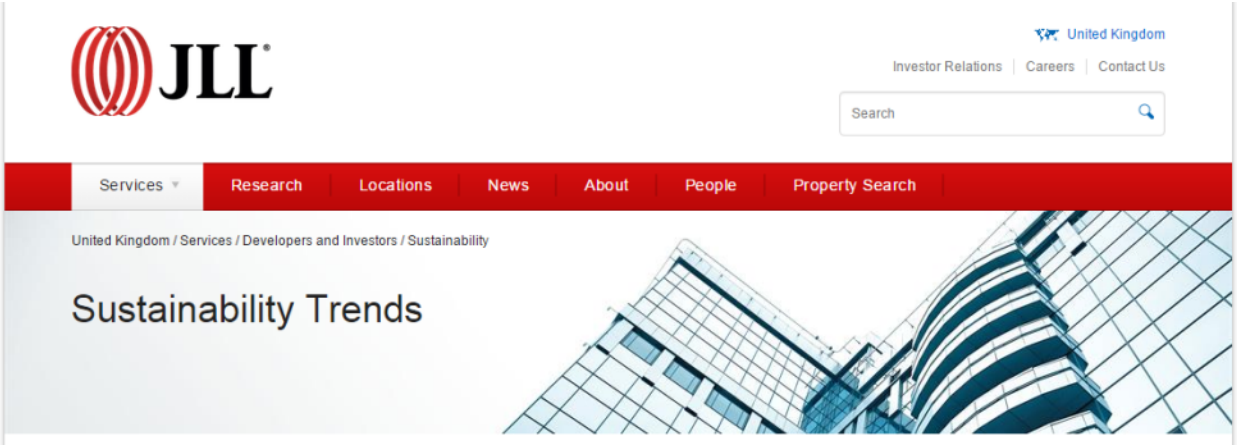
The Environmental Impact of Industrial Bamboo Products

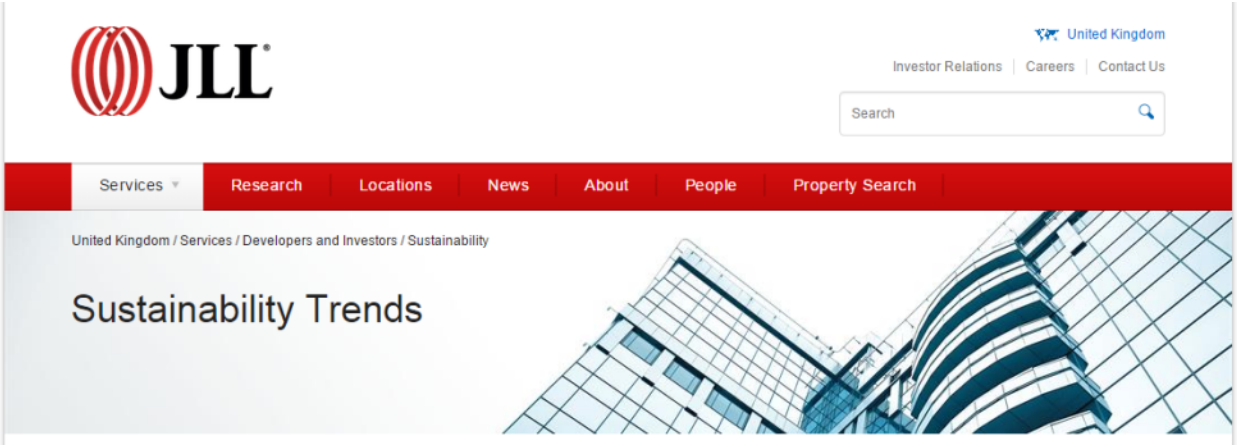
Life-cycle Assessment and Carbon Sequestration

Pablo van der Lugt - MSc Eng PhD
MOSO International / Delft University of Technology

Source: T. Larasati



- Investors will continue to divest from carbon intense assets, whatever the outcome of the UN Climate Summit >>
- On the path to 2050? Real estate companies start publishing carbon reduction targets to get us there >>
- The business benefits of tackling diversity trigger concerted action >>
- Green = prime. Healthy becomes a differentiator >>
- Income inequality and the skills crisis enter Boardroom discussions >>
- The future is here. Leading real estate players look ahead to protect their business models >>
- Collaboration by landlords and tenants to comply with the Energy Savings Opportunity Scheme >>
- Energy compliance dominates the workload of real estate sustainability professionals >>
- Scope 3 footprinting in real estate takes off >>
- Sustainability training for whole workforces becomes the norm >>



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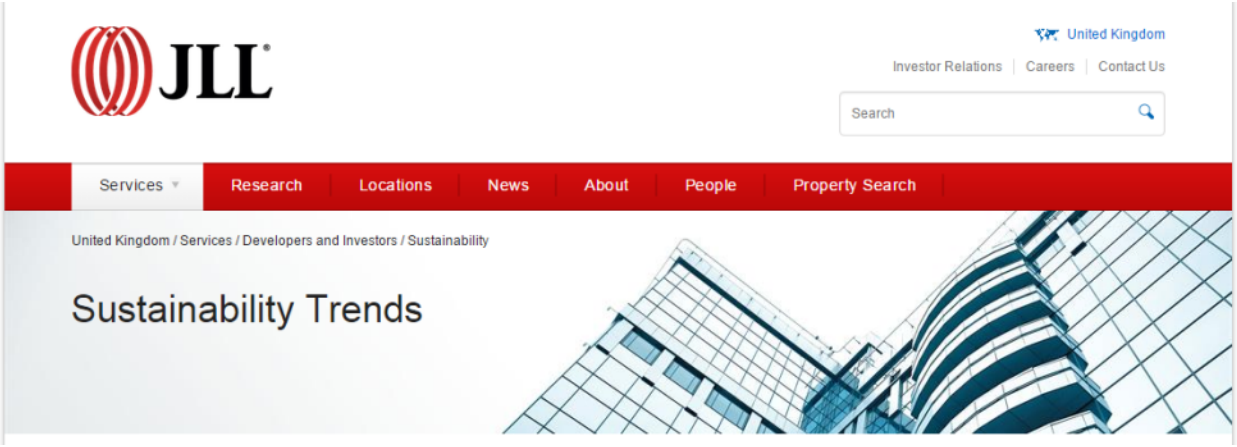
- Trend to stay - compliance
- Generates additional income
- Stand out from Crowd



