The Ecology of Timber Utilization
Life Cycle Assessment
Carbon Management etc.

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Greetings from Hamburg


Our Campus
Forestry, Wood,
Markets and Univ.
course WST

University of Hamburg Wood Science and Technology

Federal Research Centre for Forestry and Forest Products

Core Team: 9 Professors
6 Scientists
30 Third Party funded Scientists
50 Students p. year

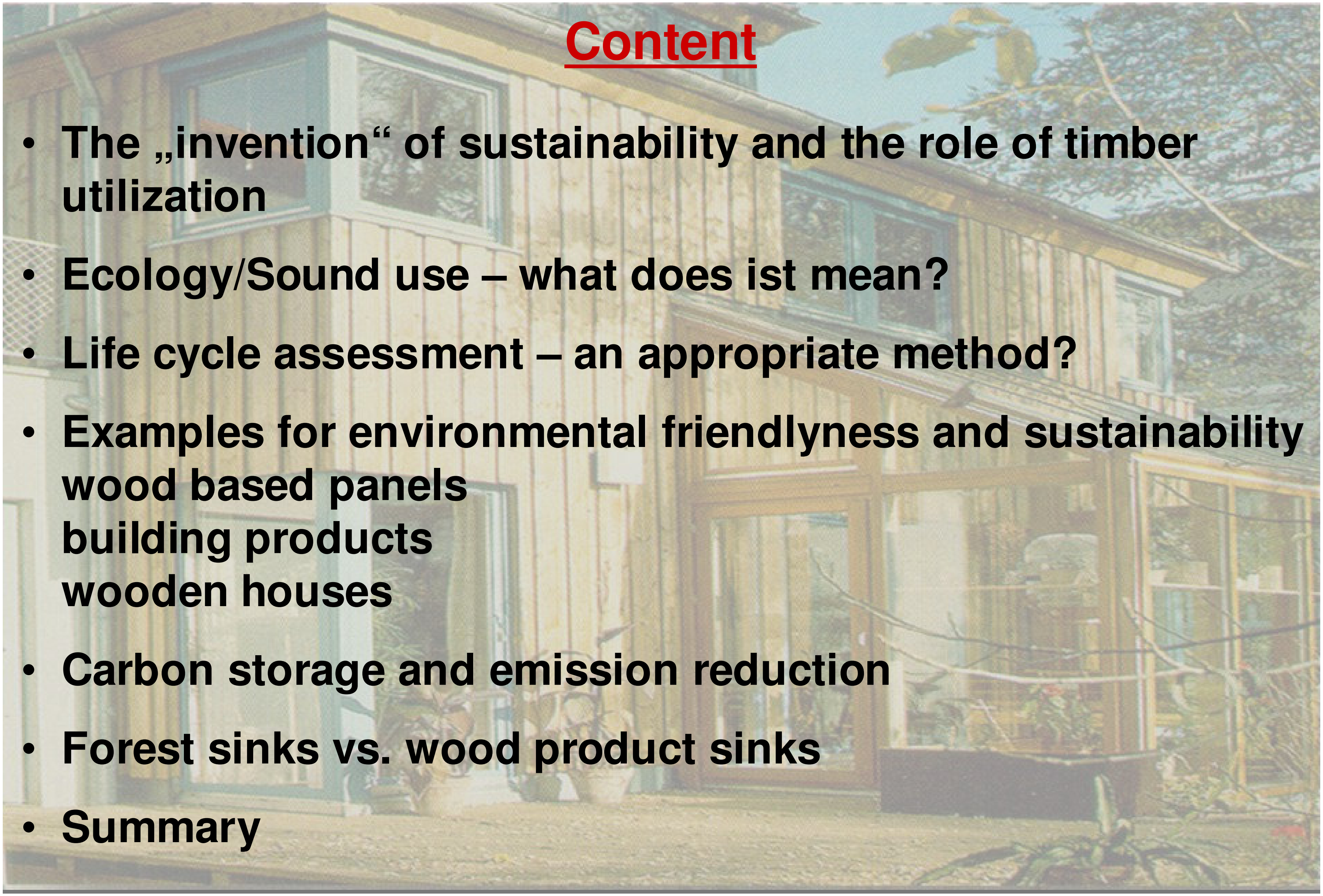
Supported by
600 University Professors
1500 Scientists of Hamburg University

185 Staff
60 Scientists
35 Third Party Funded Sientists

2007 Award of the German Association of Prefabricated Buildings Manufactures for R+D in Sustainable Building Production

Sound Use of wood

Sustainable Forestry
Sound logging
Low energy demanding manufacturing processes
Low emissions from processes and products
Recyclability of products
Low CO_2 - emissions
Carbon Storage in forests and wood products



Content

- The „invention“ of sustainability and the role of timber utilization
- Ecology/Sound use – what does ist mean?
- Life cycle assessment – an appropriate method?
- Examples for environmental friendlyness and sustainability
  wood based panels
  building products
  wooden houses
- Carbon storage and emission reduction
- Forest sinks vs. wood product sinks
- Summary

Wood Industry Environmental Concerns - until 1990

Environmental protection was an important issue during 70`s and 80`s (focussing on human beings).

all industry	wood industry (specifically)
water pollution	formaldehyde
air pollution	timber preservatives (PCP,Lindane)
noise	wood dust and cancer
	destruction of tropical forests

General Environmental Concerns today

Environment is seen comprehensively

- nature which includes everything to protect
- non renewable resources
- sustainability of resources
- biodiversity
- global warming
- hazardous materials

New environmental challenges for the Forestry -Wood- Chain

- sustainable management of resources
- reduced energy consumption
- reduced Global Warming Potential
- reduced emissions to air, water, soil
- recycling of materials
- biodiversity

Driving forces:
Rio Conference, Kyoto-Protocol

Some criterias for ecological advantages

- Sustainable supply

  → renewable ressources

- Contribution to environment (nature)

  → forests are „the most valuable vegetation under the aspect of biodiversity"

- Use of wood has very low impacts to the environment

  → energy consumption

  → emissions

- Closed carbon cycle

  → renewable energy

  → closed material cycle (bio-degratation)

- Carbon sink effect (forest and wood products)

Methods to measure ecological advantages (some)

- Development of biodiversity

  ⇒ Close to nature forests vs. managed forests ⇐

- Sustainability

  ⇒ Close to nature ⇐ certification (FSC - PEFC)

- **Life Cycle Assessment**

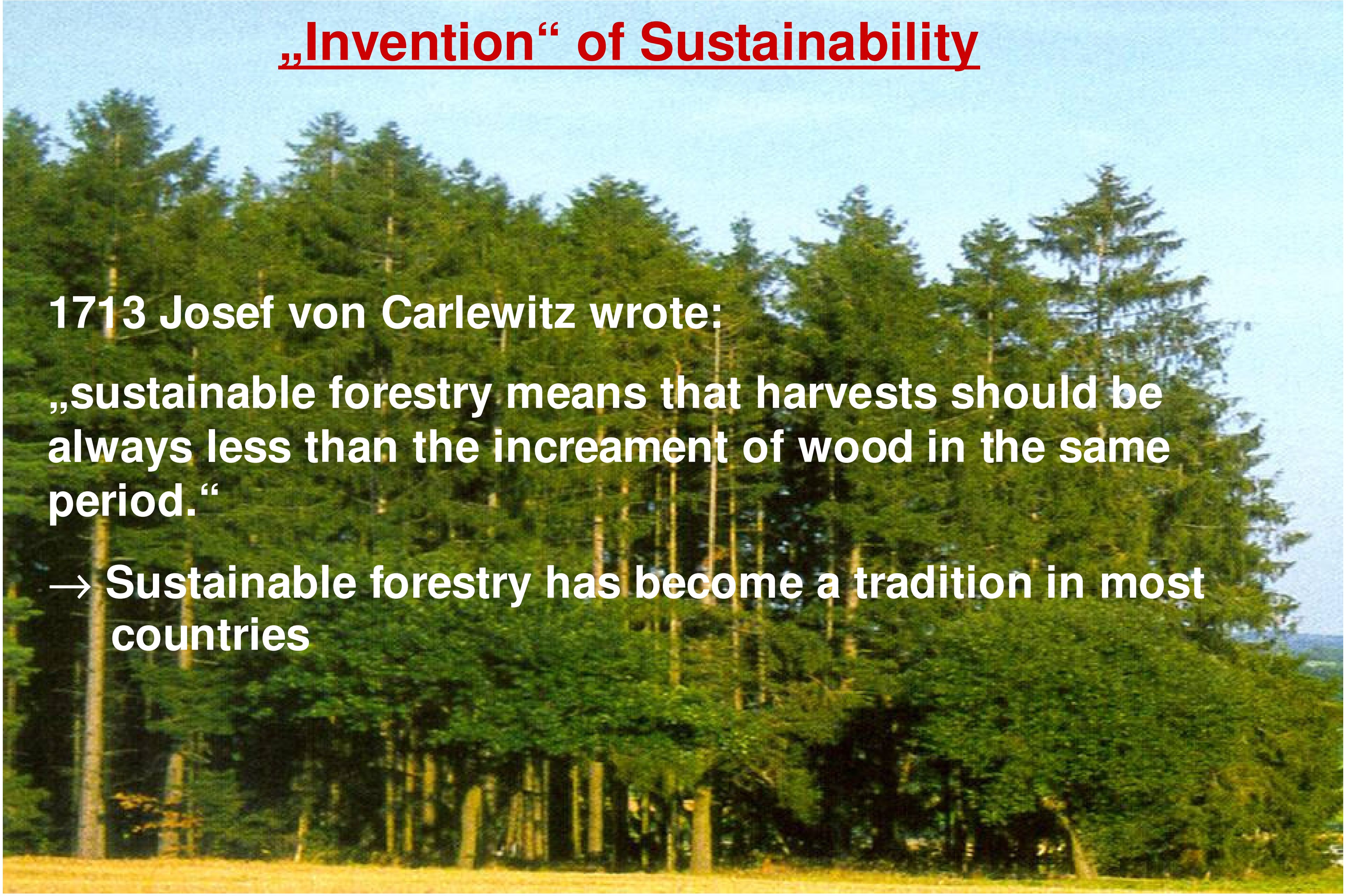
  ⇒ Evaluates inputs and outputs and the relevant impacts to environment along the life cycle ⇐

