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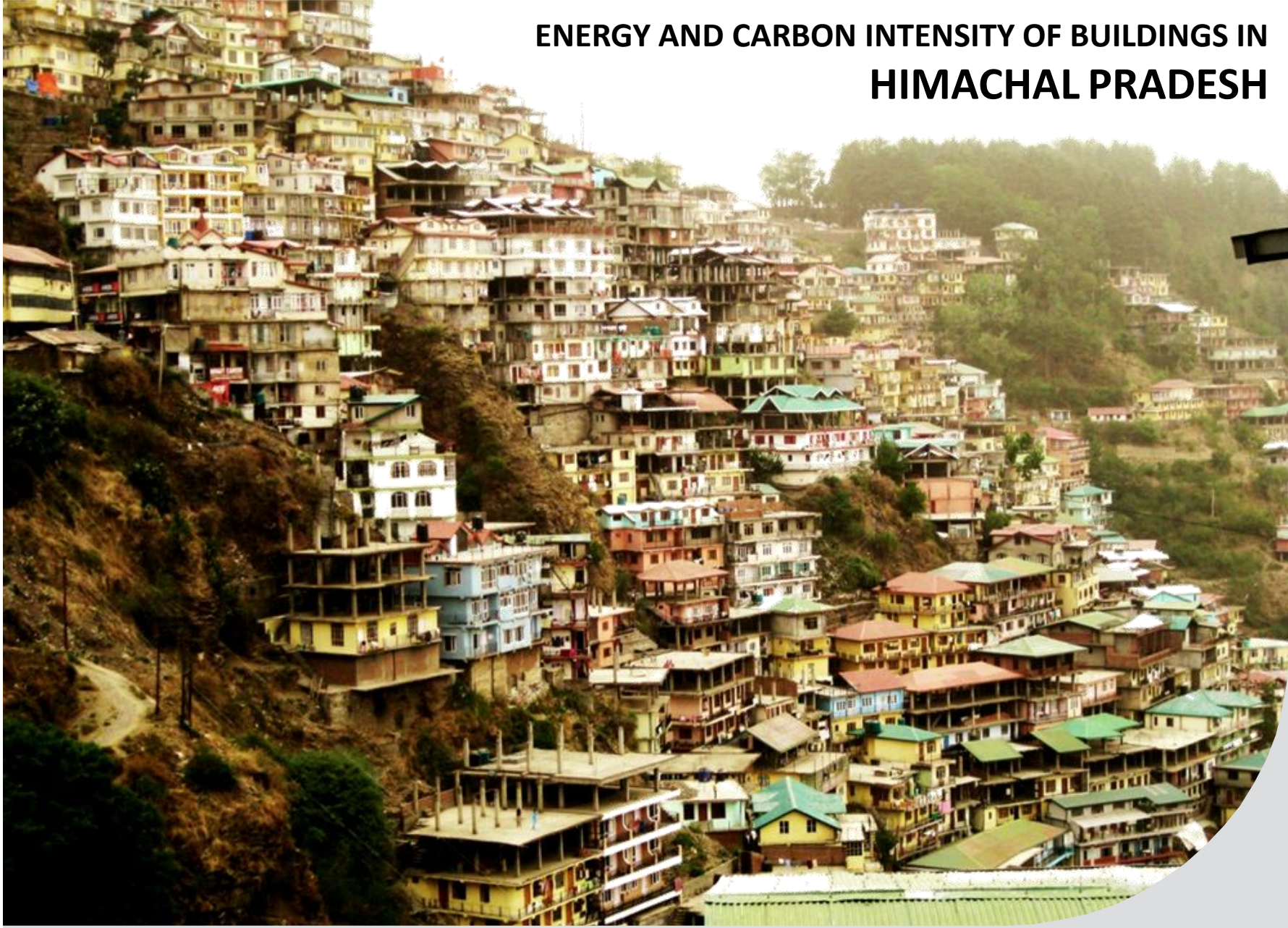
ENERGY AND CARBON INTENSITY OF BUILDINGS IN HIMACHAL PRADESH



