TECHNICAL GUIDELINES

Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future in Residential Construction Sector in Argentina

UN environment programme

International Resource Panel

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GLOSSARY

Term	Acronym, units	Description
Building Information Modelling	**BIM**	Modelling a building project in a three-dimensional environment through collaboration with architects, engineers, contractors, and suppliers.
Circular economy	**CE**	An economy where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized.
Compound Annual Growth Rate	**CAGR**	CAGR represents a constant rate of return over a period of time.
Construction & demolition waste	**C&DW**	Waste generated during the construction, renovation, or demolition of a building or infrastructure.
Dynamic Sector Map	**DSM**	A dynamic sector map represents the sector dynamics consisting of various stakeholders and the relationships and interdependencies among them.
Energy intensity	**EI. MJ/m^{2}a or MJ/km.**	Energy demand per unit (and year).
End-of-life recovery rate improvement	**EoL**	ME strategy concerned with improving the recovery and recycling of materials from products no longer in use and discarded, to increase the amount of secondary materials available.
Fabrication yield improvement	**FYI**	ME strategy which reduces the amount of material scrap in the fabrication process, thereby lessening the demand for primary materials.
The Group of Twenty	**G20**	The Group of Twenty is the premier forum for international economic cooperation. It comprises 19 countries (Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Türkiye, United Kingdom and United States) and the European Union.
Greenhouse gas emissions	**GHG, kg or Gt CO_2e**	Emissions of gases that cause the greenhouse effect. Reported in units of potency equivalent to that of a kilogram, ton, or gigaton of carbon dioxide.
Gross Domestic Product	**GDP**	Gross Domestic Product measures the monetary value of final goods and services produced in a country in a given period of time.
Gross National Income	**GNI**	Gross National Income measures the GDP plus income received from abroad in a given period of time.

Term	Acronym, units	Description
International Resource Panel	**IRP**	The International Resource Panel was launched by the United Nations Environment Programme in 2007 to build and share the knowledge needed to improve our use of resources worldwide.
Life-cycle emissions		The emissions associated with the entire life cycle of a product, including material production, construction, operations, and disposal. Includes credit for replacing primary materials when recycling at the end-of-life of a product, and for the storage of carbon in wood. Also labelled as 'systemswide' emissions. Here, they refer to the system-wide emissions associated with the production, operations, and disposal of the entire modelled product stock.
Low Energy Demand (scenario)	**LED**	A scenario aiming to limit global average temperature rise to 1.5°C through the implementation of radical energy demand reduction efforts and with renewable energy, without using CO_2 capture and storage.
Lifetime extension	**LTE**	ME strategy to increase the lifetime of products through better design, increased repair and enhanced secondary markets.
Per capita floor area	**m^2/cap**	The average residential floor area available per person.
Material Efficiency	**ME**	The pursuit of technical strategies, business models, consumer preferences and policy instruments that would lead to a substantial reduction in the production of high-volume, energy-intensive materials required to deliver human well-being; expressed as a ratio of the amount of product or service obtained by unit of material use.
Material Efficiency strategy	**ME strategy**	A unique approach to improve material efficiency. In this report, a range of strategies is modelled and their implementation through policy is investigated.
Multi-family home	**MFH**	A type of housing where multiple housing units are contained within one or several buildings within a complex (e.g., apartments).
Material intensity	**MI, kg/m^2**	Amount of material content per unit or product.
Material substitution	**MSu**	ME strategy in which materials in products are replaced by other materials (e.g., wood replacing cement and steel in buildings).
Nationally Determined Contributions	**NDC**	Nationally Determined Contributions constitute the efforts each country takes to reduce national emissions and adapt to the impacts of climate change.
Open dynamic material systems model	**ODYM**	An open model for Material Flow Analysis developed by Pauliuk and Heeren (2019).

Term	Acronym, units	Description
Open dynamic material systems model for the resource efficiency and climate change mitigation project	**ODYM-RECC**	A modular depiction of product stocks in major end-use sectors and the associated material cycles of climate-relevant bulk materials.
Participatory Systems Mapping	**PSM**	Participatory Systems Mapping is a participatory modelling methodology in which a group of stakeholders collaboratively develop a simple causal map of an issue during the course of a workshop.
Resource Efficiency	**RE**	Efficient use resources including materials, water, energy, biodiversity, land and, in the context of climate change, financial resources.
Reduce, reuse, recycle	**3Rs**	Indicates an order of priority for strategies to reduce and manage waste.
Reuse	**ReU**	ME strategy consisting of recovery, remanufacturing, and reuse of components or products displacing the production of spare parts or primary products.
Single-family home	**SFH**	A housing unit with a stand-alone structure and its own lot intended for one family.
Shared Socioeconomic Pathway	**SSP**	Narratives and socioeconomic scenarios used by modellers to develop global energy and GHG emissions scenarios.
Sustainable consumption and production	**SCP**	A framework encompassing any and all issues that seek to improve the way that products and materials are sourced, manufactured and marketed and the way that products are purchased, used, and disposed of at the end of their useful lives.
Using Less Material by Design	**ULD**	ME strategy regarding reducing the size or solid mass of products, which reduces the amount of materials in the product and potentially also the energy required for operation (e.g. using less steel in the bearing structure of buildings).
Zero Energy Building	**ZEB**	A building with a very low energy demand. When equipped with photovoltaics, such buildings produce as much energy as they consume.

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FOREWORD

Material resources – in the form of biomass, fossil fuels, metals and minerals – are fundamental to meeting essential human needs including that for housing. At the same time, unsustainable patterns of material use are, by and large, driving the global planetary crises of climate change, biodiversity loss and pollution. According to research by the **International Resource Panel**, material extraction and processing account for a staggering 55 per cent of global greenhouse gas emissions, 90 per cent of biodiversity loss and water stress, and 40 per cent of pollution.[i]

Cities, where almost 60 per cent of the global population currently reside, are central to addressing the environmental crisis. Meeting the needs of a growing and increasingly affluent and urban population, whilst avoiding further transgression of planetary boundaries, will require concrete and concerted policy action to build more energy and material efficient cities.

The International Resource Panel (IRP), in its global 2020 report titled "Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future" (RECC), examined the potential of material efficiency strategies as applied in residential buildings, and which are often overlooked compared to those targeting energy efficiency and uptake of renewables, in helping to mitigate greenhouse gas (GHG) emissions.[ii] Updated IRP modelling shows that resource efficiency strategies could reduce the built environment's material stock by around a quarter and its energy demand by around a third by 2060, compared to continuing with historical trends. Material savings are mainly in terms of steel and concrete, but also other metals such as copper and aluminium. These resource efficiency measures, when accompanied by climate measures, correspond to a 50 per cent GHG emission reduction over the same period.[iii]

Material, energy and GHG emission savings in residential buildings are realized by implementing demand-side solutions, which reduce the need for new housing space. This is achieved through more intensive use of buildings by lowering floor space per capita and encouraging higher household occupancy, limiting empty spaces, and promoting multifunctional use of space. In constructing new buildings, strategies that reduce material use by design have promising GHG emission abatement potential. These include lightweighting/lean building design and extending their lifespan (for example, designs adaptable to repurposing), increasing use of recycled materials in construction, as well as designing and constructing buildings in ways that reduce waste and allow for reuse and recycling of used materials. Decarbonization measures are further required, including switching to low emission fuels in manufacturing construction materials, alongside substituting high-carbon materials such as concrete and steel with low-emission bio-based ones such as wood, clay, reinforced rammed earth or processed bamboo.

In order to enhance the national relevance and policy uptake of its global analysis, the IRP has endeavoured to contextualise the key results and messages of the global RECC report for the construction sector in Argentina. This was made possible through funding by Germany's Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, and with similar "national spin-off" reports developed for Mexico and Indonesia.

The findings of these Technical Guidelines for Argentina's residential building sector have been both informed and validated by consulting with local stakeholders from the public and private sector, civil society and academia, and by engaging regional experts. The results of the IRP modelling work demonstrate that implementing a range of material efficiency strategies – without requiring development of new technologies – would by 2060 lead to a 45% reduction in material demand and a 47% reduction of GHG-emissions relating to residential building construction in Argentina. The national assessment serves to highlight the material efficiency strategies with the largest GHG emission reduction potential.


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i IRP (forthcoming in 2024). **Global Resources Outlook** 2024. United Nations Environment Programme. Nairobi, Kenya.

ii IRP (2020). **Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future.** Hertwich, E., Lifset, R., Pauliuk, S., Heeren, N. A report of the International Resource Panel. United Nations Environment Programme, Nairobi, Kenya

iii IRP (forthcoming in 2024). **Global Resources Outlook** 2024. United Nations Environment Programme. Nairobi, Kenya.

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1 INTRODUCTION

In its global report "Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future (RECC)", the International Resource Panel (IRP) conducted a rigorous assessment of the contribution of material efficiency to Greenhouse Gas (GHG) abatement strategies. More importantly, the RECC report assessed the reduction potential of GHG emissions resulting from material efficiency strategies applied in residential buildings and light duty vehicles, and reviewed policies that addressed these strategies. The report used the 'Open Dynamic Material Systems for Resource Efficiency and Climate Change' (ODYM-RECC) model to show GHG emissions reduction potential from material efficiency strategies in G7 countries as well as China and India.

The IRP has been recently commissioned to disseminate more strategically its global knowledge products also at regional and national level through its work programme by its member countries. To operationalise this mandate and continue its work on strengthening the knowledge of resource efficiency, the IRP will contextualise the results and key messages of the global RECC report for the construction sector in Argentina, Mexico, and Indonesia according to national contexts. Under the grant, the IRP will support further science-based decision-making opportunities on resource efficient and low carbon future in the aforementioned countries.

The G20 Environment Communiqué acknowledges that resource efficiency and circular economy are important tools to achieve sustainable development and can contribute to sustainable consumption and production, address climate change, reduce biodiversity loss, land degradation and pollution (G20 2021). The G20 Environment Communiqué and the G20 Resource Efficiency Dialogue Roadmap 2021 encourage the provision of financial, technological, and capacity building support to emerging economies and developing countries, making the best use of existing governance frameworks, and working to identify new and innovative solutions.

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OBJECTIVES

2.1 Overall objective

The primary objective of the IRP is to contribute to an improved understanding of sustainable development from the perspective of natural resources, provide science-based policy options while enhancing human well-being. While the Panel provides insights at the global level, it plays a critical role at the national level. As recognized in the theory of change concept of the IRP Work Programme 2022-2025, the IRP uses a systems approach to influence policy by, among others, translating knowledge to the regional and national levels (International Resource Panel 2022).

The objective of this project is to contextualise findings and recommendations of the global RECC report to Argentina, Mexico, and Indonesia, by delving into the specifics of the national priorities and circumstances and highlighting material efficiency strategies with the biggest potential for GHG emissions reduction. In these Technical Guidelines, the construction sector is prioritised for having high GHG emission reduction and sustainability potential. The project will leverage on international scientific cooperation and policy engagement that was carried out for the "parent" report while increasing its policy relevance and acceptance to national contexts by: applying the core conceptual framework contained in the RECC report, conducting a stakeholder consultation with key local actors (national level actors, private sector representatives, knowledge institutions, civil society, youth organizations and etc.) in Argentina, Mexico, and Indonesia and cooperating with local experts on the development of three national policy documents to be presented as IRP Technical Guideline. The insights gained from the project will support the IRP Work Programme 2022-2025, High Impact Priority Area 2, Sustainable Resource Management for effective action on Climate Change, Biodiversity, and Pollution.

2.2 Specific objectives

This project's specific objectives were to conduct national stakeholder consultations in the form of online and in-person meetings for presentation of the main findings and recommendations of the IRP RECC report and identification of national priorities for material efficiency strategies with GHG emissions reduction potential in the construction sector. These consultations brought together experts of the IRP, IRP Steering Committee members, GIZ, UNEP Regional Offices and key national stakeholders. These stakeholder consultations were used to collect further case studies from Argentina, Mexico and Indonesia to identify national priorities and sensitize national actors, including representatives from national governments on the contribution of material efficiency to GHG abatement strategies.

Following the workshops, the participatory information gathering and mapping, the case studies and knowledge gaps were reviewed and expanded with assistance from the regional experts. The process included refining the maps and establishing three national Priority Action Frameworks, which include a summary of the key challenges, opportunities, along with proposed strategies for policy, process, and practice. Follow up (virtual) review process took place to verify the proposed strategies for the partner countries on the Priority Action Frameworks, to ensure the system mapping, proposed actions, and that the understanding of the policy, process and practices are well founded.

