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Seeing the wood for the trees....

How does building with wood help tackle climate change?
Simon Smith **RAMBOLL**

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Building with wood

- Creation of woodland
- Lighter
- Faster
- Less waste
- **Less CO2**
- But.....
 - Cost
 - Fire
 - Thermal mass
 - Acoustics
 - Flexibility
 - Longevity

A steel or concrete structure is typically 4x heavier than timber option

A timber building is typically 15-20% quicker to construct where MMC is adopted

A timber structure can save up to £50k in onsite waste disposal costs

A timber structure is carbon negative?

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Less CO2

- New building embodied CO2 = 300 to 1000 kgCO2/m2
- New building operational CO2 = 30 to 100 kgCO2/m2
- Steel frame embodied CO2 = 185 kgCO2/m2
- Concrete frame embodied CO2 = 185 kgCO2/m2
- Timber frame embodied CO2 = 50 kgCO2/m2
- Timber frame sequestered CO2 = 200 kgCO2/m2

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Supporters of wood

- Stern Review
- IPCC
- German Environment Minister
- Forestry Commission Scotland
- Read Report
- Wood for Good
- UK Government?
- United Nations & IPCC?

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Stern Review

Planting new trees could be cost effective in many countries.

Forest cover can be increased in most areas of the world. Eight thousand years ago, 50% of the global land surface was covered by forest, compared with only 30% now. As traded carbon prices, there are potentially large areas of land in many countries where new forests could be planted, should the enabling environment be conducive. The costs of planting new forests depend on the value of an alternative land use and may be offset in the medium term by revenues from sustainable forest use. Rehabilitation (re-establishing former forests) and afforestation (establishing new forests) in marginal agricultural land and on abandoned land offer significant local benefits by reducing vulnerability to soil erosion and desertification.

Planting new forests (afforestation and reforestation) could save at least an additional 1 GtCO₂e/yr at a cost estimated at around \$5/CO₂e - \$15/CO₂e. The full technical potential of forestry-related measures would go beyond this. An IPCC report in 2000 estimated a technical potential of 4 - 6 GtCO₂e/yr from the planting of new forests alone between 1995 and 2050, 70% of which would come from tropical countries. Revised estimates are expected from the Fourth Assessment Report of IPCC.

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IPCC

Building codes and other government policies that, where appropriate, can promote substitution of use of sustainably harvested forest products wood for more energy-intensive construction materials may have substantial potential to reduce net emissions (Munby, 2004). Private companies and

Wood products can displace more fossil-fuel intensive construction materials such as concrete, steel, aluminium and plastics, which can result in significant emission reductions (Peterson and Solberg, 2002). Research from Sweden and Finland suggests that constructing apartment buildings with

The embodied energy in building materials needs to be considered along with operating energy in order to reduce total lifecycle energy use by buildings. The replacement of materials that require significant amounts of energy to produce (such as concrete and steel) with materials requiring small amounts of energy to produce (such as wood products) will reduce the amount of energy embodied in buildings. Whether

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German Environment Minister



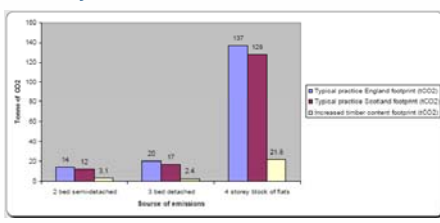
Bundesministerin Aigner wirbt für Beuen mit Holz

Deutsche ist die höchste in Europa
 Bundesministerin Aigner wirbt für Beuen mit Holz

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Forestry Commission Scotland



Source of emissions	Typical practice England (tCO2)	Typical practice Scotland (tCO2)	Increased timber content (tCO2)
2 bed semi-detached	14	12	3.1
3 bed detached	22	17	2.4
4 store block of flats	137	128	21.8

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Read Report



- UK Forestry Commission report
 - UK woodland could provide 10% CHG abatement (Scotland already 12%).
 - UK 'forest carbon sink' reducing from 16mt CO2 in 2004 to 5mt CO2 in 2020.
 - Wood fuel potential to save 7mt CO2 in UK.
 - Wood substitution potential to save 4mt CO2 in UK.
 - Estimated 70mt CO2 stored in timber housing in UK.