Development Alternatives

Energy and Carbon Intensity of Buildings

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CARBON IMPACT OF BUILDINGS

- **Material resources extraction and processing** for production leading to deforestation, loss of top soil
- **Transportation** of raw materials and finished products
- **Operational energy of buildings** for comfortable indoor environments

At the national level, activities of the construction sector

Emission of about 22% of the total annual national CO_2 emissions (80% results mainly from production of energy intensive building materials - steel, cement, bricks and lime)

Embodied Energy

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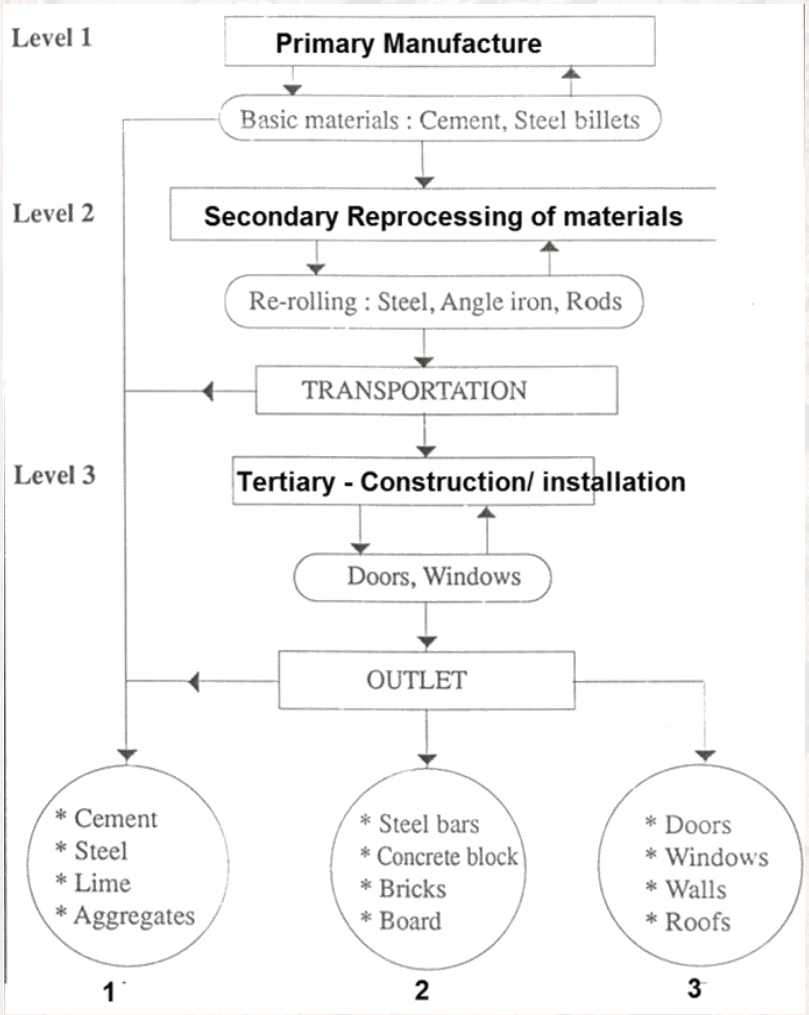
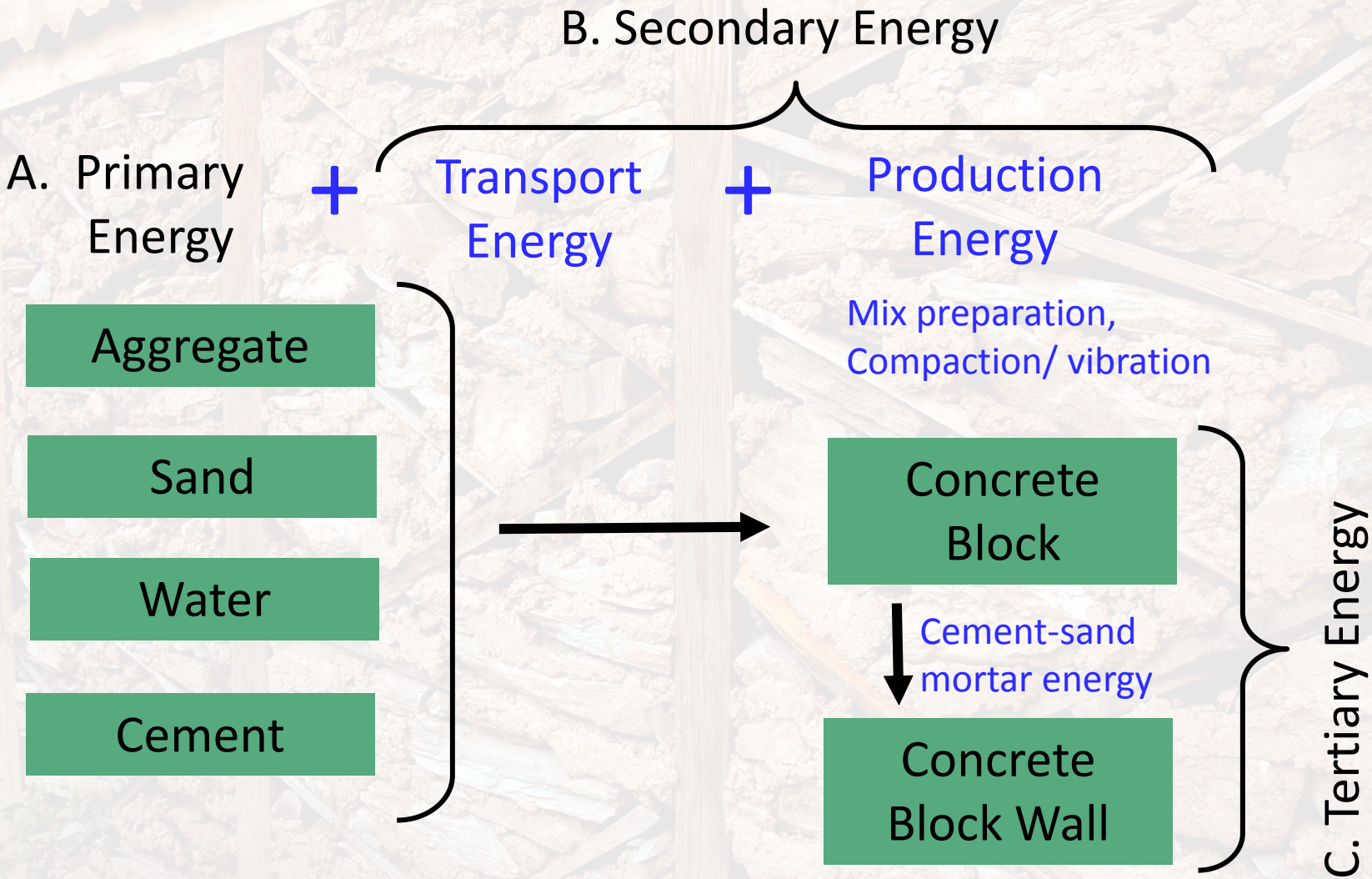
A summation of energy consumed in manufacture of raw materials, re-processing for producing building elements and in construction. (Commonly measured in Joules, kWh)

