Promoting Circularity in Construction and Demolition in Pacific Island Countries

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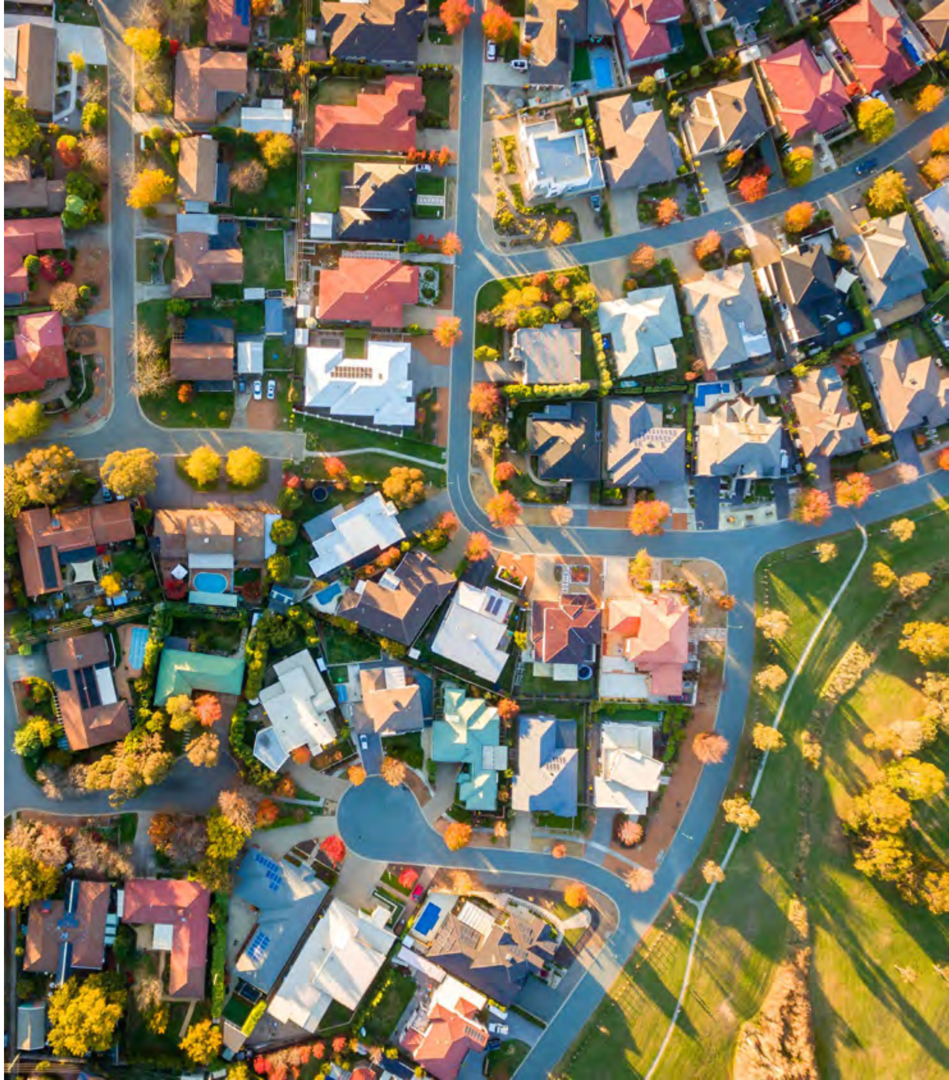
SIDS (Pacific Island Countries) Capacity-Building Training Workshop on the Implementation of the Jaipur Declaration on 3R and Circular Economy (2025-2035), 23 July 2025

Australia's National Science Agency

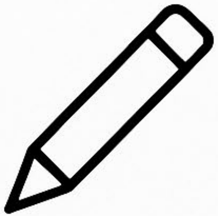
Why we are here

- Construction & demolition waste already makes up ~30 % of global solid waste and is rising fastest in the Pacific.
- Tiny landmass + growing urban build demand ⇒ landfills are strained.
- Cyclones routinely generate thousands of tons of rubble.
- Keeping materials in the loop (circular strategies) can slash costly imports, create local jobs, and improve housing affordability.



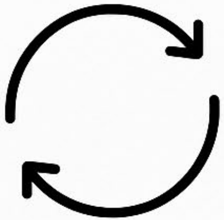
What is a Circular Economy??

Circular Economy



Design out waste and pollution

Build products, materials, and systems that prevent waste from the start.

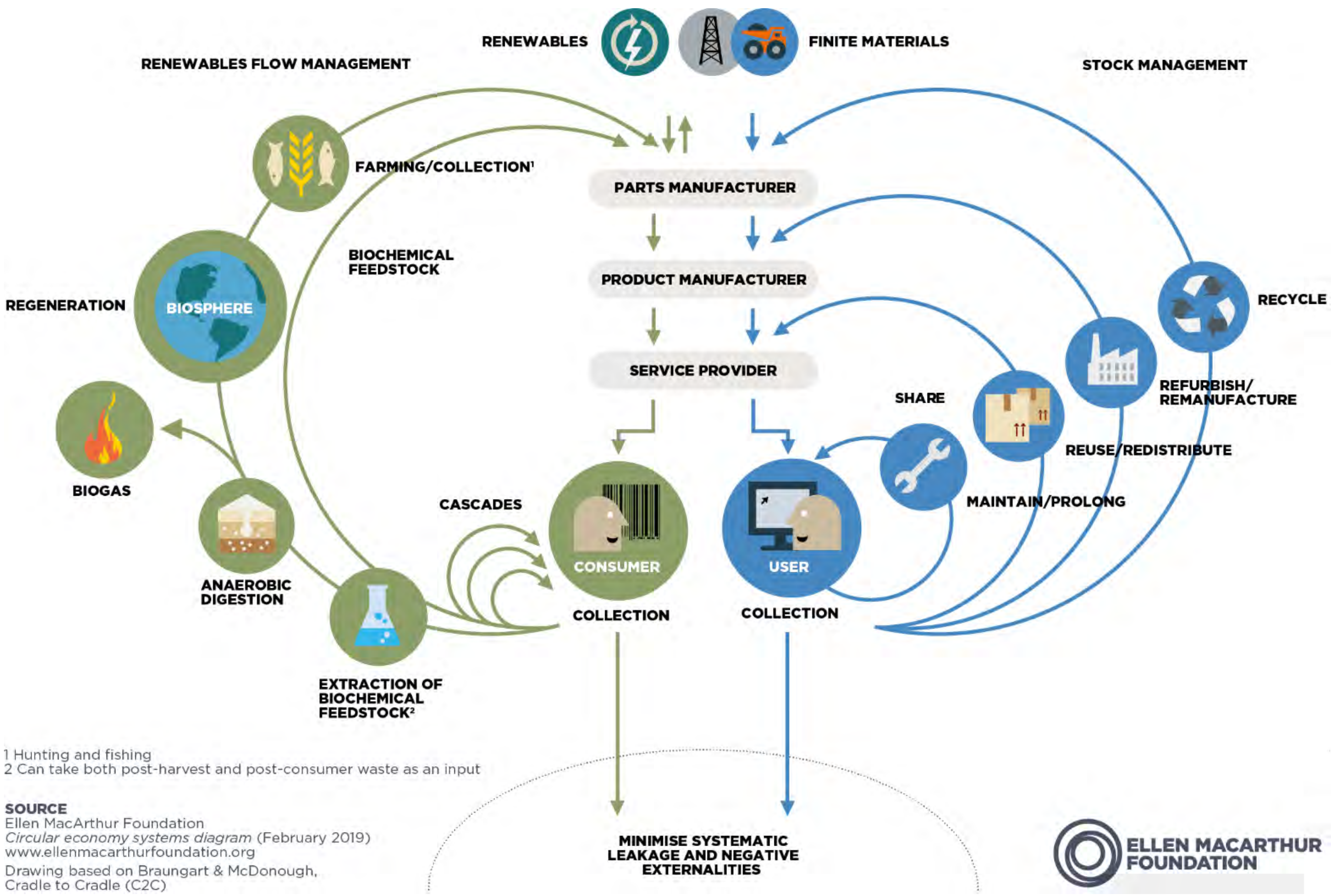


Keep materials in use

Repair, reuse, remanufacture and recycle to circulate resources and avoid depletion.

Regenerate nature

Restore ecosystems, enrich soils, and return nutrients to support natural cycles.



1 Hunting and fishing
2 Can take both post-harvest and post-consumer waste as an input

SOURCE
Ellen MacArthur Foundation
Circular economy systems diagram (February 2019)
www.ellenmacarthurfoundation.org
Drawing based on Braungart & McDonough, Cradle to Cradle (C2C)

ELLEN MACARTHUR FOUNDATION

Priorities for Key Material Groups in a Circular Economy

Fossil Fuels (Energy Materiels)

- Phase out completely to achieve decarbonision.
- Cannot be recycled– must stay in the ground.
- Transition to renewable energy and efficiency.

Biological Materials (Biomass)

- Keep within regenerative natural cycles.
- Compost and return nutrients to ecosystems.
- Support biodiversity and avold overharvesting.

Technical Materials (Metals & Minerals)

- Keep in use as long as possible.
- Extend product lifespans, reduce material intensity.
- Reuse and recycle to close resource loops.

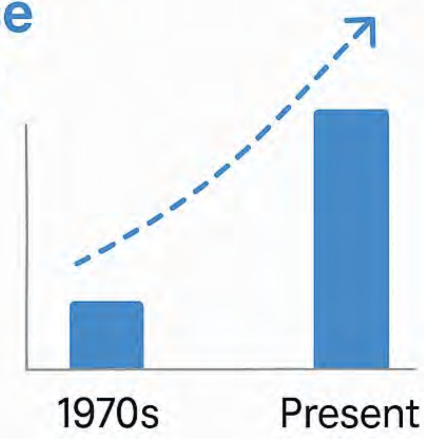
Why do we need a Circular Economy?

