Circular economy & Construction

Vanderley M. John
Polytechnic School – University of São Paulo, Brazil
vmjohn@usp.br

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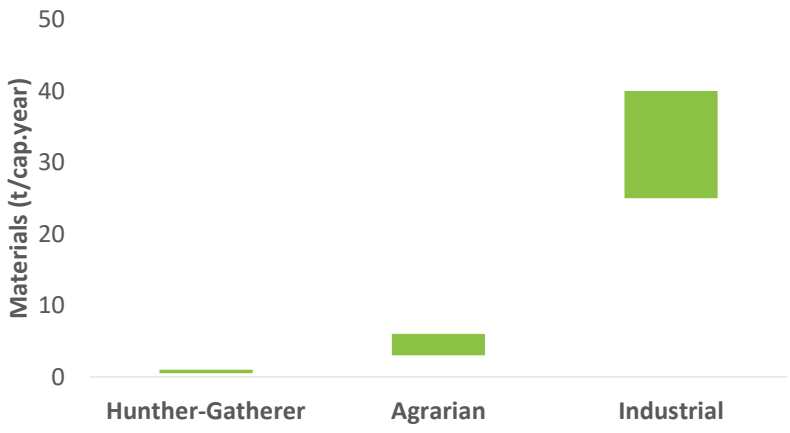
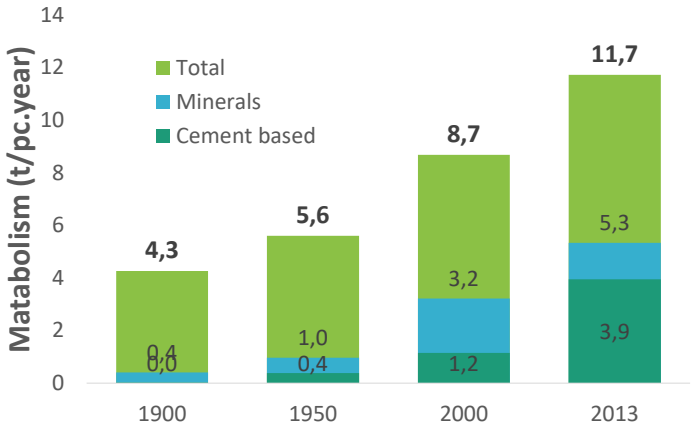
Materials metabolism & society



Krausmann *in* **Fundamentals of Materials for Energy and Environmental Sustainability** MRS/Cambridge 2012 p.82

2

Industrial society
Materials extraction grows faster than population



Data: Krausman et al (2009), Materialsflows.net (2015) & CDIAC (2006), UN (2015)

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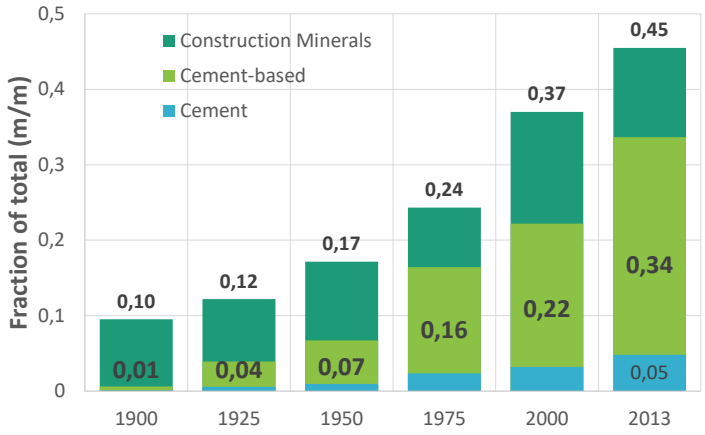
Industrial society:
Construction materials grows faster than others. Cement overperforms all.



Data: Krausman et al (2009), Materialsflows.net (2015) & CDIAC (2006), UN (2015)

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Landfill: a inconveniente solution

Construction & Demolition Waste Landfill, São Paulo
Photo: Marco Antonio Fialho

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Circular Economy

K. Breene, Can the circular economy transform the world's number one consumer of raw materials?, World Economic Forum Global Agenda. (2016). https://www.weforum.org/agenda/2016/05/can-the-circular-economy-transform-the-world-s-number-one-consumer-of-raw-materials.