The Technical Guidelines for national policy documents will also leverage the cooperation and engagement for the RECC report. The contextualised national Technical Guidelines are intended to increase policy relevance and acceptance of the IRP RECC report among national stakeholders (including public and private sector, civil society, research institutions). The Technical Guidelines for the national policy apply the core conceptual frameworks of the RECC report to national priorities and circumstances of Argentina, Mexico and Indonesia and highlight national material efficiency strategies with the biggest potential for GHG emissions reduction and develop science-based policy recommendations for the residential construction sector. The data and case studies gathered during national stakeholders' consultation have particularly informed these policy documents.

3

BACKGROUND

3.1 Country profile

In its updated NDC report 2020, Argentina committed not to exceed the net emission of 349 MTCOe2 by 2030. Argentina is one of the largest economies in Latin America, with a Gross Domestic Product (GDP) of approximately USD 597.93 billion. After a fall of 9.9 per cent in 2020 due to the COVID-19 pandemic, Argentina's economic activity has recovered faster than expected, with an increase of 10.4 per cent of GDP in 2021 and 5.2 per cent in 2022. Argentina has vast natural resources in energy and agriculture and is a leading food producer with large-scale agricultural and livestock industries (World Bank 2023). The population of Argentina in 2022 was 45.28 million, and it is projected to be 46.04 million in 2023 (National Institute of Statistics and Census [INDEC] 2023c). With the growing population size and a growing economy, the demand for residential buildings construction is expected to grow in the future.

3.1.1 Argentina's construction industry

The construction industry in Argentina was valued at USD 17 billion in 2021 (Statista 2023). The portion of Gross Domestic Product (GDP) of the construction industry grew by 3.2 per cent in the first quarter of 2023 (National Institute of Statistics and Census [INDEC] 2023b). The residential construction sector's output is expected to be supported by investments in the housing sector as population grows and the government focuses on addressing the country's housing deficit (Global Data 2023).

The single-family housing construction sector in Argentina registered a positive Compound Annual Growth Rate (CAGR) of 50.21 per cent during the period 2017 to 2021 (Global Data 2022). The Housing Index in Argentina averaged 3.34 per cent from 2015 until 2023, reaching an all-time high of 13.39 per cent in November of 2020 and a record low of -1.16 per cent in April of 2020 (National Institute of Statistics and Census [INDEC] 2023a). Overall, the construction sector is an important contributor to Argentina's economy, with significant growth potential. The housing sector has also seen growth in recent years, particularly in the single-family housing construction sector. However, the construction sector's material use has significant environmental impacts, particularly in terms of greenhouse gas emissions. The section below shows the economic activities of Argentina's construction material industry.

3.1.2 Argentina's construction material industry

Despite the economic insecurity, Argentina's cement industry has continued to grow in the past decade. In 2013, Argentina produced 11.89 million metric tons of cement, which reduced to 9.87 million metric tons in 2020 and increased to 13.03 million metric tons in 2022. Argentina's cement export drastically reduced from 218 thousand tons in 2013 to 81 thousand tons in 2018 despite similar amounts of cement production. Though cement export increased again to 132 thousand tons in 2020, it was reduced to 88 thousand tons in 2022, signalling an increased domestic consumption of cement. Compared with the increase in production to 2022, this evidences an increase in the internal demand for cement from 2018 to 2022. More significantly, though the cement production capacity remained between 15.35 to 15.77 million metric tons from 2013 to 2021, the production capacity has dramatically increased to 18.47 million metric tons in 2022. Among the various regions in the country, Buenos Aires Region (including the Autonomous City of Buenos Aires, Great Buenos Aires, and the rest of the Buenos Aires Province) has been the largest domestic consumer of cement, consuming 41.05 per cent of the total cement consumption followed by Central and Northwest regions (Portland Cement Manufacturers Association [AFCP] 2022).

Argentina also has a large crude steel production industry, totalling a production of 4.87 million metric tons in 2021 and 5.09 million metric tons in 2022 (Acero Argentino 2023). Argentina exports its steel to Mexico, Brazil and the United States, while imports much larger amounts from Mexico, Brazil and Germany (Volza 2023a; Volza 2023b). At the same time, the apparent consumption of hollow bricks, steel and round iron for construction, and portland cement has decreased by 15.1 per cent, 8.3 per cent and 1.5 per cent respectively in 2023 as compared to 2022. In contrast, the apparent consumption of limes and finished concrete has increased by 8.7 per cent and 8.3 per cent respectively in 2023 (National Institute of Statistics and Census [INDEC] 2023b). This signals a change in the demand for construction materials mix as well as reduction of demand for construction materials from 2022 to 2023. Despite the short-term decrease in demand for construction materials, there continues to remain a large proportion of housing deficit that would demand more construction materials in the future.

It is important to note that construction materials are used differently in different bioenvironmental regions in Argentina. Argentina has a territory with more than 3,500 km from north to south, and more than 1,200 km from east to west. The national standard IRAM 11603 specifies six bioenvironmental zones ranging from very hot in the north-east to very cold in the west and southwest of the country (Argentinian Institute of Standardization and Certification [IRAM] 2011). As the regional distribution of resources also vary according to the bioenvironmental zones, certain regions use higher proportion of wood for residential building constructions (such as zone VI: Very Cold), while there is higher proportion of use of bricks and rammed earth (such as zone I: Very Hot). Therefore, the detailed standards for material efficiency strategies should be detailed for each of these six bioenvironmental zones.

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RESEARCH METHODS

These Technical Guidelines build on a literature and policy review, two national consultation workshops and quantitative modelling. Based on desk-based literature and policy review, an online consultation workshop was conducted to map the dynamics of the construction sector. Using the participatory systems mapping tool (PSM), the participants of the workshop identified all stakeholders involved in the residential construction industry and their relationships with one another. A Dynamic Sector Map was created and shared with all the participants for their additional and continued inputs. Based on the dynamic sector map, the project team consulted with key stakeholders to explore the opportunities and barriers for achieving material efficiency in the construction sector in Argentina. The dynamic sector map is attached in **Annex II: Dynamic Sector Map**.

Based on the information produced in the 1st online national workshop and subsequent stakeholder consultations, a 2nd in-person national workshop was conducted in Argentina. The in-person workshop was designed as a full-day event with welcoming remarks by the Secretary of Climate Change, Sustainable Development and Innovation, presentations from the IRP expert team, presentations from local experts, and two roundtable discussions with national stakeholders from Argentina. The workshop was planned to build on the dynamic sector map and deliberate over key actions to be prioritised in Argentina. A list of key actions (see **Annex I: Detailed Action Framework**) was compiled based on RECC report (International Resource Panel 2020), Roadmap for Energy-Efficient Buildings and Construction in ASEAN (International Energy Agency 2022) and Building Materials and the Climate: Status and Solutions (United Nations Environment Programme 2023).

The format of the roundtable discussions allowed participants to deliberate over key focused areas. Each roundtable comprised of 5-7 participants representing different sectors to facilitate cross-sectoral deliberations. Participants were asked to deliberate on one of the five proposed goals to achieve material efficiency. In the 1st roundtable discussion, the participants were asked to discuss key opportunities and barriers in undertaking priority actions to achieve the proposed goals. The participants then discussed solutions to fulfil the opportunities and removing the barriers to achieve material efficiency in Argentina. After the first round of discussions, the participants were asked to comment on two additional goals deliberated on by other groups. The commenting rounds were useful in getting feedback from more than one group. In the 2nd roundtable, participants discussed the tentative timeframes required to fulfil key priority actions and the reasons for the expected timeframe. Later, the participants recommended actions to accelerate the net-zero transition in Argentina.

The IRP team then analysed the findings from the 1st and the 2nd national workshops, in conjunction with the literature and policy review, to propose key recommendations for Argentina. Lastly, an online review process was conducted to receive feedback from the national stakeholders to verify the feasibility of proposed recommendations and disseminate the findings of the research. Diagram 1 shows the process followed during the research and table 2 shows the number of participants involved throughout the research process.

Figure 1: Research process guiding the project.

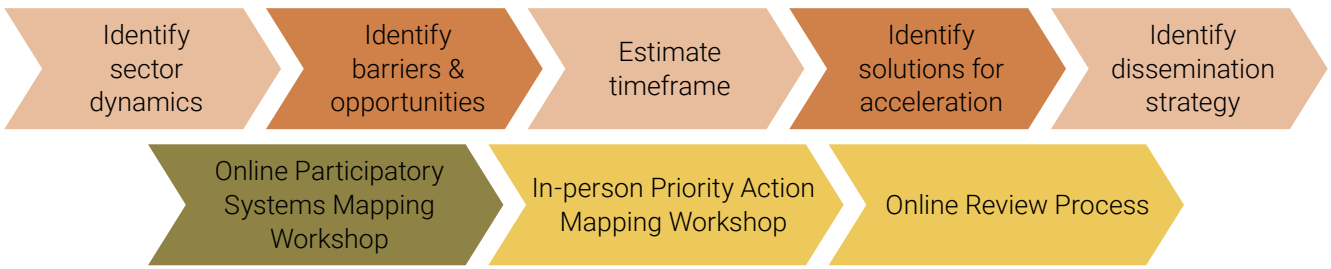

Table 1: Number of participants attending the workshops

Stakeholders	Number of expert participants	
	1st Online Systems Mapping Workshop	2nd In-Person Priority Action Mapping Workshop
Government	9	5
Private Sector	1	5
Civil Society	3	4
Academia	0	1
Total	**13 [8 females, 5 males]**	**15 [7 females, 8 males]**

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MODEL ANALYSIS

5.1 Modelling the residential sector

While emissions caused by the operation of buildings and measures for improving energy efficiency have increasingly gained recognition, environmental impacts related to the materials requirements for the construction of residential buildings are not identified in emission statistics. This section assesses the potential reductions in life-cycle greenhouse gas (GHG) emissions of materials in the residential buildings sector and analyses the environmental benefits of the implementation of policies to regulate the use of materials for construction.

Within the context of numerical modelling, regulatory policies are implemented as Material Efficiency (ME) strategies, namely initiatives that aim to optimise the use of materials to reduce material footprints and promote sustainable development. Understanding the implications of such strategies necessitates an in-depth analysis of material flows across the various phases of buildings' life cycle. This includes demand for new constructions, waste management and primary resource extraction to secure adequate primary production. The effectiveness of ME strategies is evaluated by comparing a baseline scenario, in which the set of variables describing the system does not change beyond the projected future state of economic and societal development, to scenarios in which the dynamics of the system changes in response to initiatives aimed at using materials more efficiently.

The scenario modelling addresses the production and consumption of primary and secondary materials, the material content of buildings, their manufacturing and use phase and their End-of-Life management. For each of these life-cycle steps, material balance and emissions are evaluated based on data derived from engineering calculations, empirical observations, case studies from the literature and statistics.

The time horizon for the scenario modelling is set at 2060. The selected narrative projects a continued growth in driving forces such as population and the economy and the implementation of ME strategies reflects an optimistic view of the future with favourable conditions to facilitate climate change mitigation.

5.2 Material Flows Accounting and GHG

This section outlines an overview of the application of the modelling framework to the residential building sector and the materials accounting approach is outlined. The modelling results have been informed by the ODYM-RECC model (Open Dynamic Material System Model for Resource Efficiency and Climate Change) developed by Pauliuk et al. (2021), which combines the analysis of material flows with life-cycle assessment thinking and engineering calculations (Pauliuk and Heeren 2020).

5.2.1 Buildings demand

Floor area per capita is the main driver of building demand. As the population grows, living conditions improve and old buildings are demolished, new buildings are needed. The scenario for future floor space per capita is based on the value of 27m^2 in 2020 (International Energy Agency 2017) its past dynamics and the general trend of increasing floor space with growing GDP. It is assumed that this trend continues and therefore the floor area per capita in 2060 is set to 40m^2.

5.2.2 Existing building stocks and archetypes

The building stock of Argentina is described using archetypes of residential buildings. Archetypes are representative models of buildings that share similar occupancy patterns, geometry and material composition. The most commonly used materials in building construction were derived from the analysis of the literature and case studies of Argentina's architecture. In Argentina, 32.3 per cent of the building stock is represented by Multi-Family Homes (Andersen et al. 2016). 25 per cent of the population lives in poverty (Puig and Lynch 2019), mostly residing in informal settlements around cities. The remaining fraction of the building stock is modelled as Single-Family Homes. The model utilises three basic archetypes for the corresponding building category, which are summarised in **Table 2**.

