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Potential for reducing greenhouse gas emissions in the South African building sector

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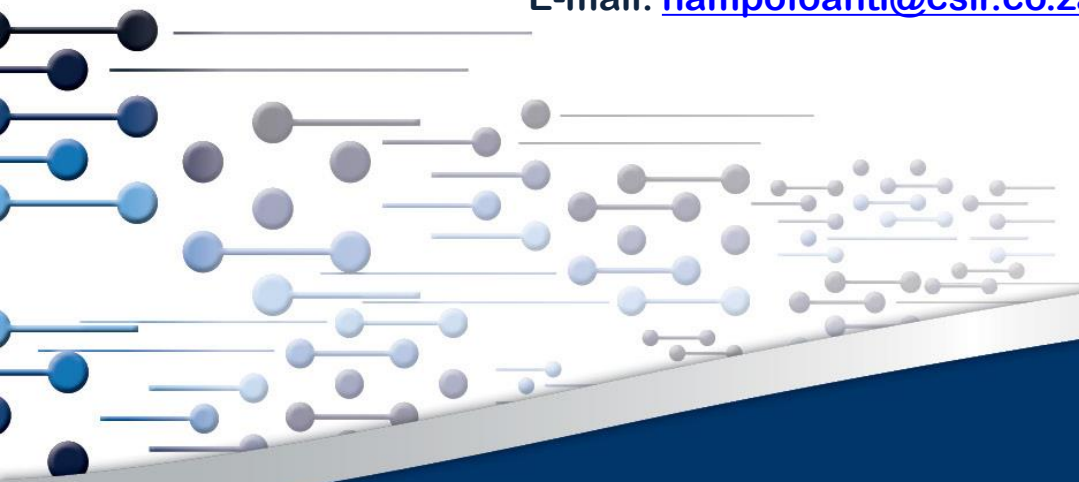

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Study background

- The Green Fund, administered by the DBSA, was set up by the DEA to support South Africa's transition to a low-carbon, resource-efficient and pro-employment path.
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- This CSIR BE study is one of 16 research projects which received Green Fund research grants under the DBSA initiative "Research and policy development to advance a green economy in South Africa".
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- The full study is published as a "Green economy research report" at www.sagreenfund.org.za

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Introduction

Most greenhouse gas emissions in the world come from buildings…..

Contribution to global annual total

- Operational emissions: 33% / embodied emissions possibly 7 - 10%

Contribution to regional (EU) annual total

- Operational 36% / embodied 8-12%

Contribution to national annual total

- USA: Operational 38% / embodied not reported
- UK: Operational 37% / embodied not reported
- SA: Operational 23% / embodied 5%

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Introduction

Near zero energy buildings (NZEBs) and low energy buildings (LEBs) have emerged as operational emissions are regulated. However, the problem is shifting .....

NZEBs / LEBs use more resources and contribute more embodied emissions

Conventional building energy profile

Operational 80% / embodied 20%

LEB/NZEB energy profile

Operational 38% / embodied 62%

Embodied emissions therefore require measurement and policy action and that is the focus of the present study

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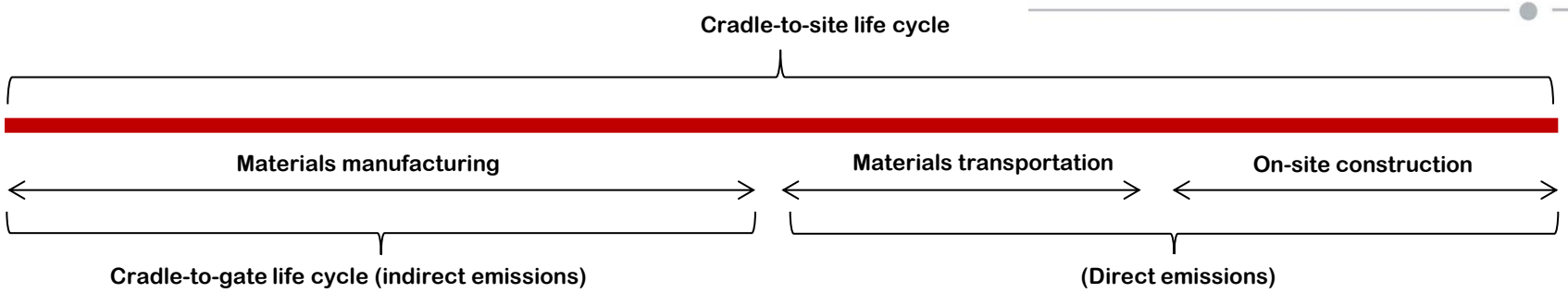
Introduction: previous international studies

