTER 4: Systemic Gaps and Institutional Limitations in Operationalizing CE in Affordable Housing

4.1. Introduction:

Ensuring access to affordable housing has become a central policy priority in India, exemplified by ambitious initiatives like the Pradhan Mantri Awas Yojana (PMAY) aimed at achieving "*Housing for All*". At the same time, CE principles – emphasizing resource reuse, waste reduction, and regeneration – are gaining prominence as a strategy for sustainable urban development. Having established where current instruments align (and where provisions are missing), this chapter diagnoses the institutional and operational reasons these provisions do not translate into outcomes – *circularity in affordable housing.* This diagnostic chapter explains why the promise–performance gap persists by identifying gaps across thematic policy design, operational implementation, and sustainability monitoring that may be challenging for more resilient and inclusive housing outcomes.

4.1.1. Thematic gaps and fragmentation

One prominent gap is the absence of explicit CE principles in affordable housing policies and schemes. Terms like "circular economy," "closing resource loops," or "life-cycle approach" are virtually non-existent in housing scheme guidelines or urban housing policies. While some environmentally friendly practices are encouraged in passing, they are not framed as part of an overarching circular strategy. In practice, affordable housing initiatives have traditionally focused on socio-economic objectives – addressing housing shortages, improving living conditions, and poverty alleviation. In contrast, environmental sustainability has been dealt with separately through distinct laws and missions. There is a missing intersection between these agendas. For instance, India has comprehensive Solid Waste Management Rules (2016) and a flagship housing mission (PMAY). However, the housing scheme guidelines do not reference waste management requirements or assign responsibilities for them – those are left to a different authority in the urban local bodies. This siloed approach leads to fragmented efforts: multiple uncoordinated directives that do not necessarily reinforce each other. For example, a city might run a cleanliness drive under the Swachh Bharat Mission (with funding for better waste management infrastructure) completely independently of new housing developments under PMAY. If the two are not coordinated, one could end up with newly built housing blocks lacking adequate waste segregation and collection points, undermining the cleanliness initiative. Similarly, on one hand, the government strongly promotes renewable energy (e.g., through solar rooftop programs and the National Solar Mission), yet on the other hand, affordable housing projects often come without solar panels or other renewable systems by default. In fact, the PMAY (Urban) guidelines have no specific requirement for solar energy integration, even though environmental regulations like the Environment Impact Assessment (EIA) notification of 2006 recommend solar power usage in buildings. Without explicit policy linkage between housing and environmental programs, opportunities for synergy are missed – for example, incorporating solar water heaters or photovoltaic panels into housing by design,

or mandating on-site waste management in housing projects to complement city-wide waste rules[74].

Another thematic gap is the narrow focus of "affordable housing" policies on new construction rather than circular alternatives like reuse and regeneration of existing buildings. A proper CE approach would emphasize strategies such as rehabilitating and retrofitting old or under-utilized buildings, and enabling shared housing models (e.g., co-housing, community rentals) to efficiently use existing space and materials. Indian housing policy has only lightly touched upon these aspects. Slum rehabilitation and redevelopment is one area where existing urban spaces are regenerated for housing, but beyond that, there is little emphasis in policy on adapting old building stock for new housing needs or encouraging multi-family rentals to optimize space. The prevalent approach remains a build–new paradigm, often on greenfield sites or through demolition and reconstruction of slums, rather than adaptive reuse. A circular perspective would suggest maximizing use of what is already built – for example, filling the enormous number of vacant houses in cities before constructing anew. According to the Census of India 2011, roughly 11.1 million urban housing units (about 12% of the urban housing stock) were vacant across the country. This indicates a paradox of housing scarcity coexisting with under-utilized assets. Mobilizing this existing stock (through measures like rental housing promotion and reform of rent control laws) could meet a substantial part of the demand without fresh resource consumption[75]. However, policies to bring these vacant or under-used homes into the market – such as a robust urban rental housing policy – have been slow to materialize. Notably, rental housing has been a blind spot in the affordable housing framework: the initial PMAY-U program provided no provisions or incentives for rental housing, focusing entirely on home ownership and new unit construction. Although a draft National Urban Rental Housing Policy was formulated in 2015, it has yet to be fully adopted and enforced. The lack of attention to renting and reuse means that opportunities to utilize existing housing stock or innovative sharing models (which align well with CE ideals) remain largely untapped in India's housing strategy. In summary, current policies exhibit thematic shortfalls – they operate in silos (housing vs. environment) and favor linear "build-new" solutions over circular approaches like reuse, refurbishment, and shared utilization. Recognizing these blind spots is the first step to making housing policy more holistic.

4.1.2. Operational and institutional challenges

Even where sustainability or "green" practices are acknowledged on paper, implementation on the ground faces significant challenges. One issue is the weak enforcement of environmental and building standards in mass affordable housing projects. Building codes and model bye-laws now include provisions for rainwater harvesting, energy efficiency (e.g., the Eco-Niwas Samhita for residential buildings), and the use of certain materials. However, ensuring compliance in thousands of affordable housing units is difficult. Urban Local Bodies (ULBs), which are responsible for approving plans and inspecting construction, often lack the workforce and technical capacity to monitor every project for compliance with these provisions rigorously[76]. In practice, the priority for housing authorities is usually on speed and volume of construction – delivering the targeted number of units – rather than verifying each "green"

[74] Chen, L., Hu, Y., Wang, R., Li, X., Chen, Z., Hua, J., ... & Yap, P. S. (2024). Green building practices to integrate renewable energy in the construction sector: a review. *Environmental Chemistry Letters*, *22*(2), 751–784.

[75] Ault, R. W., Jackson, J. D., & Saba, R. P. (1994). The effect of long-term rent control on tenant mobility. *Journal of Urban Economics*, *35*(2), 140–158.

[76] Saha, S., Hiremath, R. B., Prasad, S., & Kumar, B. (2021). Barriers to adoption of commercial green buildings in India: A review. *Journal of Infrastructure Development*, *13*(2), 107–128.

feature. As a result, sustainability elements can get value-engineered out or ignored during construction if there is cost or time pressure. For example, a contractor might omit installing a rainwater harvesting system or proper insulation to cut costs or meet deadlines, which might go unnoticed until much later (if it is noticed at all). The overall regulatory environment for building is still catching up; studies note that in India, poor enforcement of building regulations remains a significant barrier to sustainable building adoption[77].

Another operational challenge is the limited technical know-how and awareness regarding innovative, low-waste construction methods among many builders and contractors in the affordable segment. The construction industry for budget housing tends to rely on conventional techniques and materials with which it is familiar. Institutional inertia and skepticism toward new methods exist, especially in government-sponsored projects where any deviation from tried-and-tested practices is considered a risk. Many local contractors building Economically Weaker Section (EWS) or Low-Income Group housing may not be knowledgeable about the latest alternatives – such as precast systems that minimize waste, the use of recycled construction materials (e.g., pulverized fly ash bricks, recycled aggregates), or modular designs that allow easy disassembly and reuse of components. Additionally, there is a perception that "green" or innovative building equals higher cost or complexity, which makes adoption harder in this cost-sensitive sector[78]. These perceptions are not always accurate – some sustainable measures can save money over a building's life – but they persist. Research on green building uptake has identified factors like lack of awareness, scarcity of readily available green materials, and limited R&D support as key hurdles[79]. Practitioners tend to stick with business-as-usual methods without clear demonstration projects and capacity-building programs to showcase how circular or sustainable practices can be implemented affordably. The result is that adoption of circular construction practices is sporadic and pilot-based, rather than scaled across all affordable housing.

Institutional silos exacerbate these issues. Different arms of the government and urban governance system work in isolation, missing opportunities for collaboration. For example, a city's housing board or development authority might be focused solely on sanctioning and constructing housing units, while the municipal environmental department runs a recycling or waste-management program; if they do not actively coordinate, the housing authority may not stipulate the use of locally available recycled construction materials or ensure that new housing complexes are integrated into the city's waste recycling system. Likewise, financing for green building features (such as credit lines from national housing banks or international funds for energy-efficient housing) often exists. However, housing scheme officials do not always link developers or beneficiaries to these resources. The lack of a unified approach means sustainable technologies or materials – even when available and financially supported – often remain on the sidelines of mainstream housing projects.

A further challenge lies in beneficiary engagement and behavior. Introducing new technologies or systems into affordable housing (for instance, solar water heaters, rooftop solar panels, biogas digesters, rainwater harvesting systems, or dual-plumbing for greywater reuse) requires that end-users understand and accept them[80]. If residents are not adequately trained or oriented

[77] Saha, S., Hiremath, R., & Sanjay, P. (2022). Barriers to adoption of green buildings–a review. *Cardiometry*, (22), 377–385.
[78] Abraham, P. S., & Gundimeda, H. (2020). Greening offices: Willingness to pay for green-certified office spaces in Bengaluru, India. *Environment, Development and Sustainability*, *22*(3), 1839-1857.
[79] Eze, E. C., Sofolahan, O., & Omoboye, O. G. (2023). Assessment of barriers to adopting sustainable building materials (SBM) in the construction industry of a developing country. *Frontiers in Engineering and Built Environment*, *3*(3), 153-166.
[80] Bielig, M., Kacperski, C., & Kutzner, F. (2024). Increasing retrofit device adoption in social housing: Evidence from two field experiments in Belgium. *Journal of Environmental Psychology*, *95*, 102284.

on how to use and maintain such systems, there is a risk that these features will fall into disrepair or be misused[81]. In current practice, once a housing project is handed over, residents' associations or individual owners are expected to take up the operation and maintenance of standard amenities[82]. There is little in the policy framework that addresses capacity building at the community level for managing sustainable infrastructure. Indeed, under typical public-private partnership models, the developer maintains standard facilities for only a few years, after which upkeep becomes the residents' responsibility. In lower-income housing, residents may have limited resources and technical knowledge for maintenance, so more complex centralized systems (like a conventional sewage treatment plant or centralized solar power system) often prove unsustainable in the long run[83]. This underscores the need for simpler, decentralized solutions and community training – aspects that current policies largely overlook. A truly circular and sustainable approach would treat residents as partners in managing water, waste, and energy at the community scale (through awareness programs, user-friendly designs, and participatory maintenance models). However, the social-institutional support for such engagement is minimal, as the rush is usually to build the physical units and move on. These operational and institutional gaps mean that even well-intentioned sustainability provisions may not translate into tangible outcomes.

4.1.3. Lack of monitoring and evaluation mechanisms

A significant limitation in the current framework is the absence of robust monitoring and evaluation (M&E) focused on sustainability and circularity outcomes. Affordable housing programs today are primarily evaluated on quantitative outputs – for example, the number of housing units constructed or allotted, the amount of subsidy disbursed, and the pace of implementation. While these metrics are important, there is typically no tracking of environmental performance indicators such as the energy efficiency of the homes built, the amount of materials or waste recycled during construction, the water savings achieved through installed systems, or the reduction in household resource consumption due to design interventions. Program success reports rarely mention metrics like average energy use per dwelling or the functioning status of rainwater harvesting structures a year after installation. Essentially, once keys are handed over to beneficiaries, the project is considered complete from the scheme's perspective, and any follow-up on environmental functionality is unusual. For instance, compliance might be checked at commissioning if a guideline required LED lighting in common areas of a housing complex. However, a year later, there is no mechanism to check whether less efficient bulbs have replaced those LEDs due to maintenance issues. Similarly, a contractor might dutifully build a rainwater harvesting tank to meet the mandate. However, whether that tank collects and reuses water effectively (or is maintained to do so) is not evaluated post-occupancy. Without systematic data collection or feedback loops, policymakers and program managers do not fully understand the environmental performance and longevity of the sustainability measures in affordable housing.

This lack of monitoring has several consequences. First, what is not measured often gets neglected. If no one is assessing whether solar panels or composting pits in a housing project are working, these features may gradually stop functioning, defeating their purpose. Second, learning opportunities are missed – innovative pilots and best practices do not inform broader

[81] Trachtenberg, A., Hill, S., McCoy, A., & Ladipo, T. (2016). The Impact of Green Affordable Housing. *Southface Energy Institute and the Virginia Center for Housing Research, January*.
[82] https://housing.com/news/dda-to-hand-over-maintenance-work-to-rwas-within-a-year/
[83] Tsinda, A., Abbott, P., Pedley, S., Charles, K., Adogo, J., Okurut, K., & Chenoweth, J. (2013). Challenges to achieving sustainable sanitation in informal settlements of Kigali, Rwanda. *International journal of environmental research and public health*, *10*(12), 6939–6954.

policy because there is no formal process to evaluate and compare them. For example, if one experimental affordable housing project used hollow concrete blocks or recycled steel, reducing material use by 20%, that information might remain isolated to that project team. Without a central repository of performance data or case studies, it is not easy to propagate successful circular practices nationwide. Third, the current M&E frameworks under the PMAY-U 2.0 provide little accountability for sustainability outcomes. A housing agency can claim full achievement by citing the number of houses built, even if those are thermally uncomfortable or resource-inefficient. Residents might face high electricity bills due to poor design, or issues like water scarcity if promised harvesting systems are non-functional. However, these aspects do not feed back into program evaluation meaningfully. Recognizing this gap, recent policy discussions have suggested improvements. For instance, a draft update to the EIA regulations proposed empowering local bodies to impose environmental performance conditions on medium-sized building projects (which include many housing projects) and to conduct third-party environmental audits for them[84]. If implemented, such measures would be an introductory start to accountability for operational sustainability (ensuring that housing projects have design provisions for waste management or energy efficiency and perform as intended over time).

4.2. Conclusion

India's affordable housing agenda, most visibly through PMAY (Urban & Rural), has delivered scale and administrative momentum that merit recognition. This diagnostic has not sought to criticise that achievement, but to clarify why circular-economy intent sometimes stalls between policy text and outcomes. The emerging picture is consistent and solvable: provisions touching resource efficiency and waste reduction exist in parts, yet mandates are uneven; responsibilities are diffused across agencies; procurement and supervision processes rarely reward circular performance; and monitoring focuses on counting units rather than tracking environmental functionality over time. Addressing these gaps is crucial if affordable housing evolves from a narrow focus on unit delivery into a more holistic, circular approach that provides shelter and does so in a resource-efficient, sustainable, and livable manner.

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[84] https://www.dghindia.gov.in/assets/downloads/5e82fe3f6fb4aDraftEIA2020.pdf

CHAPTER 5: Embedding Circular Economy in Affordable Housing: Learnings through Comparative Analysis of Practices across Australia, Netherlands, Singapore, and North America

5.1. Introduction

The intersection of sustainability and housing affordability has led governments across the world to embed circular economy (CE) principles into their housing policies. This chapter undertakes a comparative analysis of how CE concepts have been institutionalized in affordable housing frameworks across four key jurisdictions—Australia, the Netherlands, Singapore, and North America (United States and Canada)—using five thematic lenses: Material Circularity, Design Adaptability, Life-cycle Integration, Local Resource Synergy, and Community Embeddedness. Each jurisdiction represents a distinct legal, institutional, and cultural context, shaping its own pathway for integrating resource efficiency, adaptability, and sustainability into housing systems.

Rather than ranking these approaches, the chapter draws lessons from diverse practices—ranging from from Australia's *Recycling and Waste Reduction Act 2020*[85], to the Netherlands' *Woningwet* (Housing Act 2015)[86], Singapore's *Resource Sustainability Act 2019*[87], and cornerstone North American housing laws like the U.S. *Housing Act of 1937*[88] and Canada's National Housing Strategy (2017)[89]. The objective is twofold: first, to appreciate the shared commitment of these jurisdictions toward transforming affordable housing into regenerative, resilient systems; and second, to identify elements of these experiences that can inform India's own policy frameworks as it seeks to align housing affordability with circularity imperatives.

5.1.1. Material circularity

All four jurisdictions emphasize reducing construction waste and boosting the use of recycled materials in housing, embedding material circularity through laws, standards, and incentives. Australia has taken a legislative lead by enacting the *Recycling and Waste Reduction Act 2020*, which bans the export of unprocessed construction and demolition (C&D) waste and thereby incentivises domestic re-use and recycling.[90]. This law supports Australia's National Waste Policy goal of 80% resource recovery by 2030[91], directly targeting the built environment as a key waste stream. In practice, Australian housing projects are starting to incorporate more

[85] Australian Government. (2020). Recycling and Waste Reduction Act 2020. Canberra: Commonwealth of Australia.
[86] Rijksoverheid (Government of the Netherlands). (2015). Woningwet (Dutch Housing Act 2015). The Hague: Ministry of the Interior and Kingdom Relations.
[87] Government of Singapore. (2019). *Resource Sustainability Act 2019* (No. 29 of 2019), Part 3 (Regulation of Waste).
[88] United States Congress. (1937). U.S. Housing Act of 1937, 50 Stat. 888, Section 3(a) (as amended, authorizing rent hardship exemptions). Washington, DC: U.S. GPO.
[89] Canada Mortgage and Housing Corporation (CMHC). (2023). *Rapid Housing Initiative: Program Guidelines*. Ottawa
[90] Australian Government. (2020). *Recycling and Waste Reduction Act 2020*. Canberra: Commonwealth of Australia
[91] Department of Climate Change, Energy, the Environment and Water. (2019). *National Waste Policy Action Plan 2019*. Canberra: Commonwealth of Australia

reclaimed materials; for example, the voluntary Green Star Homes standard rewards recycled timber, aggregates, and other salvaged inputs, nudging developers toward circular material choices (a trend increasingly adopted in public housing projects). Although national building codes (the *National Construction Code*, NCC) do not yet mandate recycled content, some state-level planning frameworks – such as Victoria's planning policies – now encourage developers to submit Waste Management Plans for resource recovery in significant housing developments, normalizing circular practices in project approvals.