Global material use has grown rapidly since the 1970s

30 → 100+

BILLION TONNES

on track to 160 billion tonnes by 2050



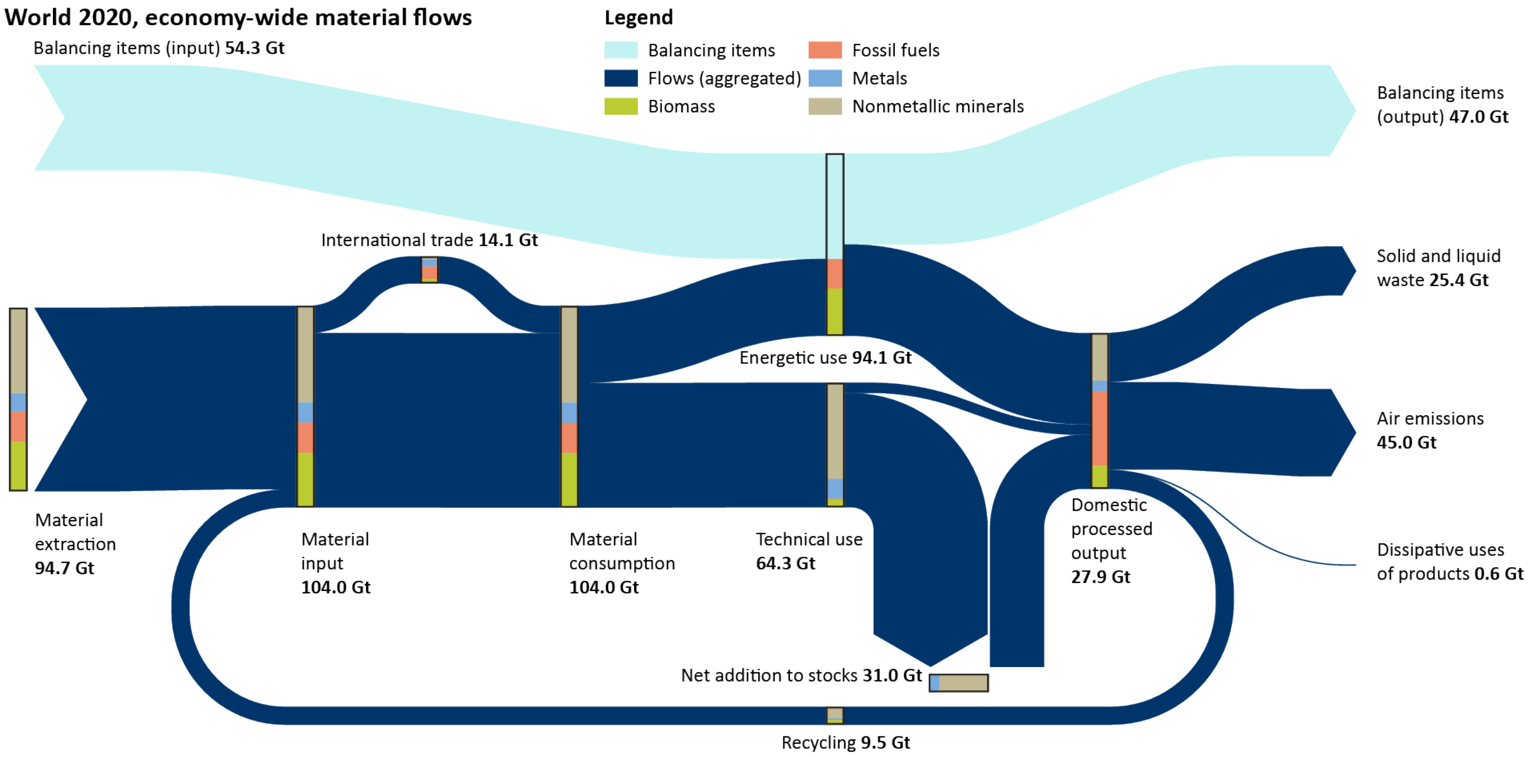
55%
of climate change

90%
of biodiversity loss and water use

30%
of pollution

We must manage the global economy to achieve universal human wellbeing within planetary boundaries

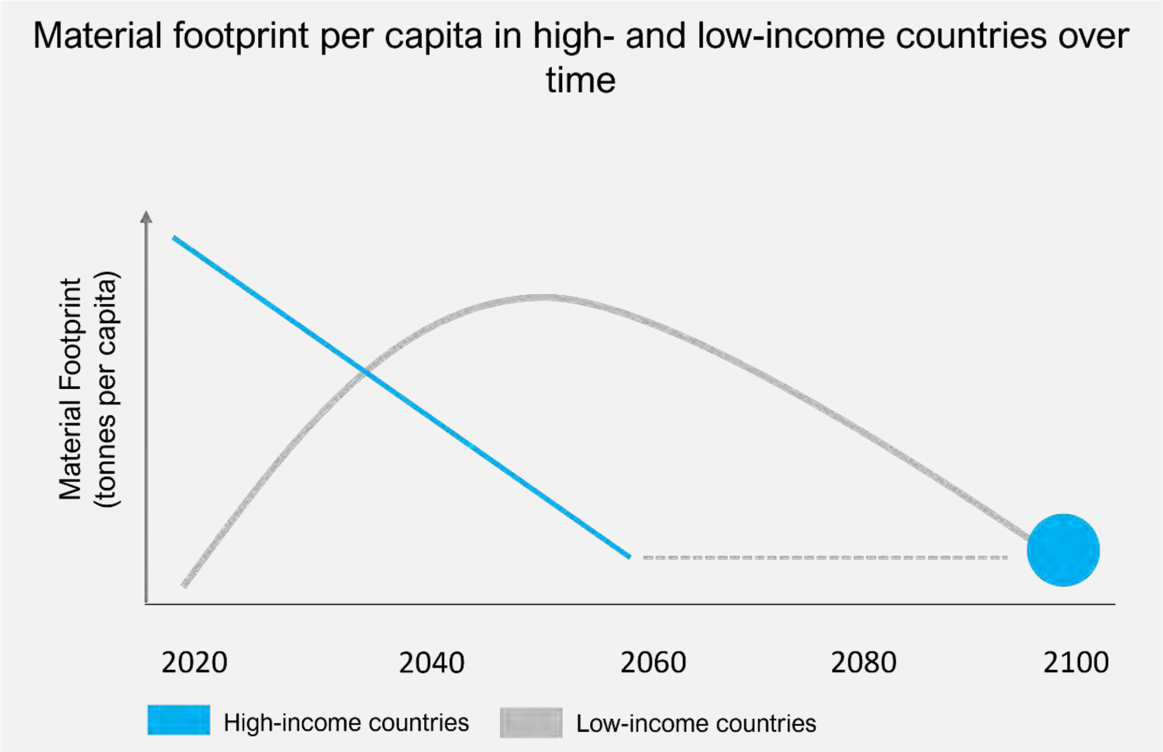
Structure of global material flows



Schandl et al 2024. Global Material Flows and Resource Productivity. The 2024 Update. Journal of Industrial Ecology

The need to reduce material footprint

High-income countries consume 6-10 times more material compared with low-income countries.



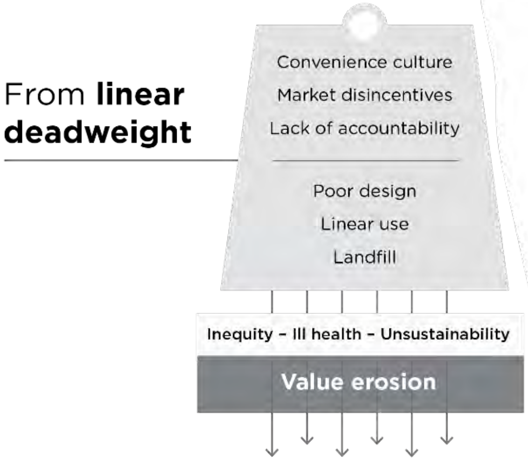
How do we get to a Circular Economy?

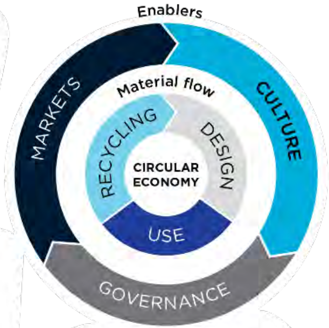
Circular Economy Theory of Change

From **linear deadweight**

Schandl et al. 2024. Mission-Oriented Research and Theory of Change: Driving Australia's Transition to a Circular Economy. Circular Economy and Sustainability

Circular Economy Theory of Change





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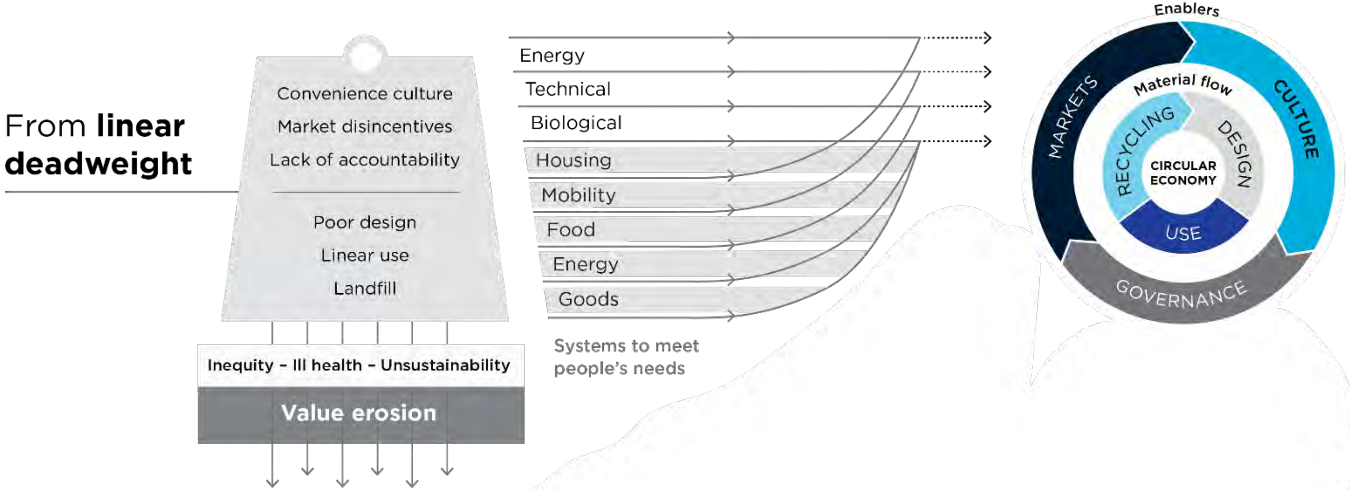

