

EMBODIED CARBON IN NATURAL BUILDING STONE IN SCOTLAND

Dr Suzy Goodsir and Naeeda Crishna

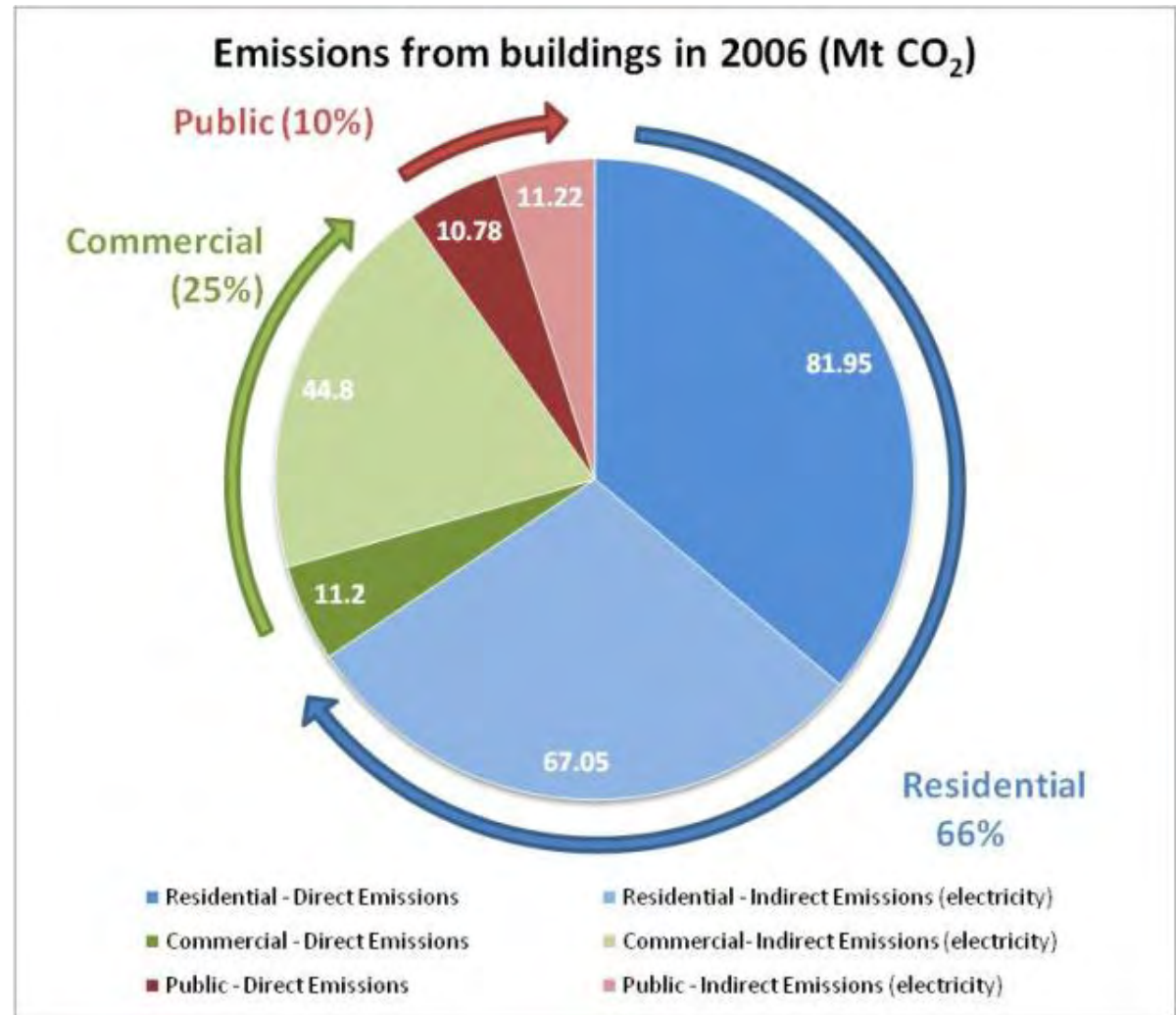
Our Presentation



- Context to this project
- Stone industry in Scotland / the UK
- Energy used in the stone life cycle
- Our approach
- Results
- Implications for stone industry

CO₂ and Buildings

- Scotland's target – 80% reduction in GHGs by 2050.
- The CCC estimated that emissions from the built environment account for 42% of total UK emissions.



