Composites in Construction - innovative architectural design

FRP Composites – Contribution to sustainable Building Concepts

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The severity of future climate changes will depend partly on how our plant's complex system responds and – more importantly –

on what choices we make!

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The severity of future climate changes will depend

on what choices we make!

Do we have choices to influence climate change?

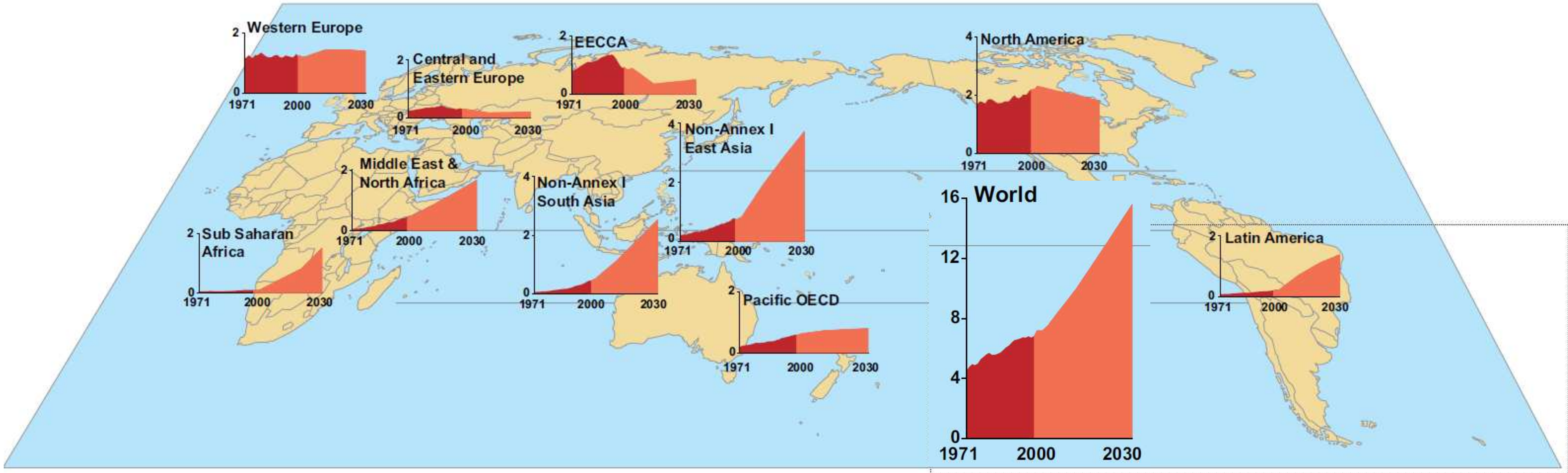
Is there a role for the Building Sector?

And how do FRP Composites come into play?

Climate Change

The contribution of Buildings

1. The anthropogenetic impact on climate change is a widely accepted scientific truth
2. The building sector contributes 30% of all global greenhouse gas emissions and consumes up to 40% of all energy.
3. Without additional efforts greenhouse gas emissions will double in the next 20 years



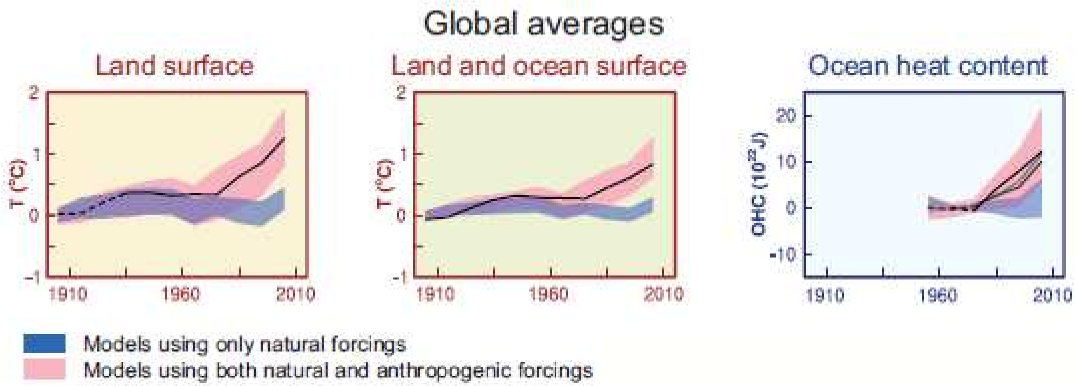
Buildings related CO2 emissions; IPCC 2007

OBESERVED CHANGES IN THE CLIMATE SYSTEM

1. Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased

DRIVERS OF CLIMATE CHANGE

1. Total radiative forcing is positive, and has led to an uptake of energy by the climate system. The largest contribution to total radiative forcing is caused by the increase in the atmospheric concentration of CO2 since 1750



Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system.