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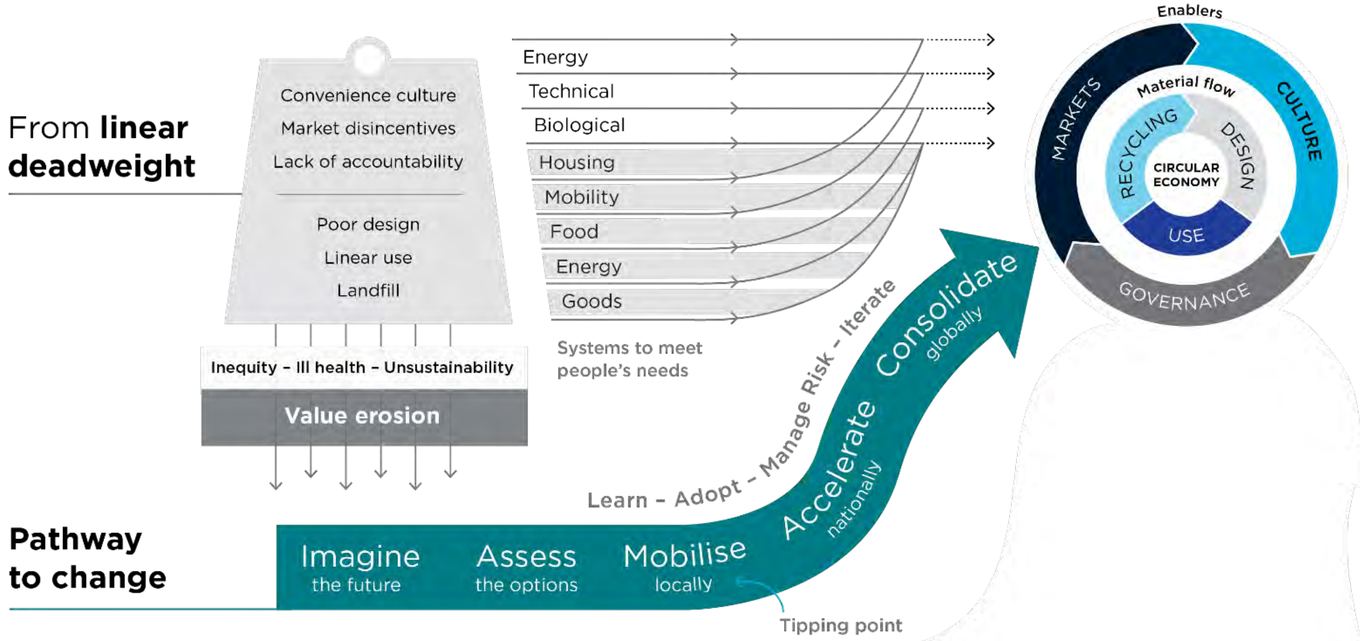
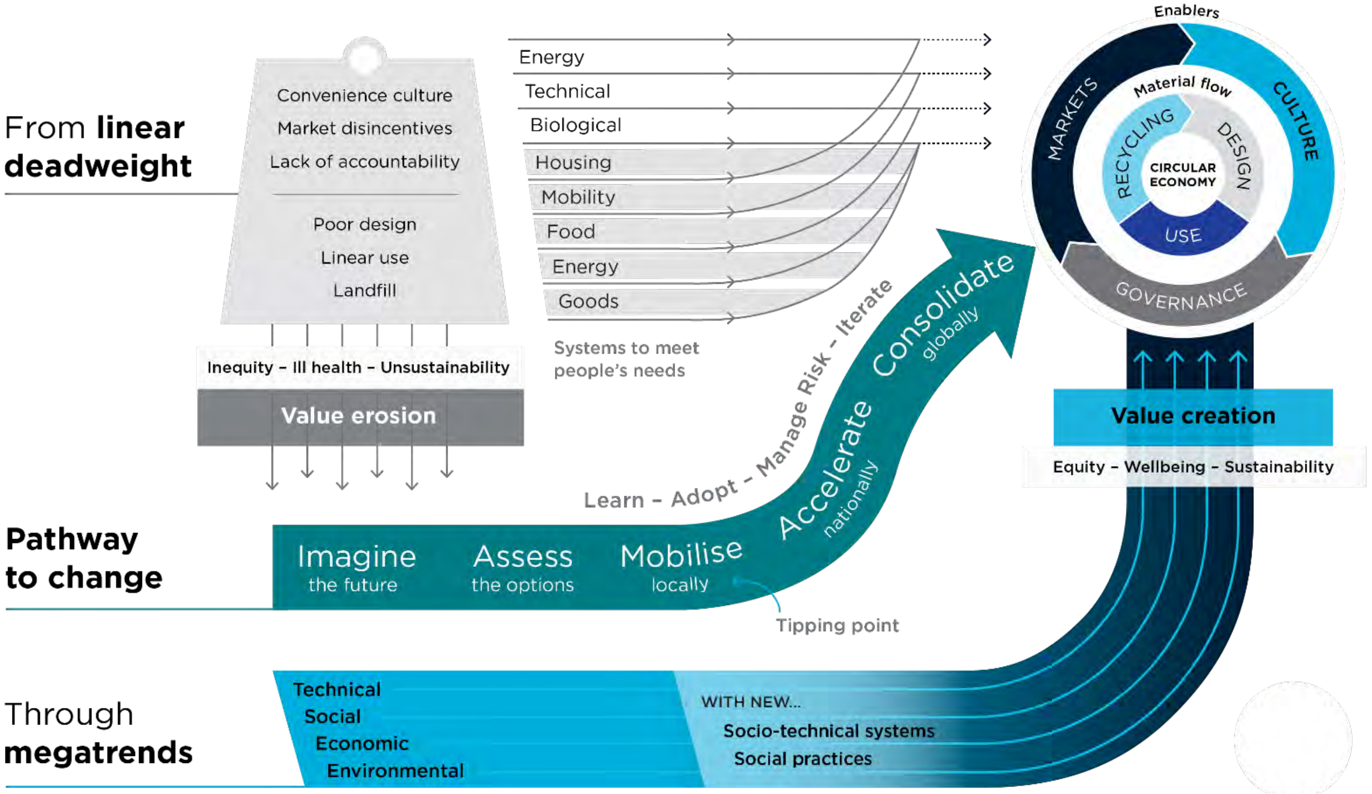


Schandl et al. 2024. Mission-Oriented Research and Theory of Change: Driving Australia's Transition to a Circular Economy. Circular Economy and Sustainability

Circular Economy Theory of Change

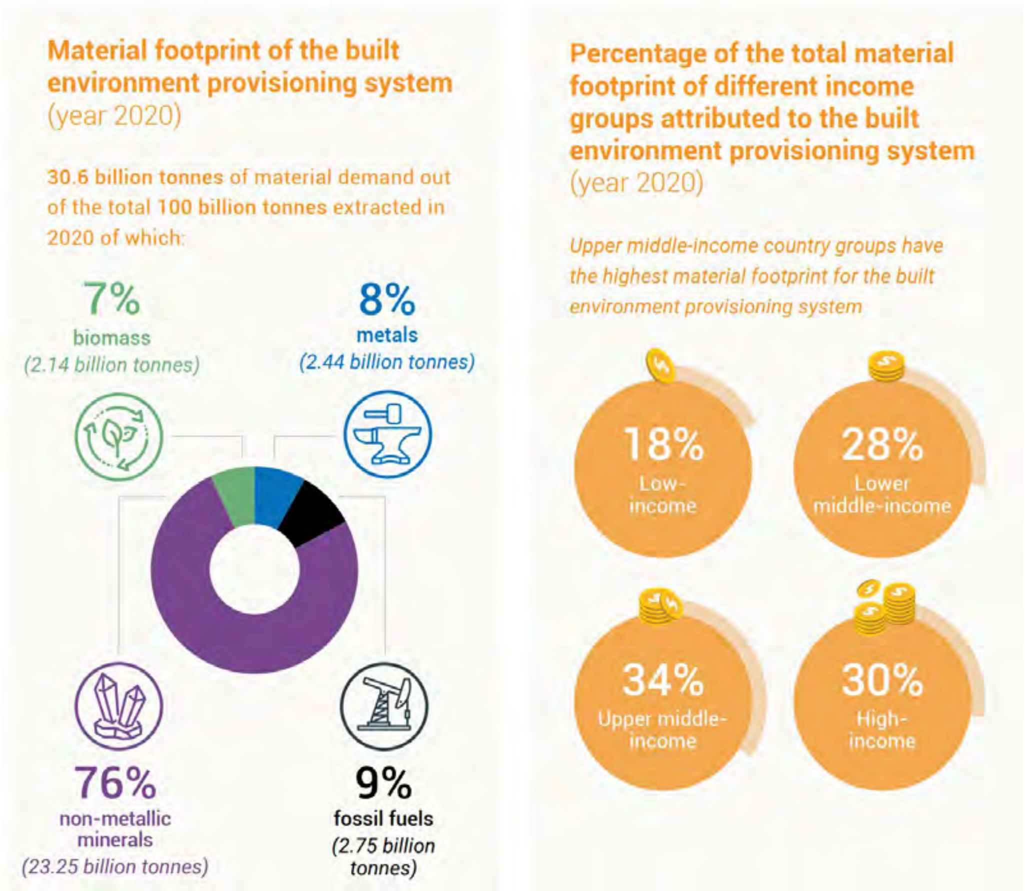
How can we meet Australia's needs for a **circular economy**



Schandl et al. 2024. Mission-Oriented Research and Theory of Change: Driving Australia's Transition to a Circular Economy. Circular Economy and Sustainability

