Greenhouse Gas Emissions in the Built Environment

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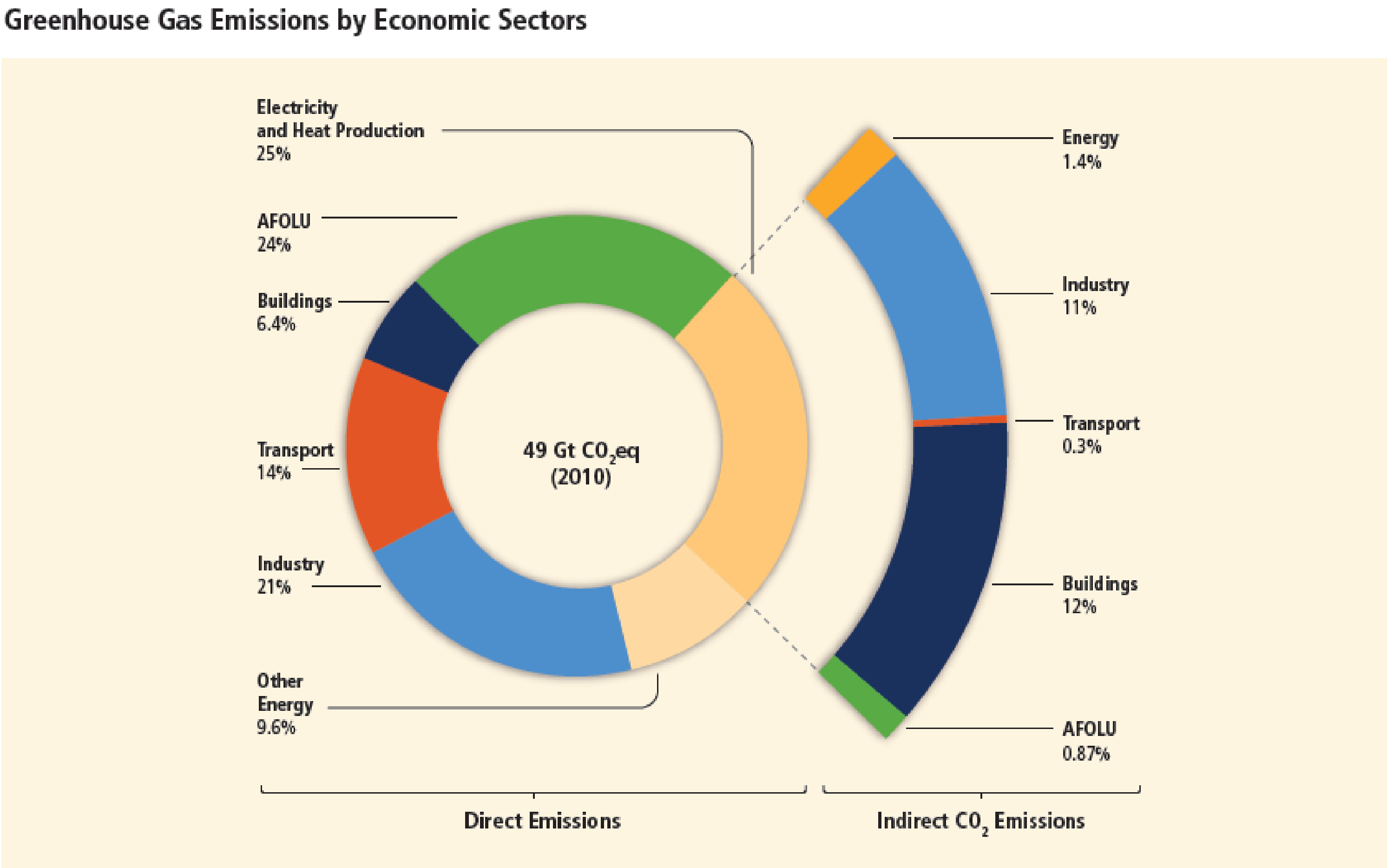
Outline