In the Netherlands, material circularity is a pillar of national strategy. The government's *Nederland Circulair in 2050* program aims to halve the use of primary raw materials by 2030 and achieve a fully circular economy by 2050[92]. National and local measures have cascaded. This ambitious agenda has cascaded into the housing sector. For instance, the Dutch Building Decree has been amended to integrate environmental performance requirements (life-cycle assessments) into building permits, which pushes developers – including social housing providers – to minimize embodied energy and waste[93]. Major cities reinforce these goals: Amsterdam's Circular Construction Strategy mandates that at least 20% of materials in municipal construction tenders be circular (re-used or recycled content)[94]. Such requirements have spurred using reclaimed brick, recycled concrete, and timber in affordable housing projects across Dutch cities. Moreover, technical tools like the MPG (Milieuprestatie Gebouwen) calculator help quantify a building's environmental impact, ensuring material choices are transparent and meet circular standards. These combined national and municipal efforts position the Netherlands as a leader in closing resource loops in construction.

Singapore's high-density urban context has driven a pragmatic approach to material circularity in housing. The *Resource Sustainability Act 2019* introduced mandatory requirements for sorting and reporting C&D waste from construction projects, directly affecting Housing & Development Board (HDB) public housing demolitions and renovations[95]. This ensures that materials from programs like the Selective En Bloc Redevelopment Scheme (SERS), which redevelops older estates, are systematically recovered and recycled rather than discarded. In tandem, Singapore has mainstreamed the use of secondary materials in new construction: recycled concrete aggregates (RCA) and even recycled metal slag are now commonly used in HDB projects, significantly reducing reliance on imported virgin sand and gravel[96]. These practices are reinforced by the Building and Construction Authority's Green Mark certification program, which awards points (and thus incentivizes developers) for using recycled content and low-carbon materials in buildings. Notably, while Singapore's Building Control Act does not explicitly mandate recycled materials, it ties compliance to codes and standards that favor sustainability – effectively an indirect regulation[97]. The result is a closed-loop supply chain for public housing: old building components are harvested and fed into new projects, aligning with CE principles in a highly urbanized environment.

In North America, efforts to advance material circularity in affordable housing are evident in federal guidance and building regulations. In the United States, the Department of Housing and

[92] Government of the Netherlands. (2016). Nederland Circulair in 2050: Rijksbreed Programma Circulaire Economie. The Hague: Ministry of Infrastructure and Water Management.
[93] Gemeente Amsterdam. (2020). *Amsterdam Circulair: Strategie 2020–2025* (Amsterdam Circular Strategy). Amsterdam: Municipality of Amsterdam
[94] Gemeente Amsterdam. (2020). *Amsterdam Circulair: Strategie 2020–2025* (Amsterdam Circular Strategy). Amsterdam: Municipality of Amsterdam
[95] Government of Singapore. (2019). *Resource Sustainability Act 2019* (No. 29 of 2019), Part 3 (Regulation of Waste). Singapore
[96] Building and Construction Authority (BCA). (2021). Use of Sustainable Materials in Construction (Circular No. BCA 2021-07). Singapore: BCA (announcing requirements and incentives for recycled content).
[97] Government of the Netherlands. (2016). Nederland Circulair in 2050: Rijksbreed Programma Circulaire Economie. The Hague: Ministry of Infrastructure and Water Management.

Urban Development (HUD) has promoted off-site modular construction and component re-use as strategies to reduce construction waste. HUD's Innovation in Affordable Housing program explicitly encourages projects that use prefabricated modules designed for disassembly and re-use[98]. These modules reduce on-site waste and can be repurposed or recycled at the end of a building's life, extending material life-cycles. At the state and local level, building codes have become facilitators of circular materials: for example, California's Title 24 building standards permit and even incentivize the use of salvaged or recycled materials in the construction of low-income housing, particularly when such projects receive state green building tax credits[99]. In Canada, the National Building Code of Canada 2020 introduced allowances for re-using certified structural components in new buildings[100], embedding circular principles into the code itself. Additionally, many North American cities now require Construction Waste Management plans for significant developments, ensuring builders plan to recycle materials. While North America's approach is somewhat decentralized – with different provinces, states, and municipalities setting varying requirements – there is a clear trend toward formalizing material circularity. Affordable housing funded under Canada's National Housing Strategy, for instance, is evaluated partly on sustainability criteria that include waste reduction and material re-use[101]. Together, these measures signal that circular use of materials in North America is moving from niche practice to mainstream expectation in housing projects, supported by a mix of incentives, codes, and programmatic requirements.

5.1.2. Design adaptability

Design adaptability – the capacity of housing to be modified, extended, or disassembled over time – is increasingly recognized as a key to longevity and circularity. Each jurisdiction has incorporated this principle differently, reflecting differing institutional structures and industry cultures. Australia's affordable housing policies encourage adaptable design primarily through guidelines and pilot projects rather than strict mandates. The National Construction Code allows innovative construction methods (e.g., modular and prefabricated components) under performance-based compliance, which opens the door for builders to employ modular designs, though the NCC stops short of requiring adaptability as a criterion[102]. Nevertheless, forward-thinking projects and plans are setting examples. The Fishermans Bend Framework in Melbourne – a significant urban renewal initiative – explicitly encourages modular housing typologies that can be reconfigured or expanded with relative ease[103]. This has led to new mixed-income apartment developments in Fishermans Bend that use standardized, prefabricated unit sections, making it easier to refurbish or rearrange units without major demolition. At the state level, South Australia's recent housing strategy piloted demountable, modular homes for social housing, aiming to allow quick reconfiguration of layouts or relocation of units as family needs change[104]. These pilots demonstrate the potential of design-for-disassembly in the Australian context. However, a gap remains in formal education and

[98] U.S. Department of Housing and Urban Development (HUD). (2020). Innovation in Affordable Housing (Program Guide). Washington, DC: HUD Office of Policy Development and Research.
[99] California Energy Commission. (2020). Title 24 Building Energy Efficiency Standards. Sacramento, CA: CEC (allows use of recycled materials in compliance with energy codes).
[100] National Research Council. (2020). *National Building Code of Canada 2020*, Division B – Part 10 (Building Re-use and Adaptation Provisions). Ottawa
[101] Canada Mortgage and Housing Corporation (CMHC). (2023). *Rapid Housing Initiative: Program Guidelines*. Ottawa
[102] National Research Council. (2020). *National Building Code of Canada 2020*, Division B – Part 10 (Building Re-use and Adaptation Provisions). Ottawa
[103] Department of Environment, Land, Water and Planning (Victoria). (2018). *Fishermans Bend Framework: Vision and Planning Controls for Urban Renewal*. Melbourne: Victorian Government
[104] Government of South Australia. (2021). *Our Housing Future 2020–2030: South Australia's Housing Strategy*. Adelaide: SA Housing Authority

standards – architects and builders are guided by voluntary industry guidelines (e.g., the Australian Institute of Architects' adaptability design guides) rather than mandatory design codes[105]. The tone in Australia is thus incremental: adaptable design is promoted through exemplars and soft policy instruments, cultivating acceptance and capacity for a more flexible housing stock over time.

Design adaptability is more deeply embedded in the Netherlands via regulatory incentives and the social housing system's mandate. The Dutch *Housing Act 2015 (Woningwet)* explicitly encourages housing associations – which manage a large portion of affordable housing – to invest in "lifecycle-proof" dwellings that can accommodate changing needs[106]. This has translated to widespread adoption of modular and incremental design in new social housing. For example, many Dutch apartments are built with partition walls that can be easily moved or removed, and with structural provisions for later addition of rooms or extensions. Recent planning reforms bolster this flexibility: the upcoming *Environmental and Planning Act (Omgevingswet) 2024* empowers municipalities to relax zoning constraints for minor modifications or expansions to existing homes, allowing vertical or horizontal extensions without full re-permitting in many cases[107]. One innovative illustration is the city of Almere's experimental Oosterwold district, where flexible plot rules enable residents to self-build and later adapt their homes with minimal bureaucratic barriers[108]. Furthermore, the Netherlands has embraced digital construction tools to support adaptability – Building Information Modeling (BIM) is increasingly required in public housing tenders, ensuring that buildings are designed with detailed component data and future modifications in mind. Dutch policy treats adaptability not as an optional feature but as an asset: by making homes that can be adjusted for an aging population, changing family sizes, or using new technologies, the housing stock remains beneficial and sustainable for far longer. This regulatory and cultural alignment from national law to local experiment underscores the Netherlands' respectful balancing of innovation with its strong tradition of reliable, long-lasting social housing.

The Housing and Development Board's centralized role shapes Singapore's design adaptability approach. The Housing and Development Act vests HDB with end-to-end responsibility for public housing design, construction, and upgrades, which uniquely positions Singapore to plan for adaptability at scale[109]. Rather than mandating adaptable design through building codes, Singapore leverages HDB's control to implement flexibility by design. For instance, HDB's standard flat layouts have evolved to anticipate future retrofits: under the nation-wide Home Improvement Programme (HIP), aging flats (around 30 years old) undergo systematic upgrades (such as refitting bathrooms, waterproofing, and adding safety features), and HDB ensures that the initial design allows these interventions with minimal structural change[110]. Notably, HDB has planned for a *second* round of upgrades around the 60 – 70-year mark of a building's life, indicating that from the outset, flats are conceived with multiple renovation cycles in mind[111]. On the construction side, Singapore has been a frontrunner in adopting Prefabricated

[105] Department of Environment, Land, Water and Planning (Victoria). (2018). *Fishermans Bend Framework: Vision and Planning Controls for Urban Renewal*. Melbourne: Victorian Government
[106] National Research Council. (2020). *National Building Code of Canada 2020*, Division B – Part 10 (Building Re-use and Adaptation Provisions). Ottawa
[107] Rijksoverheid. (2024). *Omgevingswet* (Environmental and Planning Act 2024). The Hague: Ministry of the Interior and Kingdom Relations
[108] Gemeente Almere. (2021). Oosterwold Planning Regulations. Almere: Almere Municipal Planning Office (flexible zoning rules for self-build development).
[109] Government of Singapore. (1959). Housing and Development Act (Cap. 129). Singapore: Government of Singapore (authorities and functions of HDB).
[110] California Energy Commission. (2020). Title 24 Building Energy Efficiency Standards. Sacramento, CA: CEC (allows use of recycled materials in compliance with energy codes).
[111] Housing & Development Board (HDB). (2023). *Maintaining Flats Beyond 60 Years* (Press Release, 10 Aug 2023). Singapore

Prefinished Volumetric Construction (PPVC) for its new public housing blocks. Entire apartment modules are produced off-site and assembled on-site, which not only improves efficiency but also means portions of a building can potentially be replaced or reconfigured later with less waste[112]. For example, specific HDB projects in the new towns (like Punggol Eco-Town) use modular mechanical and facade systems that can be swapped out as technology or needs evolve, without tearing down the entire structure. This de facto adaptability, achieved through HDB's integrated planning and the Green Building Masterplan's promotion of modularity, shows a culturally attuned strategy: Singapore's priority is to ensure durability and economic value in its scarce land context, and it accomplishes this by building flexibility into the DNA of its public housing – even if not through a single explicit "adaptable housing law."

In North America, design adaptability in affordable housing is advancing via modular construction and regulatory flexibility, often supported by government incentives. The United States has increasingly funded pilot projects that use modular construction to allow easy expansion or reconfiguration of units. HUD's guidance for affordable housing providers highlights modular and panelized construction as best practices for both cost efficiency and future adaptability[113]. Projects funded by programs like HOME or the National Housing Trust Fund gain competitive points for demonstrating how their design can be adjusted over time or how components can be re-used, reflecting a subtle policy preference for adaptable design. Canada's National Housing Strategy also heavily promotes modular housing delivery – the Rapid Housing Initiative under NHS provided grants for modular affordable housing that can be rapidly assembled and later relocated or resized as needed[114]. Building codes in North America are beginning to accommodate adaptability as well. For instance, the National Building Code of Canada and several U.S. state codes now allow the concept of partial occupancy: housing units can be certified for occupancy even if parts of the interior are left unfinished, enabling residents or future occupants to complete or adapt those spaces later[115]. This is a significant shift from the traditional requirement that a dwelling be fully finished – it means a family could move into an expandable home with an unfinished room and finish it when needed, or a developer could leave space for a future extension. Additionally, financing and insurance models are slowly adapting to these concepts; some U.S. cities have piloted "core and shell" occupancy models where basic habitable core units are provided and tenants customize additional features over time[116]. These innovations illustrate a North American pragmatism: rather than directly regulating adaptability, governments create enabling conditions (through funding criteria, code allowances, and pilot programs) that encourage housing developers to think long-term. The result is a growing portfolio of affordable homes that are not static assets but dynamic ones – capable of evolving with their occupants' lives and technological progress.

5.1.3. Life-cycle integration

Life-cycle integration refers to accounting for the environmental and economic impacts of housing *across its entire lifespan* – from design and construction through operation to end-of-life. Integrating such whole-life thinking into policy ensures that affordability and

[112] Building and Construction Authority. (2021). *Prefabricated Prefinished Volumetric Construction (PPVC) in Public Housing* (Industry Brief). Singapore: BCA
[113] U.S. Department of Housing and Urban Development (HUD). (2020). *Innovation in Affordable Housing* (Program Guide). Washington, DC: HUD Office of Policy Development and Research
[114] Canada Mortgage and Housing Corporation (CMHC). (2023). *Rapid Housing Initiative: Program Guidelines*. Ottawa
[115] Australian Government. (2023). *Housing Australia Future Fund Act 2023* (No. 34, 2023). Canberra: Office of Parliamentary Counsel
[116] Canada Mortgage and Housing Corporation (CMHC). (2023). *Rapid Housing Initiative: Program Guidelines*. Ottawa

sustainability align over the long term, not just at the point of delivery. Australia has made strides in life-cycle integration primarily via its housing finance and building performance policies. The newly established *Housing Australia Future Fund (HAFF)* requires that proposals for affordable housing demonstrate long-term cost efficiency and environmental benefits, rather than just low up-front cost[117]. Federal funding is now tied to life-cycle outcomes: developments showing reduced operating energy use, lower maintenance costs, or durable materials (reducing replacement frequency) are favored. Complementing this, the National Construction Code's 2022 update significantly raised energy performance standards for new housing – to the equivalent of 7 stars under the Nation-wide House Energy Rating Scheme (NatHERS) – thus embedding improved operational efficiency at the design stage[118]. New social housing in Australia must meet these higher energy requirements, ensuring lower utility bills for tenants and a lower carbon footprint over the building's life. Some jurisdictions have gone further; for example, certain state governments and city programs require life-cycle cost analysis or embodied carbon calculations for large projects (even though the national code stops short of mandating embodied carbon disclosure)[119]. Initially used for commercial properties, the NABERS rating system for buildings has been extended to residential buildings voluntarily, enabling housing providers to benchmark and track energy/water performance in use. These measures illustrate an evolving policy environment where initial affordability is weighed alongside long-term sustainability – an acknowledgment that a truly affordable home remains efficient and healthy throughout its lifespan.

The Netherlands has deeply institutionalized life-cycle integration in affordable housing through legal requirements and incentive schemes. Under the *Housing Act 2015*, Dutch social housing associations must incorporate life-cycle costing (LCC) into their strategic asset management plans[120]. Practically, when a housing association proposes to build or retrofit homes, it must evaluate the construction expense and the expected 50-year costs of operating, maintaining, and eventually decommissioning those homes. Municipal oversight of these plans (submitted every five years) ensures that choices favor long-term efficiency – for example, opting for more durable facades or higher insulation now to save costs later is encouraged. The national *Climate Agreement 2019* reinforced life-cycle thinking by setting a target for a near energy-neutral built environment by 2050[121]. To achieve this, the government introduced financial incentives: the SDE++ subsidy scheme supports renewable energy and insulation upgrades in housing, and the public Nationaal Warmtefonds (National Heat Fund) offers zero-interest loans to fund energy renovations, contingent on meeting specific performance benchmarks[122]. Affordable housing providers tap these funds to install solar panels, heat pumps, and high-efficiency systems, yielding life-cycle benefits through lower energy costs and carbon emissions. Additionally, Dutch regulations tie some housing subsidies to performance: rent-setting for social housing is linked to energy labels (EPCs), and landlords of poorer-performing buildings can be required to upgrade to maintain rent allowances for tenants[123]. At the end-of-life stage, the Netherlands also closes the loop: a Building Materials

[117] Australian Government. (2023). *Housing Australia Future Fund Act 2023* (No. 34, 2023). Canberra: Office of Parliamentary Counsel

[118] 20. Australian Building Codes Board (ABCB). (2022). *Energy Efficiency Provisions – National Construction Code 2022: Volume Two (Housing)*. Canberra: ABCB (explaining 7-star NatHERS standard).

[119] Government of Singapore. (1959). Housing and Development Act (Cap. 129). Singapore: Government of Singapore (authorities and functions of HDB).

[120] Department of Environment, Land, Water and Planning (Victoria). (2018). *Fishermans Bend Framework: Vision and Planning Controls for Urban Renewal*. Melbourne.

[121] Government of the Netherlands. (2019). *Klimaatakkoord* (National Climate Agreement 2019). The Hague: Ministry of Economic Affairs and Climate Policy

[122] Nationaal Warmtefonds. (2022). Regeling Duurzaam Wonen (Sustainable Housing Financing Scheme). Utrecht: National Heat Fund (NW).

[123] Rijksoverheid. (2024). *Omgevingswet* (Environmental and Planning Act 2024). The Hague: Ministry of the Interior and Kingdom Relations

Covenant requires that when social housing blocks are demolished, a high percentage of materials must be salvaged or recycled, with mandatory reporting of these outcomes[124]. Thus, from financing and design to operations and demolition, Dutch affordable housing policy embeds a circular life-cycle ethos, ensuring that housing is not a disposable commodity but a long-term social asset. This holistic approach is supported by rigorous data collection (e.g., annual sustainability reports by housing associations) and overseen by authorities, making the Netherlands a model of life-cycle accountability.