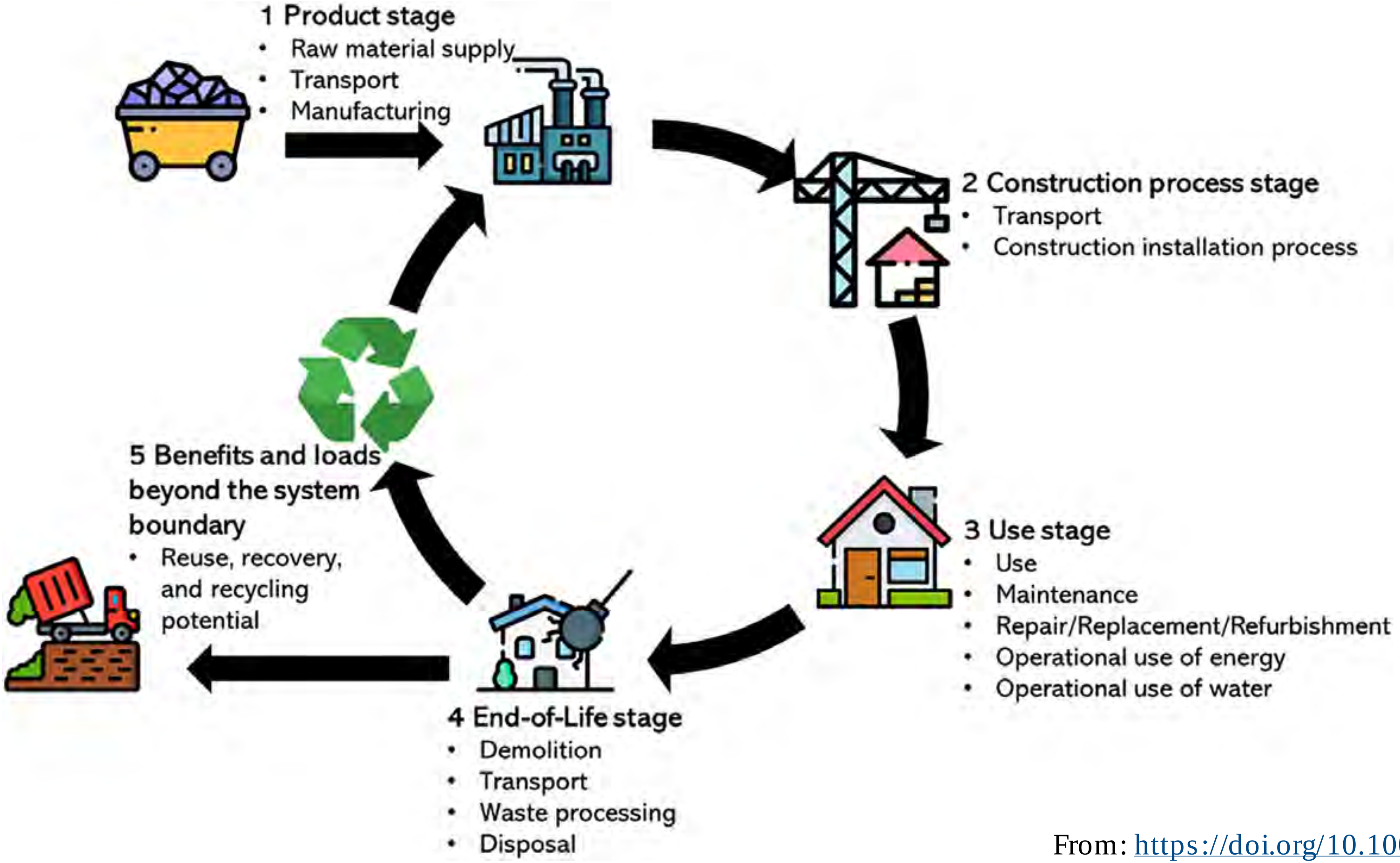
Circular Economy in Constructions

Problem setting



From: https://www.resourcepanel.org/file/3443/download

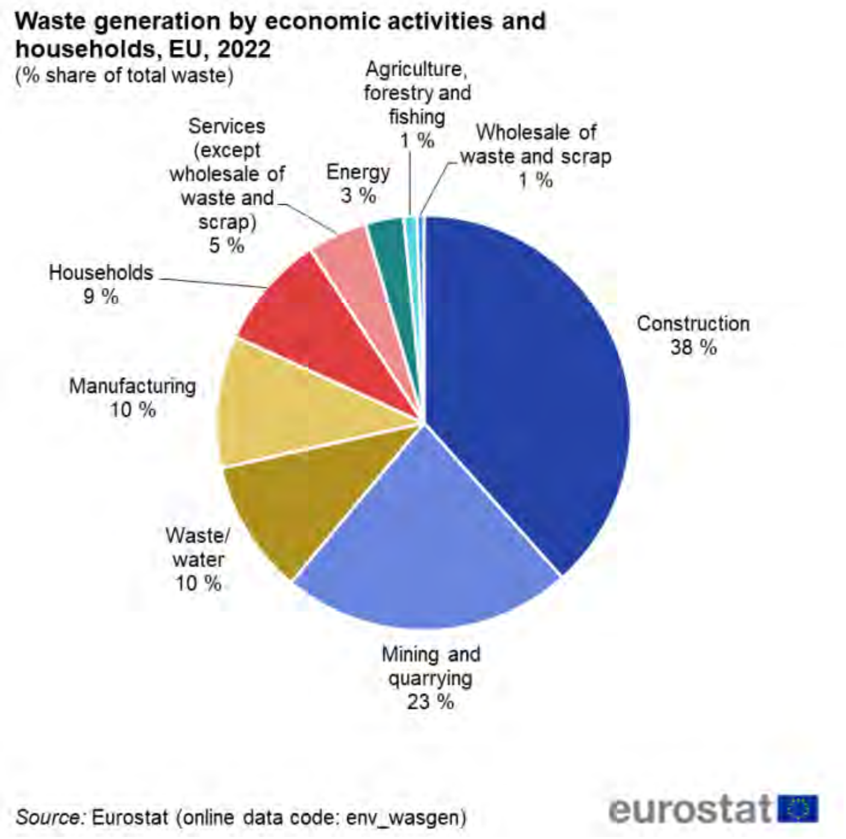
What Is Circularity in Construction & Demolition?



From: https://doi.org/10.1002/ep.14105

Global C&D waste in numbers

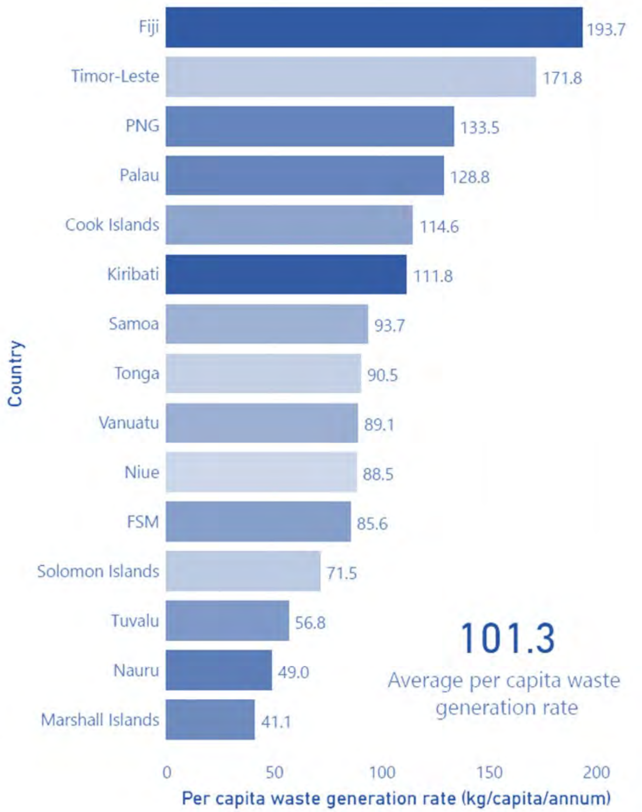
- C&D waste now accounts for more than a third of total waste globally.
- 2.2 billion t of C&D waste will be generated worldwide in 2025, up ~70 % from 2012.
- It is the largest waste category in Europe (38.4%)



From: https://ec.europa.eu/eurostat/databrowser/view/env_wasgen/default/table?lang=en

Pacific Island and C&D waste

- Land is scarce and legal dumps are overflowing.
- Heavy dependence on imported building materials.
- Extreme disaster exposure leads to debris surges.
- Fragile ecosystems & groundwater at risk.



From: https://library.sprep.org/sites/default/files/2023-08/Regional-Analysis-Report.pdf

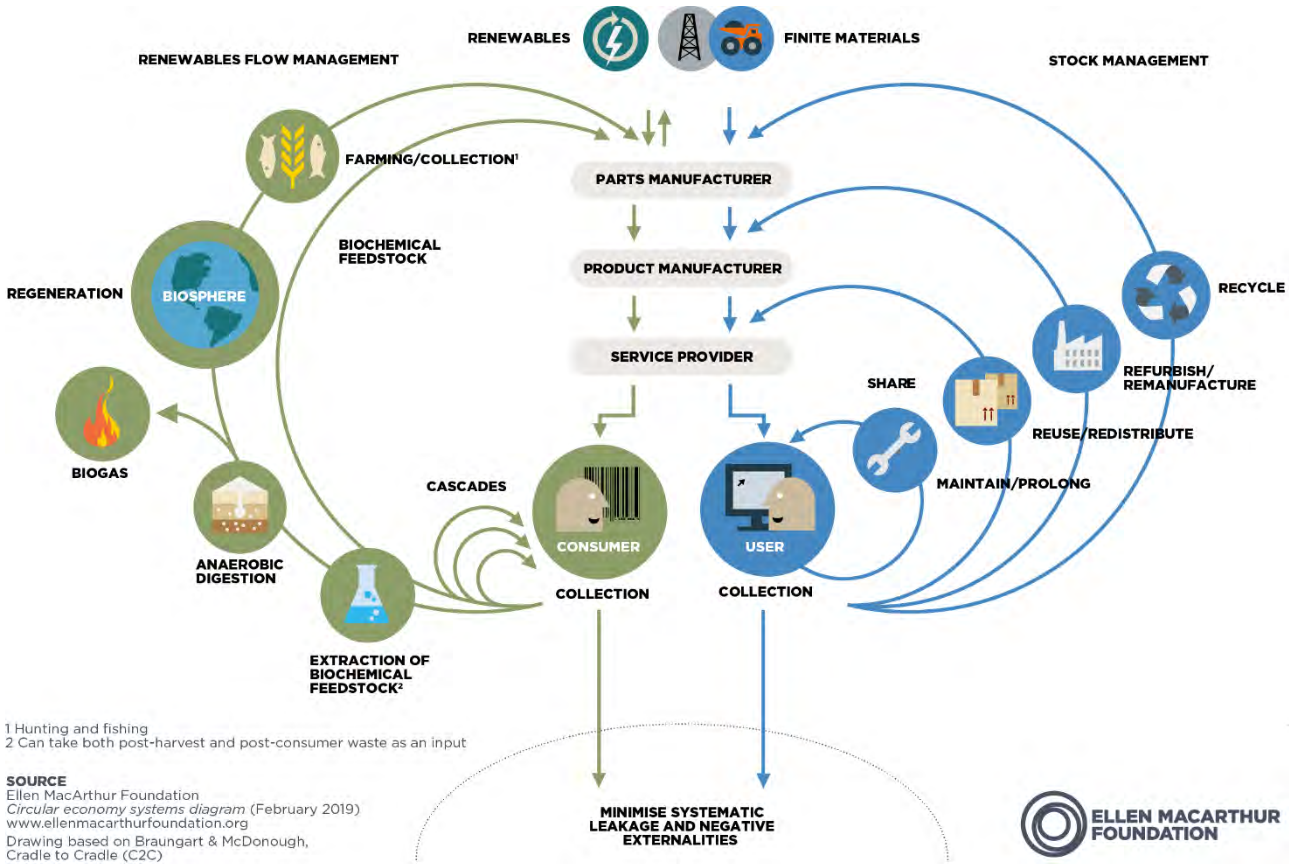
C&D Waste Baseline in Pacific Island Countries

- C&D waste data unclear, but likely in the double-digit area of the waste generation pie.
- No information on weight of disaster waste disposed.
- Lack of detailed information on C&D waste generation and pathways.