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Wood for Good

- 'every cubic metre of wood used instead of other building materials saves between 0.7 and 1.1 tCO2'



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UK Government

- Recognises that in 2007 forest in England removed 2.9mt CO2, but that this rate is falling.
- Recognises that a major woodland creation scheme is required, target of 10,000 ha per year for 15 years (to remove 50mt CO2 by 2050).
- Woodland creation can also help with employment creation, flood alleviation, water quality improvement and support for wildlife.
- Recognises that woodland resource (timber) needs to be used for fuel and construction.

Woodland creation is a very cost-effective way of fighting climate change over the long term, but it requires an upfront investment.




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United Nations and IPCC

- Harvested Wood Products (HWP)
 - UNECE, UN Economic Commission for Europe
 - UNFCCC, UN Framework Convention on Climate Change
 - IPCC, Intergovernmental Panel on Climate Change



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Science

- Wood is about 50% carbon (by dry mass)
- x 3.67 to convert C to CO₂
- Broadleaf forests 100-250 tC per ha
- Conifer plantations 70-90 tC per ha
- Carbon uptake 4 tC per ha per year in fast growing stands

Figure 2.2
Carbon changes in the carbon stored in a 1000-acre plantation on a sandy grey sand as conifers. See the text for explanation. The line shows increasing frequency of disturbance of timber from the top line down.

Accumulation of carbon in the sample stand

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Some typical tCO₂/m³ for various timbers

Table 6.6
Timber carbon content (tCO₂e m⁻³), typical ranges of maximum mean annual volume increment (MMAI; m³ ha⁻¹ year⁻¹) and ages of MMAI for a range of conifers and broadleaves grown in Britain or which might be considered for planting under anticipated climate change (after Edwards and Christie, 1981; Lawrie, 1983).

Conifers					Broadleaves				
Species	Scientific name	Carbon content	MMAI	Age	Species	Scientific name	Carbon content	MMAI	Age
Siberia spruce	<i>Picea sibirica</i> (Bong.) Cat.	0.82	8-24	64-66	Oak	<i>Quercus robur</i> L., <i>Q. petraea</i> (Mill.) Link.	1.12	4-8	90-88
Norway spruce	<i>Picea abies</i> L. Karst.	0.64	8-20	84-65	Birch	<i>Betula pendula</i> (Roth.) B. pubescens (Ehrh.)	1.10	4-12	49-40
Scots pine	<i>Pinus sylvestris</i> L.	0.84	6-12	82-69	Sweet chestnut	<i>Castanea sativa</i> Mill.	0.84	4-10	50-41

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UK estimates

Figure 1.3
Carbon pools in UK Forests (MtC)

Table 1.3
Stock of carbon stored in UK woodlands (trees only)

	Stock of carbon (MtC)	Flows of carbon from atmosphere to forests (MtC per year)
England	80	3.39
Scotland	82	2.95
Wales	18	0.40
Northern Ireland	6	0.17
UK	150	4.12

- Two thirds of UK current woodlands were planted after 1950 and in the last 85 years area of forest has more than doubled
- Rate of new plant has fallen from 30,000ha in 1980's to 7,500ha in 2008

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TRADA documents

- Life cycle assessment
 - ISO, BREEAM, PAS
- PAS 2050
 - An attempt to include measurement of imported goods?
- Timber carbon footprints
 - Footprint scenarios for various timbers using PAS 2050

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PAS 2050

- Publicly available specification
 - Issued October 2008
 - Will be replaced by ISO 14067 in 2011
 - Life cycle GHG emissions associated with creating, modifying, transporting, storing, using, providing, recycling and disposing of goods and services

Where carbon of biogenic origin forms part of a product, the impact of this carbon storage over the 100-year assessment period shall be included in the assessment of the life cycle GHG emissions of the product, subject to the conditions described in 5.4.1 to 5.4.4.

