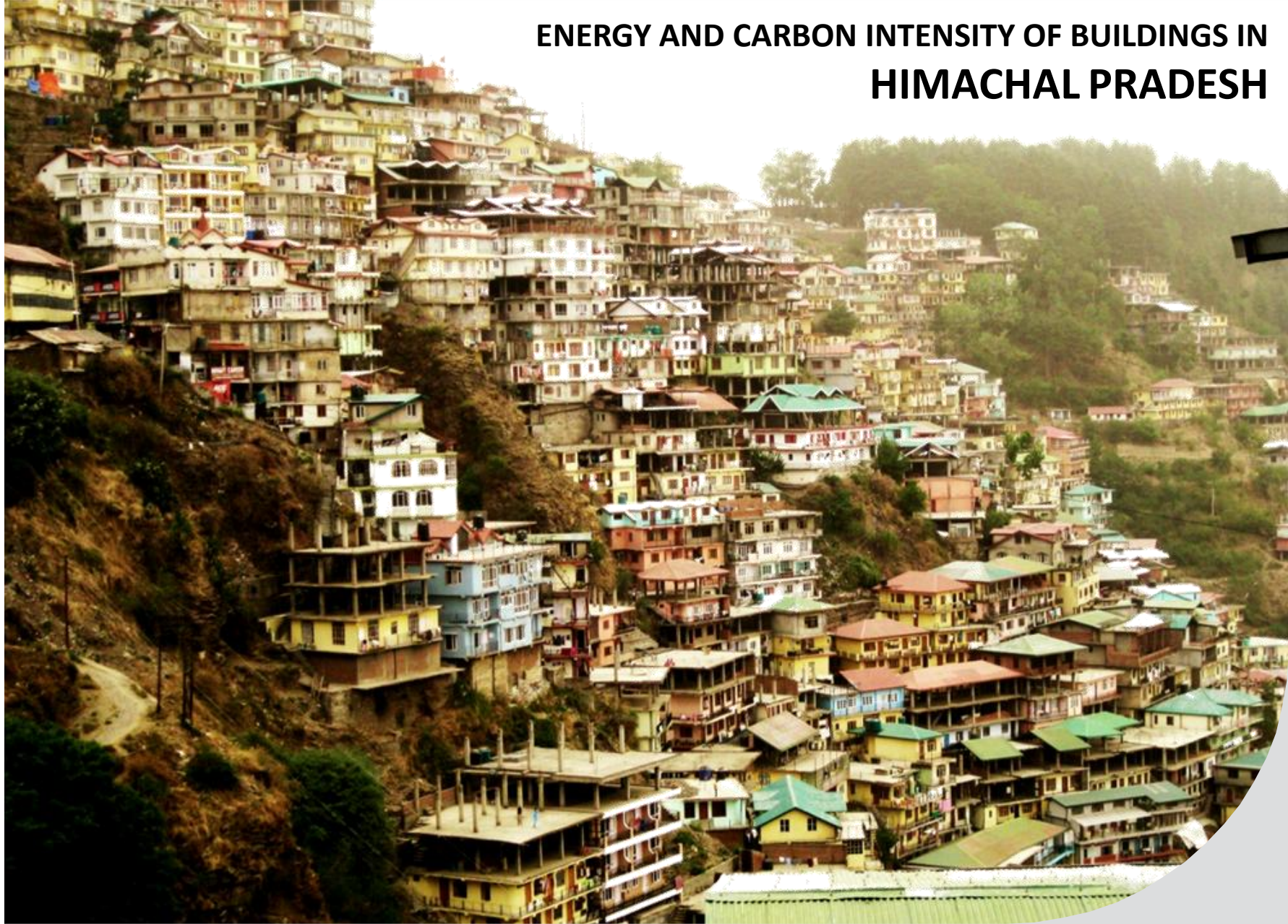


# ENERGY AND CARBON INTENSITY OF BUILDINGS IN HIMACHAL PRADESH





# Energy and Carbon Intensity of Buildings

## 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<sub>2</sub> emissions (80% results mainly  
from production of energy intensive building  
materials - steel, cement, bricks and lime)