- **Carbon cycle aspects (carbon sequestration)**

- Others: ISO 14.000
  CEN TC 350 Sustainable Buildings

  ⇒ Mainly for industrial operations ⇐

„Invention“ of Sustainability

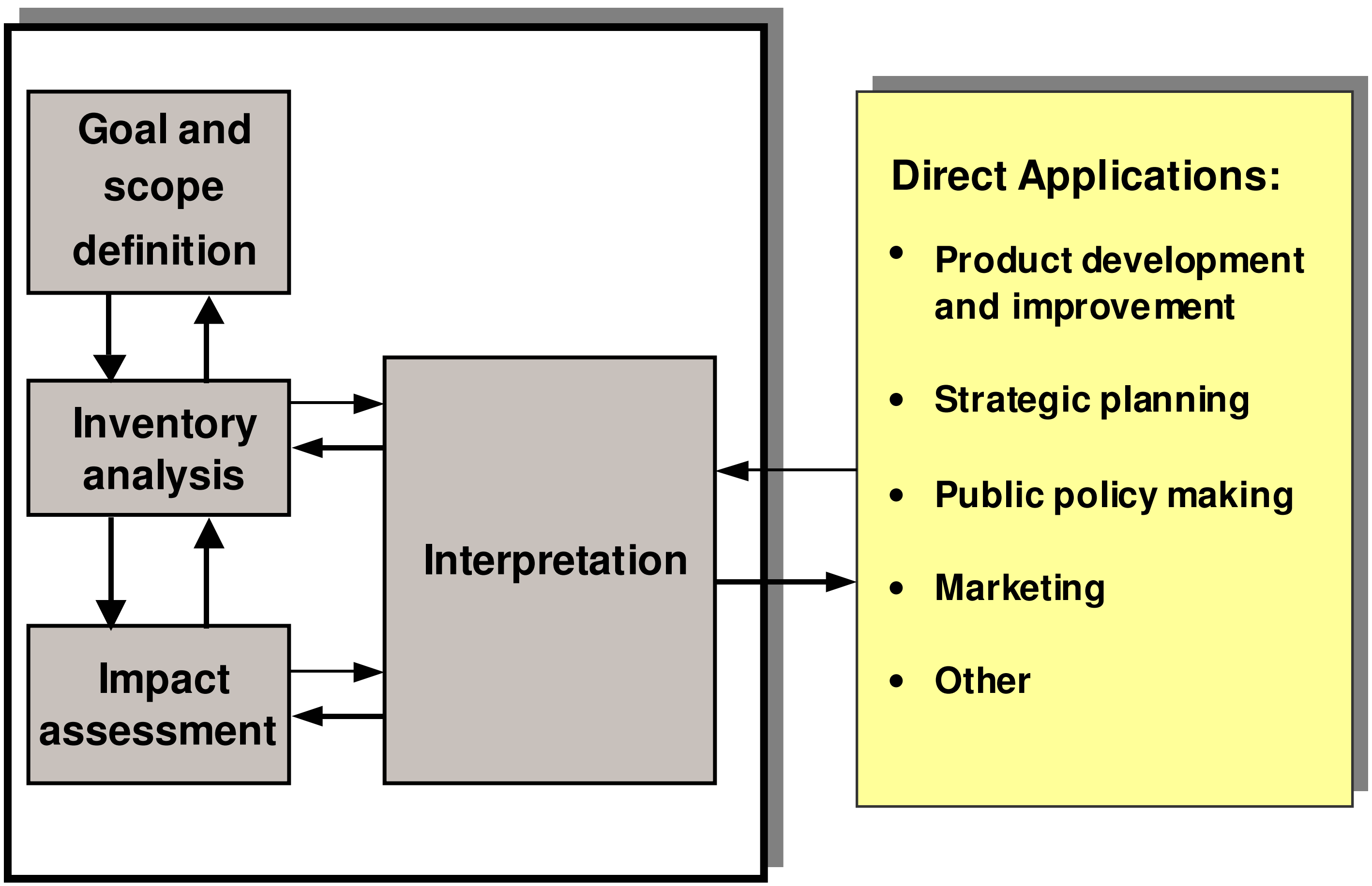


1713 Josef von Carlewitz wrote:

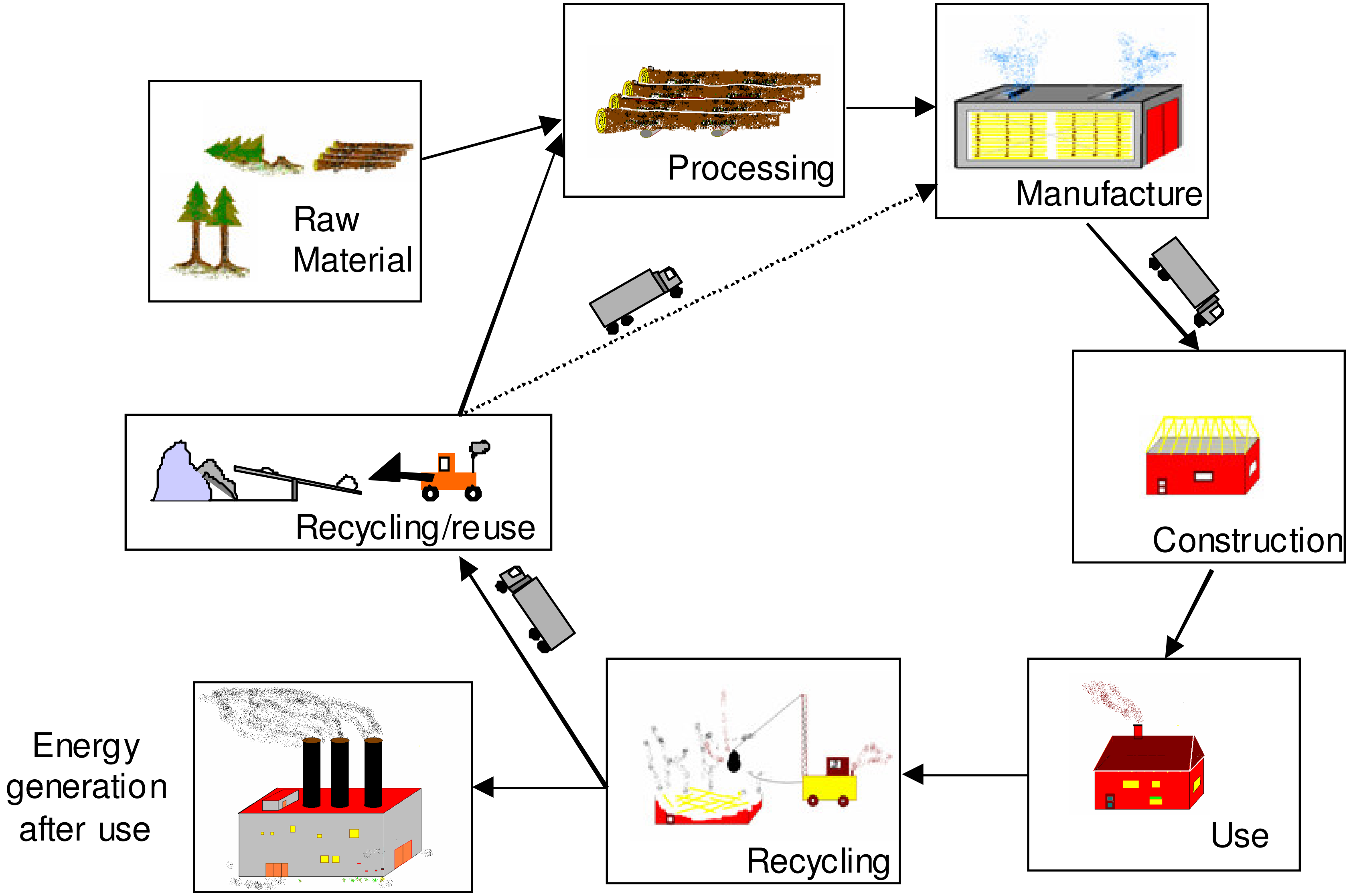
„sustainable forestry means that harvests should be always less than the increament of wood in the same period.“

→ Sustainable forestry has become a tradition in most countries

The LCA-method consists of four steps

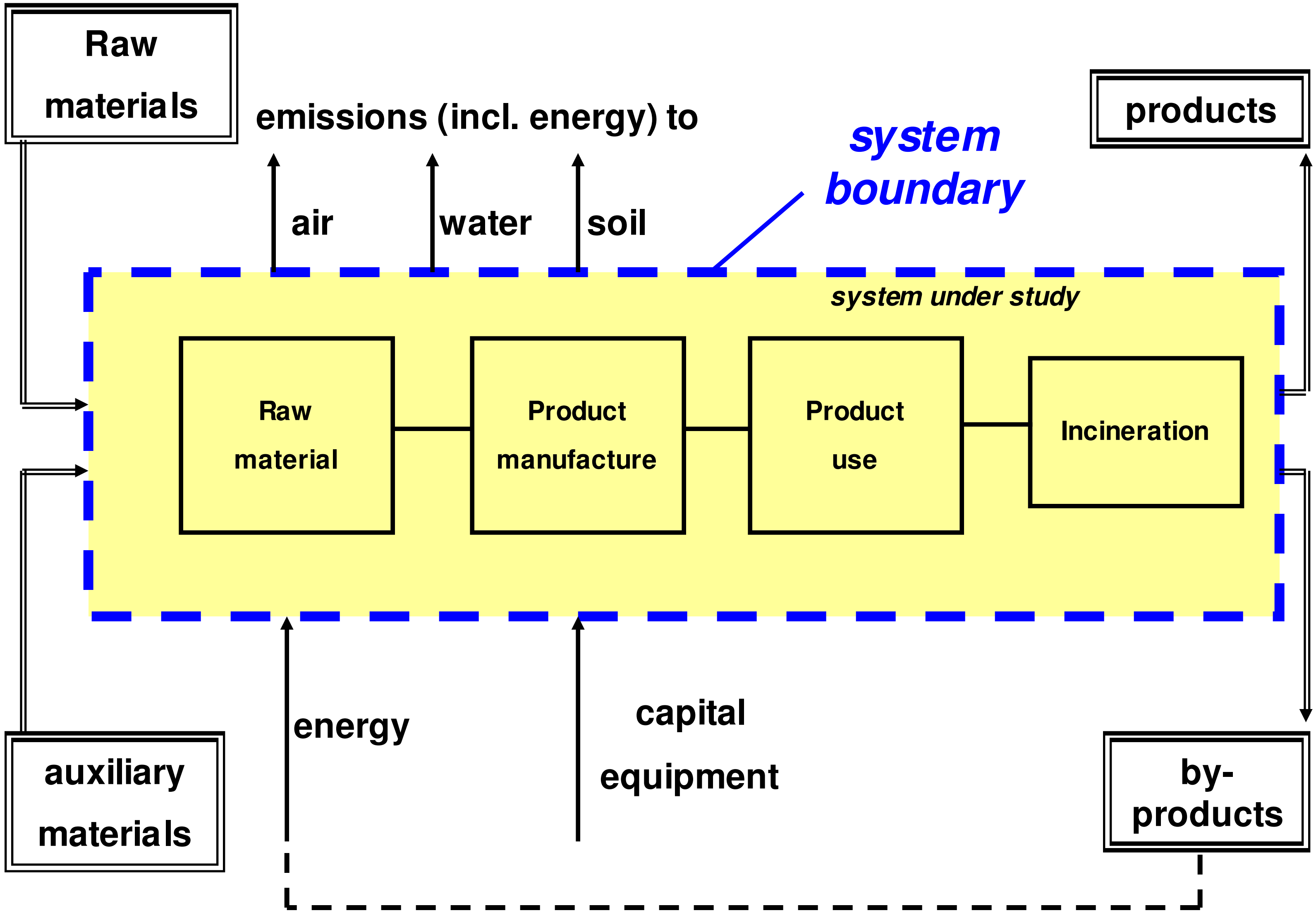


A life cycle



Raw Material
Processing
Manufacture
Construction
Use
Recycling
Recycling/reuse
Energy generation after use

An inventory analysis



Material in- and outflow for particleboard V20 and V100

Input (kg/m^3)	V 20	V100	Output (kg/m^3)	V 20	V 100
round wood[1)]	94	87	boards[1)]	642	636
industrial residues[1)]	471	394	water in boards	55	54
recovered wood incl. recycled boards[1)]	95	184			
wood total[1)]	**660**	**665**	**total boards**	**697**	**690**
water in wood	416	411	by-products(mainly sander dust)	82	105
glue (dry matter)[2)]	**58**	**65**	process water	192	225
water in glue	31	63	solid waste	2	2
process water	254	240	metals	1	1
other materials	3	3	packaging material	1	1
			emission to air (watervapor)	448	425
total	**1.423**	**1.449**	**total**	**1.423**	**1.449**

[1)] dry matter
[2)] incl. paraffine, hardener etc.

Primary energy consumption for the manufacture of particleboard

Primary energy input in MJ/m³	V 20	V 100
fossil fuel	**344**	**219**
wood fuel		
bark	37	32
recovered wood	462	73
production residues		
- chip preparation	519	892
- sander dust	719	908
- others	294	246
total wood	**2.032**	**2.151**
total thermal energy	**2.375**	**2.370**
electricity	**1.383**	**1.553**
transport within the mill	**16**	**16**
total energy	**3.774**	**3.939**