Irish study: Acquaye & Duffy, 2010	Swedish study: Nässén et al, 2007
Cradle-to-site (indirect + direct emissions)	Cradle-to-site (indirect + direct emissions)
Construction sector emissions (buildings & civil engineering works)	Building sector emissions only
IO-Analysis method	IO-Analysis method
11% total Irish national emissions in 2005 (excluding international emissions)	6% total Swedish GHG emissions in 2000 (including imported emissions)
	Building investments low in 2000, accounting for 6% GDP as compared to average 12% GDP in the period prior to 2000

Introduction: previous international studies



Component of embodied GHG emissions	Description of emissions source	Irish study, IO-analysis result (% total GHG emissions)	Swedish study, IO-analysis result (% total GHG emissions)
Indirect emissions	Materials manufacturing (national)	42%	46%
	Materials manufacturing (international)	41%	31%
Direct emissions	Materials transport to site	17%	23%
	On-site related energy use		

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Introduction: previous South African study

Study background

- *Greenhouse gas emission baselines and reduction potentials from the building sector in South Africa*, funded by UNEP-SBCI and undertaken by the CIDB in 2007. Main focus was operational GHG emissions reductions with limited investigation of embodied GHG emissions

Study review (embodied GHG emissions only)

- Study scope – manufacturing (indirect) emissions
- Sector scope – buildings sector, 2006 as baseline year
- Emissions quantification methodology
  - ✓ Internationally available carbon emission factors (CEFs) were used
  - ✓ Assessment limited to 5 emissions-intensive major building material groups (MBMGs) – cement, steel, masonry, roof covering, vertical cladding

Study result

- 18 mt CO_2eq (5% total South African GHG emissions in 2006) – not clear whether international emissions included / excluded

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Methodology

Overall approach:

- Cradle-to-gate analysis, i.e. indirect building sector GHG emissions only, excluding *imported materials*

Key methodological steps:

1. Identify and categorise South African major building product groups (MBPGs)
2. Quantify MBPGs used in new construction and alterations / additions in 2014
3. Develop carbon emission factor (CEF) for each MBPG using "localised" Eco-invent data
4. Select "already made" CEF from UK Inventory of Carbon and Energy (ICE) database for MBPGs lacking Eco-invent data
5. Allocate bulk materials – steel and cement – to MBPGs to avoid double counting GHG emissions
6. Calculate GHG emissions for each MBPG (CEF multiplied by MBPG quantity in tonnes, litres, $m^{2, etc}$)

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Methodology

Key assumptions

- Quantities of MBPGs are accurate reflection of building materials produced in South Africa in 2014
- Quantified materials exclude MBPGs used in civil and engineering works
- Quantified emissions exclude imported MBPGs

Key limitations

- “Already made” CEFs selected from ICE Database reflect UK environmental conditions
- Reflective foil insulation (50% of all thermal insulation) omitted from GHG inventory due to lack of appropriate CEF
- Building services MBPGs omitted from GHG inventory due to lack of appropriate CEFs

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Methodology: MBPGs and MBPG categories