- Some background to steel and concrete GHG
- Built environment GHG at a national level
- Case study at a project level
- Reducing GHG
- Implications for Zero Carbon Economy

Materials GHG



Cement: 5% of global GHG

Steel: 5% of global GHG

Materials GHG

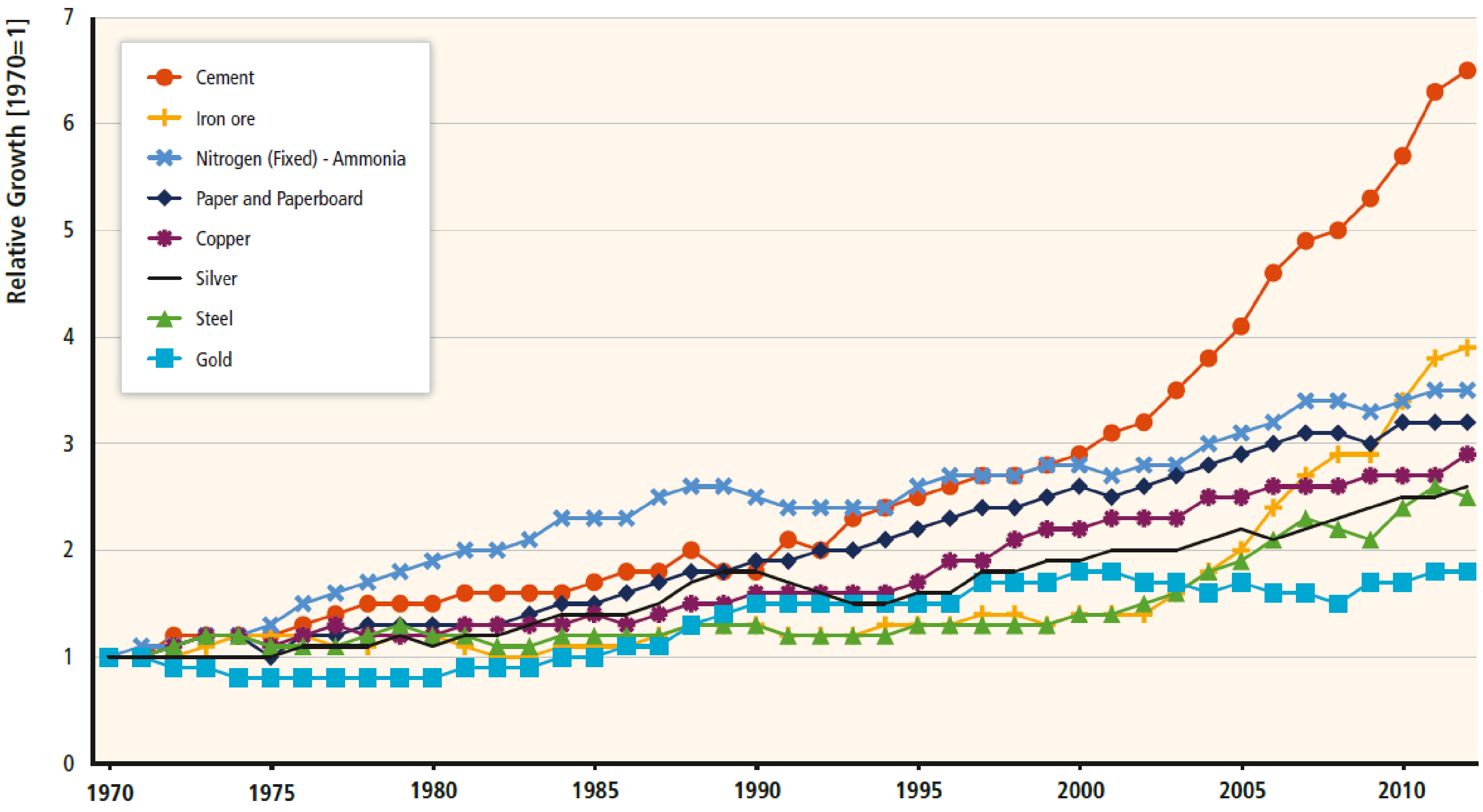


Figure 10.3 | World's growth of main minerals and manufacturing products (1970 = 1). Sources: (WSA, 2012a; FAO, 2013; Kelly and Matos, 2013).