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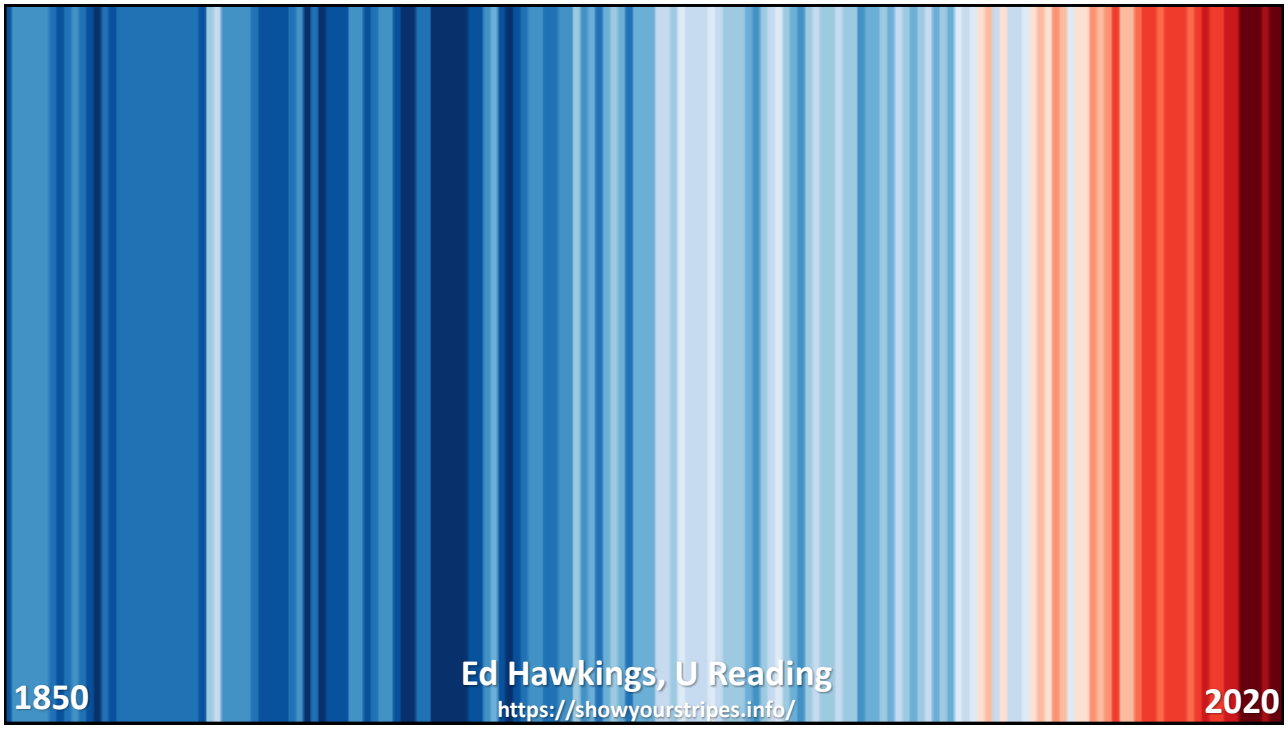
1850
Ed Hawkings, U Reading
https://showyourstripes.info/
2020

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Erftstadt-Blessem
Failure of a construction aggregate quarry
AP

8


Paradise, California (2021)
Why California's Wildfires Are Getting Worse | Teen Vogue
VM John USP ©

9


Franca, Brasil (26 set 2021)
VM John USP © 2021
VM John Poli USP 2018
POLI USP

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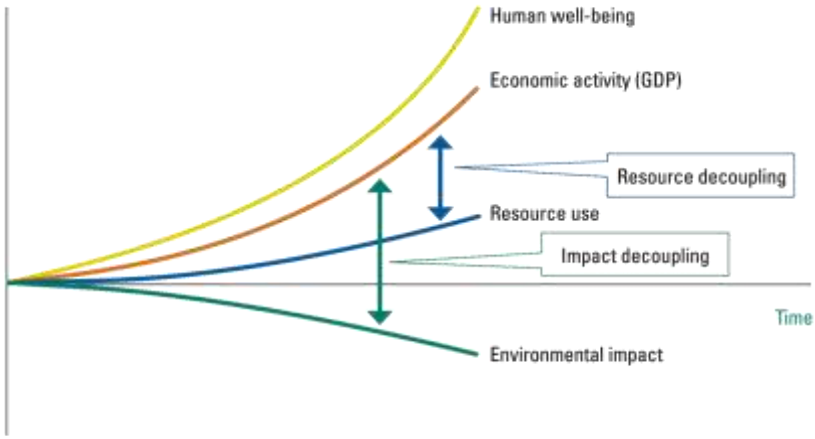
Decoupling the whole economy is the real objective