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Market place UK

- **Steel**
 - 1.4m tonnes of constructional steelwork 2007
- **Concrete**
 - 24m tonnes of ready mix concrete 2007
- **Timber**
 - 11m m3 of sawn wood in 2006
 - 7m m3 of wood based panels in 2006
- **Summary**
 - 400m tonnes of construction material used annually
 - 90m tonnes of construction waste annually (50% re-cycled)





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Policy and regulation




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Policy and regulation



- www.dcc.gov.uk
 - Department for Energy and Climate Change
 - The UK Low Carbon Transition Plan - July 2009
- www.communities.gov.uk/planningandbuildingtheenvironment
 - Communities and Local Government
 - Building a Greener Future - July 2007
 - Code for Sustainable Homes
 - Consultations on definition of zero carbon
 - EPC's and DEC's
 - www.zerocarbonhub.org
- www.berr.gov.uk/volumes/defaultsectors/construction
 - Department for Business, Innovation and Skills
 - Strategy for Sustainable Construction - June 2008




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Zero carbon

- 2016
 - All new homes
- 2018
 - All new public sector buildings
- 2019
 - All new buildings

Climate Change Mitigation

Reducing total UK carbon dioxide (CO2) emissions by at least 40% on 1990 levels by 2020 and by at least 20% by 2025. Within this, Government has already set out the policy that new homes will be zero carbon from 2016, and an ambition that new schools, public sector non-domestic buildings and other non-domestic buildings will be zero carbon from 2016, 2018 and 2019 respectively.





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Embodied carbon?


1.17 CLG recognises that there is increasing interest from industry and other stakeholders in the embodied energy/carbon of both products and buildings, but while the EU's work is ongoing, we are not minded to begin regulating in this area. Industry (especially the products industry) is already making voluntary moves to demonstrate the environmental impacts of their products, and this kind of market-driven change is strongly supported.

All products used in the construction industry have embodied environmental impacts - whether from raw materials, manufacture or transportation. The amount of embodied carbon is generally far less than the energy consumed during the lifetime of the building or infrastructure project. Nevertheless, embodied carbon is addressed in the BRE Green Guide to Specification and the EU Emissions Trading Scheme encourages materials manufacturers to reduce emissions.

Low carbon construction

- Renewable resources can substitute for oil based materials in a wide range of other non energy applications, for instance construction products, industrial chemicals, and plastics. The Government is investing up to £8 million to construct 60 more low carbon affordable homes built with innovative, highly insulating, renewable materials. The new scheme will demonstrate the viability of these materials, and act as a spur for the renewable construction materials industry.



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London Olympics 2012

the wider carbon footprint of the London 2012 programme. The revelation that more than half of the CO2 emissions are embodied in the construction process (and not flying) is significant for the Olympic Games and Strategic Games and for the UK as a whole. Construction projects do not have a carbon footprint.



The ODA should calculate embodied emissions based on "as built" data for at least 10% and preferably more, significant permanent values to enable future projects to understand the correlation between "value/cost" and "as built" emissions. Failure to do this would significantly delay wider understanding of this important issue.



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Stadthaus London

- Telford Homes / Waugh Thistleton Architects
 - Solid timber panel construction, 186tCO₂ stored
 - 29 apartments, operational 29 kgCO₂/m² pa
 - 10% renewables obligation waived by Hackney

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Other industry activity

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Strategic Forum for Construction

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BREEAM, CfSH and BRE

Figure 3: The nine design categories (in order of significance)

Code category	Maximum points
1 Energy	36.4 points
2 Health and well-being	16.0 points
3 Air Quality	12.0 points
4 Management	12.0 points
5 Water	8.0 points
6 Materials	7.2 points
7 Waste	6.4 points
8 Pollution	2.8 points
9 Site Resource Use Off	2.2 points
Total	90.0 points

BREEAM 2009 Update Changes by Environmental Weightings

Element	2008 Weightings	2009
Management	15	12
Health & Wellbeing	15	16
Energy	20	19
Transport	0	2
Water	8	8
Materials	10	12.5
Waste	10	7.5
Land Use & Ecology	15	15
Pollution	15	15
Total	108	100

THE CODE FOR SUSTAINABLE HOMES™

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BRE Green Guide to Specification

- Embodied CO₂ figures given
 - Floors - 18 to 150 kgCO₂/m²
 - Roofs - 4 to 290 kgCO₂/m²
 - External walls - 3 to 370 kgCO₂/m²

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Industry figures

- Industry claims
 - Steel (SCI) 782 kgCO₂/t
 - Concrete (Concrete Centre) 115 kgCO₂/t
 - Timber (Wood for Good) -900 kgCO₂/t


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Other figures

- Edinburgh Centre for Carbon Management
 - Steel 2300 kgCO2/t
 - Concrete 250 kgCO2/t
 - Timber -1000 kgCO2/t
- Bath University
 - Steel 1440 kgCO2/t
 - Concrete 210 kgCO2/t
 - Timber 390 kgCO2/t