Source: UK Committee on Climate Change, 2008



Embodied and Operational CO₂



- CCC figures refers to 'operational' energy use only.



Source: New Civil Engineer, 2009

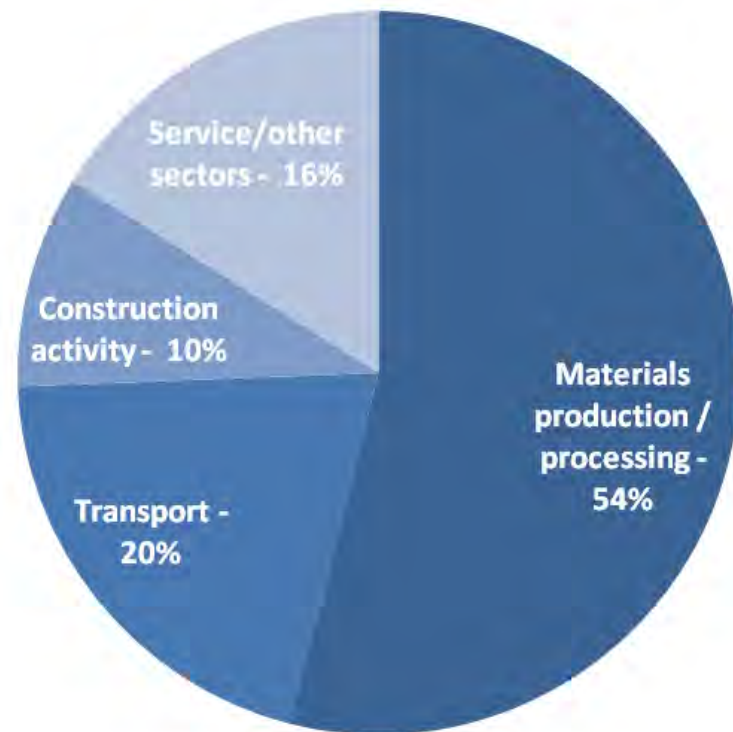


Embodied Energy in buildings



- Production of materials and transport of materials contribute significantly to embodied energy in building production

Distribution of average energy used to produce a multi-dwelling residential building



Source: Nassen et al., 2007



This project



Historic Scotland commissioned a team from SISTech and Professor Phil Banfill at Heriot-Watt University to:

- To quantify 'embodied carbon (CO_2e) in Scottish and UK sandstone, granite and slate (used for building purposes)
- To understand the carbon impact of importing stone



Stone Industry in Scotland / UK



- Annual production of the top ten stone producing countries in the world in 2007
- UK production in 2007 was 0.79 million tonnes

Million tonnes

China	22.0
India	21.5
Iran	11.1
Italy	10.0
Turkey	9.5
Spain	8.0
Brazil	7.5
Egypt	3.5
Portugal	3.0
France	1.2

Source: AIDICO, 2008



Stone Industry in Scotland / UK



Industry characterised by:

