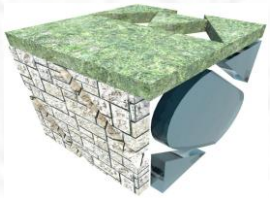
MODULE 1

GENERAL PRINCIPLES OF HOLISTIC BUILDING AND CONSTRUCTION DESIGN

Training for Sustainable Building

Vocational Training Modules for the Natural Energy Efficiency and Sustainability (NEES) Project



University of ULSTER

Umeå University

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

GCU
Glasgow Caledonian University

ARCTIC TECHNOLOGY CENTRE

THE NEES PARTNERS

SOUTH KERRY DEVELOPMENT PARTNERSHIP LTD.

Northern Periphery Programme
2007-2013

European Union
European Regional Development Fund

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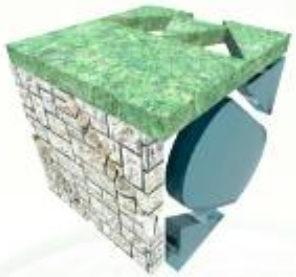

Where can I get more information on NEES?

If you wish to find out more about the NEES Project, please check our comprehensive Web Site, contact your NEES regional rerpesentative or the NEES Project Manager at the address below.

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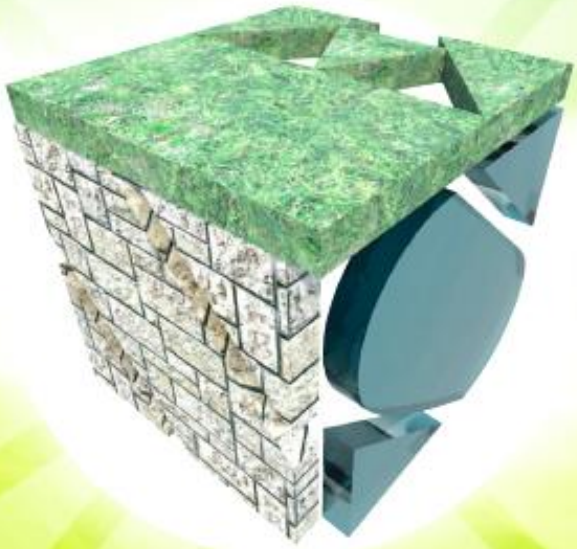
Northern Periphery Programme
2007–2013

Innovatively investing in Europe's Northern Periphery for a sustainable and prosperous future

European Union
European Regional Development Fund



Natural - Energy Efficient - Sustainable

NEES PROJECT

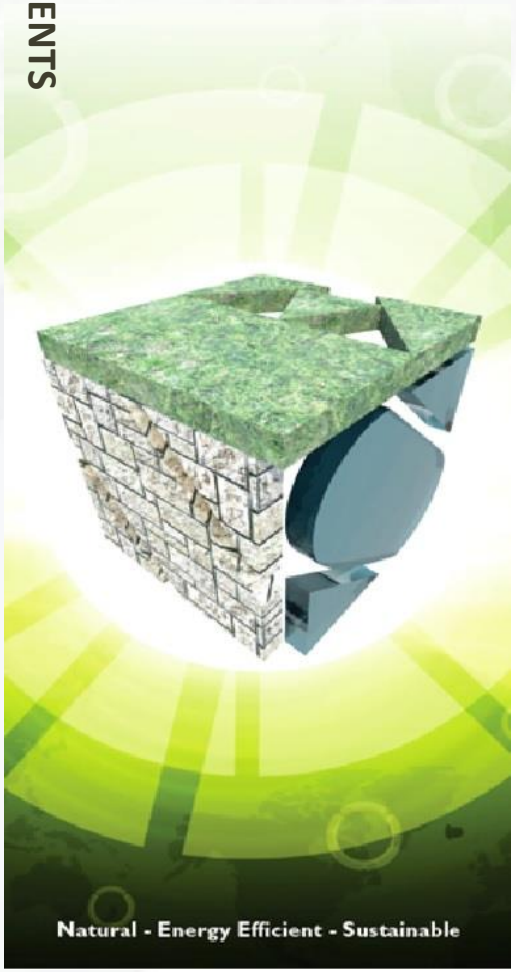
NATURAL ENERGY EFFICIENT SUSTAINABLE

VOCATIONAL TRAINING MODULES

Module 1

General principles of holistic building and construction design

CONTENTS



1.0 General principles of whole house holistic building.

ECOLOGICAL DESIGN

following the NEES Principles using Natural, Renewable Materials

1.0 Introduction

NEES Training materials.

Training manual Principles of sustainable design and defining and identifying renewable materials

Module 1 General Principles of holistic design

Module 2 Housing Construction Methods and principles

Module 3 House Envelope 1 Roofs and Earth construction

Module 4 House Envelope 2 Windows and natural Insulation

Module 5 Certification and accreditation

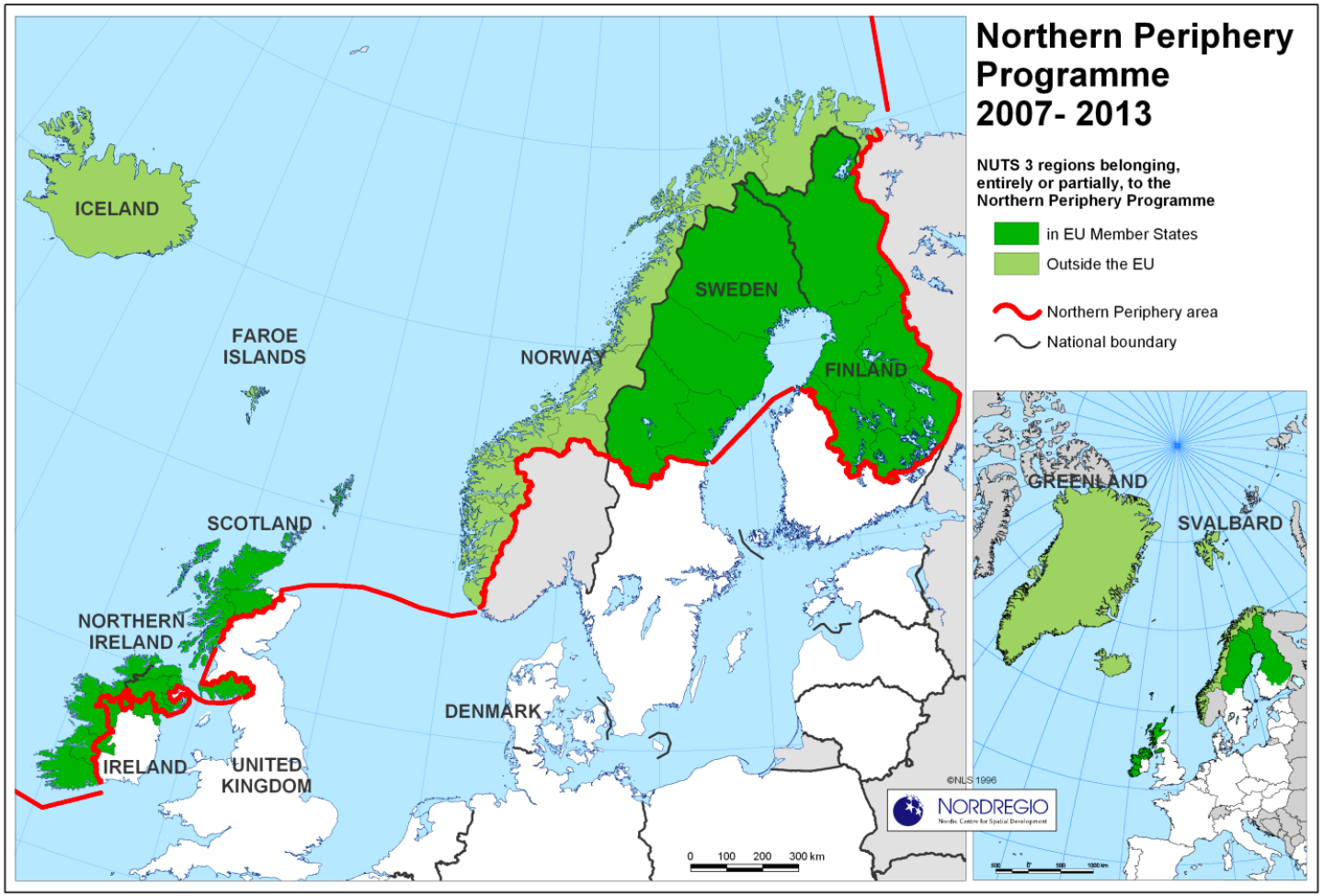
Module 6 Energy and Water usage

1.1. The NEES Mission – Principles

To accelerate the transformation to a sustainable built environment and society, by championing the understanding and use of ***demonstrably*** *sustainable building products.*

Details of these criteria are set out in the document NEES Criteria

THE NEES PROJECT EXAMINED OPPORTUNITIES IN THE NPP AREA



THE NEES CRITERIA ARE ABOUT ..

Promoting a **products and materials agenda** so that their performance and impacts becomes an essential cornerstone of good design.

Encouraging a **step change** in the understanding, identification, specification and use of sustainable building products.

Promoting a new **business models and approaches** to ensure that product and material sustainability is optimised and delivered in reality.

NEES Principle

- * '**NATURAL**' is defined as being non-fossil fuel derived material(s) that do not require significant and / or energy intensive processing prior to fabrication or recycled / reused material(s) that meet the above criteria.

- Examples of qualifying materials are wood, wool, stone, and hemp.

- See Training Manual Section B Identifying renewable and non renewable materials

1.2 Sustainable materials principles and criteria

- Natural (see Defining renewable materials document)
- (1.3) Embodied Energy
- (1.4) Carbon footprint and LCA principles
- Health and Pollution
- Life Cycle Durability and Disposal

Natural and Renewable Materials

- Materials that are made from almost unlimited resources, either naturally occurring or recycled.
- Materials that are renewable can be grown again such as bio based materials such as wood or hemp
- Processing and additives should involve the use of minimal petrochemical resources

Natureplus is the leading European standard for natural and renewable materials.
Over 150 products are certified by Natureplus which comes closest to the NEES standard.
Products with the Natureplus label must pose no danger to health, be produced in an environmentally friendly manner, tested for their functionality.
Products must be made from a minimum of 85% renewable raw materials or mineral based materials that are almost unlimited in their availability

www.natureplus.org

natureplus
for better living

ABOUT NATUREPLUS

Natureplus is the only existing standard which rigorously applies minimal petrochemical and the unlimited resource standard

It has been operating in Germany, Switzerland and Austria since 2003 and is rapidly expanding into other European countries

While Natureplus certifies over 150 products it remains relatively marginal in terms of mainstream construction though it is supported by many large Industrial building material producers

While there are many other “green” labels and standards, these generally allow use of petrochemical resources, for example the BRE Green Guide (see module 5)

http://www.natureplus.org

From Natureplus web site

“Certification Criteria

The criteria and requirements for the awardance of the natureplus eco-label are laid down in the Awardance Guidelines.