Fisher-Kowalski et al. Decoupling natural resource use and environmental impacts from economic growth. UN Environment 2011

How to measure circularity

Circular materials

- Secondary materials
- Biomaterials if sustainable grown/harvested

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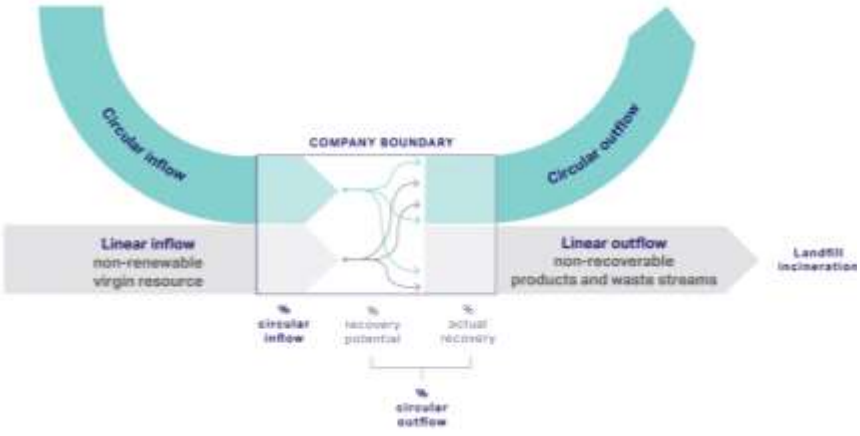
Measuring circularity - WBCSD



WBCSD Circular Transition Indicators V2.0 2021

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Circularity (in mass)

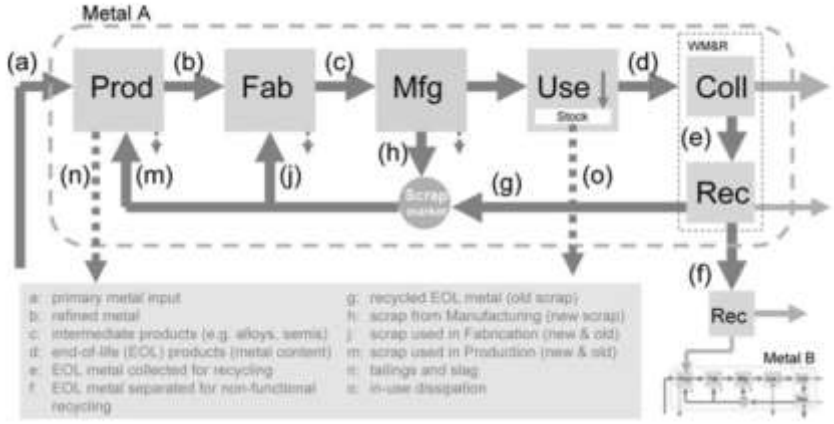
- **Inflow**
  - (Renewable + Secondary)/Total input
  - **Immediate & measurable benefits**

Best for construction because servisse life is very long.

- **Outflow**
  - (Recovery Potential * fraction actually recovered)/Total output
  - **Future potential benefits can be estimated**

average = inflow + outflow

Flows of a simplified life cycle (metals)



Graedel et al 2011
DOI: 10.1111/j.1530-9290.2011.00342.x

Recycling indicators

- Waste: Process waste + End of life (EOL)
- Recycled content
  - Recycled/total materials
- EOL recycled content (i*nflow circularity)*
  - (EOL recycled)/total
- Recycling rate
  - Recycled/total waste

Graedel et al 2011
DOI: 10.1111/j.1530-9290.2011.00342.x

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Resource efficiency: the bigger picture

Recycling and Circularity are not enough

- Narrow the material flow
  - Dematerialization of product
  - Reduction of process waste (increase yield)
    - Mining
    - Production
    - Construction
- Creating material loops
  - Recycling (circularity)
  - *Reuse (future potential benefit)*
- Slowing the material flow
  - Durability
  - *Obsolescence prevention (future potential benefit)*
  - *Retrofitting/refurbishing (future potential benefit)*