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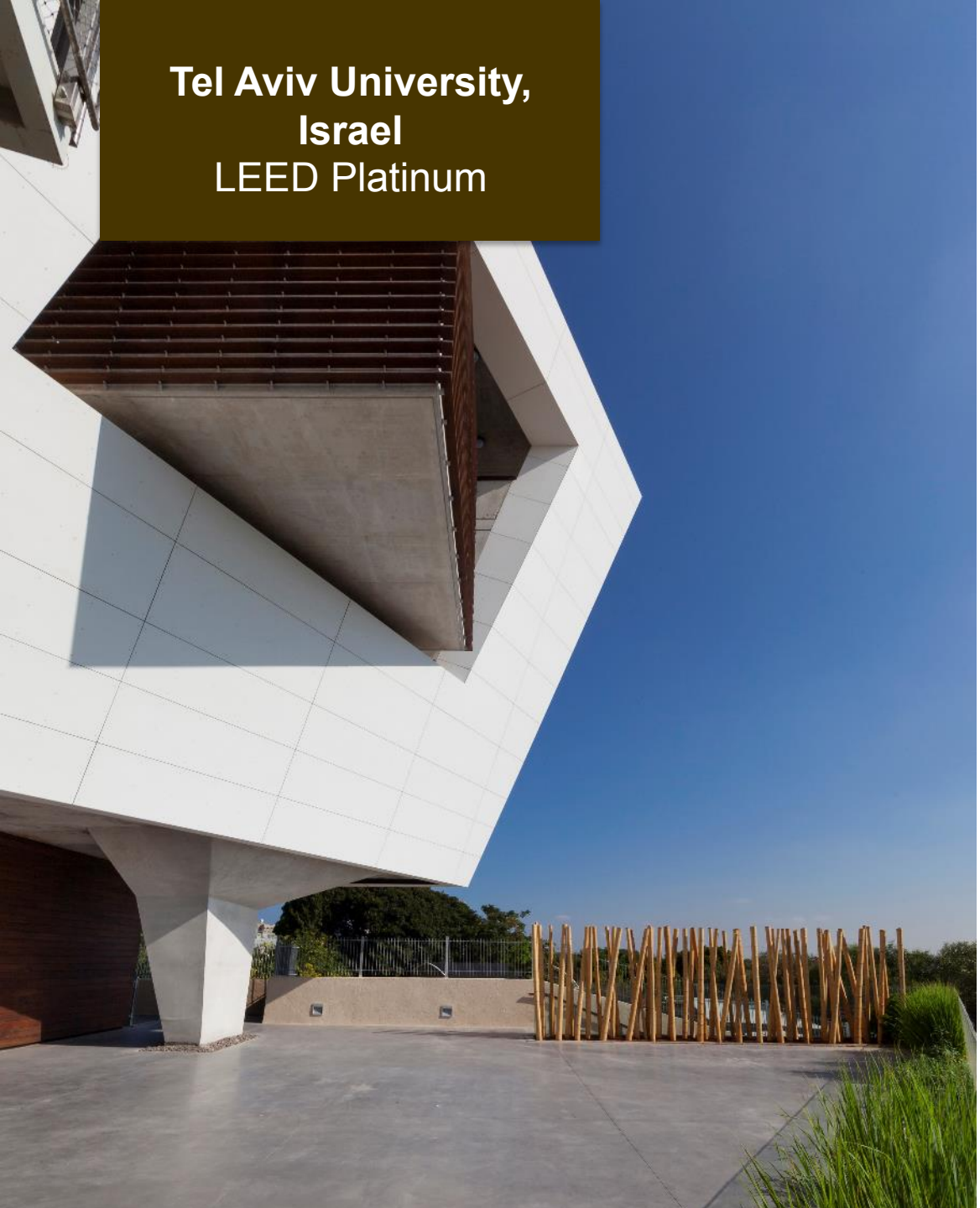
Park 20 20 – Hoofddorp, Netherlands

Park 20 20 – Hoofddorp, Netherlands

Results have been better than expected:

- Realized in the heart of the worst real estate crisis Holland has ever seen.
- No problem financing projects.
- Renting at a market premium of 37.5%
- Zero concessions required to obtain commitment.
- Exit yields = +/- 40 basis points better than the market average.
- Satisfied customers and a thriving community.



Tel Aviv University, Israel
LEED Platinum


Tel Aviv University, Israel
LEED Platinum

Fugro Headoffice, Netherlands
LEED Platinum


Fugro Headoffice, Netherlands
LEED Platinum

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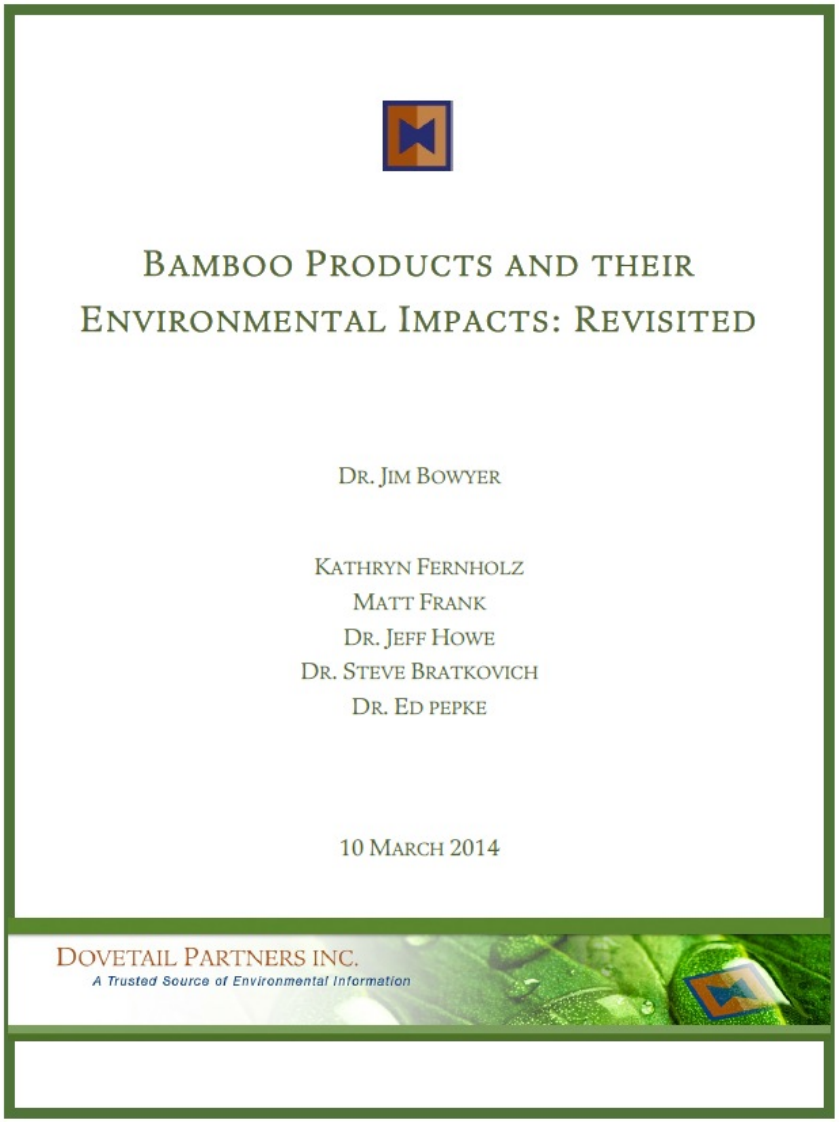
LEED Platinum

