SHOCKING FACTS BEHIND

# GREEN BUILDINGS

## ENERGY SYSTEMS & RENEWABLES

Harshit Chaurasia
A/3271/2019 | 3C
SCHOOL OF PLANNING & ARCHITECTURE - NEW DELHI

STUDIO FACULTY: Ar. Gaurav Shorey.

## INTRODUCTION

Climate Change is real and buildings play a major role in carbon emissions. In 2019 we emitted 33.6 Gt[1] of carbon dioxide out of which 1.9 Gt was from residential buildings. The solutions proposed are many out which using “green materials” holds the highest stake. But the question is how *green* are they?

To explore that, in this study we calculate the embodied energy and Global Warming Potential (GWP) of our houses and then replace the materials with green materials referred from ‘India Construction Materials Database’ by IFC, World Bank. Then we recalculate the embodied energy and GWP and compare the two datasets.

Further we go on to analyse the number of trees required to sequestrate that carbon and the results are shocking!

## KEY TERMS

**EMBODIED ENERGY**

Embodied energy (EE) of building materials constitutes the total energy expenditure for manufacturing of building materials including that for raw material extraction and associated transportation.

**GLOBAL WARMING POTENTIAL**

The Global Warming Potential (GWP) is an indicator of the overall effect of the process related to the heat radiation absorption of the atmosphere due to emissions of greenhouse gases ($CO_2$-eq) of the network.

# COLUMNS, BEAMS & SLABS

**MATERIAL -** Ready Mix Concrete with Ordinary Portland Cement (OPC).

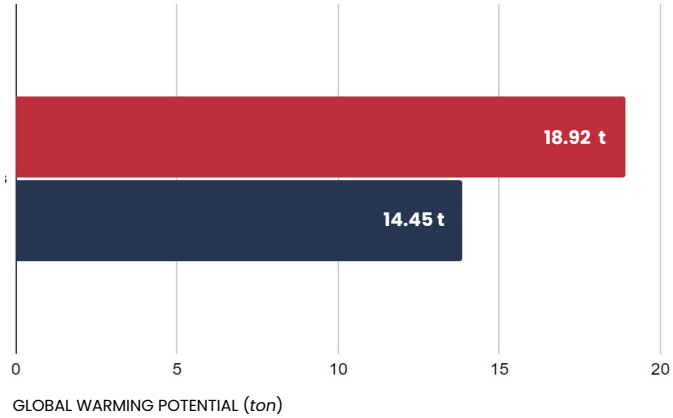
Volume = **68.8 m³** **x** Density = **2500 kg/m³** **=** Total weight ~ **172,000 kg**

Embodied energy = 0.87 MJ/kg
Total embodied energy = 149,650 MJ

GWP = 0.11 kg/kg
Total GWP = 18.92 t

**0.32%**
**of total EE from traditional materials**

**0.43%**
**of total GWP from traditional materials**




**MATERIAL -** Ready Mix Concrete with fly-ash (30% pozzolana).

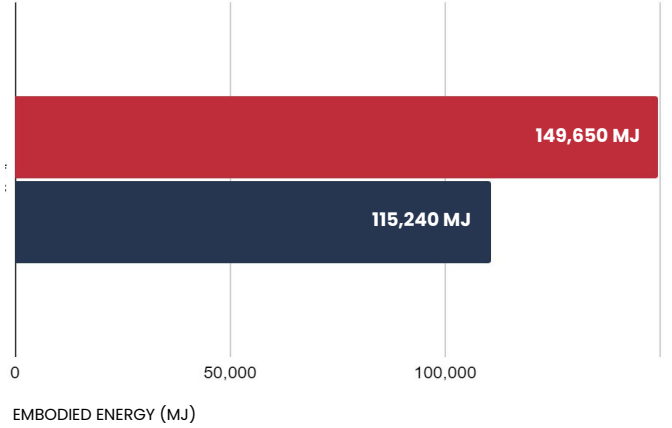
Volume = **68.8 m³** **x** Density = **2500 kg/m³** **=** Total weight ~**172,000 kg**