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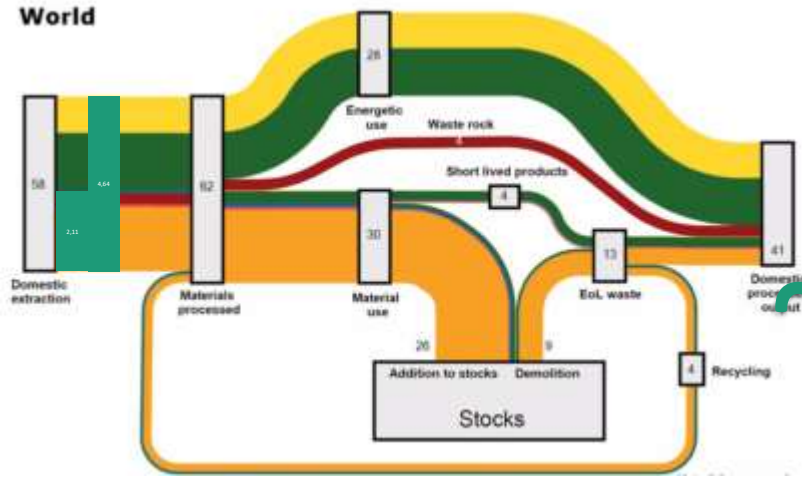
How circular is the world industry



Circular inflow

~11%

Haas et al. How Circular Is the Global Economy?. ***J Industrial Ecology*** 19, no. 5 (2015): 765–77. https://doi.org/10.1111/jiec.12244.

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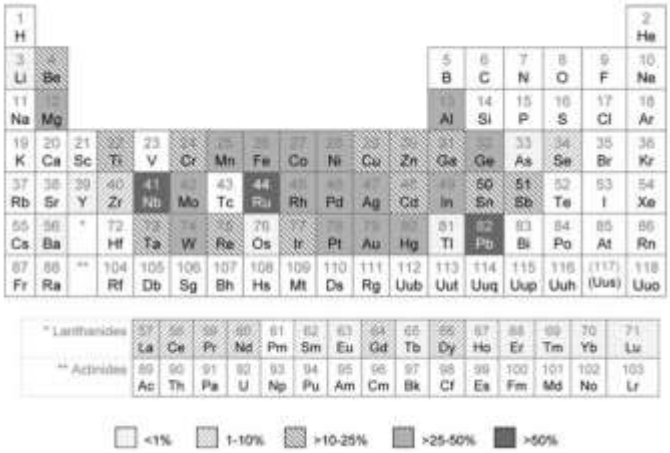
Global average recycled content



Graedel et al 2011
DOI: 10.1111/j.1530-9290.2011.00342.x

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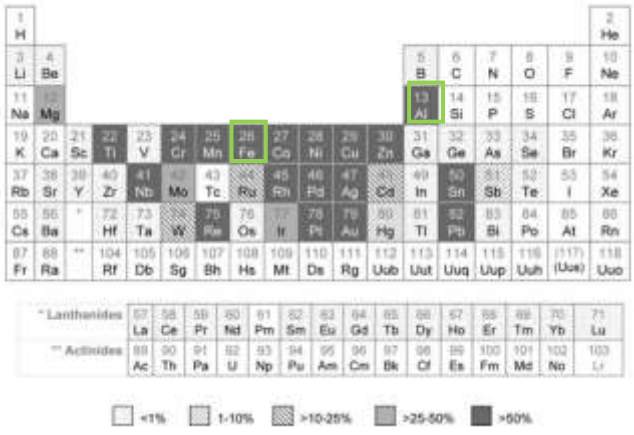
Global Average EOL Recycling rate 60 metals



Graedel et al 2011
DOI: 10.1111/j.1530-9290.2011.00342.x

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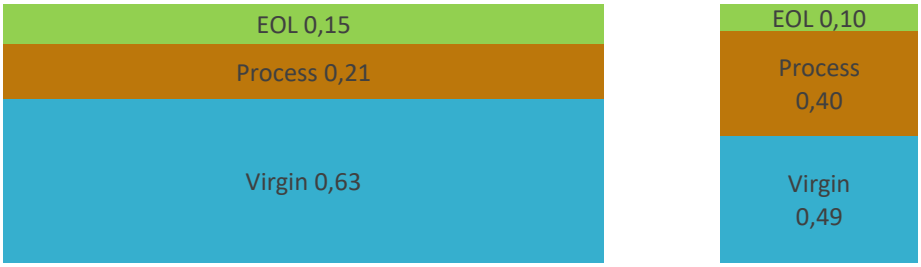
Circularity in Steel and Aluminium