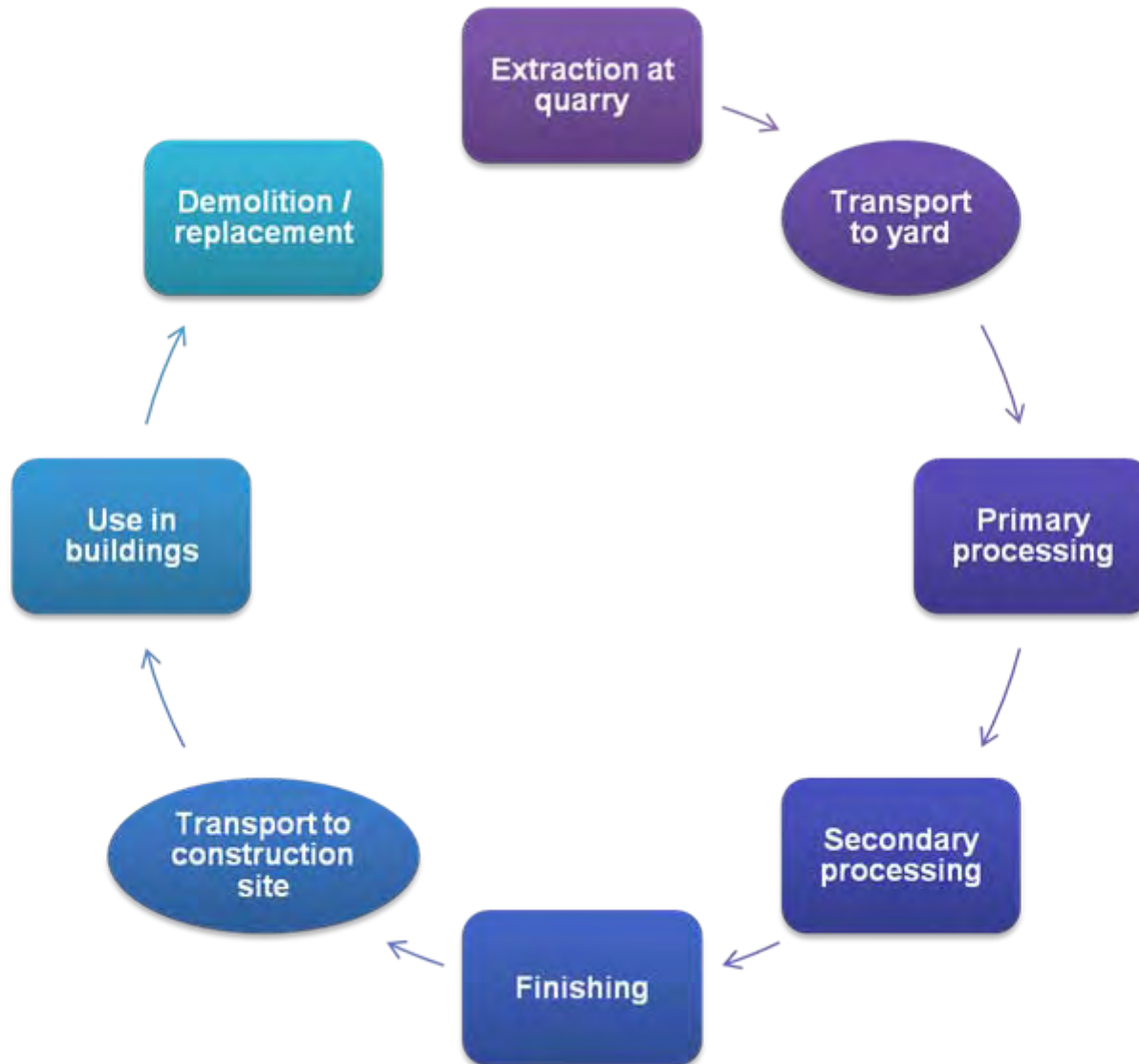
- Smaller producers - 500 tonnes per annum, larger producers – 5,000 to 10,000 tonnes per annum
- Overall industry has largely small producers, but few large producers are responsible for over half the industry output