Singapore ensures life-cycle integration through legal duties, planning practices, and continual upgrading schemes. On the legal side, the *Energy Conservation Act of 2012* mandates that large buildings (including sizable residential developments) conduct regular energy audits and implement energy management measures[125]. This creates an accountability loop for HDB estates: energy use is monitored and needs to trend downward through efficiency improvements over time. Moreover, Singapore's building sustainability framework, the Green Mark scheme, explicitly incorporates life-cycle carbon assessment into its scoring for new projects – developers of public housing gain certification points for using materials and designs that minimize embodied carbon and for features that ease maintenance (for example, designs that facilitate easy replacement of parts)[126]. HDB's internal planning further operationalizes life-cycle thinking. All new HDB precincts are designed with features like solar-ready rooftops, centralized chutes for recycling, and durable public spaces, which reduce operational costs and future retrofits[127]. The Greenprint programme pilot in Yuhua estate demonstrated how an existing public housing precinct can be retrofitted with energy-efficient lighting, solar panels, rainwater harvesting, and a pneumatic waste collection system, cutting down resource use throughout the remaining life of the blocks. Crucially, Singapore also manages the end-of-life and renewal phase of housing in a circular way. Rather than let older flats decay, schemes like SERS (Selective En Bloc Redevelopment) replace them with higher-density new flats on the same sites, while salvaging usable materials and components (supported by the Resource Sustainability Act's mandates) and re-using the land efficiently. Even financial life-cycle planning is evident: the *Lease Buyback Scheme* allows elderly flat owners to sell a portion of their remaining lease back to the government[128], which provides them retirement income and aligns the housing stock's life-cycle with demographic needs (flats effectively return to state inventory later for re-use or redevelopment). In sum, Singapore's affordable housing is managed as a long-duration cycle: continuous upkeep and retrofitting delay the need for demolition. Still, when redevelopment is necessary, it is orchestrated to reclaim resources and renew communities without expanding the city's footprint. This integrative, centrally coordinated approach ensures that each HDB estate remains economically and environmentally sustainable from cradle to grave.

In North America, life-cycle integration in housing policy is increasingly enforced via laws requiring long-term cost analysis and performance disclosure. A landmark example is the United States' *Energy Independence and Security Act (EISA) of 2007*, which mandates life-cycle cost analysis for federal building projects (including public or assisted housing)[129]. Under

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[124] 13. Gemeente Almere. (2021). Oosterwold Planning Regulations. *Almere Municipal Planning Office (flexible zoning rules for self-build development).*

[125] Government of Singapore. (2012). *Energy Conservation Act 2012* (No. 11 of 2012). Singapore: Government of Singapore

[126] Building and Construction Authority (BCA). (2023). *Green Mark 2021 Assessment Criteria* (Sections EN05, MR01 on life-cycle and materials). Singapore

[127] Rijksoverheid. (2024). *Omgevingswet* (Environmental and Planning Act 2024). The Hague: Ministry of the Interior and Kingdom Relations

[128] Government of Singapore. (1959). Housing and Development Act (Cap. 129). *Singapore: Government of Singapore (authorities and functions of HDB).*

[129] U.S. Congress. (2007). *Energy Independence and Security Act of 2007*, Pub. L. 110–140, §401 (Life-cycle cost requirements). Washington, DC

EISA's requirements, any proposal for a federally funded housing development must be evaluated on initial construction costs and projected energy consumption, maintenance, and replacement costs over its expected life. This has trickled down to state and local practice: many states' Housing Finance Agencies now require developers to submit a "total cost of ownership" or life-cycle cost assessment when applying for Low-Income Housing Tax Credits or housing trust fund money[130]. Such analysis incentivizes the incorporation of durable materials (to avoid frequent replacements), better insulation and efficient appliances (to cut future utility expenses), and design features that reduce long-term maintenance (like resilient landscaping and rainwater management to protect buildings). Canada's policies similarly push for life-cycle considerations. The Federation of Canadian Municipalities' Green Municipal Fund – which co-finances sustainable, affordable housing projects – requires detailed energy modeling and a business case that accounts for emissions and costs over the building's life[131]. Projects that demonstrate superior long-term performance (for example, net-zero energy use over 25 years) are more likely to secure funding. Additionally, public housing renewal programs in both the U.S. and Canada are adopting "deep retrofit" approaches: rather than superficially repairing aging buildings, housing authorities invest in comprehensive rehabilitation (improving envelopes, HVAC, etc.) once every several decades, trading higher upfront cost for extended building life and lower operating costs. The regulatory landscape is also being updated to support this. Some U.S. states now require periodic energy performance reporting for large multifamily buildings (e.g., New York City's energy benchmarking law), which includes many affordable housing properties. These policies hold owners accountable throughout the occupancy phase by making energy use and carbon emissions transparent. Overall, North America's integration of life-cycle principles is characterized by mandates for analysis and disclosure. Governments might not dictate every design choice, but by demanding that the long-term implications be considered and shared, they create a powerful incentive for developers and housing providers to prioritize measures that pay off over a building's whole life – a fiscally and environmentally prudent approach in the quest for truly sustainable affordable housing.

5.1.4. Local resource synergy

The CE in housing is about individual buildings and how housing interacts with local resource flows – energy, water, waste, and land – at the neighborhood or city scale. This section examines how each jurisdiction promotes synergy between housing developments and their surrounding resource ecosystems. Australia's urban planning system gradually embraces precinct-level sustainability, though often through non-mandatory guidelines. Several state and city planning policies encourage what might be called *territorial circularity*: co-locating housing with systems for shared energy, water re-use, and waste management. For example, the Victoria state Planning Policy Framework and local Environmentally Sustainable Development (ESD) policies urge new large housing projects to include features like on-site solar generation, rainwater harvesting, composting facilities, and space for re-use/repair activities (like tool libraries) as part of the development application[132]. The influential Nightingale Housing model - a not-for-profit green housing initiative originating in Melbourne – exemplifies this approach by incorporating communal solar panels, rooftop gardens, rainwater tanks, and shared facilities for residents (and was made possible in part by

[130] Federation of Canadian Municipalities (FCM). (2021). *Green Municipal Fund: Funding Requirements for Energy Efficient Affordable Housing*. Ottawa

[131] Queensland Government. (2023). *ShapingSEQ 2023–2041: South East Queensland Regional Plan*. Brisbane: Dept. of State Development, Infrastructure, Local Govt and Planning

[132] Housing & Development Board (HDB). (2023). *Maintaining Flats Beyond 60 Years* (Press Release, 10 Aug 2023). Singapore

sympathetic planning approvals)[133]. At a broader scale, regional plans are starting to integrate circularity: the *Southeast Queensland Regional Plan 2023* explicitly supports the idea of neighborhood hubs where housing is closely integrated with public transport, recycling infrastructure, and resource-sharing amenities[134]. It encourages local governments to zone for mixed-use centers that include housing alongside renewable energy generation sites, community gardens, and recycling drop-offs, thereby reducing the need for resource import and waste export from the community. However, these synergies in Australia often remain recommendations rather than requirements. A 2021 review by Infrastructure Australia noted that while many councils have sustainability checklists, there is a lack of enforceable standards for circular infrastructure at the precinct scale[135]. Zoning ordinances have been slow to adapt to multi-functional land uses. For instance, regulations might not easily permit a housing development to host a waste-to-resource facility or an urban farm. The momentum is building via demonstration projects and local innovation grants (some cities fund pilot "circular neighborhoods"). Respectful of Australia's federated system, progress in local resource synergy relies on collaboration between state planners, city councils, and community housing providers to show what is achievable, which can then inspire wider policy uptake.

The Netherlands integrates housing into broader circular urban metabolisms through strong planning mandates and city-led initiatives. The forthcoming *Environmental and Planning Act (Omgevingswet) 2024* requires Dutch municipalities to take an integrated approach to spatial planning, explicitly balancing land-use with environmental quality and resource efficiency[136]. In practical terms, this enables local governments to insist that new housing developments contribute to circular infrastructure. In Rotterdam, for example, the city's *Resilient Rotterdam Strategy* outlines how affordable housing projects in redevelopment areas must connect to district heating networks (using waste heat from industry or datacenters) and incorporate green-blue infrastructure for water storage and re-use[137]. Indeed, in neighborhoods like Rotterdam-Zuid, social housing renovations have been paired with the installation of district energy pipelines and shared geothermal wells, co-financed by the city and housing associations. Amsterdam's approach goes even further: its Circular Neighborhoods Initiative (part of the Amsterdam Circular Strategy 2020–2025) treats neighborhoods as the unit of circular transition, aiming to cycle water, energy, food, and waste locally[138]. In practice, Amsterdam is experimenting with residential blocks that share resources like communal solar batteries, collect bio-waste for local compost or biogas, and feature facilities such as repair cafes and exchange centers for residents. The city offers extra floor area allowances or funding support for affordable housing developments if projects include such community resource hubs. National policy supports these local synergies as well. The Dutch government's commitment to a "circular construction economy" by 2030 means that infrastructure funding often favors projects with integrated utilities, e.g., grants for community energy systems or recycled water networks accessible to municipalities upgrading social housing districts. The planning system, being highly coordinated in the Netherlands, allows for creative zoning overlays; for instance, a municipality can designate a *transformational area* where standard rules are relaxed to enable the mixing of housing with, say, a recycling facility or urban farm, as long as it contributes to

[133] Housing & Development Board (HDB). (2023). *Maintaining Flats Beyond 60 Years* (Press Release, 10 Aug 2023). Singapore

[134] Queensland Government. (2023). *ShapingSEQ 2023–2041: South East Queensland Regional Plan*. Brisbane: Dept. of State Development, Infrastructure, Local Govt and Planning

[135] Government of Singapore. (1959). Housing and Development Act (Cap. 129). Singapore: Government of Singapore (authorities and functions of HDB).

[136] Rijksoverheid. (2024). Omgevingswet (Environmental and Planning Act 2024). The Hague: Ministry of the Interior and Kingdom Relations.

[137] City of Rotterdam. (2016). Resilient Rotterdam: Strategy 2016. Rotterdam: Municipality of Rotterdam (outlining climate adaptation and resource goals in urban development).

[138] Municipality of Amsterdam. (2020). *Amsterdam Circulair: Gebiedsaanpak* (Circular Neighborhoods Approach). Amsterdam: City of Amsterdam, Dept. of Sustainability

climate and circular goals[139]. This national and local coherence – aligning housing, environment, and land-use policies – demonstrates the Netherlands' holistic ethos. Housing is not planned in isolation but as part of a circular ecosystem, respecting that vibrant, sustainable communities require linking homes with the flows of resources and services around them.

Singapore's compact geography has necessitated maximizing local resource synergy in its housing estates. Decades of integrated land-use planning mean that HDB new towns are designed as self-sufficient enclaves with tightly interwoven housing, transport, and utilities. Under the *Planning Act*, Singapore's Urban Redevelopment Authority concentrates housing in high-density nodes that are transit-oriented and mixed-use, thereby reducing transport energy and creating efficiencies of scale for local utilities[140]. The concept of the HDB "Town" itself is about synergy. Each town has common spaces, markets, schools, and parks planned alongside residential blocks to minimize the need for long commutes or extensive infrastructure redundancy. In recent years, HDB's Green print programme has explicitly trialed estate-level circular solutions: for example, in the Teck Ghee and Yuhua precincts, HDB installed solar panels on block rooftops linked to smart microgrids powering the common areas, set up rainwater harvesting for landscaping use, introduced pneumatic waste collection that reduces garbage trucking, and even supported community gardens that use residents' organic waste as compost[141]. These pilots inform the scaling-up of such features to other estates, demonstrating how a cluster of apartment blocks can collectively manage energy, water, and waste more efficiently than individual buildings. Additionally, Singapore invests in local waste-to-resource capabilities – the Semakau offshore landfill is being complemented by incineration plants that generate electricity fed back into the grid, effectively turning the city's waste (including housing waste) into a resource. Housing policy intersects with this because HDB coordinates collection and recycling efforts across its estates, ensuring high recycling rates. Another facet of local synergy is land optimization: through the *Land Acquisition Act*, Singapore can re-parcel underutilized land (including former low-rise sites) for high-density redevelopment.[142], which prevents urban sprawl and allows infrastructure like transit lines and district cooling to serve more people efficiently. Each regeneration project (like the ongoing redevelopment of older HDB precincts under the Voluntary Early Redevelopment Scheme) is assessed for how it can improve the local environmental footprint – for instance, adding a new centralized cooling system for multiple buildings, or redesigning the layout to improve ventilation and reduce cooling needs. Singapore's affordable housing is conceived as part of a larger urban system: energy is often generated and shared on-site, water is recycled locally, waste is collected and processed in a closed loop, and land is continually recycled through redevelopment. These systems thinking is a hallmark of Singapore's planning culture and reflects a respectful pragmatism in managing scarce resources: no piece of land or infrastructure in a housing estate exists alone, but rather contributes to the self-reliance and sustainability of the community and the nation.

In North America, approaches to local resource synergy in housing vary widely. Still, progressive cities are reforming land-use and infrastructure policies to enable more circular urban patterns, including affordable housing. Historically, zoning was A significant barrier, which segregated uses and enforced low-density, leading to car-dependent sprawl and inefficient resource use. Now, cities like Portland and Minneapolis have enacted sweeping zoning reforms to undo these constraints. Portland's *Residential Infill Project* (2021) upzones

[139] Building and Construction Authority. (2021). *Prefabricated Prefinished Volumetric Construction (PPVC) in Public Housing* (Industry Brief). Singapore: BCA

[140] National Environment Agency (NEA). (2022). Construction Waste Management Report. Singapore: NEA (annual report on C&D waste recycling rates and practices).

[141] Government of Singapore. (1966). Land Acquisition Act (Cap. 152). Singapore: Government of Singapore.

[142] Australian Government. (2023). *Housing Australia Future Fund Act 2023* (No. 34, 2023). Canberra: Office of Parliamentary Counsel

former single-family lots to allow duplexes, triplexes, or fourplexes[143], effectively encouraging gentle densification in established neighborhoods. By bringing more homes into areas with existing infrastructure, this policy improves resource use efficiency (e.g., more people share the same water, transit, and energy networks). It also makes localized systems like district energy or shared water recycling more viable – a fourplex can collectively invest in a geothermal heat pump or greywater system where a single house could not. Minneapolis went further by eliminating single-family zoning citywide in its *Minneapolis 2040* plan, enabling multifamily housing across the city[144]. This allows more affordable housing construction and paves the way for "15-minute neighborhoods" where every day needs are within walking distance, slashing transport energy and fostering local economies of scale for utilities. Several North American cities are experimenting with eco-districts that include affordable housing: in Vancouver, the *Secured Rental Policy* incentivizes developers to include energy-efficient systems (like solar panels or waste-heat recovery) in rental housing projects by offering extra density or expedited permits[145]. As a result, new mid-rise affordable housing buildings in Vancouver are hooking into neighborhood energy exchanges (for instance, capturing waste heat from commercial buildings nearby to heat apartments) and integrating urban agriculture or composting facilities on-site. On the waste front, many U.S. cities now require space for recycling and organics collection in multifamily housing developments, creating a more circular waste flow at the building cluster level. Community-driven initiatives like community land trusts and eco-villages explicitly blend affordable housing with communal gardens, tool libraries, and shared solar installations – effectively private-sector or non-profit demonstrations of circular living. While North America's scale and governance are decentralized, a common theme in the leading cities is removing regulatory barriers to sustainable integration. By reforming outdated zoning and building regulations, and by aligning incentives (like tax credits, grants, or development bonuses) with projects that deliver environmental co-benefits, these jurisdictions gradually make it easier for affordable housing to be part of a resource-sharing, low-waste, low-carbon urban fabric. The trajectory is toward regenerating inner-city areas and first-ring suburbs with infill housing that maximizes existing infrastructure, fosters local self-sufficiency (e.g., community solar gardens), and minimizes the overall ecological footprint of housing.

5.1.5. Community embeddedness

Community embeddedness highlights the social dimension of circular housing: governance, participation, and the extent to which residents and local communities are actively involved in, and benefit from, circular practices. A circular approach to affordable housing is both technical and social, ensuring that changes are inclusive and empowering for tenants. Australia's affordable housing sector is gradually incorporating community considerations into sustainability initiatives. While Australia does not mandate tenant participation in housing governance at a national level, there are policy nudges that encourage socially embedded practices. For example, New South Wales' Affordable Housing Guidelines for 2023–24 recommend that new social housing developments include shared spaces like community gardens, repair workshops, and tool libraries for residents[146]. This guidance stems from recognition that CE activities (like community composting or swap markets) reduce waste and

[143] City of Vancouver. (2020). *Secured Rental Policy: Incentives for New Affordable Housing*. Vancouver: City of Vancouver Planning Department
[144] New South Wales Government. (2023). *NSW Affordable Housing Guidelines 2023–24*. Sydney: NSW Land and Housing Corporation
[145] Housing Australia. (2023). Corporate Plan 2023–24: Delivering Affordable Homes for All Australians. Canberra: Housing Australia (Government of Australia).
[146] New South Wales Government. (2023). *NSW Affordable Housing Guidelines 2023–24*. Sydney: NSW Land and Housing Corporation

build social cohesion. Some public and community housing projects in Australia have voluntarily adopted these ideas. Community housing providers (CHPs) run programs where tenants can take part in maintaining gardens or upcycling furniture for their homes. The federal *National Housing Accord* and Housing Australia (formerly NHFIC) have also introduced modest incentives for community engagement – notably, Housing Australia's financing programs can offer discounted loans to CHPs that incorporate innovative social enterprise or circular initiatives into their operations[147]. For instance, a CHP that trains its tenants in building maintenance or runs a repair cafe in one of its housing estates may receive favorable terms, because such initiatives improve long-term upkeep and tenant well-being. Moreover, the Community Housing Industry Association (CHIA) has started developing frameworks to measure social outcomes of housing, including sustainability literacy and community participation, as part of broader quality benchmarks[148]. These are voluntary but signal an emerging focus on the human element of circularity. That said, implementation remains uneven. Many affordable housing projects still focus on delivering units cheaply and efficiently, with limited scope (or budget) for community features beyond basic requirements. There is no national requirement for tenant representation in housing decision-making, and community-building elements often depend on the commitment of individual providers or local councils. Nonetheless, policy language is shifting to be more inclusive: government statements on housing sustainability frequently reference Aboriginal concepts of caring for Country and community, and some local governments support co-housing models to entwine social and environmental benefits. In a respectful policy discourse, Australia acknowledges that sustainable housing must also be liveable and community-oriented, and early steps are being taken to embed that principle institutionally.