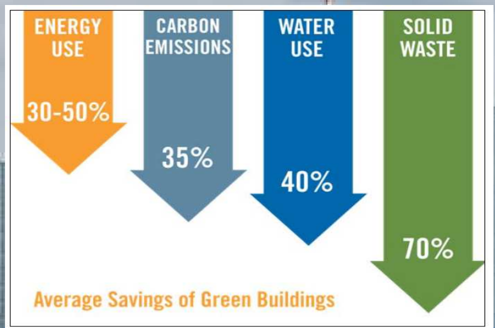
SOURCE: IPCC's Fifth Assessment Report (AR5); The Physical Science Basis – September 2013

Climate Change

The contribution of Buildings

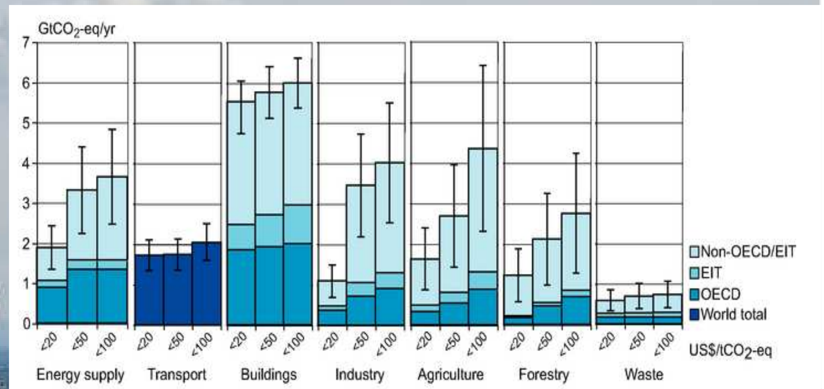
Buildings sector offers largest potential to mitigate antropogenetic environmental impact

The "Green Building" concept argues additional environmental benefits



Average savings of Green Buildings for hospitality venues; USGBC 2011

IPCC estimates an up to 80% GHG emission reduction potential just by use of current proven technologies



GHG emissions reduction potential by sector in 2030; IPPC 2007

LEED (Leadership in Energy and Environmental Design) provides third-party verification of green buildings. It addresses the entire lifecycle of a building by focusing on 6 crucial criteria: site location, water use, energy performance, materials and resources, indoor quality, and innovation & design

- 40 = minimum for certification
- 50 = silver certificate
- 60 = gold certificate
- 80 = platinum certificate

40 50 60 80

Climate Change

The contribution of Buildings

Most countries use regulatory instruments with legislation on energy efficiency in buildings
However, these policies have not resulted in an actual reduction in emissions.

It is *extremely likely* that human influence has been the dominant cause of observed warming since 1950, with the level of confidence having increased since the fourth report. **(IPCC AR5; 2013)**

Building codes implemented all over the world in 2005; United Nations Environment Program 2007