Every building product awarded the eco-label must fulfil the requirements of the basic criteria, the product group criteria and (if applicable) those of its product category.

The numbering of the various criteria is organised hierarchically.

RL0000 Basic Criteria – These requirements apply to all products.

RL0100, RL0200 etc – These criteria apply to all products within this product group.

RL0101, RL0205 etc – These are product-specific criteria.

From Natureplus web site

“Certification Criteria

You will find all the current product certification criteria under the navigation links on the left-hand side of this page.

If a natureplus awardance guideline for your product doesn’t yet exist, enquire at the natureplus head office if a relevant awardance guideline is in preparation or whether a deadline has been set for the creation of such a guideline.

If you are explicitly interested in a certification, then it may be possible to bring forward the deadline for the creation of the relevant awardance guideline. As a natureplus member, you have the opportunity to take an active part in the definition/preparation of the awardance criteria.”

1.3 Embodied Energy

Why embodied energy is important

- The carbon footprint of materials and products are central to considering their sustainability. This requires an evaluation of embodied energy

- Mainstream industry frequently assumes that if a material or product contributes to energy efficiency that this alone is sufficient to claim that it is green, eco or sustainable

- The energy used to extract, process, manufacture, transport, package and install the product maybe greater than the energy it saves.

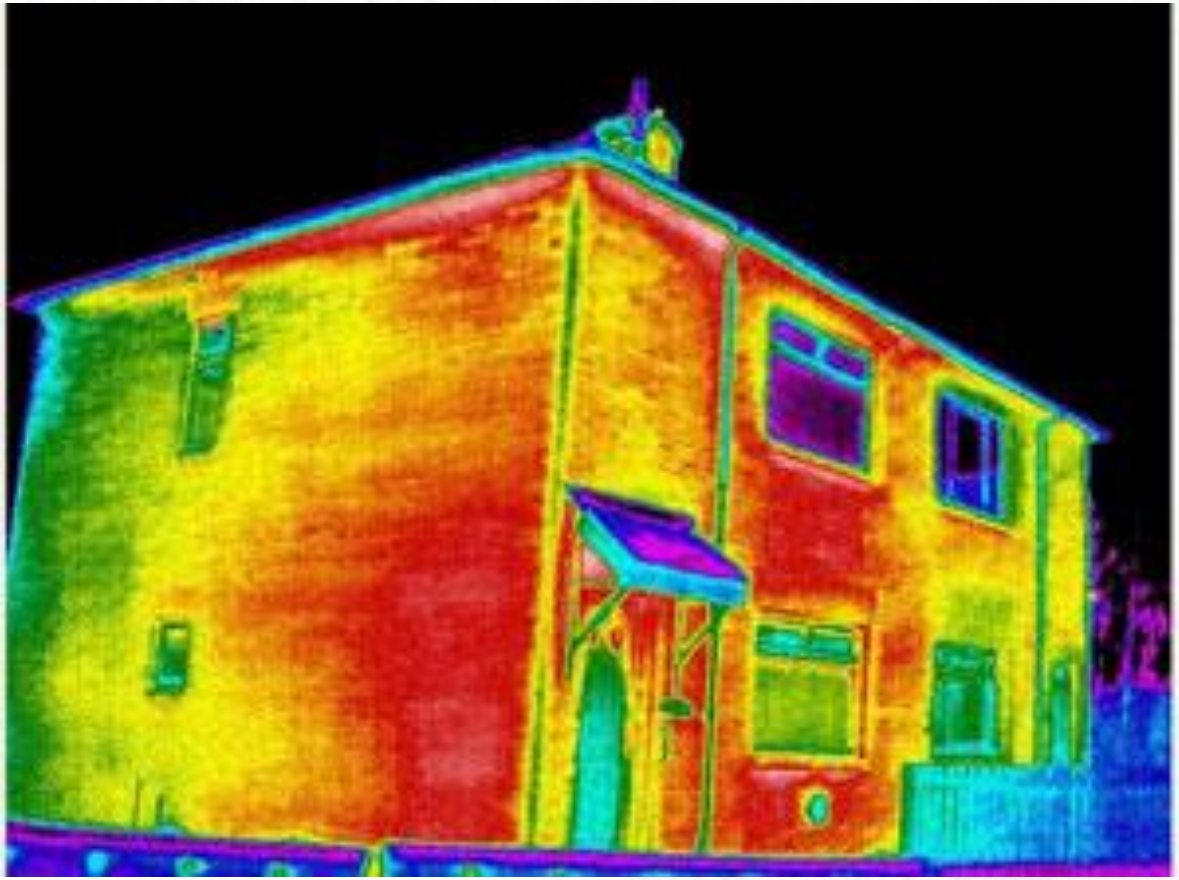
Understanding embodied energy

- The use of petrochemical resources in manufacturing products and then packaging, transporting and installing them can be measured. Petrochemical resources, once used, cannot be replaced and also contribute to CO2 emissions.

- When this resource consumption is measured we can express embodied energy in terms of CO2, oil or MegaJoules of energy used

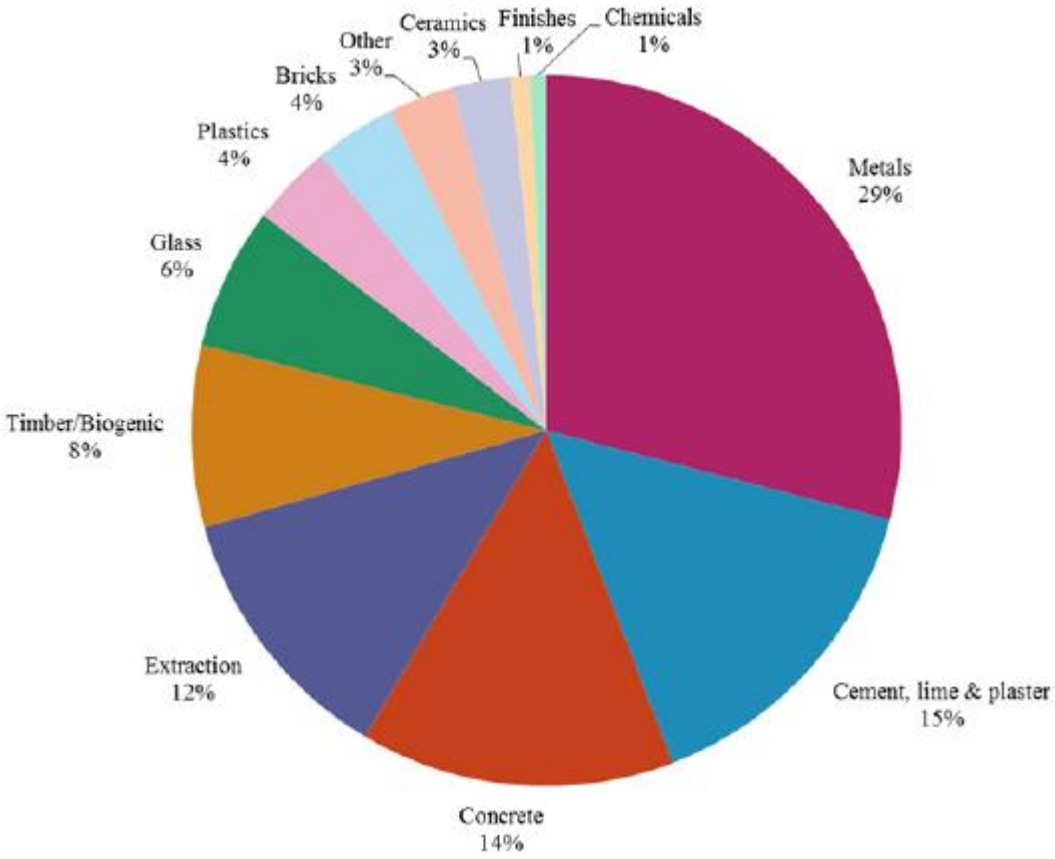
NEES aims to reduce dependence on petrochemical resources

Many professionals and Government policy makers are only interested in **energy efficiency** and **ignore embodied energy**



Carbon emissions from materials

Buildings and building material product are responsible for as much as 50% of all CO2 emissions



These figures are likely to be similar in other NPP areas

Carbon Emissions from UK construction by material
Ref. Green Construction Board (2013)

CURRENT EMBODIED CARBON EMISSIONS FROM UK CONSTRUCTION (2010)