ACG Glass Head Office, Belgium
BREEAM Excellent

Madrid International Airport, Spain
Richard Rogers

BMW Dashboard

How green is bamboo? sceptics



BAMBOO PRODUCTS AND THEIR ENVIRONMENTAL IMPACTS: REVISITED

DR. JIM BOWYER

KATHRYN FERNHOLZ
MATT FRANK
DR. JEFF HOWE
DR. STEVE BRATKOVICH
DR. ED PEPKE

10 MARCH 2014

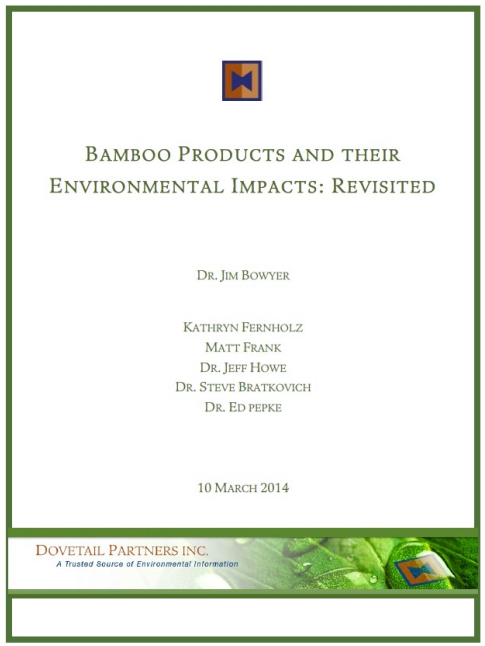
DOVETAIL PARTNERS INC.
A Trusted Source of Environmental Information

In fact, the rise in bamboo production has come with environmental harm, the Dovetail study says, including:

- Over-harvesting and, because one species of bamboo in particular is favored, monoculture plantations, encouraged by the authorities and financial gain
- Other types of forests have been clear-cut to make way for bamboo plantations
- Because it grows fast, bamboo demands a lot of nutrients, and requires fertilizers, herbicides and pesticides whereas maple needs none

However, bamboo's social benefits are many, the study says. Increased production has reduced poverty and swelled household incomes. Planting bamboo on terraced slopes once used for agricultural production causes less runoff and erosion.

The bottom line, the study says, is that those benefits come at a cost when bamboo forests are not managed properly, and ultimately "should never be designated as environmentally preferable materials without at the very least carefully judging its environmental impact throughout the supply chain.



MENTS 16 HIDE COMMENTS

« 1 2 »

Rick Kellso Wednesday, 16 April 2014
Tree Hugger website has been publishing articles about bamboo not being green for many years. The arguments are very hard to ignore. Boo Bamboo!!!
QUOTE REPLY Report Abuse

Aaron Roworth Wednesday, 16 April 2014
FINALLY! It is great to finally see an article on Bamboo and it's apparent green qualities.
I have long been a skeptic of Bamboo and it's 'green' properties, however more due to the manufacturing aspects. Hard to believe that these chinese mills aren't soaking it in formaldehyde.
Great article. I am sure they could have written a book on their study, not just a short article.
QUOTE REPLY Report Abuse

MinervaMink33 Wednesday, 16 April 2014
It's about time someone looked into this! I am so sick of having to sound like 'Debbie downer' when people come into the showroom with green dreams about saving the planet by choosing bamboo. It comes from from the other side of the planet, it's not like they're rowing those boats over here. Also, we

How green is bamboo? believers

Sustainability as principle – the MOSO case

- Proof: Increasing importance of ecolabels & environmental assessments
  - FSC (forestry)
  - BREEAM & LEED (green building)
  - C2C, Svanen, Blaue Engel, etc (material health)
  - VOC and formaldehyde (indoor emissions)
  - LCA & carbon footprint

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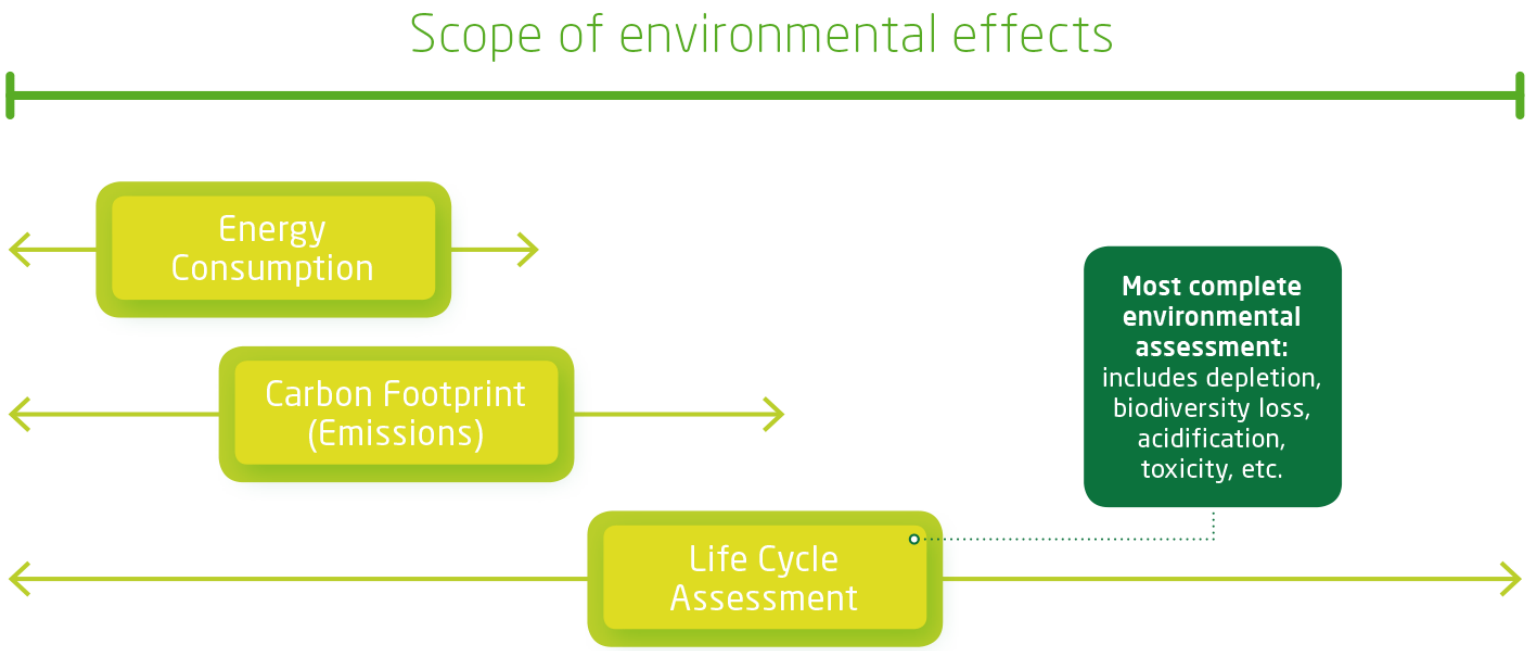
LCA – carbon footprint

