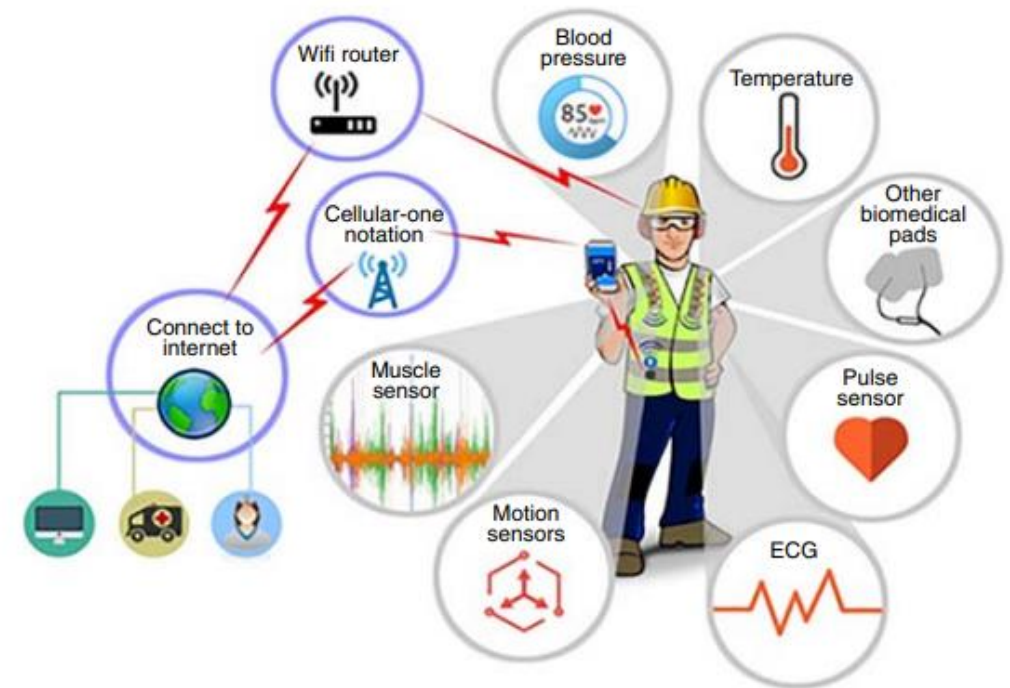# Life cycle analysis (LCA) of building carbon emissions and construction waste quantification

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Supervisor: Alice Chang-Richards

Decarbonisation in construction

Embodied Carbon
Manufacture, transport and installation of construction materials

Operational Carbon
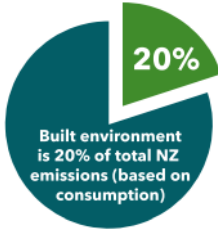Building energy consumption

Average new 200 m² stand-alone house:

63 tCO₂e

By 2025: 5% reduction   By 2050: 29% reduction

Average new 900 m² non-residential:

450 tCO₂e

By 2025: 19% reduction   By 2050: 51% reduction

20%
Built environment is 20% of total NZ emissions (based on consumption)

2050 potential CO₂e savings:

1.2Mt = 460,000 cars off the road

Short-term (2025)
- Concrete: replace 30% of cement with SCM
- Aluminium: source from renewable energy smelters (e.g. Tiwai Point)
- Steel: optimise steel beam designs

Long-term (2050)
Short-term improvements plus:
- Cement: replace additional 40% coal with alternative fuels
- Steel: replace coking coal with bio-charcoal or use hydrogen tech

Understanding carbon

New Zealand's Zero Carbon Plan

LCA analysis of building's environmental impact

Quantitative evaluations of a building's environmental impacts must be conducted using life cycle assessment (LCA), a method which quantifies the impacts of resources and emissions associated with construction and operation of buildings. However, it can be challenging to compare the results of building LCAs because of differences in scope and analysis methodologies.
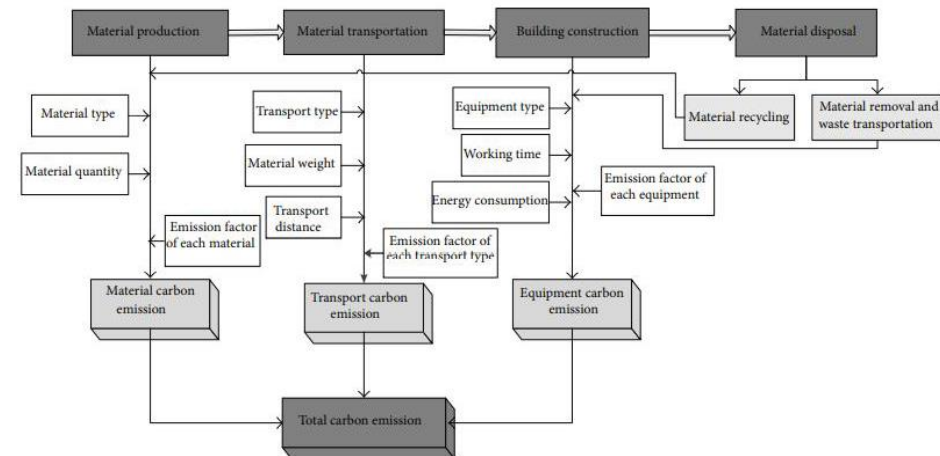
System boundaries of the construction process
Source: (Fu, Luo, Zhong, & Hill, 2014)