33 $MTCO_{2E}$

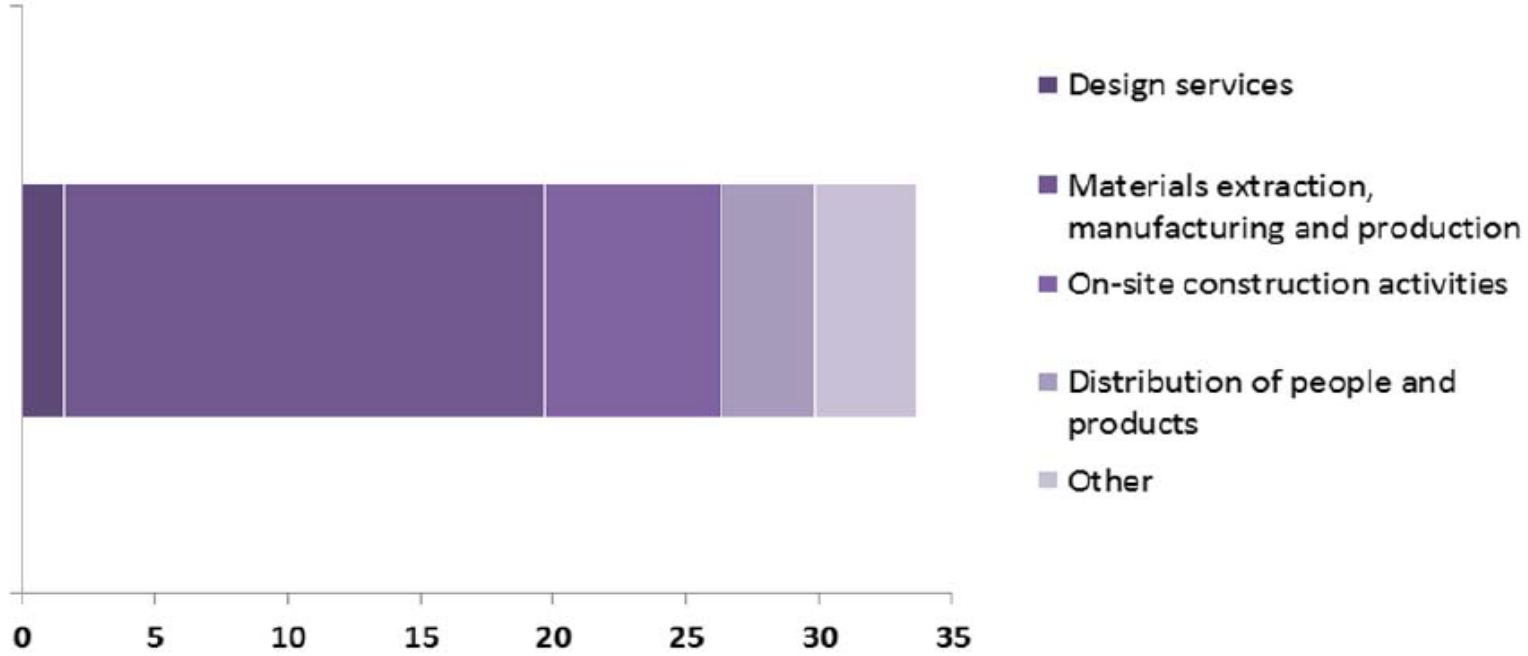
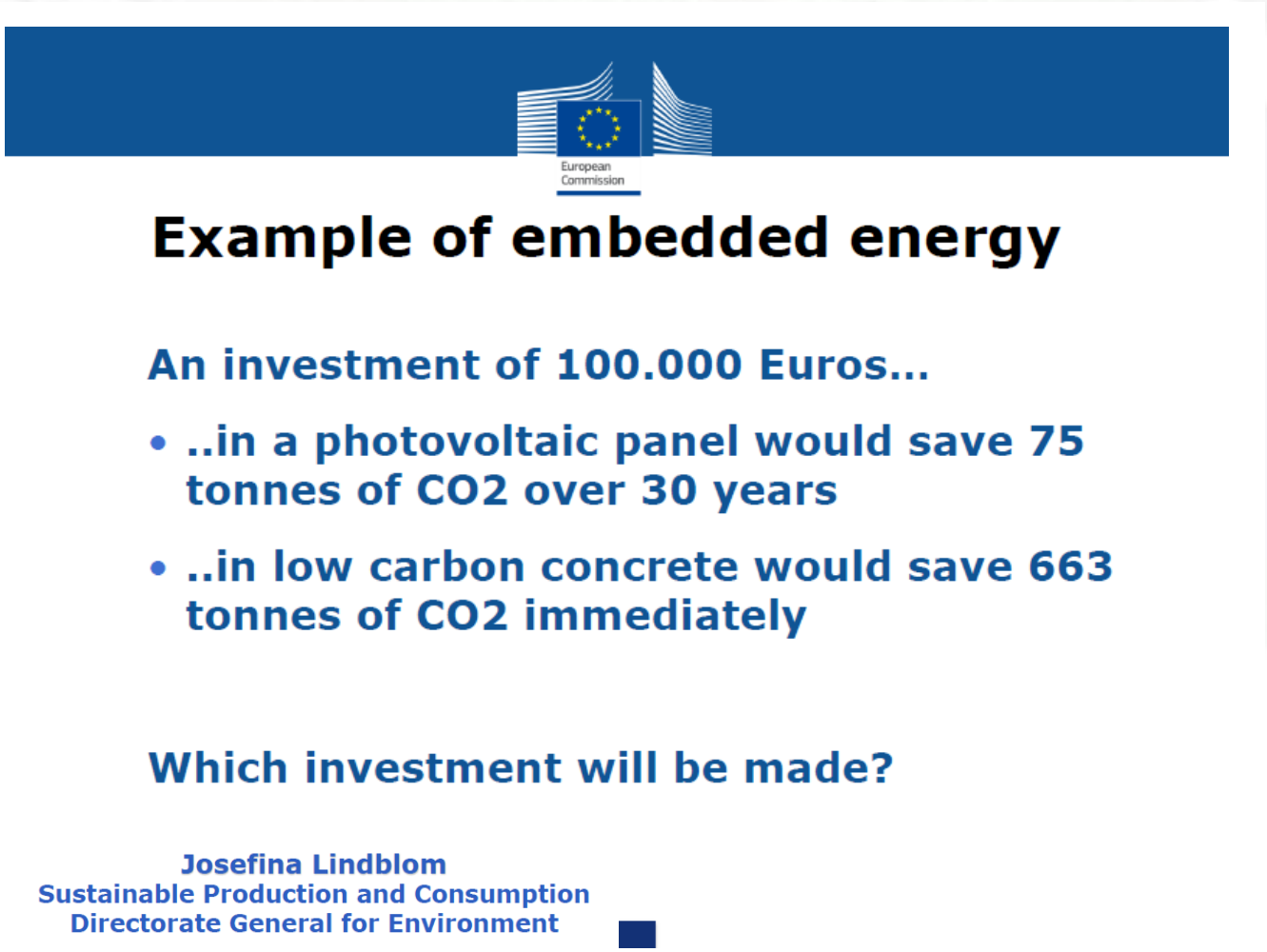


Figure 10: Capital carbon emissions in 2010 (MtCO2e)

Ref. Green Construction Board Roadmap (2013)

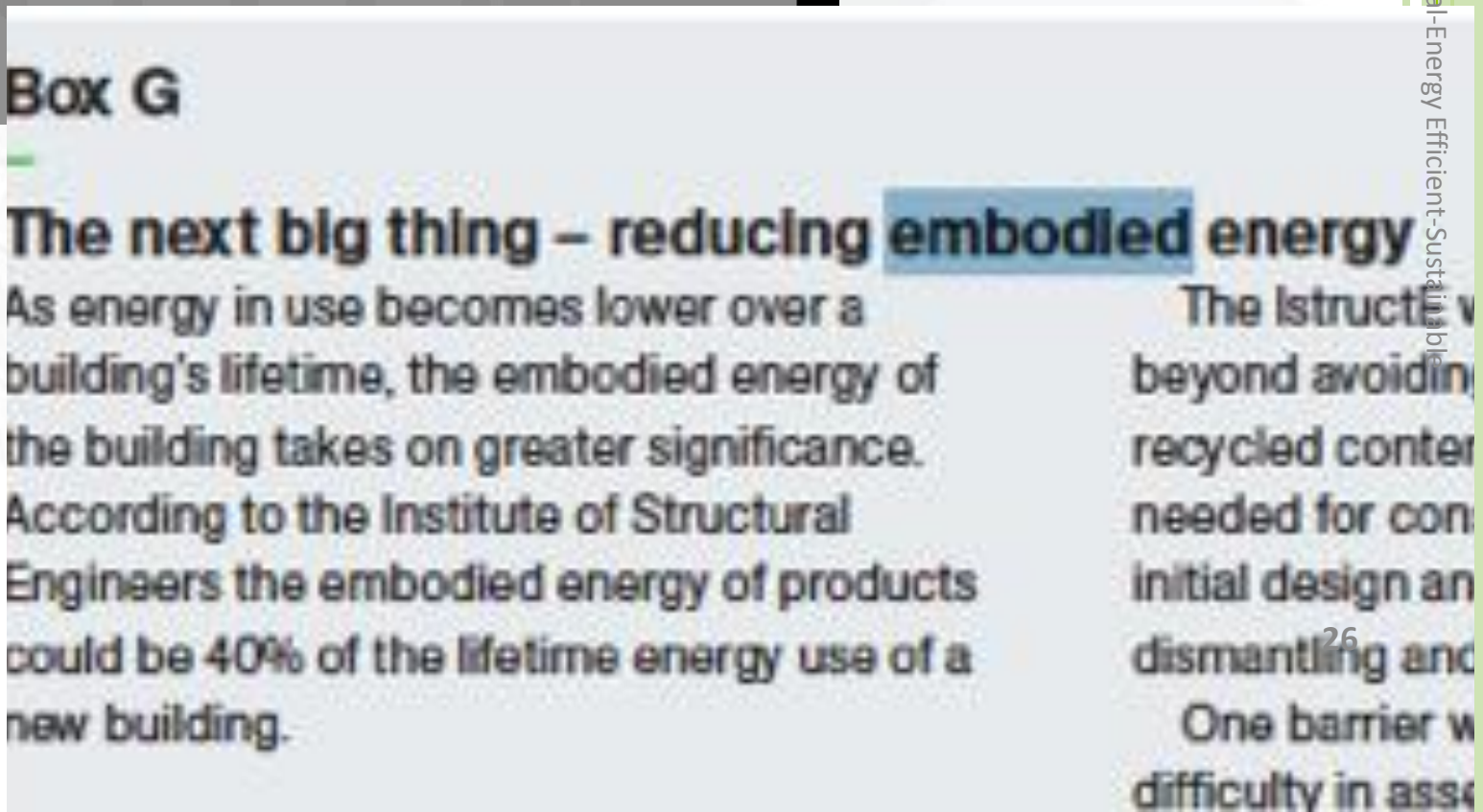
The EU has recognised the importance of embodied energy
This is from a presentation by Josefina Lindblom from EC DG Environment 2013



Re-energising the green agenda

Report from the Commission of Inquiry into Sustainable Construction and the Green Deal

From a report by the UK All Party Parliamentary Group on sustainable construction 2013



Box G

The next big thing – reducing embodied energy

As energy in use becomes lower over a building's lifetime, the embodied energy of the building takes on greater significance. According to the Institute of Structural Engineers the embodied energy of products could be 40% of the lifetime energy use of a new building.