Allwood et al Going in a metal diet 2011

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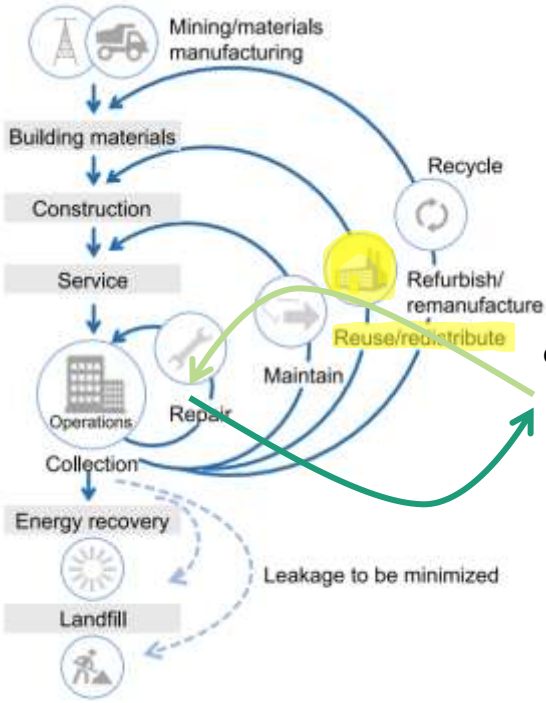

Circular Economy

other markets

K. Breene, Can the circular economy transform the world's number one consumer of raw materials?, World Economic Forum Global Agenda. (2016). https://www.weforum.org/agenda/2016/05/can-the-circular-economy-transform-the-world-s-number-one-consumer-of-raw-materials.

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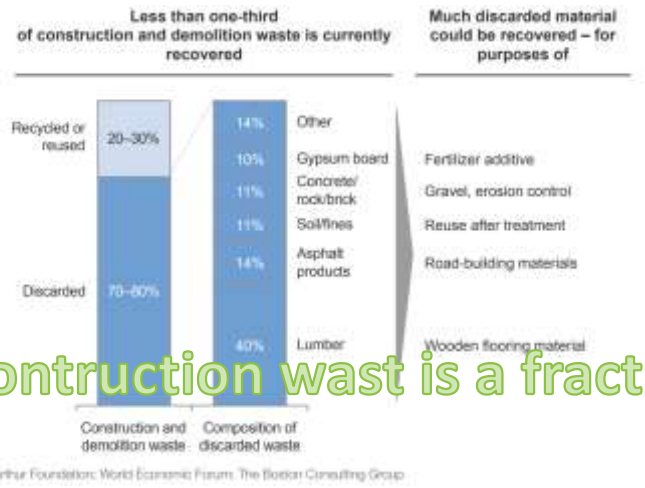
CDW Recycled Fraction



Contruction wast is a fraction of total waste

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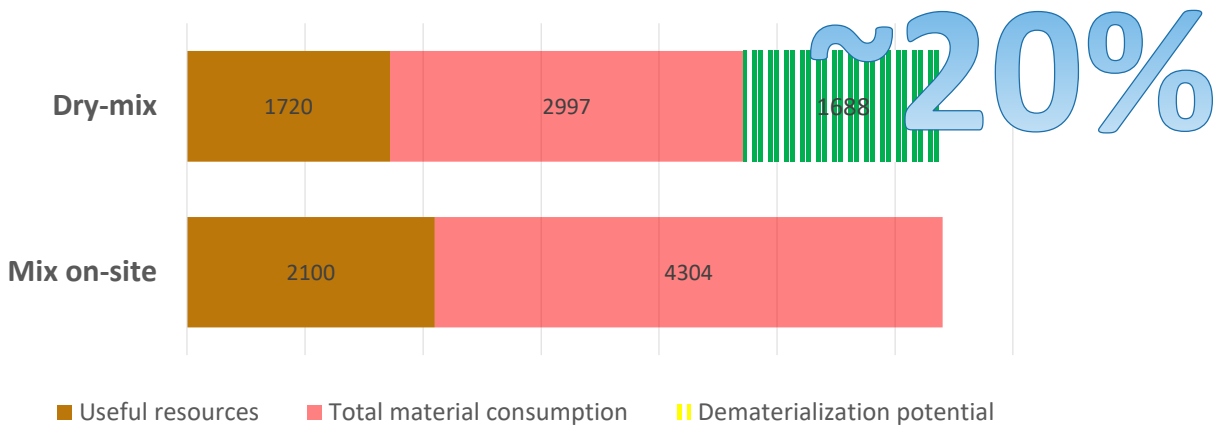
Industrialized mortar & dematerialization