bamboo products

Green Credentials over Life Cycle

- For full picture of environmental impact:
- Analyse complete life cycle from ‘Cradle till Grave’:

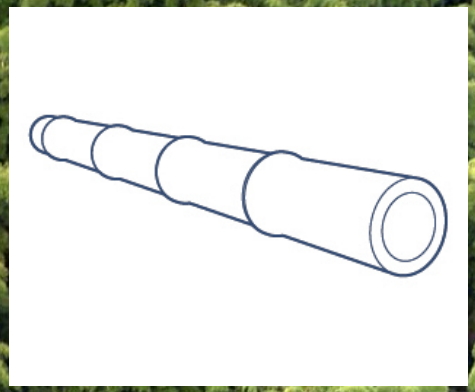
Measuring environmental impact

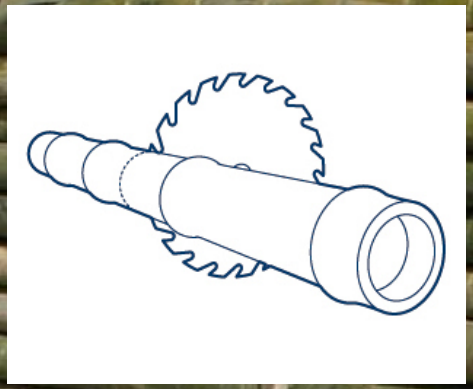


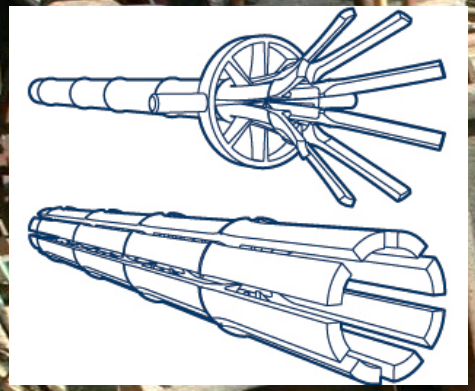
- Based on MOSO production chain – best practice
- 2010: LCA & carbon footprint executed by TU Delft
- 2014: Update (new products, latest production figures)
- ISO 14040 & 14044 compliant

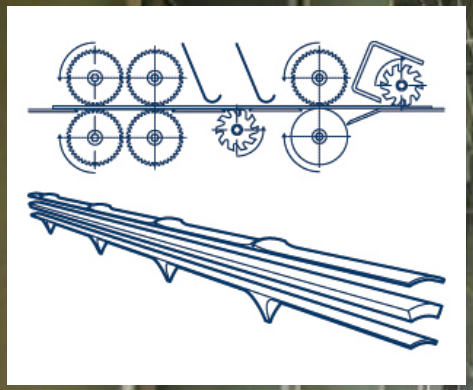
TU Delft Delft University of Technology

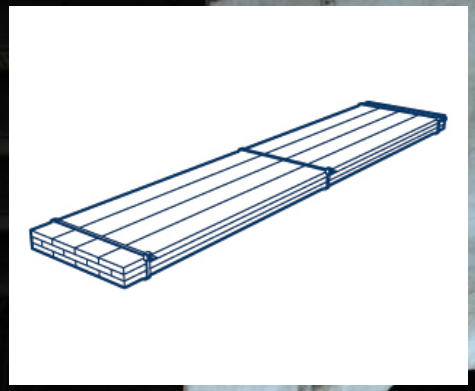
moso®

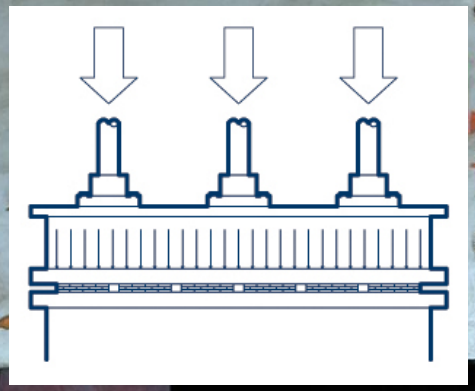












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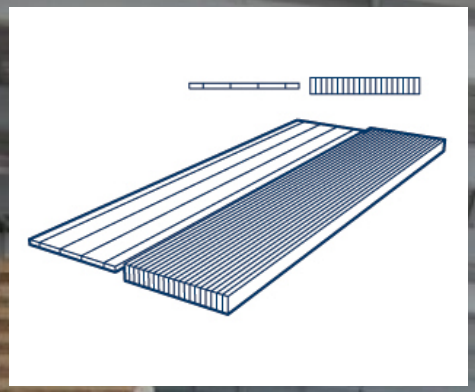