Climate Change

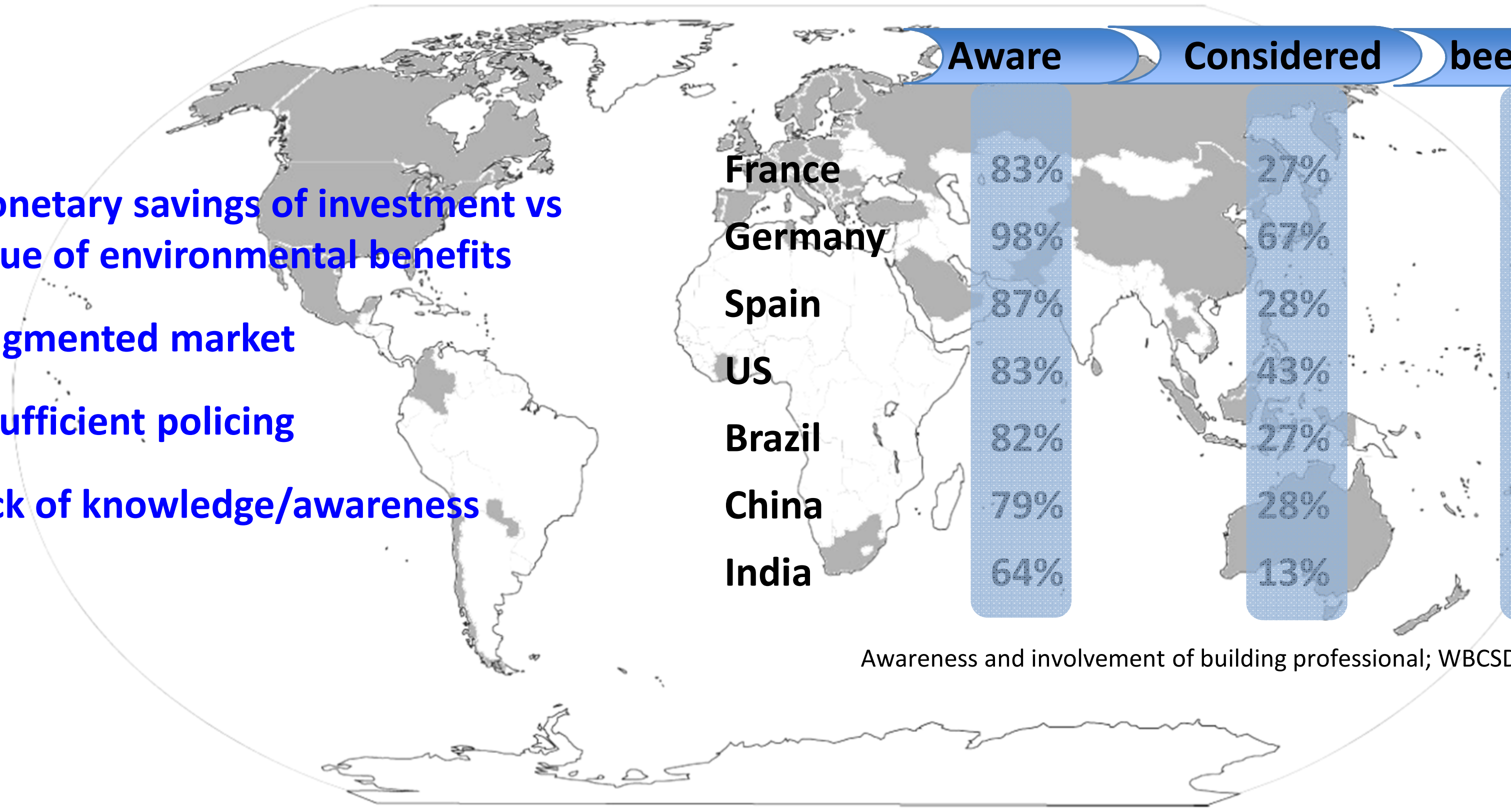
The contribution of Buildings

Barriers to possible emission reductions in the buildings sector:

"What is your level of awareness of sustainable buildings?

e.g.

- **Monetary savings of investment vs value of environmental benefits**
- **Fragmented market**
- **Insufficient policing**
- **Lack of knowledge/awareness**



	Aware	Considered	been involved
France	83%	27%	8%
Germany	98%	67%	45%
Spain	87%	28%	9%
US	83%	43%	16%
Brazil	82%	27%	9%
China	79%	28%	10%
India	64%	13%	5%

Awareness and involvement of building professional; WBCSD/UNEP 2007

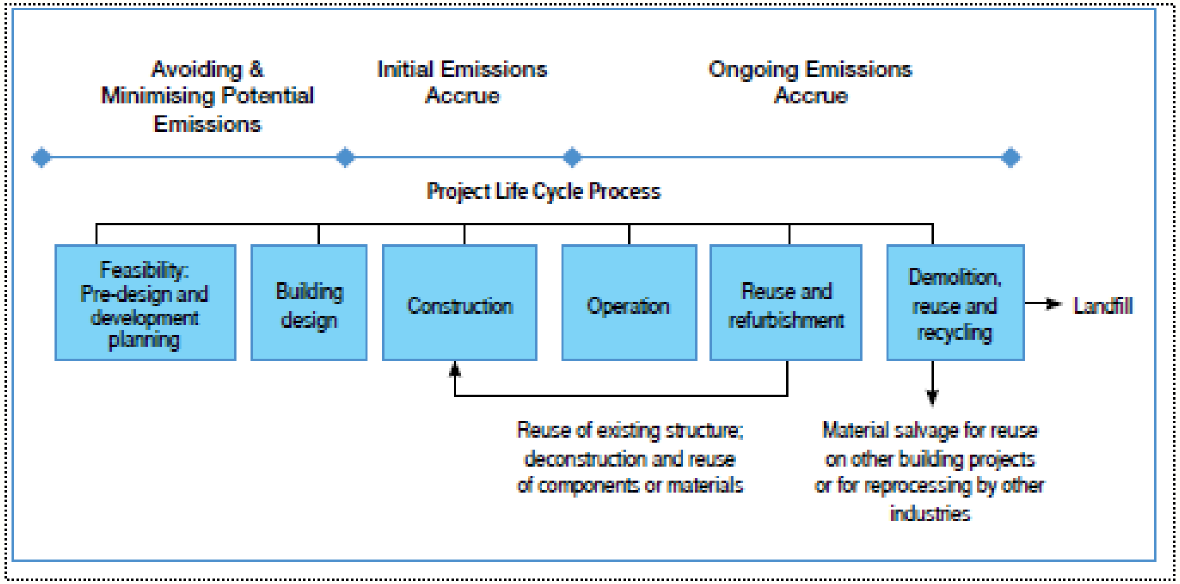
Climate Change

The contribution of Buildings

- ~ 80% of building related GHG emissions take place when operating the building, only ~20% are consumed during material production, transport and construction (Graham, 2003)

HOWEVER

- **Design, selected materials and quality of construction impact on energy use and emission levels during the operating phase**

