CARBON DIOXIDE EMISSIONS OF RECYCLED CEMENT PRODUCTION

V. Sousa
CERIS, IST-University of Lisbon

J.A. Bogas
CERIS, IST-University of Lisbon

S. Real
CERIS, IST-University of Lisbon

I. Meireles
RISCO, University of Aveiro

PRESENTATION INDEX

TÉCNICO LISBOA

REPÚBLICA PORTUGUESA

FCT Fundação para a Ciência e a Tecnologia

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

With a 30-fold increase since 1950 and almost 4-fold since 1990, cement production became the third largest source of anthropogenic emissions of carbon dioxide (CO_2), after fossil fuels and land-use changes (Andrew 2018, 2019).

The high carbon emissions from cement production result from the combination of two of the three main sources of anthropogenic emissions of CO_2 to the atmosphere:

- carbonate decomposition;
- oxidation of fossil fuels.

Process emissions (calcination) contributes to approximately 5%-8% of the total anthropogenic CO_2 emissions (Boden et al. 2017).

The emissions resulting from the thermal processing of the raw material to obtain the clinker, referred to as energy emissions, can add further 60% to 90% of CO_2 to the process emissions, depending on the technology used (IEA 2016).

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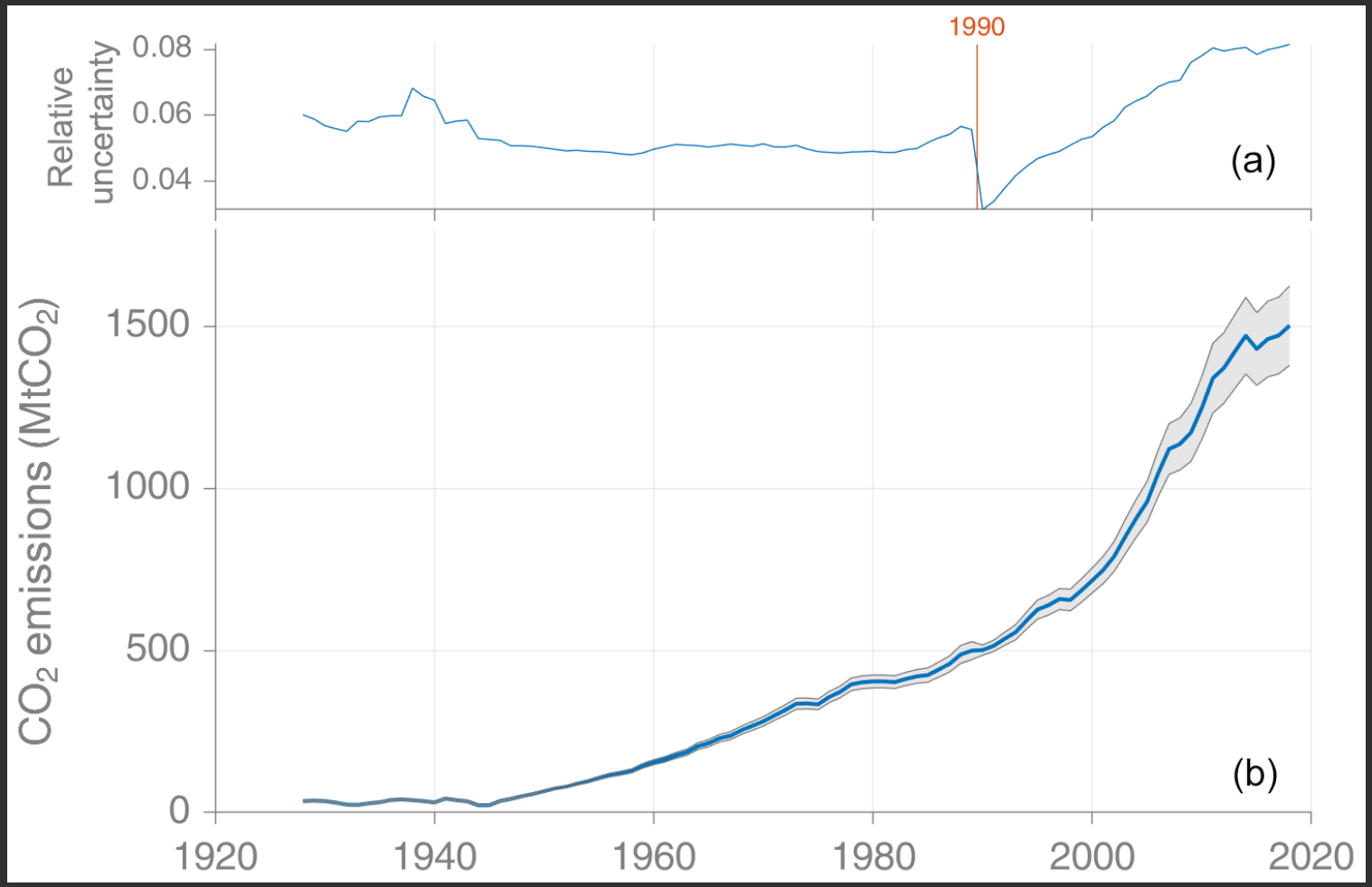
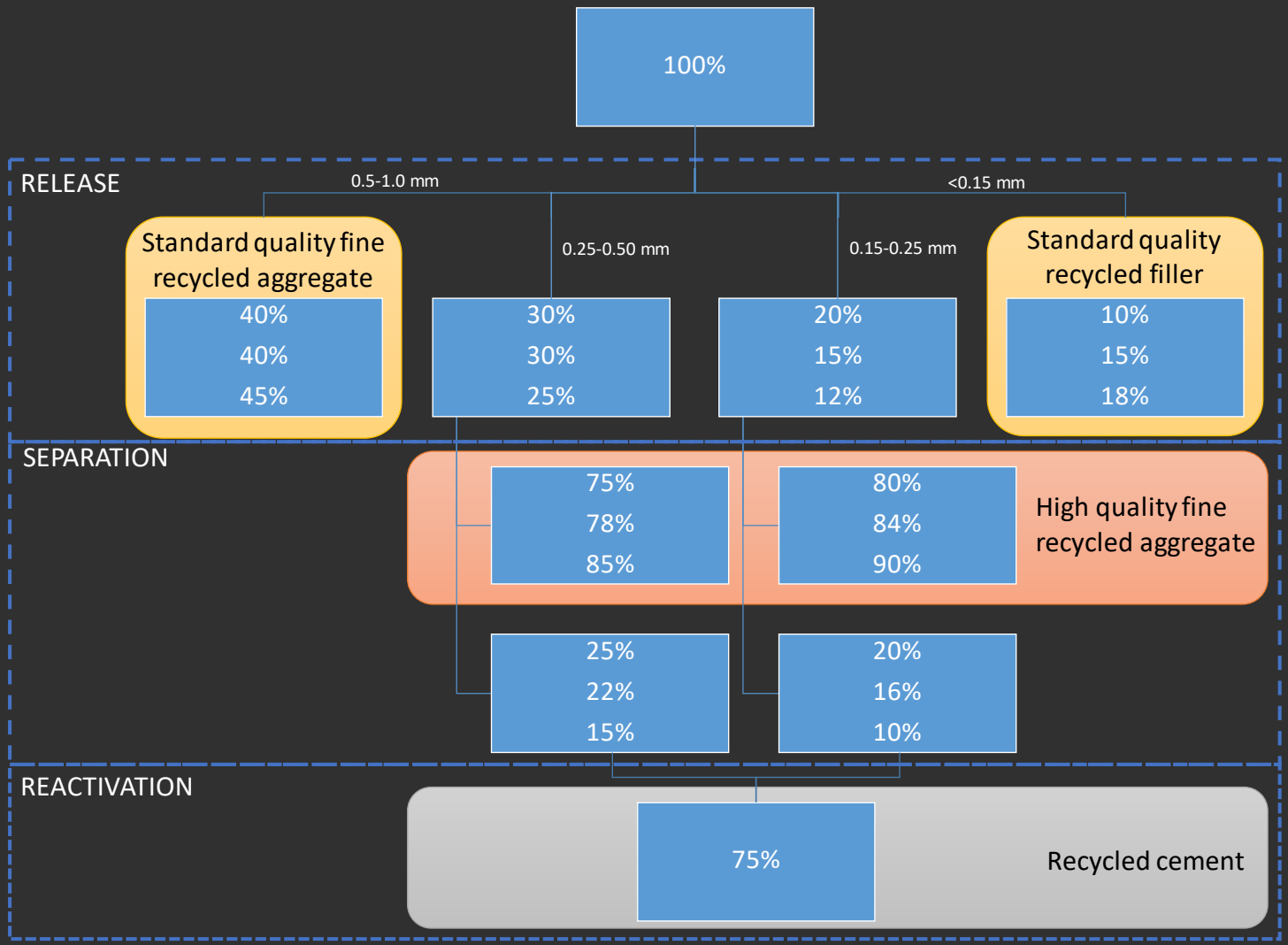