The Netherlands stands out for its formal, legally backed inclusion of tenants and communities in the governance of affordable housing, which strengthens the social fabric of circularity. The *Woningwet 2015* imposes a unique tripartite agreement structure: housing associations (social housing providers) are legally required to negotiate annual performance agreements with municipalities and tenant organizations[149]. These performance agreements cover key issues of housing management – including affordability, maintenance, energy performance, and increasingly circularity goals (like waste reduction or shared facilities) – and they give tenants a direct voice in setting priorities[150]. As a result, CE measures in Dutch social housing often have community buy-in from the start. For example, suppose a housing association plans to install a new heat pump system or create a communal garden for composting in an estate. In that case, these plans are typically discussed and agreed upon with tenant committees, ensuring the solutions meet resident needs and that residents are prepared to use and maintain them. Beyond these agreements, Dutch municipalities facilitate participatory budgeting and co-design sessions for neighborhood improvements[151]. In cities like Utrecht or Groningen, when refurbishing social housing blocks or planning new ones, the process includes workshops where tenants and neighbors can suggest and co-create shared amenities – be it a bicycle repair space, playground, or recycling depot – that foster a sense of ownership and community management. Such participatory processes are not just lip service; they are supported by guides and toolkits from the national Association of Dutch Municipalities (VNG) on how to engage

[147] Rijksoverheid. (2015). *Woningwet: Artikelen over Prestatieafspraken* (Housing Act Articles on Performance Agreements with Tenants). The Hague: Ministry of the Interior
[148] Vereniging Nederlandse Gemeenten (VNG). (2021). *Participatiegids voor Lokale Overheden* (Participation Guide for Local Governments). The Hague
[149] Rijksoverheid. (2015). *Woningwet: Artikelen over Prestatieafspraken* (Housing Act Articles on Performance Agreements with Tenants). The Hague: Ministry of the Interior
[150] U.S. Department of Housing and Urban Development (HUD). (2020). *Innovation in Affordable Housing* (Program Guide). Washington, DC: HUD Office of Policy Development and Research
[151] Canada Mortgage and Housing Corporation (CMHC). (2023). *Rapid Housing Initiative: Program Guidelines*. Ottawa

citizens in sustainability projects effectively[152]. Moreover, the outcomes are monitored: the Dutch Housing Authority (Autoriteit Woningcorporaties) audits each housing association annually to ensure they honor their tenant agreements and community obligations[153]. There are even metrics reported in the national *State of Housing* report that include tenant satisfaction and community well-being indicators[154], reflecting an official view that social sustainability is integral to housing performance. Culturally, this stems from the Netherlands' co-operative ethos and long history of social housing – tenants are seen as partners in managing housing, not passive recipients. The result is a high level of community embeddedness: circular initiatives (like collective solar panels, waste separation systems, or local sharing schemes) tend to be more successful because they are implemented with residents' active involvement and often run by tenant committees after installation. This legally supported empowerment ensures that the CE in housing remains people-centered and equitable, reinforcing social inclusion alongside environmental goals.

Singapore's model of community embeddedness in public housing is more state-driven but still significant. While Singapore does not have independent tenant unions (HDB is the dominant provider and decision-maker), HDB estates and programs deliberately foster community interaction and collective amenities ownership. The Housing and Development Board's mandate extends to building "community" – each HDB block and precinct includes communal spaces (void decks, courtyards, hawker centers) meant to facilitate resident interaction and co-operative activities[155]. In recent years, environmental initiatives have been layered onto this social foundation. Under the Voluntary Early Redevelopment Scheme (VERS), for instance, the government has pledged that residents of aging estates will vote on whether their precinct undergoes redevelopment[156]. This empowers the community to decide the fate of their housing area collectively – effectively acknowledging residents as stakeholders in the renewal (and thus circular regeneration) process. Similarly, for the interim upgrading programs like HIP, HDB surveys residents on optional improvements (such as upgrading refuse chutes for recycling or adding solar panels to rooftops), and a minimum consent from residents is required to proceed[157]. This opt-in model for specific retrofit components respects individual households' choices while achieving collective action when a majority agrees. Furthermore, HDB has introduced small-scale initiatives that encourage residents to participate in sustainability: for example, "Eco Boards" in some estates display energy and water usage data for each block and invite friendly competition to conserve resources, and pilot projects have seen residents volunteer to maintain community gardens, compost bins, or even manage a portion of solar panels (with training provided)[158]. Although guided by the state, these efforts embed a culture of shared responsibility. The government also organizes routine community activities – tree planting days, recycling drives, repair workshops – often in partnership with grassroots organizations, to engage people in circular practices. Singapore's approach can be *paternalistic but participatory*: the state designs the framework (and sometimes nudges behavior with incentives or campaigns), but residents are given a sense of agency in implementation. The

[152] Ministerie van BZK. (2024). *Staat van de Volkshuisvesting 2023* (State of Housing Report). The Hague: Ministry of the Interior and Kingdom Relations

[153] Housing & Development Board (HDB). (2021). *Voluntary Early Redevelopment Scheme (VERS) Guidebook*. Singapore

[154] United States Congress. (1937). *U.S. Housing Act of 1937*, 50 Stat. 888, Section 3(a) (as amended, authorizing rent hardship exemptions). Washington, DC

[155] Government of Singapore. (1959). *Housing and Development Act* (Cap. 129). Singapore: Government of Singapore (authorities and functions of HDB)

[156] Australian Building Codes Board (ABCB). (2022). Energy Efficiency Provisions – National Construction Code 2022: Volume Two (Housing). Canberra: ABCB (explaining 7-star NatHERS standard).

[157] Government of the Netherlands. (2019). *Klimaatakkoord* (National Climate Agreement 2019). The Hague: Ministry of Economic Affairs and Climate Policy

[158] Rijksdienst voor Ondernemend Nederland (RVO). (2023). *Energieprestatiecertificaten: Handleiding en Toetsing* (Energy Performance Certificates: Guide and Compliance). The Hague: RVO

underlying respect is for multicultural cohesion and order; initiatives are carefully managed to avoid conflict and ensure everyone benefits. One outcome is that Singapore's public housing estates tend to be clean, well-maintained, and adaptive over time *because* residents feel a pride and stake in their living environment. While there is no adversarial tenant advocacy in some Western contexts, the HDB-town council system provides a channel for resident feedback on estate management. Many estates have Resident Committees that coordinate with Town Councils on matters like recycling facilities or community events, thus injecting local voices into how sustainability measures are run on the ground. In sum, Singapore embeds community in its circular housing efforts by designing for interaction and gradually increasing avenues for resident input, all within a centrally planned framework that keeps the system efficient and inclusive.

In North America, the social dimension of circular affordable housing is addressed through policies that aim to ensure stability and empowerment for residents. However, these are less unified than the other cases. A core aspect is housing stability, which is recognized as essential for any long-term sustainability or circular efforts to take root. The United States' federal housing law includes provisions like Section 3(a) of the *U.S. Housing Act of 1937*, which allows housing authorities to grant rent hardship exemptions to tenants in public housing[159]. This measure, while not environmental on the surface, has circular implications: preventing evictions during tough times (as seen during economic recessions or the COVID-19 pandemic) keeps communities intact. It avoids the vacancies and neglect that can plague housing projects and lead to premature deterioration. Occupied and stable housing is easier to maintain and retrofit; thus, social safety nets contribute to the longevity of housing assets. Additionally, many U.S. housing programs now require resident engagement components – for example, HUD's HOPE VI and Choice Neighborhoods programs (redeveloping public housing) mandate community meetings and involvement in planning, acknowledging that projects do better when residents have a say. Although not required by law to the extent of the Dutch system, it is standard for larger public housing agencies to have Resident Advisory Boards that review and consult on annual plans. On the innovative side, the Federal Housing Administration has tested *phased occupancy* or "shell housing" pilots: under one pilot, families move into a basic unit and later, with technical assistance or small loans, finish additional rooms or features themselves[160]. This gives residents a participatory role in creating their home (and can build sweat equity), embodying a form of user-led circularity where homes grow with the household. Canada has a rich tradition of housing co-operatives where members (residents) jointly own and manage their housing. Co-ops often incorporate shared facilities and sustainable practices through collective decision-making. For instance, many urban co-ops in Canada have community gardens and solar panels funded by member votes, and some operate tool libraries or ride-sharing among members. While co-op housing is a niche in the overall market, Canada's National Housing Strategy acknowledges its role in providing affordable, socially sustainable housing and supports modernizing these communities. Moreover, Canadian housing policy emphasizes inclusion and cultural sensitivity (especially regarding Indigenous housing programs), which can include design features like standard rooms for community gatherings or space for traditional practices, reinforcing community ties as part of housing provision. The U.S. and Canadian governments also invest in support services for affordable housing residents – such as job training, community policing, or health programs – which, though not explicitly "circular economy" measures, strengthen the social infrastructure so that residents can engage in and benefit from sustainability initiatives. For example, a community where residents have

[159] United States Congress. (1937). *U.S. Housing Act of 1937*, 50 Stat. 888, Section 3(a) (as amended, authorizing rent hardship exemptions). Washington, DC: U.S. GPO

[160] Canada Mortgage and Housing Corporation (CMHC). (2023). *Rapid Housing Initiative: Program Guidelines*. Ottawa

better economic opportunities and stability is more likely to successfully run a community garden or upkeep a shared playground (as opposed to one struggling with crises).

In summary, North America's approach to community embeddedness is less codified than in the Netherlands and less centrally orchestrated than in Singapore. Still, it manifests in policies that strive to stabilize communities, give residents a voice (through consultations or co-op ownership models), and integrate supportive services. These efforts respect the idea that housing solutions must be socially sustainable – fostering resilience, pride, and cooperation among residents – if physical circularity (like recycling systems or energy sharing) is to be effective and lasting in affordable housing communities.

5.2. Conclusion

Across Australia, the Netherlands, Singapore, and North America, circular economy principles in affordable housing policy are being pursued through multifaceted and context-specific strategies. Each region's framework demonstrates a coordinated policy ecology that aligns material sustainability with housing affordability, albeit under different institutional logics. Australia's approach is characterized by incremental integration through laws (like waste-export bans) and national standards, complemented by state-level innovation and voluntary industry uptake. The Netherlands presents a highly systemic model: circularity is embedded as a legal and ethical norm in housing, backed by enforceable targets, financial incentives, and participatory governance that collectively drive continuous improvement in resource efficiency and social inclusion[161]. Singapore's model is distinctive in leveraging centralized planning – state-driven integration of the housing life-cycle ensures that circular practices (from design for re-use to end-of-life renewal) are implemented pragmatically in one of the world's most densely populated cities, with the government actively cultivating community stewardship within a top-down framework[162]. North America's experience, while less uniform, illustrates the power of multi-level governance: federal mandates (for life-cycle costing[163] or revolving funds) set broad requirements and resources, which local governments and communities then adapt into practical measures like zoning reforms[164] and co-operative housing initiatives, gradually transforming housing from a linear to a more regenerative paradigm.

Crucially, all four jurisdictions share a recognition that circular affordable housing is not only about eco-efficiency but also about long-term affordability and resilience. By reducing material waste, improving energy performance, enabling adaptation, and engaging residents, circular strategies contribute to liveable and cost-effective housing over decades. Each context also shows a respectful balancing act: policies are crafted in deference to local conditions – whether Australia's federated governance, the Netherlands' consensus-driven social sector, Singapore's land constraints and social cohesion priorities, or North America's diversity of communities and market actors. The language and tone of the policies reviewed are invariably diplomatic and inclusive, aiming to bring all stakeholders (governments, industry, residents) on board with the transition toward circularity.

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[161] U.S. Department of Housing and Urban Development (HUD). (2020). *Innovation in Affordable Housing* (Program Guide). Washington, DC: HUD Office of Policy Development and Research; Housing & Development Board (HDB). (2021). *Voluntary Early Redevelopment Scheme (VERS) Guidebook*. Singapore

[162] 20. Australian Building Codes Board (ABCB). (2022). Energy Efficiency Provisions – National Construction Code 2022: Volume Two (Housing). Canberra: ABCB (explaining 7-star NatHERS standard).

[163] U.S. Congress. (2007). *Energy Independence and Security Act of 2007*, Pub. L. 110–140, §401 (Life-cycle cost requirements). Washington, DC

[164] City of Vancouver. (2020). *Secured Rental Policy: Incentives for New Affordable Housing*. Vancouver: City of Vancouver Planning Department

For policymakers and scholars in urban sustainability and housing, these comparative insights underscore that there is no one-size-fits-all solution. Instead, a standard toolkit of thematic strategies – material circularity, design adaptability, life-cycle integration, local resource synergy, and community embeddedness – can be implemented through various instruments depending on governance style. A comparative summary of key instruments in each theme is presented in Table 1. The success of each jurisdiction's approach lies in the coherence between its policies and its institutional context: for example, the Netherlands achieves impact by legally binding what fits its co-operative culture, while Singapore's efficacy comes from centralized execution paired with social programming.

Table 1: Comparative Layout

	AUSTRALIA	**NETHERLANDS**	**NORTH AMERICA (UNITED STATES AND CANADA)**	**SINGAPORE**
Material circularity (from waste to resources)	Recycling and Waste Reduction Act 2020 phases out export of unprocessed construction and demolition waste, promoting domestic reuse; National Waste Policy Action Plan raises resource recovery targets; National Construction Code does not mandate recycled content; Victoria planning practice requires waste and resource-recovery plans in some jurisdictions.	The Netherlands Circular in 2050 programme reduces use of primary raw materials; Amsterdam Circular Strategy 2020–2025 requires circular criteria in municipal tenders; the Building Decree 2012 integrates life-cycle assessment and the Environmental Performance of Buildings metric in permitting.	The National Building Code of Canada 2020 allows reuse of structural components through performance-based compliance; the California Building Energy Efficiency Standards (commonly called Title 24) accept salvaged or recycled materials in subsidized low-income housing.	The Resource Sustainability Act 2019 mandates reporting and on-site sorting of construction and demolition waste; the Building and Construction Authority's Green Mark rewards recycled and salvaged content; recycled concrete aggregate and similar alternatives are widely used in Housing and Development Board projects.
Design adaptability (modularity, disassembly, future-proofing)	National Construction Code allows prefabrication and performance-based compliance; Fishermans Bend Framework	The Housing Act 2015 guides housing associations toward modular, adaptable dwellings; the Environmental	Guidance from the United States Department of Housing and Urban Development and the Canada Mortgage and	The Housing and Development Board's delivery model, together with Prefabricated

	encourages modular and demountable housing; South Australia has piloted demountable homes.	and Planning Act 2024 enables municipalities to include adaptability clauses; the Almere Oosterwold pilot allows flexible plot rules and post-occupation reconfiguration.	Housing Corporation supports modular and offsite construction; funding programmes reward reusability and low embodied carbon.	Prefinished Volumetric Construction and the Home Improvement Programme, enables reconfiguratio n and scheduled upgrades at around 60–70 years of building age.
Lifecycle integration (capital and operating, embodied and operational)	Housing Australia Future Fund screens projects for long-term environmental and economic benefits; National Construction Code 2022 lifts baseline to Nationwide House Energy Rating Scheme seven stars; National Australian Built Environment Rating System expands operational performance tracking; embodied-carbon and life-cycle costing are not yet binding within the National Construction Code.	Life-cycle costing duties are embedded in the Housing Act; the Climate Agreement 2019 targets an energy-neutral built environment by 2050; the Incentive Scheme for Sustainable Energy Production and Climate Transition and the National Heat Fund finance retrofits and new works; reuse thresholds are applied at demolition.	The Energy Independence and Security Act of 2007 requires life-cycle-cost analysis for federal and federally assisted housing; the Federation of Canadian Municipalities Green Municipal Fund requires energy modelling and benchmarking.	The Energy Conservation Act requires energy management and audits; the Green Mark scheme incorporates whole-life and operational carbon; the Home Improvement Programme and the Housing and Development Board Greenprint institutionalise mid-life renewal and operational efficiency improvements.
Local resource synergy (precinct-scale energy, water, waste loops)	Precinct overlays promote shared solar energy, greywater reuse, composting, and repair spaces, but most are optional; Infrastructure Australia notes	Resilient Rotterdam links housing with district heating, greywater, and bio-based material flows; Amsterdam’s neighbourhood	Zoning reforms enable compact “missing-middle” housing that supports shared energy, water, and waste systems—for example, the Portland	The Housing and Development Board Greenprint pilots estate-scale solar energy, energy storage,

	limited enforceable tools for precinct-scale sustainability.	approach integrates zoning with circular systems; the Environmental and Planning Act requires integrated environmental and resource priorities in local plans.	Residential Infill Project, the Minneapolis 2040 Comprehensive Plan, and Vancouver's Secured Rental Policy.	greywater reuse, and composting; the Planning Act supports compact, mixed-use clustering; local facilities process construction and demolition debris into recycled concrete aggregate, reducing haulage and imports.
Community embeddedness (participation, stability, social infrastructure)	New South Wales affordable-housing guidance encourages community gardens and repair spaces; concessional lending allows community housing providers to run reuse and skills programs; there is no national benchmark for social embeddedness.	The Housing Act requires annual performance agreements between housing associations, municipalities, and tenant unions, monitored by the national Housing Authority; participatory co-design and budgeting are mainstreamed in many municipalities.	Section 3(a) of the United States Housing Act of 1937 allows hardship rent waivers that stabilise occupancy; Canadian building codes allow partial occupancy to support phased retrofits and upgrades.	The Housing and Development Board's planning powers include community design; the Voluntary Early Redevelopment Scheme and the Home Improvement Programme provide resident choice; Greenprint fosters resident-led circular amenities and activities.
Procurement and permitting (what is required at approval)	Victoria Planning Policy Framework requests waste and resource-recovery plans; Fishermans Bend Framework requires life-cycle sustainability	Amsterdam mandates circular criteria in tenders and uses the Environmental Performance of Buildings tool in permitting.	California's Title 24 and city ordinances (Portland, Minneapolis, Vancouver) tie density and development	Green Mark scoring is used in public-housing procurement, and the Resource Sustainability

	statements in development applications.		approvals to performance standards.	Act imposes compliance obligations on construction and demolition waste management.
Finance levers (how capital supports circular outcomes)	Housing Australia Future Fund and concessional loans channel capital toward circular and energy-efficient outcomes.	The Incentive Scheme for Sustainable Energy Production and Climate Transition and the National Heat Fund support life-cycle-sound retrofits and construction.	The United States National Housing Trust Fund (created by the Housing and Economic Recovery Act of 2008), Canada Mortgage and Housing Corporation co-investment programmes and the Rapid Housing Initiative, and the Green Municipal Fund provide capital for circular and energy-efficient affordable housing.	Lifecycle programming by the Housing and Development Board and the Lease Buyback Scheme align household finance with the physical lifecycle of buildings.