Major building product group or sub-group	Major building product group categories				
	Structure	Envelope	Finishes	Site works	Building services
Cement	✓	✓		✓	
Aggregate and sand	✓	✓		✓	
Reinforcing steel and sections	✓	✓		✓	
Particleboard and MDF	✓				
Roof structure	✓			✓	
Masonry	✓	✓		✓	
Internal partitioning		✓			
Roof covering		✓			
Vertical cladding		✓			
Building glass		✓			
Door frames		✓			
Window frames		✓			
Building insulation		✓			
Doors		✓			
Ceiling finishes			✓		
Floor finishes			✓		
Wall finishes			✓		
Decorative paint			✓		
Plumbing					✓
Electrical					✓
HVAC					✓

Note: building services MBPGs (marked in blue) excluded from inventory due to data issues

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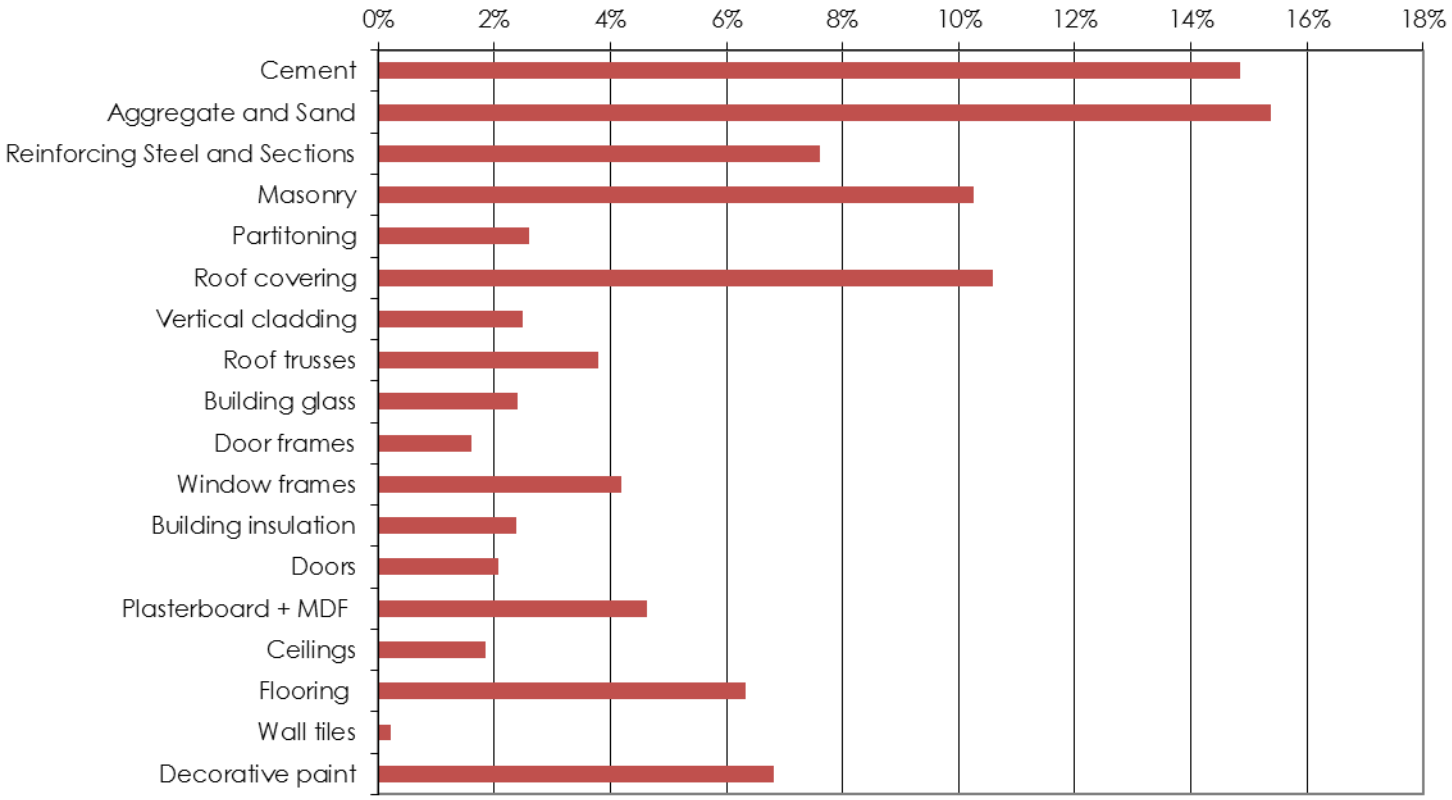
Results: market sizes (rand) of 18 MBPGs