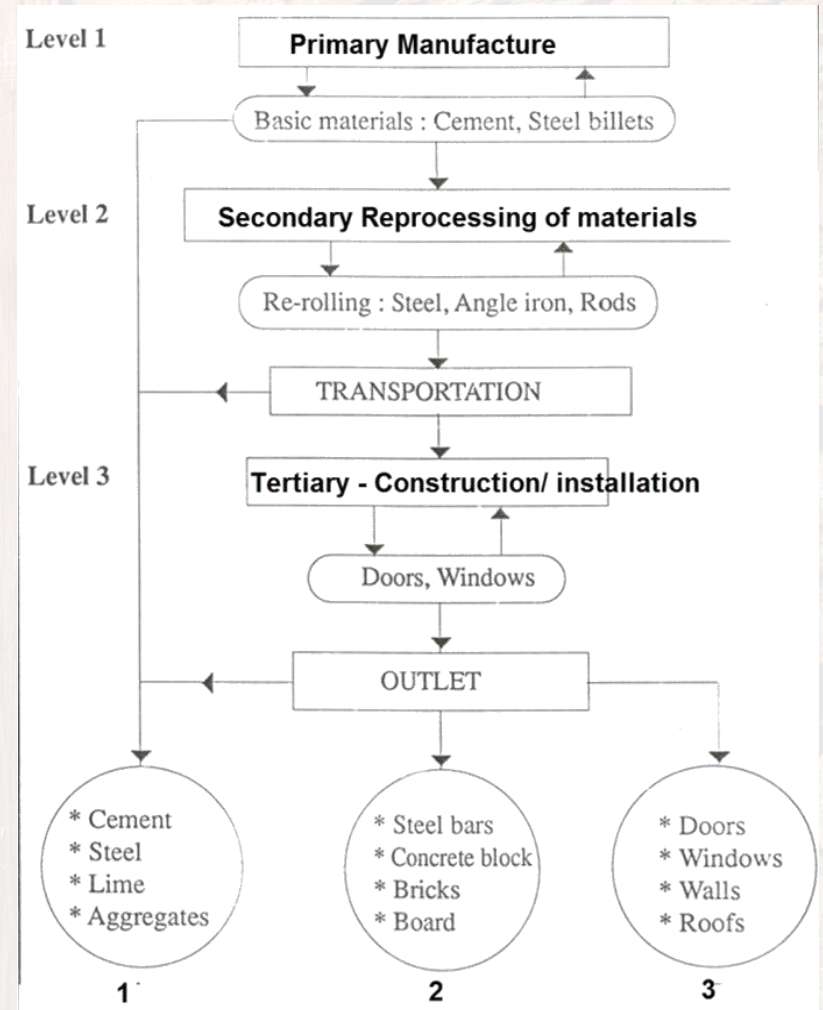


# Embodied Energy

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

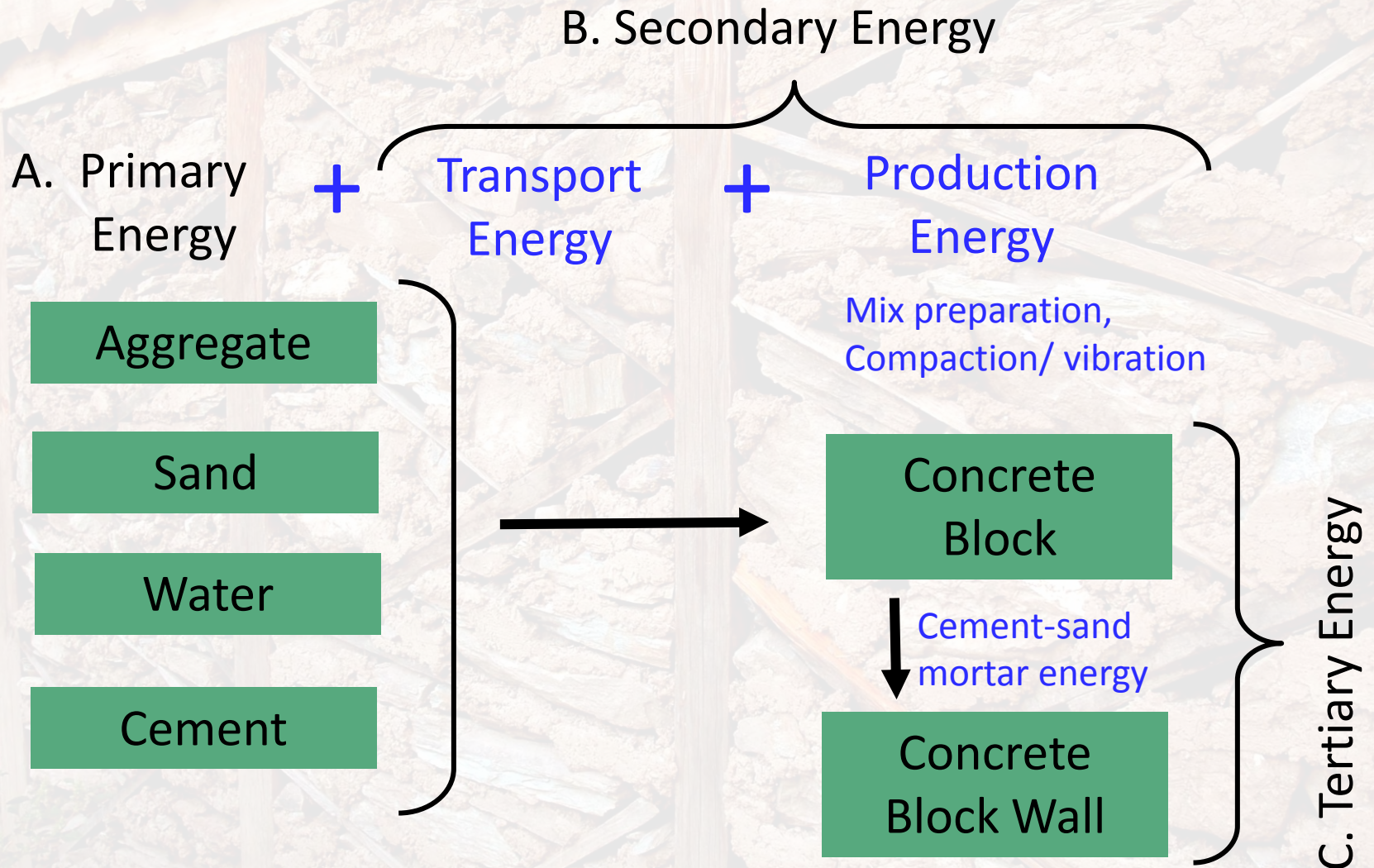
Embodied energy can be significantly reduced by