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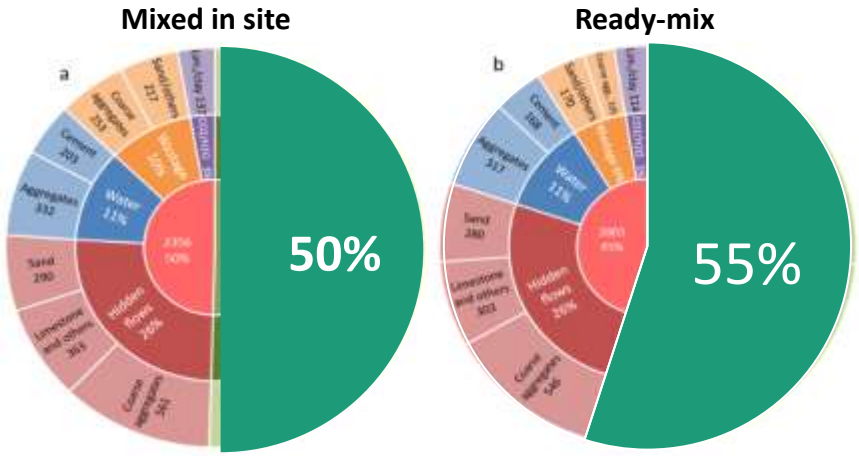
Resource efficiency in concrete (Brazil)



Reis, Mack-Vergara, John. To be published.

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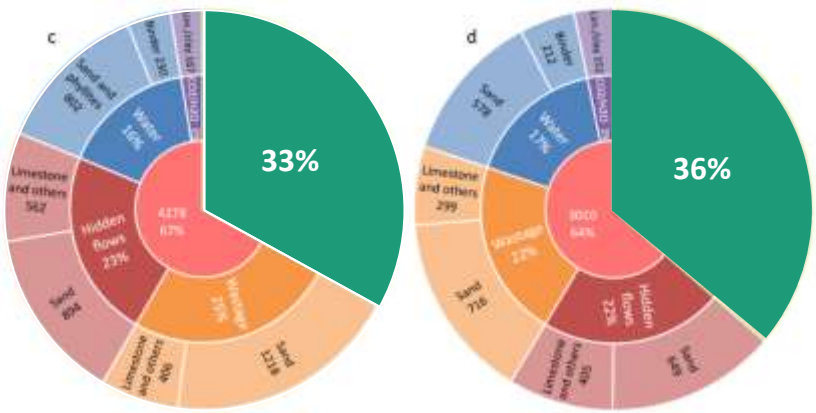
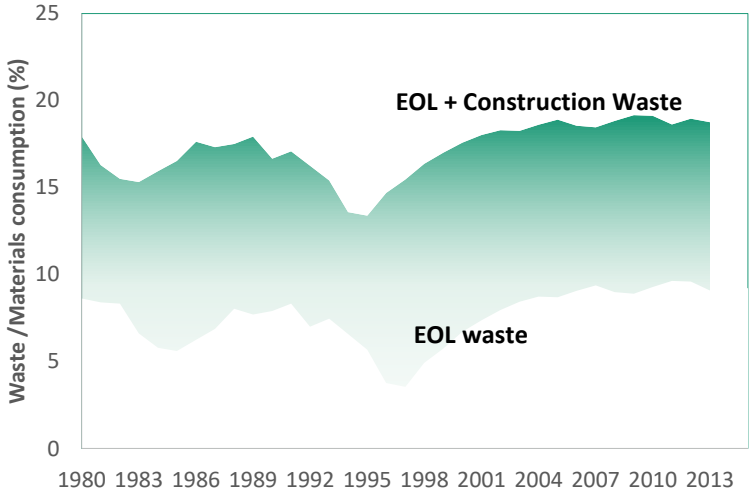
Materials use efficiency for mortars

Industrial Dry-mix **Industrial Dry-mix**



Global cement-based materials waste



Waste flow

~15%

materials flow

very rough estimative
50 years average service life

Circular inflow of construction

2-5%

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Why circularity is low in cement-based materials?