Material and energy for glue lam and construction solid wood for structural use

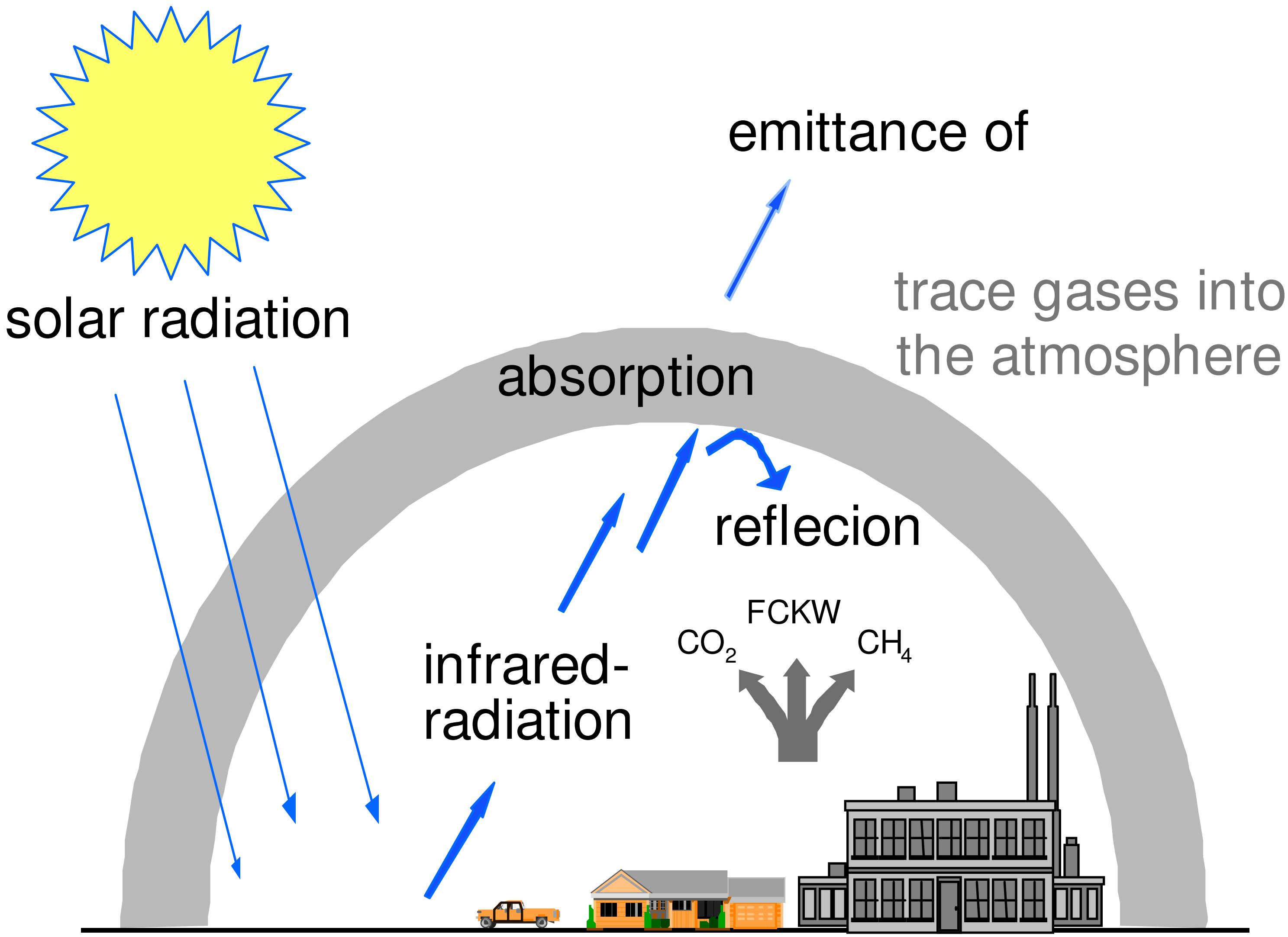
	gluelam		construction solid wood	
materials	lumber	592	lumber	529
	water	467	water	423
kg / m³				
	oil + grease	0,2	oil + grease	0,3
	varnish	0,7	glue	0,4
	plastics	0,2	plastics	0,2
	metals	22		
	glue	14		
	total:	**1.096**	**total:**	**953**
energy	electricity	391	electricity	241
	diesel	273	diesel	216
kWh/m³	wood	518	wood	220
primary	fuel oil	36	fuel oil	11
	total:	**1.218**	**total:**	**688**

Impact assessment

ISO/EN 14.042 recommends assessment according to various impact categories like

GWP:	Global Warming Potential
EP:	eutrophication
HTP:	human toxicity potential
AETP:	aquatic ecological toxicity potential
POCP:	photochemical ozone formation potential
AC:	acidification
TETP:	terrestric ecological toxicity potential
Land:	land use

Greenhouse Effect

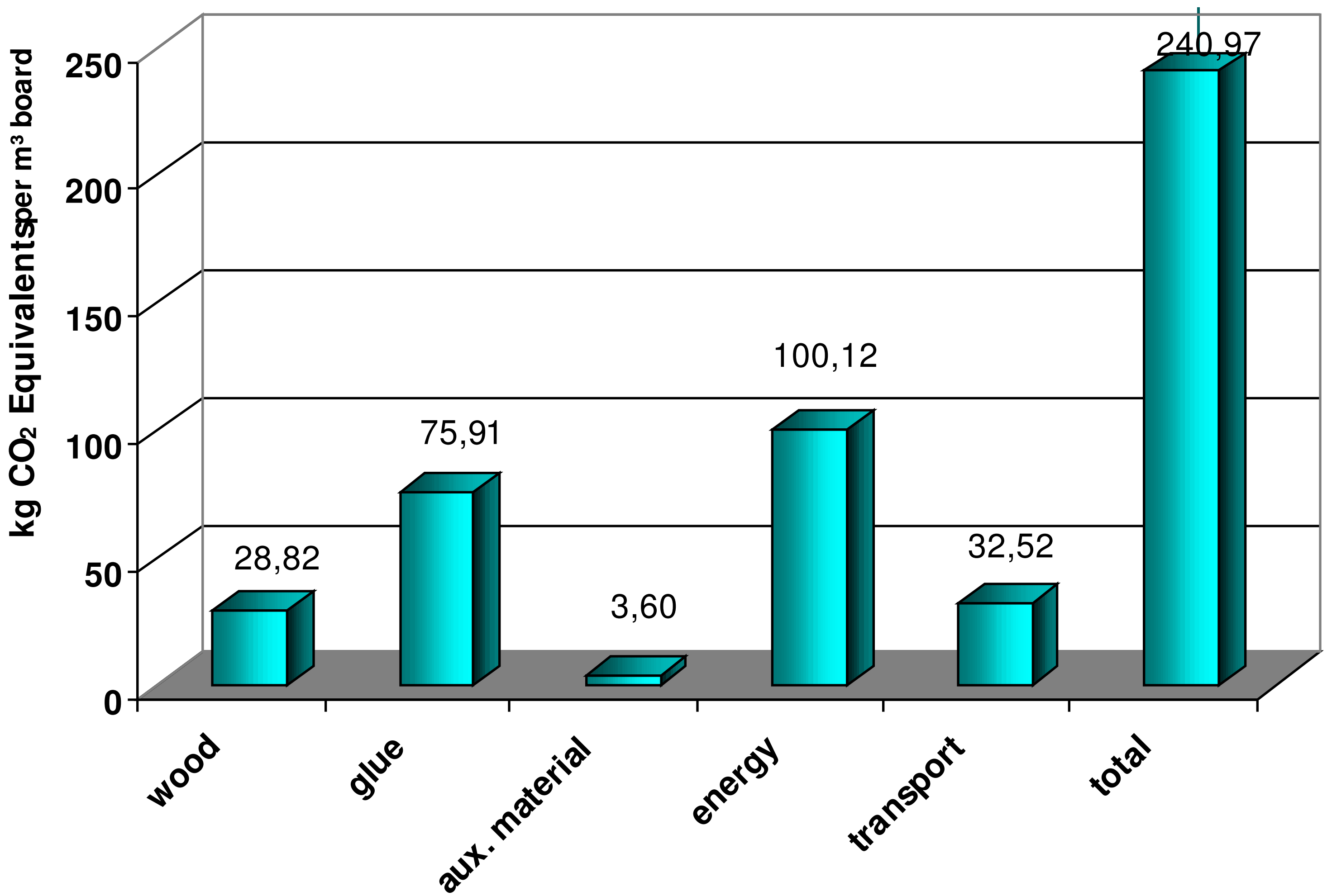


Green House Gases

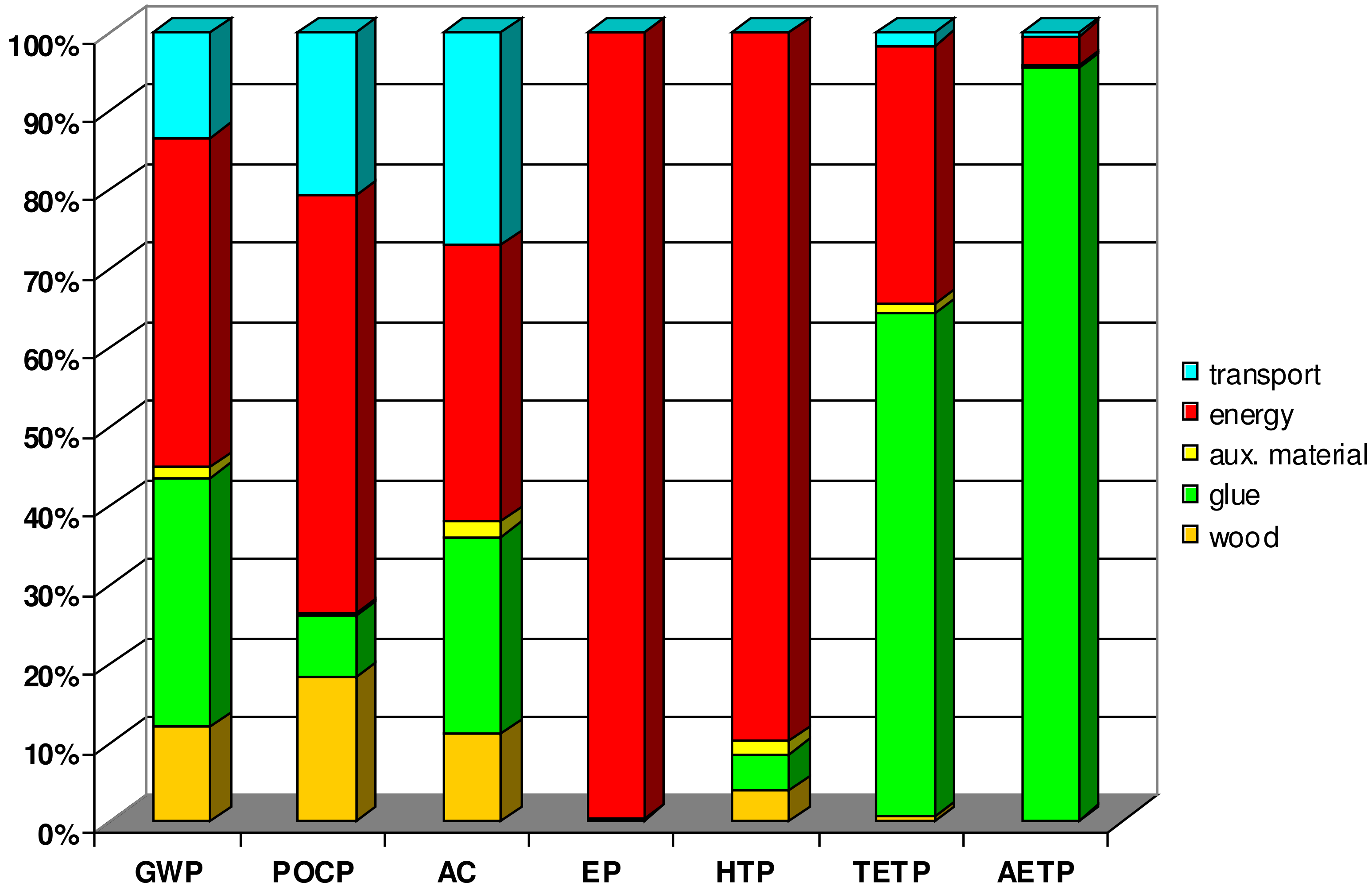
chemical compound	CO_2-Äquivalent (100 years)
CO_2	1
CH_4	24,5
NO_2	320
O_3	2000
H1201 Halon	5600
FCKW	1500

all impacts are calculated as Carbon dioxide (CO_2) or Carbon (C)