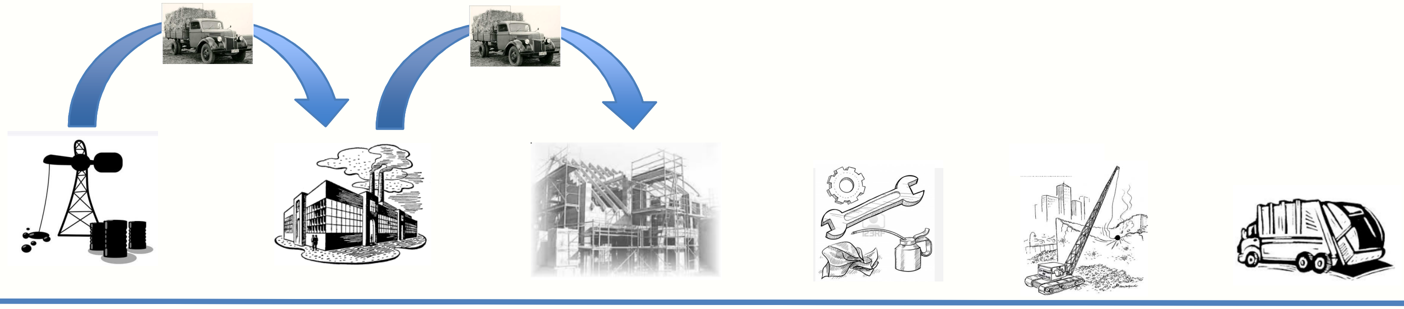


Life cycle phases of buildings; Graham, 2003

Sustainable Buildings

The cost of Composites

Life Cycle



Total Cost = Raw Materials and Manufacturing **+** Construction and Installation **+** Operation and Maintenance **+** Replacement and End of Life

- Composites can be More expensive to purchase → Raw Materials and Manufacturing
- Low weight means lower transport and installation cost → Construction and Installation
- Less Maintenance and repair work and cost → Operation and Maintenance
- Durability means less replacement cost → Replacement and End of Life

Sustainable Buildings

The REAL cost of Buildings

- The TOTAL COST OF OWNERSHIP differs from the TOTAL COST TO SOCIETY.
- Our economic systems uses cost/price/ demand relations to steer the allocation of limited resources
- Not considering “negative externalities” does result in market failures and creates unsustainable structures

TOTAL COST

=

SOCIAL COST

- **Agricultural productivity**
- **Health**
- **Property risks**
- **Ecosystem services**

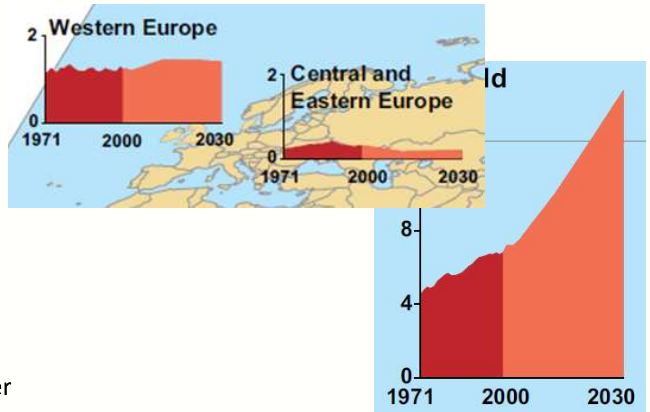
+

DIRECT COST OF BUILDING

- **Operation & maintenance**
- **Construction & Installation**
- **Products & Materials**

	Discount Rate	
Year	5%	3%
2020	$7,00	$26,00
2030	$10,00	$33,00
2040	$13,00	$39,00
2050	$16,00	$45,00

Present Social Cost of Carbon by 2050 - for Regulatory Impact Analysis Under Executive Order 12866; United States Government, 2010



- In 2007 European construction activities generating an estimated EUR 562 billion of value added (Eurostat; 2009)
- Corresponding Cost of CO2 emissions alone is € 78 Bio or 14%
- Until 2030 additional 7GtCo2 global emissions will create social cost of € 177 Bio

Sustainable Buildings

The REAL cost of Buildings

- Investment decisions are based on total cost of ownership and payback period
- Policy makers need to provide inventive to promote sustainable buildings (eg US Energy Policy Act 2005)
- Measurement Systems to size the incentive are available

TOTAL COST

=

SOCIAL COST

+

DIRECT COST OF BUILDING

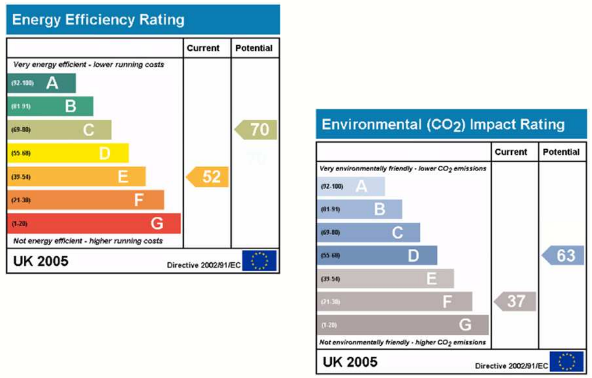
- **Agricultural productivity**
- **Health**
- **Property risks**
- **Ecosystem services**

- **Operation & maintenance**
- **Construction & Installation**
- **Products & Materials**