Total investment in buildings (market value of 18 MBPGs) in 2014 = R 55.6 billion

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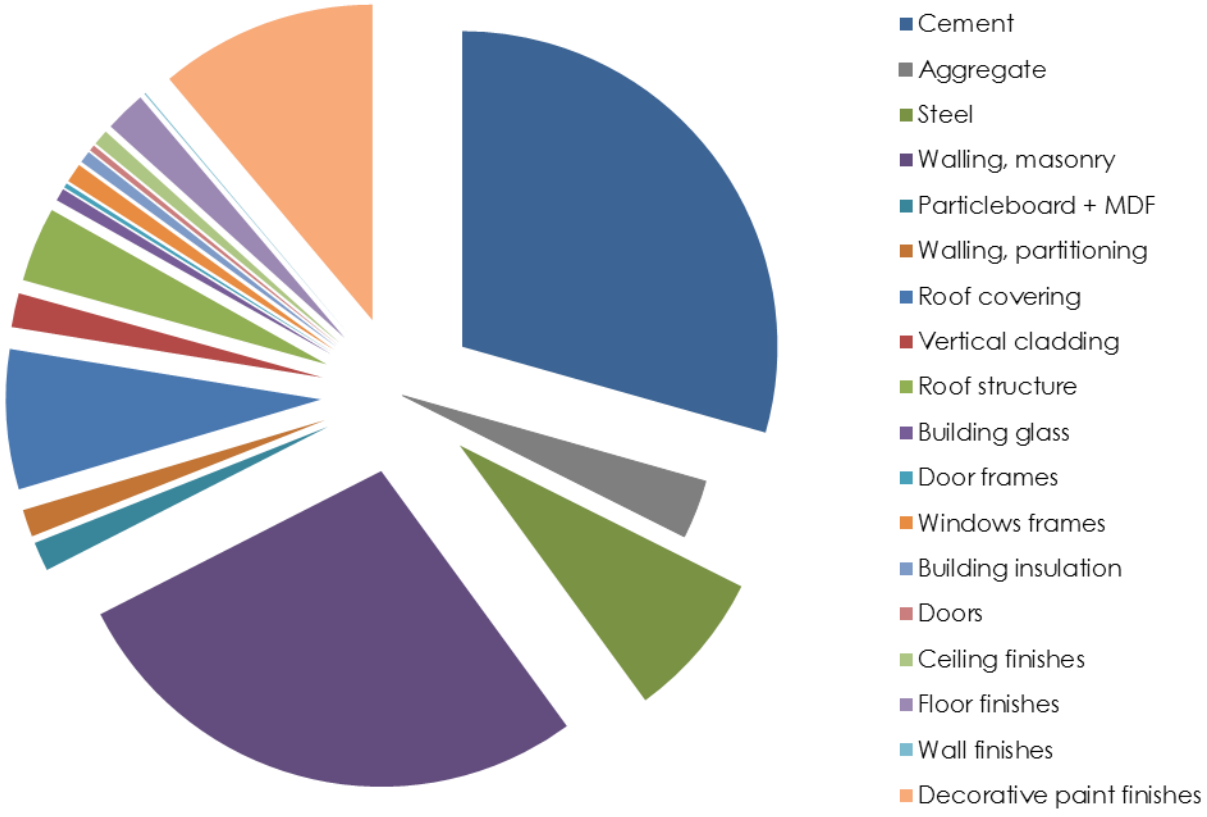
Result: baseline GHG emissions for 18 MBPGs, 2014