Land-constraint snapshot

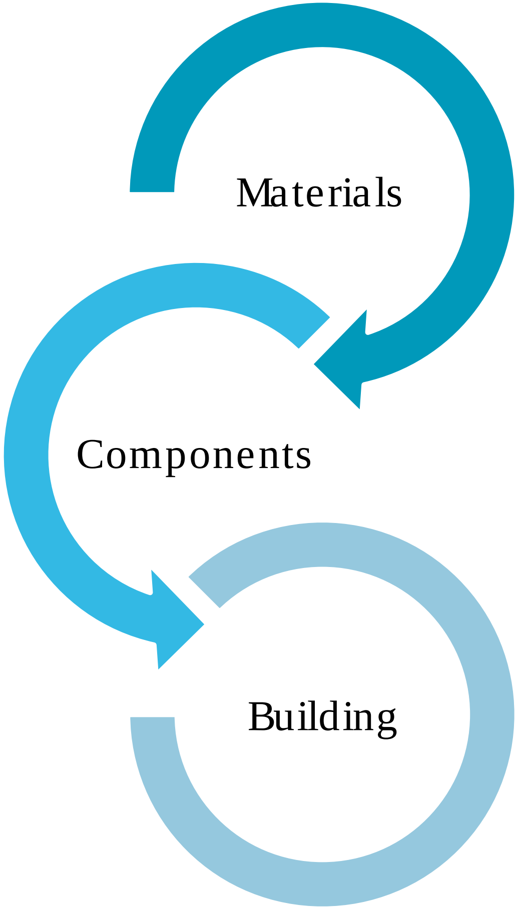
- Overflowing Jable–Batkan dumpsite in Majuro (Marshall Islands) is beyond capacity. (see image)
- Samoa's landfill capacity if projected to end by 2032.
- Of the 26 square kilometers of landmass that make up the Pacific Island of Tuvalu, 11 acres are taken up by their dumpsite.

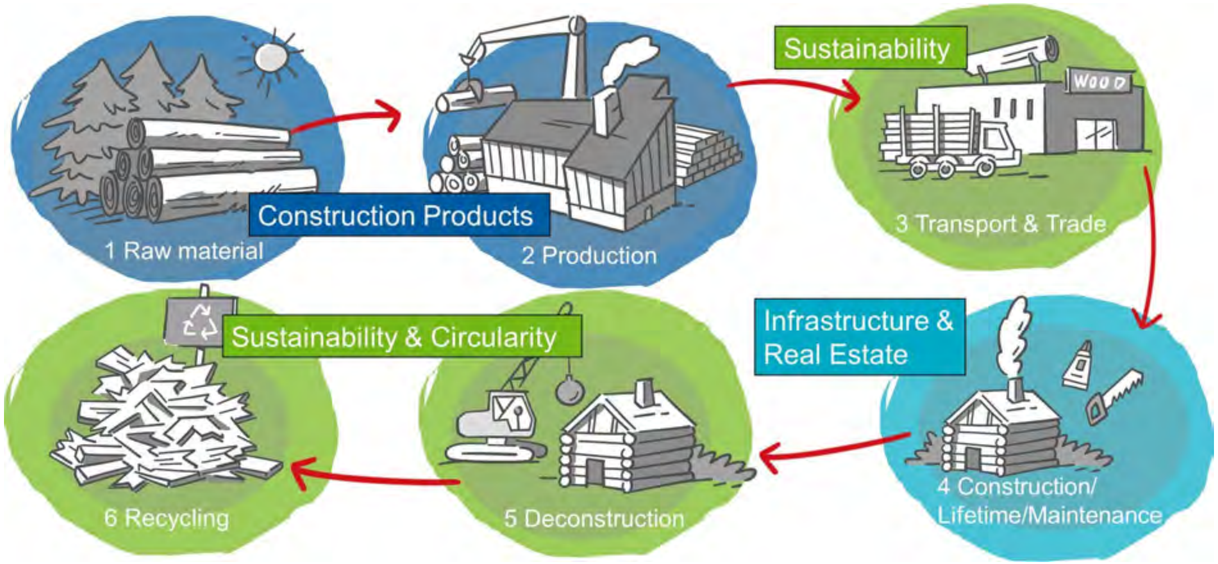
The circular economy approach



From: https://www.ellenmacarthurfoundation.org/circular-economy-diagram

Construction: a multi-tiered approach





From: https://www.kiwa.com/de/en-de/areas-of-expertise/sustainable-solutions/circularity-construction-industry/

Embodied vs operational carbon

- 39 % of global energy-related CO_2 comes from buildings: 28 % operational, 11 % embodied.
- As grids decarbonise, up-front material emissions will dominate new projects → design buildings with this in mind.

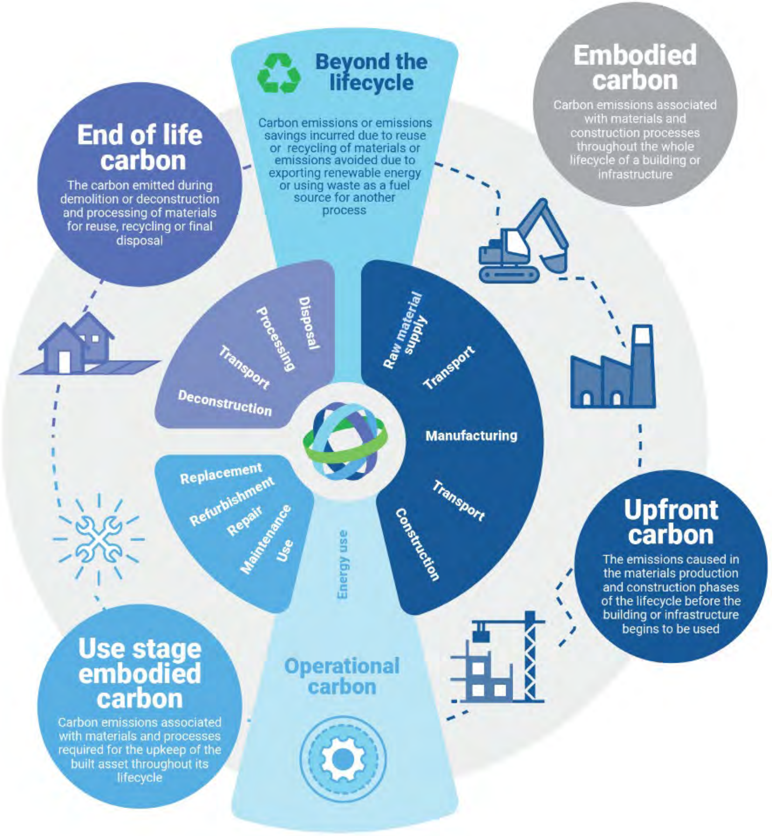


Figure 3: Project lifecycle showing both the scope of the definition and need for whole life consideration.

From: https://worldgbc.s3.eu-west-2.amazonaws.com/wp-content/uploads/2022/09/22123951/WorldGBC_Bringing_Embodied_Carbon_Upfront.pdf

Construction materials

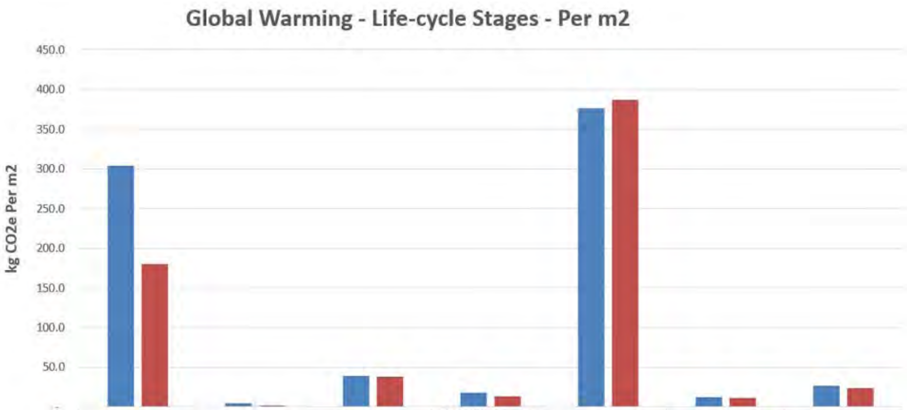
Traditional construction materials

Timber

Bricks

Timber and bricks

- Timber frame: 654 kg CO_2e/m^2: 16 % lower than brick masonry (41 % lower production); stores biogenic carbon.
- Long-lived, repairable, locally familiar. But kiln energy vs forest stewardship drives impact.

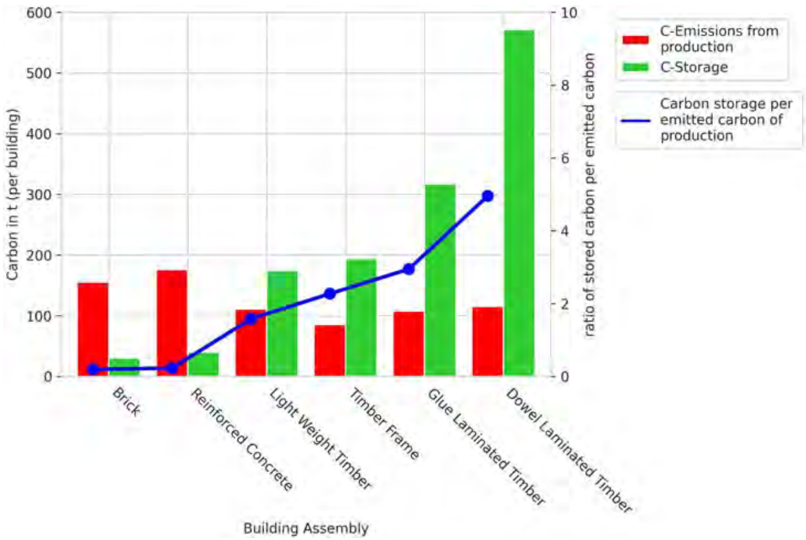


	A1-A3 Materials	A4 Transportation	A5 Construction	B1-B5 Maintenance and replacement	B6 Energy	B7 Water	C1-C4 End of life
Masonry Construction	304.0	4.3	39.2	18.4	376.5	11.9	26.9
Timber Frame Construction	179.9	1.7	37.7	13.2	386.6	11.1	23.8

From: https://jwpm.ie/wp-content/uploads/2021/04/Embodied-Energy-JWPM.pdf

Timber and bricks: circular options

- Timber assemblies: ~33 % less cradle-to-gate CO_2 than brick and store carbon.
- Reclaimed bricks. UK study: fired clay bricks have 211–242 kg CO_2e / t; reclaimed bricks ~3 kg CO_2e / t.
- Design timber for cascading reuse; set up brick-cleaning hubs and deconstruction protocols to keep both materials in local loops.