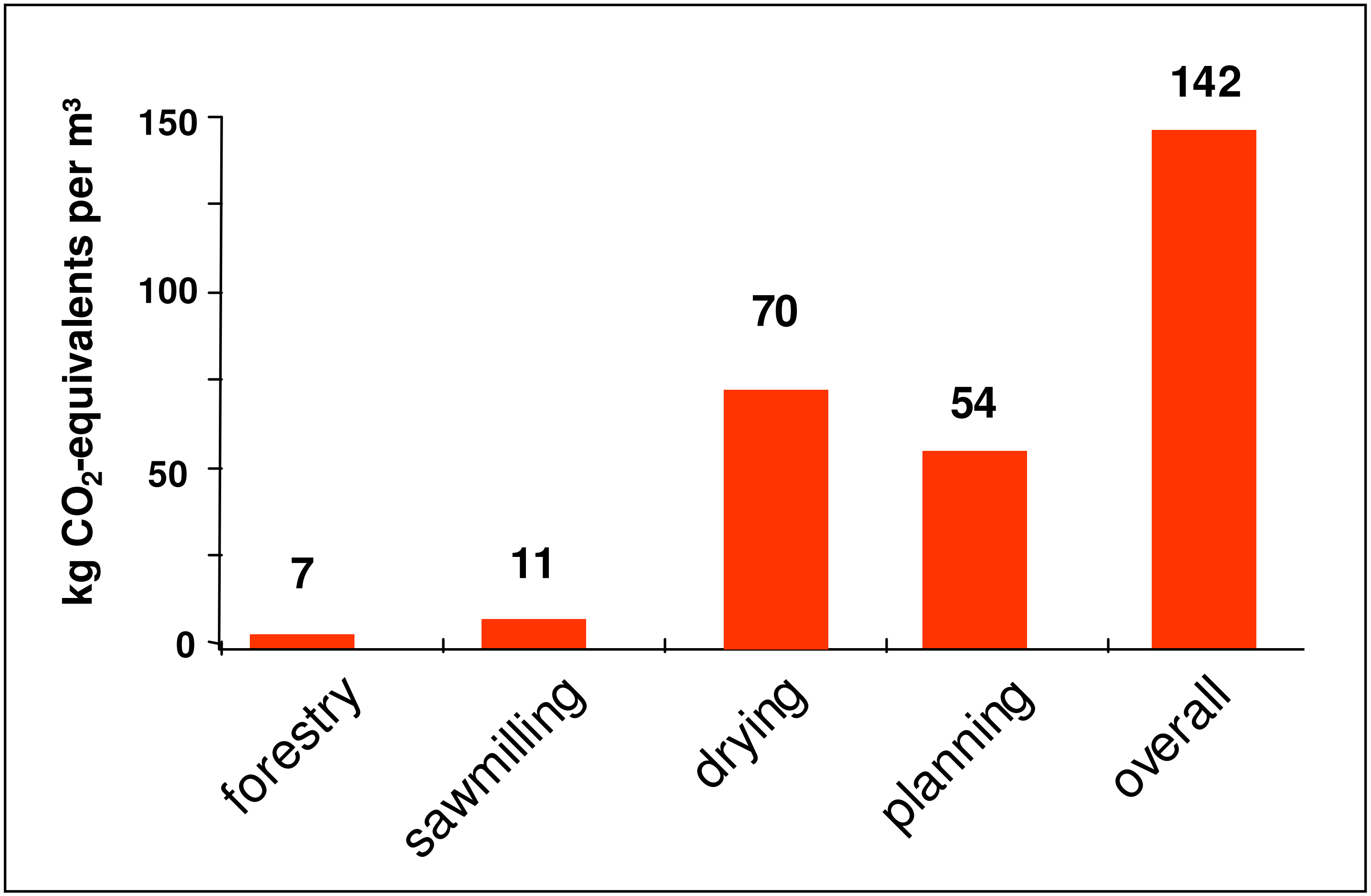
GWP Particleboard (dry condition V20)



Impact assessment categories, particleboard (dry condition V20)

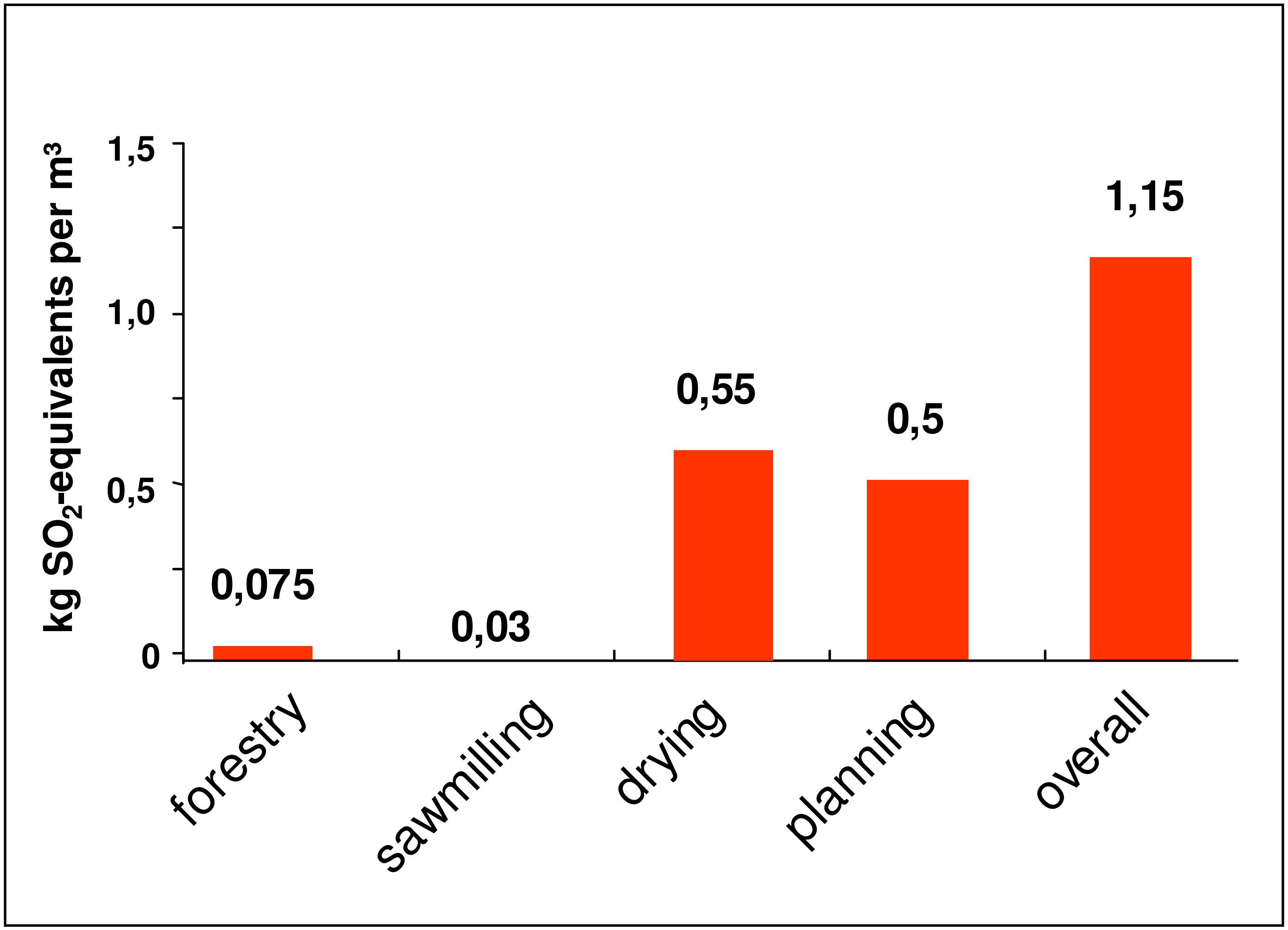


Greenhouse gas emission of construction solid timber (GWP)



Fixed CO_2/m³: 925,5 kg

Acidification Potential (AP) of construction solid timber



Energy consumption vs. Energy potential

	Consumption			Energy potential in		
	Fossil fuel [MJ/m³]	Wood fuel [MJ/m³]	Electricity [MJ/m³]	residues [MJ/m³]	product [MJ/m³]	consump. / potent.
Logs	70	0	0	4.500	8.800	< 1%
Green lumber	100	5	85	4.000	8.300	1,5%
Planned dry lumber	1.000	850	250	5.500	9.000	15%
Glue lam	1.000	2.800	470	8.000	9.200	20%
OSB	200	3.000	470	2.200	12.900	25%

Always to Remember

Raw material → Manufacturing of Products
Energy content   Energy demand
↑   ↓
Recycling ← Use of Products
Energy generation   Energy Input

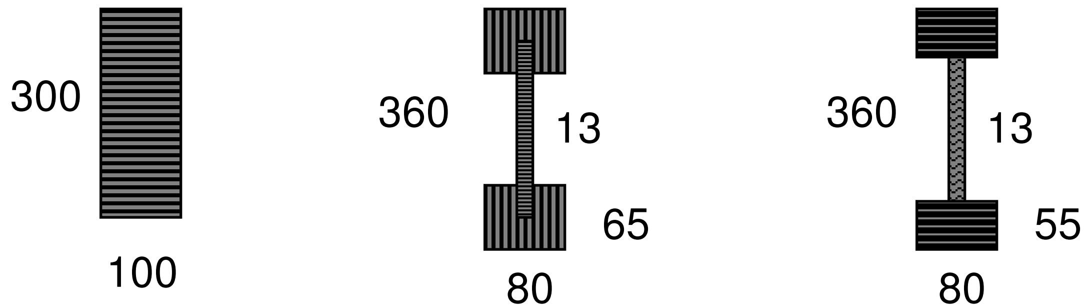
Example: Construction Solid Wood (dry basis)

energy content

16.5MJ/kg → minus 2.5 MJ/kg processing
↵
14.0 MJ/kg ← Same as other material
Recycling Energy   based products

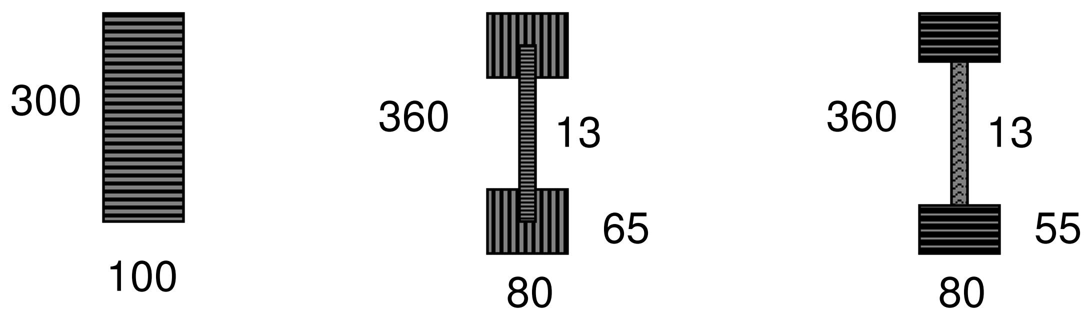
What other raw material basis is comparable?

Ecological aspects of beam structures



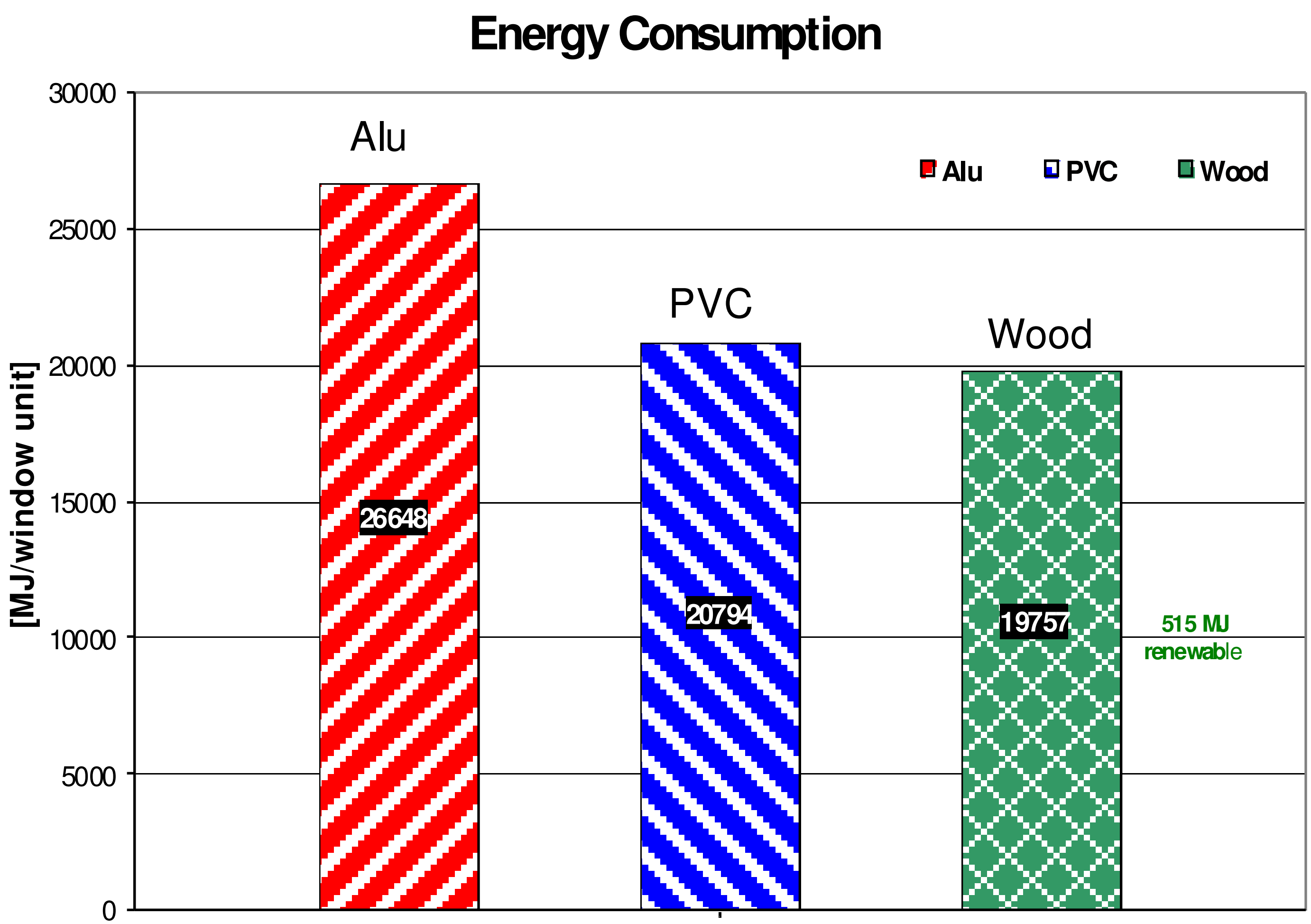
	Glue Lam	CSL/Parallam	LVL/OSB
moment of inertia	22.500 cm^4	20.000 cm^4	17.500 cm^4
wood volume per 10m beam	0,70 m^3	0,22 m^3	0,26 m^3
type of logs	large diam.	thinnings	large d. 75% thinn. 25%