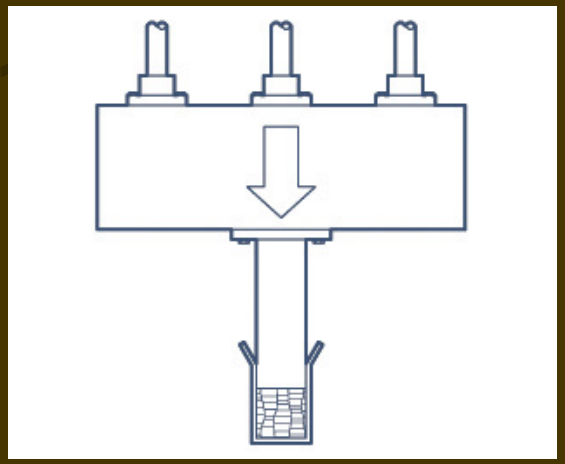

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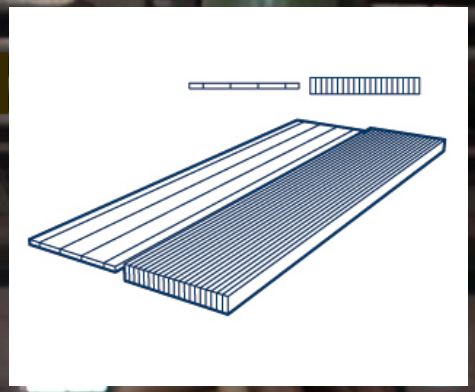

Thermally modified bamboo strips

Pressing

Emissions per Process

- 3 main production technologies:
  - Laminated strips (sidepressed / plain pressed)
  - Compressed strips – Strand Woven Bamboo (high density)
  - Flattened bamboo (MOSO Bamboo Forest)

Description of process step	amount	unit	CO2equ/FU	CO2equ/kg	percentage
1. Cultivation and harvesting from plantation					
Gasoline consumption	0,224	liter / FU	0,651	0,0156	1,5%
2. Transport from plantation to strip manufacturing facility					
Eco-costs of a 5 tons truck (EURO 3, transport of 23.1 FUs)	30	km / truck	0,699	0,0168	1,6%
3. Strip making	1,38	kWh/ FU	0,797	0,0191	1,9%
4. Transport from strip manufacturing facility to factory					
Eco-costs (28 tons truck EURO3, 300km)	12,51	ton.km / FU	2,314	0,0555	5,5%
5. Rough planing	8,62	kWh/ FU	4,977	0,1193	11,7%
6. Strip selection					
7. Carbonization	4,73	kWh/FU	2,731	0,0655	6,4%
8. Drying carbonized strips	9,66	kWh/FU	5,577	0,1337	13,1%
9. Fine planing	5,8	kWh/FU	3,349	0,0803	7,9%
10. Glue application (1-layer boards)					
Added amount of Melamine formaldehyde (dry condition)	0,483	kg / FU	1,657	0,0397	3,9%
11. Pressing strips to 1- layer board	1,89	kWh/FU	1,091	0,0262	2,6%
12. Sanding 1- layer board	1,62	kWh/FU	0,935	0,0224	2,2%
13. Glue application (3-layer board)					
Added amount Emulsion Poly Isocyanate (dry condition)	0,908	kg / FU	1,476	0,0354	3,5%
14. Pressing three layers to one board	1,65	kWh/FU	0,953	0,0228	2,2%
15. Sawing	0,29	kWh/FU	0,167	0,0040	0,4%
16. Sanding 3-layer board	0,86	kWh/FU	0,497	0,0119	1,2%
17. Dust absorption (during all steps)	8,67	kWh/FU	5,005	0,1200	11,8%
18. Transport from factory to harbour					
Eco-costs (28 tons truck EURO3, 300km)	12,51	ton.km / FU	2,314	0,0555	5,5%
19. Transport from harbour to harbour					
Eco-costs (20ft container in a transoceanic freight ship, 19208 km)	801	ton.km / FU	6,456	0,1548	15,2%
20. Transport from harbour to warehouse					
Eco-costs (28 tons truck EURO5, 115km)	4,80	ton.km / FU	0,806	0,0193	1,9%
TOTAL carbonized			42,45	1,018	100,0%