- 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 –  $140 \times 27.5 = 3850$  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/m<sup>2</sup>**

**9" wall with burnt clay bricks**

Number of bricks in 1m<sup>2</sup> wall 116

Weight of bricks in 1m<sup>2</sup> wall 250 kg

EE of bricks in 1m<sup>2</sup> wall  $250 \times 1.75 = 445$  MJ

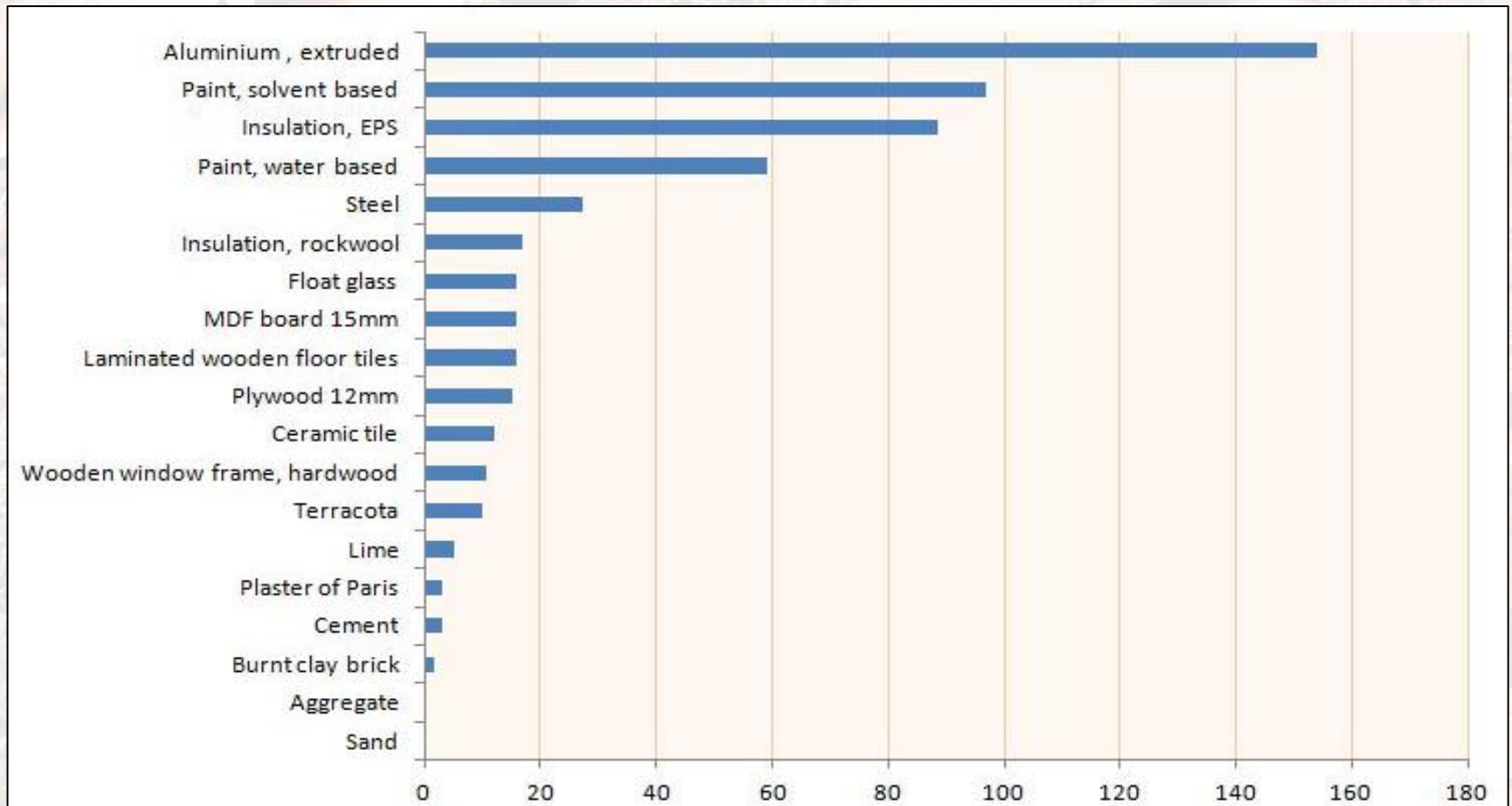
Mortar volume in 1m<sup>2</sup> wall 0.07 m<sup>3</sup>