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Value of metal scrap

- Aluminium $1000-1,500/t
- Steel $120-220/t

- What is the value of CDW?

Scrap Metal Prices | Ingot Metals Nov. 2021

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Mineral Construction & Demolition Waste

- Abundant materials
- Available everywhere
- Cost of reverse logistics + segregation is higher than extraciton (most of the times)

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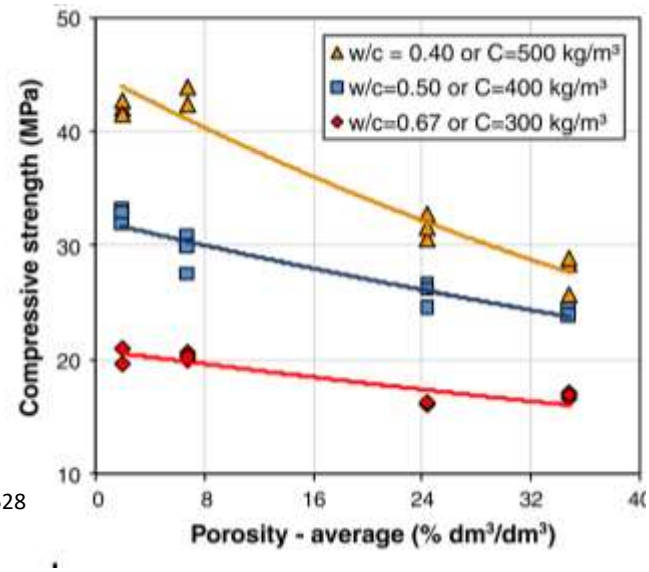
Recycled aggregate are diferent than natural ones



Angulo et al. Materials and Structures (2010) 43:519–528
DOI: 10.1617/s11527-009-9508-9

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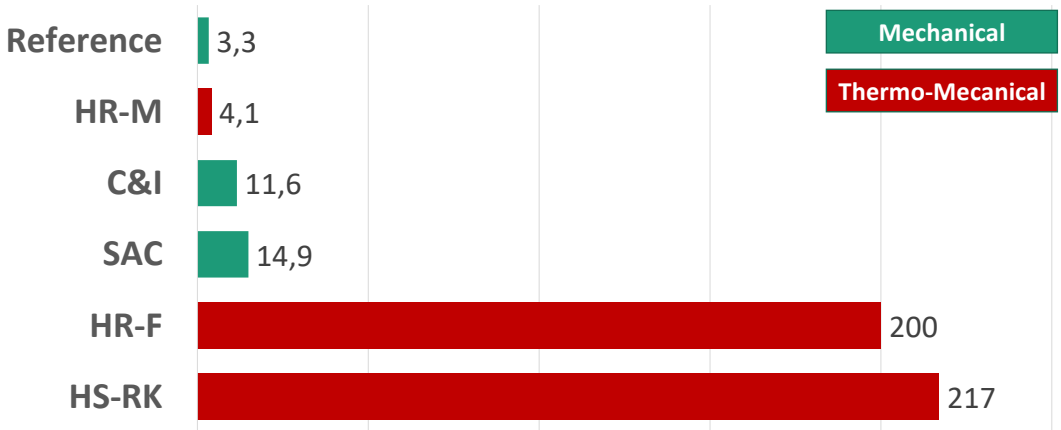
CO_2 direct emissions (kg/t coarse aggregate)



Quattrone, Angulo, John Resource Conservation and Recycling. 2015
http://dx.doi.org/10.1016/j.resconrec.2014.06.003

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Recycling can be more costly than production from natural materials

- Logistics is everything
- Processing can be more complex

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NIMBY

The environmental problems that the producers of natural aggregate (crushed stone and sand and gravel) face today are mostly difficult social and political concerns associated with the large holes dug in the ground and the large volume of heavy truck traffic associated with quarry and pit operations.
DREW 2002 https://doi.org/10.1023/A:1014283519471