Embodied energy can be significantly reduced by

- Combining raw materials in a way that optimizes durability at low embodied energy
- Designing construction systems in a way that structural requirements are met, using low embodied energy



Embodied Energy of a Concrete Block Wall



Embodied Energy – Material Level

At secondary level – measured per weight of building component (kg, Tonne)

BRICK:

Weight of brick – 2.2 kg

Weight of 1000 bricks – 2200 kg

Coal required for 1000 bricks – 140 kg

Energy Content of coal 27.5 MJ/kg

EE of 1000 bricks – 140 x 27.5 = 3850 MJ

EE of 1 brick = 3.85 MJ

EE of brick = 3.85 / 2.2 = 1.75 MJ per kg

Embodied Energy – Construction Level

At tertiary level – measured per quantity of wall, roof constructed – MJ/m²

9” wall with burnt clay bricks

Number of bricks in 1m² wall 116

Weight of bricks in 1m² wall 250 kg

EE of bricks in 1m² wall 250 x 1.75 = 445 MJ

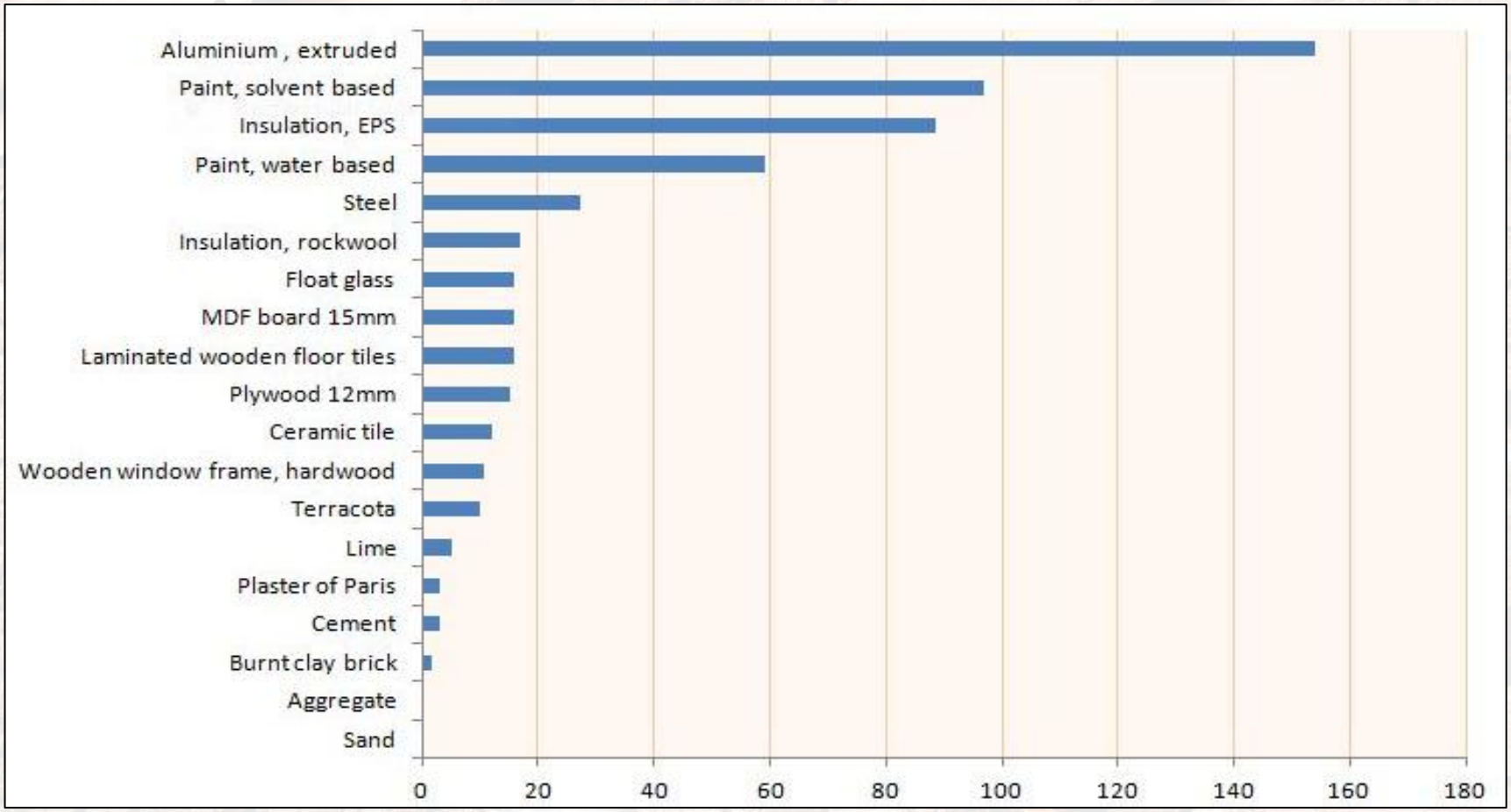
Mortar volume in 1m² wall 0.07 m³

Mortar weight in 1m² wall 0.07 x 2080 kg/m³ = 145 kg

EE of mortar in 1m² wall 145 x 0.75 = 108 MJ

EE of 1m² brick wall = 108 + 445 = 553 MJ

Embodied Energy

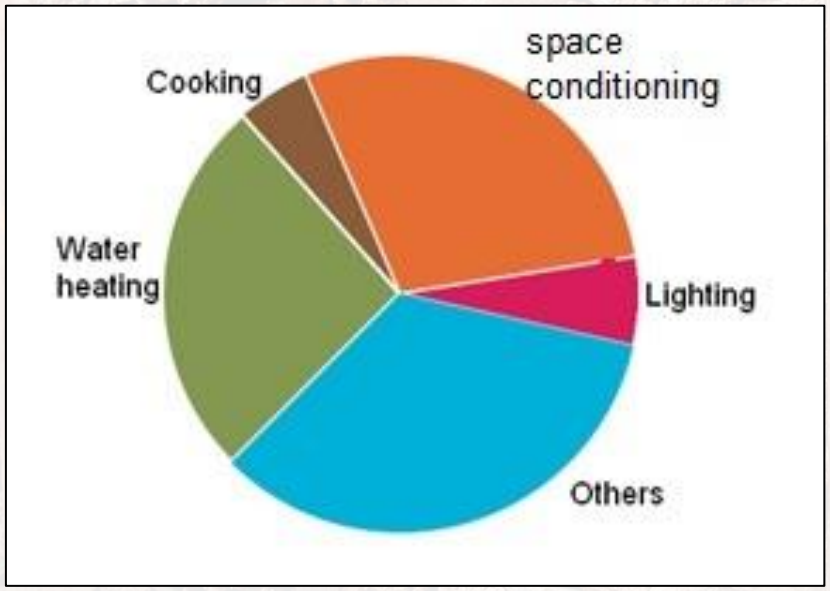


Generally, for low-rise buildings which use bricks and RCC roofs –

- **Bricks and steel are the top 2 contributors to total embodied energy**
- **Bricks and cement are the top 2 contributors to CO_2 emissions**

Operational Energy

Energy used for day-to-day operation - lighting, heating, ventilation, air-conditioning (HVAC), use of appliances, water pumping, etc.



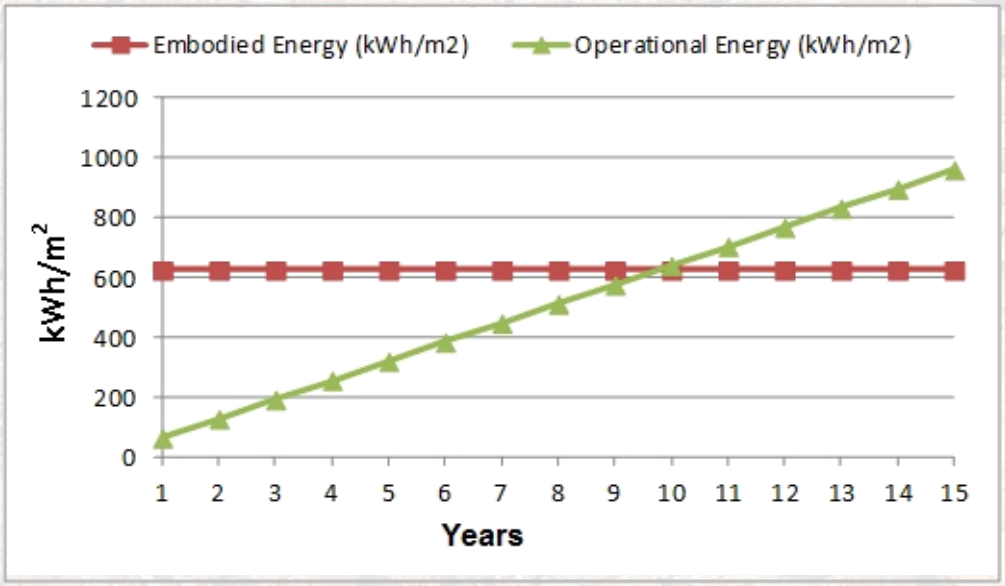
Electricity Consumption in Residential Buildings