The Istructe
beyond avoidin
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One barrier w
difficulty in asse

1.4 Carbon Footprint

- Carbon footprinting works out the total weight of materials in a building and calculates the embodied energy, life cycle impact and CO2 emissions

- If done during the design stage significant savings can be made through simple low impact specification choices

Embodied Energy (EE)

The total primary energy required to produce a material i.e. *MJ/Kg*

Global Warming Potential (GWP)

The metric adopted by the IPCC to assess Green House Gases

i.e. *$KgC0_2e$ in atmosphere over 100 years*

Embodied Carbon: positive GWP of material production – a function of energy generation

Sequestered Carbon: negative GWP of the Carbon stored in plant based renewable materials

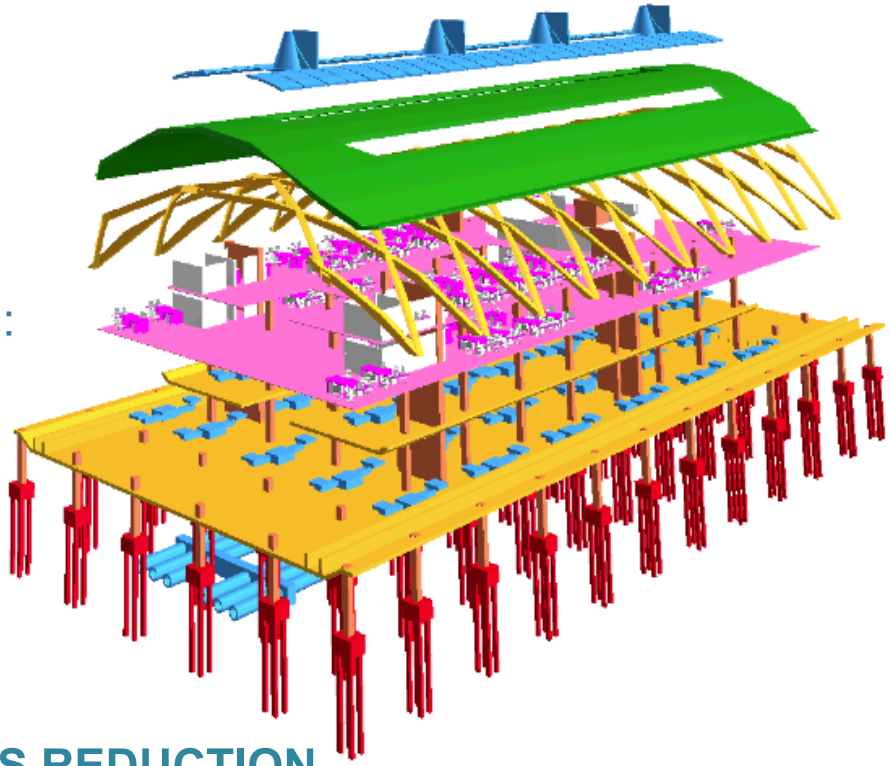
WWF HQ Embodied Energy case study
While largely using conventional materials CO2 emissions were reduced at the design stage

WWF CASE STUDY EXAMPLE (WHILE NOT IN NPP AREA THIS PROVIDES AN INDICATION OF HOW EMBODIED ENERGY HAS BECOME A CONSIDERATION)

New WWF HQ:

'Whole Life'
Embodied CO2e

ACHIEVEMENTS:



- **42% EMISSIONS REDUCTION**
- **5,400+ TONNES SAVING**
- **NO FINANCIAL COST**

sturgis carbon profiling™

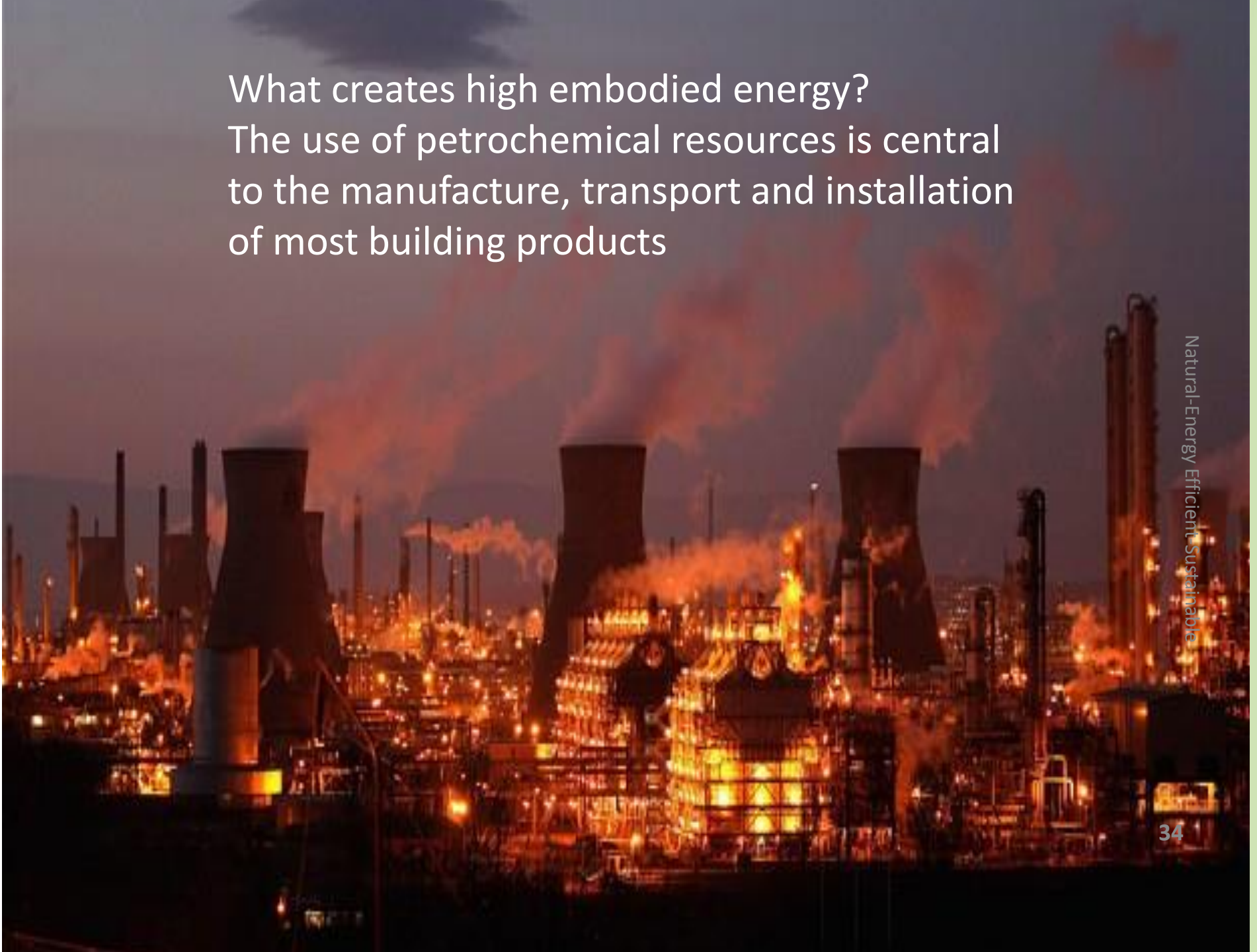
David Attenborough opens WWF building

WWF BUILDING SAVES 42% CARBON EMISSIONS WITHOUT USING ANY ECO MATERIALS PART FROM THE GLULAM BEAMS , ***WHAT COULD THEY HAVE ACHIEVED IF THEY HAD USED ALTERNATIVE MATERIALS RATHER THAN SO MUCH STEEL AND CONCRETE ?***

“…..what is most innovative in this building is completely invisible and didn’t cost a penny. Through a comprehensive carbon-tracking procedure led by Sturgis Carbon Profilng (SCP), the embodied carbon of more than 1,700 building components was measured. Brought in by the project manager at Stage C, SCP, together with contractor Willmott Dixon, delivered a remarkable 42 per cent reduction in the embodied carbon of the building at completion (from a Stage C baseline) with no additional cost. This target was a contractual obligation. substitution of double-glazed windows for triple-glazing in certain locations, use of natural polymer glue in place of synthetic glue in the glulam beams (to reduce CO_2e), 98 per cent recycled reinforcement in the concrete (market standard is 60 per cent).”

AJ 3 December, 2013 | By Hattie Hartman

What creates high embodied energy?
The use of petrochemical resources is central to the manufacture, transport and installation of most building products

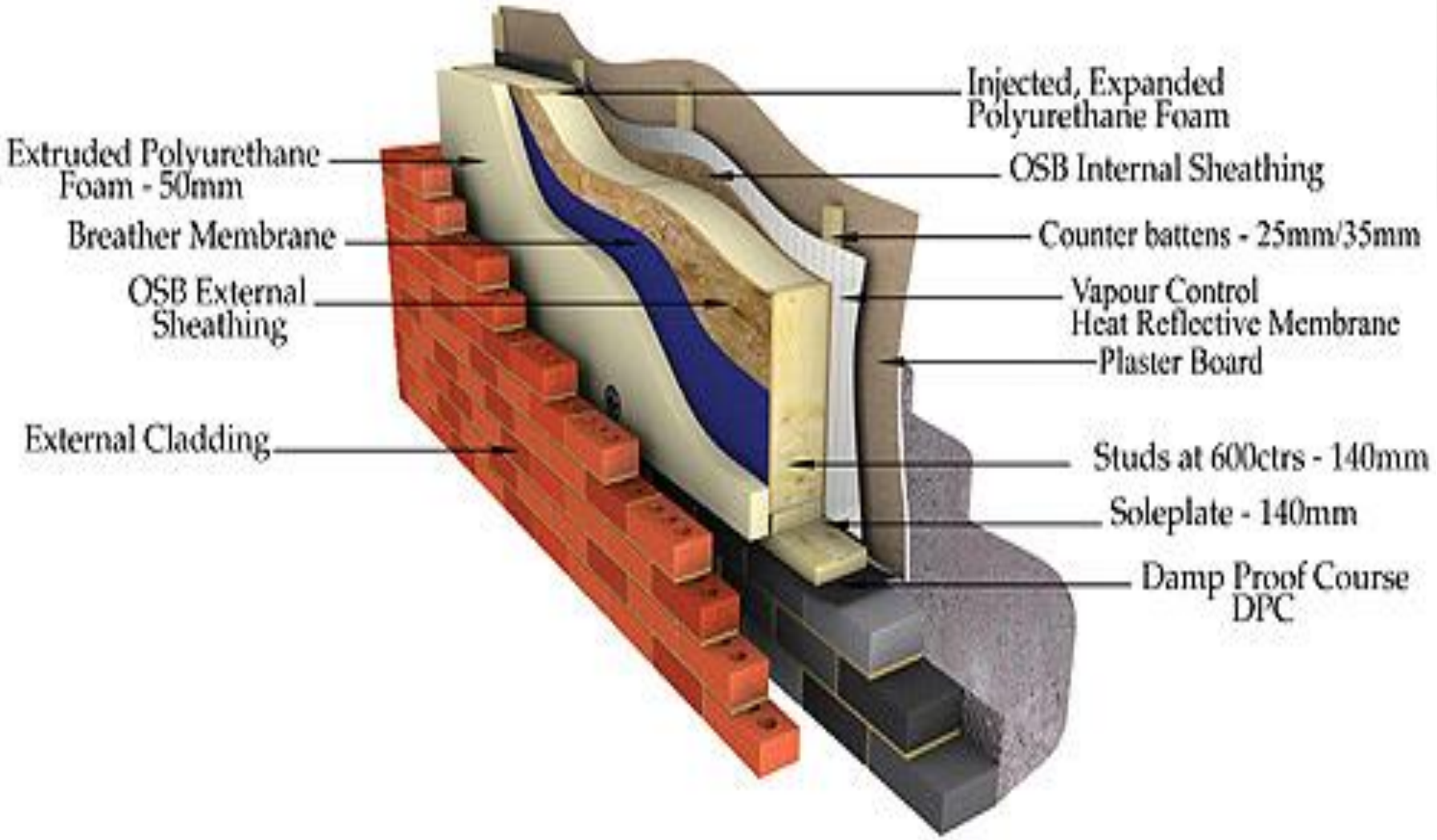


Synthetic Insulation materials while intended to save energy
Use almost as much petrochemical energy to create them

Natural-Energy Efficient-Sustainable

Typical synthetic petrochemical foam based insulation

Embodied energy 4000 MJ per m3



Typical conventional timber frame construction with brick outer leaf using synthetic insulation

Natural-Energy Efficient-Sustainable

..... legendary American architect Frank Gehry ruffled many green feathers by declaring that green architecture and sustainable design are "political" and that LEED certification is often given for "bogus stuff". that green building had become "fetishized" like "wearing an American flag pin".