In conclusion, embedding CE principles in affordable housing is a complex but profoundly beneficial endeavor. The cases of Australia, the Netherlands, Singapore, and North America demonstrate that when done thoughtfully, such integration leads to housing that is not only environmentally sustainable but also economically prudent and socially enriching. Each jurisdiction's pathway offers valuable lessons – whether Australia's layering of standards and incentives, the Netherlands' fusion of ecological and social governance, Singapore's long-term planning horizon, or North America's innovation through diversity. In any country, future housing policy can draw inspiration from these varied experiences to craft a locally appropriate journey toward circular, sustainable, and inclusive housing for all.

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CHAPTER 6: Policy-Embedded Levers and Framework-Based Pathways for Circularity in India's Affordable Housing

6.1. Introduction

This chapter addresses two pertinent questions: what within the existing rulebook can be repurposed to lower lifetime costs and reduce waste, and how should those provisions be read to work together? To answer this question, the chapter proceeds on two complementary tracks. First, the chapter surfaces the policy in-built opportunities scattered across four domains - housing delivery, urban systems, resource-efficiency rules, and finance/institutional arrangements - and organizes them to identify the levers. Second, we read the same terrain through four analytical lenses from the CE literature - urban metabolism, industrial symbiosis, the performance economy, and design-for-disassembly/adaptability - to translate high-level ideas into design, procurement, and operations choices that keep costs down across the building life cycle. The pay-off of this approach is practical: it reframes affordability as a function of how homes are designed, connected to city services, financed, and maintained. By the end of the chapter, the reader has a clear map of existing levers and a set of theory-informed cues for using them - so that India's affordable housing can be delivered at scale and remain affordable over time.

6.1.1. Housing delivery schemes as vehicles of circularity

The most prominent of India's housing interventions, the Pradhan Mantri Awas Yojana (Urban) – PMAY-U, launched in 2015, aims to provide "Housing for All" through four verticals: In-Situ Slum Redevelopment, Credit Linked Subsidy Scheme, Affordable Housing in Partnership, and Beneficiary-Led Construction.[165] While mainly evaluated based on numbers sanctioned — over 12.3 million houses by 2022 — its design also contains significant entry points for CE practices. The Technology Sub-Mission (TSM) explicitly promotes green and sustainable technologies, opening the door to construction with recycled C&D aggregates, fly-ash bricks, and low-carbon alternatives. TSM has been set up to facilitate modern, innovative, and green technologies; supports layouts/building plans for diverse geo-climatic zones, and mainstreams alternative walling/roofing systems—an on-ramp for industrialized, resource-efficient construction. The Global Housing Technology Challenge -India initiative, under the PMAY(U), focuses on promoting innovative and sustainable construction technologies through Light House Projects.

Similarly, the Affordable Rental Housing Complexes (ARHCs) initiative, launched in 2020 under PMAY-U, offers a distinct opportunity. Recognising rental housing for migrants and urban poor indirectly aligns with the performance economy concept, shifting emphasis from ownership to service provision, and promoting longevity and adaptability of stock.[166]
The National Urban Housing and Habitat Policy (NUHHP), 2007, while predating CE discourse, embeds several relevant principles. It advocates "environmentally friendly, cost-effective, and innovative building materials and technologies" and emphasises the role of rental

[165] Ministry of Housing and Urban Affairs (MoHUA), PMAY (Urban) Guidelines, Government of India, 2015
[166] MoHUA, Affordable Rental Housing Complexes (ARHCs) Guidelines, 2020

housing and public–private partnerships (PPPs).[167] These provisions are consistent with CE thinking, particularly the emphasis on sustainability and housing-as-service.
PMAY-U and NUHHP illustrate how schemes primarily concerned with affordability also contain latent normative openings for embedding CE, provided their provisions are activated through regulations and incentives.

6.1.2. Integrated urban missions

Affordable housing gains further circular potential when viewed through the lens of India's integrated urban missions. The Smart Cities Mission (SCM), launched in 2015, promotes "area-based development" with integrated water, waste, and energy systems.[168] Affordable housing projects located in these zones can directly benefit from decentralised energy, water reuse, and waste recovery systems — situating housing units as nodes in the urban metabolism of cities.
The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) adds to this by prioritising water supply, sewerage, and green spaces in 500 cities.[169] Its water-use efficiency and recycling provisions intersect directly with housing projects, enabling greywater reuse and integration of sustainable drainage systems. new PMAY-U sites, make treated wastewater reuse (gardening, flushing, construction curing), dual plumbing, and on-plot rainwater harvesting default design aligned with AMRUT.

Likewise, the Swachh Bharat Mission – Urban (SBM-U) drives scientific solid waste processing and sanitation infrastructure.[170] SBM-U drives source-segregation, collection, and processing of C&D waste, setting up a supply for recycled aggregates, pavers, and blocks that can feed affordable housing. When its provisions converge with PMAY-U construction sites, C&D debris and household waste can be channelled into recycling streams rather than uncontrolled dumping. Together, these missions show that circularity in housing is not confined to building-level interventions but can be embedded in the urban systems that support them. Housing becomes part of a city-wide flow of energy, water, and materials.

6.1.3. Resource-efficiency regulations

India's environmental and building regulations also provide crucial levers for CE in housing. The Construction and Demolition Waste Management Rules, 2016 mandate the segregation, collection, and processing of C&D waste and encourage the reuse of recycled materials in new construction.[171] Affordable housing, especially large-scale in-situ redevelopment under PMAY-U, is a natural sector for operationalising these mandates.

Under the Environment Protection Act, the fly ash notifications require all construction projects within 300 km of coal or lignite power plants to use fly ash products in building materials.[172]8 The Central Public Works Department (CPWD) has reinforced this through its manuals,

[167] Ministry of Housing and Urban Poverty Alleviation (MoHUPA), National Urban Housing and Habitat Policy 2007
[168] MoHUA, Smart Cities Mission Guidelines, 2015
[169] MoHUA, AMRUT Mission Guidelines, 2015.
[170] MoHUA, Swachh Bharat Mission – Urban Guidelines, 2016
[171] Ministry of Environment, Forest and Climate Change (MoEFCC), Construction and Demolition Waste Management Rules, 2016
[172] MoEFCC, Fly Ash Notification, Gazette of India, 1999 (amended 2003, 2009, 2016).

mandating fly ash bricks in public projects, effectively embedding industrial symbiosis into housing construction.[173]

Eco-Niwas Samhita (ENS) for residential buildings, a code for energy-efficient envelopes, lighting, and appliances, which aims to reduce lifetime resource use, is a natural fit for PMAY. The Model Building Bye-Laws (2016) and the National Building Code (NBC, 2016 edition) introduce mandates for rainwater harvesting, solar rooftops, and energy efficiency measures, all resonating with CE principles of resource circulation and reduced ecological footprint.[174] Similarly, Standards like BIS IS 383:2016, which allows recycled aggregates and manufactured aggregates for concrete, provide a standards-based route to circular materials.

Further, the Energy Conservation Building Code (ECBC) 2017, while designed primarily for commercial and large residential buildings, signals the growing centrality of energy efficiency standards in India's built environment. Its principles — daylight optimisation, passive ventilation, and thermal comfort — can inform affordable housing clusters.[175]These frameworks demonstrate how technical standards and environmental regulations provide a baseline for circular practices in housing, even if implementation remains uneven.

6.1.4. Financial and institutional enablers

The financial architecture of affordable housing also holds potential to embed CE incentives. The Reserve Bank of India (RBI) classifies loans for affordable housing under priority sector lending.[176] If tied to compliance with green building standards or CE certification, this could provide a direct financial incentive for developers to adopt circular practices.

Additionally, India's rise of green finance and ESG frameworks reshapes developer incentives. The Securities and Exchange Board of India (SEBI) requires listed companies to submit Business Responsibility and Sustainability Reports (BRSR), which are compelling disclosures of sustainability practices.[177] Linking affordable housing projects with these requirements could leverage market-based pressures toward CE-aligned design.

NITI Aayog's circular economy and resource efficiency (CE-RE) series provides a structured roadmap for India's transition toward sustainable resource use across sectors. The series sets clear narratives, targets, and pathways, beginning with the Strategy on Resource Efficiency (2017) and followed by sectoral strategy papers (2019) for steel, aluminium, construction & demolition waste, and e-waste. The Status Paper on RE & CE (2019) and the Draft National Resource Efficiency Policy (2019)[178] proposed institutional mechanisms like the National Resource Efficiency Authority, while the Circular Economy Mission (2021-ongoing), reinforced during India's G20 Presidency, has built global and domestic coalitions such as the Resource Efficiency & Circular Economy Industry Coalition (RECEIC). More recently, in 2024, NITI Aayog created working groups for emerging waste streams such as EV batteries, tyres, e-waste, and scrap metals. Together, these initiatives provide policy vision and coalitions,

[173] CPWD, Works Manual, (2019). See also, https://www.grihaindia.org/all-cpwd-constructions-0
[174] Town and Country Planning Organisation (TCPO), Model Building Bye-Laws 2016.
[175] Bureau of Energy Efficiency (BEE), Energy Conservation Building Code 2017
[176] Reserve Bank of India, Master Directions on Priority Sector Lending, 2022
[177] Securities and Exchange Board of India (SEBI), Business Responsibility and Sustainability Reporting (BRSR) Framework, 2021
[178] NITI Aayog's Draft National Resource Efficiency Policy (2019) identifies the construction sector as a priority area for material recovery and recycling, explicitly noting that housing must be integrated into a larger circular resource framework- NITI Aayog, Draft National Resource Efficiency Policy, Government of India, 2019.

metrics, and sectoral tools that support embedding CE principles under affordable housing policies in India. The National Building Code (NBC, 2016) also offers a policy lever. Its dedicated chapter on sustainability legitimizes circular practices — from energy-efficient design to waste management — within a nationally recognized standard. When cities and states prepare Detailed Project Reports (DPRs) for PMAY-U, the NBC provides a ready legal anchor for circularity clauses. Thus, national institutions are already moving toward embedding CE logics in construction and urban development, with affordable housing as a critical application site.

6.2. Circular economy frameworks for rethinking housing and analytical lenses

The circular economy is not a single doctrine but a cluster of theoretical frameworks that converge on closing resource loops, extending product lifespans, and aligning human activity with ecological cycles. For affordable housing in India, four frameworks are particularly illuminating: urban metabolism, industrial symbiosis, the performance economy, and design for disassembly/adaptability. Each provides a distinct prism to reinterpret existing national policies and laws, revealing opportunities often hidden by the dominant focus on affordability and quantity of housing delivery.

The CE is best understood not as a singular theory but as a composite of interrelated frameworks that provide different vantage points for rethinking the built environment. The perspective of urban metabolism conceptualises cities as living organisms that consume, transform, and expel resources. When applied to housing, it emphasises mapping material and energy flows over the whole building life-cycle, including construction, use, and demolition.[179]. Complementing this, industrial symbiosis highlights the potential of cross-sectoral linkages, where the by-products of energy, steel, or manufacturing industries—such as fly ash or scrap metals—are repurposed as construction inputs, thus reducing virgin resource demand.[180]. The performance economy advances the idea of shifting value from product ownership to service provision, and in housing, this resonates with models that extend asset life—such as rental, cooperative housing, and adaptive reuse—rather than perpetuating cycles of ownership-driven demolition[181]. Finally, design for disassembly and adaptability calls for modular construction, reversible connections, and flexible design so that housing stock can be dismantled, reused, or adapted to changing demographic and environmental needs, thereby avoiding premature obsolescence[182] (Guy and Kibert, 1998; Webster and Costello, 2005; Durmisevic, 2006). Together, these frameworks provide a layered conceptual foundation for

[179]Kennedy, C., Pincetl, S. and Bunje, P. (2011). 'The study of urban metabolism and its applications to urban planning and design', *Environmental Pollution*, 159(8–9), pp. 1965–1973; Zhang, Y., Yang, Z. and Yu, X. (2015). 'Urban metabolism: A review of current knowledge and directions for future study', Environmental Sustainability, 2(1), pp. 19–25; Rapoport, E. and Hult, A. (2017). 'The travelling business of sustainable urbanism: International consultants as norm-setters', *Environment and Planning A*, 49(8), pp. 1779–1796.

[180] Chertow, M. (2007). '"Uncovering" industrial symbiosis', Journal of Industrial Ecology, 11(1), pp. 11–30; Lombardi, D.R. and Laybourn, P. (2012). 'Redefining industrial symbiosis: Crossing academic–practitioner boundaries', *Journal of Industrial Ecology*, 16(1), pp. 28–37; Baas, L. and Boons, F. (2004). 'An industrial ecology project in practice: exploring the boundaries of decision-making levels in regional industrial systems', *Journal of Cleaner Production*, 12(8–10), pp. 1073–1085

[181] Stahel, W. (2010). The Performance Economy. 2nd ed. Routledge, London; Tukker, A. (2015). 'Product services for a resource-efficient and circular economy – a review', Journal of Cleaner Production, 97, pp. 76–91

[182] Guy, B. & Kibert, C. (1998). 'Developing indicators of sustainability: US experience', *Building Research & Information*, 26(1), pp. 39–45; Webster, M. and Costello, D. (2005). 'Design for de-construction and materials reuse', *Proceedings of the CIB Task Group 39–De-construction Meeting*, Rotterdam. CIB

aligning CE principles with affordable housing, opening space for a housing strategy that reconciles the urgency of mass provision with the imperatives of ecological sustainability.

6.2.1. Urban metabolism: Housing as a node in resource flows

The concept of urban metabolism treats cities as living systems that consume energy, materials, water, and land, and produce waste, emissions, and cultural outputs.[183] Housing is central to this metabolic process as one of the largest material and energy sinks. Integrating affordable housing into urban missions like Smart Cities and AMRUT in India creates a direct entry point for metabolic thinking.

For instance, Smart Cities Mission promotes decentralised energy generation, waste recycling, and water reuse at the neighbourhood scale.[184] Affordable housing within these smart city precincts can be designed as metabolic nodes, where household-level greywater is channelled into local treatment plants, rooftop solar panels contribute to micro-grids, and segregated waste is linked with city-wide recycling networks. The result is a shift from housing as an isolated unit to a functional component of city-wide material cycles. BIS IS 383:2016 even provides the technical envelope by permitting recycled aggregates in concrete. Instead of being an optional green feature, this is enforceable compliance — and a natural way to embed circularity in PMAY-U.

Global examples reinforce this view. In Singapore, public housing developed by the Housing and Development Board (HDB) integrates centralised district cooling, pneumatic waste conveyance, and water reuse systems, effectively embedding housing estates in the city's metabolism.[185] Similar principles could be adapted within India's urban missions, especially since AMRUT already prioritises water efficiency and SBM promotes scientific waste management.

Thus, urban metabolism highlights that the genuine circular opportunity lies not at the level of the dwelling alone but in connecting affordable housing to the city's circulatory infrastructure. Existing Indian laws and missions, if better integrated, already provide a foundation for this.

6.2.2. Industrial symbiosis: Housing as a consumer of by-products

Industrial symbiosis refers to the process by which waste or by-products of one industry are used as inputs for another, creating a resource loop that reduces virgin material use.[186] The construction sector is particularly well-suited to this, given its high material intensity and compatibility with industrial residues like fly ash, slag, and recycled aggregates.