While electrical appliances determine operational energy in urban areas, cooking and lighting are the primary energy consumers in rural areas.

Measured as Energy Performance Index (EPI) expressed in kWh/m2/annum.

EPI of conventional residential buildings in Composite climate with significant cooling loads is 50 – 60 kWh /m2/ annum .

Embodied Energy vs. Operational Energy



Comparison of embodied and operational energy for a typical low-rise (G+3) residential building in Delhi

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Carbon Footprint

Carbon Footprint is…

The total set of GHG emissions caused directly.

Globally, Carbon footprints are a tangible parameter to assess environmental impact in terms of mass of emissions and a means of promoting Low-Carbon practices.

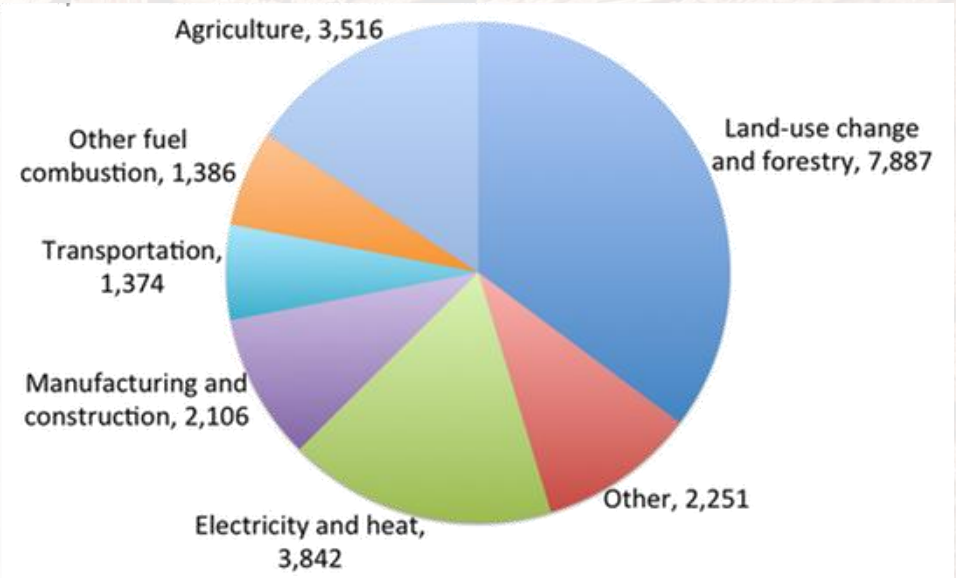

Chart showing **carbon dioxide emissions (Million Metric tonnes)** by source for **developing countries, 2000.**
Image courtesy of **Little Green Data Book 2007**

For buildings, it is acceptable to assume CO_2 as the primary GHG emission arising from 2 causes -

- **Production of materials and their consumption in building construction**
- **Emissions from electricity use to maintain comfortable indoor environments**

CARBON FOOTPRINT – Calculation for Brick Masonry

CO_2 emissions per kg coal	2.42 kg
CO_2 emissions due to bricks (= 140/1000 x 120) x 2.42	40.65 kg .....(4)
CO_2 emissions per tonne of cement produced	1830 kg
CO_2 emissions due to cement used in mortar (=1.83 x 15.5)	28.4 kg .....(5)
Total CO_2 emissions of burnt clay brick masonry ...(4+5)	**69 kg CO_2/ m^2**

Thank you.

Disclaimer

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Climate & Development Knowledge Network

Development Alternatives