Embodied energy = 0.67 MJ/kg
Total embodied energy = 115,240 MJ

GWP = 0.084 kg/kg
Total GWP = 14.45 t

**2.11%**
**of total EE from green materials**

**5.31%**
**of total GWP from green materials**



# BRICKS

**MATERIAL -** Brick (common/facing).

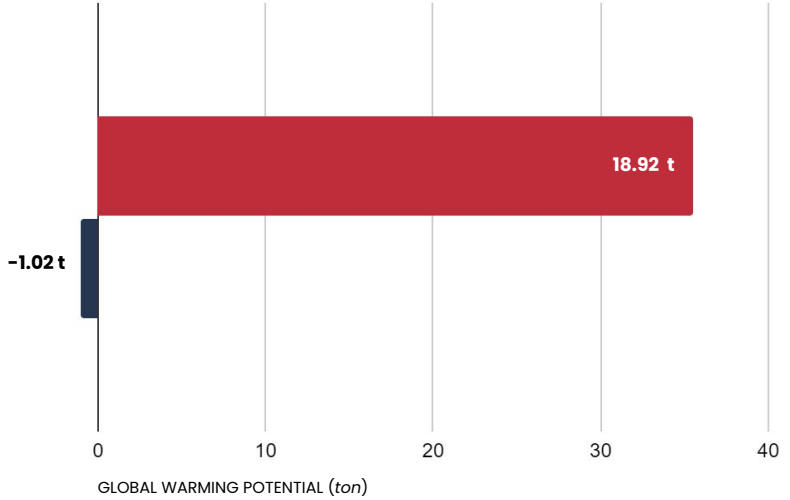
Volume = **60.75 m³** **x** Density = **1500 kg/m³** **=** Total weight ~ **91,125 kg**

Embodied energy = 4.4 MJ/kg
Total embodied energy = 400,950 MJ

GWP = 0.39 kg/kg
Total GWP = 35.54 t

**0.85%**
**of total EE from traditional materials**

**0.81%**
**of total GWP from traditional materials**




**MATERIAL -** Rammed earth block.

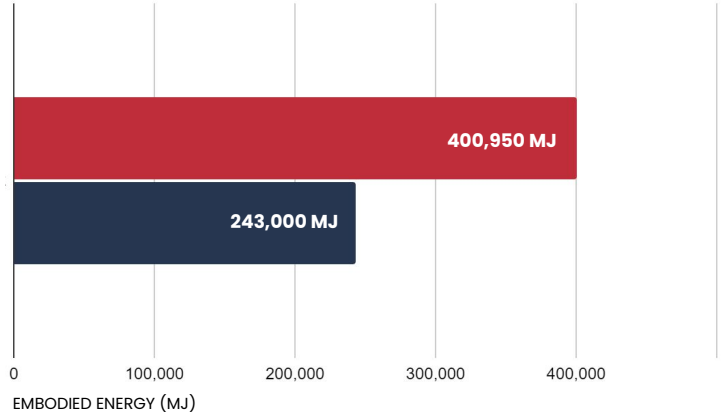
Volume = **60.75 m³** **x** Density = **2000 kg/m³** **=** Total weight ~**121,500 kg**

Embodied energy = 2 MJ/kg
Total embodied energy = 243,000 MJ

GWP = -0.0084 kg/kg
Total GWP = -1.02 t

**4.45%**
**of total EE from green materials**

**-0.37%**
**of total GWP from green materials**



# MORTAR

**MATERIAL -** Cement mortar.

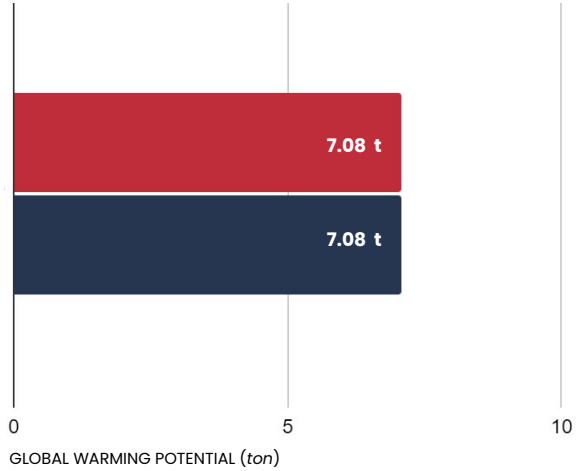
Volume = **20.25 m³** **x** Density = **2500 kg/m³** **=** Total weight ~ **50,625 kg**