[183] Kennedy, C., Cuddihy, J. & Engel-Yan, J. (2007). *The Changing Metabolism of Cities*. Journal of Industrial Ecology, 11(2).
[184] MoHUA, *Smart Cities Mission Guidelines*, 2015
[185] Housing and Development Board (HDB), Singapore. *Sustainability Reports*, 2019–2022
[186] Chertow, M. (2000). *Industrial Symbiosis: Literature and Taxonomy*. Annual Review of Energy and the Environment, 25

India has already moved in this direction through regulatory nudges. The Fly Ash Utilisation Notification, 2021, again under the Environment (Protection) Act, mandates 100% utilisation of fly ash, and requires construction agencies within 300 km of plants to use ash-based products, and the CPWD guidelines reinforce this obligation.[187] Similarly, the C&D Waste Management Rules (2016) provide for recycling demolition debris into aggregates that can be used in new housing projects.[188]

Affordable housing schemes such as PMAY-U represent scale-based opportunities for industrial symbiosis. By mandating fly ash bricks or recycled aggregates in PMAY-U and ARHC projects, the government could simultaneously reduce environmental burdens from coal-based power and landfill pressure from demolition debris. Fly-ash bricks and blocks are cheaper, lighter, and thermally more efficient than conventional clay bricks. By law, they must be used; by design, they improve comfort and affordability.

International parallels exist. The Netherlands' "Green Deal for Circular Construction" actively promotes the reuse of construction materials, and recycled aggregates account for over 30% of Dutch construction inputs.[189] Australia, too, has piloted housing projects using high percentages of recycled concrete and steel.[190] India's policy scaffolding is not far behind — but the regulatory will to enforce and mainstream industrial symbiosis in affordable housing remains the missing link.

6.2.3. The Performance economy: Housing as a service

The performance economy, advanced by Walter Stahel, emphasises extending the service life of goods and shifting from product ownership to performance delivery.[191] Applied to housing, this framework suggests moving beyond ownership-driven models toward service-based ones, such as rental housing, cooperative housing, or shared infrastructure.

The National Urban Housing and Habitat Policy (2007) explicitly acknowledged the importance of rental housing, and PMAY-U has operationalised this through the ARHC scheme.[192] These initiatives are early steps toward embedding performance economy principles in India's housing policy. Rental housing reduces the pressure to expand ownership stock indiscriminately and instead prioritises existing housing's maintenance, adaptability, and long-term serviceability. This approach also intersects with circularity in terms of resources. A rental housing model incentivises developers or operators to design for durability, since they bear long-term responsibility for upkeep. In contrast, one-time ownership subsidies may encourage low-cost, short-lifespan construction.

Examples from abroad highlight the potential. In Germany, cooperative housing models extend building lifespans through collective maintenance, while in Singapore, public rental housing is maintained to uniform standards by the HDB, ensuring longevity and adaptability.[193] India's ARHC scheme could evolve similarly, embedding performance-based incentives into affordable housing.

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[187] MoEFCC, *Fly Ash Notifications*, Gazette of India, 1999–2016
[188] MoEFCC, *Construction and Demolition Waste Management Rules*, 2016
[189] Government of the Netherlands, *Green Deal for Circular Construction*, 2018
[190] Commonwealth of Australia, Department of Industry, Science, Energy and Resources. *National Waste Policy Action Plan*, 2019
[191] Stahel, W. (2010). *The Performance Economy*. Palgrave Macmillan
[192] MoHUPA, *National Urban Housing and Habitat Policy 2007*; MoHUA, *ARHC Guidelines*, 2020.
[193] Scanlon, K. & Whitehead, C. (2008). *Social Housing in Europe II: A Review of Policies and Outcomes*. London School of Economics.

Further, a house is more than walls. The comfort of its residents depends on design and energy use. Here enters the Energy Conservation Act, 2001, which empowered the Bureau of Energy Efficiency to create codes: the Eco-Niwas Samhita (ENS) for residences and the Energy Conservation Building Code (ECBC) for larger buildings. ENS is a binding code when notified, and its 2024 version integrates energy, water, and waste considerations.

This is the legal expression of the performance economy - shifting focus from upfront cost to life-cycle savings. A wall built to ENS specifications keeps interiors cooler, reducing electricity bills. For a low-income family, this is affordability in practice. Thus, the performance economy lens suggests that circularity in housing is not only about materials but also about tenure and institutional design. By strengthening rental and cooperative models, India's housing policies can align affordability with sustainability.

6.2.4. Design for disassembly and adaptability: Future-proofing housing stock

The fourth framework, design for disassembly (DfD) and adaptability, emphasises creating buildings that can be dismantled, reused, or adapted over time rather than demolished.[194] This approach directly challenges the culture of "build, neglect, demolish" that characterises much of global urban development.

India's housing schemes have not explicitly embraced DfD principles, but the seeds exist. The Technology Sub-Mission under PMAY-U promotes alternative construction technologies such as prefabricated components and modular systems, which are more amenable to disassembly and reuse.[195] The National Building Code (2016) and CPWD manuals also permit modularity and encourage innovation in structural systems. Over time, walls crack and pipes leak. Too often, repairs require demolition. This is where the Global Housing Technology Challenge (GHTC) and PMAY-U's Technology Sub-Mission (TSM) come in. While policy-driven, they are backed by concession agreements and technical approvals with legal enforceability.
By promoting prefabrication and modular design, these platforms enact the theory of design-for-disassembly (DfD). A service shaft with accessible pipes means future repairs are a matter of unscrewing and replacing, not breaking walls. The opportunity is significant: affordable housing built today will constitute a large portion of India's housing stock for decades. These units can serve multiple generations without demolition if designed for adaptability, allowing for incremental expansion or flexible reconfiguration. International lessons are again instructive. In the Netherlands, the "Superlofts" project pioneered modular apartment shells that residents can adapt over time, reducing the need for demolition.[196] In Australia, guidelines for adaptable housing emphasise reconfigurable spaces and reusable components to extend building lifespans.[197] By embedding adaptability into Indian affordable housing standards — for example, through BIS codes or MoHUA guidelines - India could ensure that its massive housing investments remain sustainable in the long term.

[194] Guy, B. & Ciarimboli, N. (2005). *Design for Disassembly in the Built Environment: A Guide to Closed-Loop Design and Building*.
[195] MoHUA, *PMAY-U Technology Sub-Mission Guidelines*, 2016.
[196] Tummers, L. (2017). *Superlofts and the Future of Modular Housing*. Journal of Housing and the Built Environment, 32(4).
[197] Australian Government, *Livable Housing Design Guidelines*, 2017

6.3. Conclusion

India's affordable housing ecosystem does not await a bespoke "circular housing law"; it already comprises a dense but disjointed patchwork of schemes, missions, regulations, and financial frameworks that embed the ingredients of circularity. Housing schemes such as PMAY-U and NUHHP provide the normative levers to steer technology choice and tenure; urban missions like the Smart Cities Mission, AMRUT, and Swachh Bharat-Urban furnish the connective tissue of water, waste, and energy systems; environmental instruments—including the C&D Waste Management Rules and fly-ash utilisation mandates - push material recovery; and finance and disclosure regimes nudge developers toward better practice. The problem, therefore, is not absence but fragmentation: the scaffolding for the CE in housing exists in siloed pieces. Reading these instruments through four complementary lenses clarifies what to connect and why. Urban metabolism positions housing as a node in city-wide flows, where dual plumbing, reuse networks, and distributed energy reduce lifetime costs. Industrial symbiosis repurposes by-products such as fly ash and recycled aggregates into standard construction inputs, aligning PMAY-scale delivery with waste reduction. The performance economy recasts affordability as service over time - via rental models like ARHCs and robust O&M - so durability and maintainability become economic incentives, not afterthoughts. Design for disassembly and adaptability brings modularity, reversible connections, and flexible layouts into the mainstream, future-proofing low-cost stock against premature obsolescence. This way, circularity is not alien to India's policy imagination; it is latent, widely distributed across PMAY-U, NUHHP, and the urban missions, and awaiting activation through integration rather than invention. Turning that insight into practice means wiring delivery, standards, and finance into a single specification and accountability chain. Hence, circularity becomes the operating logic of affordable housing rather than a discretionary add-on. The core claim follows: India can deliver more affordable housing by making it circular by design—connecting existing provisions into one enforceable system. Build once, tie homes into the city's loops, maintain them well, and the savings compound for households and municipalities for decades.

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CHAPTER 7: Mapping Barriers Through National Policies, Standards, and Legal Frameworks

7.1. Introduction

Affordable housing in India stands at a crossroads. Affordable housing in urban India is at a critical moment. The need is clear, and much has already been achieved through national missions and standards. This part adopts a circular view of affordability.[198] as a lifetime balance of monthly payments, utilities, maintenance, and commuting, it builds on the strong foundation created by PMAY-U, the Model Building Bye-Laws and National Building Code, URDPFI guidance, the Eco Niwas Samhita, CPHEEO manuals, the Construction and Demolition Waste Rules, and emerging green finance signals. At the site level, however, some systems face practical constraints after handover, recycling markets are still maturing, and approvals, standards, and incentives do not always align seamlessly. This part maps where small gaps can open despite good intent. To make those gaps fixable, the analysis organises barriers across six dimensions - Rethinking affordability (structural), Financing, access to credit, and risk (financial), Land challenge in circular housing (spatial), Market for recycling (regulatory–market), Data poverty in housing (institutional: coordination & data), and Operation and maintenance gap in water reuse (institutional–sociocultural). This part offers a practical diagnosis of where and why the slips between policy and practice occur so that the fixes can be targeted and the promise of affordable, circular housing can hold over time. The present analysis is aimed at helping ongoing efforts work even better on the ground.

7.1.1. Rethinking affordability

Income thresholds and unit types traditionally measure affordability—for instance, PMAY-U caps eligibility for Economically Weaker Sections (EWS) at ₹3 lakhs and Lower Income Groups (LIG) at ₹6 lakhs, governed by carpet-area norms.[199]. However, experts argue that such static metrics miss the broader burden of low- and moderate-income households, who balance EMIs or rent alongside recurring costs: utilities, transportation, and upkeep. The residual-income approach—where housing is affordable only if substantial non-housing needs remain—better captures this dynamic reality. However, urban planners and think-tank reports repeatedly emphasise that affordability cannot be captured by static income bands alone.[200]. The residual income approach, widely discussed in global housing literature, suggests that housing is affordable if a household can meet non-housing needs after paying for shelter.[201] This disconnect becomes clear in published narratives where it is noted that households may technically qualify under PMAY-U income ceilings but still struggle with life-cycle costs—

[198] Ministry of Housing and Urban Affairs (then MoUD). (2016). Model Building Bye-Laws, 2016. Government of India.
[199] Measuring Housing Affordability Using the Residual Income Method for Million-plus Cities in India, Available at https://iccaua.com/PDFs/2021Conference%20full%20bool%20proceedings/4_Habitat%20Studies/ICCAUA2021257%20Prabhat%20Rao.pdf
[200] Karmali, N. M. (2022). Housing demand and affordability in India. World Bank. (*The need to move beyond static affordability and the importance of services*)
[201] Stone, M. E. (2006). What is housing affordability? The case for the residual income approach. Housing policy debate, 17(1), 151–184.

commuting, utilities, school fees—that push practical affordability far beyond unit price.[202] In this respect, affordability emerges not as a fixed threshold but as a moving target shaped by urban geography, access to employment, and consumption demands.

Integrating CE principles reframes affordability not as a one-off transaction but as a lifetime promise. Circularity aims at expanding the lens. The monthly burden for a low or moderate-income household is EMI or rent plus utilities, maintenance, commuting, and time costs.[203]. If building rules and housing programmes help reduce the last four through efficient design, recycled materials that perform well, and location choices that shorten daily travel, then affordability becomes more stable and less fragile.

India already possesses a scaffold of enabling policies:

- **PMAY-U**: Beyond specifying typologies and subsidies, it could require basic thermal performance targets, recycled-content materials where standards exist, and linkage with Construction & Demolition (C&D) Waste Rules to enable on-site reuse.
- **Model Building Bye-Laws 2016 / National Building Code**: These encourage rainwater harvesting, daylight, ventilation, and safety. Aligning them with modular and maintainable wet areas or replaceable components increases affordability.
- **URDPFI Guidelines**: Emphasize serviced, accessible land. When read through a circular lens, shorter commutes and stronger local services are affordable levers akin to EMI relief.
- **Eco Niwas Samhita**: Energy-efficiency norms that predictably lower electricity bills directly aid financial resilience.
- **C&D Waste Management Rules**: Encourage material recovery, reduce landfill volume, stabilize the supply of compliant secondary materials, and buffer projects from virgin-material price volatility.
- **Green finance and housing credit**: Green bonds and priority-sector lending can lower cost-of-capital when life-cycle savings (e.g., energy efficiency, reduced maintenance) are recognized. This makes financing circular projects more accessible while reducing long-run risk.

The opportunity lies not in rewriting law, but in weaving these instruments together—from tender requirements (*e.g., kWh per m² caps, LPD from non-mains, recycled content quotas, de-construction plans*) through to bye-law checklists and operational contracts.

7.1.2. Financing, access to credit, and risk

India's affordable housing finance architecture has progressed meaningfully, providing a strong foundation for integrating circular practices that lower household life-cycle costs.[204]. At the same time, some inclusion challenges can slow uptake, while the Credit-Linked Subsidy

[202] Pethe, A., Sharma, R., & Desai, D. D. (2023). The pathway to affordable housing in urban India: a case study of Mumbai. In The path to affordable housing in urban India: a case study of Mumbai: Pethe, Abhay| uSharma, Rashmi| uDesai, Dhaval D.. New Delhi, India: ORF, Observer Research Foundation.
[203] Stone, M. E. (2006). What is housing affordability? The case for the residual income approach. *Housing Policy Debate, 17*(1), 151–184. Taylor & Francis
[204] Ministry of Housing and Urban Affairs (MoHUA). (2024). Pradhan Mantri Awas Yojana (Urban) 2.0: Scheme guidelines (Operational Guidelines). Government of India. https://pmay-urban.gov.in

Scheme under PMAY Urban reduces effective interest costs for eligible families.[205]Many urban workers in informal employment may find it challenging to meet conventional documentation requirements.[206], which can limit access to homes that would otherwise benefit from lower energy and water bills through basic circular design. Micro-mortgage models are a promising bridge, though their smaller ticket sizes can carry proportionately higher administrative costs.[207]; streamlining processes and recognising simple, standards-compliant measures such as improved thermal envelopes, efficient fixtures, and approved recycled materials would help lenders see the stability of monthly savings these features can deliver. Prudential considerations set by the Reserve Bank of India, including risk-weight norms for non-bank lenders and housing finance companies, play an essential role in safeguarding financial stability; within that prudent framework, more precise data on the performance of circular features and standardised specifications can make such investments feel familiar rather than unfamiliar. On the supply side, timely subsidy disbursals support liquidity planning for smaller developers. Predictive cash flows make coordinating energy code compliance, construction and demolition waste plans, and maintainable detailing from the outset easier. These are not roadblocks, but they are areas where finance, policy, and practice can align so that verified reductions in utilities and maintenance are reflected in underwriting and project appraisal.[208]. When that alignment happens within existing safeguards, the modest premiums that make homes cooler, cheaper to run, and easier to repair are understood as part of affordability itself, and circular housing becomes a practical, inclusive pathway rather than an added burden.

Circular features like modular design elements, durable finishes, or recycled aggregates often promise value over time.[209]. They lower maintenance costs, extend the life of structures, and can even recover value at the end of a building's life. However, the problem is simple: those benefits accrue years later, while the costs come up front. Moreover, in a system where developers are judged on delivery schedules, cost efficiency, and immediate compliance, long-term value is an abstract concept that banks, buyers, and regulators rarely factor in.[210].

The perceived cost premium is one of the most persistent barriers to circular adoption. Developers and contractors often assume that circular materials or design features will add 10–15% to project costs. In reality, studies such as the National Housing Bank's 2024 report on Green Residential Buildings show that the real premium for "green" or circular features is closer to 3–5% during the construction phase[211].For example:

- Using fly-ash bricks instead of conventional bricks can lower costs, provided supply chains are consistent.
- Recycled aggregates are often cheaper than virgin aggregates in urban centres, where transport costs for natural stone are high.

[205] Ministry of Housing & Urban Poverty Alleviation (2015), Credit Linked Subsidy Scheme for EWS/LIG - Operational guidelines.
[206] Housing for India's Low-Income Urban Households, available at https://icrier.org/pdf/Working_Paper_402.pdf
[207] Grubbauer, M., & Escobar, L. (2021). World Bank experiments in housing: Microfinance for self-organised housing in Mexico in the era of financial inclusion. International Journal of Housing Policy, 21(4), 534-558.
[208] Kaza, N., Quercia, R. G., & Tian, C. Y. (2014). Home energy efficiency and mortgage risks. Cityscape, 16(1), 279–298.
[209] Cambier, C., Caspeele, R., & Debacker, W. (2021). Expandable (design-for-change) houses: An explorative life-cycle cost analysis. Sustainability, 13(12), 6974. MDPI.
[210] Miles, B. (2019). Housing finance: Development and evolution in mortgage markets. *In* The Routledge Handbook of Housing Policy and Planning, Taylor & Francis/Routledge.
[211] National Housing Bank (2024), *Green residential building in India: Cost, affordability and financing strategies, available at* https://www.nhb.org.in/wp-content/uploads/2024/04/Green-residential-building-in-India-Cost-affordability-and-financing-strategies.pdf?prophazecheck=1

- Modular design may have slightly higher upfront design and fabrication costs, but saves money during construction through faster assembly and fewer errors.

The real issue is not the absolute cost but the timing of costs and returns. Developers bear the costs immediately, while the benefits - lower maintenance, higher durability, and even potential recovery of materials decades later - are far down the road. Affordable housing developers operate in an environment where the pressure to keep costs low is constant:

- PMAY-U caps unit prices to keep homes accessible to low-income buyers.
- Banks and housing finance companies extend credit based on conventional cost models, not life-cycle benefits.
- RERA enforces strict delivery timelines and penalties, leaving little room for experimentation.

In such a context, even a small perceived risk, such as a fear that modular components might face delivery delays, becomes a reason to reject circular options. Without clear financial incentives or risk-sharing mechanisms, the rational choice for most developers is to play it safe. From a long-term perspective, circular housing is not more expensive; it is cheaper. Durable finishes reduce repair and replacement costs. Energy-efficient designs cut utility bills. Modular components make renovations faster and less wasteful. Recycled materials reduce dependency on volatile raw-material markets.