Andrew (2019)

2. RECYCLED CEMENT PRODUCTION



Sousa and Bogas (2021)

Two main approaches are available for extrapolating the laboratory results to an industrial setup

- by simulation;
- by analogy.

The results can also be presented in:

- absolute values;
- relative values.

Herein, it was adopted a hybrid absolute methodology. The main reason for this was the fact that the largest portion of energy consumption, and consequently the largest source of CO_2 emissions, takes place during the drying (separation stage) and thermal activation (heat treatment stage). By analogy with the Portland cement production, these are the steps resorting to thermal energy in an industrial setup. All other steps, in both Portland cement and RC production process, are powered by electricity and were estimated by a mixed of analogy and simulation.

4. RESULTS AND DISCUSSION

Stage	World	Europe	Portugal	
			Average	SECIL
Thermal energy [MJ / t recycled cement]				
Drying	5457.9	4869.5		
Reactivation	1238.3	1332.1	1339.6	1350.5
Total	6696.2	6201.7	6209.1	6220.1
Emissions from thermal processing [kg CO_2 / t recycled cement]				
Drying	499.3	436.6	403.3	378.3
Reactivation	113.3	106.6	91.5	85.8
Total	612.6	543.1	494.9	464.1

Stage	World	Europe	Portugal	
			Average	SECIL
Thermal energy [MJ / t recycled cement]				
Drying	5783.6			
Reactivation	1281.0	1378.1	1385.8	1397.1
Total	7064.6	7161.7	7169.4	7180.7
Emissions from thermal processing [kg CO_2 / t recycled cement]				
Drying	529.1	462.6	427.4	400.8
Reactivation	117.2	110.2	94.7	88.8
Total	646.3	572.9	522.1	489.6

4. RESULTS AND DISCUSSION

Clinker production	Proportion [%]	Consumption [kWh/t clinker]	RC production	Proportion [%]	Consumption [kWh/t RC]
Raw material preparation			Release		
Extraction	2	3			
Preparation	24	37	Crushing and sieving	57	145
			Separation		
			Washing and drying	18	45
			Magnetic separation	1	4
Thermal processing			Reactivation		
Kiln	29	45	Kiln	12	30
Coal mill	7	11	Coal mill	3	7
Cement processing					
Gridding	31	48	Gridding	9	24
Packaging	7	11			
Total	100	154		100	254

Considering that, in 2017, the average CO_2 emissions for producing electricity in the EU-28 was 294 g/kWh (EEA, 2017) and the emissions from land transportation was 140 g/t.km (EEA 2017). Assuming an average distance of 200 km between the construction and demolition waste treatment facilities and the cement plants, the total emissions for clinker and RC are:

Stage	CO2 emissions [kg/t]	
	Clinker	Recycled Cement
Thermal energy	815	629
Electrical energy	45	75
Transport		28
Total	861	732

Cement is simultaneously a largely consumed material worldwide with high CO_2 emissions in its production, resulting in significant contribution to the global CO_2 emissions. Additionally, concrete make up a large portion of the construction and demolition waste generated. Therefore, attempting to recycle cement using a green technology may contribute to solve these two problems.

The present research effort demonstrates that the RC production process developed under the scope of the EcoHydb project funded by the Portuguese National Science Foundation allows for reducing the CO_2 emissions by 15% in comparison with the clinker production. These saving are highly conservative and there is the potential for a significant increase if a dry production process can be implemented. Avoiding the washing and drying of the material prior to the magnetic separation would reduce the CO_2 emissions from thermal energy consumption in the RC production from 629 kg/t to roughly 115 kg/t.

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