- **Estimated total national GHG emissions in 2014 were 590 mtCO_2eq**
- **Total GHG emissions for 18 MBPGs in 2014 were12.2 mtCO_2eq (2.1% total national emissions)**

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Results: relative contribution of MBPGs and MBPG categories

Contribution of MBPGs

- The top 2 MBPGs which together account for 57% of the total GHG emissions are cement (concrete, plaster, screed, mortar) and masonry (concrete and clay)

Contribution of MBPGs categories

- Structure
- Envelope
- Site works

86% of total result

- Finishes

14% of total result

- Building services

Not assessed

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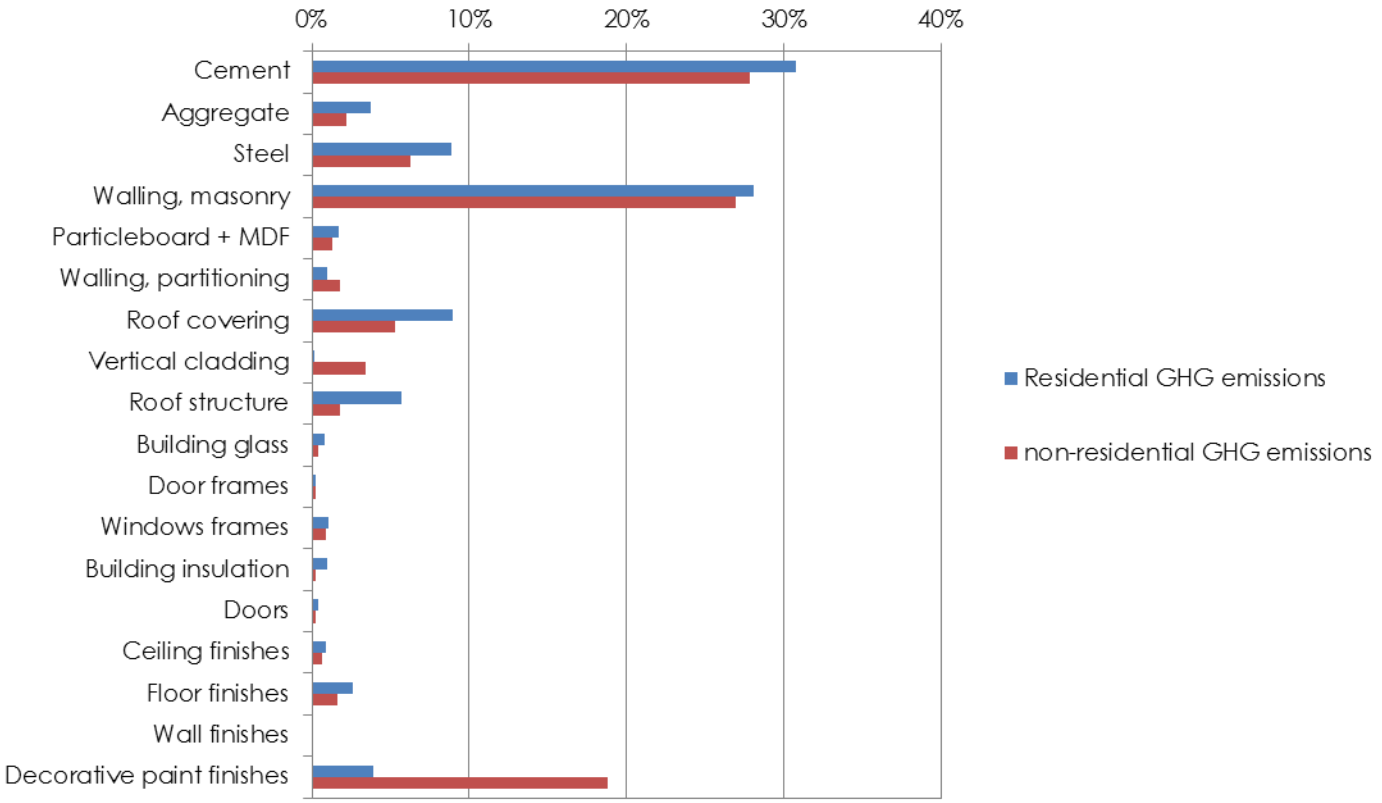
Results: relative contribution of building sub-sectors