- **Agricultural productivity**
- **Health**
- **Property risks**
- **Ecosystem services**

INCENTIVES

- **Operation & maintenance**
- **Construction & Installation**
- **Products & Materials**



QSAS
QATAR SUSTAINABILITY ASSESSMENT SYSTEM

Climate Change

Towards green or SUSTAINABLE buildings

1. ***"Obtain commitment** from legislature, utility commission, or other body*
2. ***Evaluate existing building energy code** and other laws and options for implementation and **enforcement***
3. *Involve key stakeholders and assess their support early*
4. *Use sound economic and environmental quantitative analysis – determine cost-effective achievable potential for energy efficiency*
5. *Start with low-cost well established programs, lighting for instance*
6. ***Set annual and cumulative targets** using analysis and stakeholder input, e.g., % of base-year energy sales*
7. *Establish a long-term frame to overcome market and funding cycles*
8. *Ensure that **workable funding methods** are available to meet EEPS target*
9. *Take care to select the most appropriate entities responsible for program implementation and/or meeting the target and the procurement rules they must follow*
10. *Assess **training needs and other forms of technical support** for code officials, builder associations, building supply organizations, auditors, etc.*
11. *Contact material and equipment suppliers to **ascertain availability of code compliant products."***

Following the analysis of energy efficiency technologies and policies respectively their success of implementation in USA, India and other countries SATHAYE at al (2006) recommend 11 principles to be followed for the implementation of such efficiency programs

s ;

Sathaye et al. 2006

Climate Change

Sustainable Building Materials – FEF Insulation

Open cell fiber insulation

Humidity intake at seams/damaged cladding: performance loss; corrosion under insulation

Closed cell elastomeric foam

Reliable long-term performance with consistent insulation properties

ELASTOMERIC FOAM SAVES:

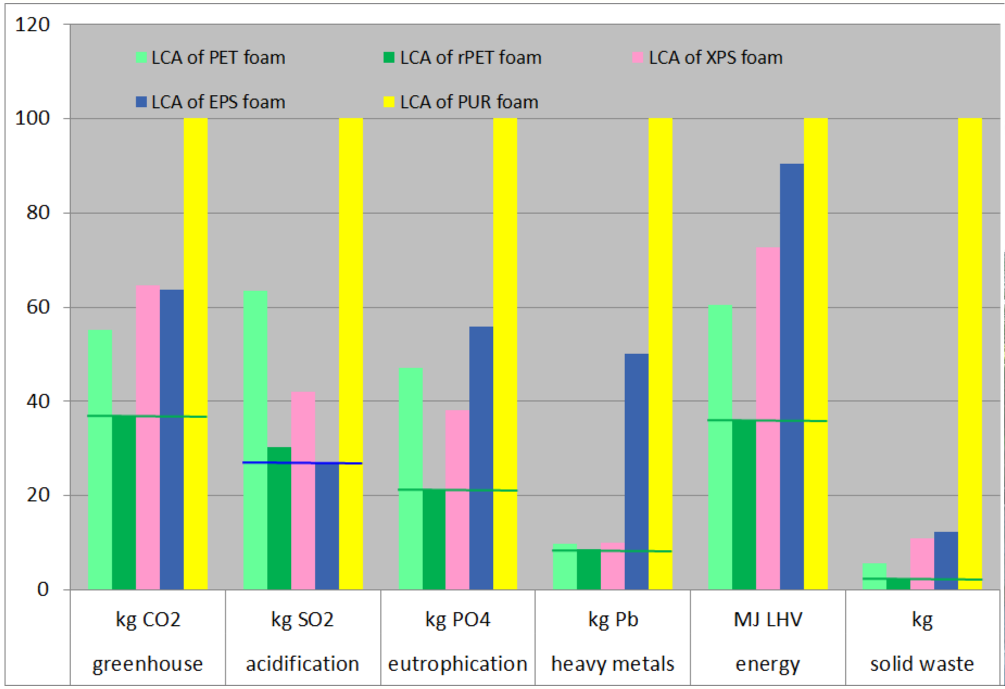
150 x CO_2 emitted during production

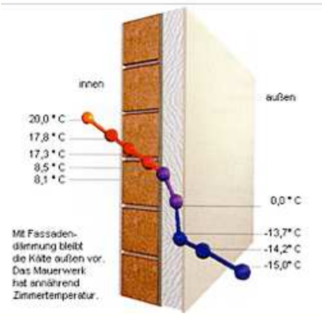
140 x energy consumed during production

Over 20yrs period

Climate Change

Sustainable Building Materials – Polymeric Sandwich Composites





- Closed cell Polymeric Foam Insulation as core in External Thermal Insulation Composite Systems (ETICS) have better long term performance compared to fiber based products
- PET and in particular **rPET has lowest environmental impact** compared to other Core Foam Materials in sandwich composites
- FRP Sandwich Composites compare positively with traditional building materials in LCA studies

Sustainable Buildings

The contribution of FRP Composites

Haydar Aliev Cultural Centre in Baku, Azerbaijan. 18,000m2 panels; 50 yr building life span