Literature Review: Embodied carbon in building stone

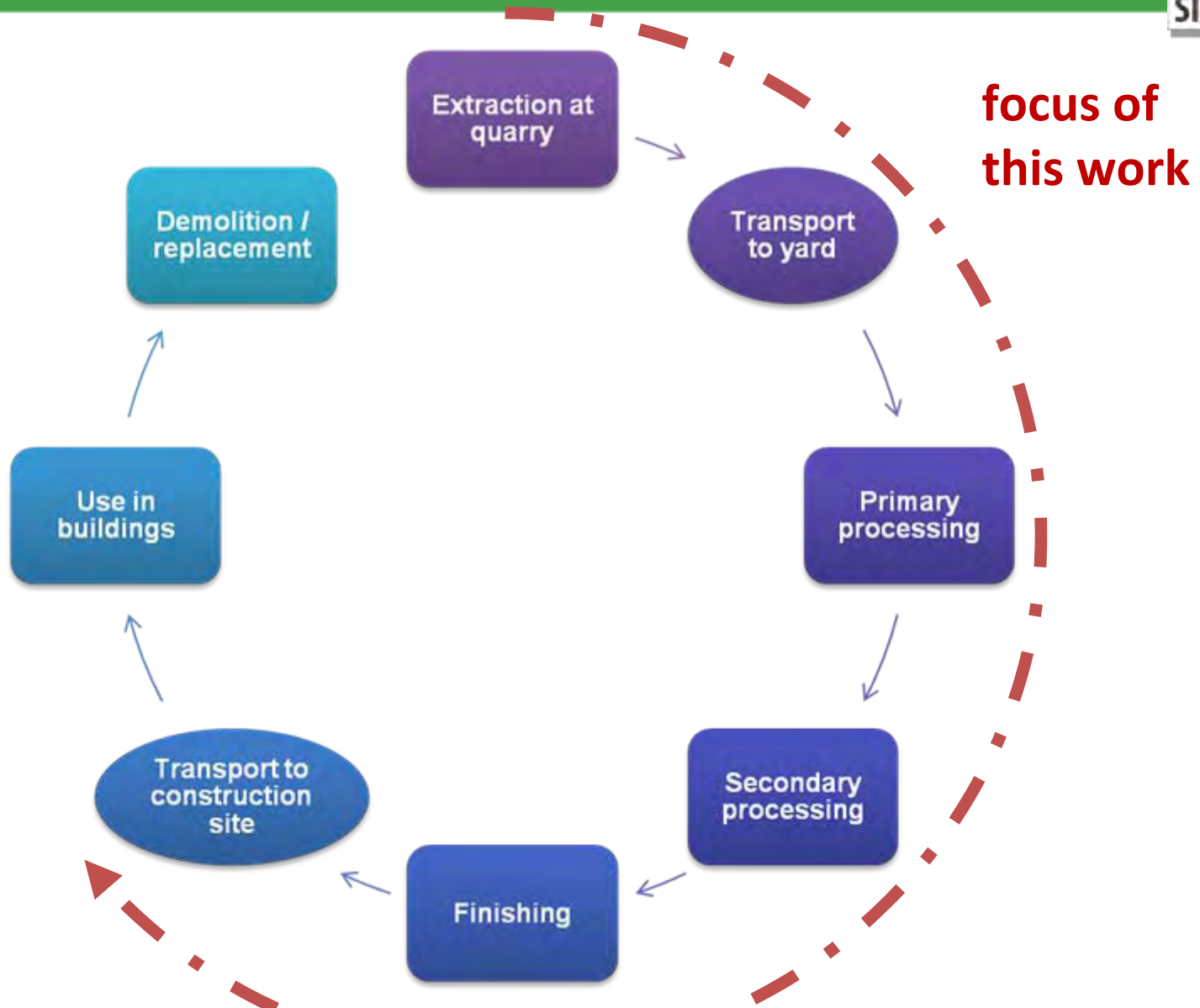
- Variety in results of studies focussing on stone - 0.1 to 13.9MJ / kg!
- Discrepancies in system boundaries used



Life Cycle of Stone



Life Cycle of Stone





Life Cycle of Stone: Quarrying





Life Cycle of Stone: Primary processing





Life Cycle of Stone: Secondary processing





Life Cycle of Stone: Secondary processing



Our Approach



- Process based life-cycle analysis
- Boundaries in accordance with PAS 2050
- Data collected from 21 quarries and stone yards
- Site visits to 8 operations in Scotland, Wales and Northern Ireland
- Interviews of experts and evidence review of four stone exporting countries – Spain, Poland, India and China