Embodied energy = 1.1 MJ/kg
Total embodied energy = 55,687 MJ

GWP = 0.14 kg/kg
Total GWP = 7.08 t

**0.12%**
**of total EE from traditional materials**

**0.16%**
**of total GWP from traditional materials**




**MATERIAL -** Cement mortar.

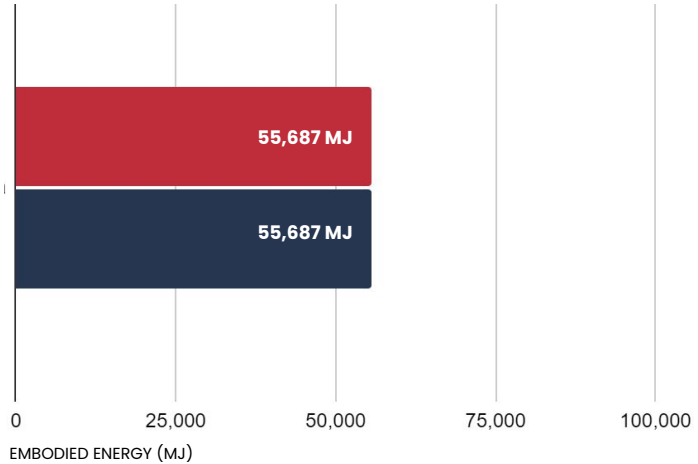
Volume = **20.25 m³** **x** Density = **2500 kg/m³** **=** Total weight ~ **50,625 kg**

Embodied energy = 1.1 MJ/kg
Total embodied energy = 55,687 MJ

GWP = 0.14 kg/kg
Total GWP = 7.08 t

**1.02%**
**of total EE from green materials**

**2.60%**
**of total GWP from green materials**



# PLASTER

**MATERIAL -** Cement based plaster.

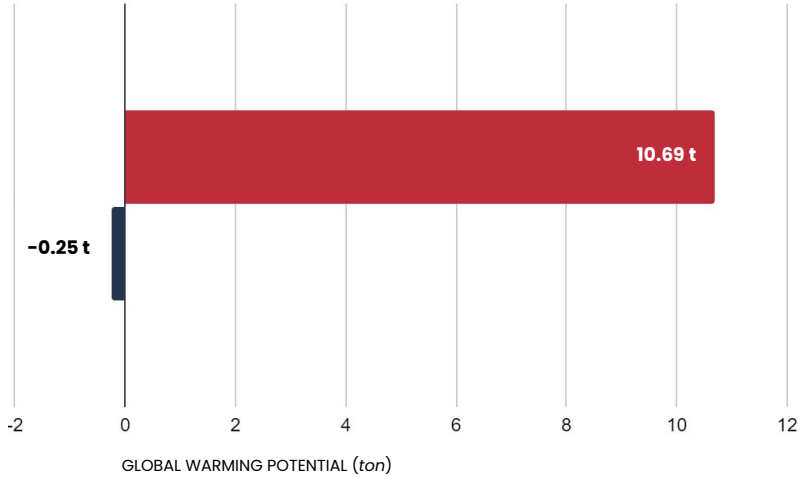
Volume = **9.72 m³** **x** Density = **2500 kg/m³** **=** Total weight ~ **24,300 kg**