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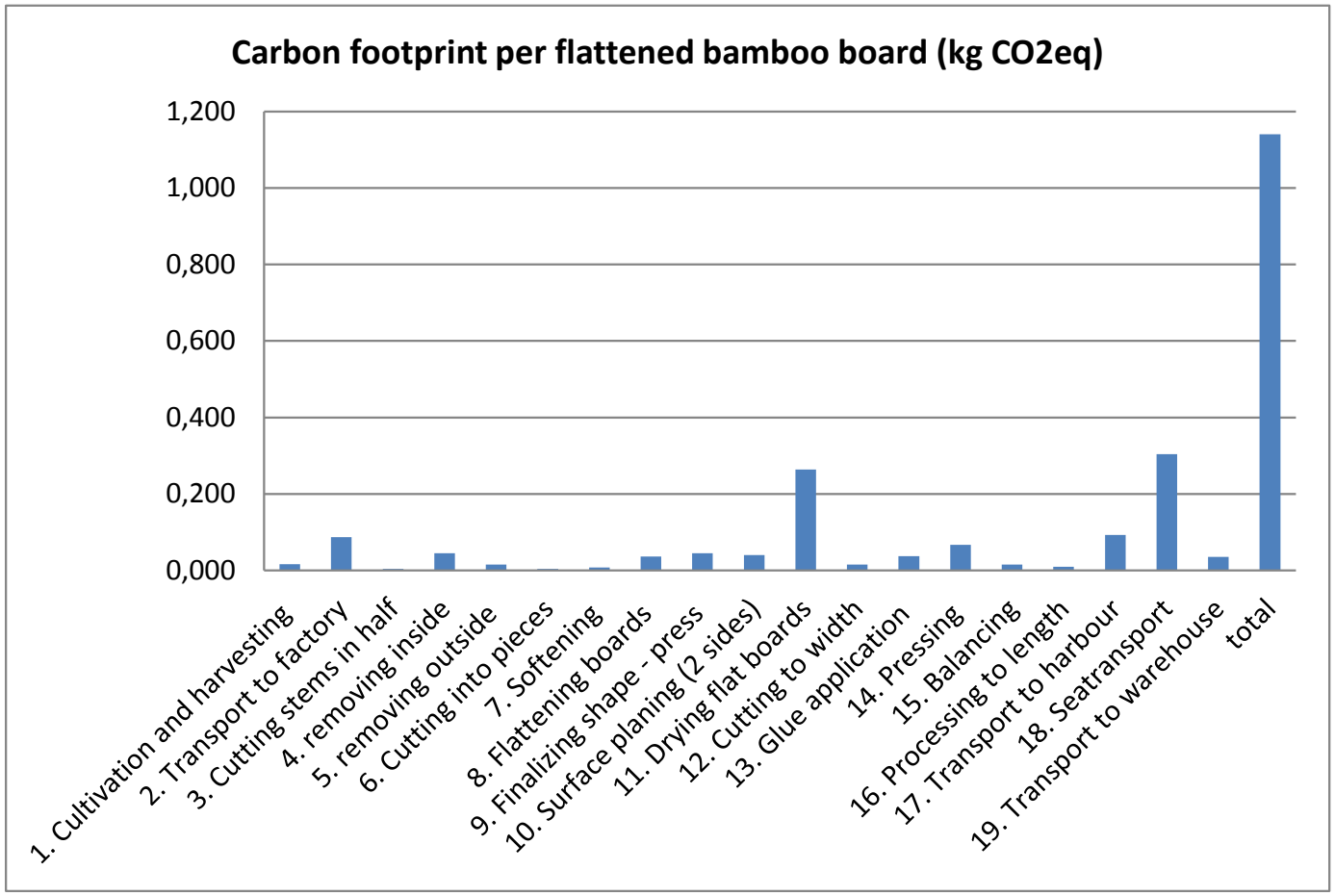
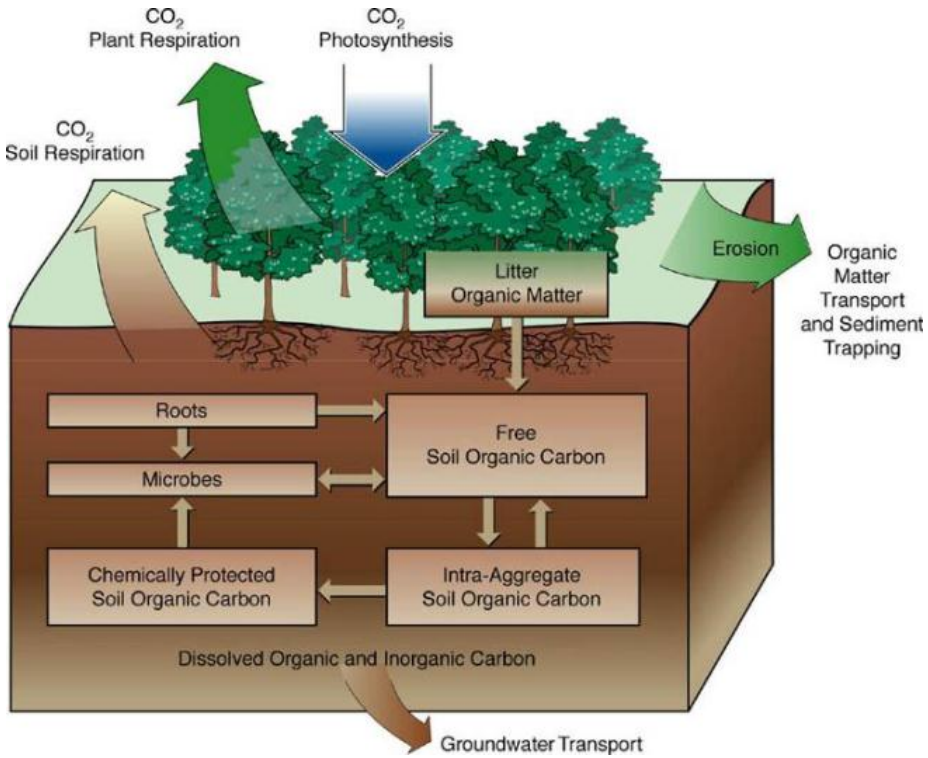
Emissions per Process

- Example: Flattened bamboo (MOSO Bamboo Forest)



Carbon Sequestration – Product level

- Bamboo absorbs CO2 during growth – locked in plantation / forest
- CO2 locked in the material during Use phase



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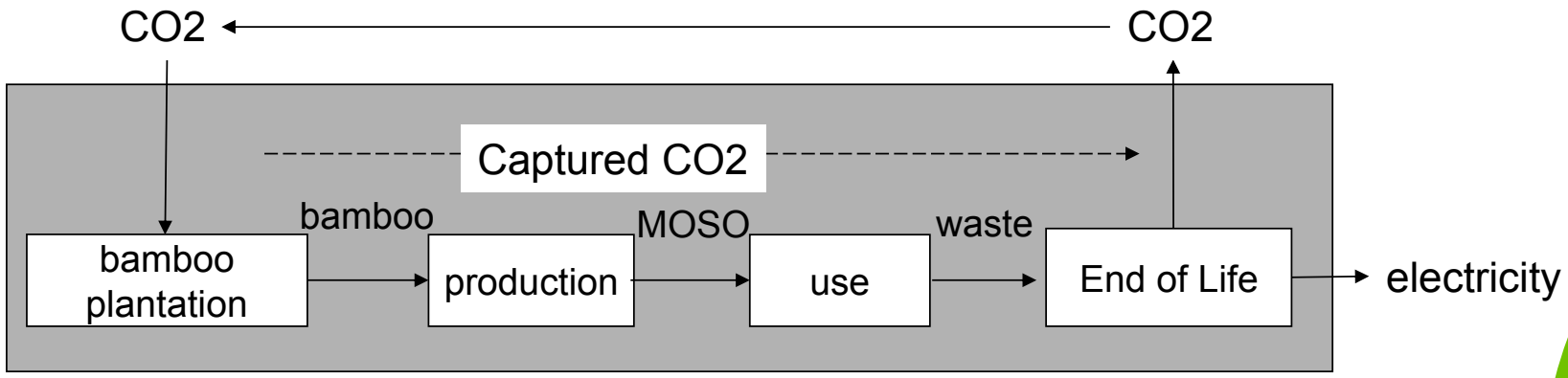
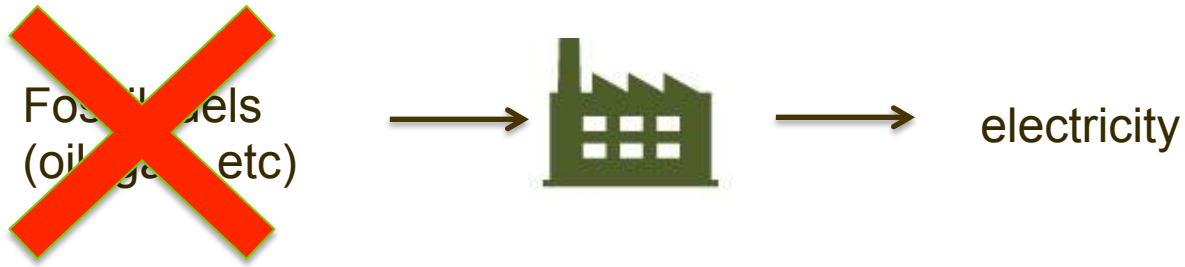
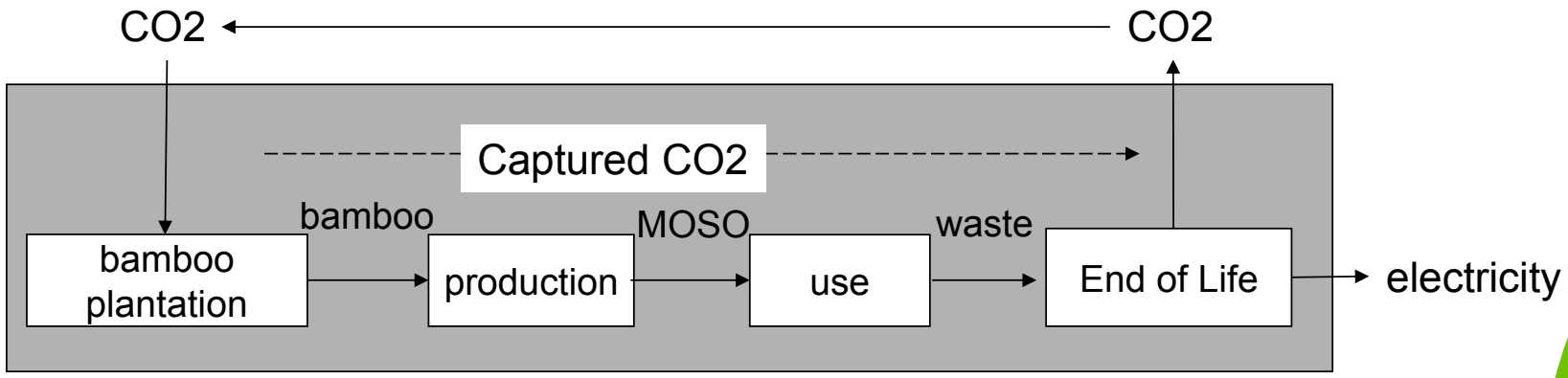