Our Approach

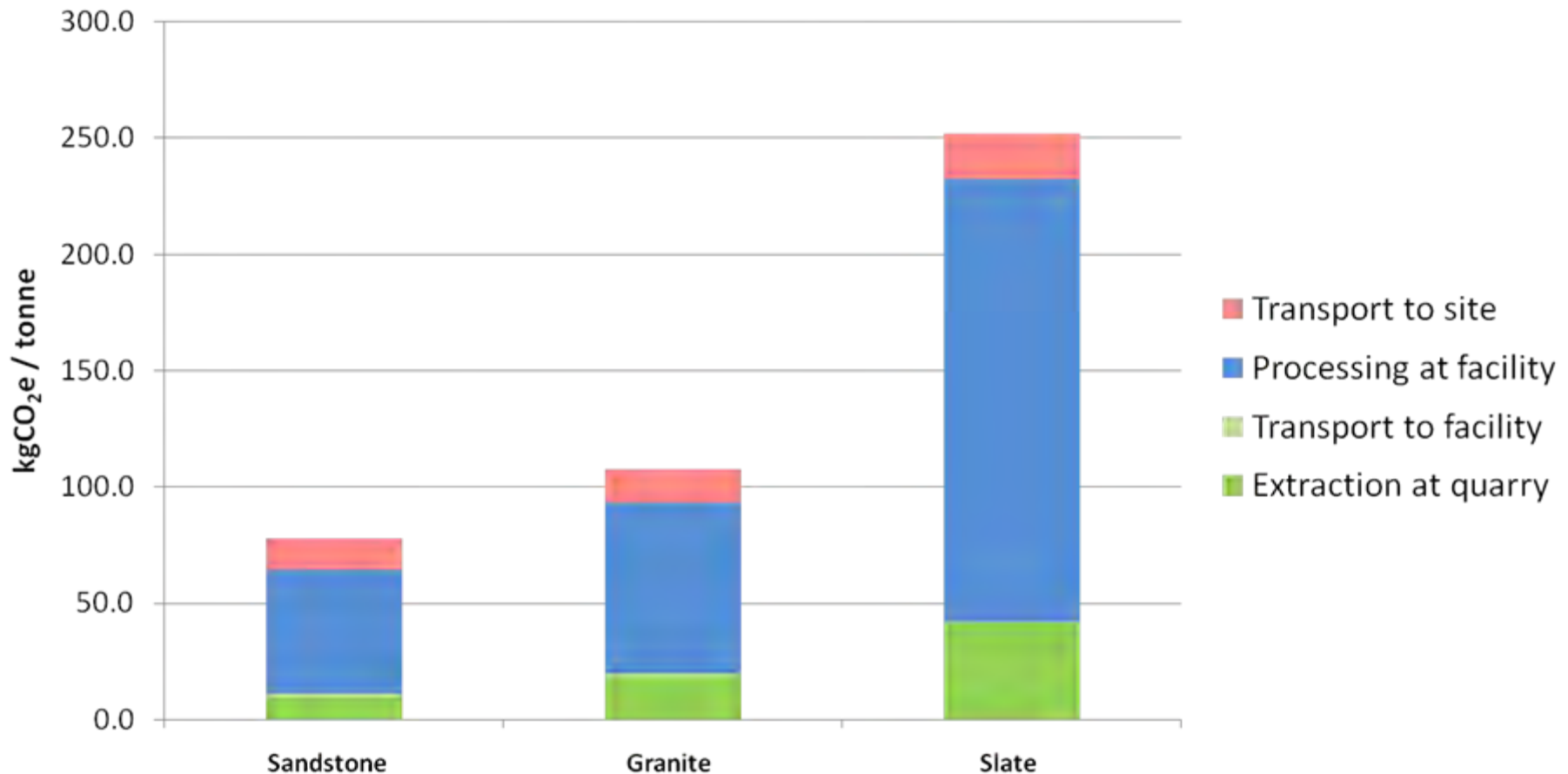


- Sandstone data largely from Scotland; granite and slate from Cumbria, Cornwall, Northern Ireland and Ireland
- Data sample small but representative due to nature of industry