Table 2: Archetype characteristics.

Parameter	Single-Family Home	Multi-Family Home	Informal housing
Floor area	58 m^2 per unit, 2 units	87 m^2 per unit, 346 m^2 per floor	55 m^2
Footprint and height	8.5 m by 9.5 m, two-storeys, 3.2 m floor to floor	7.2 m by 12 m, twelve-storeys, 3.3 m floor to floor	5.5 m by 6 m, two-storeys, 3 m floor to floor
Additional floor area	35 m^2 – entrance and corridors	415 m^2 on ground floor parking	–
Perimeter length	39 m	132 m	23 m
Gross exterior wall area	249.6 m^2	5068.8 m^2	138 m^2

The material intensity of archetypes depends on the selected ME strategies scenario, and the standard design derived from the analysis of literature is compared in **Table 3** to alternative designs derived from architectural investigation. The approach for these Technical Guidelines focus on strategies tightly linked to main bulk materials: concrete, cement, bricks, steel, and timber.

5.2.3 From waste recovery to primary production and emissions

Quantifying the future availability of secondary materials requires modelling the stock of buildings currently in use and its age structure. At the End-of-Life of buildings, recycling rates of construction materials determine the quantity of demolition waste that can be converted into secondary material. It is estimated that over half of the building stock was built after the year 2000. This has significant implications for the potential availability of secondary material, as a large number of materials would be available in the form of waste to be recycled or reused in the second half of this century. Once the availability of the secondary material is estimated, the production of primary materials is calculated to meet the remaining demand. Finally, the production processes of materials are converted to environmental impacts through emission factors.

5.3 Modelling Material Efficiency strategies for buildings

There are significant opportunities to achieve reductions of emissions in the residential building sector if ME strategies are put in place. Material efficiency primarily aims to reduce emissions associated with the life cycle of construction materials, by reducing the demand of primary production. A range of strategies is analysed in a what-if counterfactual framework. The assessment comprises different scenarios, each presenting a potential future with its development pathways and underlying assumptions, which determine the material cycles and resulting GHG emissions until 2060. The benefits of the implementation of ME strategies are calculated as the difference in GHG emissions with a baseline scenario without the adoption of the strategies.

5.3.1 Reducing waste and recycling

Reducing waste benefits GHG emissions savings by conserving resources. Indirect reduction of emissions related to the production of materials can be achieved by increasing the recycling rates of materials at the end of life of buildings and reusing construction components. Recycling steel from structures with a recovery rate of more than 90 per cent was considered in the baseline scenario (Pauliuk et al. 2013). Case studies suggest that up to 29 per cent of the steel components (Milford et al. 2013) and up to 27 per cent of the concrete (Shanks et al. 2019) can be reused without requiring crushing, shredding, and/or remelting. Additionally, improving fabrication yields in the production

phase of materials can reduce the amount of material scrap generated during production, thereby lessening the demand for material inputs for the manufacturing sector. In a high waste reduction scenario, it is assumed that yields in cement and bricks production could be increased by 1.5 percentage points s (Shanks et al. 2019). Integrating higher material recovery and reuse rates into waste streams, alongside improvements in fabrication yields, could save 10 per cent of the cumulative emissions linked to primary production of materials for residential buildings by 2060 by reducing the production of primary material by 5 per cent. In total, almost 9 per cent of demolition waste to be disposed could be saved.

5.3.2 Materials substitution

Opportunities for GHG savings rise when buildings are designed with materials with low carbon emissions during their life cycle. The material substitution scenario replaces the building envelope, internal walls, and structural elements with sustainably harvested wooden constructions. To ensure that the alternative design does not compromise the functionality of buildings or worsen energy efficiency, additional layers of insulation are added within the envelope's construction to match the same thermal resistance of the traditional design. In this scenario, by 2060 35 per cent of new buildings would use low-carbon materials. The resulting material footprints of buildings are reported in **Table 3**. By using materials with low life-cycle emissions in buildings, 4 per cent of cumulative emissions up to 2060 could be reduced, as well as 7 per cent of bulk materials. Structures made of timber have a two-fold effect, given their capability of replacing high carbon-intensive concrete and their capacity to store carbon.

5.3.3 Use less material by design

Planning construction can help optimise the design of buildings and prevent using redundant materials. In a scenario with material efficient design, it is assumed that the amount of brick and reinforced concrete in external and internal walls and roofs can be reduced by 20 per cent, in internal floors by 8 per cent and the amount of construction grade steel in beams by 36 per cent. In this scenario, by 2060 70 per cent of new buildings would use optimised design. The resulting material footprints of buildings are reported in **Table 3**. An optimised design approach to building constructions could result in a reduction of cumulative emissions up to 2060, achieving savings of 8 per cent. Moreover, the adoption of such an approach would also yield a corresponding reduction in total material demand of 4 per cent, because of lower material requirements in building construction.

Table 3: Material footprints of building archetypes. Values are expressed in kg/m^2.

Housing type	Concrete	Cement	Steel	Wood products	Bricks	Other
Single-Family Home						
Standard design	1359.9	85.4	75.7	6.4	634.1	68.6
Material-substitution	962.1	96.1	143.6	115.0	491.3	68.7
Optimized design	1326.3	85.4	63.1	6.4	605.5	68.6
Multi-Family Home						
Standard design	1021.1	111.7	76.7	4.4	616.4	121.8
Material-substitution	512.6	129.0	48.5	193.8	81.1	121.9
Optimized design	942.0	111.7	63.8	4.4	509.3	121.9
Informal housing						
Standard design	1488.1	94.9	110.2	3.7	515.9	122.7
Material-substitution	850.0	106.4	171.3	159.8	63.7	122.7
Optimized design	1454.5	94.9	97.3	3.7	425.5	122.7

5.3.4 User behaviour

Reducing demand for new buildings is the most direct way to reduce emissions related to material production, by the construction of smaller houses, reduction of vacant buildings or more effective use of floor space. In this scenario, it is assumed that the target for the floor area per capita in 2060 would be 10 per cent less than the baseline scenario. Additionally, extending the lifetime of buildings before demolition, by repurposing of the space or by increased refurbishment, would also contribute to a reduction in new constructions. It is assumed that the lifetime of buildings could be extended by 90 per cent of the standard lifetime. More intensive use of building space has the highest reduction potential. Materials demand could be directly reduced by 35 per cent. Together with the extension of lifetime to reduce new construction demand and manufacturing, 34 per cent of emissions could be saved. Repurposing allows significant savings in terms of waste prevented from buildings demolition, achieving savings of 49 per cent.

5.4 Conclusions of model analysis

5.4.1 Implementation of all ME strategies

The simultaneous implementation of all the examined ME strategies would result in a 47 per cent reduction of the cumulative system-wide GHG emissions related to the construction and disposal of residential buildings by the year 2060. In this scenario, the total savings do not correspond to all the savings explored in the previous scenarios because of the interaction of different ME strategies. For example, directly reducing the material demand by optimising the building design also jointly reduces the secondary availability in the future, hence limiting the effectiveness of waste reducing scenarios. The modelling results indicate that material cycle improvements could reduce the cumulative production of materials for the construction of residential buildings in Argentina by 45 per cent. Notably, the reduction of emissions could be achieved without requiring the development of new technologies.

5.4.2 Decarbonisation of production systems

The energy required for material production processes in Argentina is sourced from the national electricity mix. Shifting to cleaner energy sources would result in a direct reduction of emissions during the production phase of materials. Currently, in Argentina 33 per cent of electricity is generated from renewable sources. In the clean energy scenario, it is assumed that by 2060 electricity production in Argentina from renewable sources would double up to 60 per cent. The increased employment of energy produced from renewable sources in the production phase of materials would lead to up 52 per cent reduction of cumulative emissions for the materials cycle, almost halving the total environmental pressure of materials in the residential buildings sector.

5.4.3 Modelling discussion

Since building lifetimes are longer compared to other durable products, some of the ME strategies may not fully realise their potential within the relatively short modelling horizon until 2060. This highlights the critical need for the implementation of impactful strategies aimed at mitigating GHG emissions within the residential building sector.

Some of the ME strategies rely on improvements in recycling and reuse patterns. Nonetheless, in some cases, the bulky and heavy nature of construction materials may lead to substantial environmental consequences during transportation which is not captured in the model. Additionally, recycling concrete may require larger amounts of additional cement, which is responsible for most of the impact of concrete.

The material substitution scenario relies on the availability of timber or similar wood products. However, the assessment is not linked to any forestry model, and sustainable management of forests should be ensured with proper regulations in line with Argentina's Law 26.331 of Minimum Budgets for the Environmental Protection of Native Forests.

Users' behaviour strategies contrast with the ongoing improvement of living conditions in Argentina and rely on the population's resilience toward sustainable development. Nevertheless, smaller heating and cooling spaces also reduce energy demand and emissions related to the operational phase of buildings, providing a crucial synergy between material and energy use reduction.

Table 4: Material efficiency strategies summary.

	Scenario					
	Reducing waste	Material substitution	Optimised design	User behaviour	All ME strategies	Production decarbonisation
ME strategies	**ME strategies implemented in the scenario**					
Improvement of recovery rates Improve recycling rates and availability of secondary materials to replace primary production.	x				x	x
Reuse of components Replacement of the production of spare parts or even primary products.	x				x	x
Improved fabrication yields Reduction of production of scrap in material production by improving fabrication yields.	x				x	x
Material substitution Use of construction materials with lower life-cycle emissions.		x			x	x
Using less material by design Use less material by optimised design of buildings without loss in functionality.			x		x	x
More intensive use Reduction of space demand by more effective use of existing space.				x	x	x
Lifetime extension Repurposing of existing buildings to extend their lifespan before demolition.				x	x	x
Energy supply decarbonisation Increased share of renewable energy sources in production processes.						x
	Saving potentials compared to baseline					
Waste generation	-9%			-49%	-54%	-54%
Material production	-5%	-7%	-4%	-35%	-45%	-45%
GHG emissions	-9%	-4%	-8%	-34%	-47%	-52%

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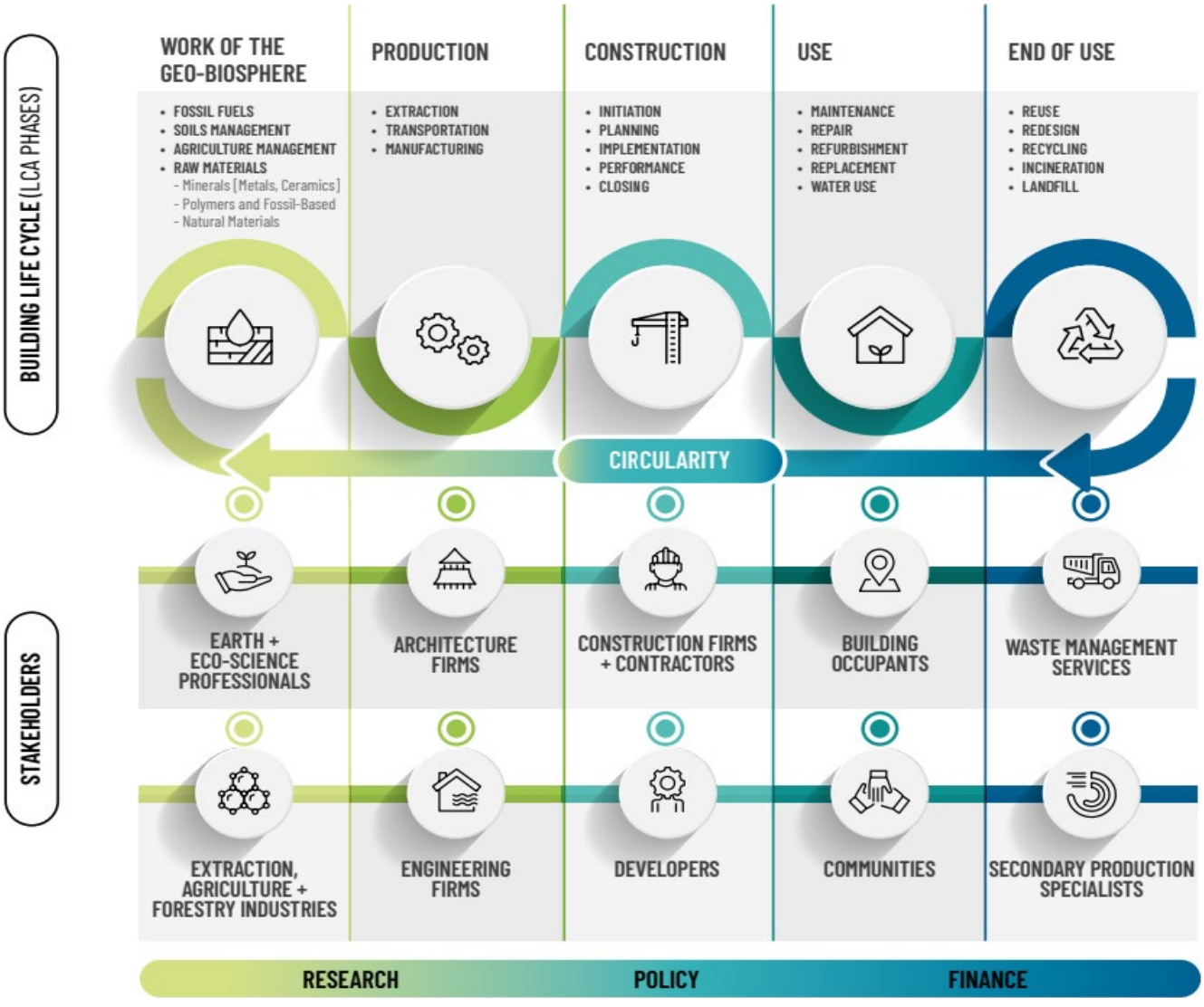
6