Ecological aspects of beam structures



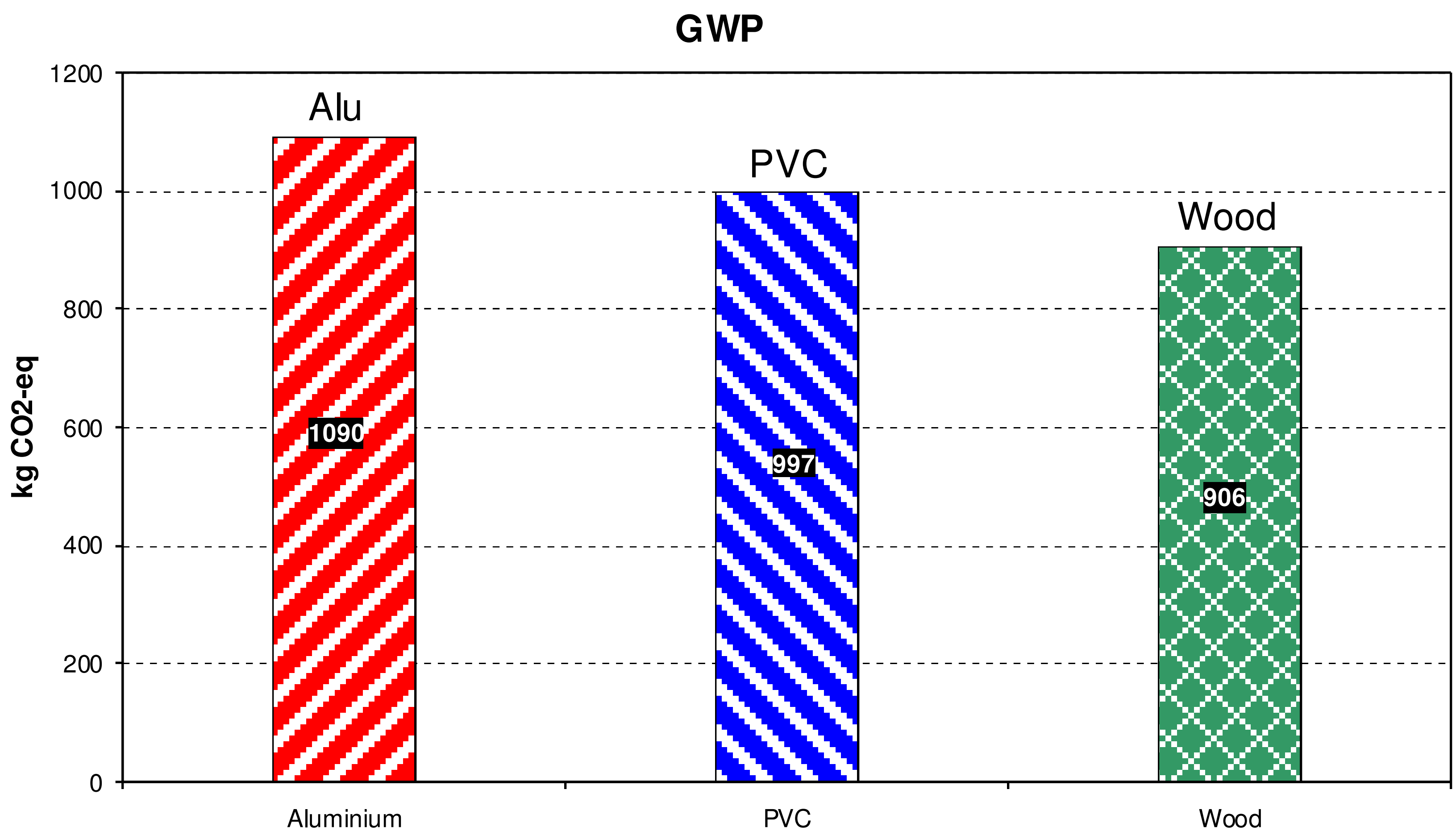
	Glue Lam	CSL/Parallam	LVL/OSB
wood volume per 10m beam	0,70 m^3	0,22 m^3	0,26 m^3
energy input	1.400 MJ	900 MJ	1.300 MJ
fossil	57 %	37 %	50 %
non-fossil (n. f.)	43 %	63 %	50 %
CO_2-Equiv.	33 kg	17 kg	27 kg
C-sink	150 kg	50 kg	45 kg
CO_2 Reduction potential	210 kg	70 kg	65 kg
net energy surplus (n. f.)	4.500 MJ	1.500 MJ	900 MJ

Example: Window frames



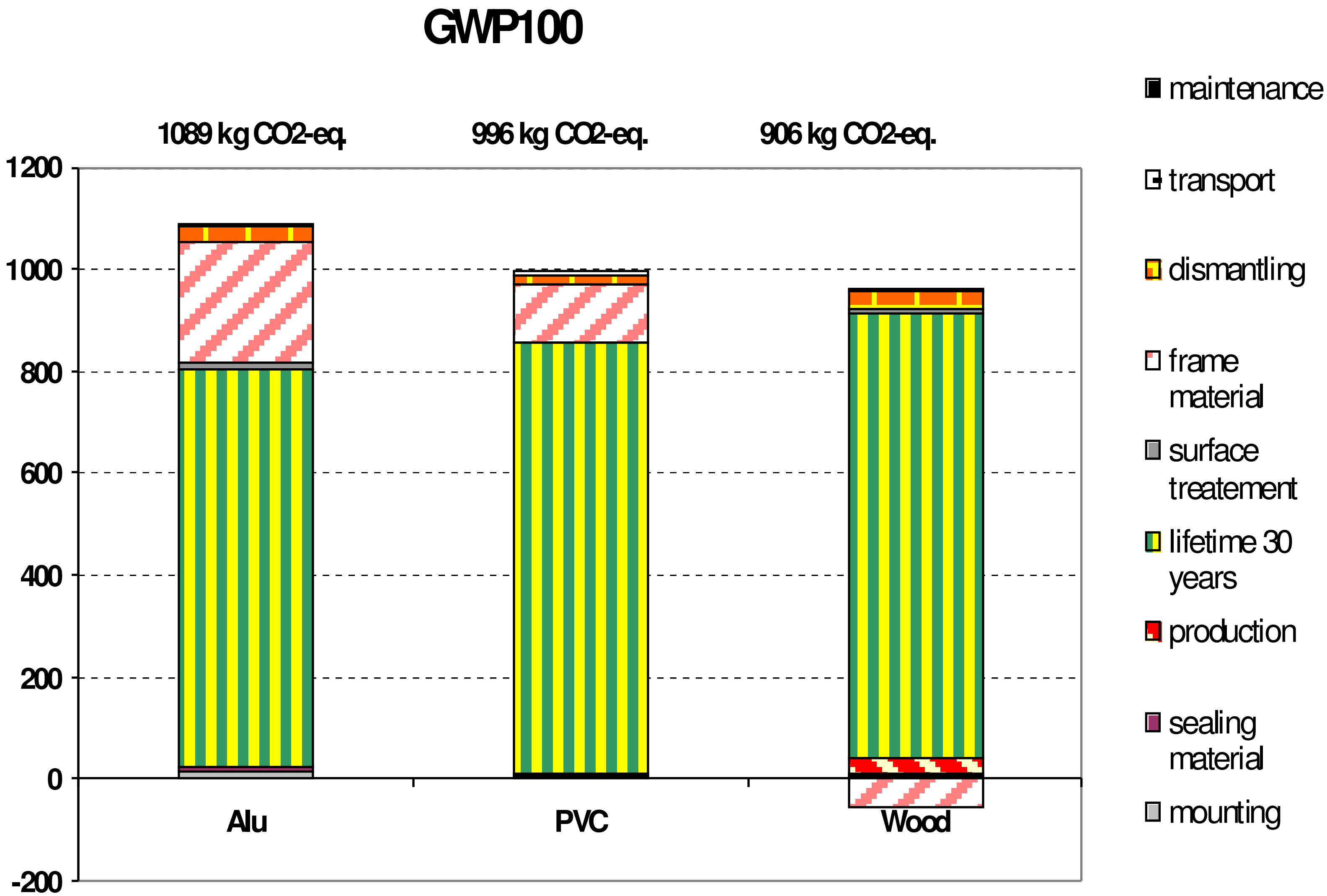
Source: Richter 2000

Example: Window frames



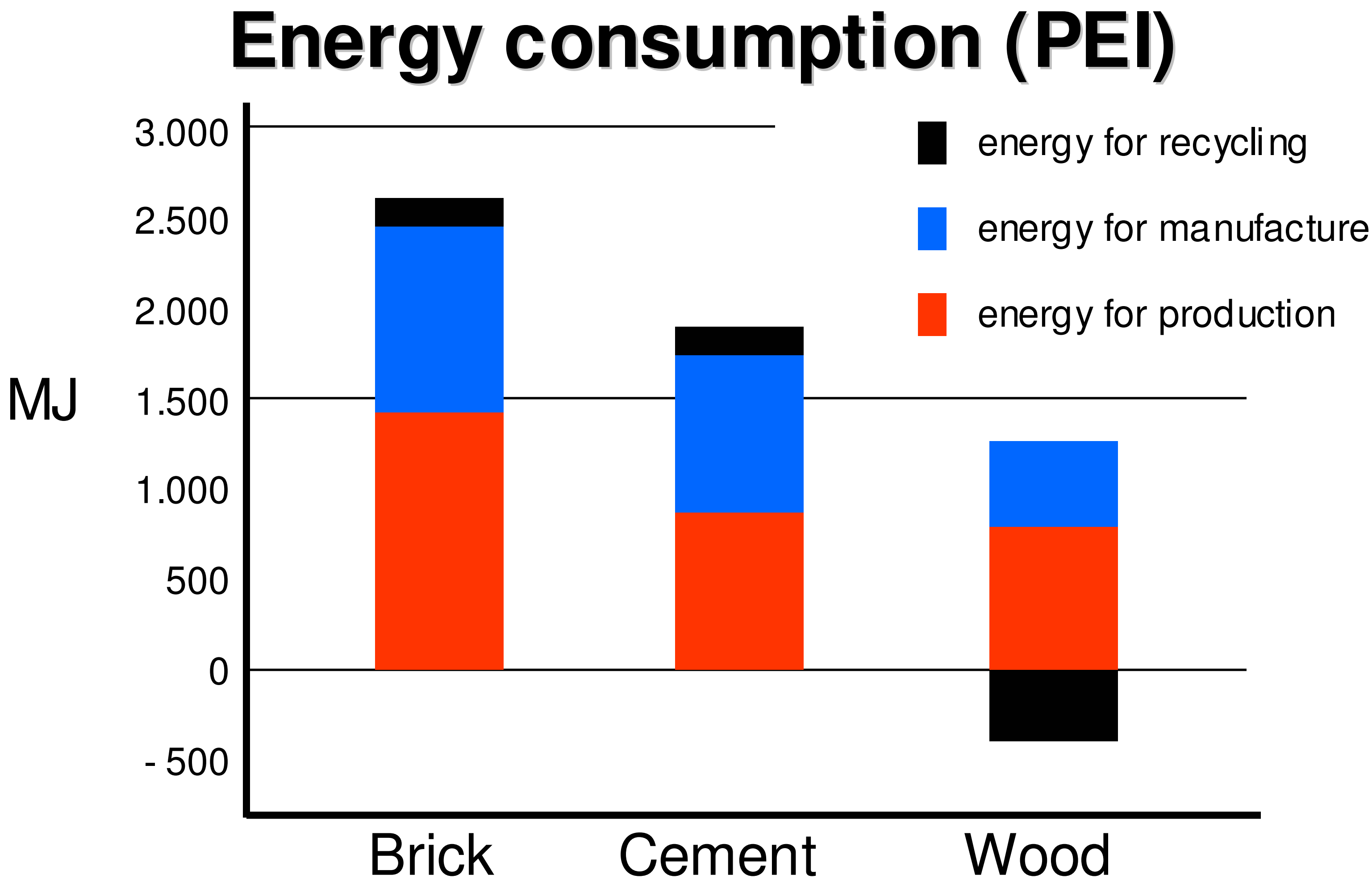
Source: Richter 2000

Example: Window frames



Source: Richter 2000

Example: Noise protection elements



Source: Richter, Künniger, 2001

C-emissions during life cycle and C-sink

Timber Construction

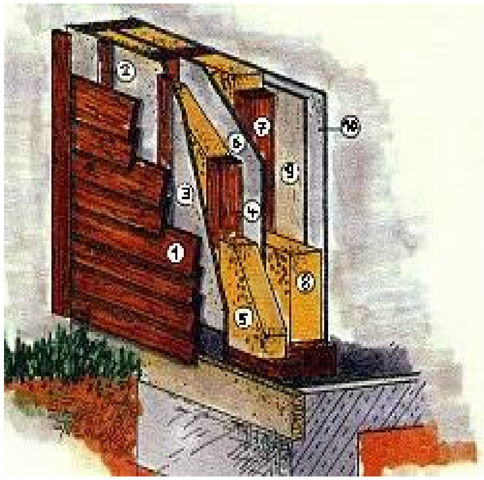
200 m² living space

	C-Emissions [t]
manufacture	28,1
construction	0,6
maintenance of house	5,5
use (60 y)	43,7
recycling	3,3
transport	0,4
total	**82 t C**
C-sink during 60 years	**26 t C**