Life cycle analysis (LCA) of residential houses
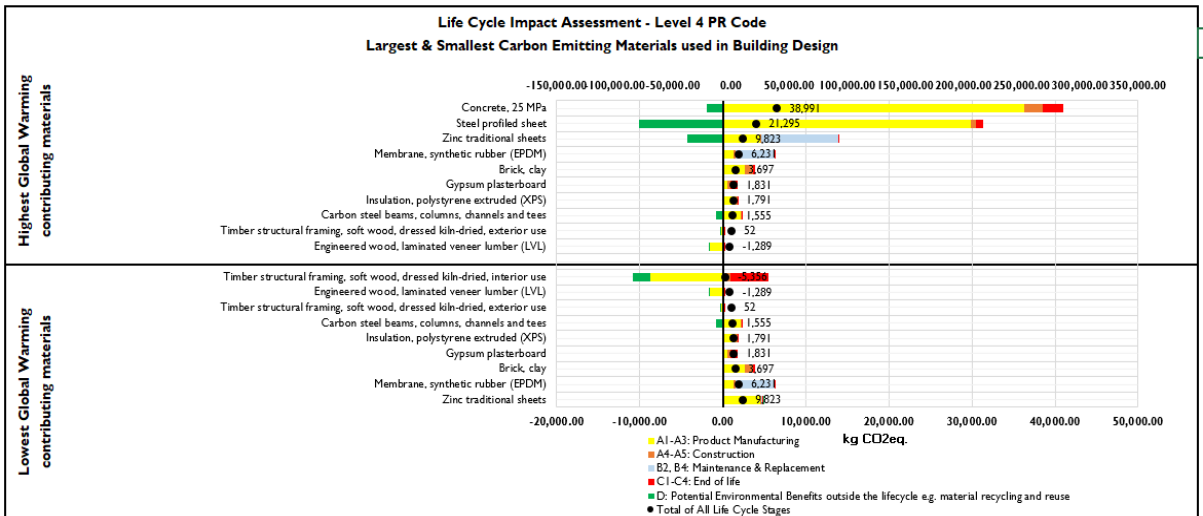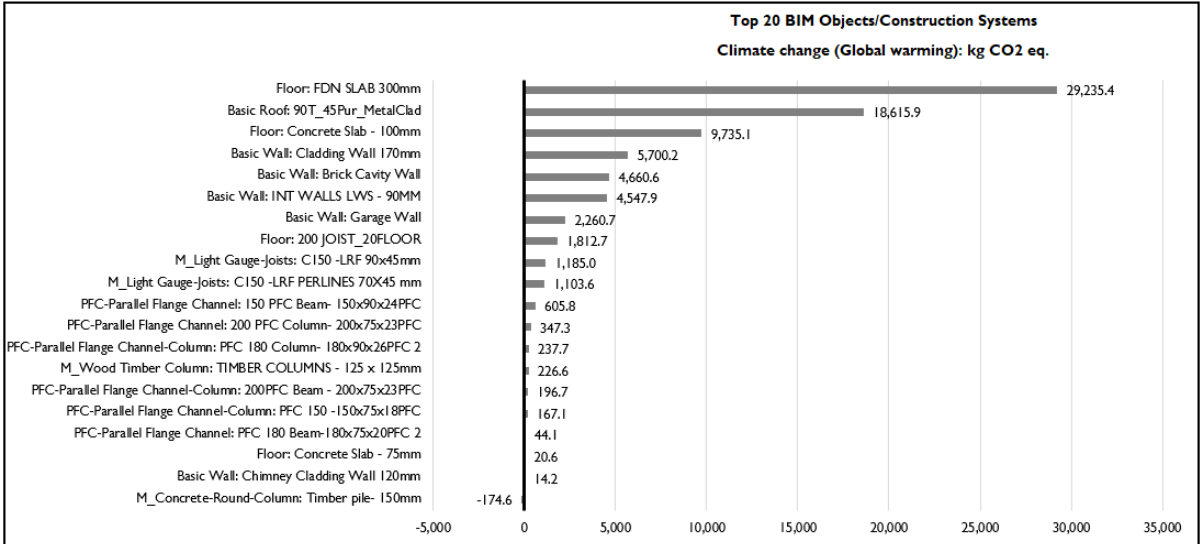
BUILDING INFORMATION PANEL		LCAQuickV3.4.3		23-Feb-21
Building Name	LGS Framed Building	Project No.		I
Design Phase	Detailed Design ▼	Select Scope of Construction Work	New Build ▼	
HVAC Type	No - HVAC ▼		Click for Notes	
Select Nearest Building Location / City	Zone I	Auckland ▼		
Select Building Activity	R-DS	Residential: Detached, Double Store ▼		
No. of Building Occupants	4			
No. of Annual Occupied Hours per Person	4	BEES Default	2520 hrs	

Enter Building Areas (m²) & Number of Storeys	GFA	TFA	# Storeys	New Build, Zone I, R-DS, Strata I
	133	97	2	
Calculated Strata Size	Strata I	GFA <649		
Building Lifespan (Years)	90			
Main Lateral Load Structural System	Rigid frame system ▼			
Main Structural System Material	Steel ▼			
Year Building Operation Starts	2021			

Top 20 BIM Objects/Construction Systems
Climate change (Global warming): kg CO2 eq.