Embodied energy = 4.8 MJ/kg
Total embodied energy = 116,640 MJ

GWP = 0.44 kg/kg
Total GWP = 10.69 t

**0.25%**
**of total EE from traditional materials**

**0.25%**
**of total GWP from traditional materials**




**MATERIAL -** Mud plaster.

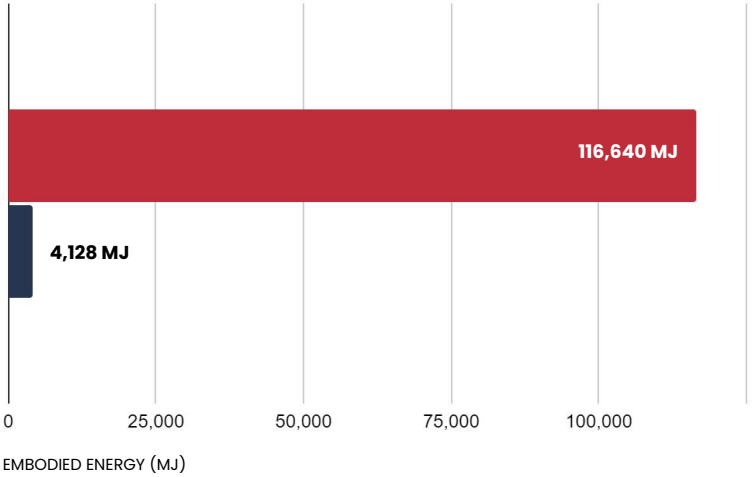
Volume = **9.72 m³** **x** Density = **885 kg/m³** **=** Total weight ~ **8,600 kg**

Embodied energy = 0.48 MJ/kg
Total embodied energy = 4,128 MJ

GWP = -0.029 kg/kg
Total GWP = -0.25 t

**0.07%**
**of total EE from green materials**

**-0.09%**
**of total GWP from green materials**



# GLASS

**MATERIAL -** Float glass (single-glazed).

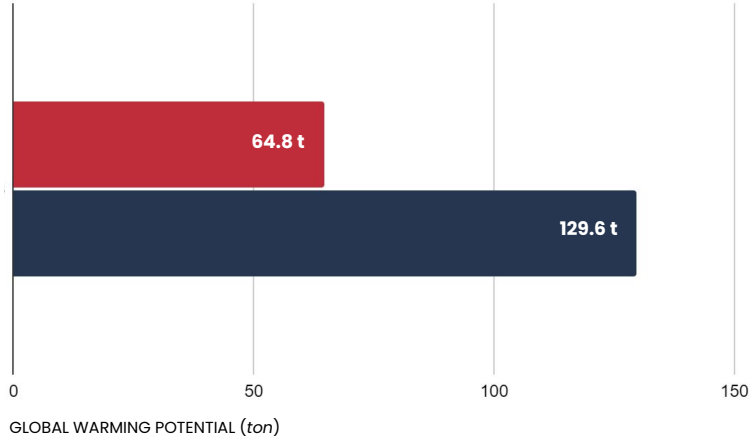
Volume = **21.6 m³** **x** Density = **2500 kg/m³** **=** Total weight ~ **54,000 kg**

Embodied energy = 17 MJ/kg
Total embodied energy = 918,000 MJ

GWP = 1.2 kg/kg
Total GWP = 64.8 t

**1.95%**
**of total EE from traditional materials**

**1.48%**
**of total GWP from traditional materials**




**MATERIAL -** Float glass (double glazed).

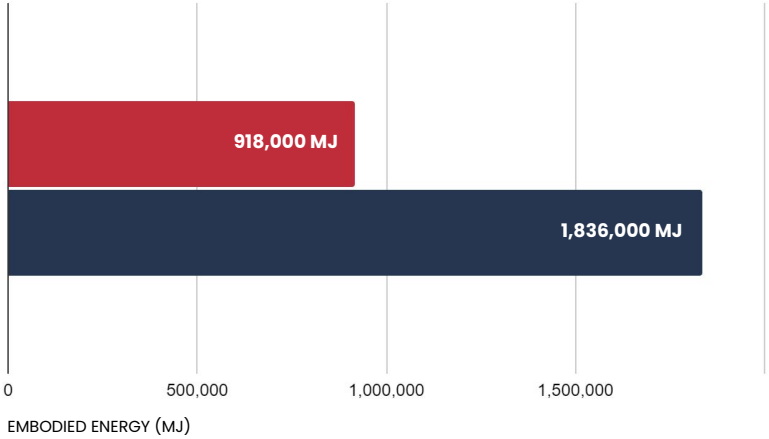
Volume = **43.2 m³** **x** Density = **2500 kg/m³** **=** Total weight ~ **108,000 kg**