to be compared with other buildings

Source: Pohlmann 2002

Comparison of timber and non timber products

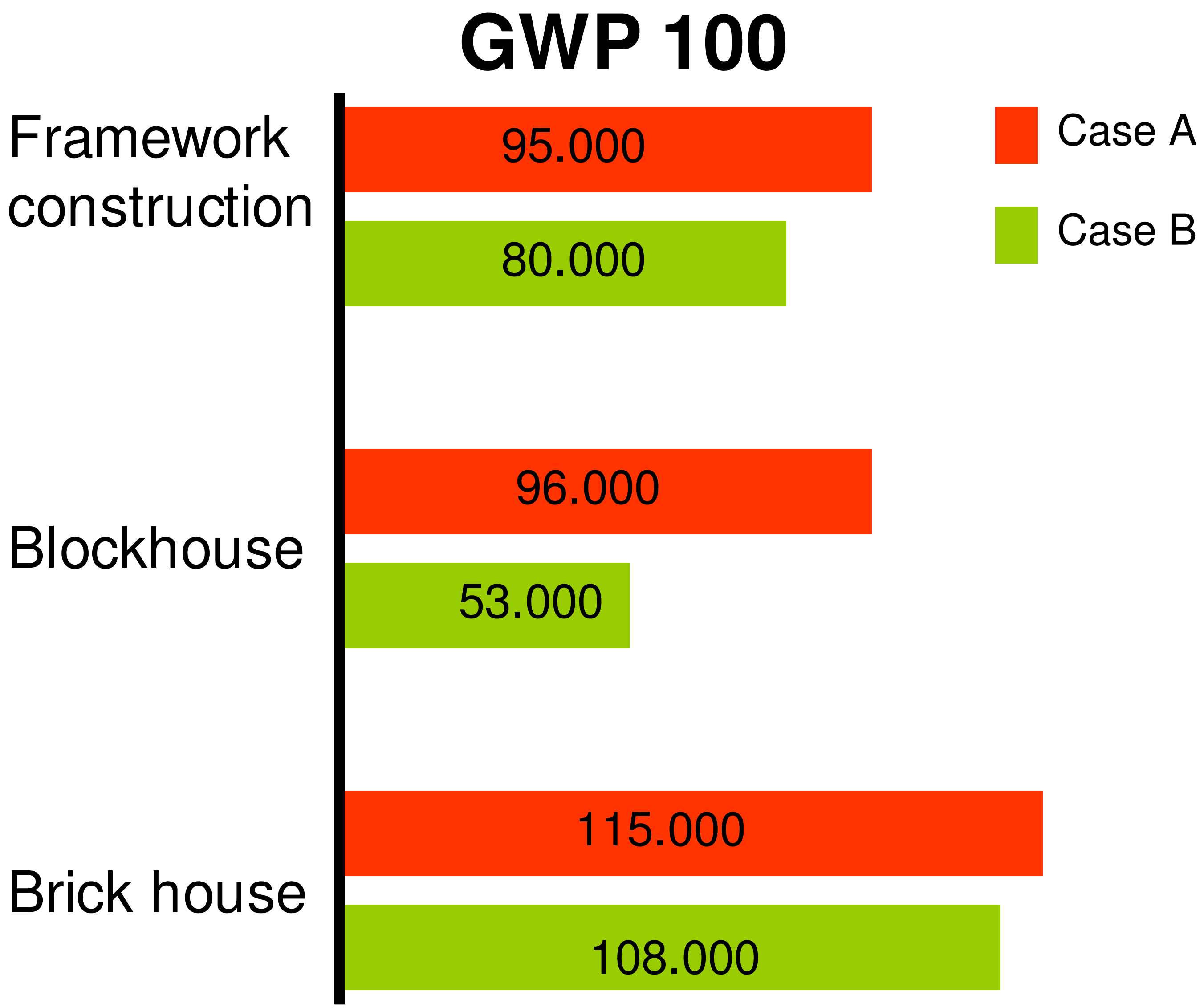


1 m² wall elements

	wooden house	brick type house
weight [kg]	71	273
energy [MJ]	271	876
CO_2-emissions [kg]	- 50	58
acidification [kg]	128	196

Source: Waltjen, R. et al. 1999

Example: single family houses



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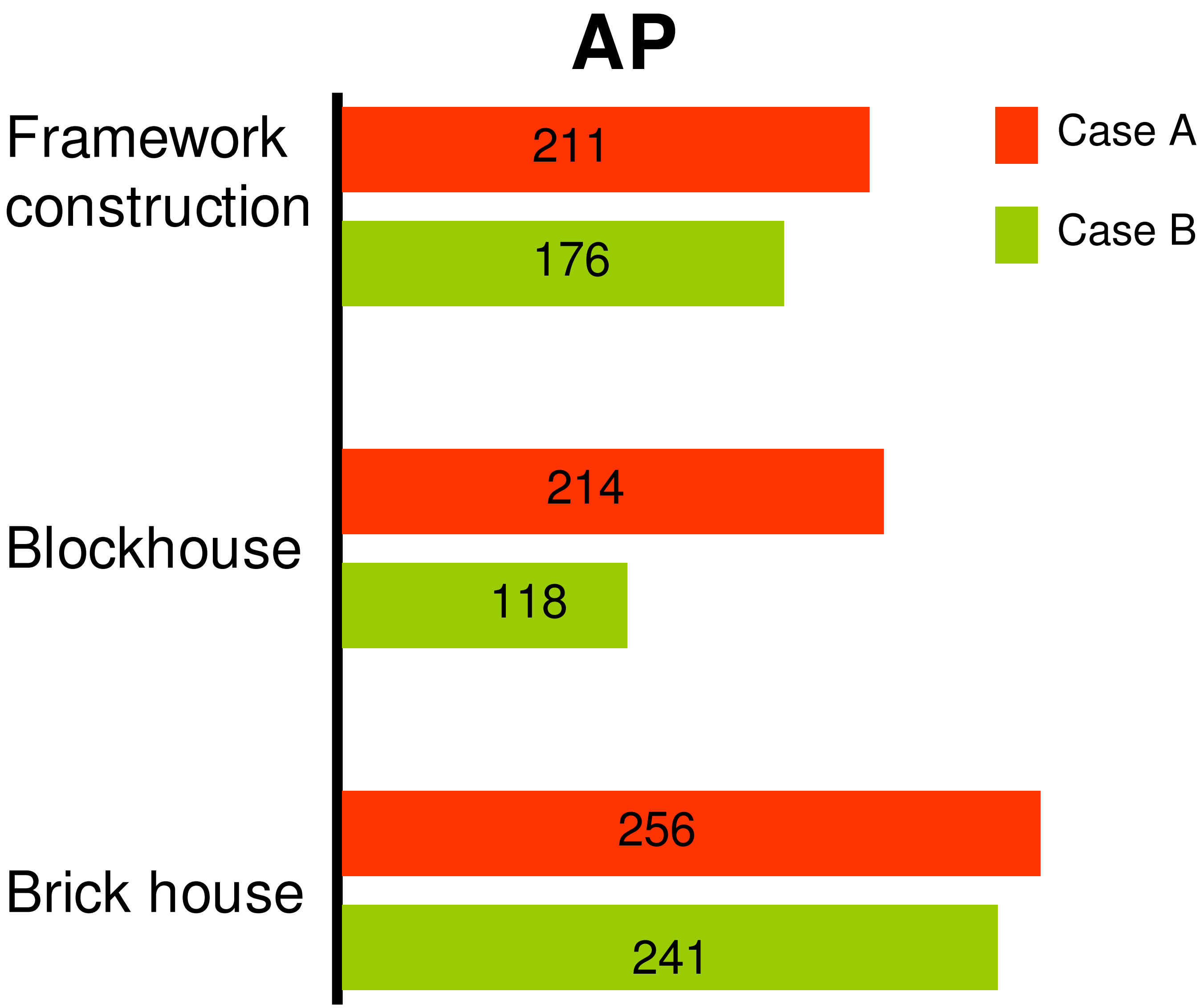
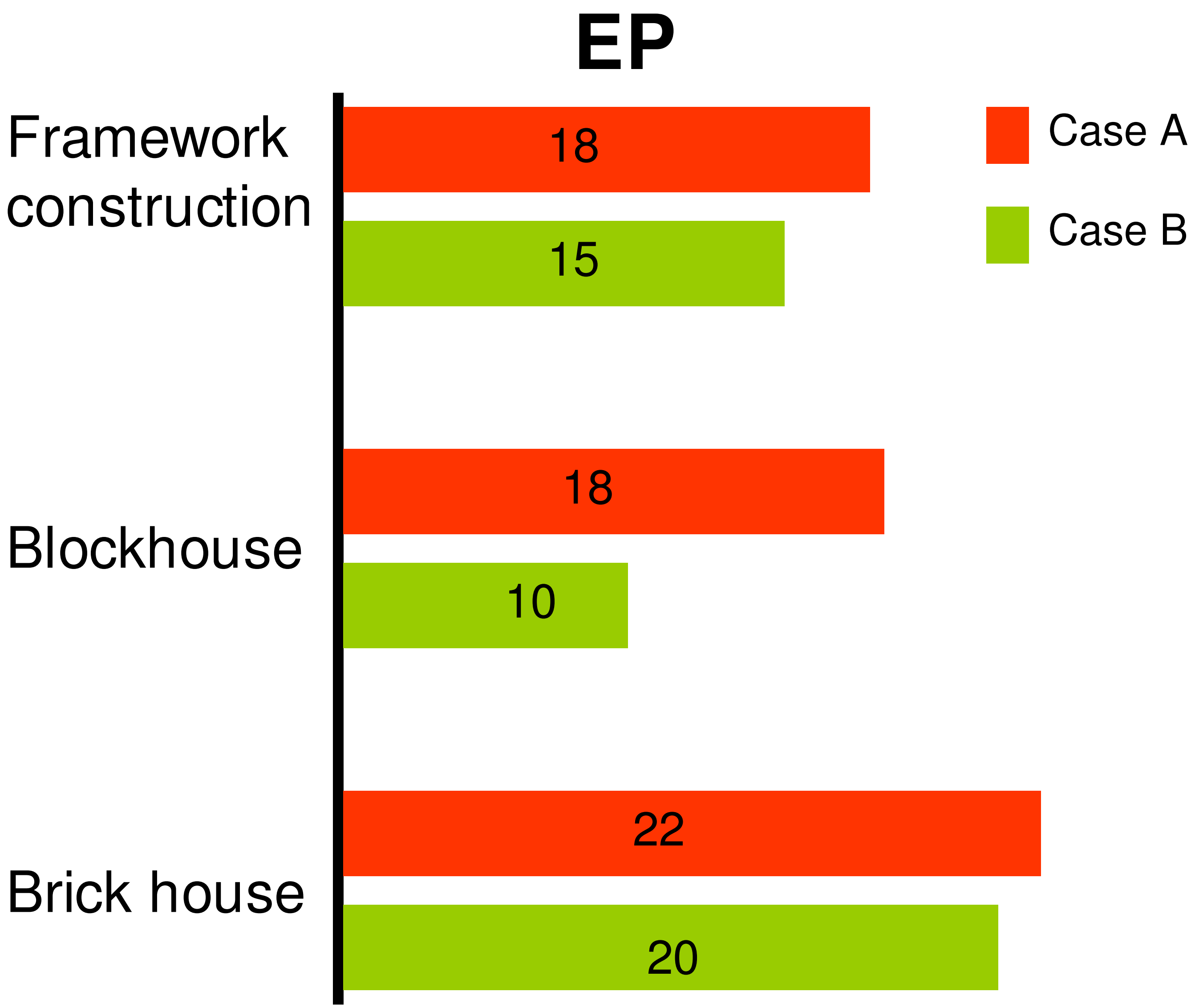
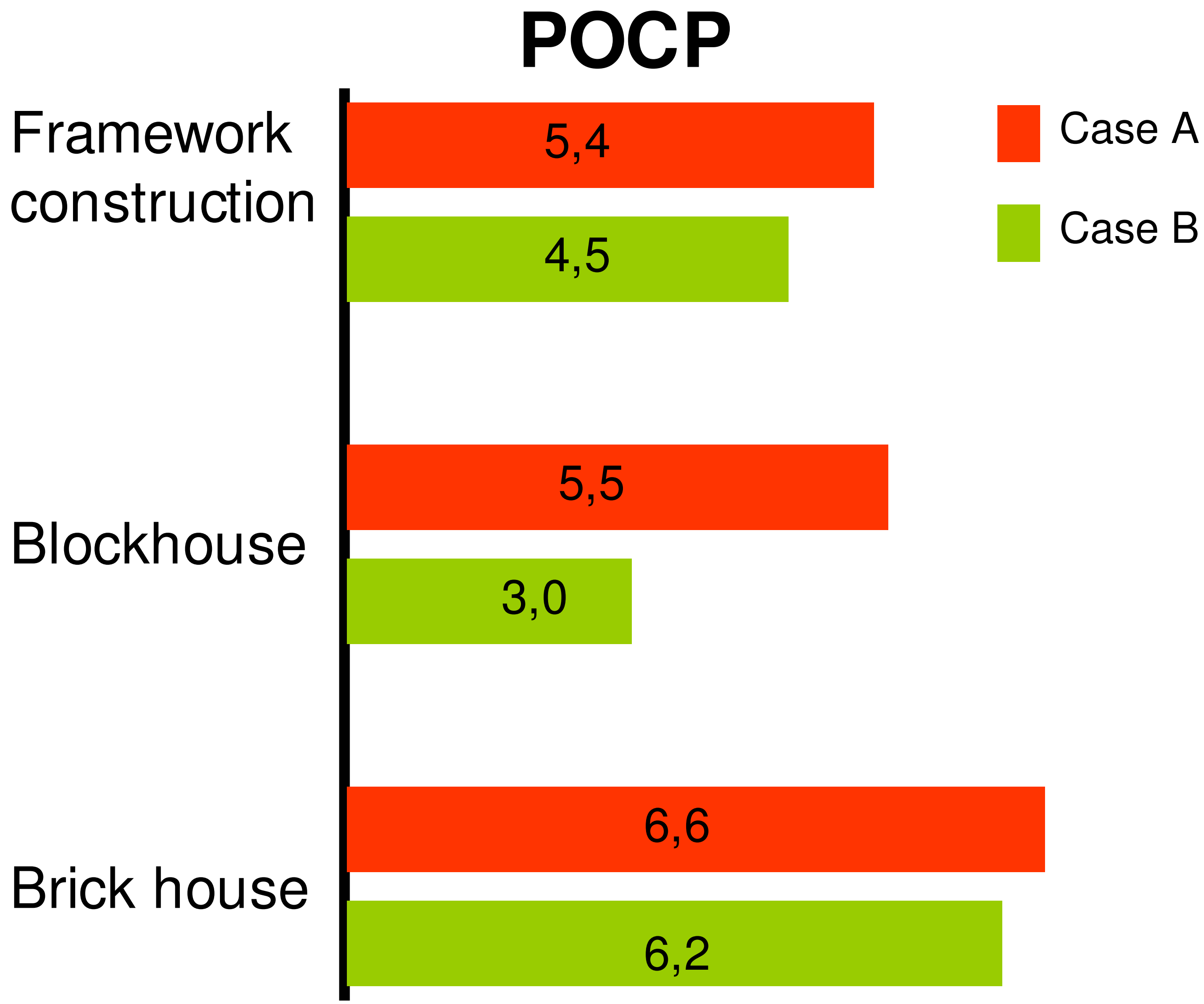