Floor: FDN SLAB 300mm	29,235.4
Basic Roof: 90T_45Pur_MetalClad	18,615.9
Floor: Concrete Slab - 100mm	9,735.1
Basic Wall: Cladding Wall 170mm	5,700.2
Basic Wall: Brick Cavity Wall	4,660.6
Basic Wall: INT WALLS LWS - 90MM	4,547.9
Basic Wall: Garage Wall	2,260.7
Floor: 200 JOIST_20FLOOR	1,812.7
M_Light Gauge-Joists: C150 -LRF 90x45mm	1,185.0
M_Light Gauge-Joists: C150 -LRF PERLINES 70X45 mm	1,103.6
PFC-Parallel Flange Channel: 150 PFC Beam- 150x90x24PFC	605.8
PFC-Parallel Flange Channel: 200 PFC Column- 200x75x23PFC	347.3
PFC-Parallel Flange Channel-Column: PFC 180 Column- 180x90x26PFC 2	237.7
M_Wood Timber Column: TIMBER COLUMNS - 125 x 125mm	226.6
PFC-Parallel Flange Channel-Column: 200PFC Beam - 200x75x23PFC	196.7
PFC-Parallel Flange Channel-Column: PFC 150 -150x75x18PFC	167.1
PFC-Parallel Flange Channel: PFC 180 Beam-180x75x20PFC 2	44.1
Floor: Concrete Slab - 75mm	20.6
Basic Wall: Chimney Cladding Wall 120mm	14.2
M_Concrete-Round-Column: Timber pile- 150mm	-174.6

Life Cycle Impact Assessment - Level 4 PR Code
Largest & Smallest Carbon Emitting Materials used in Building Design

Highest Global Warming contributing materials

Concrete, 25 MPa	38,991
Steel profiled sheet	21,295
Zinc traditional sheets	9,823
Membrane, synthetic rubber (EPDM)	6,231
Brick, clay	3,697
Gypsum plasterboard	1,831
Insulation, polystyrene extruded (XPS)	1,791
Carbon steel beams, columns, channels and tees	1,555
Timber structural framing, soft wood, dressed kiln-dried, exterior use	52
Engineered wood, laminated veneer lumber (LVL)	-1,289

Lowest Global Warming contributing materials

Timber structural framing, soft wood, dressed kiln-dried, interior use	
Engineered wood, laminated veneer lumber (LVL)	-1,289
Timber structural framing, soft wood, dressed kiln-dried, exterior use	52
Carbon steel beams, columns, channels and tees	1,555
Insulation, polystyrene extruded (XPS)	1,791
Gypsum plasterboard	1,831
Brick, clay	3,697
Membrane, synthetic rubber (EPDM)	6,231
Zinc traditional sheets	9,823

kg CO2eq.

- A1-A3: Product Manufacturing
- A4-A5: Construction
- B2, B4: Maintenance & Replacement
- C1-C4: End of life
- D: Potential Environmental Benefits outside the lifecycle e.g. material recycling and reuse
- Total of All Life Cycle Stages

PHD topic: Real time quantification of carbon emissions of construction wastes
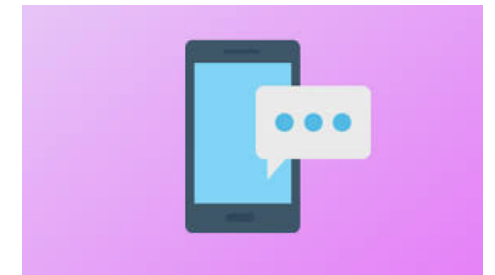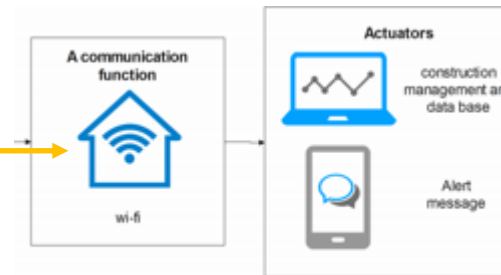
- Deploy <u>an IoT-based sensor network</u> to monitor and evaluate the environmental impact or carbon emissions for construction wastes on site.
  - A new methodology of quantification
  - A network of sensors and AI
  - A prototype for a national database of construction wastes and emissions

- "**Detect**, **calculate** and **<u>alert for actions</u>**"
- Maximise the use of waste management facilities
- Motivate construction workers to take interventions/actions for sustainability purpose
- Case studies: UoA Rec centre project and building 201 (Hawkins collaboration)

Methodology