Embodied energy = 17 MJ/kg
Total embodied energy = 1,836,000 MJ

GWP = 1.2 kg/kg
Total GWP = 129.6 t

**33.58%**
**of total EE from green materials**

**47.65%**
**of total GWP from green materials**



# WINDOW FRAME

**MATERIAL -** Aluminium extruded profile (window frame).

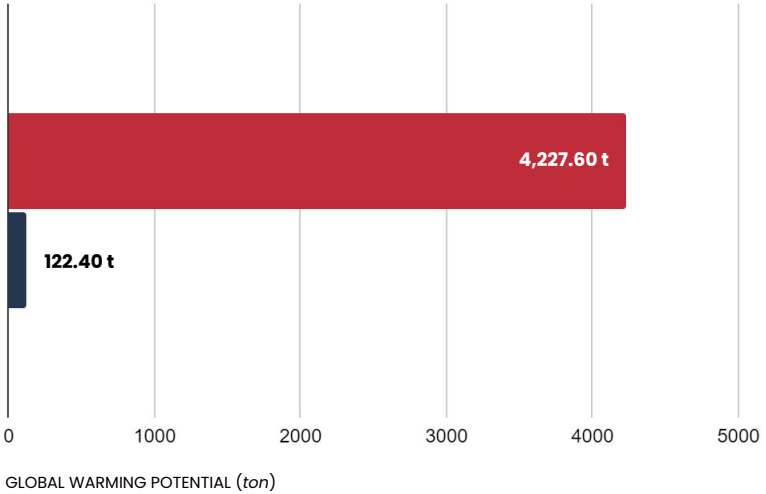
Volume = **60 m³** **x** Density = **2710 kg/m³** **=** Total weight ~ **162,600 kg**

Embodied energy = 280 MJ/kg
Total embodied energy = 45,528,000 MJ

GWP = 26 kg/kg
Total GWP = 4,227.60 t

**96.50%**
**of total EE from traditional materials**

**96.83%**
**of total GWP from traditional materials**




**MATERIAL -** Timber window frame.

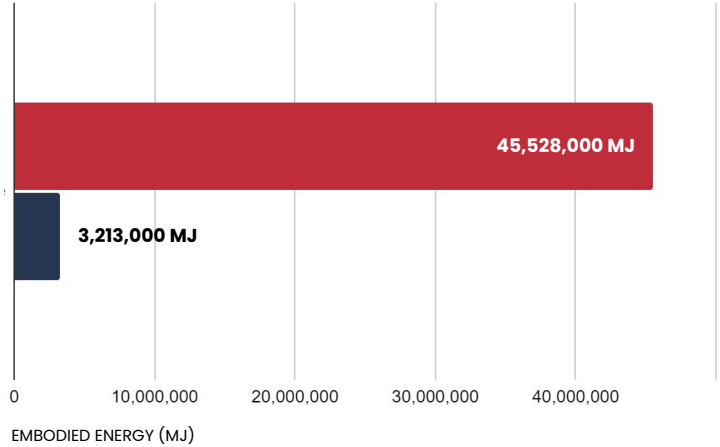
Volume = **60 m³** **x** Density = **850 kg/m³** **=** Total weight ~ **51,000 kg**