Example: single family houses



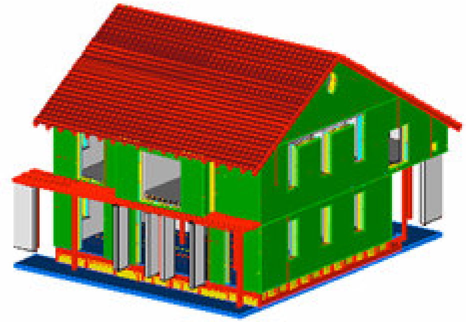
Example: single family houses



Example: single family houses

House type	Impact potential	Production	Construction
Framework house	GWP100	70100.00	24752.00
	AP	156.37	55.21
	EP	13.32	4.70
	POCP	4.03	1.42
Blockhouse	GWP100	71546.00	24752.00
	AP	159.59	55.21
	EP	13.59	4.70
	POCP	4.12	1.42
Brick house	GWP100	85277.00	29702.00
	AP	190.22	66.26
	EP	16.20	5.64
	POCP	4.91	1.71

Carbon aspects of wooden houses

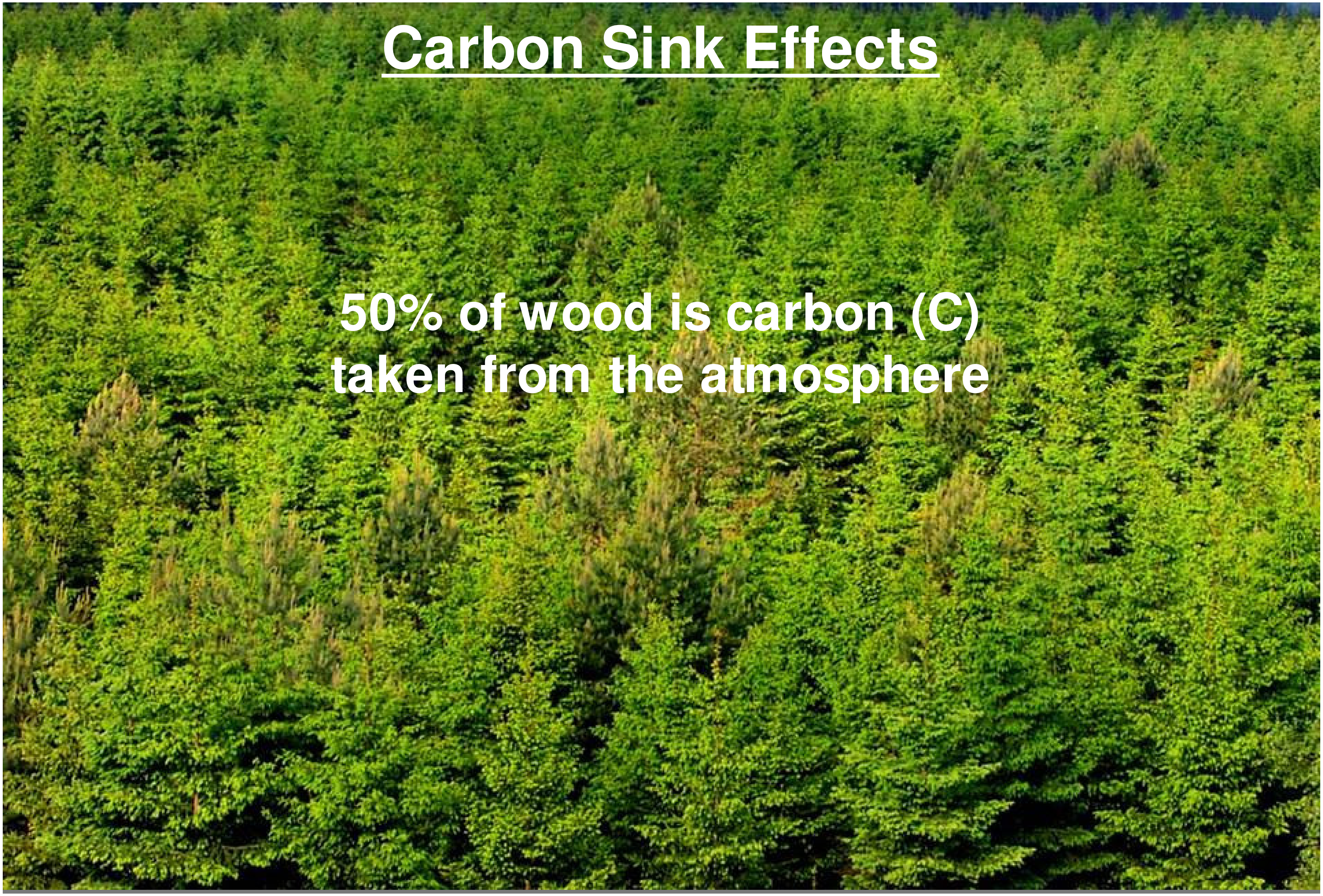


A wooden house compared to a brick type houses reduces C-emissions in the order of 10 t

⇒ If additional 10 % of all houses in Europe would be build with wood, the C-emissions are reduced by

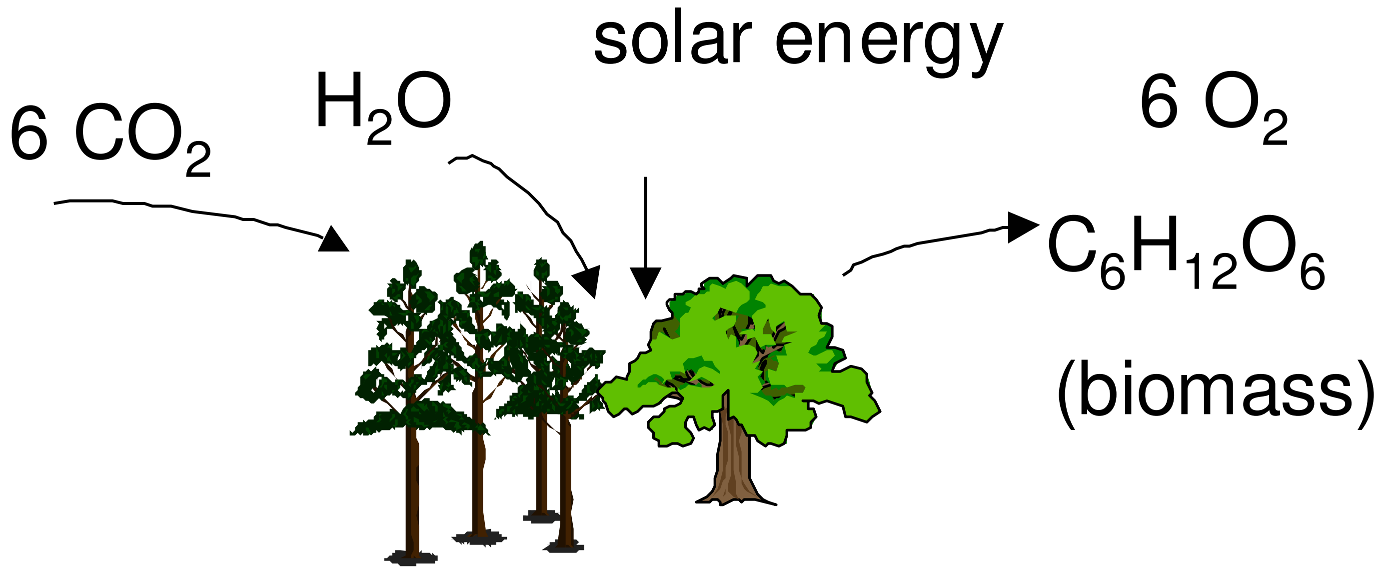
1,8 Mio. t (~ 2% of all C-emissions)