MATERIAL	EMBODIED ENERGY MJ/kg	MJ/m3
Aggregate	0.10	150
Straw bale	0.24	31
Soil-cement	0.42	819
Stone (local)	0.79	2030
Concrete block	0.94	2350
Concrete (30 Mpa)	1.3	3180
Concrete precast	2.0	2780
Lumber	2.5	1380
Brick	2.5	5170
Cellulose insulation	3.3	112
Gypsum wallboard	6.1	5890
Particle board	8.0	4400
Aluminum (recycled)	8.1	21870
Steel (recycled)	8.9	37210
Shingles (asphalt)	9.0	4930
Plywood	10.4	5720
Mineral wool insulation	14.6	139
Glass	15.9	37550
Fiberglass insulation	30.3	970
Steel	32.0	251200
Zinc	51.0	371280
Brass	62.0	519560
PVC	70.0	93620
Copper	70.6	631164
Paint	93.3	117500
Linoleum	116	150930
Polystyrene Insulation	117	3770
Carpet (synthetic)	148	84900
Aluminum	227	515700

Titanium cladding embodied energy 430 MJ/kg

How to calculate embodied energy?

- ICE database and other sources?
- ICE: - The Inventory of Carbon and Energy
- www.circularecology.com/ice-database.html
- The Bath ICE database is the most widely used information source
- It is very useful but the data is largely from secondary sources and should be treated with scepticism in some cases

Hammond, G. & Jones, C., 2008. Embodied energy and carbon in construction materials. *Energy*, 161(EN2), 87-98.

Other sources and tools

- Life-Cycle Environmental Performance of Renewable Building Materials. B. Lippke et. al. June, 2004 Journal of Forest Products
- http://buildingsdatabook.eren.doe.gov/ChapterIntro1.aspx?1#6
- www.athenasmi.org/tools/ecoCalculator/index.html

ATHENA ECO CALCULATOR

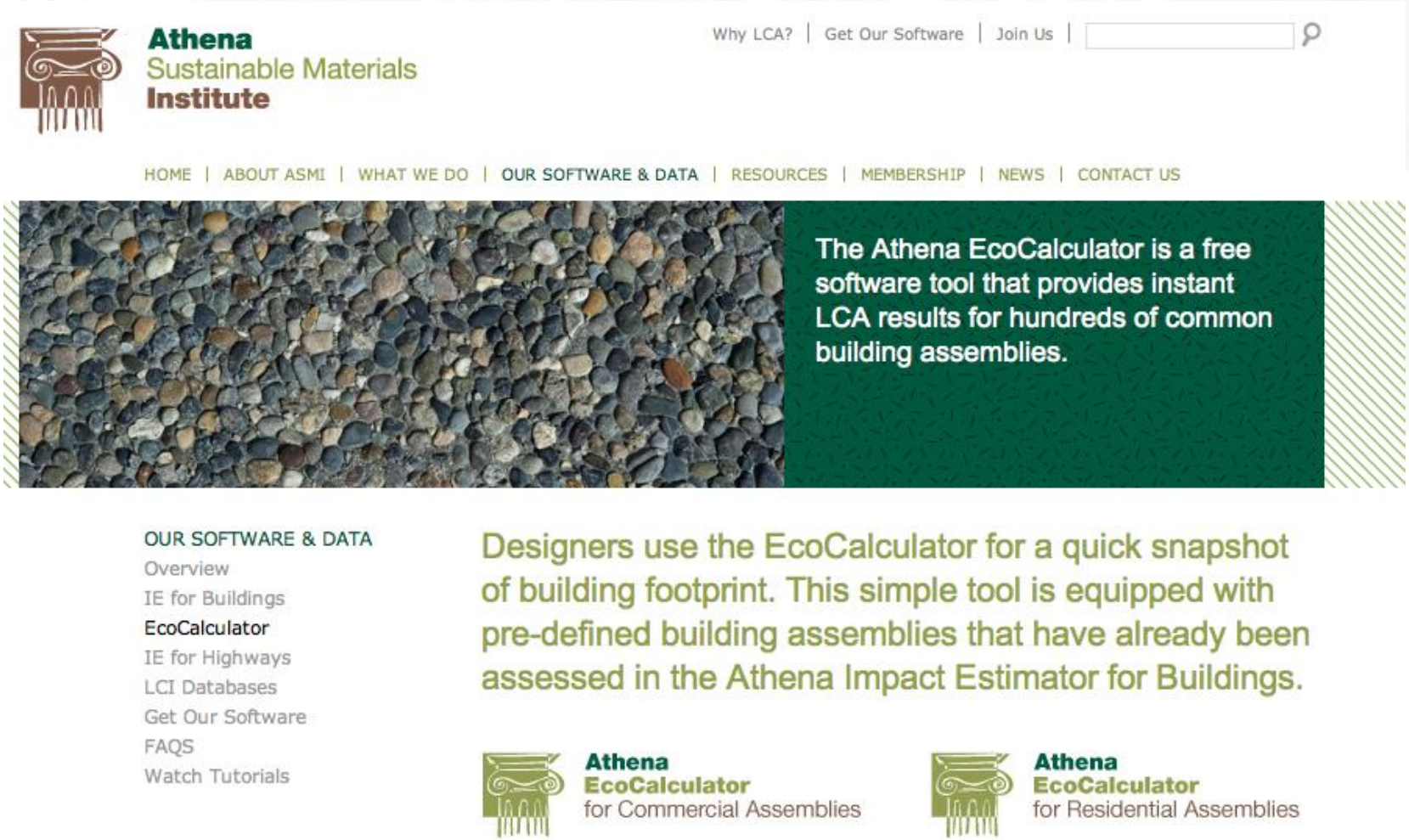
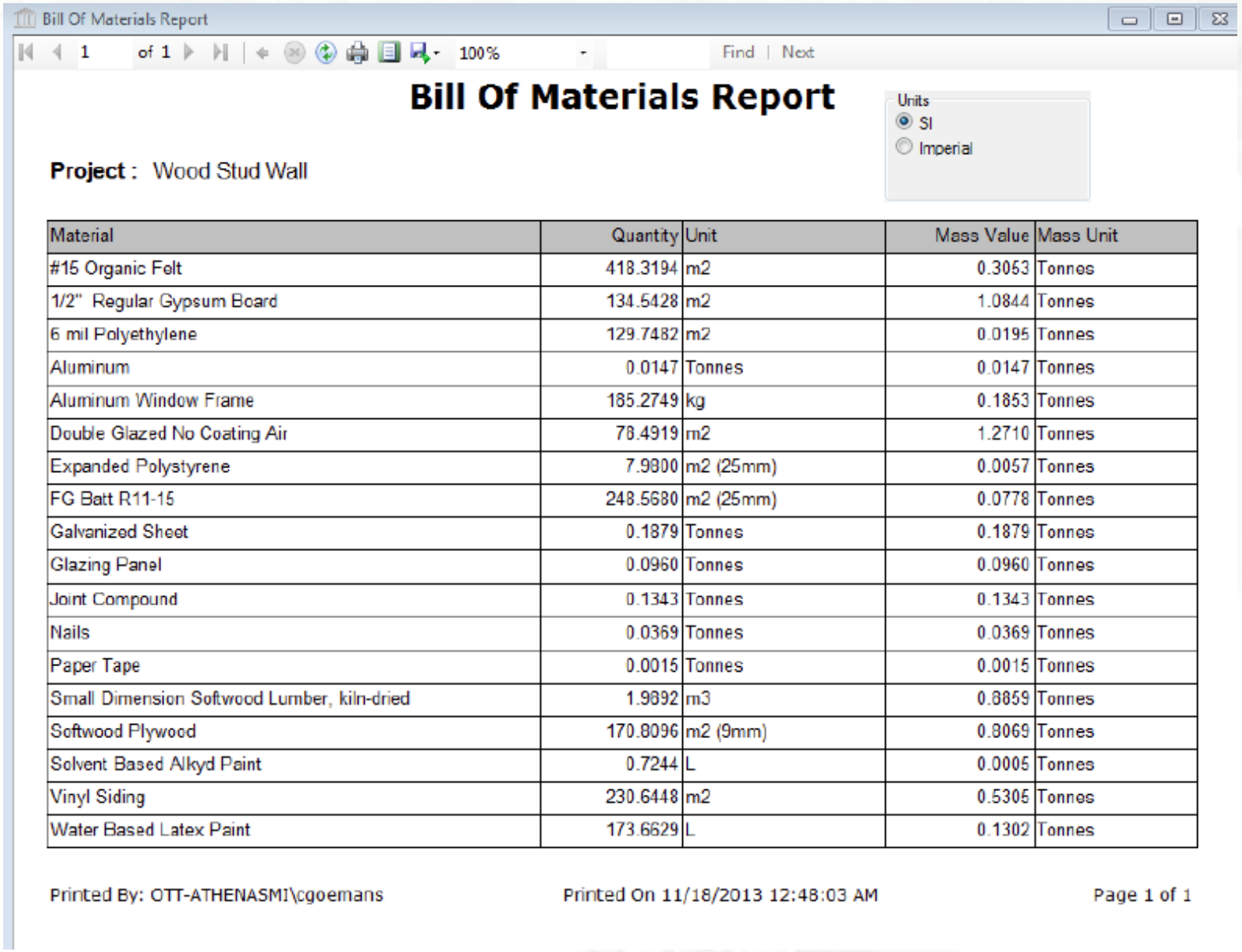


TABLE FROM ATHENA ECO CALCULATOR



Bill Of Materials Report

1 of 1 100% Find | Next

Bill Of Materials Report

Units
- SI
- Imperial

Project : Wood Stud Wall

Material	Quantity	Unit	Mass Value	Mass Unit
#15 Organic Felt	418.3194	m2	0.3053	Tonnes
1/2" Regular Gypsum Board	134.5428	m2	1.0844	Tonnes
6 mil Polyethylene	129.7482	m2	0.0195	Tonnes
Aluminum	0.0147	Tonnes	0.0147	Tonnes
Aluminum Window Frame	185.2749	kg	0.1853	Tonnes
Double Glazed No Coating Air	78.4919	m2	1.2710	Tonnes
Expanded Polystyrene	7.9800	m2 (25mm)	0.0057	Tonnes
FG Batt R11-15	248.5680	m2 (25mm)	0.0778	Tonnes
Galvanized Sheet	0.1879	Tonnes	0.1879	Tonnes
Glazing Panel	0.0960	Tonnes	0.0960	Tonnes
Joint Compound	0.1343	Tonnes	0.1343	Tonnes
Nails	0.0369	Tonnes	0.0369	Tonnes
Paper Tape	0.0015	Tonnes	0.0015	Tonnes
Small Dimension Softwood Lumber, kiln-dried	1.9892	m3	0.8859	Tonnes
Softwood Plywood	170.8096	m2 (9mm)	0.8069	Tonnes
Solvent Based Alkyd Paint	0.7244	L	0.0005	Tonnes
Vinyl Siding	230.6448	m2	0.5305	Tonnes
Water Based Latex Paint	173.6629	L	0.1302	Tonnes