Embodied energy = 63 MJ/kg
Total embodied energy = 3,213,000 MJ

GWP = 2.4 kg/kg
Total GWP = 122.40 t

**58.69%**
**of total EE from green materials**

**44.8%**
**of total GWP from green materials**



# FLOORING

**MATERIAL -** Stone floor tile.

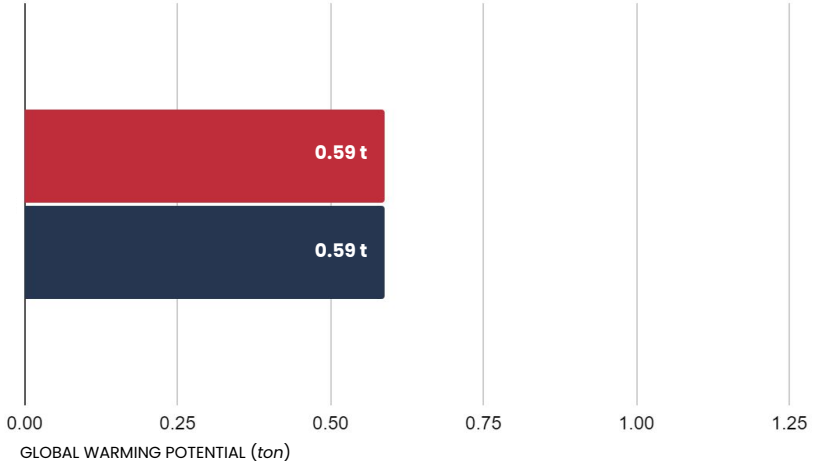
Volume = **4.2 m³** **x** Density = **2500 kg/m³** **=** Total weight ~ **10,500 kg**

Embodied energy = 0.44 MJ/kg
Total embodied energy = 4,620 MJ

GWP = 0.056 kg/kg
Total GWP = 0.59 t

**0.01%**
**of total EE from traditional materials**

**0.01%**
**of total GWP from traditional materials**




**MATERIAL -** Cement mortar.

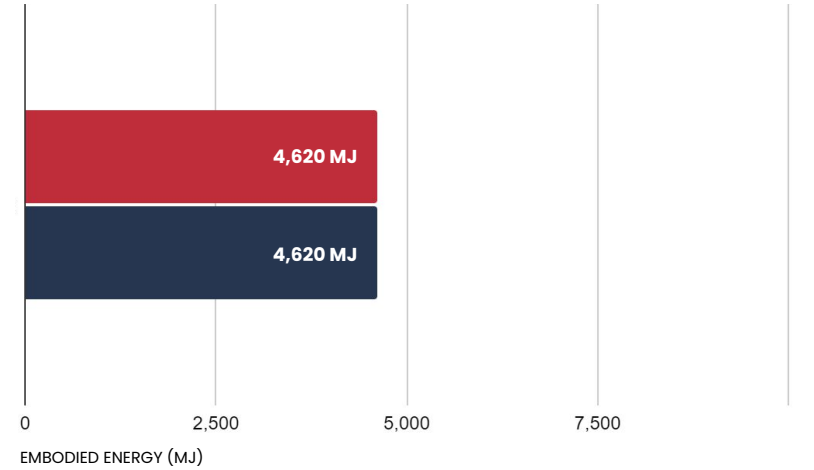
Volume = **4.2 m³** **x** Density = **2500 kg/m³** **=** Total weight ~ **10,500 kg**

Embodied energy = 0.44 MJ/kg
Total embodied energy = 4,620 MJ

GWP = 0.056 kg/kg
Total GWP = 0.59 t

**0.08%**
**of total EE from green materials**

**0.20%**
**of total GWP from green materials**



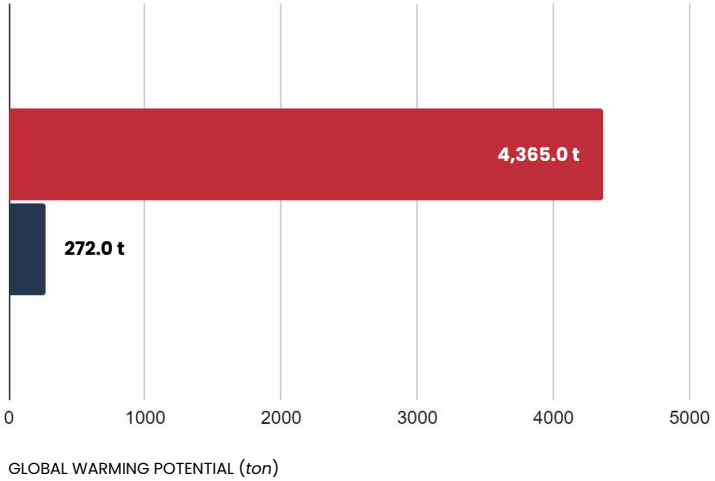
# SUMMARY

We can clearly see that the green materials are bringing substantial change to the Global Warming Potential and Embodied energy.