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Related to structural performance



- Timber beam 15kgCO2/m
- Concrete beam 50kgCO2/m
- Steel beam 60kgCO2/m
- But...60kgCO2/m stored in timber beam

TIMBER	CONCRETE	STEEL	MASONRY
-1.01 kgCO2/kg	0.15 kgCO2/kg	1.8 kgCO2/kg	0.08 kgCO2/kg
-177 kgCO2/m ³	197 kgCO2/m ³	218 kgCO2/m ³	161 kgCO2/m ³



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Embodied CO2 studies – Commercial offices

- Statistics
 - 32,500m² GIA
 - Embodied 765 kgCO2/m²
 - Operation 60-90 kgCO2/m²





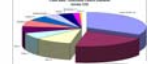
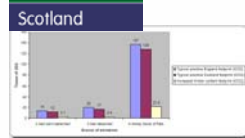




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Embodied CO2 studies – Residential

- Statistics
 - 3 bed house 20-40 tCO2
 - Embodied 300-675 kgCO2/m²
 - Operation 30-50 kgCO2/m²


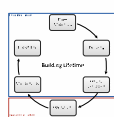
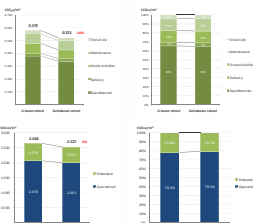

UK housing: The total embodied CO₂ of BeCIED is 675kg/m², whilst typical volume house builders build to 600-800kg/m². Despite the increased

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Embodied CO2 studies – Schools


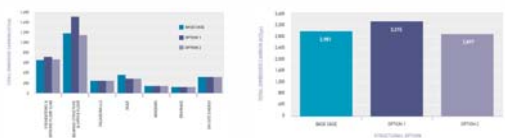

- Statistics
 - 2 structure solutions studied
 - Embodied 300-600 kgCO2/m²
 - Operation 25-35 kgCO2/m²

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Embodied CO2 studies – Schools


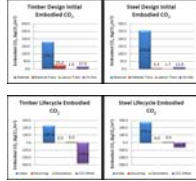


- Steel Industry Research
 - £22.5m 10,000m²
 - Embodied 300-350 kgCO2/m²
 - Operation 27 kgCO2/m²
 - Structure 10% cost, 60% CO₂

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Ramboll and UoC study

- Peterborough School
 - 975m² sports hall and studio
 - Timber LCA -40 tCO₂
 - Steel LCA 220 tCO₂
 - Embodied CO₂ of structure only







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Mossbourne Academy, London

- Exposed timber frame
 - £22.5m new build school
 - 960m³ timber, 800t CO₂ stored
 - Equivalent to 20% renewables for 20 years?




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St John Fisher School, Peterborough




1000m³ of timber design by Ramboll UK using cross laminated timber panels. Currently UK largest compressed CLT scheme.

Saving... **800 tCO₂**

- Solid timber panel construction
 - £11m new build and extension
 - 1000m³ timber, 800t CO₂ stored
 - Equivalent to 30% renewables for 20 years?



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Waingels College, Wokingham





- Major timber education development
 - £27m BSF school programme
 - 2300t CO₂ stored
 - Bespoke exposed timber cassettes



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Open Academy, Norwich




- UK's largest timber frame
 - £22m secondary school
 - 3500m³ timber, 2900t CO₂ stored
 - Equivalent to 30% renewables for 20 years?




2900 tCO₂




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Skelleftea, Sweden

- Mixed use timber building
 - 141 space multi-storey car park
 - Cross laminated timber
 - Fire engineered

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L'Aquila, Italy

- Earthquake rebuilding
 - 381 apartments in 2 phases
 - 11,000m³ of cross laminated timber
 - Fast track construction






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How much can building with wood help tackle climate change in the UK?

- Carbon Trust
 - Transforming carbon performance of buildings we work in will generate 11mt CO₂ pa savings through building regulations by 2020
- Read Report
 - Suggests opportunity to store 4mt CO₂ pa in new and refurbished homes by 2020 with increased use of timber
- UK Low Carbon Transition Plan
 - Suggests additional 1mt CO₂ pa abatement can be achieved through woodland creation
- OR
 - Double UK sawn wood use to match Germany by 2020 and get an additional 8mt CO₂ pa stored in timber




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