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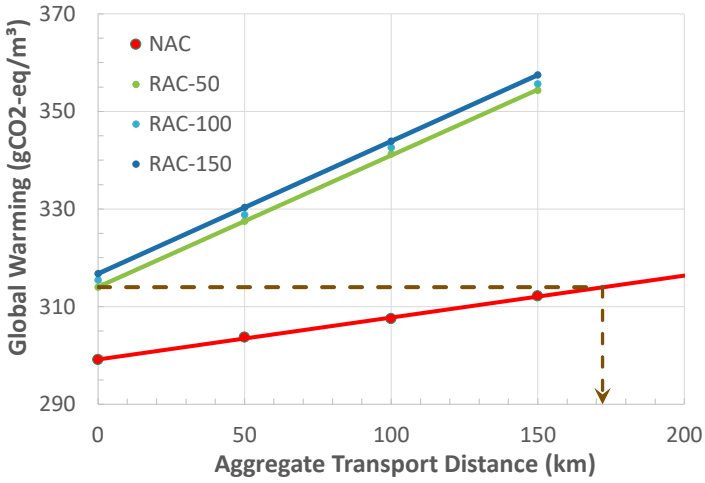
Recycled aggregate, higher CO_2 footprint



Marinkovi et al.W*aste Management* **30,** 2255–2264 (2010). doi:10.1016/j.wasman.2010.04.012.

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How can we overcome does limits?

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Downcycling may be a solution

- Recycling "something in such a way that the resulting product is of lower (economic) value than the original item."
- *It indicates a loss of the material/ product's original characteristics that precludes use in a similar function to its previous cycle (functional equivalence). Downcycling is usually used to describe a product's material properties, their level of degradation or, in the case of metals, if they have become impure, which leads to a loss of economic value.*

Nocycling is the real problem.

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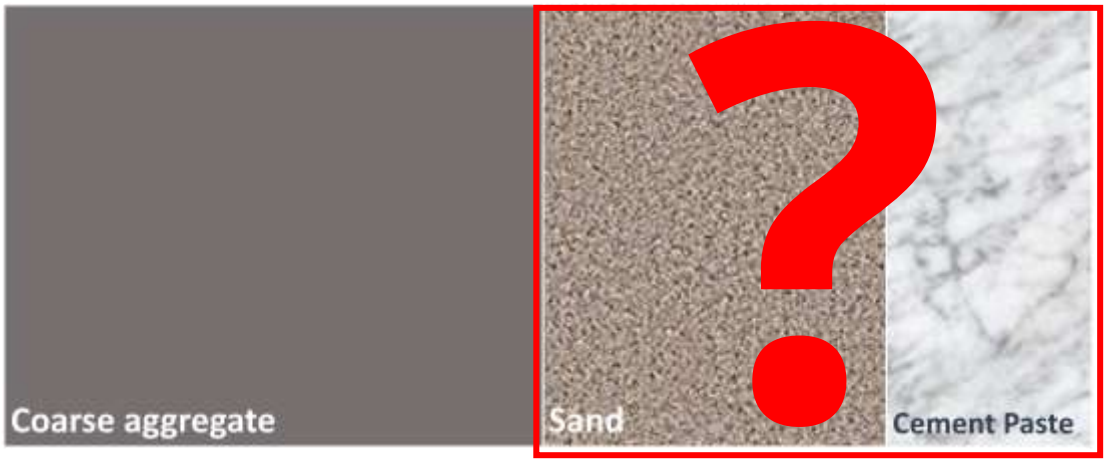
Recycling CDW as sand



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Two sand frations from mixed CDW

High density

Low-density

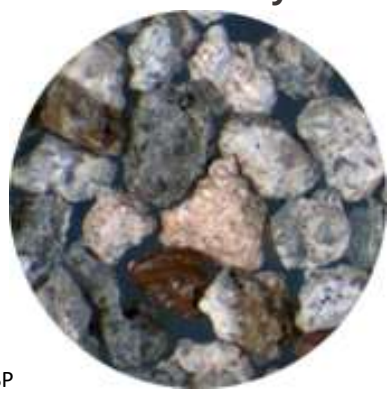

Foto: Carina Ulsen, USP

Fines can be a filler, cement raw material or a weak cementitious material

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Public policies are required to a more circular construction

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Thank you!

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