Iron oxide reduction to iron:

$Fe_3O_4 + 4C \rightarrow 3Fe + 4CO$

Cement reduction:

$CaCO_3 \rightarrow CaO + CO_2$

$CaO + H2O \rightarrow Ca(OH)_2$

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H2O$

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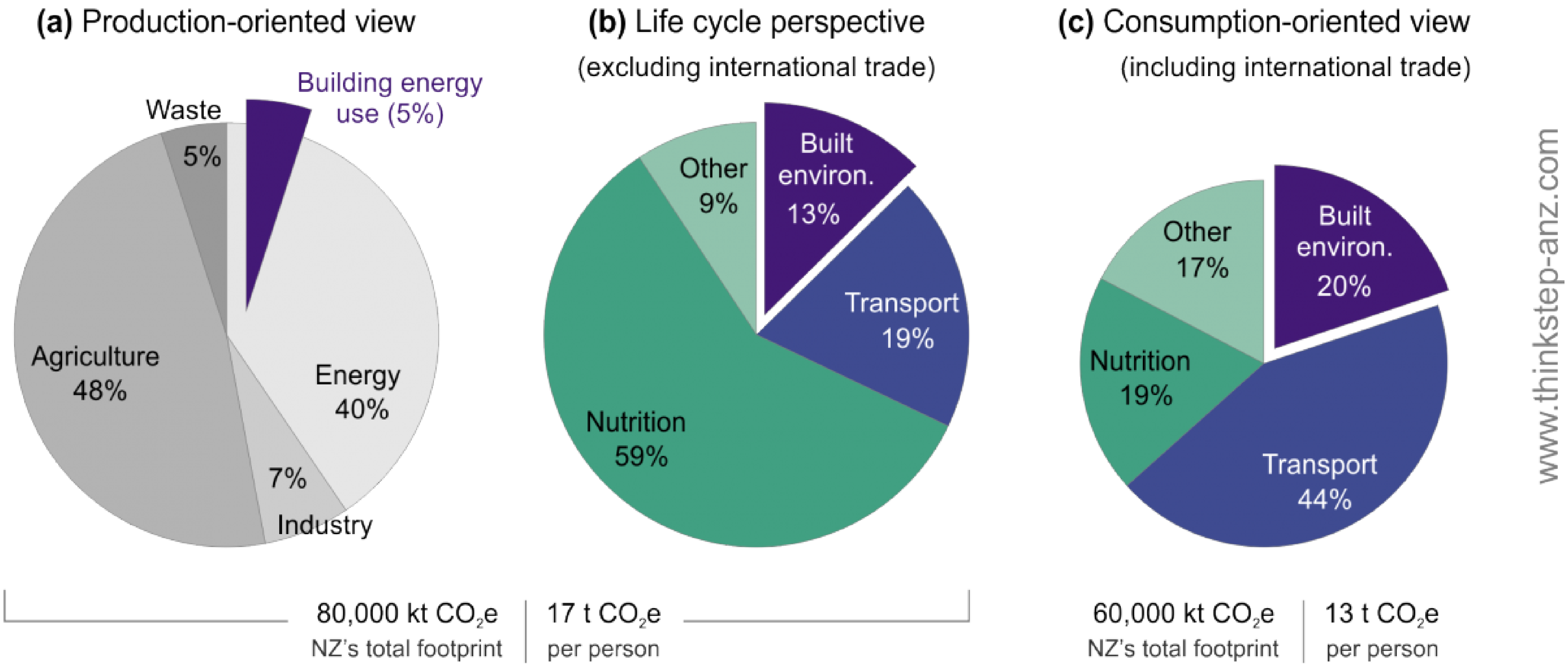
Built environment GHG