From: https://doi.org/10.3389/fbuil.2024.1330105

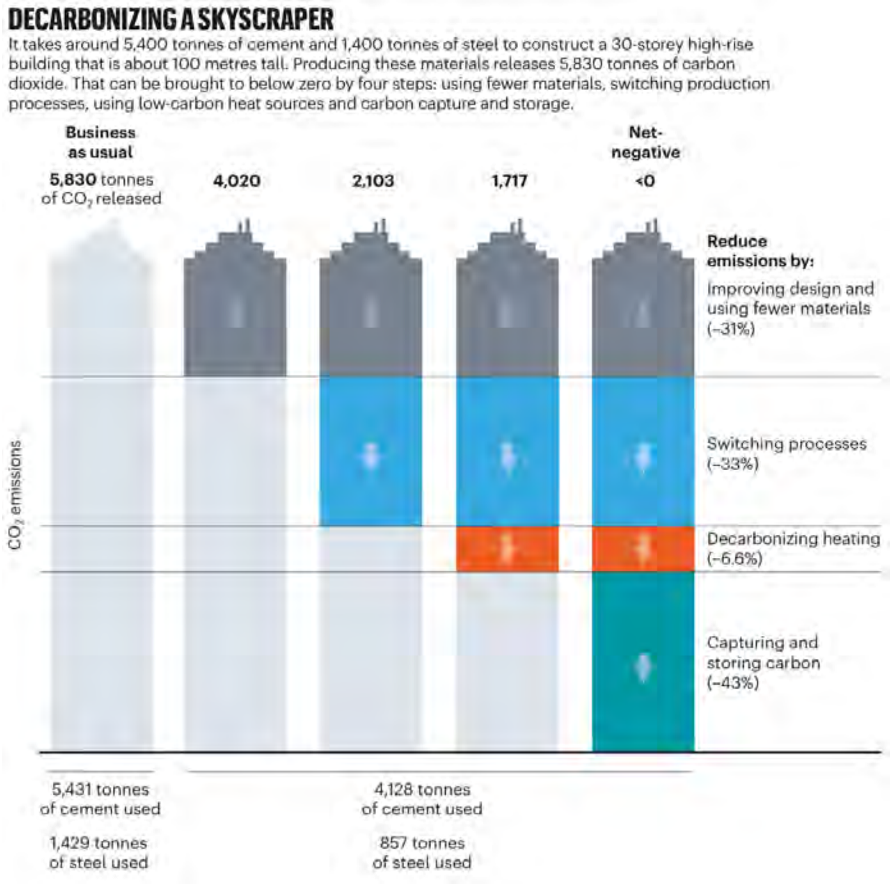
"Modern" construction materials

Steel

Concrete

Concrete and steel

- Cement 2.3 Gt CO_2 / yr (~6.5 %), steel 2.6 Gt CO_2 / yr (~7 %). Together ~15 % of global emissions.
- Annual demand: 530 kg cement and 240 kg steel per person worldwide.
- Carbon intensity today: ~800 kg CO_2 / t cement; 1.8 – 2.3 t CO_2 / t steel.

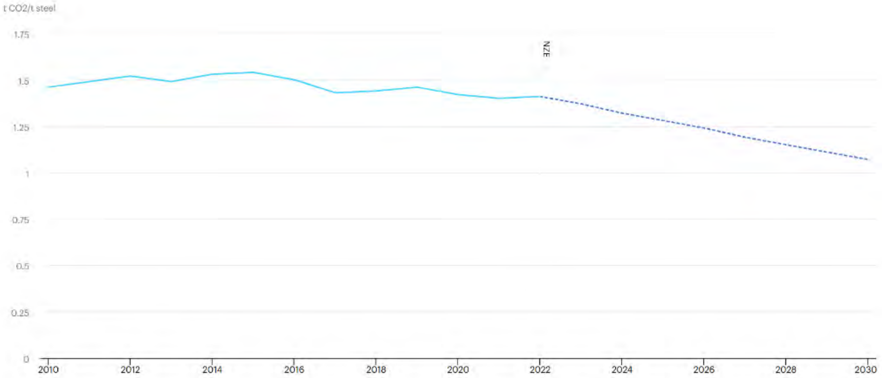


From: https://www.nature.com/articles/d41586-022-00758-4.pdf

Concrete and steel: circular options

- Concrete: Portland cement ~0.8 t CO_2/t. Replacing ≤ 50 % clinker with slag, fly ash or calcined clay + 30 % recycled aggregate can cut up-front CO_2 by 40-50 %.
- Steel: BF-BOF route 2.32 t CO_2/t vs scrap-EAF 0.67 t CO_2/t; reusing intact beams avoids remelting and virtually zeros new emissions.

Emissions and emissions intensity of cement production

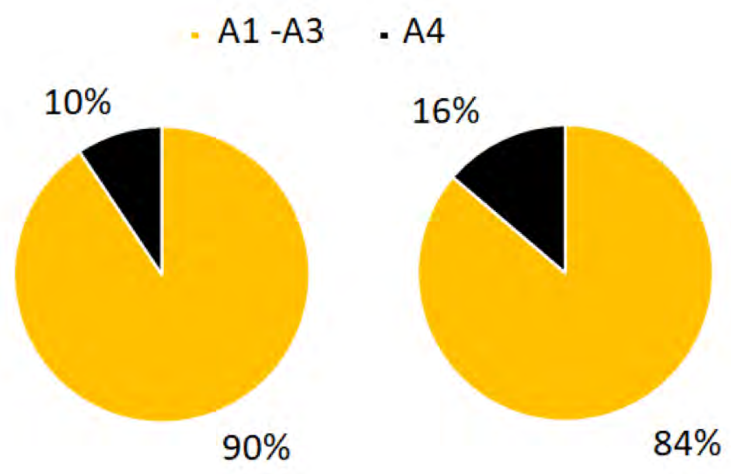


Direct CO2 intensity of the iron and steel sector in the Net Zero Scenario, 2010-2030

From: https://www.iea.org/data-and-statistics/charts/key-progress-indicator-emissions-and-emissions-intensity-of-cement-production
And https://www.iea.org/data-and-statistics/charts/direct-co2-intensity-of-the-iron-and-steel-sector-in-the-net-zero-scenario-2010-2030

Extraction and supply-chain pressures

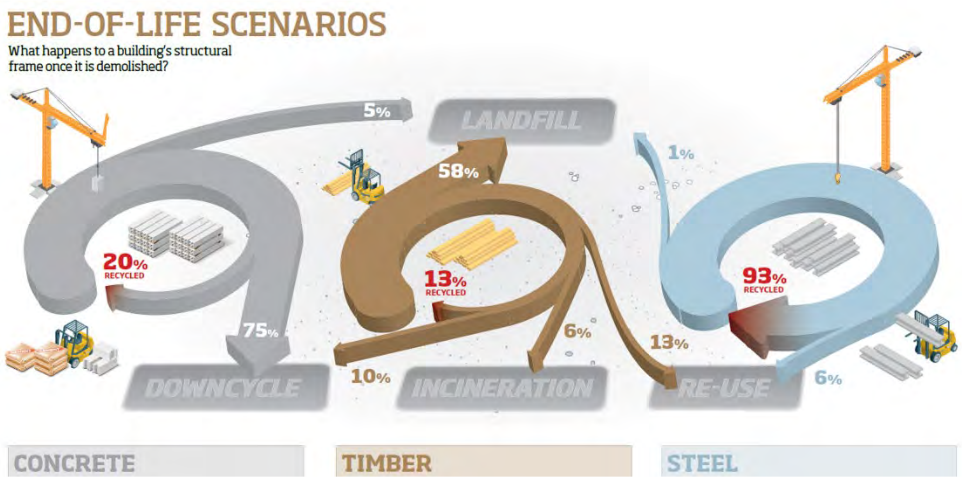
- 40-50 Gt of sand and gravel mined every year.
- Haul distance matters: a 150 km journey can increase by 50% the carbon share of transport compared with sourcing within 5 km.
- Local reuse & recycled aggregates cut quarry demand and slash import-linked emissions and costs for island states.