Carbon Sink Effects



50% of wood is carbon (C) taken from the atmosphere

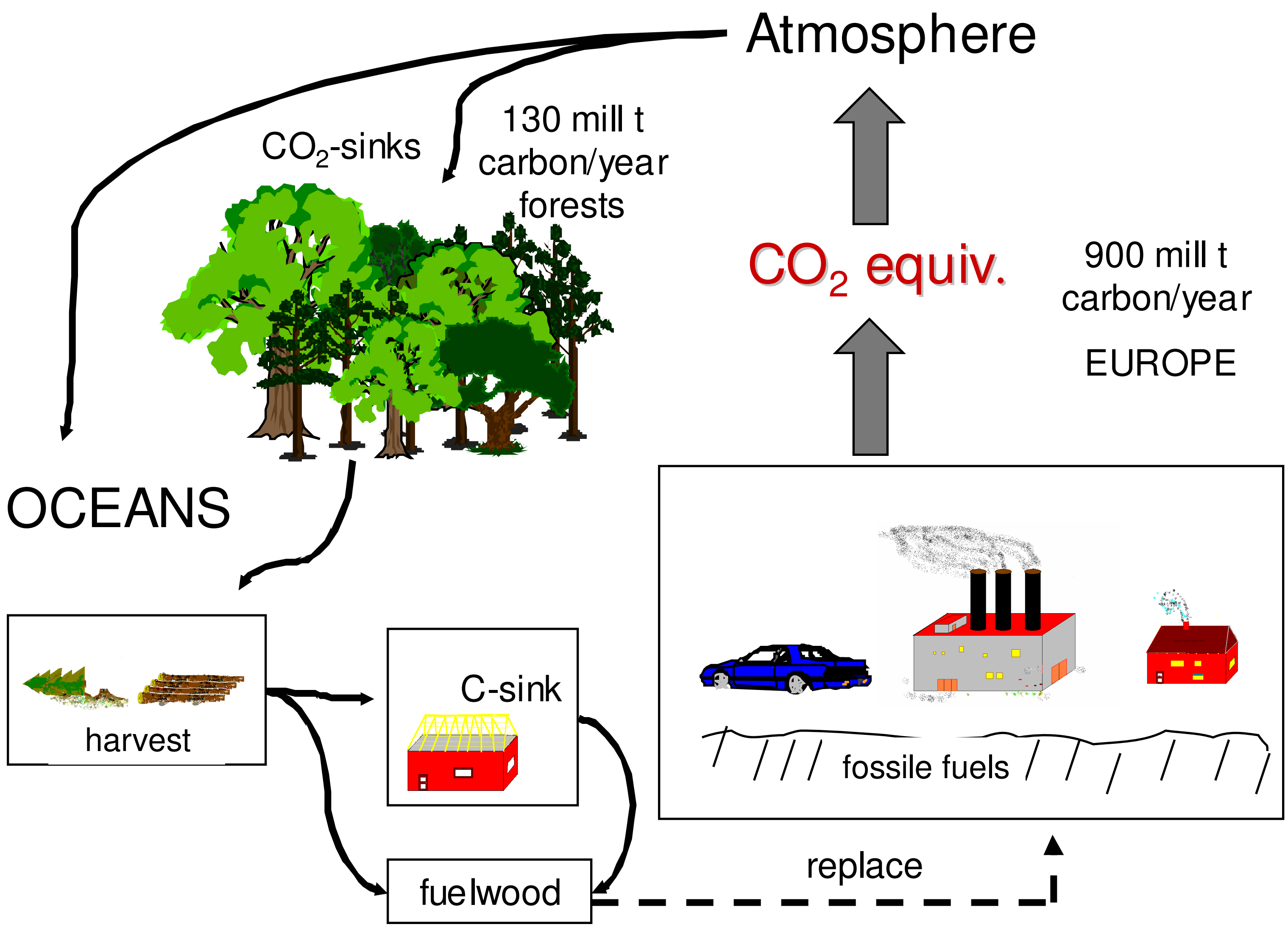
Photosynthesis



Balance for 1 kg wood

Input	Output
1,44 kg CO_2	1 kg biomass
0,56 kg H_2O	1 kg O_2
18,5 MJ solar energy	18,5 MJ thermal use

Closed carbon cycle



Carbon sink in Forests

carbon stocks in trees and soils	
of European Forests	**~ 20.000 Mio t C**
of which	
carbon stock in tree biomass	~ 8.000 Mio t C
estimated net sequestration	
- in trees	~ 100 Mio t C/y
- in soils	~ 30 Mio t C/y
- total	~ 130 Mio t C/y
total carbon emission Europe	~ 900 Mio t C/y

(Source: Karjalainen et al. 2000)

Carbon sink - wood products

carbon stocks in wood products

• wooden windows	25 kg C/unit
• wooden floor (parquet)	5 kg C/m²
• furniture per family	1.000 kg C/family
• roof brick type house	1.000 - 3.000 kg C/unit
• wooden house	10.000 - 25.000 kg C/unit

estimated carbon stock in

wood products - Europe	~ 1.000 Mill t C
estimated net sequestration	~ 30 - 50 Mill t C/y

C-sink wood products - Germany

	Volume [Mio t]	Carbon sink [Mio t]
35 Mio. houses with 2.000 kg furniture and wooden fitmens	70	35
17 Mio. wooden single- and double family houses (25 m³ each)	255	128
2,75 Mio. residential buildings with more than two appartments, used wood 40 m³	85	43
Wood in exterior use	80	40
Wood in non-residential buildings	100	50
Wood as packaging material	10	5
Paper products	50	25
Semifinished products - production and storage	15	8
together	**665**	**334**
per capita	**8**	**4**

Expansion of German values to European sink

Germany	80 Mio people	- 334 Mio C-sink in wood/paper products
EU (15)	375 Mio people	⇒ 1.565 Mio C-sinks in wood products

remarks:

- building sector is different within EU regarding wooden buildings (North - South)
- other wood utilization sectors differ much within the EU

Total carbon Emission Europe 900 Mio t/y

C-sink in wood products EU (15)

Estimates based on German situation:

total C-sink	1.565 Mio t
net sequestration	13 - 16 Mio t/y

Total C-emissions ~ 900 Mio t/y

	in % of total emissions	in % of reduction obligation
C-sink in wood products	3,5 - 4,5 %	40 - 50 %
C-sink in forests	14 %	130 %

Average life time of wood products - Germany

Results from inquires and field research:

newspaper	0,2	years
magazines	0,5	years
books	25	years
packaging	2	years
furniture		
low price	10	years
high price	30	years
outdoor uses	15	years
buildings		
decoration	30	years
structural use	75	years
average	33	years (weighed by volume)

Substitution effects

In general:

If wood products substitute non wood based products less fossil energy is required because of:

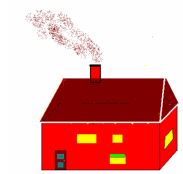
- wood based products require less energy for manufacture
- processing residues and products after use are a source for energy

Substitution effects reduce fossil fuel consumption and therefore have a direct influence on GHG emission reduction („100% Kyoto-Protocol“)

Substitution effects

no wood utilisation
C-sink remains

Processing residues



energy

carbon and
energy pool

reduced carbon and
energy pool

timber products replace
non-timber products

energetic comparison
(production energy)

Processing residues and
wood products after use
replace fossil energy

Substitution of material

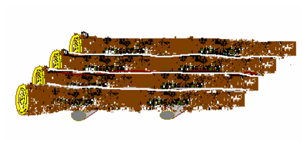
Substitution of fossil fuels

Energy aspects of wooden products

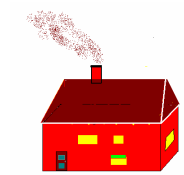
energy input

3.000 MJ

1 m³
logs



processing



0,8 m³
products

recycling
or energy

7.200 MJ

0,2 m³ for energy

1.800 MJ

1 m³ for energy

9.000 MJ

Δ = 6.000 MJ/m³ energy surplus

Energy aspects of non-wooden products

Alternative building material (non-wood)

(equiv. to 1 m³ of logs)

processing

recycling or landfill

~ 6.000 MJ

no energy

Δ = 6.000 MJ/m³ energy consumption

Summary comparison wood - non wood system

a) from wood system — 6.000 MJ/m³ logs surplus energy (to replace fossil energy)

b) from non wood systems — 6.000 MJ/m³ logs equivalent input (fossil energy)

Wood system replaces 12.000 MJ/m³ logs fossil energy

=> equivalent to 1,10 t CO_2 or 0,30 t C emitted into atmosphere

Compared to storage in the forest

1 m³ is equivalent to ~ 0,25 t C or 0,90 t CO_2

The consequences: use more wood

- **first to produce products**
- **second to produce energy**

C-storage in products and in forests (above ground)

0,25 t C per m³ wood

C-substitution

0,30 t C per m³ wood

Reduction of emissions!

Timber cuttings in Europe (EU 15) 251 Mio m³/y

20 % increase 50 Mio m³/y

⇒ C-emission reduction 12,5 Mio t C/y

1,4 % of all emissions

Do we have enough wood to increase utilization ?

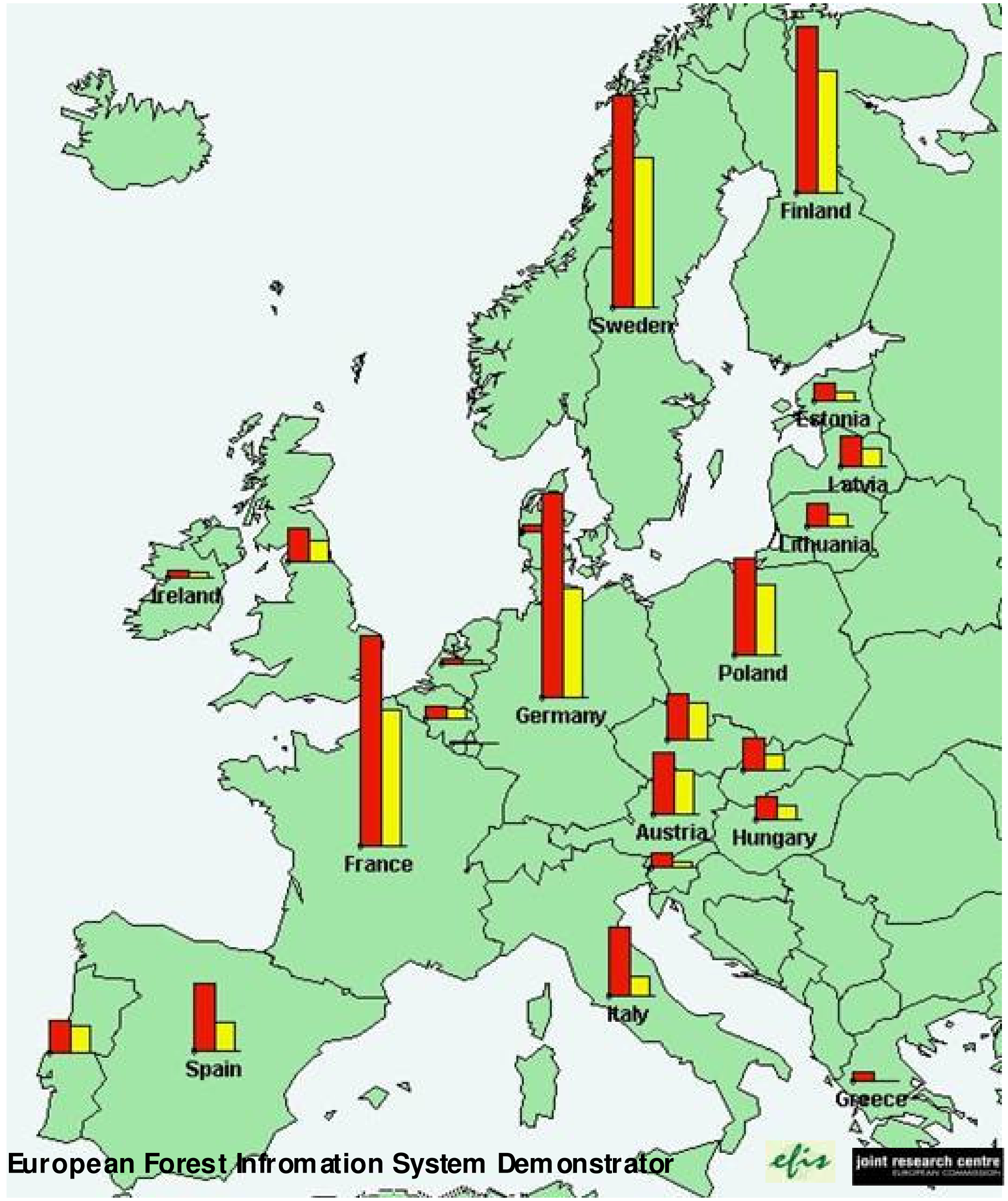
Example Europe

Net annnual increment > fellings

EU 15 (mill m³):
483 ⇔ 302

Additional 10 EU states (mill m³):
125 ⇔ 81

Source: UNECE/FAO, 2000; no data for Greece, Luxembourg and Malta)



Conclusions

1. Forest and long life timber products are important carbon sinks
2. Wood products require little energy for manufacture
3. More than 75% of the required energy is produced from wood residues and recovered wood
4. Wood and wood products after use are important energy sources
5. Alternative non-wood based products require more energy for manufacture
6. 1 m^3 of round wood used in building sector can reduce the CO_2 emission from fossil fuels up to 1,25 tons; the total CO_2 reduction potential by using wood ist up to 300 Mill. tons of CO_2 per year in Europe, 15-20% of all CO_2-Emissions in Europe
7. For environmental reasons: **use more wood!**
8. **There is enough wood!**

Thank you for listening