Case study 1 – Wharf construction

Name of Project:	Wharf structure

Beca GHG Calculator — Beca

Concrete quantity / Concrete specifications / Concrete Outputs

Description	Quantity	Unit	Waste	Calculate fuel	Kg/m3 Steel Reinforcing	MPs (in Mpa)	Material	Material GHG	Waste GHG	Fuel Use GHG	Total GHG	Percentage	Uncertainty
Concrete in piles (30 Mpa)	8527	Tonne	5%	Yes	213	30	25% PFA	2,453.7	122.7	13.8	**2,590**	21%	
Concrete (ground)	8901	Tonne	5%	Yes	213	50	25% PFA	2,999.0	149.9	16.4	**3,165**	26%	
Precast concrete	506	Tonne	5%	Yes	213	50	25% PFA	170.5	8.5	0.9	**180**	1%	
Insert Text	0	Tonne	5%	Yes	213	50	25% PFA	-	-	-	**-**	0%	
												49%	***Less uncertainty***

Steel quantity / Steel specifications / Steel outputs

Description	Quantity	Unit	Waste	Calculate fuel	Type of finish	Material GHG	Waste GHG	Fuel Use GHG	Total GHG	Percentage	Uncertainty
Deck	1651.6	Tonne	1%	Yes	Zinc	5,632.0	56.3	154.5	**5,843**	48%	
Mooring dolphin	71.3	Tonne	1%	Yes	Zinc	243.1	2.4	6.7	**252**	2%	
Gangway pile	4.9	Tonne	1%	Yes	None	14.0	0.1	0.4	**15**	0%	
										51%	***Less uncertainty***

Rubber fender / Rubber Specifications / Rubber outputs

Description	Quantity	Unit	Waste	Calculate fuel	% steel by weight	Material GHG	Waste GHG	Fuel Use GHG	Total GHG	Percentage	Uncertainty
Insert Text	9.3	Tonne	5%	Yes	25%	23.6	1.2	0.5	**25.3**	0%	
										0%	***More uncertainty***

Milling and excavation / Milling and excavation type / Excavation outputs

Description	Type	Quantity	Unit	Calculate fuel	Ground type	Material GHG	Waste GHG	Fuel Use GHG	Total GHG	Percentage	Uncertainty
Insert Text	Milling	0	Metres squared	Yes	Asphalt	-	-	-	**-**	0%	
Insert Text	Excavation	0	Tonne	Yes	Mud, sand	-	-	-	**-**	0%	
										0%	***More uncertainty***

Fuel use input / Transport Specifications / Fuel use outputs

(use only if fuel use is available)

Description	Fuel	Quantity	Unit	Type of fuel	Material GHG	Waste GHG	Fuel Use GHG	Total GHG	Percentage	Uncertainty
Insert Text	Diesel	0	Litre	*Note required*	-	-	-	**-**		
Insert Text	Petrol	0	Litre	Petrol default	-	-	-	**-**		
Insert Text	LPG	0	Kg	*Not required*	-	-	-	**-**		
									0%	***Less uncertainty***

Total

	Material GHG	Waste GHG	Fuel Use GHG	Total GHG
Total Greenhouse Gas Emissions (tonnes)	11,536	341	193	**12,070**
Percentage	96%	3%	2%	***Less uncertainty***