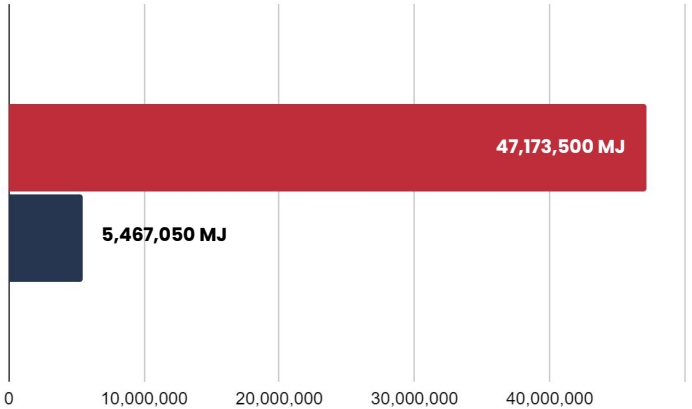
**93.8%** reduction in GWP

**88.5%** reduction in embodied energy

Let's calculate what it takes to offset all of this carbon.




GLOBAL WARMING POTENTIAL (*ton*)




EMBODIED ENERGY (MJ)

# CARBON OFFSET

Trees are the only practical means to offset carbon dioxide emissions. Since now we know how much carbon dioxide is emitted by the considered set of materials, let us calculate the number of trees and time it demands.

A large canopy tree can absorb carbon dioxide each year.

**22 kg**

**315 $m^2$** is the area covered by the tree. (*considering 10m radius*)

**TRADITIONAL MATERIALS**

| | |
|---|---|
| Number of trees required | = (4,365,000)/(22)<br>= **198,400 trees.** |
| Area for trees required | = 198,400 x 315<br>= **62,496,000 $m^2$.** |

**GREEN MATERIALS**

| | |
|---|---|
| Number of trees required | = (272,000)/(22)<br>= **12,360 trees.** |
| Area for trees required | = 12,360 x 315<br>= **3,893,400 $m^2$.** |

Let's see how many trees (*corresponding to time*) will it take to sequestrate all the carbon emitted.

# 1 YEAR

## TRADITIONAL MATERIALS

Area of the house. ×347,200

Area of Rashtrapati Estate. ×47

Area of Monaco. ×31

Area of Indira Gandhi International Airport. ×3

## GREEN MATERIALS

21,630× Area of the house.

3× Area of Rashtrapati Estate.

2× Area of Monaco.

0.2× Area of Indira Gandhi International Airport.

It’s the old new year.

# 500 YEARS

## TRADITIONAL MATERIALS

Area of the house. ×700

Area of Sydney Opera House. ×7

Area of Colosseum. ×6.2

Area of Buckingham Palace. ×1.5

## GREEN MATERIALS

44× Area of the house.

0.43× Area of Sydney Opera House.

0.39× Area of Colosseum.

0.1× Area of Buckingham Palace.

**Mughals have invaded India!**

# 2,500 YEARS

## TRADITIONAL MATERIALS

Area of the house. ×140

Base area of Eiffel Tower. ×17

Area of Parthenon. ×13

## GREEN MATERIALS

9× Area of the house.

1× Base area of Eiffel Tower.

0.75× Area of Monaco.

**You can meet Lord Buddha in person!**

# 4,500 YEARS

## TRADITIONAL MATERIALS

Area of the house. ×77

Area of Great Pyramid of Giza. ×68

## GREEN MATERIALS

5.3× Area of the house.

4.6× Area of Great Pyramid of Giza.

**The pyramids are under-construction.**

## 12,000 YEARS

**TRADITIONAL MATERIALS**

Area of the house. **×30**

**GREEN MATERIALS**

**1.4×** Area of the house.

**Neolithic age started! We will now grow crops.**

# CONCLUSION

We reached the neolithic age just to know that if we planted a large canopy tree (*which would not even fit into the site area of the house*) then, today it would have successfully sequestrated all the carbon emitted by **green materials.** (***assuming it stays alive for so long***)

Sure, the green materials are better relative to the traditional ones but their absolute potential towards climate change remains a matter of concern.


*Click on the image to visit the website.*