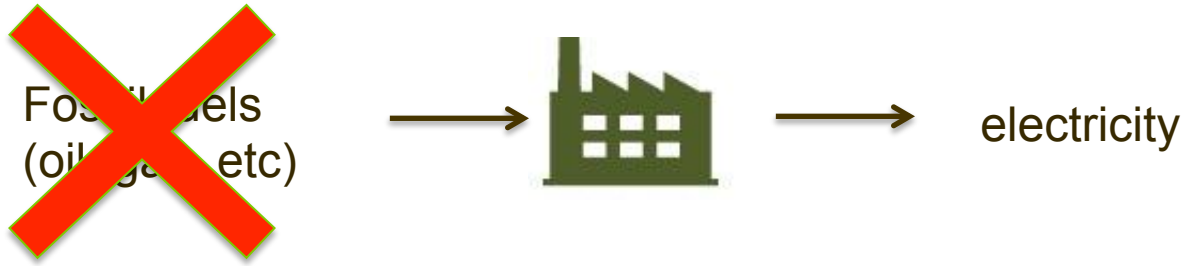


Carbon footprint Bamboo - Assumptions

- At end of life:
  - Dump: 10%
  - Incineration for bioenergy: 90%
  - For Netherlands credible assumption
  - Based on Eco-invent v3.1 & Idemat 2015
  - **Result:** **credit 0,704 kg CO2 / kg**

Carbon Sequestration – Product level



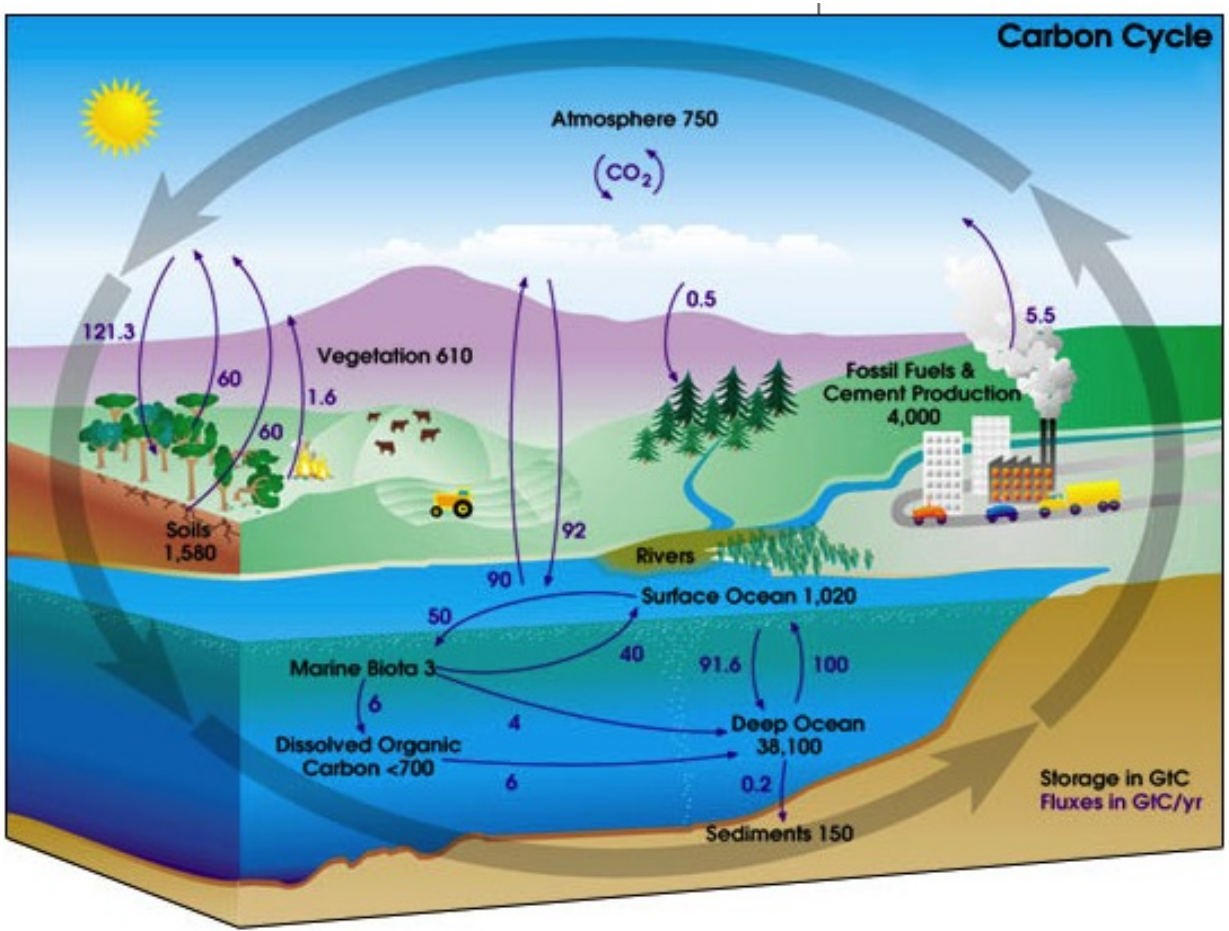


- Optional credit for temporary storage in some LCA systems (ILCD, PAS 2050: 2011) > not very realistic