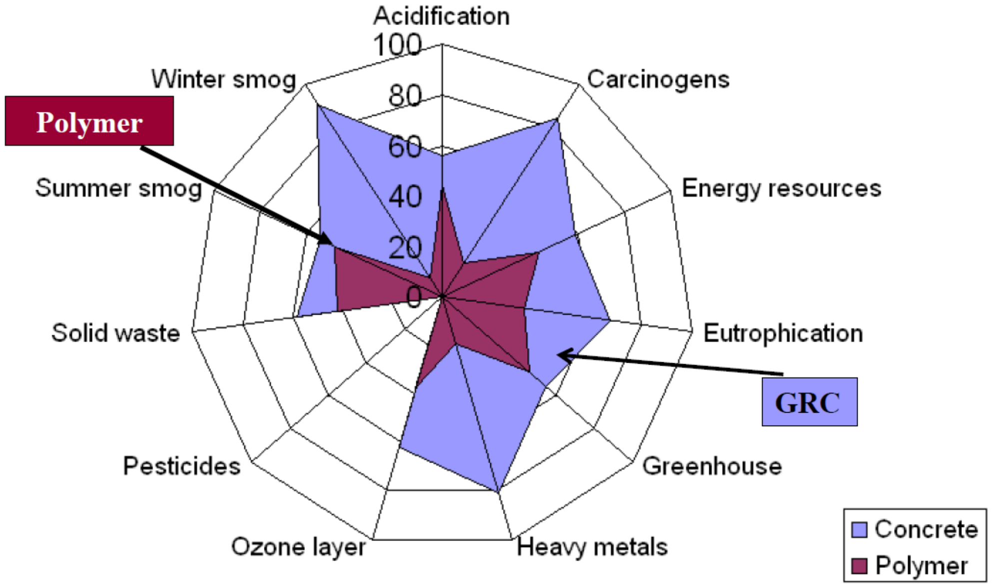
Glass-reinforced Polymer

versus

Glass-reinforced Concrete

Study performed by: Prof. Lepech,

Civil and Environmental Engineering, Stanford University



Sustainable Buildings

The contribution of FRP Composites

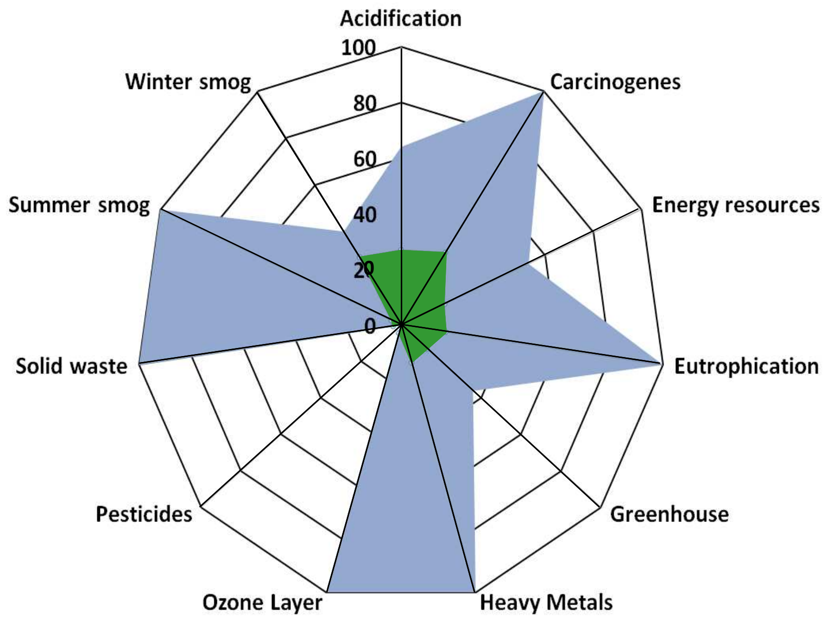
Replacing limestone cladding panels with FRP panels on the Public Health Services Hospital in San Francisco's Presidio Park.

FRP Panels

versus

Limestone Façade

Study performed by: Stanford University;
Stanford CEE 226: Life Cycle Analysis Project