Mortar weight in 1m<sup>2</sup> wall  $0.07 \times 2080 \text{ kg/m}^3$   
 $= 145$  kg

EE of mortar in 1m<sup>2</sup> wall  $145 \times 0.75 = 108$  MJ

EE of 1m<sup>2</sup> brick wall  $= 108 + 445 = 553$  MJ

# Embodied Energy



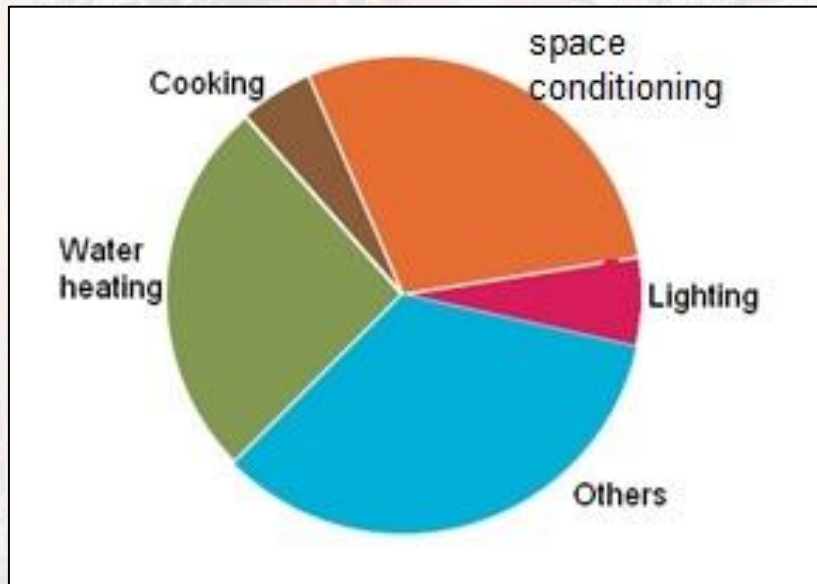
Generally, for low-rise buildings which use bricks and RCC roofs –

- Bricks and steel are the top 2 contributors to total embodied energy
- Bricks and cement are the top 2 contributors to CO<sub>2</sub> 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