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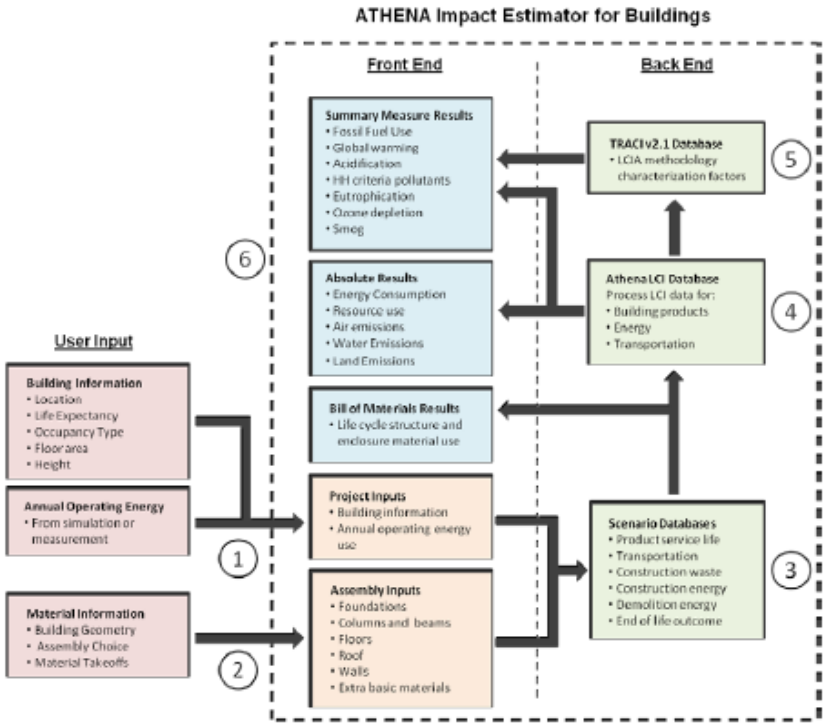
ATHENA METHODOLOGY

Athena Impact Estimator for Buildings

Athena Impact Estimator for Buildings V 4.5 Users Manual, Software and Database Overview



November 2013

GOVERNMENT ASSUMPTIONS FOR 80% REDUCTION IN EMBODIED CARBON EMISSIONS

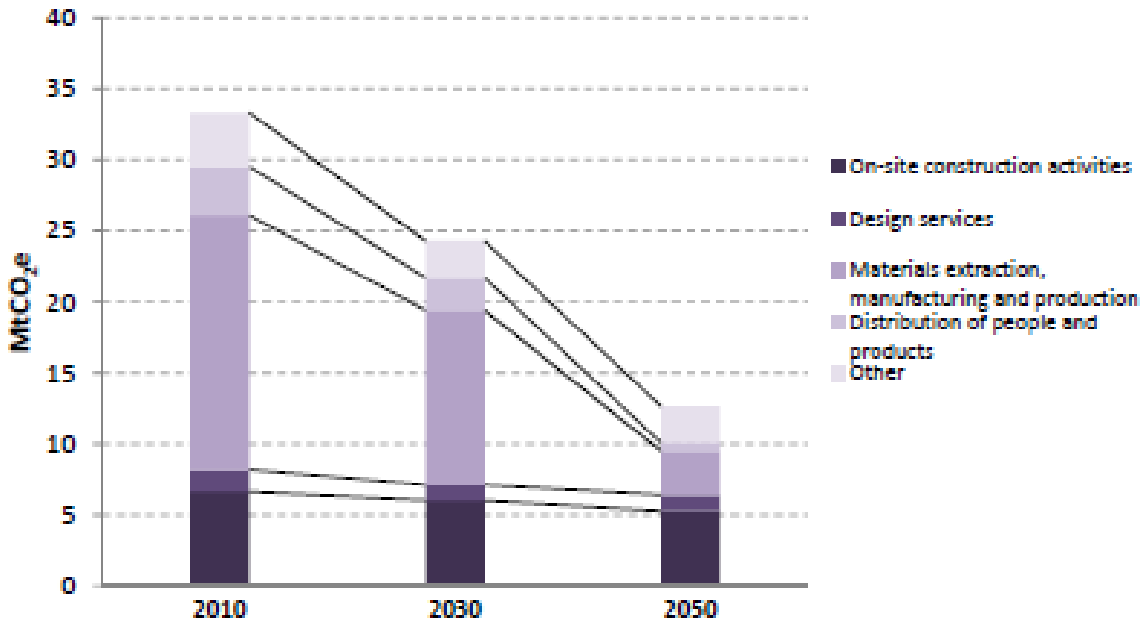


Figure 45: Projected capital carbon emissions under the 80% Scenario

Ref. Green Construction Board Roadmap (2013)

Almost entirely predicated upon decarbonisation of the electricity grid and substantial impact from carbon capture and storage

(not behaviour change)

1.5 Natural Materials

BIO BASED NATURAL & RENEWABLE MATERIALS HAVE MUCH LOWER EMBODIED ENERGY

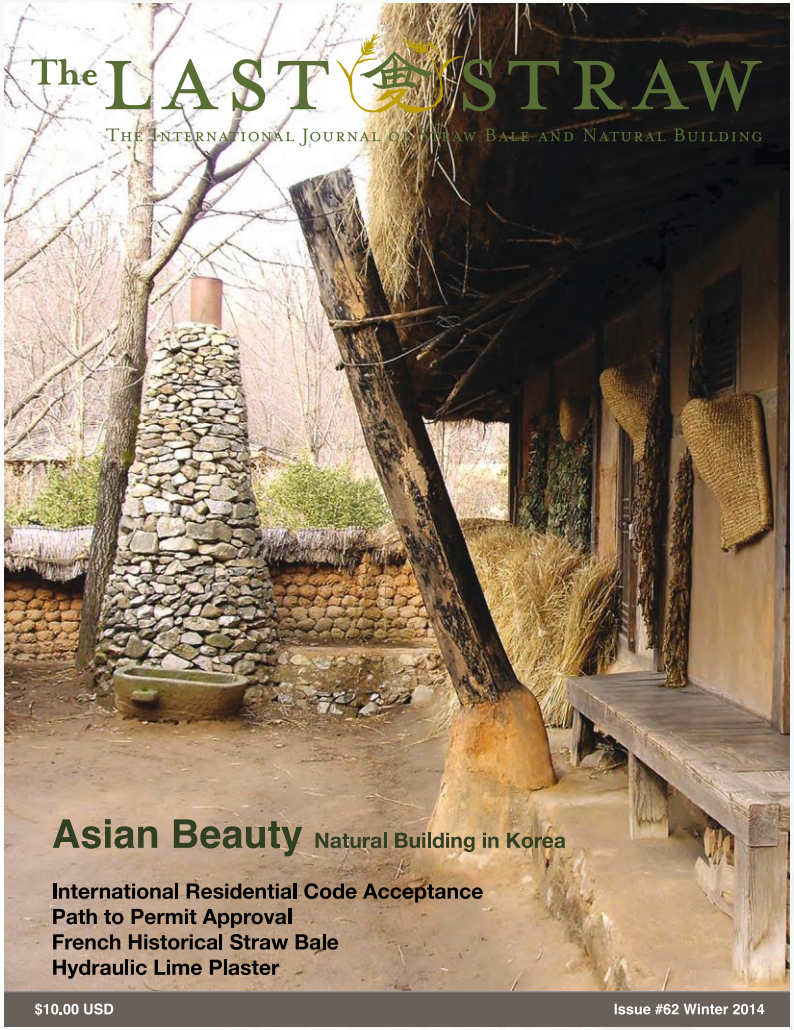


Image from The Last Straw No. 62

Biogenic sequestered carbon – a climate change mitigation strategy, if natural materials were used we could lock up CO_2

Biogenic sequestered carbon

If biogenic materials such as wood, hemp, straw, wool etc. were used in all NPP buildings this could lead to a net carbon sequestration as high as:

10 $MtCO_2$/year by 2020 and

22 $MtCO_2$/year by 2050

Non- Renewable Material

- Finite: extract once
  or develop over a long period of time

e.g. Crude oil reserves for about 40 years [5]

Renewable Material

- One Kilogram of dried timber can contain
  1.8 Kilograms of $C0_2$eq/kg stored as Carbon or a negative GWP -1.8 Kg$C0_2$eq/kg [5]
- Sustainability depends consumption not exceeding regeneration
- Sustainable production can have benefits to the wider ecosystem
- Procure responsibly from sustainable sources

Some of the things you can do to reduce embodied energy

- Explore the use of bio-based materials and finishes such as various types of board (sheathing and or insulation board made from agricultural waste and byproducts, including straw, wheat, barley, soy, sunflower shells, peanut shells, and other materials).

- Use insulation for natural materials, hemp, flax, straw, wood fibre

- Use timber and wood products from certified forests where the forest is managed and lumber is harvested using sustainable practices. Use resource efficient engineered wood products in lieu of full dimension lumber which comes from older growth forests.

Some of the things you can do to reduce embodied energy

- Evaluate all products and systems used for their ability to be recycled when they reach the end of their useful life.
- Recognize that transportation becomes part of a product or building materials embodied energy. Where practical, specify and use locally harvested, mined and manufactured materials and products to support the regional economy and to reduce transportation, energy use and emissions.
- Develop a strict waste-management practice to divert construction wastes from reaching the landfill.

Some of the things you can do to reduce embodied energy

- Use materials and resources found on the site in the site design and construction. Make a designated area for on-site materials to be reused including lumber for fire blocking and spaces, scraps of drywall for filler in hidden areas, etc. Save concrete chunks, broken bricks, blocks and other masonry rubble for backfill. Use cleared brush and trees chipped for mulch. Use joint compound buckets for other materials and your tools.

- Ask suppliers to take or buy back unused items.

- When possible avoid material brands with excessive packaging.

- Research your local recycling and salvage options.