SECTOR DYNAMICS

The residential building construction sector in Argentina consists of a wide range of actors that relate to one another as per market dynamics. The market dynamics of the residential building construction sector can be linked to the building's whole life cycle. Residential building life cycle includes four stages: 1) Production of materials, 2) Construction of buildings, 3) Use of buildings, 4) End of use (United Nations Environment Programme 2023). To decarbonise the residential building construction sector, actions must be taken in all four stages of building life cycle to achieve maximum material efficiency. **Figure 2** explains the four stages of the residential building life cycle.

The whole life cycle of materials used in residential buildings is predominantly dependent on the materials market, the housing market, and the financial market. These primary markets further depend on market dynamics within the transportation industry, energy production and supply, and land markets. Presently, Argentina's state institutions regulate different markets through various fiscal and non-fiscal policies. Moreover, financial institutions, such as banks, provide monetary support to the residential building construction sector — including the material manufacturing industry — operating within the state regulations. To facilitate the analysis of various actors, their roles and responsibilities, and relations to one another, the residential building construction sector is divided into five sub-sectors, namely: (1) Governance and Planning, (2) Financial Regulation, (3) Material Supply Chain, (4) Construction and Design, (5) Civil Society and Academia.

Figure 2: Key stakeholders whose participation is critical to the decarbonization of buildings at different life phases (United Nations Environment Programme 2023, p.13).



Scientific report on resource efficiency and climate change suggests that all actors have a role to play in reducing the GHG emissions along the entire life cycle of the residential building stock. As the participants of the national consultations in Argentina also proposed, a collaborative and collective effort will accelerate the efforts to achieving a net-zero future in Argentina's residential building sector. To this effect, the rest of this section articulates some of the roles and responsibilities of various actors. The actors currently engaged in the residential building construction sector in Argentina are indicated in **Table 5**.

It is crucial to note that labour participation across the entire life cycle of the residential building construction process is highly differentiated across various sub-sectors and dependent on the prevailing socio-cultural dynamics. In this context, women are currently underrepresented in Argentina's construction industry at 4.6% (D'Alessandro et al. 2020). Currently women face numerous barriers towards equal participation in the construction industry in Argentina (Agence France-Presse 2021). Critical issues such as unpaid domestic work, traditional gender norms and gender pay gaps affect women's participation in the labour market in Argentina (D'Alessandro et al. 2020). At the same time, women have shown higher concerns about environmental issues globally (Shiva 1992; Kiptot and Franzel 2012). Consequently, decarbonisation of the construction sector stands to gain from the inclusion of women in various levels of activities.

In sectors such as forestry, women have played a critical leadership role in resource management and biodiversity conservation practices globally (Shiva 1992; Kiptot and Franzel 2012). In relation to forest management, the Ministry of Environment and Sustainable Development supports various programmes, including 'Reducing emissions from deforestation and forest degradation in developing countries (REDD+)' and Native Forest Producers Programme. Together, these programmes have aimed to (1) reduce gender inequalities in forest communities, (2) guarantee active participation of women, (3) support strategic investments that enable comprehensive management, (4) make visible women's contributions to forest management and (5) support economic independence. Similar efforts to finance and recognise women's contributions to the construction industry would be key to advance gender equality throughout the lifecycle of residential buildings. Embedding equity considerations across all sectors, and national and subnational institutions listed in the following sections would further enable gender equality in the country.

Table 5: Selected actors involved in the residential building construction sector in Argentina

Governance and Planning	Financial Regulation	Material Supply Chain	Construction and Design	Civil Society and Academia
■ Ministry of the Environment and Sustainable Development (MAyDS)	■ The Central Bank of Argentina	■ Cement producers	■ Argentine Chamber of Construction (CAMARCO)	■ The Association of Portland Cement Manufacturers (AFCP)
■ Ministry of Industry and Productive Development (MPD)	■ The National Securities Commission (CNV)	■ The Argentine Chamber of Steel (ACERO)	■ Association of Structural Engineers (AIE)	■ The Argentinian Association of Processed Concrete (AAHE)
■ Ministry of Territorial Development and Habitat (MDTyH)	■ The National Superintendence of Insurance	■ Steel producers	■ The Professional council of Civil Engineering (CPIC)	■ Argentine Industrial Union (UIA)
■ Ministry of Works, Employment and Social Security (MTEySS)		■ The Argentine Federation of the Wood and Related Industry (FAIMA)	■ Private Developers	■ The National Institute of Industrial Technology (INTI)
■ The Ministry of Economy		■ Material wholesalers	■ Architects	■ The Argentine Normalization and Certification Institute (IRAM)
		■ Material retailers	■ Engineers (Civil, HVAC, Electrical)	
		■ Transport companies	■ Consultants	
			■ Contractors	
			■ Demolition companies	

6.1 Governance and planning

The governance and planning sector involves various state institutions and actors — including ministries, national institutes, subnational governments, and local municipalities. The main role of the governance and planning sector is to regulate and monitor the entire supply chain of materials used in residential buildings. This includes regulating the extraction of resources, production and manufacturing of building materials, transportation and procurement by construction industry, management during the building use, and recycling, reuse, and safe destruction of materials at the end of life. The following actors are currently involved in regulating and monitoring the residential building constructions in Argentina and can potentially take up the role of regulating and monitoring a net-zero transitions in the residential building sector.

The Ministry of the Environment and Sustainable Development (MAyDS) works to promote Argentina's transition towards sustainable development. The ministry currently undertakes actions such as policy development and implementation, environmental education, collect data related to sustainability and enforce laws. The Ministry of Industry and Productive Development (MPD) coordinates activities related to industrial development, through promotion, financing, training, data collection and repository, as well as development of digital tools. MAyDS and MPD can support in policy development and implementation related to sustainable material production and manufacturing, including decarbonising cement and steel industries or producing sustainable wood.

The Ministry of Territorial Development and Habitat (MDTyH) works for the right to decent housing throughout the country. MDTyH runs various housing programmes such as the Program "Casa Propia — Construir Futuro" for housing, urbanisation, infrastructure, services and community equipment works. Casa Propia aims to generate 264 thousand housing solutions throughout the national territory during the 2021/2023 triennium. The subprograms contemplate gender perspective, the rights of the elderly, sustainability criteria and the incorporation of new technologies, as well as respect for cultural traditions and the different ways of building in each population.

The main objective of the Program "Eficiencia Energética y Energía Renovable en la Vivienda Social Argentina — GEF" is to contribute to the reduction of greenhouse gas (GHG) emissions as a result of reducing the energy consumption in social housing. The specific objective is to develop new minimum habitability standards, incorporating energy efficiency (EE) and renewable energy (RE) measures for the construction of social housing based on the results of the social housing prototypes with EE and RE built and monitored during the project. The design and construction of housing prototypes with EE and RE are planned, and their monitoring throughout a year in the six different bioenvironmental regions defined by the IRAM standards.

The Ministry of Works, Employment and Social Security (MTEySS) prepares, administers, and supervises policies and actions to improve the working conditions, training, labour insertion and social coverage of all citizens. Their presence in the ME strategies would be crucial in generating a politically sustainable pathways towards low carbon future.

6.2 Financial regulation

The financial sector directly or indirectly influences residential building constructions in Argentina. The financial sector involves actors such as international, national, as well as private banks, investment companies, pension providers, and insurance companies. Currently there is a lack of direct involvement by financial institutions in funding material efficiency and decarbonisation processes. However, their already existing links with the material manufacturing as well as building construction sectors can be leveraged to support the material efficiency agenda.

The Ministry of Economy, the Central Bank of Argentina, the National Securities Commission, and the National Superintendence of Insurance have jointly signed a statement towards the promotion of the development of sustainable finance in Argentina. The National Securities Commission (CNV) regulates, supervises, promotes, and develops the capital market. Given the need for development of sustainable capital market, CNV has identified two challenges within the country, namely (1) little understanding about sustainable financing, (2) little understanding about the application of responsible investment strategies. Considering these challenges, CNV has focused on creating educational and regulatory documents for the generation of technical skillset and establishment of sustainable instruments in the market (Argentina, National Securities Commission [CNV 2022]).

6.3 Material supply chain

The material supply chain includes actors ranging from material production and manufacturing companies to wholesale and resale traders, and demolition and recycling agencies. Actors involved in the material supply chain can support material efficiency by reducing the embodied carbon content of materials. The material supply chain actors can support decarbonisation by reducing the energy used in producing, manufacturing, transporting, and recycling the building materials. Among the various building materials, decarbonising the most carbon-intensive materials — namely, cement and steel — must be prioritised. While there are several wholesale and retail traders in the country, there is scope for increasing the number of recycling agencies to increase material lifespan.

Argentine Industrial Union (UIA) is a manufacturing business association representing 1070 partner institutions and all sectoral and regional industrial chambers. The UIA advocates for productive growth and value-added development. The Argentine Chamber of Steel (ACERO) represents the main steel producing companies in the country. The Chamber watches over the interests of member companies, while providing them with legal support, representing company and trade union interests, and maintain statistics of steel production.

The Argentine Federation of the Wood and Related Industry (FAIMA) represents the forestry-industrial value chain at national level, including manufacturers of various wood-based building products. FAIMA acts towards promoting greater consumption of wood while stimulating sustainable management of renewable resources with the preservation of the environment.

6.4 Construction and design sector

The construction and design sector also has a critical role to play in achieving material efficiency in the residential building constructions. The embodied carbon of buildings include carbon used during the construction of buildings. Therefore, by reducing the energy used during constructions, such as by reducing the materials used for scaffolding and framing, reducing transportation and material waste, or designing buildings for longer lifespans would reduce the embodied carbon of buildings and achieve material efficiency.

The actors involved in the construction and design sector include developers, contractors, construction workers, designers such as architects, civil engineers, HVAC consultants, landscape and interior designers, building operators, and demolition companies. With increasing number of architectural and engineering faculties in Argentina, there are numerous designers and consultants across the country. The Argentine Chamber of Construction (CAMARCO) has a clear objective of promoting the harmonious development of the sector. CAMARCO actively participates in the drafting of legal instruments regulating the relationships between companies and workers, organises meetings and annual conventions, generates and maintains technical indicators, provides training courses, maintains information base, and develops proposals for action. Likewise, the Argentine Association of Concrete Technology (AATH) is a non-profit association that brings together people interested in the study, progress, and development of concrete technology.

The Association of Structural Engineers (AIE) has its objectives to contribute to development of structural engineering, professional dignity, and the maintenance of high ethical sense among associates. Some of AIE's action areas include promotion of information and technical experiences, dissemination of knowledge, establishment of links, and facilitate compliance with laws of professional practice. The Professional council of Civil Engineering (CPIC) is a public institution with a mission to promote and ensure responsible professional practice with an ethical framework. CPIC aims to strengthen links with engineering institutions, influence institutionally in academic, political-institutional and societal contexts, and promote participation, improve communication and expand services to enrolees The institution also has as its aim to defend and promote environmental sustainability.