Case study 2 – Pavement works

Name of Project:	Pavement Works

Beca GHG Calculator

Beca

0% *Less uncertainty*

Bitumen quantity					Asphalt specifications	Asphalt outputs					
Description	Quantity	Unit	Waste	Calculate fuel	Bitumen content	Material GHG	Waste GHG	Fuel Use GHG	Total GHG	Percentage	Uncertainty
Insert Text	800	Cubic metre	5%	Yes	4.5-5.4% virgin bitumen	104.2	5.2	24.6	**134**	18%	
Insert Text	0	Cubic metre	5%	Yes	4.5-5.4% virgin bitumen	-	-	-	**-**	0%	

18% *Medium*

Aggregate quantity					Aggregate Specifications	Aggregate outputs					
Description	Quantity	Unit	Waste	Calculate fuel	Type of Aggregate	Material GHG	Waste GHG	Fuel Use GHG	Total GHG	Percentage	Uncertainty
Insert Text	4275	Cubic metre (loose)	5%	10 Km	Gravel	33.9	1.7	7.9	**43.5**	6%	
Insert Text	0	Cubic metre (loose)	5%	10 Km	Gravel	-	-	-	**-**	0%	
Insert Text	0	Cubic metre (loose)	5%	10 Km	Gravel	-	-	-	**-**	0%	

6% *More uncertainty*

Binder quantity					Binder Specifications	Binder outputs					
Description	Quantity	Unit	Waste	Calculate fuel	Type of binder	Material GHG	Waste GHG	Fuel Use GHG	Total GHG	Percentage	Uncertainty
Insert Text	225	Cubic metre	5%	10 Km	Cement	551.5	27.6	0.4	**579.6**	76%	
Insert Text	0	Cubic metre	5%	10 Km	Lime	-	-	-	**-**	0%	

76% *Less uncertainty*

Milling and excavation					Milling and excavation type	Excavation outputs					
Description	Type	Quantity	Unit	Calculate fuel	Ground type	Material GHG	Waste GHG	Fuel Use GHG	Total GHG	Percentage	Uncertainty
Insert Text	Milling	8000	Metres squared	Yes	Asphalt	-	-	1.4	**1.4**	0%	
Insert Text	Excavation	6000	Cubic metre	Yes	Very compact soil, up to 75% stone	-	-	1.5	**1.5**	0%	

0% *More uncertainty*

	Material GHG	Waste GHG	Fuel Use GHG	Total GHG
Total Greenhouse Gas Emissions (tonnes)	690	34	36	760
Percentage	91%	5%	5%	*Less uncertainty*

How can we reduce GHG

- Different concrete specs have different GHG

Composition	Steel reinforcing	MPA	GHG / T
20% PFA	213	50	0.3448
20% PFA	100	50	0.2461
35% PFA	100	50	0.2297
35% PFA	100	25	0.1771
75% GGBS	100	25	0.1462
Cement			1.6255
Steel			2.8500

How we can reduce GHG

Table SPM.1. Profile by process or industrial activity of worldwide large stationary CO_2 sources with emissions of more than 0.1 million tonnes of CO_2 ($MtCO_2$) per year.

Process	**Number of sources**	**Emissions ($MtCO_2\ yr^{-1}$)**
Fossil fuels		
Power	4,942	10,539
Cement production	1,175	932
Refineries	638	798
Iron and steel industry	269	646
Petrochemical industry	470	379
Oil and gas processing	Not available	50
Other sources	90	33
Biomass		
Bioethanol and bioenergy	303	91
Total	**7,887**	**13,466**

How we can reduce GHG

- Alternatives?
- Biogenic feed stocks? (steel only)
- Design / SiD
- Eliminate construction waste
- Retrofit of existing buildings / structures
- Safety considerations most important
- Starts with awareness

Source: Stuff

Typical steel frame construction with reinforced concrete slab walls in Christchurch

Case study 3: Alternatives

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Implications for zero carbon economy

- How does NZ address GHG from the built environment?
- Is a consumption approach more appropriate than a production approach?
- What does zero emissions roads, buildings and other infrastructure look like?