1.6 Health Issues

http://www.ukieg.org/

UK Indoor Environments Group

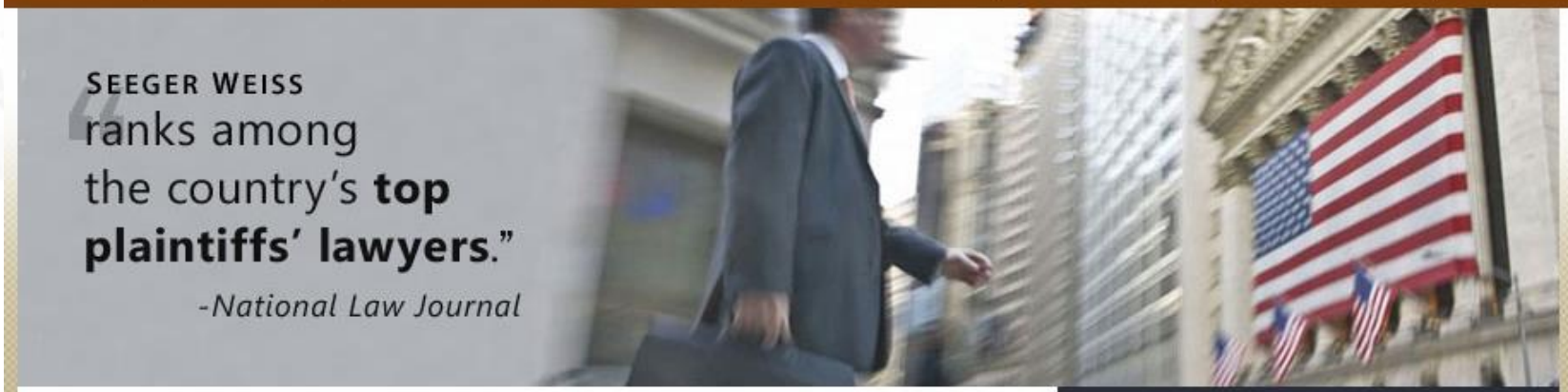
Health and Pollution: Indoor air quality is a key issue for sustainable buildings

Would you sleep under a plastic sheet?
Using plastic is bad for our health and the environment
Synthetic materials are not breathable

Natural-Energy Efficient-Sustainable

Spray foam is a popular way to insulate
but in the USA householders are taking the manufacturers
to court for allegedly making them ill

Spray foam is made from petrochemical based polyurethane



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SEALECTION 500 Spray Polyurethane Insulation

SEALECTION 500 and SEALECTION Agribalance are home insulation foams being investigated for their potentially toxic polyurethane.

The spray polyurethane foam insulation (SPF), which is manufactured by Texas-based company Demilec, is described on the company's website as "an open cell spray foam that uses water as a blowing agent." Spray-foam insulation products such as SEALECTION 500 are marketed as a "green" way to reduce energy costs for homeowners, but when a product turns toxic it can become a hazard to your and your family's health.

Seeger Weiss is offering free consultations for potential Demilec class action to anybody who believes they may have been affected by this toxic polyurethane foam.

If you believe you might be one of these victims, please contact Seeger Weiss by filling out the form on the side of this page, or by calling us direct at **888.584.0411.**

"Green" Home Polyurethane Foam Turns Toxic

According to the safety data sheet found on the company's website, the material used in the spray foam "is classified hazardous under OSHA Hazard Communication Standard," and may be "Irritating to eyes, respiratory system and skin."

Affected by toxic insulation?

Please fill out this form for a
Free Case Evaluation

Recipient of *The National Law Journal's* Plaintiffs Hot List

Full Name
Email
Phone

Has SEALECTION insulation led to health problems? If so, please describe below.

Align the slider to the arrow

Man dies spraying polyurethane "soya" foam

"On a Saturday afternoon this past May, while pumping a two-part 'GREEN' soy-based foam into the attic ceiling of a Cape Cod home renovation, a fireball erupted, taking the hose man's life."

Many regard fibreglass as dangerous
http://www.lung.org/healthy-air/home/resources/fiberglass.html


Household chemicals in direct link to asthma rise

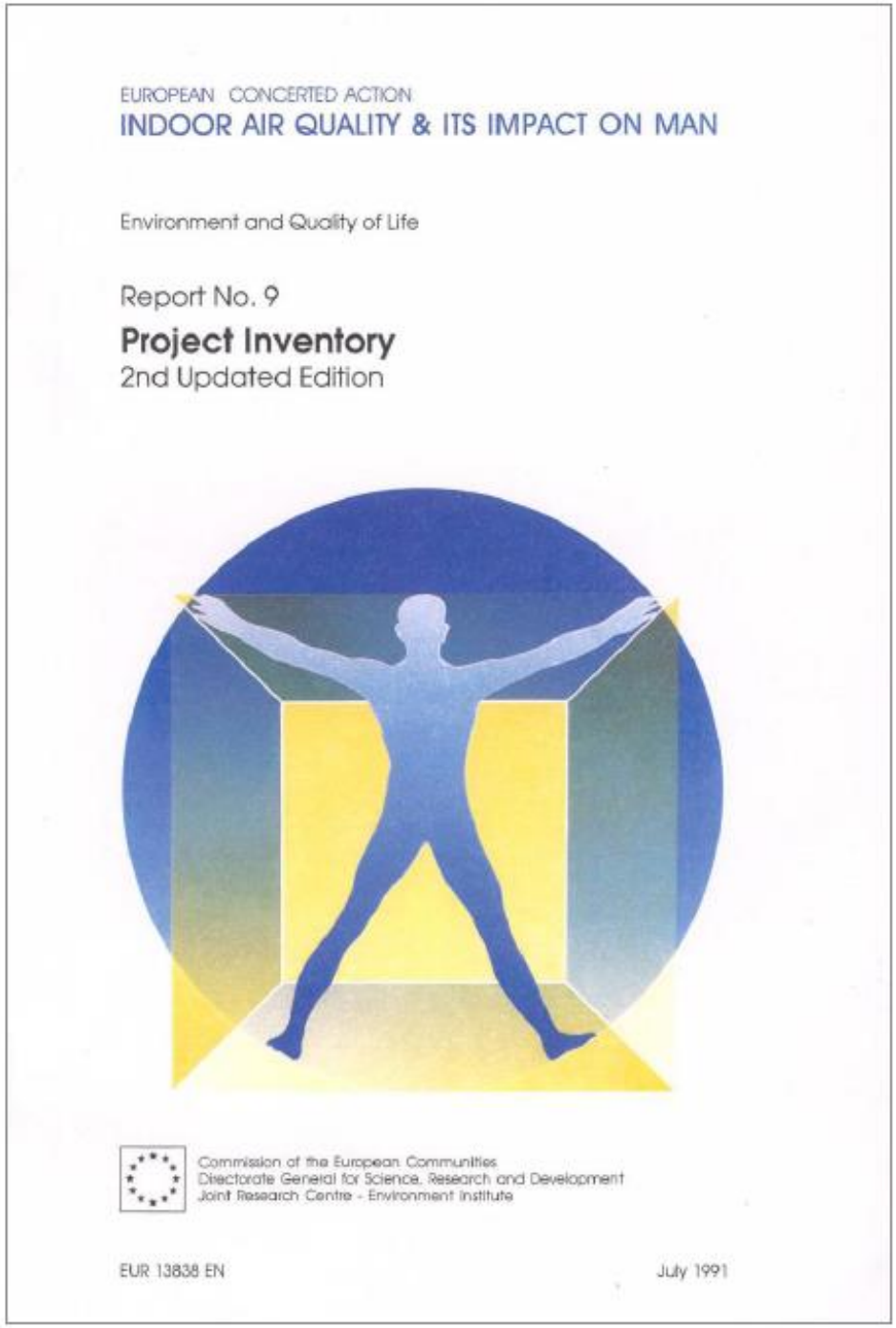
THE CULPRITS

Mould growth can have a serious impact on a range of respiratory illnesses

Synthetic Petrochemical based non renewable materials
invariably contain a wide range of toxic and damaging chemicals

Below are some examples of reports and sources of information about this

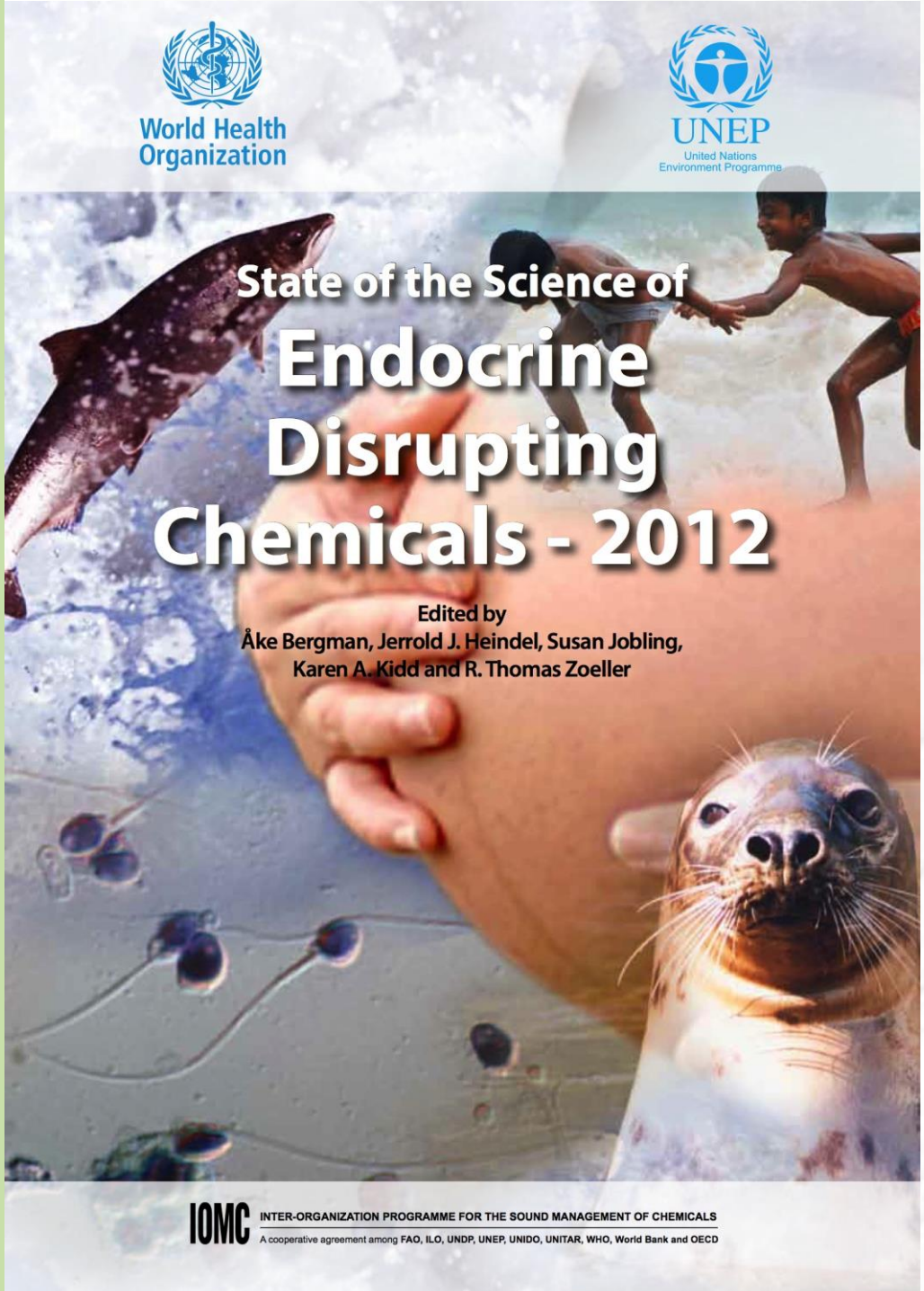
WARNING!
Reading these reports will make you feel ill!!