6.5 Academia and Civil Society

Academic and civil society organisations can provide crucial insight and technical advancement towards low carbon futures through Research & Development, collaborative work, and dissemination of knowledge. To this end, the Association of Portland Cement Manufacturers (AFCP) acts as non-profit entity promoting growth and technological and sustainable development in the cement industry. AFCP promotes the use of cement in public construction and infrastructure, collaborates with other institutions to preserve the environment, promote staff training, and take action aimed at improving working and social conditions. The Argentinian Association of Processed Concrete (AAHE) is also a non-profit organisation that aims to increase and disseminate the use of processes concrete in all possible areas. The organisation works towards improving the quality of concrete by creating and supporting laboratories dedicated to the industry. It also establishes contracts and agreements between people, companies, laboratories, research establishments nationally and internationally, and promote and disseminate the Association's interests through seminars, conferences, and information meetings.

The Union of Construction Workers (UOCRA) is a trade union that represents the interests of construction workers while upholding the principles of solidarity, decent work, and social justice. Through the UOCRA Social Network, the union has generated a broad response group to work towards a sustainable future that guarantees worker rights.

The Argentina Green Building Council (AGBC) is a non-governmental, non-profit organisation that aims to contribute to the necessary transformation of buildings, cities and communities into sustainable, socially responsible, healthy and prosperous environment. AGBC promotes a construction industry that complies with standards, promotes and facilitates policies and practices aimed at sustainable building construction, act as guide and support to construction professionals, and raise awareness within the sector. Institutions such as UOCRA and AGBC can support training, knowledge dissemination and collaboration between designers, engineers, private developers, and construction workers.

The National Institute of Industrial Technology (INTI) aims to strengthen industrial competitiveness, accompany the growth of Argentine SMEs, promotes the development of the federal industry through innovation and technological transfer. The Argentine Normalization and Certification Institute (IRAM) is a non-profit private civil association that represents International Standards Organisation for Argentina. IRAM works towards the development of technical standards, offer services to certify the compliance of such standards, and provide training. Such research-led institutions could support the training and knowledge dissemination about low carbon materials and technologies.

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7

PRIORITY ACTION FRAMEWORK

Achieving material efficiency in the residential building construction sector requires a multipronged and whole life cycle approach. Since residential building constructions are dependent on a variety of actors throughout the lifespan of the building, decarbonising the sector requires involvement from all the involved stakeholders. This section outlines the roles and responsibilities of various stakeholders involved in the residential building construction in Argentina.

Considering the four stages of the building life cycle, five goals and respective actions are proposed for material efficiency in the residential building sector in Argentina. All the proposed goals and detailed actions to decarbonise construction materials are detailed in the **Annex I: Detailed Action Framework**. The five proposed goals significantly overlap with the ME strategies presented in **Section 5**. While ME strategies presented in **Section 5** were guided by modelling considerations, the five goals presented in this section were designed to facilitate effective roundtable discussions during stakeholder consultations. More specifically, the tables included in this section elaborate on key actions that need to be prioritised for effective and accelerated implementation of the net-zero agenda. In the following tables, actions for each stakeholder are elaborated in detail. The tables also explain the current opportunities that exist for each stakeholder to fulfil the respective action along with barriers that are currently impeding the stakeholders in utilising the opportunities. Finally, the tables also elaborate on the solutions that can be implemented to reduce the barriers and fulfil the opportunities for effective implementation of the goals. The five proposed goals are as follows:

GOAL 1: Use Low-Carbon Materials

To achieve material efficiency, low-carbon materials must be widely produced and used in residential buildings. This goal relates to the first two stages of the building life cycle, namely 1) Production of materials and 2) Construction of buildings. A successful implementation of this goal depends on providing incentives for material manufacturers to produce low-carbon materials and for private developers, building owners, and users to use them during construction. In keeping with Argentina's nationally determined contributions, government institutions and manufacturing industries are expected to commit to lowering embodied carbon emissions of materials. Financial support will be required to encourage and fulfil the commitments towards lowering embodied carbon emissions of materials. To make production and use of low-carbon materials widespread across the country, pilot projects and public procurement are deemed the most effective means. Lastly, to make the goal most widespread, all stakeholders must be made aware of appropriate and available materials and technologies.

GOAL 2: Use Less Material by Design

Material efficiency can be achieved by using less material by design during the second phase of the building life cycle, namely 2) Construction of buildings. Using less material in buildings will reduce the demand on raw and processed materials — effectively reducing the embodied carbon of buildings. To achieve this goal, designers such as architects, civil engineers, interior designers, HVAC consultants need to incorporate strategies to use less material while designing residential buildings. This includes using minimum required standards for steel and concrete for structurally sound and disaster resilient constructions or using least material in building envelops while achieving optimum indoor comfort. Moreover, using less material also means designing for long building lifespans — without compromising disaster and hazard resilience of building constructions. Here, designs must be adaptable for changing uses and structures must be designed to sustain wear and tear for long periods of time. Simultaneously, high quality and improved decarbonisation methods such as optimising construction management for reducing material waste need to be incorporated into all housing constructions. Lastly, the construction techniques themselves must be optimised for minimum use of materials — including efficient use of materials for framing and scaffolding, using prefabricated and modular materials to reduce on-site use of casting materials, or using building information modelling. With most efficient use of materials by design has significant potential to reduce the embodied carbon in buildings.

GOAL 3: Material Decarbonisation and Substitution

Cement and steel contribute to the GHG emissions the most among the building materials used globally. Cement and steel also do not have perfect substitutes within building construction sector. Therefore, it is imperative that cement and steel sectors are decarbonised at an accelerated rate along all stages of their life cycle. This includes taking steps to decarbonise material extraction, manufacturing, transportation, assembly, as well as recycling and reuse of materials. As cement and steel require high levels of energy for production, fuel substitution will substantially reduce the embodied carbon of cement and steel. Similar steps can be undertaken to reduce the carbon footprint of building material processing such as aluminium or plastics. Alongside decarbonising material processing, minimizing material downcycling will also increase the lifespan of materials thereby reducing the carbon emissions. Lastly, high-carbon materials such as concrete and steel must be substituted with low-carbon materials. Low-carbon materials include bio-based materials such as wood produced from sustainable forestry and bamboo, and earth-based materials such as clay or rammed earth. While most of the bio-based and earth-based materials do not permit the construction of high-rise and heavy-weight constructions, new and hybrid material technologies such as processed bamboo or reinforced rammed earth can be further developed and used to minimise the use of high-carbon materials such as concrete and steel.

GOAL 4: Decarbonisation of Manufacturing Processes

Manufacturing processes contribute to the embodied carbon in the building materials. Therefore, decarbonising the material manufacturing processes are key to achieving material efficiency in the residential building sector. To this effect, manufacturers need to be trained in most efficient low-carbon technologies for material manufacturing. However, the bigger challenge is that low-carbon manufacturing technologies are currently not available. Therefore, investments in innovation and R&D must be increased. Some of the known decarbonisation processes include using higher clinker ratio or using less carbon in producing steel to the required strength. Similarly, significant potential lies in switching high GHG emission fuels to sustainable forms of energies, as well as using fuels more efficiently in the manufacturing of the construction materials. Lastly, these efforts could be streamlined with clear policies for material decarbonisation.

GOAL 5: Reduce Waste and Increase Reuse and Recycling

A significant, yet currently neglected, dimension of material efficiency is material reuse and recycling. Residential buildings are currently not designed to be dismantlable and produce high amount of material waste upon end of use. Often buildings are demolished in a manner that does not permit the reuse of materials. Therefore, for the purposes of material efficiency, it is imperative that buildings are designed and constructed in a manner that reduces waste and allows for the reuse and recycling of the used materials. To this effect, building renovations and repurposing must be encouraged to expand the lifespan of buildings. Buildings must be designed in a manner that permits dismantling at the end of use and enable reuse and repurposing of materials — by using materials such as precast concrete panels. To facilitate the effective reuse of materials, recycling companies must be incentivised and brought into the supply chain of materials for building construction.