The challenge is that affordable housing finance is not structured for life-cycle thinking. Loans are typically tied to construction milestones and unit sales, with no mechanism to value future savings or residual material value. This creates a structural bias toward the cheapest short-term option, even when it is more expensive in the long run.

7.1.3. Land challenge in circular housing

Land availability can become a quiet but decisive brake on circularity in affordable housing because the most effective circular outcomes occur where land is well located, serviced, and legally clear, and those parcels are often hard to assemble in practice.[212]. National planning guidance already points in the right direction: the URDPFI Guidelines emphasise bringing serviced land to market and organising compact, accessible development, yet scarcity of such parcels tends to push projects to urban fringes, where longer commutes and new trunk infrastructure can erode the very lifetime savings circular design is meant to secure[213].

The National Transit Oriented Development Policy makes the affordability link explicit by encouraging higher intensity, mixed-use development near mass transit so that households spend less on daily travel; however, without timely assembly of plots in these influence zones, the benefits remain difficult to scale[214].

[212] Ministry of Urban Development (now MoHUA). (2014). Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines (Vols. I–II). Government of India. https://mohua.gov.in/
[213] Makarewicz, C., & Haas, P. M. (2020). Another look at location affordability: Understanding the detailed effects of income and urban form on housing and transportation expenditures. Housing Policy Debate, 30(6), 1092–1113.
[214] Ministry of Housing and Urban Affairs (2017). National Transit-Oriented Development (TOD) Policy. Government of India. https://mohua.gov.in/

PMAY Urban offers workable delivery verticals, including in situ redevelopment and affordable housing in partnership, but these pathways function best when titles and tenures are clear and land can be pooled or reused; where parcels are fragmented or encumbered, the coordination needed for circular features, shared systems, maintainable detailing, and material recovery becomes slower and costlier[215].

Essential legal safeguards in the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act protect rights and due process, and they also shape feasibility: acquisition steps and the Act's limits on multi-crop irrigated land narrow centrally located options and lengthen timelines, which in turn reduces the supply of brownfield or transit-proximate sites where circularity is easiest to achieve[216]. Circular construction ecosystems also need land to work: under the Construction and Demolition Waste Management Rules, cities are expected to plan collection and processing infrastructure; where such sites are not reserved, recycling markets remain thin and projects default to virgin materials, weakening circular procurement in affordable schemes.[217].

Progress on land-record modernisation under the Digital India Land Records Modernization Programme is steadily improving clarity and integration of records, which lowers dispute risk and helps brownfield reuse, but coverage and data harmonisation are still uneven in places, and that uncertainty can delay infill—the very settings where circularity leverages existing infrastructure[218]. Taken together, these are not critiques of policy intent; they show that circular affordability flourishes when serviced, well-connected, and clear-titled land is available, and that administrative alignment, assembling land in transit areas, earmarking plots for C&D systems, and deepening land-record integration allow India's existing laws and missions to deliver circular benefits at scale.

7.1.4. Market for recycling

Circularity in housing depends on having the proper rules and creating markets where recycled materials have steady, predictable demand. Standards and procurement are necessary, but demand hinges on buyer confidence and social preference for 'new' materials, which requires visible QA labels and demonstration use in public works. India's construction and demolition waste management frameworks have been in place for nearly a decade. However, the ground reality remains stark: less than 2% of the country's waste is recycled.[219]. Most of it still ends up in landfills, low-lying areas, or is informally dumped on city outskirts.[220]

This is not because the technology is unavailable. Across cities like Delhi, Ahmedabad, and Bengaluru, recycling plants run by public-private partnerships have proven that debris can be

[215] Ministry of Housing and Urban Affairs. (n.d.). Pradhan Mantri Awas Yojana (Urban): Operational Guidelines.
[216] Lok Sabha, Government of India (2025, August 8). Unstarred Question reply on RFCTLARR Act—Multi-crop irrigated land (Section 10) (Parliament reply clarifying the restriction and the "exceptional cases" proviso.)
[217] Ministry of Environment, Forest and Climate Change (2016) Construction and Demolition Waste Management Rules, 2016.
[218] Department of Land Resources, Ministry of Rural Development (2021–2026) Digital India Land Records Modernization Programme (DILRMP): Guidelines, Technical Manuals & MIS.
[219] Centre for Science and Environment. (2020, August 25). India manages to recover and recycle only about 1% of its construction and demolition (C&D) waste. https://www.cseindia.org/india-manages-to-recover-and-recycle-only-about-1-per-cent-of-its-construction-and-demolition-10326
[220] Ain, S., Singhal, S., & Pandey, S. (2019). Construction and demolition waste generation in cities in India. International Journal of Construction Management. Taylor & Francis. https://www.tandfonline.com/doi/full/10.1080/19397038.2019.1612967

turned into usable aggregates, paving blocks, and bricks.[221]. What is missing is the market signal that would make such recycling the norm rather than the exception. The core issue lies here is - recycling without buyers is not recycling—it is just a different form of waste storage. The Ministry of Housing and Urban Affairs' 2022 guidance on CE clearly recognises this gap. It recommends:

- Guaranteed public procurement of recycled products by central and local agencies[222]
- Integration of recycled content in standard schedules of rates, so that architects and contractors can specify them easily, and
- Tax and tariff nudges like reduced GST or lower electricity tariffs for recycling plants.

These recommendations are sound, but implementation has been slow and uneven. Without predictable demand, private players hesitate to invest in scaling up recycling facilities.

India's frameworks for circular materials are not weak. In fact, they are surprisingly well-developed when read closely. The Bureau of Indian Standards (BIS) has opened doors for recycled aggregates in concrete through IS 383:2016. The Central Pollution Control Board (CPCB) has published practical guidelines on processing construction and demolition (C&D) waste. The Central Public Works Department has endorsed using recycled materials for non-structural elements in government projects.[223].

However, despite this progress, the ground reality tells a different story: these standards remain underused in affordable housing projects. What holds developers, engineers, and regulators back is not a lack of regulations, but a lack of trust - a deep-seated hesitation around quality, risk, and accountability[224]. However, when it comes time to place the order, a question looms:

- What if the recycled material does not meet compressive strength standards?
- What if an inspector questions the mix during a random check?
- Who takes responsibility if cracks appear after handover?

With so many unknowns, the safe bet is to go with virgin aggregates everyone knows and trusts, even if they cost slightly more. This is not ignorance or apathy; it is rational risk

[221] NITI Aayog. (2018, November 5). Strategy for promoting processing of construction and demolition (C&D) waste in India. (Details PPP plants in Delhi & Ahmedabad.) https://www.niti.gov.in/sites/default/files/2019-03/CDW_Strategy_Draft%20Final_011118.pdf; Amdavad Enviro Projects Pvt. Ltd. (n.d.). About the Ahmedabad C&D waste facility (PPP with AMC; capacity details). https://amdavadenviro.in/about-us/amdavadenviro.in; Bengaluru Mirror. (2022, January 11). Bengaluru does not have a concrete plan (Rock Crystal 1,000 TPD; low offtake). https://bangaloremirror.indiatimes.com/bangalore/cover-story/bengaluru-doesnt-have-a-concrete-plan/ 88818640

[222] Ministry of Housing and Urban Affairs. (2022). Circular economy in municipal solid and liquid waste (recommends reduced GST for recycled products, priority lending). https://mohua.gov.in/pdf/627b8318adf18Circular-Economy-in-waste-management-FINAL.pdf
Ministry of Housing and Urban Affairs; Central Pollution Control Board. (2017). Guidelines on environmental management of construction & demolition (C&D) wastes (mandate/incentivise use; electricity tariff/price measures; utilisation targets). https://dste.py.gov.in/ppcc/pdf/Guidelines/Guidelines_Final_C%26D_March_2017.pdf

[223] Central Public Works Department. (2022). *CPWD Works Manual 2022* (directions on use of recycled C&D materials in works). https://www.ndmc.gov.in/departments/Departments/Finance/nodal_cell/CPWD%20Works%20Manual%202022.pdf; Central Public Works Department. (2021). *Delhi Schedule of Rates / Analysis of Rates (DSR/AOR 2021)*—includes items referencing recycled concrete aggregate (RCA) & recycled aggregate (RA). https://www.daojharkhandgroup.in/wp-content/uploads/2021/09/DSR-2021.pdf

[224] Down To Earth. (2025, August 7). Delhi not consuming all products made from recycled construction and demolition waste. https://www.downtoearth.org.in/waste/delhi-not-consuming-all-products-made-from-recycled-construction-and-demolition-waste

management in a system where penalties for failure are immediate and rewards for innovation are rare.[225].

7.1.5. Institutional coordination map for circular housing

A look at India's policy and regulatory landscape for affordable housing, one thing stands out: there is no shortage of intent.[226]. Multiple ministries, bureaus, and agencies have issued guidance, standards, or missions that touch on different aspects of circularity—waste, energy, water, durability, and design[227]. But what is missing is a single coordinating anchor[228]. CE principles in affordable housing live in fragments, each supported by a well-meaning institution acting in its own domain. The result is a system where everyone tries to do the right thing, but no one brings the pieces together. A glance at the institutional map reveals the following:

- Ministry of Housing and Urban Affairs - Oversees affordable housing missions like PMAY-U, develops Model Building Bye-Laws, and issues CE advisories for urban waste and infrastructure.
- Ministry of Environment, Forest and Climate Change; and Central Pollution Control Board - Regulate C&D waste management, publish processing guidelines, and monitor compliance.
- Bureau of Indian Standards - Creates technical standards for recycled aggregates, fly-ash bricks, and durability parameters for building materials.
- Bureau of Energy Efficiency under the Ministry of Power
- Develops and promotes Eco-Niwas Samhita for energy efficiency in residential buildings.
- Central Public Works Department - Issues manuals and technical guidelines for public works, including recycled materials and water efficiency recommendations.
- National Housing Bank and other financial institutions - Provide credit and refinancing frameworks for housing developers and buyers.

Each of these bodies is doing useful, often progressive work. The problem is that their frameworks rarely intersect in a way that developers, municipal officials, or contractors can navigate easily. Imagine being a mid-sized developer trying to build a 1,000-unit affordable housing project. The key compliance and operational considerations include:

Compliance with the *Pradhan Mantri Awas Yojana – Urban* (PMAY-U) framework requires adherence to eligibility and technical criteria related to unit size, design specifications, and cost limits[229]. For construction and demolition (C&D) waste, project proponents must submit waste-

[225] Sharma, M., & Shukla, A. (2020). A mini-review of construction and demolition waste management in India. *Waste Management & Research*, 38(5), 486–495.
SAGE. https://journals.sagepub.com/doi/10.1177/0734242X20916828
[226] Ahluwalia, I. J. (2019). Urban governance in India. Journal of Urban Affairs, 41(S1), 83–102. Taylor & Francis.
[227] Ministry of Housing and Urban Affairs (2016). Model Building Bye-Laws, 2016.
[228] da Cruz, N. F., Rode, P., & McQuarrie, M. (2019). New urban governance: A review of current themes and future priorities. *Journal of Urban Affairs, 41*(1), 1–19. (On multi-level fragmentation and coordination gaps.)
Global Buildings Performance Network (GBPN). (2023). *Healthy Affordable Housing in India: White Paper*. GBPN.

[229] Ministry of Housing and Urban Affairs (MoHUA). (2024). Pradhan Mantri Awas Yojana (Urban) 2.0: Scheme/Operational Guidelines.

handling plans to the municipal authority, referencing the guidelines.[230] issued by the Central Pollution Control Board (CPCB). While adherence to the Eco-Niwas Samhita (ENS) standards[231] on energy efficiency, it is currently encouraged rather than mandatory; projects that seek to incorporate recycled aggregates must interpret the relevant Bureau of Indian Standards (BIS) codes and source materials exclusively from certified suppliers[232]. Similarly, integrating water reuse systems necessitates alignment with the Central Public Health and Environmental Engineering Organisation (CPHEEO) manuals and compliance with applicable local approval procedures.[233]. Despite these regulatory and technical requirements, financing partners tend to prioritise cost efficiency and sales velocity, often placing limited emphasis on the circularity features of housing developments.[234]. The result is a maze of overlapping but non-integrated frameworks, where compliance becomes so complex that developers choose the path of least resistance: build conventionally, submit the minimum paperwork, and avoid anything that might trigger additional scrutiny or delays.

7.1.6. Data deficiency

CE thinking depends on good information about what materials went into a building, where they are located, how they are performing, and what can be recovered when the building is repaired, renovated, or demolished[235]. This material memory is almost non-existent in India's affordable housing sector. Most projects are documented through paper blueprints, PDF drawings, or fragmented contractor invoices. Once a building is handed over, its *data* stays scattered between developers, contractors, and local authorities and often becomes inaccessible within a year or two. Planning for reuse, recovery, or disassembly is almost impossible without this memory. Circular housing is more than a design philosophy; it also demands information symmetry. To reuse materials or track performance, it is essential to understand:

- What materials were used, and in what quantities
- Which components are modular or detachable
- What certifications or performance tests were conducted
- Where high-value materials (*like steel or aluminium, etc.*) are embedded

[230] Ministry of Environment, Forest and Climate Change (MoEFCC). (2016). *Construction and Demolition Waste Management Rules, 2016*; Central Pollution Control Board (2017) *Guidelines on Environmental Management of Construction & Demolition (C&D) Wastes*

[231] Bureau of Energy Efficiency (BEE). (2018). *Eco-Niwas Samhita (Energy Conservation Building Code for Residential Buildings), Part 1: Building Envelope*; Bureau of Energy Efficiency (2025). *Eco-Niwas Samhita—Resources and updates (ENS, 2018; ENS 2021 Part 2; ENS, 2024)*

[232] Bureau of Indian Standards (2019/2020). IS 383:2016—Coarse and Fine Aggregate for Concrete; Building Materials & Technology Promotion Council (2018) Ready Reckoner for Utilization of Recycled Produce of C&D Waste.

[233] Central Public Health & Environmental Engineering Organisation (CPHEEO), MoHUA. (2023–2024). *Manual on Water Supply and Treatment Systems (Drink-from-Tap), Part A (Engineering) / Part B (O&M)*; Central Public Health & Environmental Engineering Organisation (CPHEEO), MoHUA (2013) *Manual on Sewerage and Sewage Treatment Systems* (Parts A–C)

[234] National Housing Bank (2022). *Booklet on Refinance Schemes*; Reserve Bank of India (RBI). (2025). *Master Directions—Priority Sector Lending* (effective April 1, 2025).

[235] Honic, M., Kovacic, I., & Rechberger, H. (2021). Material Passports for the end-of-life stage of buildings. Journal of Cleaner Production, 319; Global Alliance for Buildings and Construction (2021). The Building Passport: A tool for capturing and sharing building-related data - https://globalabc.org/sites/default/files/2021-09/GABC_The-Building-Passport_FINAL.pdf, Çetin, S., D'Urso, D., Picco, M., & Bueno, C. (2023). Data requirements and availabilities for material passports: Stakeholder needs and gaps. Journal of Building Engineering, 77

This information is vital not only for future recovery but also for building trust in circular practices today. A developer who can show regulators that their recycled aggregates meet BIS standards, or a financier who can show that their modular design reduces life-cycle costs, stands a better chance of getting approvals and funding[236]. India already has some of the pieces needed to build similar systems:

- BEE's ENS compliance portal helps developers input building energy data and generate compliance reports.
- PMAY-U's digital dashboards track project progress and unit completion in near real-time[237].
- Municipal e-governance platforms are digitising approvals and plan submissions.[238].

What is missing is a way to connect these platforms with material data, even in a basic format, to create a living record of what went into each project. The pertinent question here is how data will work for affordable housing. A modest approach could start with voluntary material inventories for PMAY-U projects. Developers may be encouraged to:

- List primary materials used—*cement, steel, aggregates, bricks*—in standard formats
- Upload compliance certificates for recycled materials or modular components
- Record design details for water and energy systems

Over time, these records could evolve into digital passports linked to a national platform, accessible to regulators, financiers, and even future buyers. This would create three clear benefits:

- Trust: Regulators and engineers could approve circular materials more confidently.
- Efficiency: Recyclers could plan for future material recovery, reducing costs and uncertainty.
- Value: Developers could demonstrate life-cycle performance to banks, unlocking better financing terms.

7.1.7. Operation and maintenance gap in water reuse

Water often gets less attention than materials or energy when discussing circularity in affordable housing. However, water is one of urban India's most pressing sustainability challenges.[239]. Affordable housing projects, massive under PMAY-U, add thousands of new residents to already stressed municipal water networks.[240]. It is worth mentioning that national guidelines already encourage water efficiency and reuse. The Model Building Bye-Laws

[236] Kaza, N., Quercia, R. G., & Tian, C. Y. (2014). Home energy efficiency and mortgage risks. Cityscape, 16(1), 279–298; Balasbaneh, A. T., Abdullah, S., & Muniandy, R. (2025). A systematic review of life-cycle cost estimation for building refurbishment and retrofit. Environmental Science and Pollution Research.
[237] Ministry of Housing and Urban Affairs. (n.d.). PMAY (Urban) portals and dashboards, https://pmay-urban.gov.in
[238] Ministry of Housing and Urban Affairs(2023). Annual Report 2022–23 (see Clause 5.15: Online Building Permission System—operational in 2,465 ULBs).
[239] Rosenzweig, C., Solecki, W., Romero-Lankao, P., Mehrotra, S., Dhakal, S., & Ibrahim, S. A. (Eds.). (2018). Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network (Ch. 14: Urban Water Systems). Cambridge University Press.
[240] Press Information Bureau, Government of India. (2025, August 13) - *Additional 1.47 lakh houses approved under PMAY-U 2.0, taking total sanctions to over 120 lakh - https://www.pib.gov.in/PressReleasePage.aspx?PRID=2156126&utm*

(MBBL 2016) require rainwater harvesting.[241]. The CPHEEO manuals recommend wastewater recycling for non-potable uses[242]. The National Water Policy advocates reuse as a key demand management tool. However, in many affordable housing complexes, those carefully designed systems stop working a few months or years after inauguration. Tanks get clogged, treatment plants idle, and residents revert to using only fresh municipal water.[243].