Sustainable Buildings
The contribution of FRP Composites

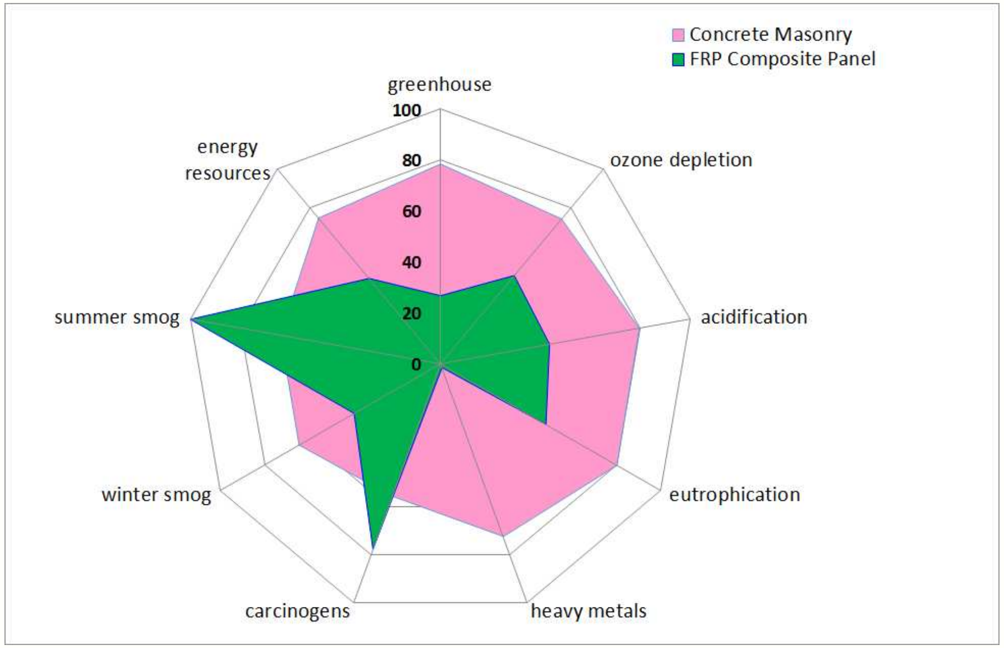
Environmental impact of FRP Composite panel based composite shelter compared to same size build of concrete masonry.

FRP Composite Panels

versus

Concrete Masonry

Life Cycle Assessment of Composite Material Homes for Disaster Areas
Prof. M. Lepech et al.; Stanford 2010



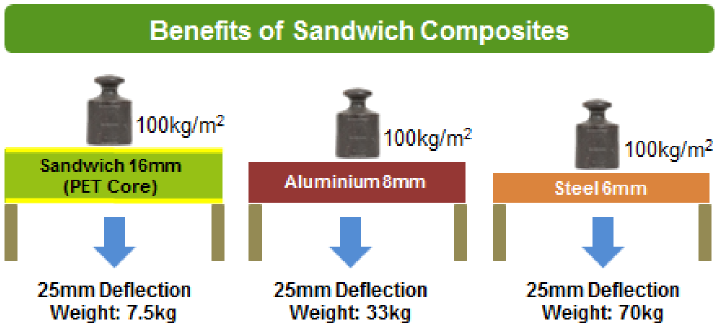
Thermal Renovation of Buildings

Using polymeric foam composites

- Renovating existing building structures with an ETICS System (External Thermal Insulation Composite System) improves thermal efficiencies substantially
- For a 4 story building with 2000 sqm ground floor it would take 3 weeks for a team of 5 to install common ETICS systems
- To reduce disturbance of residents a pre-fabricated one shot façade element (including openings for doors and windows) is under development for a 110 000 Houses refurbishment project Netherlands

Renovation of Buildings

Using polymeric foam composites



- Weight savings up to 90% (compared to steel) and 77% (Aluminium) at same strength (deflection)

- Light weight combined with structural strength and low thermal conductivity make PET cored Sandwich an innovative product to be considered as solution for projects in Building and Construction
- Using post-consumer recycled PET helps to reduce plastic debris and has a very low carbon footprint
- Lightweight composite structure might be acceptable as rooftop penthouse under load considerations for the existing structure

Innovative Building Solutions

Using PET foam composites

Under Design: Al Wakhra Stadium, Qatar; Thermal and Structural; (Zaha Hadid)

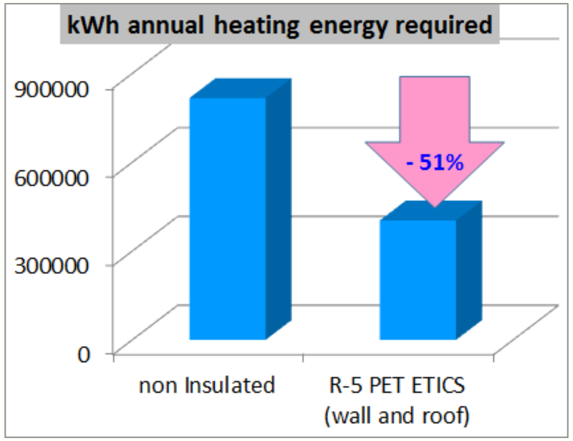
Completed: Al Haramain Railway Station KSA; 15.000 cbm; structural and thermal requirements (Foster)

Delivering: Façade Cladding World Trade Center Riyadh, KSA ; Structural and Decorative (Permasteeliza)