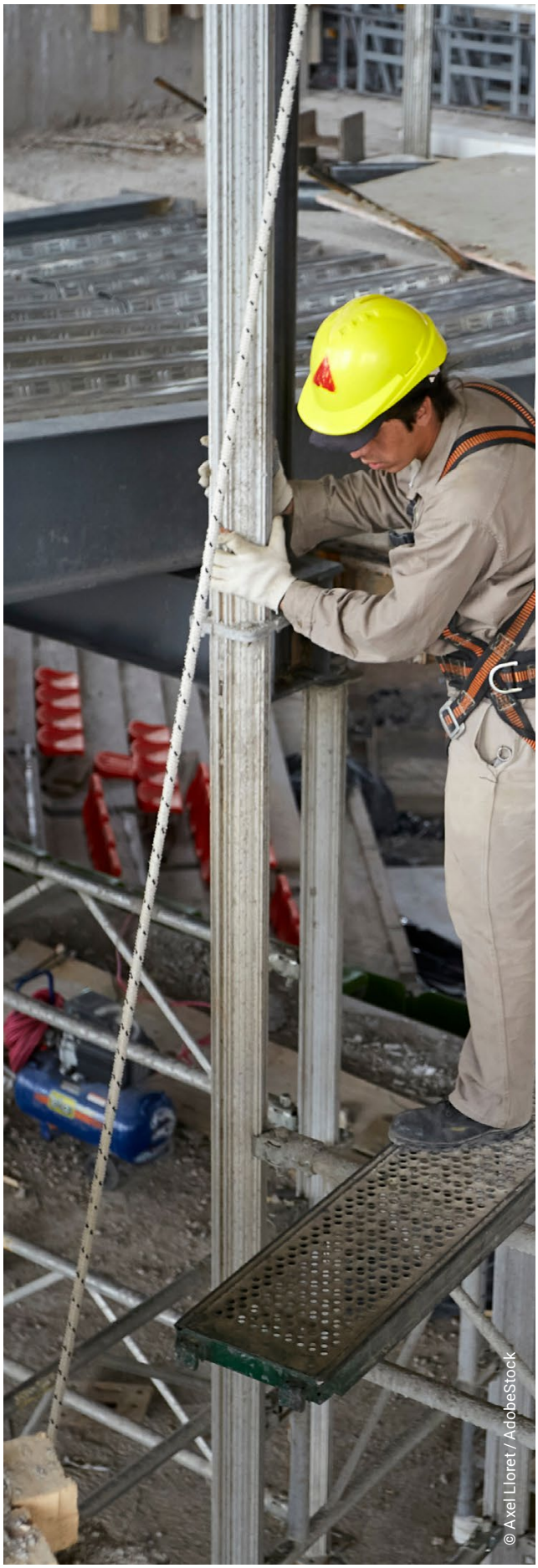

Table 6: Priority Action Framework for Goal 1

GOAL 1: USE LOW-CARBON MATERIALS				
	Priority Actions	**Opportunities**	**Barriers**	**Solutions**
A: National, Subnational and Local Governments	1.1 Provide incentives for high material efficiency by creating supply and demand for low carbon materials.	• Norms for building envelops and national law for energy labelling already exist. • Standards for wood production have been developed by the Programme for the Endorsement of Forest Certification (PEFC). • National law for energy labelling already exists.	• Lack of supply/ demand for low carbon materials.	• Develop technical norms for low carbon products. • Provide incentives for the manufacturers for product development. • Invest in low carbon materials. • Professionalise the workers. • Provide incentives to architects, contractors, investors, and buyers. • Train professionals and workers about low carbon materials. • Inform and preview as per beneficiaries.
	1.4 Raise awareness of benefits of low embodied carbon construction	• Spaces for knowledge dissemination and sensitization. • Interest in the topic already exists.	• Lack of skillset on the topic.	• Incorporate the topic in university education.
B: Financial Institutions	1.1 Provide incentives for high material efficiency by creating supply and demand for low carbon materials.	• Markets are flexible and can be changed to accommodate material efficiency.	• Lack of supply/ demand for low carbon materials.	• Invest in low carbon materials. • Invest in the transformation of industry. • Provide incentives to architects, contractors, investors, and buyers.
C: Manufacturers, Retailers and Suppliers	1.1 Provide incentives for high material efficiency by creating supply and demand for low carbon materials.	• Markets are flexible and can be changed to accommodate material efficiency.	• Lack of supply/ demand for low carbon materials.	• Develop technical norms for low carbon products. • Provide incentives for product development. • Invest in low carbon materials. • Invest in the transformation of industry. • Professionalise the workers. • Provide incentives to architects, contractors, investors, and buyers. • Train professionals and workers.
	1.4 Raise awareness of benefits of low embodied carbon construction	• Spaces for knowledge dissemination and sensitization.	• Lack of skillset on the topic.	• Develop awards for sustainable designs. • Promotion through networking.
E: Architects, Designers, and Consultants	1.4 Raise awareness of benefits of low embodied carbon construction	• Educational infrastructure is already available.	• Lack of skillset on the topic.	• Embed ME into university and professional courses. • Promotion through networking.
F: Demolition and Recycling Companies	1.1 Provide incentives for high material efficiency by creating supply of low carbon materials.	• Large numbers of buildings will require reconstruction in the future.	• Lack of supply of low carbon materials.	• Develop technical norms for low carbon products. • Provide incentives for the manufacturers for product development. • Invest in R&D for low carbon materials. • Invest in the transformation of industry.
H: Academia and Research Institutes	1.1 Provide incentives for high material efficiency by creating supply of low carbon materials.	• Spaces for knowledge dissemination and sensitization.	• Lack of supply of low carbon materials.	• Develop technical norms for low carbon products. • Invest in R&D for low carbon materials.
	1.4 Raise awareness of benefits of low embodied carbon construction	• Accumulated knowledge through tools and methodologies.	• Lack of skillset on the topic.	• Develop awards for sustainable designs. • Promotion through networking.
I: Civil Society	1.1 Provide incentives for high material efficiency by creating supply and demand for low carbon materials. / 1.4 Raise awareness of benefits of low embodied carbon construction	• Spaces for dissemination and sensitization.	• Lack of supply of low carbon materials. • Lack of skillset on the topic.	• Professionalise the workers. • Train professionals and workers about low carbon materials. • Develop awards for sustainable designs.

Table 7: Priority Action Framework for Goal 2

GOAL 2: USE LESS MATERIAL BY DESIGN				
	Priority Actions	**Opportunities**	**Barriers**	**Solutions**
A: National, Subnational and Local Governments	2.1 Boost capacity of designers	• Norms for building envelops and national law for energy labelling already exist. • Energy secretary has developed a software to measure energy (including renewables, building envelop, and energy usage). • Standards for wood production have been developed by the Programme for the Endorsement of Forest Certification (PEFC).	• There are no certifications for adobe, wood, steel framing, cement, or structural insulated panels.	• Link design professionals with users and contractors. • The building controller must be trained.
	2.4 Develop regulations for building constructions	• External professionals can be employed as inspectors. • Professionals will comply with regulations.	• Current standards are not well enforced. • Less human resource to monitor control.	• Upgrade standards. • Increase the number of building inspectors. • Strengthen state capacities for effective policy enforcement and control. • Promote sustainable materials to change user perception.
C: Manufacturers, Retailers and Suppliers	2.1 Boost capacity of designers	• Companies such as Holcim, Saint-Gobain have undertaken life cycle analysis of materials.	• Less knowledge of product design and market demand.	• Develop regulations. • Provide education and training.
	2.4 Develop regulations for building constructions	• Timber and Structural Insulated Panel provides better thermal efficiency and are readily available.	• There is loss of materials and energy in transportation.	• Transport materials more efficiently.
D: Private Developers and Contractors	2.1 Boost capacity of designers	• Encourage contractors to contract professionals.	• Less knowledge about low carbon materials.	• Provide information sheets along with building materials to the users.
E: Architects, Designers, and Consultants	2.4 Develop regulations for building constructions	• Sustainable materials are available in the market.	• Designers do not prefer to use prefabricated wood.	• Promote sustainable materials to change user perception.
G: Building Owners, Tenants, or Occupiers	2.1 Boost capacity of designers	• Reduction of costs and use of energy	• No formal contracts with professionals. • Not many courses exist on timber construction.	• Provide information sheets along with building materials to the users.
	2.4 Develop regulations for building constructions	• High potential and environmental benefits from using low carbon materials.	• The users consider bricks as a durable material and therefore do not prefer to use other materials.	• Promote sustainable materials to change user perception.
H: Academia and Research Institutes	2.1 Boost capacity of designers	• National Institute of Industrial Technology already works on building materials.	• Lack of budget for investigation in sustainable construction for private institutions. • No budget priority for research in material efficiency in public institutions.	• Provide additional funding for R&D. • Prioritize research on material efficiency in residential building constructions. • Build capacities about new and hybrid materials. • Promote sustainable materials to change user perception.

Table 8: Priority Action Framework for Goal 3

GOAL 3: MATERIAL DECARBONISATION AND SUBSTITUTION				
	Priority Actions	**Opportunities**	**Barriers**	**Solutions**
A: National, Subnational and Local Governments	3.1 Accelerate multiple pathways to decarbonisation in the cement sector	• Adopt the Global Cement and Concrete Association (GCCA) Roadmap 2021.	• Restrictions for using alternative materials to produce concrete. • Bureaucratic delays in obtaining permissions. • Outdated and generic norms for the use of waste. • Resistance for the use of low clinker concrete. • High level of informality in the residential sector. • Prescriptive and inconsistent norms for cement and concrete specifications. • Logistical infrastructural deficit (e.g., trains). • Lack of information and commitment for the use of low carbon materials.	• Develop policies with benefits and incentives instead of prescriptive norms. • Study the cost benefits and feasibility for sector transformation. • Support public recognition through labelling. • Incorporate norms and standards into existing regulations and monitor its enforcement.
	3.3 Invest in the radical transformation of building material processing (e.g., aluminium) and minimize downcycling	• Substitute raw non-renewable materials with alternative materials.	• Lack of legal benchmark that encourage or mandate the separation of construction and demolition waste at origin.	• Provide incentives for the use of alternative raw materials to produce steel and concrete. • Generate metrics, indicators, and a model for analysis to evaluate solutions with alternative materials. • Support innovation and creation of technologically based companies, including startups. • Update norms and regulations that promote the maximisation of the use of recycled materials through criteria-based benefits.
B: Financial Institutions	3.1 Accelerate multiple pathways to decarbonisation in the cement sector	• Adopt the Global Cement and Concrete Association (GCCA) Roadmap 2021. • Substitute raw non-renewable materials with alternative materials. • Develop financial products that favour low carbon footprint for cement.	• Lack of economic incentives for the use of low carbon materials and alternatives fuels. • Lack of normative/legal benchmark for compensations (insetting – offsetting).	• Support innovation and creation of technologically based companies, including startups.
C: Manufacturers, Retailers and Suppliers	3.1 Accelerate multiple pathways to decarbonisation in the cement sector	• Adopt the Global Cement and Concrete Association (GCCA) Roadmap 2021. • Certifications and financing processes that generate capital gains.	• Lack of economic incentives for the use of low carbon materials and alternatives fuels. • Limitations in the transport and distribution of renewable electricity.	• Provide incentives for the use of alternative raw materials to produce steel and concrete. • Generate metrics, indicators, and a model for analysis to evaluate solutions with alternative materials.
	3.3 Invest in the radical transformation of building material processing (e.g., aluminium) and minimize downcycling	• Substitute primary non-renewable materials with alternative materials.	• Lack of incentives to use recycled aggregates. • Lack of logistical infrastructure.	• Generate incentives for the use of recycled aggregates.

GOAL 3: MATERIAL DECARBONISATION AND SUBSTITUTION				
	Priority Actions	**Opportunities**	**Barriers**	**Solutions**
D: Private Developers and Contractors	3.1 Accelerate multiple pathways to decarbonisation in the cement sector	• Adopt the Global Cement and Concrete Association (GCCA) Roadmap 2021.	• Lack of economic incentives for the use of low carbon materials and alternatives fuels. • Limitations in the transport and distribution of renewable electricity.	• Embed principles of efficiency in design, specifications, and construction. • Control the quality and technologies for the classification and preparation of alternative materials.
F: Demolition and Recycling Companies	3.1 Accelerate multiple pathways to decarbonisation in the cement sector	• Adopt the Global Cement and Concrete Association (GCCA) Roadmap 2021. • Old building retrofitting.	• Lack of economic incentives for the use of low carbon materials and alternatives fuels.	• Control the quality and technologies for the classification and preparation of alternative materials.
	3.3 Invest in the radical transformation of building material processing (e.g., aluminium) and minimize downcycling	• Substitute primary non-renewable materials with alternative materials.	• Lack of legal benchmark that encourage or mandate the separation of construction and demolition waste at origin. • Informality in the market for construction and demolition waste.	• Close the technological gap to produce alternative raw materials to produce high clinker concrete.
I: Civil Society	3.1 Accelerate multiple pathways to decarbonisation in the cement sector	• Adopt the Global Cement and Concrete Association (GCCA) Roadmap 2021.	• Lack of economic incentives for the use of low carbon materials and alternatives fuels.	• Provide incentives for the use of alternative raw materials to produce steel and concrete. • Generate metrics, indicators, and a model for analysis to evaluate solutions with alternative materials.

Table 9: Priority Action Framework for Goal 4

GOAL 4: DECARBONISATION OF MANUFACTURING PROCESSES				
	Priority Actions	**Opportunities**	**Barriers**	**Solutions**
A: National, Subnational and Local Governments	4.3 Promote fuel switching and higher efficiencies in manufacturing of construction materials	• Green hydrogen • Renewable electricity production. • Bio combustibles and biomass.	• Lack of political support for the use of land for forestry development.	• Develop a legal framework for sustainable material production. • Develop public policies that encourage the use of bio-combustibles.
	4.4 Have clear policies on material decarbonisation	• Accelerated pathway towards low carbon future. • Ease of compliance.	• Lack of political agreement. • Lack of local level metrics and indicators. • Lack of models of analysis to prioritize solutions with technical criteria.	• Develop profitable political arrangements. • Promote sustainable construction activities through dissemination of information. • Establish metrices, indicators and service models of best practice. • Generate cultural change.
C: Manufacturers, Retailers and Suppliers	4.3 Promote fuel switching and higher efficiencies in manufacturing of construction materials	• Green hydrogen • Renewable electricity production. • Bio combustibles and biomass.	• Lack of financial and political support for fuel switching.	• Develop a legal framework for sustainable material production. • Develop public policies that encourage the use of bio-combustibles.
	4.4 Have clear policies on material decarbonisation	• Accelerated pathway towards low carbon future. • Ease of compliance.	• Lack of local level metrics and indicators. • Lack of models of analysis to prioritize solutions with technical criteria.	• Develop profitable political arrangements. • Promote sustainable construction activities through dissemination of information. • Establish metrices, indicators and service models of best practice.
F: Demolition and Recycling Companies	4.4 Have clear policies on material decarbonisation	• Accelerated pathway towards low carbon future. • Ease of compliance.	• Lack of political agreement. • Lack of local level metrics and indicators. • Lack of models of analysis to prioritize solutions with technical criteria.	• Develop profitable political arrangements. • Promote sustainable construction activities through dissemination of information. • Establish metrices, indicators and service models of best practice.
H: Academia and Research Institutes	4.4 Have clear policies on material decarbonisation	• Accelerated pathway towards low carbon future. • Ease of compliance.	• Lack of local level metrics and indicators. • Lack of models of analysis to prioritize solutions with technical criteria.	• Promote sustainable construction activities through dissemination of information. • Establish metrices, indicators and service models of best practice. • Generate cultural change.