From: https://doi.org/10.3390/engproc2023057005

End-of-life pathways for major materials

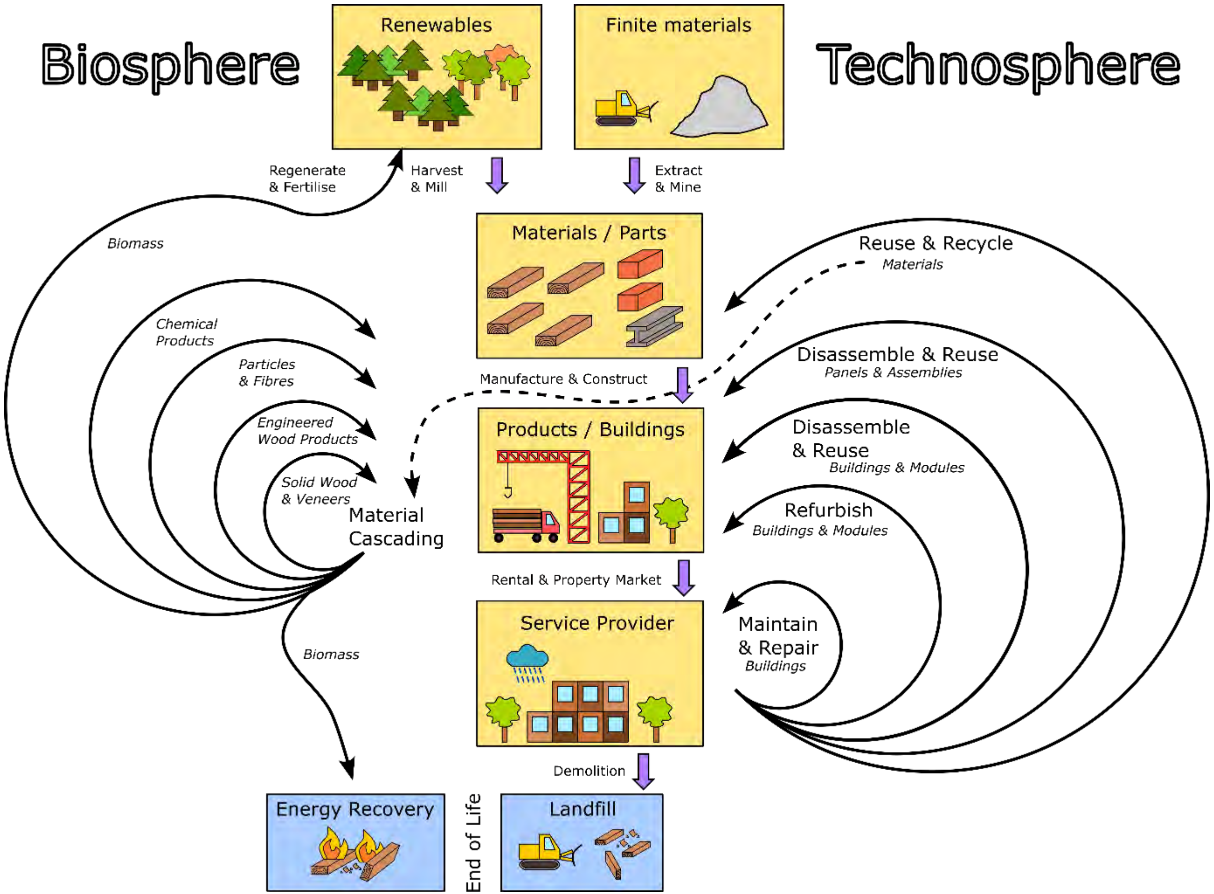
- Up to 93% of building steel can be recovered for reuse or closed-loop recycling at end-of-life.
- Timber: 81 % of UK construction timber is now reused or recycled through deconstruction.
- Concrete / masonry: the heaviest flow; most is crushed and down-cycled into road base, not true recycling, so value and carbon savings are limited.



From: https://www.steelconstruction.info/Recycling_and_reuse

Building material circular flow diagram

- Inner loops first: maintain, reuse, refurbish. Keep value highest.
- Material-specific paths: timber in bio-cycle; steel &concrete in technical cycle.
- Goal: longest life, local loops, least new extraction.

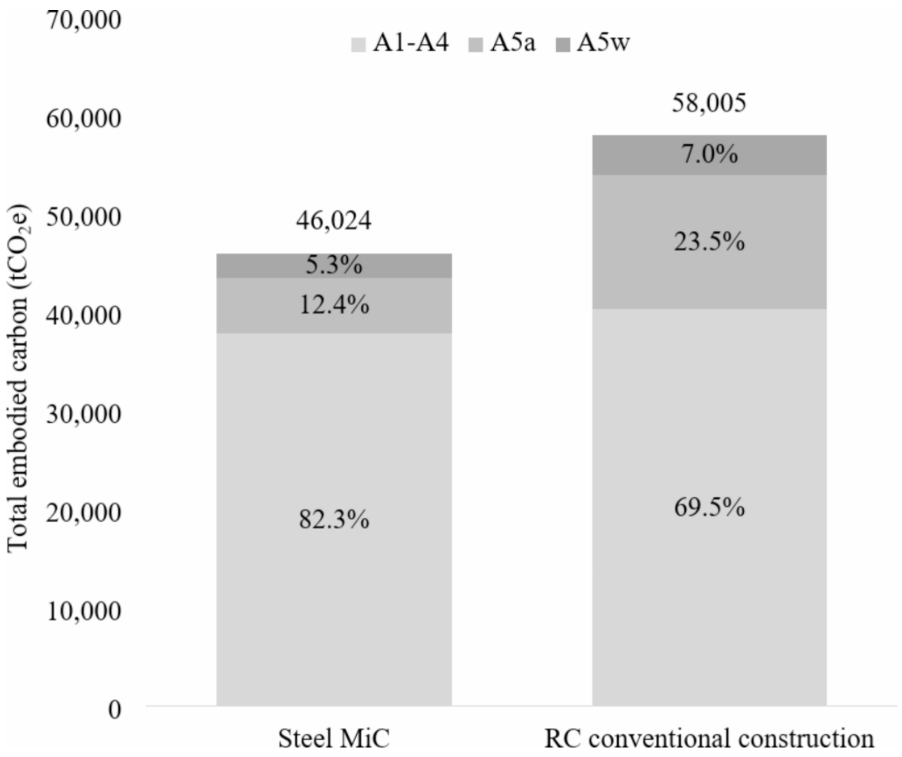


From: https://doi.org/10.6084/m9.figshare.21249573.v1

Construction Components

Prefabrication and modular construction

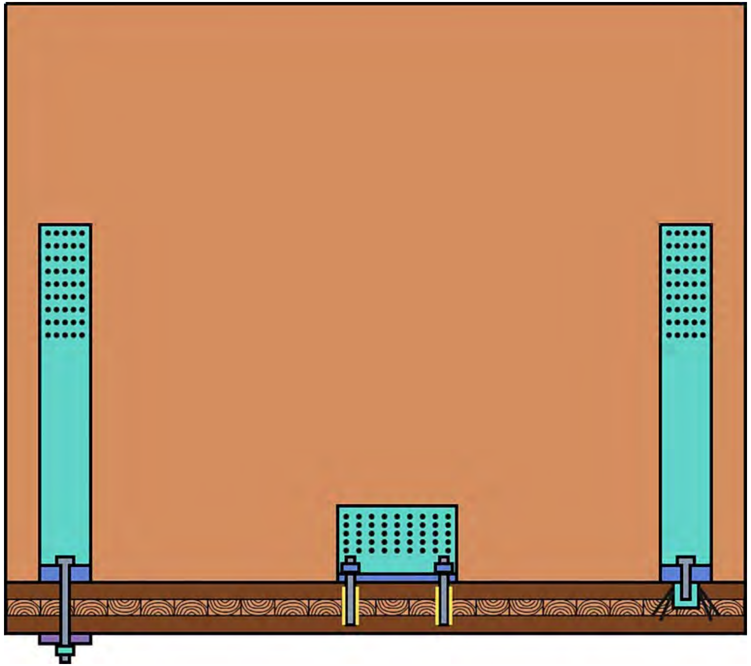
- -20.7 % embodied CO_2, -58 % on-site fuel, -75 % material waste in a full-scale modular integrated construction (MiC) project. Precision factory work and shorter timelines deliver the cuts.
- Multi-unit modular housing in Canada built 37 % faster with -43 % construction-phase CO_2 compared with site-built methods.



From: https://doi.org/10.1038/s41598-024-73906-7

Prefabrication and modular construction

- Unscrew, unbolt, reuse. Reversible fasteners (bolts, screws, dry brackets) keep components intact, enabling high-value salvage instead of down-cycling.
- Steel tells the story: today ~ 90 % of EU scrap steel is recycled yet only 5 % is actually reused—because most frames are welded, not bolted.

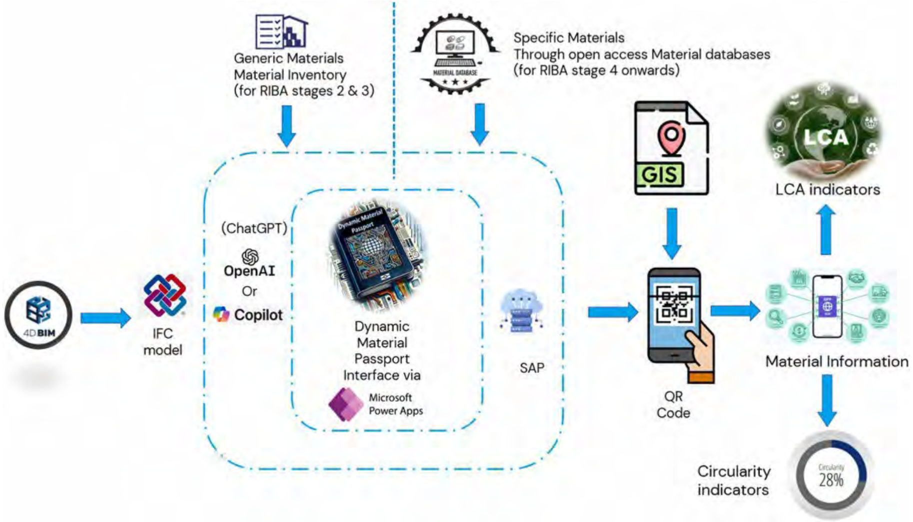


Examples of reversible hold-down and angle bracket assembly options. Through-bolt to the underside of a floor panel (left) glued-in rod (centre) rod fastened to a connection system (right, e.g. Sihga IdeFix).

From: https://doi.org/10.1016/j.conbuildmat.2023.132823

Material passports

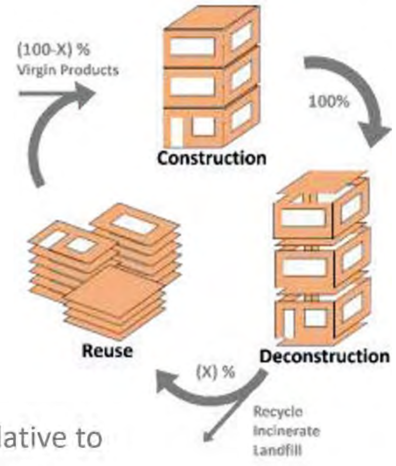
- Track & trace: QR-coded passport links every element to BIM, storing composition, embodied-carbon and hazard data through the building life-cycle.
- Market enabler: Emerging EU / UK platforms show passports boost reuse value and cut waste by giving buyers confidence in reclaimed components.