Systems often fail post-handover when residents are uneasy about reclaimed water or unclear about their roles and fees; basic tariff design combined with structured handover training can build confidence and improve usage. In many affordable-housing projects, rainwater harvesting and wastewater recycling systems are installed during construction to meet code requirements.[244]. However, once the project is handed over, responsibility for operation and maintenance (O&M) becomes ambiguous—cooperative societies in low-income communities may lack technical expertise or funds. At the same time, municipal authorities often assume the system is privately managed. This disconnect leads to gradual neglect and system breakdown. Water reuse succeeds only when a clear financial logic sustains it. If residents already receive municipal water at subsidised rates, they have little incentive to pay—even at a lower tariff—for treated greywater. Likewise, O&M contractors have no incentive to maintain quality without predictable revenue streams, locking projects into a cycle of underuse and system failure.

7.2. Conclusion

India's journey toward circularity in affordable housing is not a story of failure but evolving priorities. The systems in place, PMAY-U for scale and affordability, RERA for trust and transparency, ENS for energy efficiency, and BIS and CPCB frameworks for materials and waste, have delivered what they were designed to deliver. What they now face is a new expectation: to help create affordable, today and resilient, adaptable, and resource-conscious homes for decades to come. The barriers, such as fragmented institutions, weak market signals, trust gaps, data poverty, financing biases, and the invisibility of informal actors, are less about resistance and more about the absence of integration. Circularity in housing will emerge not through sweeping overhauls but through steady connections: between ministries. Hence, codes align between developers and financiers so life-cycle value becomes bankable, and between formal systems and informal actors, the people already closing material loops are recognised and equipped. At its heart, circularity is not about jargon or technology but about care for materials, communities, and the generations that will inherit these homes. Affordable housing has always been about dignity and belonging; circularity deepens that promise, ensuring homes are built to last for today and the decades ahead.

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[241] Town & Country Planning Organization, Ministry of Housing and Urban Affairs (2016). Model Building Bye-Laws, 2016 (*Ch. 9: Rainwater Harvesting; §9.1–9.6; Ch. 10: Green buildings—water reuse*)

[242] Central Public Health & Environmental Engineering Organisation, Ministry of Housing and Urban Affairs (2013) Manual on Sewerage and Sewage Treatment Systems (*Ch. 7: Recycling and reuse of sewage; Ch. 2 referencing reuse preference*)

[243] Hindustan Times. (2025, January 15). *Rainwater harvesting systems largely dysfunctional in Greater Noida West, many pits choked or not maintained https://www.hindustantimes.com/cities/noida-news/rainwater-harvesting-systems-largely-dysfunctional-in-greater-noida-west-101736881011738.html?utm*; Times of India (2025, July 4). *Ghaziabad societies lacking rainwater harvesting to face fines; many systems found non-functional* https://timesofindia.indiatimes.com/city/noida/ghaziabad-societies-lacking-rainwater-harvesting-to-face-fines-up-to-rs-3-lakh/articleshow/122235533.cms?utm

[244] Town & Country Planning Organization (TCPO), Ministry of Housing and Urban Affairs (MoHUA). (2016). *Model Building Bye-Laws, 2016* (*Ch. 9: Rainwater Harvesting; Clause 9.1–9.6; Ch. 10: Green buildings—water reuse*); Central Public Health & Environmental Engineering Organisation, MoHUA. (2013). *Manual on Sewerage and Sewage Treatment Systems* (*Ch. 7: Recycling and reuse of sewage; Ch. 2 referencing reuse preference*)

CHAPTER 8: Conclusion and Recommendations

The convergence of India's twin priorities - universal affordable housing and sustainable urban development - demands a robust integration of CE principles into policy and legal frameworks. While flagship missions such as Pradhan Mantri Awas Yojana (Urban and Gramin), AMRUT**,** and the Smart Cities Mission provide a promising scaffold, they have yet to operationalise circularity in a systemic and enforceable manner. This chapter proposes actionable recommendations that align housing policy with CE principles across material circularity, design adaptability, life-cycle integration, local resource synergy, and community embeddedness**.** The following recommendations ensure that CE principles are not merely aspirational, but actionable and measurable.

Revision of PMAY guidelines

- It is recommended that PMAY-Urban and PMAY-Gramin guidelines be updated to embed circular economy (CE) measures more explicitly. Explicit targets and a roadmap for circular construction be established.

Incorporating passive design and energy efficiency

- Integrating passive and energy-efficient design principles into PMAY-Urban could support better performance and livability. Prioritizing approvals for energy-efficient layouts could serve as a positive reinforcement for developers.

Linking green certification to financing

- Aligning PMAY funding with green certification benchmarks can incentivize sustainable construction practices. For example, concessional loans for certified green projects or tax rebates and priority lending for developers using recycled materials and energy-efficient technologies would align financial flows with CE goals.

Strengthening CE integration in PMAY-Gramin

- PMAY-Gramin already promotes locally sourced materials and local workforce training. These aspects could be further formalized and scaled to enhance circular practices.

Coordination with Urban Missions

- Affordable housing initiatives could benefit from closer integration with urban programs like Smart Cities, AMRUT, and Swachh Bharat Mission. Linking housing approvals to compliance with city-level systems for waste, water, and energy loops could ensure housing clusters function in harmony with municipal infrastructure.

Foster multi-stakeholder coordination

- Create an institutional platform or council (bringing together ministries, local governments, builders, NGOs and the informal sector) to share knowledge and coordinate initiatives. Such a forum can consolidate best practices from across the value chain (e.g. connecting waste recyclers, architects and municipalities) to drive systemic change

Updating Building Codes and Bye-Laws

- The Model Building Bye-Laws (MBBL) and National Building Code (NBC) could be strengthened to incorporate circular features as standard practice. Requiring a CE checklist as part of the permitting process would further institutionalize these measures.

Enhancing enforcement of C&D waste rules

- Stronger linkage between the C&D Waste Rules (2016) and housing project approvals could improve compliance. For example, requiring certification from State Pollution Control Boards as a precondition for project sanction, and integrating monitoring mechanisms into PMAY oversight, would help increase recycling rates beyond the current low levels.

Establishment of a Steering Committee

- Establishing a Steering Committee – as a central coordinating body with clear authority, resources, and data access could harmonize CE actions across housing, urban development, and environmental domains. Such a mechanism could ensure uniform targets, streamline approvals, and integrate CE compliance into all housing projects, from planning to occupancy.

Streamlining compliance and building capacity

- Simplifying regulatory procedures through digital platforms, such as portals for tracking construction waste and recycled-material certifications, could reduce compliance burdens. Allocating resources to urban local bodies for inspections and training would further strengthen enforcement.

Use public procurement as a lever.

- Government procurement and infrastructure spending should prioritize circular solutions in housing. For instance, require recycled or rapidly renewable materials in public housing projects, and invest in waste collection/sorting facilities. Government-backed pilot projects (e.g. prefabricated circular homes) can demonstrate feasibility and "kick-start" markets for new solutions.

Financial Mechanisms

Alongside regulations, targeted financial support can strengthen the adoption of circular practices:

- Viability Gap Funding (VGF) and subsidy frameworks could be enhanced to reward circular initiatives.
- Extending existing tax benefits for green buildings to affordable housing projects would encourage wider adoption.
- The Reserve Bank of India could consider linking affordable-housing lending guidelines to CE-compliance, with priority lending extended to certified projects. ESG-linked housing loans could also be promoted.
- Instruments such as green bonds or concessional loans (for example, through IREDA) may be leveraged to fund community recycling centres, off-grid solar systems, or other sustainable amenities within housing projects.

Technological Enablers

Scaling practical tools and innovations can accelerate CE integration:

- Promote mainstream adoption of recycled aggregates, plastic-ash bricks, bamboo, or earth blocks by encouraging BIS to publish specifications and standards, allowing public housing projects to specify these materials without procedural delays.
- Expand incentives for pre-cast and modular components, which reduce construction waste and allow design-for-disassembly. Lighthouse Projects could be adapted to showcase prefabricated EWS housing, with updates to fire and structural codes to accommodate these innovations.
- Deploy C&D waste recycling facilities near all major cities, potentially through public-private partnerships supported by municipal incentives, in line with the Swachh Bharat framework.
- Develop CE toolkits for engineers and contractors, such as mobile apps for on-site waste tracking or design tools that optimize material usage. Manuals from CPHEEO and BMTPC could be adapted into practical, hands-on guides.

Institutional Capacity Building

Effective implementation requires new skills, coordination, and stakeholder involvement:

- Form an inter-agency task force (MoHUA, MoEFCC, NITI Aayog, and state housing boards) to harmonize CE adoption in housing policies. Urban local bodies could also benefit from dedicated sustainability officers to enforce CE norms on sites.
- Expand training programs for engineers, masons, and contractors, building on existing initiatives like the PMAY-Gramin Rural Mason Training Program to include modules on waste minimization and alternative materials.
- Upgrade PMAY monitoring systems to track environmental performance, not just unit delivery. Integrating metrics like litres of water reused or tonnes of waste recycled into MIS dashboards and conducting third-party audits for green features could enhance accountability.
- Institutionalize resident engagement by mandating co-design workshops during planning and forming local maintenance committees—such as women's groups—to manage systems like rainwater harvesting or waste segregation.

Each recommendation draws on existing instruments, tightening them rather than inventing new schemes. For example, the Model Building Bye-Laws and PMAY already mention rainwater harvesting and energy norms; the suggestion is to make these clauses binding and enforceable in affordable housing projects. Similarly, policies like the Fly Ash Notification are already law – housing rules can reference and verify their implementation.

Implementation Framework: These reforms can be rolled out in phases:

- **Step 1** (Policy Revision)**:** Issue updated PMAY-U/G guidelines embedding CE criteria (mandatory waste management plans, recycled material use, green design). Revise viability gap funding (VGF) rules and offer tax incentives to green projects, ensuring central/state schemes reward circular practices. This establishes the legal and fiscal foundation for CE in affordable housing.

  Add a **CE Compliance Annex** to every PMAY-U/G Detailed Project Report and tender documents.

A1: C&D Waste Plan (ULB-approved routes, recycler tie-ups, tipping receipts).
A2: Recycled-Content Schedule (IS 383 recycled aggregates, fly-ash bricks/blocks within notified radius; supplier certifications).
A3: Energy spec (ENS/NBC part 8 compliance, window-to-wall ratios, shading, cross-ventilation, cool roofs).
A4: Water loops (dual plumbing for non-potable, rooftop RWH, on-site greywater/treated wastewater reuse where ULB has a plant).
A5: Design-for-Disassembly checklist
A6: Oversight &Maintenance and Tariff Plan (operator, fee logic, escrow for upkeep; RWA/ULB roles).

- **Step 2** (Capacity & Coordination)**:** Train officials and engineers on CE practices (waste plan preparation, green design, material reuse). Update state housing manuals and local bye-laws to incorporate CE requirements (e.g., mandatory recycling on-site). Establish inter-agency coordination mechanisms so that urban local bodies align with CE goals.

- **Step 3** (Pilot Projects)**:** Launch demonstrative "Circular Affordable Housing" pilots under Smart Cities/AMRUT. For instance, build a PMAY colony using 100% recycled construction materials, harvesting rainwater, and composting. Document the costs, savings, and social benefits. These pilots showcase feasibility, generate learnings, and publicize the concept.

- **Step 4** (Scaling & Enforcement)**:** Scale successful pilots nationwide. Make CE clauses mandatory in all new housing project approvals. Empower regulatory bodies to enforce them.

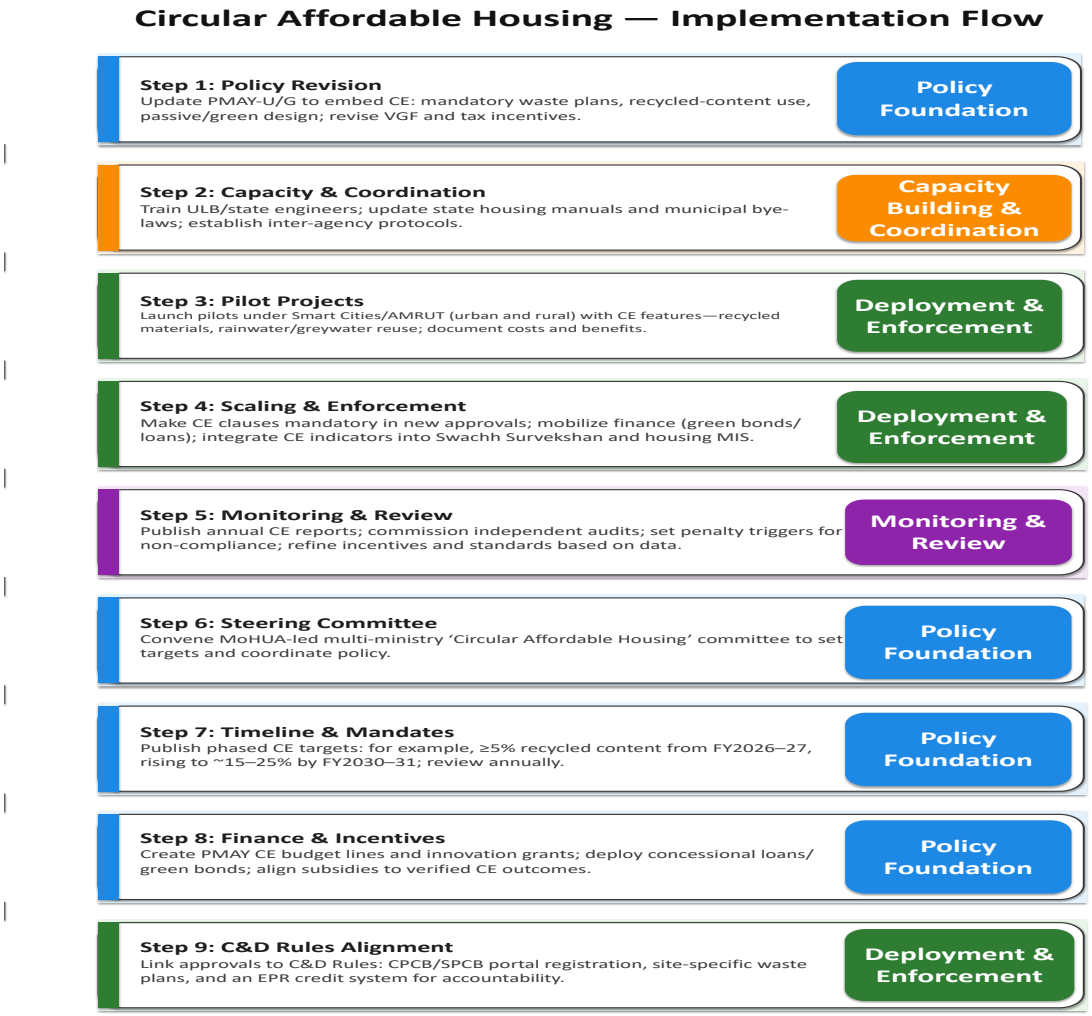
- **Step 5** (Monitoring & Review): Regularly review CE outcomes and refine policies. For example, publish annual reports on resource efficiency gains and recycled content usage in housing. Data from housing MIS and ULB reports may be used to measure progress. Update incentives or regulations in response to feedback (e.g., raise recycled content mandates if targets are met early). Enforce penalties for non-compliance (e.g., suspend funds or approvals for projects violating waste rules). This ensures continuous improvement and accountability in achieving CE goals.

- **Step 6** (Steering Committee): Constitute a high-level "Circular Affordable Housing" committee under MoHUA with key ministries (Environment, Finance, Rural Development, etc.), industry, and expert representatives. The committee would set CE targets (e.g., recycled content, green home counts) and coordinate policy across agencies.

- **Step 7** (Timeline & Mandates): Define phased targets and mandates. For example, mandate ≥5% recycled content (per C&D rules) in all central/state housing projects from FY2026–27, rising to ~15–25% by FY2030–31. Schedule gradually tightening standards (e.g., *waste reduction, water reuse*) and review them annually. This creates clear milestones and accountability for builders.

- **Step 8** (Finance & Incentives): Allocate dedicated budget for CE innovations in PMAY (*grants, R&D support*) and mobilize green finance (*green bonds, concessional loans, green climate fund financing*). Tie financial support to meet CE criteria, and plan annual incentives reviews.

- **Step 9** (C&D Rules Alignment)**:** Coordinate with C&D Waste Management Rules in approvals. All housing project proponents are required to register on the CPCB waste portal and submit a construction waste management plan (as mandated by the new rules). This plan would detail waste segregation, recycling, and disposal. Leverage the upcoming Extended Producer Responsibility (EPR) certificate system to enforce accountability, allowing developers to buy credits against unrecycled waste. These steps align housing projects with national waste norms and ensure compliance.



Integrating the CE into affordable housing is both necessary and feasible. By grounding these actions in existing laws and schemes, India can align "*Housing for All*" with sustainability. It can deliver cheaper, healthier homes while conserving India's resources. The building sector already uses green standards and innovative materials, but needs stronger policy signals to scale up. By mandating recycled content, realigning incentives, and enforcing the new C&D recycling rules, India can make its next million homes "future-proof." Aligning these changes with existing housing schemes (PMAY, RERA) ensures regulatory coherence. With concerted action – from tax policy to technical innovation – circular principles can become standard practice in India's affordable housing, yielding economic and environmental gains for all.

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