Table 10: Priority Action Framework for Goal 5

GOAL 5: REDUCE WASTE AND INCREASE REUSE AND RECYCLING				
	Priority Actions	**Opportunities**	**Barriers**	**Solutions**
A: National, Subnational and Local Governments	5.1 Incentivise renovation and repurposing of buildings to expand lifetime	• Conserve existing buildings by repurposing.	• Lack of application of knowledge into codes.	• Incorporate renovation and repurposing into building and urbanisation codes. • Facilitate in generating incentives.
	5.4 Target economic incentives to increase overall recycling volumes	• Resale of materials is possible.	• Lack of update on recyclable materials. • Lack of norms. • Lack of communication.	• Generate norms and develop procurement processes.
B: Financial Institutions	5.1 Incentivise renovation and repurposing of buildings to expand lifetime	• Conserve existing buildings by repurposing. • Opportunity to invest in a new portfolio. • Buildings are low-risk assets.	• Lack of application of knowledge into codes.	• Facilitate in generating incentives.
	5.4 Target economic incentives to increase overall recycling volumes	• Resale of materials is possible.	• Lack of communication. • Lack of financial incentives.	• Provide financial incentives.
C: Manufacturers, Retailers and Suppliers	5.1 Incentivise renovation and repurposing of buildings to expand lifetime	• Conserve existing buildings by repurposing. • Opportunity to invest in a new portfolio.	• Lack of innovation. • Lack of economic interest.	• Develop new functional units.
D: Private Developers and Contractors	5.1 Incentivise renovation and repurposing of buildings to expand lifetime	• Opportunity to invest in a new portfolio. • Renovation and re-purposing provide high returns on investment.	• Lack of innovation. • Lack of economic interest.	• Develop new functional units.

ACTIONS TO ACCELERATE DECARBONISATION OF MATERIALS

The priority action framework produced through participatory workshops with national stakeholders in Argentina show that all stakeholders need to take up actions so that existing opportunities towards achieving material efficiency can be leveraged and barriers can be removed. However, given the fast rate at which climate change is progressing, it is imperative to act towards accelerating the net-zero agenda in residential building construction sector in Argentina. To this end, the following tables indicate towards precise actions that need to be undertaken to accelerate each of the priority actions elaborated in the previous sections. The actions elaborated in the following sections are derived from 2nd national workshop through a separate roundtable discussion with national stakeholders.

Against each priority action in the following tables, participants predicted the required years to make the action widespread across Argentina. Further, key reasons for the current timeframe and actions required to accelerate the process of decarbonisation are stipulated against each priority action. To accelerate the process of decarbonisation within 5 years, participants suggested collecting data, providing financial support, providing technical support for standards development, as well as undertake research and provide training. Somewhat long-term actions (between 5-10 years) include achieving key performance indicators, institutionalise carbon taxation, increase stakeholder consultation, and decarbonise heavy industry. These actions are expected to help decarbonise Argentina's residential building construction sector within 10 years.

Table 11: Roadmap for accelerating the decarbonisation process.

Priority Actions	< 5 years	5-10 years
GOAL 1: USE LOW-CARBON MATERIALS		
G.1.1 Provide incentives for high material efficiency	• Mandatory data collection and reporting on low-carbon materials. • Provide financial support. • Provide technical standards. • Invest in life cycle assessment.	• Develop a market for green bonds. • Disseminate information about low carbon materials.
G.1.4 Raise awareness of benefits of low embodied carbon construction	• Create consciousness through dissemination and communication. • Accelerate decision making by decentralising decision at local level.	
GOAL 2: USE LESS MATERIAL BY DESIGN		
G.2.1 Boost capacity of designers	• Provide orientation programmes for construction in technical colleges. • Increase energy bills to real costs. • Train construction workers in collaboration with construction workers' unions. • Involve entrepreneurs with government incentives such as training or incubator funds.	
G.2.4 Develop regulations for building constructions	• Create national benchmarks common for the entire country. • Dissemination and communication through publications, pamphlets, courses, and free regulations.	
GOAL 3: USE LOW-CARBON MATERIALS to MATERIAL DECARBONISATION AND SUBSTITUTION		
G.3.1 Accelerate multiple pathways to decarbonisation in the cement sector	• Update norms. • Provide legal benchmark. • Provide finance. • Improve infrastructural conditions. • Give economic incentives. • Capacity building of inspectors.	
G.3.3 Invest in the radical transformation of building material processing and minimise downcycling	• Provide continued support. • Make political agreements. • Provide financial support and incentives. • Update norms.	
GOAL 4: DECARBONISATION OF MANUFACTURING PROCESSES		
G.4.3 Promote fuel switching and higher efficiencies in manufacturing of construction materials	• Update norms. • Provide legal benchmark. • Provide finance. • Improve infrastructural conditions. • Give economic incentives. • Capacity building of inspectors.	
G.4.4 Have clear policies on material decarbonisation	• Government support. • Link academic ecosystem to desseminate knowledge within the community. • Sectoral agreements and links with the scientific sector. • International support.	
GOAL 5: REDUCE WASTE AND INCREASE REUSE AND RECYCLING		
G.5.1 Incentivise renovation and repurposing of buildings rather to expand lifetime	• Coordination between relevant stake-holders (academics, researchers, NGOs) • Develop technical guidance and standard operating procedures prior to stakeholder consultation. • Discuss with users/building owners regarding their wishes and problems on renovation and repurposing.	

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ROADMAP RECOMMENDATIONS

Based on the barriers and opportunities faced by various actors in the residential building construction sector, and stakeholder suggestions for accelerating the agenda for net-zero future, following recommendations are proposed:

1) Collect and maintain accurate data regarding low-carbon materials and their utilisation to inform evidence-based implementation of ME strategies, development of policies, design practices, and prioritisation of actions.

2) Design norms and policies for the six bioenvironmental conditions within the country, by including the material efficiency indicators into thermal conditions of buildings specified in norm IRAM 11063. To ensure uniformity, develop nation-level benchmarks.

3) Provide technical and financial support for policy development and dissemination through consultative processes between academia, industry actors, financial institutions, and policymakers.

4) Provide technical and financial support for the enforcement of ME strategies by providing capacity building to architects, engineers, consultants, contractors, as well as policymakers.

5) Invest in R&D for new low carbon technologies and materials by collaborating with academic and research institutes as well as industry professionals.

6) Increase stakeholder consultation among academia, industry actors, financial institutions, policymakers, building users and civil society to obtain citizen views and generate public awareness regarding material efficiency in the building sector.

7) Embed policies for gender equality drawing on the experiences of programmes such as REDD+ into various sub-sectors of the residential building constructions. Gender equality policies should focus on providing equitable access to resources and facilities, equitable participation in decision-making processes, and equal benefit sharing among women and men, to generate a more sustained and widespread uptake of ME strategies.

8) Generate institutional and political agreements to ensure effective implementation of ME strategies.

9) Incorporate building deconstruction and material reuse and recycling into policy frameworks, construction management, and university curriculums and support the integration of demolition companies into material supply chain.

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FURTHER CONSIDERATIONS

These Technical Guidelines identified key priority actions to support decarbonisation of the residential building construction sector in Argentina through modelling, policy analysis, dynamic systems mapping, and stakeholder consultations. Based on the results from these Guidelines, following considerations can be taken forward:

- Argentina's updated NDCs provide an instructive mandate for reducing GHG emissions below its otherwise business as usual scenario, which supports the goals for material efficiency proposed in these Guidelines.
- The assumptions underlying in the ME implementation are ambitious and will require significant and collaborative effort to enforce.
- Argentina has wide ranging climatic conditions across the country — affecting the standards for thermal comfort, energy use, material availability and choice. ME strategies must be contextualised for each climatic zone.
- The demolition and recycling companies are not well integrated into the material supply chain and construction management. Integrating building deconstruction, recycling and reuse of materials has significant potential in reducing material demand.
- Current state policies are focused on energy efficiency of buildings and therefore indirectly affect the demand for low-carbon materials. Developing ME focused policies will effect change at a rapid pace.
- Procedurally, these Guidelines relied on participatory systems mapping and priority action mapping workshops and the results are derived based on the perspectives of workshop participants, quantitative modelling, and literature and policy review. The process can be repeated to monitor the progress towards low-carbon futures and update the actions based on changed circumstances.
- During the participatory sessions, the national stakeholders were sceptical about implementing the ME strategies within the period of 5-10 years in Argentina. Participants considered engagement and collaboration from all relevant actors vital for the effective implementation of ME strategies.

ANNEXES

Annex I: Detailed Action Framework

1	GOAL 1: USE LOW-CARBON MATERIALS	
1.1	**Provide incentives for high material efficiency**	• Reduce demand for high carbon materials. • Incentivise low carbon materials. • Encourage reliance on recycled and repurposed materials.
1.2	**Make commitments to lowering embodied carbon emissions of materials**	• Require embodied carbon emissions assessments or LCAs for new major and public investments. • Require public bodies to disclose information on portfolio and/or asset-level embodied carbon emissions. • Provide financial incentives for low-carbon products and business models. • Support the use of preferential loans or mortgages to stimulate a market for low-carbon materials.
1.3	**Promote low embodied carbon emissions through public procurement and pilots**	• Develop network of green material providers. • Integrate considerations of embodied carbon emissions in planning and building regulations. • Require disclosure for all new construction and for large renovation projects. • Initiate low-carbon materials pilot projects and provide development incentives to project developers. • Include requirements in public tendered contracts to use low-carbon materials for public procurement.
1.4	**Raise awareness of benefits of low embodied carbon construction**	• Provide information and raise awareness. • Promote tools, training and capacity building regarding low-carbon materials and technologies. • Conduct and commission research and case studies into low-carbon materials and approaches. • Provide training to government agencies regarding data collection on embodied carbon emissions of materials and building project, and regarding creation of an integrated policy portfolio. • Provide training on how to develop information and assessment tools for project developers, designers, and consumers such as embodied carbon emissions disclosure, LCA, labelling and EPDs.

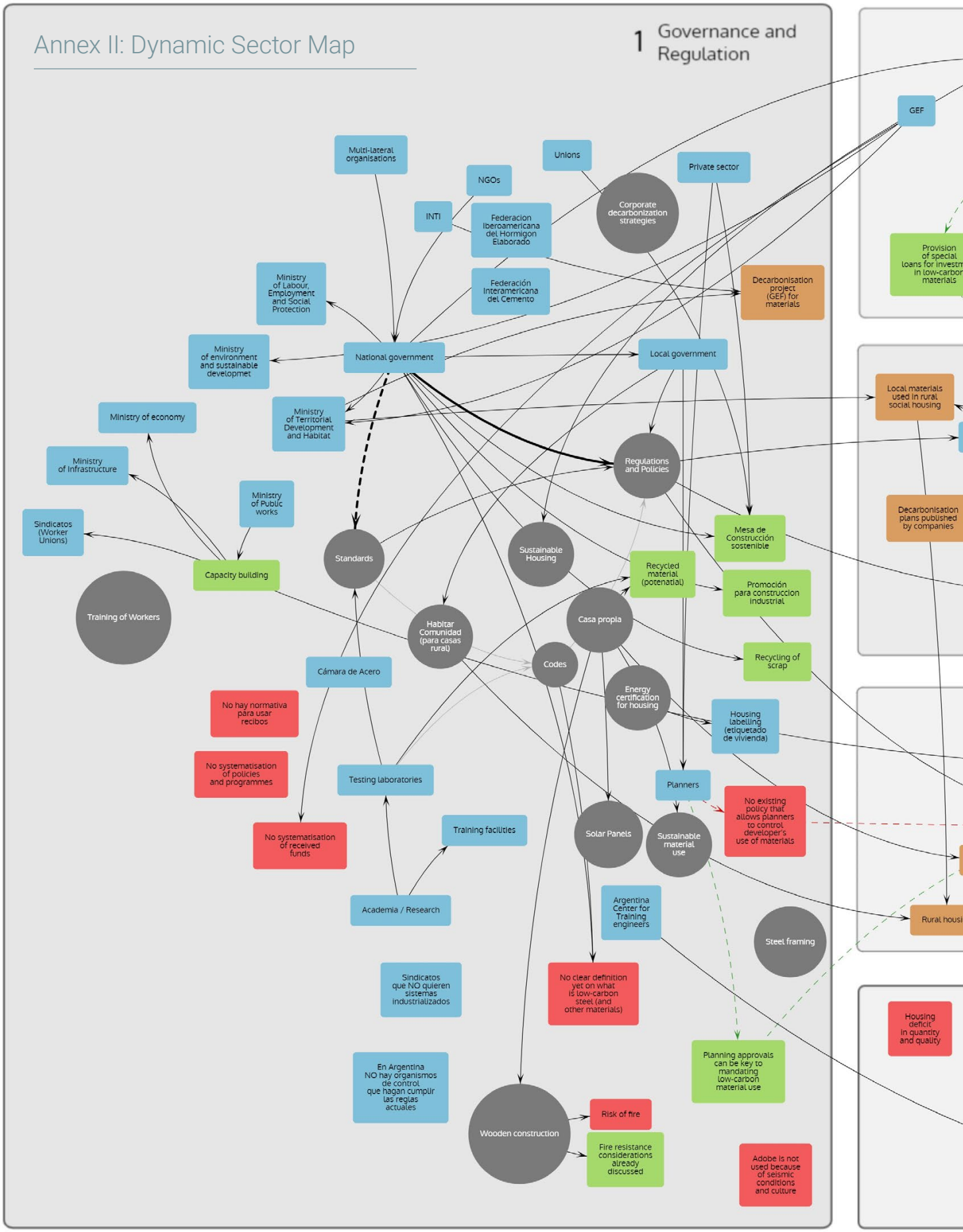
2	GOAL 2: USE LESS MATERIAL BY DESIGN	
2.1	**Boost capacity of designers**	• Training of professionals (architects, engineers, contractors etc.) • Training to comply with policies such as labelling. • Develop accreditation systems for professionals with material efficient design skills.
2.2	**Adopt design policies to promote long building lifespans**	• Incentivise appropriate design, more durable materials, modularity and renovation/ upgrading.
2.3	**Make high quality and improved decarbonisation methods available**	• Promote evidence-based material selection. • Utilise whole life carbon assessments to inform decarbonization decisions.
2.4	**Build regulations for disaster and hazard resilient constructions**	• Ensure that buildings can withstand extreme events. • Post-disaster reconstruction for durability.
2.5	**Optimise construction techniques**	• Optimise framing and scaffolding. • Optimise steel reinforcement in concrete buildings. • Use advanced framing techniques – reduce redundancies in framing. • Use building information modelling (BIM). • Use prefabrication and modular building components.