Embodied Carbon in UK stone



Embodied carbon in natural stone:
Extraction, Processing and Distribution

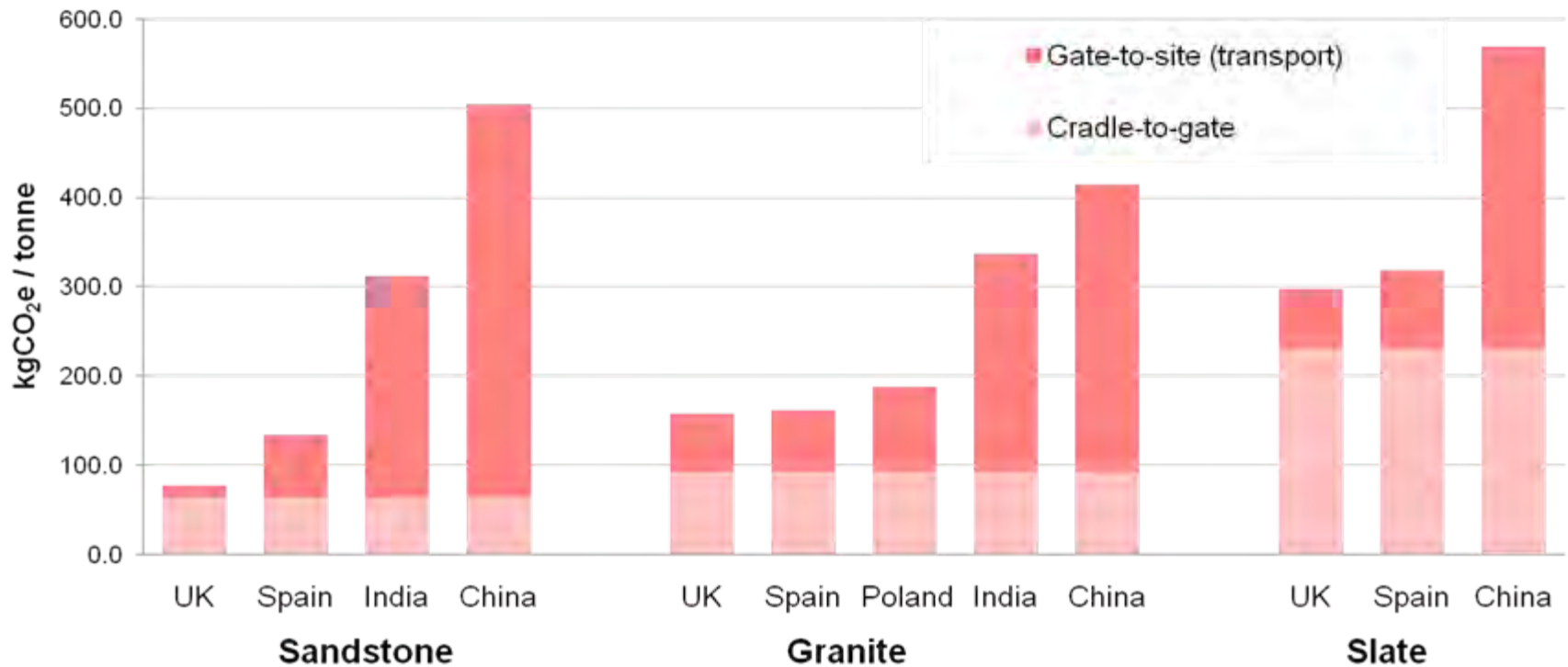




Embodied Carbon in imported stone

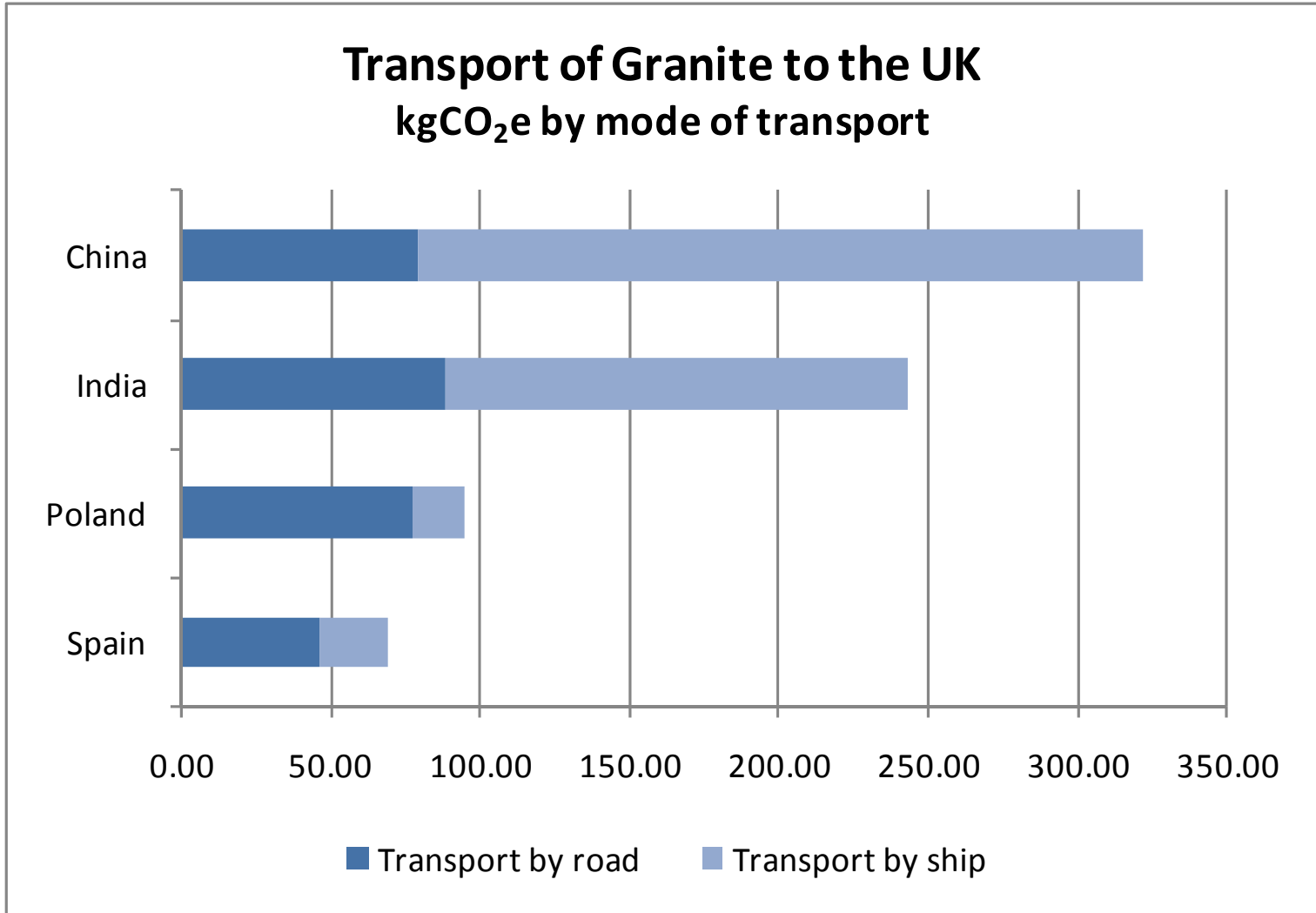


Embodied Carbon in domestic and imported natural stone:
cradle-to-gate and transport to site





Transport of imported stone





Stone vs other building materials



Building materials	kgCO ₂ /tonne
Sandstone	64
Granite	93
Marble	112
General Concrete	130
General Clay Bricks	220
Slate	232
Timber	450
Facing Bricks	520
General Building Cement	830
Steel: Bar and Rod	1710
Steel: Galvanised sheet	2820

Source: This project and University of Bath ICE

Key messages



- Electricity during processing is the largest component of UK stone footprint
- Stone is a largely low-carbon building material, provided it is domestically sourced
- Transport footprint of imported stone is significant – e.g. footprint of imported sandstone from China is 8 times the UK footprint