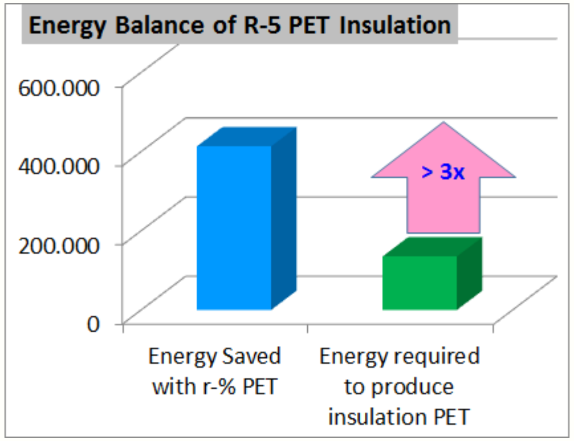
Thermal Renovation of Buildings

Using PET ETICS System

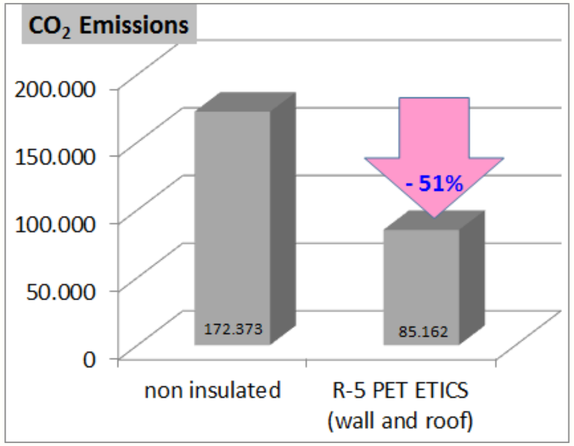
- 4 storey building; 48 flats;
- Stone on stone;
- Inside 13mm Gypsum Board with 10mm EPS
- 15% window etc opening
- 5000 Heating Degree Days



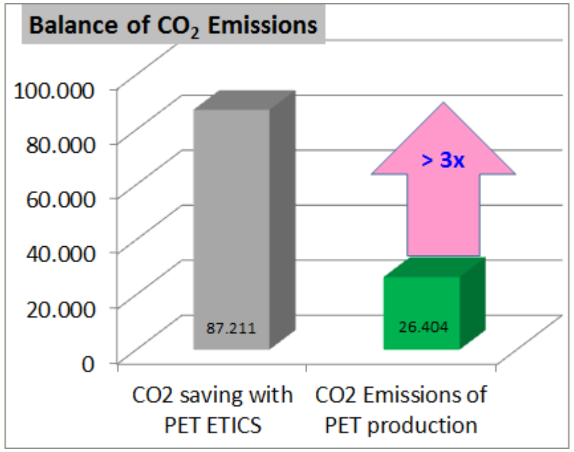
... reduces the energy bill by 51% per year



... Saves 3 times the energy used for production



... reduces CO2 emissions by 51% per year



... Saves 3 times emissions of production

Saving effects of only 1 year !

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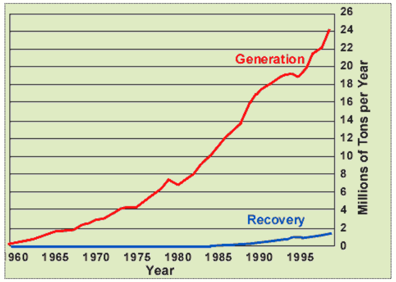
FRP a durable composite

… and durable waste



Global Plastic production and recovery

Plastic on Kamilo Beach, Hawaii

Albatross with belly full of plastic

- About 300 million tons of plastic is produced globally each year.
- Only about 10 percent of that is recycled.
- Seven million tons ends up in the sea each year. Where it breaks down into smaller and smaller fragments over the years and accumulates with toxic effect in the food chain
- Fish in the North Pacific ingest as much as 24,000 tons of plastic debris a year (Bisphenol A, Metals, Phthalates, Brominated Flame retardants; …)
- PET has a higher recycling rate: ~ 30% in the USA and ~ 50% in Europe

WE NEED TO
Improve our technologies for plastic recycling
Develop collection systems to increase the recycling rate

Armacell *"green"* PET

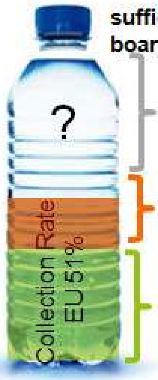
From Waste to Value

Armacell have spent more than 3 years intensive research to develop a process technology that allows to produce consistent core foam qualities from 100% PET packaging waste

PET Waste as raw material base

4.300 t of coloured rPET bottles collected in Belgium p.a.

sufficient for 50.000 cbm of PET foam boards



- 49% end up on landfills or waste our oceans
- Coloured bottles; go mainly to incineration or landfill because of impurities; > 100.000t
- Recycled to new bottles (clear, light blue PET)

New patented Armacell technology

Armacell has developed a technology (patent filed in 2011) able to recycle coloured rPET bottles to a valuable PET foam product

1. Post-consumer PET bottles as collected by waste management companies
2. The bottles have been cleaned and chipped down to PET flakes – still high amount of impurities
3. Flakes are granuled with special technology to homogenize properties and reduce impurities
4. PET Board with normal properties produced from recycled PET Granules

10 kg Insulation Foam from recycled PET …

--- can reduce CO2 emissions by an amount that is emitted by a midsized car driving 70km

… can safe enough energy to cook 23.500 cups of coffee

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