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Discussion

Major limitation	Solution	Result
CEFs from ICE Database reflect UK environmental conditions	Calculate adjustment factor; and apply factor to "localise" ICE Database results	Approximate adjustment factor is 1.63
GHG emissions result excludes reflective foil insulation due to lack of CEF	Estimate CEF from published literature	Estimated contribution to total GHG emissions is 0.03 mtCO2eq
GHG emissions result excludes building services component due to lack of CEFs	Use literature to estimate contribution of building services	Building services account for about 15% of total GHG emissions of a building

Discussion

Database	CEF adjustment factor	Initial result $mtCO_{2eq}$	Adjusted result $mtCO_{2eq}$
Eco-invent	Already adjusted	3.79	3.79
ICE	1.63	8.42	13.72
Totals		12.2 (2.1%)	17.51

Description	Final result 1: without adjustment of ICE data	Final result 2: with adjustment of ICE data
Result carried forward	12.2	17.51
Add reflective foil	0.03	0.03
Sub-total	12.23	17.54
Add building services (15%)	1.83	2.63
Final cradle-to-gate results 2014	14.10 $mtCO_2eq$ (2.4%)	20.17$mtCO_2eq$ (3.4%)
Final cradle-to-gate results 2006	4.1% of total national emissions	5.8% of total national emissions

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Discussion: present study vs previous South African study

Major building product group	Unit	Product group market size, 2006(UNEP/CIDB)	Product group market size, 2014 (present study)
Cement	Tonnes	9 226 525	4 678 245
Steel	Tonnes	700 000	460 730
Masonry	Brick equivalent	7 993 028 000	4 133 728 992
Roof covering	m^2	54 579 000	44 652 096
Vertical cladding	m^2	30 405 000	13 715 072

Market sizes of emission-critical MBPGs contracted significantly since 2006

- e.g. as compared to 2006 cement MBPG market size in 2014 was about 50%

National GHG emissions increased significantly since 2006

- Total national GHG emissions 2006: 347 mtCO2eq
- Total national GHG emissions 2014: 590 mtCO2eq

Major methodological differences between previous and current study

- Previous study CEFs inappropriate – masonry very high; and steel very low
- Previous study may have double counted emissions – no allocation for bulk materials (steel and cement) reported

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Conclusion and recommendation

Conclusion

- The total cradle-to-gate embodied GHG emissions from production of 18 MBPGs in 2014 may be 14.10 tom 20.17 mtCO2eq depending on the adjustment factor for the CEFs from the ICE Database

- 5 out of 18 MBPGs probably account for more than 75% of the embodied GHG emissions of the South African building sector and should therefore be the focus of improvement efforts. The MBPGs of concern are cement, steel, masonry, roof covering and decorative paint

Key policy message

- without a resource efficiency policy to complement current building energy efficiency policy, the embodied GHG emissions could dominate overall emissions from future South African buildings

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Thank you

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Materials and sources of LCI data

Eco-invent database	ICE Database
Cement	Roof trusses steel
Aggregate	Roof trusses, timber
Steel (rebar)	Door and window frames, steel
Window frames, UPVC	Door and window frames, timber
Walling, masonry	Door and window frames, aluminium
Internal partitioning, gypsum, fibre cement	Internal partitioning (timber)
Roof covering, concrete, clay, fibre cement	Roof covering, steel sheets, steel tiles
Vertical cladding, fibre cement sheets	Vertical cladding, profiled steel sheets
Paint, oil-based	Doors, timber
Floor covering, ceramic tiles	Building glass
Ceiling, gypsum, fibre cement	Ceiling, timber
Plasterboard, MDF	Ceiling, mineral fibre
	Paint, water-based
	Floor covering, PVC, carpet

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Life cycle stages of buildings