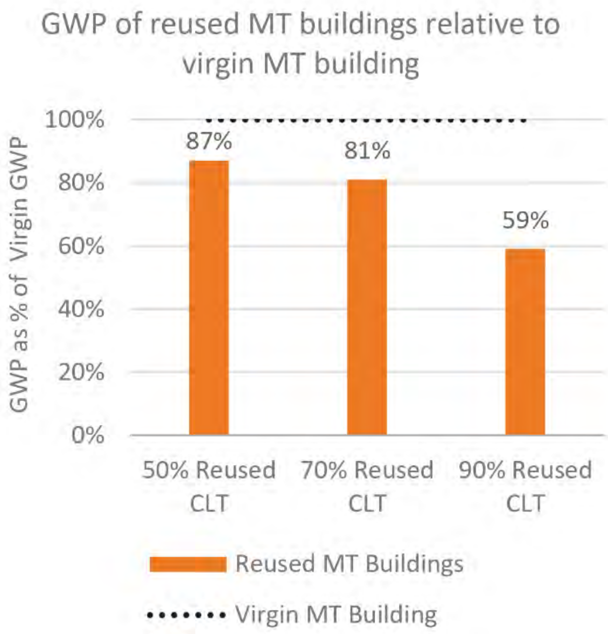
Proposed framework of dynamic material passports for future research

From: https://doi.org/10.1016/j.cscm.2025.e04267

Advantages of disassembly



- Mass-timber loop: Reusing 90 % of CLT panels in a second building cut cradle-to-grave GWP by 13–41 % versus demolish-and-landfill.
- Precast concrete loop: EU "H2020 ReCreate" pilots show that keeping structural slabs intact can slash product-phase CO_2 by 93–98 % compared with virgin casting or down-cycling to aggregate.

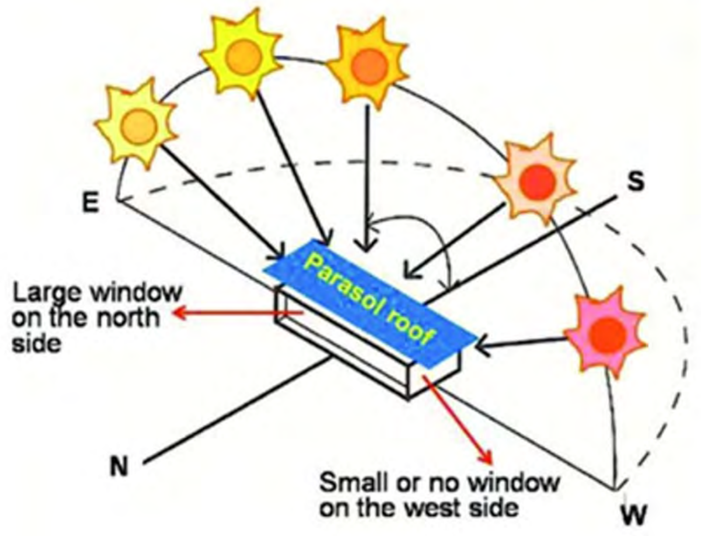


From: https://doi.org/10.52202/069179-0466

Designing for the Circular Economy

Passive design fundamentals

- Face the long sides E–W. This halves solar exposure on the largest walls and avoids the intense low-angle morning/afternoon sun; keep big windows off the east & west façades.
- Add cross-breeze. Align openings with prevailing winds to flush heat and further cut A/C demand.
- Simulated impact: correct orientation plus basic shading trims cooling energy 20 – 37 % in tropical / sub-tropical test cases.



From: https://aseanenergy.org/wp-content/uploads/2024/09/Passive-Cooling-Strategies-Report.pdf

Designing with nature

- External shading trims peaks by 2.5-4.5 °C in tropical test buildings, reducing air-conditioning needs.
- Cross-ventilation: up to 5.3 °C cooler & 58 % fewer discomfort hours (Mumbai high-rise case-study).
- Tree shade and evapotranspiration can drop local air temp by 3-4 °C, while native planting buffers wind and filters salt spray.

Technologies and Architectural Design Elements

Shading Devices:
- Crucial for blocking or filtering direct sunlight
- Helps reduce the amount of solar radiation entering a building
- Can significantly lower indoor temperatures and reduce reliance on air conditioning

Natural Ventilation:
- Cross Ventilation, when air flows between two opposite or adjacent openings
- Utilizes pressure differences between windward and leeward sides of a building
- Reduces the need for air conditioning, leading to lower energy consumption
- However, in urban areas with high pollution, it may introduce harmful pollutants and external noise

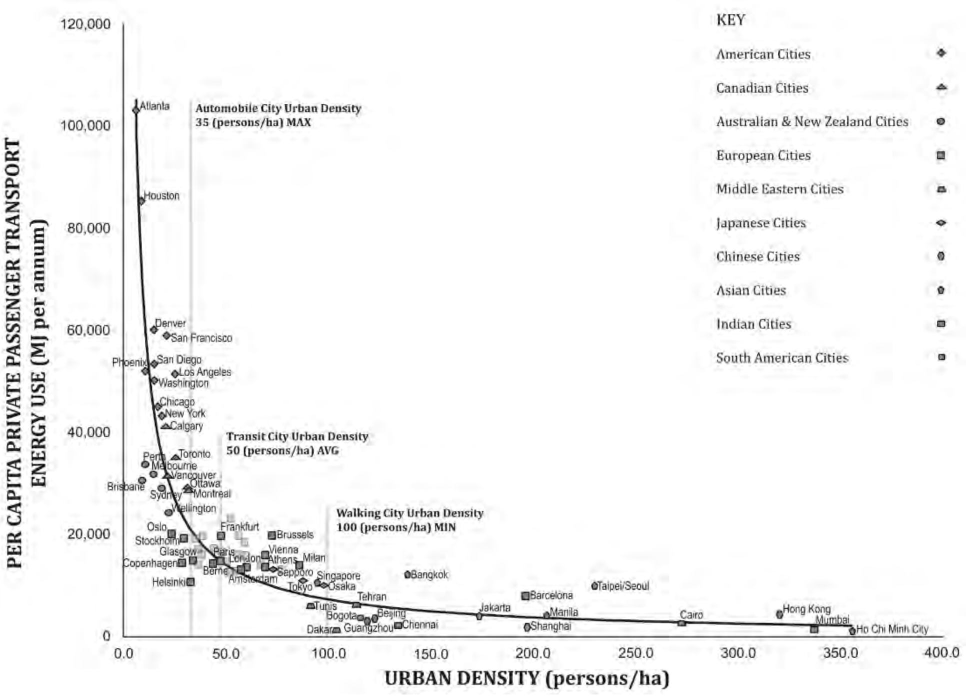
Wall Materials:
- Materials like concrete, brick, and stone can absorb heat during the day and release it slowly at night
- Proper insulation is crucial to minimize unwanted heat transfer

Cool Roof:
- Reflective Coating: A cool roof with reflective coating can significantly reduce heat load on buildings
- Helps maintain lower indoor temperatures and reduce energy consumption
- Various studies have quantified the decrease in cooling energy needs with reflective coatings

From: https://www.unescap.org/sites/default/d8files/event-documents/Study%20on%20Passive%20Cooling%20Strategies%20by%20ASEAN%20Centre%20for%20Energy.pdf

Urban form: curbing sprawl

- Density slashes travel emissions. Moving from 10 to 100 p/ha cuts per-capita transport fuel by ~80 % across global cities.
- Compact form leads to cleaner mobility. IPCC modelling shows at least -10 % car-CO_2 by 2030, rising to -64 – 70 % by 2050 when compact growth pairs with low-carbon transport.
- Materials saved, too. BaU sprawl could more than double construction materials to 90 Gt yr^{-1} by 2050.



From: https://doi.org/10.4236/cus.2021.93032

Weaving reuse & recycling into practice

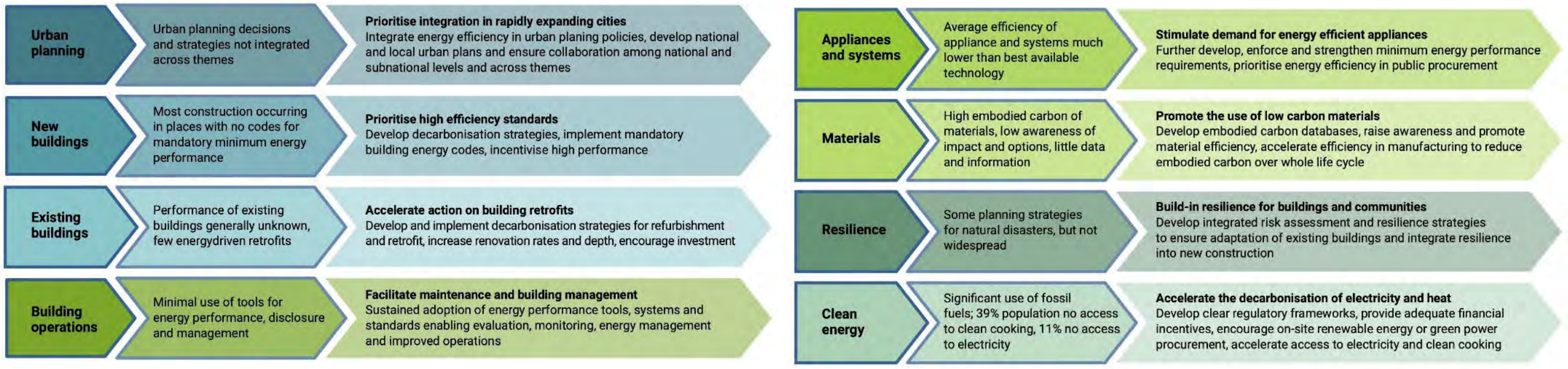
- Front-load goals: set reuse & recycled-content targets in the brief; early design decisions lock in up to 80 % of waste outcomes.
- Stage-gate checklist: at every gate ask, "can this component be reused, or made from recycled feedstock?"
- Track & feed back: keep a live material passport + site-waste plan so salvaged parts loop straight into the next project instead of landfill.

Figure 1. Materials resource efficiency as part of sustainable construction

From: https://build360.ie/wp-content/uploads/2023/01/WRAP_DOW_Guide.pdf

Conclusions

Key take-aways



- Mandate minimum recycled content & local sourcing in public projects to create a guaranteed market.
- Embed passive-design & compact-growth clauses in updated island building codes and spatial plans.
- Require design-for-disassembly in public projects to generate knowledge.

From: https://globalabc.org/climate-action-roadmaps-buildings-and-construction

Conclusion

Materials: Replace up to 50 % of cement clinker with SCMs and use scrap-based EAF steel to slash up-front CO_2 by roughly half.

Components: Specify bolt-on, screw-fix or clip connections and tag elements, so beams, slabs and panels can be lifted out intact for high-value reuse.

Building design: Orient for sun and breeze, add deep shade and green buffers; passive measures can trim cooling energy 30–50 %.

Big picture: Buildings lock in carbon and resources for decades; choosing circular options now steers the whole sustainability transition.

Thank you

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