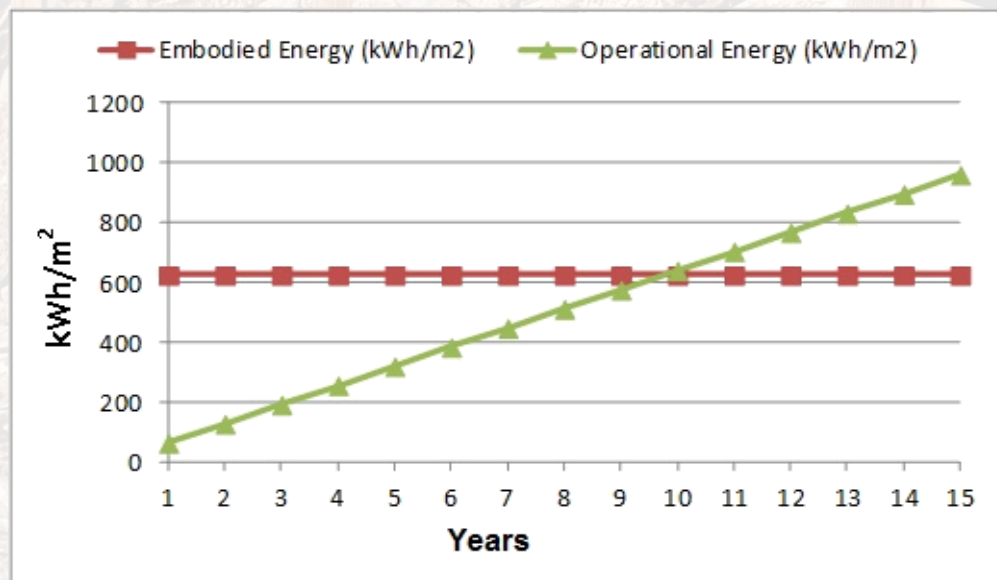
While electrical appliances determine operational energy in urban areas, cooking and lighting are the primary energy consumers in rural areas.

Measured as Energy Performance Index (EPI) expressed in kWh/m<sup>2</sup>/annum.

EPI of conventional residential buildings in Composite climate with significant cooling loads is 50 – 60 kWh /m<sup>2</sup>/ annum .



# Embodied Energy vs. Operational Energy



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





# 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.

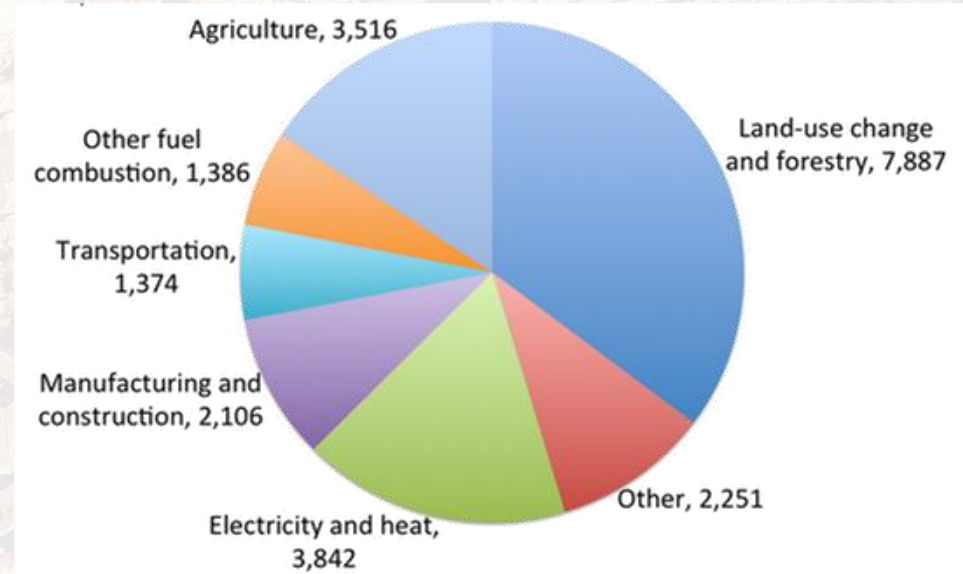


Chart showing carbon dioxide emissions (Million Metric tonnes) by source for developing countries, 2000.

Image courtesy of Little Green Data Book 2007

For buildings, it is acceptable to assume CO<sub>2</sub> 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 <sub>2</sub> emissions per kg coal	2.42 kg
CO <sub>2</sub> emissions due to bricks (= 140/1000 x 120) x 2.42	40.65 kg .....(4)
CO <sub>2</sub> emissions per tonne of cement produced	1830 kg
CO <sub>2</sub> emissions due to cement used in mortar (=1.83 x 15.5)	28.4 kg .....(5)
<b>Total CO<sub>2</sub> emissions of burnt clay brick masonry ...(4+5)</b>	<b>69 kg CO<sub>2</sub>/m<sup>2</sup></b>



Thank you.



## Disclaimer

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