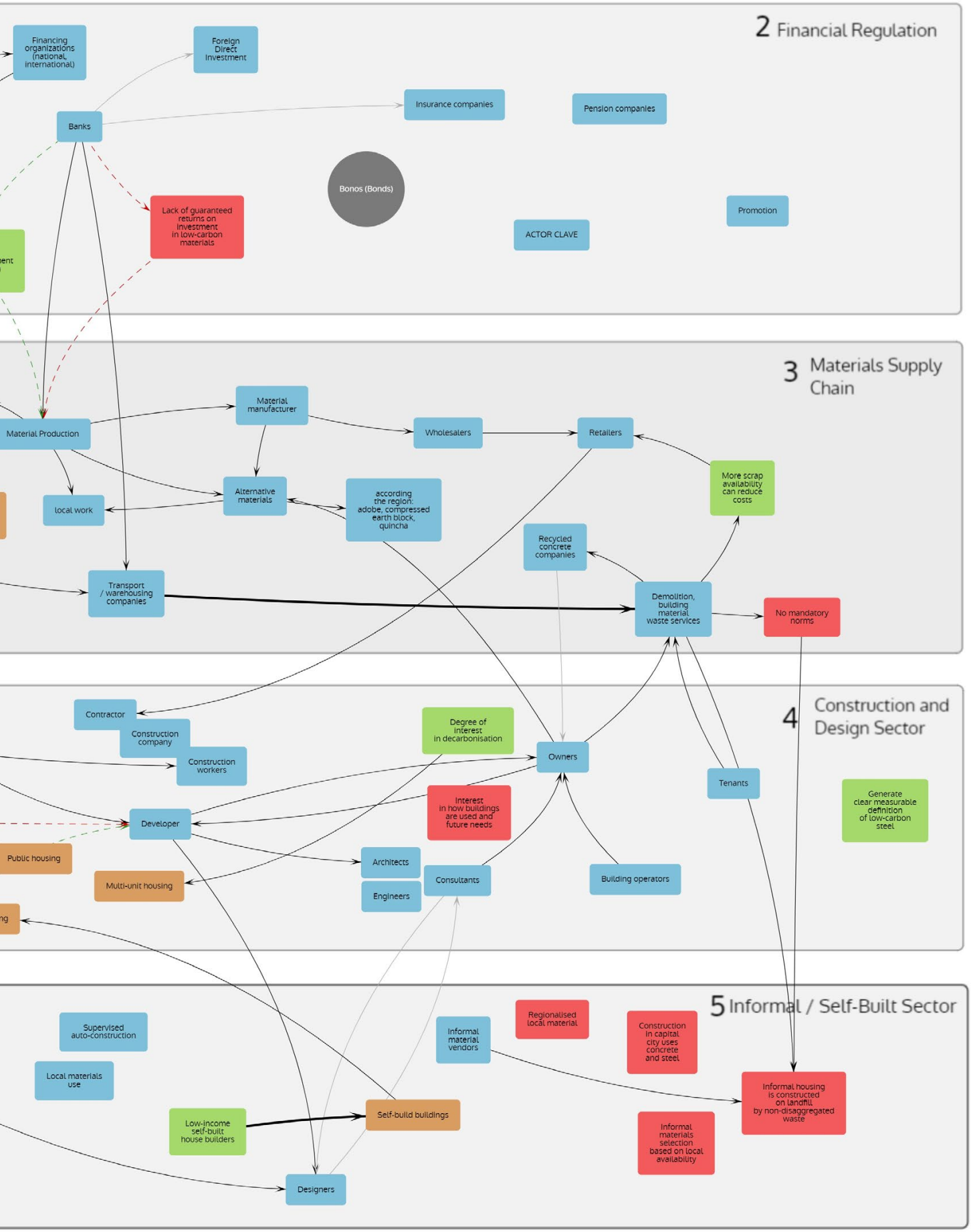
3	GOAL 3: MATERIAL DECARBONISATION AND SUBSTITUTION	
3.1	**Accelerate multiple pathways to decarbonisation in the cement sector**	• Increase funding for public-private partnerships to accelerate the development, demonstration, and commercialization of concrete decarbonization technologies and techniques. • Invest in materials science capacity in concrete technology and practice.
3.2	**Reduce the carbon footprint of the steel-making sector**	• Encourage upgrades of existing plants to best available technology in steelmaking. • Provide financial and structural support into R&D on early-stage low emission technologies. • Incentivize material efficiency strategies across the steel life cycle to increase steel's circularity and reduce its embodied carbon.
3.3	**Invest in the radical transformation of building material processing (e.g. aluminium) and minimize downcycling**	• Improve collection and grade-specific sortation at end-of-life to maximise the use of scrap in future material production without the risk of downcycling to low-value applications. • Invest in and enable the transition of digitized off-site manufacturing methods to greatly cut down on inefficient material waste and air quality emissions from antiquated, inefficient on-site construction techniques.
3.4	**Promote the adoption of bio-based materials**	• Facilitate the adoption of localized, low-carbon building materials by facilitating intensive brick-making practices with compressed soils; replacing cementitious material and mortar; and using waste by-products such as fly-ash in coal industries. • Use sustainably produced timber. • Promote awareness among building professionals by partnering with industry associations.

4	GOAL 4: DECARBONISATION OF MANUFACTURING PROCESSES	
4.1	**Boost capacity of manufacturers**	• Provide training on reducing embodied carbon emissions of materials, increasing efficiency in manufacturing processes and circular design principles. • Provide training on compliance to policies such as labelling. • Provide capacity building on the topics of light weighting structures, achieving high-density developments without relying on tall structures (i.e., reduce reliance on steel and concrete), use appropriate LCA tools and methodologies.
4.2	**Increase investment in innovation and R&D**	• Develop measures to support applied research into low-carbon, bio-based a nd locally sourced materials, and solutions. • Develop strategies for decarbonising hard-to-abate sectors. • Implement policies that enable improved design and purchasing decisions based for on embodied carbon emissions and energy.
4.3	**Promote fuel switching and higher efficiencies in manufacturing of construction materials**	• Develop measures to speed up the implementation of decarbonisation in industries manufacturing construction materials. • Include building material manufacturing industries as part of demand-side management efforts. • Promote energy management by developing best practice guides. • Support establishment/engagement of material development/training facilities/ laboratories through innovative academic and private sector actors and engaging official product and material certification bodies.
4.4	**Have clear policies on material decarbonisation**	• Promote clear and consistent standards for carbon labelling. • Ensure a fair playing field for low carbon building materials through international and multilateral engagement.

5	GOAL 5: REDUCE WASTE AND INCREASE REUSE AND RECYCLING	
5.1	**Incentivise renovation and repurposing of buildings to expand lifetime**	• Designers able to design for repurposing buildings use. • Modular designs and materials to enable repurposing to new uses. • Have building and planning policies that enable and ease repurposing.
5.2	**Reuse and recycle building waste at the end of buildings' lifetimes**	• Mandate plans and systems for collection and reuse/recycling of construction and demolition of waste. • Incentivize building designs and a marketplace for material reuse and develop standards to ensure the quality and efficacy for their use.
5.3	**Improve deconstruction processes to enable reuse and repurposing**	• Develop guidelines or protocols for deconstruction. • Promote selective sorting of materials and waste from site. • Promote and standardise material recovery and storage facilities. • Facilitate stakeholder engagement among designers and recyclers to identify choke-points and supply quality problems.
5.4	**Target economic incentives to increase overall recycling volumes**	• Incentivize efficient collection and sorting to create competitive secondary markets. • Put premiums on the cleanliness of recycling streams to minimize downcycling. • Invest in new equipment for collecting, sorting, and converting waste at the time of building demolition so that it can be efficiently repurposed into a new life cycle. • Put market (recycled content) and regulatory (collection targets) incentives into place that ensure the diversion of collected CRD polymers from landfills and towards recycling.

Annex II: Dynamic Sector Map




2 Financial Regulation
Financing organizations (national, international)
Foreign Direct Investment
Banks
Insurance companies
Pension companies
Bonos (Bonds)
Lack of guaranteed returns on investment in low-carbon materials
Promotion
ACTOR CLAVE
3 Materials Supply Chain
Material manufacturer
Material Production
Wholesalers
Retailers
More scrap availability can reduce costs
Alternative materials
local work
according the region: adobe, compressed earth block, quincha
Recycled concrete companies
Transport / warehousing companies
Demolition, building material waste services
No mandatory norms
4 Construction and Design Sector
Contractor
Construction company
Construction workers
Degree of interest in decarbonisation
Owners
Tenants
Generate clear measurable definition of low-carbon steel
Interest in how buildings are used and future needs
Developer
Public housing
Architects
Consultants
Building operators
Multi-unit housing
Engineers
5 Informal / Self-Built Sector
Supervised auto-construction
Regionalised local material
Informal material vendors
Construction in capital city uses concrete and steel
Local materials use
Informal housing is constructed on landfill by non-disaggregated waste
Low-income self-built house builders
Self-build buildings
Informal materials selection based on local availability
Designers

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ABOUT THE INTERNATIONAL RESOURCE PANEL

Aim of the Panel

The International Resource Panel was established to provide independent, coherent and authoritative scientific assessments on the use of natural resources and their environmental impacts over the full life cycle. The Panel aims to contribute to a better understanding of how to decouple economic growth from environmental degradation while enhancing well-being.

Benefiting from the broad support of governments and scientific communities, the Panel is constituted of eminent scientists and experts from all parts of the world, bringing their multidisciplinary expertise to address resource management issues.

The information contained in the International Resource Panel's reports is intended to:
- be evidence based and policy relevant,
- inform policy framing and development, and
- support evaluation and monitoring of policy effectiveness.

Outputs of the Panel

Since the International Resource Panel's launch in 2007, more than 33 assessments have been published. The assessments of the Panel to date demonstrate the numerous opportunities for governments, businesses and wider society to work together to create and implement policies that ultimately lead to sustainable resource management, including through better planning, technological innovation and strategic incentives and investments.

Following its establishment, the Panel first devoted much of its research to issues related to the use, stocks and scarcities of individual resources, as well as to the development and application of the perspective of 'decoupling' economic growth from natural resource use and environmental degradation. These reports include resource-specific studies on biofuels, water and the use and recycling of metal stocks in society.

Building upon this knowledge base, the Panel moved into examining systematic approaches to resource use. These include looking into the direct and indirect impacts of trade on natural resource use; connections between resources and human mobility; issues of sustainable land and food system management; priority economic sectors and materials for sustainable resource management; benefits, risks and trade-offs of low-carbon technologies; city-level decoupling; and the untapped potential for decoupling resource use and related environmental impacts from economic growth.

Upcoming work

In the forthcoming months, the International Resource Panel will focus on status, trends, outlook, and solutions for sustainable resource management, the socioeconomic implications of resource efficiency and the circular economy, the connections between finance and sustainable resource use and circular economy in consumer electronic products, among others.

More information about the Panel and its research can be found at:
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