Useful sources of documents

http://www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf

http://buildingecology.com/



http://www.who.int/ceh/publications/endocrine/en/

..... the use of added flame-retardant chemicals in plastic foam insulation, ... "**do not appear to provide fire safety** and a potential exists for serious health and ecological harm."

Flame retardants in building insulation: a case for re-evaluating building codes Vytenis Babrauskas , Donald Lucas , David Eisenberg , Veena Singla , Michel Dedeo & Arlene Blum (2012):

Flame retardants in building insulation: a case for re-evaluating building codes, Building Research & Information, 40:6,738-755
To link to this article: http://dx.doi.org/10.1080/09613218.2012.744533

Anna A. Stec, Ph.D., led the research, which focused on the most widely-used category of flame retardants, which contain the chemical element bromine. Scientists term these “halogen-based” flame retardants because bromine is in a group of elements called halogens.

“Halogen-based flame retardants are effective in reducing the ignitability of materials,” Stec said. “We found, however, **that flame retardants have the undesirable effect of increasing the amounts of carbon monoxide and hydrogen cyanide released during combustion.** These gases, not the thermal effects of burns on the body, are the No. 1 cause of fire deaths.” Stec, who is with the University of Central Lancashire, Centre for Fire and Hazards Science, Lancashire, U.K., spoke at an ACS symposium on “Fire and Polymers,” which included 60 presentations.

Energy and Buildings, 43 (2-3), pp. 498-506 (2011)
doi:10.1016/j.enbuild.2010.10.015
Assessment of the fire toxicity of building insulation materials
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Natural Energy Efficient Sustainable

Are natural materials durable?

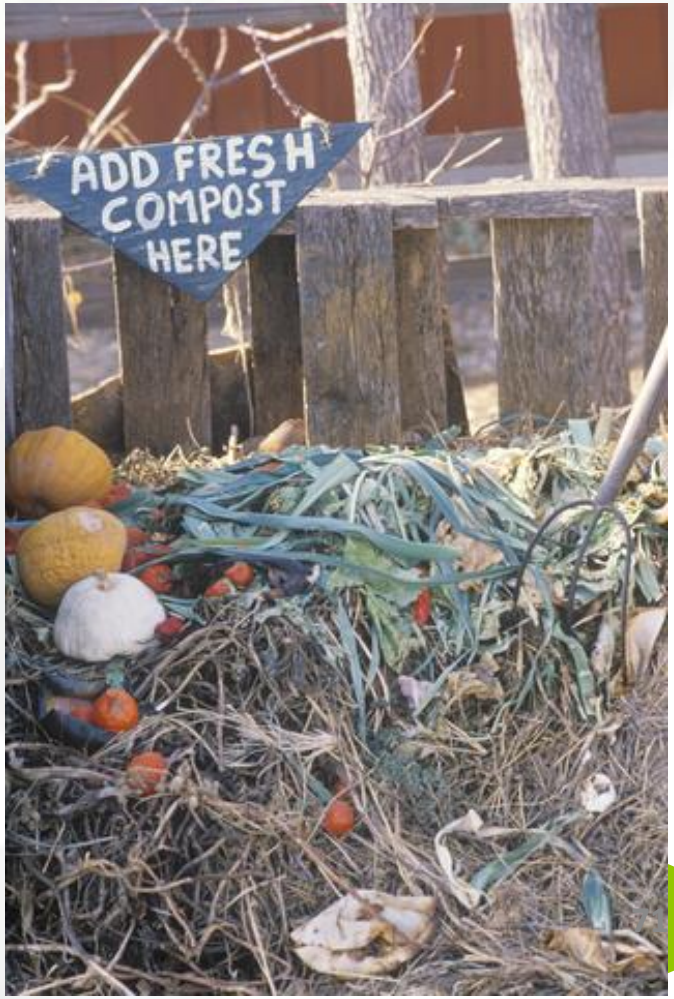
- Durability is dependent on good design, good weather and moisture protection
- Natural materials can last as long as synthetic materials if properly detailed and installed
- Some natural materials can cope with wetting and humidity better than some synthetic materials if they can dry out

1.7 Life Cycle Disposal and Durability?

93 year old strawbale house in France

Disposal of bio-based materials

- Should not go to landfill
- Disposal for compost or on land
- Natural materials can biodegrade



Demolition is a waste

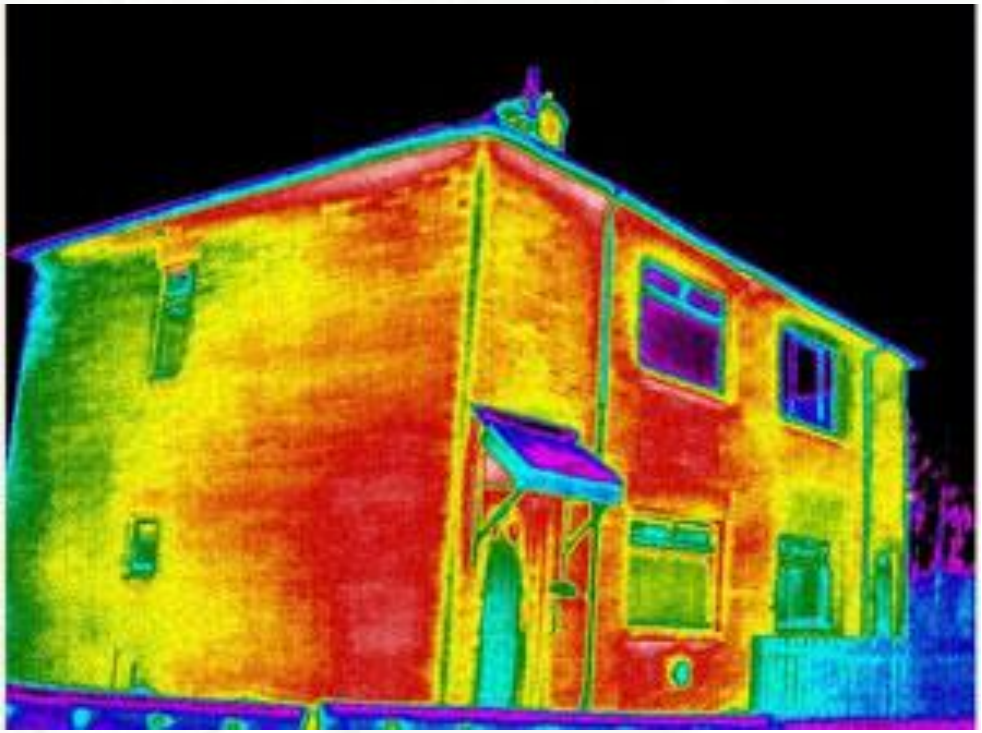
25 million tonnes of demolition materials can end up in land fill each year in the UK

Plasterboard waste in a landfill site

Many synthetic construction materials cannot bio degrade

1.8 Performance issues, in terms of energy efficiency

Achieving energy efficiency is much more complex than simply adding any sort of insulation and improving air tightness.



Synthetic and natural materials perform differently

Thermal resistance and conductivity

- “u” and “r” values of natural insulation materials compared with synthetic materials
- Do not believe the claims made about the insulation performance of synthetic materials
- These figures all come from commercial sources and are rarely independently verified
- They are usually based on hot box tests which do not replicate performance in actual buildings
- Actual performance of insulation materials is best determined from evaluating buildings in use

THERMAL MASS AND HYGROSCOPIC EFFECTS ON THERMAL PERFORMANCE.

NATURAL MATERIALS PERFORM **BETTER** THAN SYNTHETIC MATERIALS IN **HIGH HUMIDITY**

Eshrar Latif :HYGROTHERMAL PERFORMANCE OF HEMP BASED THERMAL INSULATION MATERIALS IN THE UK

PHD Thesis University of East London February 2013

“9.1.1 Hygric material properties of hemp insulations

The hygric properties of hemp insulations that have been determined in steady state hygrothermal conditions in the laboratory are: adsorption-desorption isotherm, moisture buffering capacity, vapour diffusion resistance factor and water absorption coefficient. In terms of the material properties, one of the key findings during the laboratory-based experiment is that the hemp insulations show ‘excellent’ (MBVpractical ≥ 2) and ‘good’ (2 > MBVpractical ≥ 1) moisture buffering capacity in relation to the ‘Moisture Buffer Value Classes’.

From Eshrar Latif Thesis

“9.1.1 Hygric material properties of hemp insulations

Moisture buffering capacity of hemp insulations can be very useful in moderating the relative humidity and thereby mitigating the risk of condensation inside walls and in the loft spaces. Moisture buffering capacity of hemp insulations can also be potentially utilised in interior spaces when the insulations are used in vapour open walls. Compared to hemp insulation, mineral insulations, such as stone wool, have a negligible buffering capacity due to their non-hygroscopic nature.
“

From Eshrar Latif Thesis

"9.1.1 Hygric material properties of hemp insulations

Hemp insulations can adsorb 22%-56% moisture of their dry weight at 95% relative humidity, depending on the make of the hemp insulations, while stone wool can only adsorb 1% moisture of its dry weight at 95% relative humidity. The moisture adsorption capacity combined with negligible hysteresis contributes to hemp insulation's 'good' and 'excellent' moisture buffering performance. However, in relation to moisture adsorption at high relative humidity, there are significant differences between the different makes of the hemp insulations researched in this thesis. This is due to the make of the hemp fibre insulations and the differences in the methods of hemp fibre extraction.

From Eshrar Latif Thesis

“9.1.1 Hygric material properties of hemp insulations .

It was observed from the laboratory-based dynamic and quasi steady state hygrothermal experiments that, when exposed to high relative humidity, the likelihood and frequency of interstitial condensation was higher in the stone wool insulations than in the hemp insulations. It confirms that hemp has better moisture management capacity in dynamic hygrothermal conditions. “

From Eshrar Latif Thesis

Picture of climate Chamber where Eshrar Latif compared performance of hemp and stone wool insulations