Carbon Sequestration – Global level

The human role of the CO_2 emissions is three-fold (period 2000-2010):

- **6.4 Gt carbon** emissions per year caused by burning of fossil fuels
- **1.93 Gt carbon** emissions per year caused by deforestation
- **0.85 Gt carbon** sequestration per year by re-growth of forests



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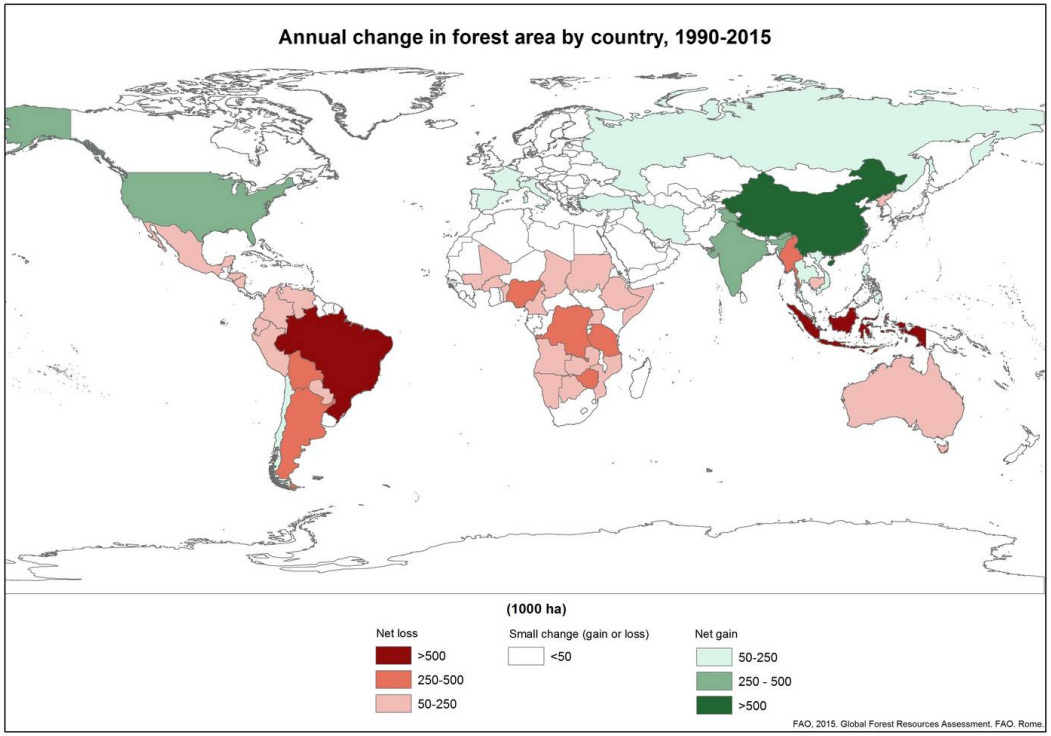
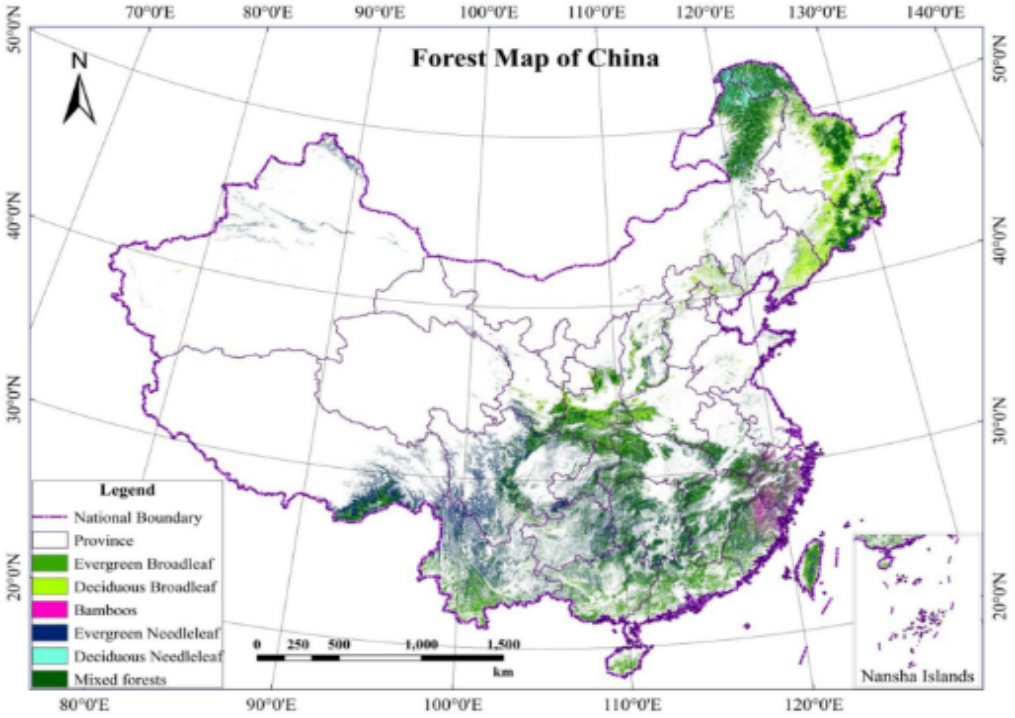


Carbon footprint Bamboo - Assumptions

- Global carbon sequestration driven by increasing demand
- Market growth: 20-25%
- Actual Moso resource surface growth 2004-2011: **5,5%** annual growth
- Carbon store Moso plantation 55 tC/ha (Zhou and Jiang 2004); conservative assumption



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- **Result: credit 0,51 – 0,54 kg CO2 / kg**

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- **Result:** **credit 0,51 – 0,54 kg CO2 / kg**
- **Excludes** potential carbon sequestration gain through better management

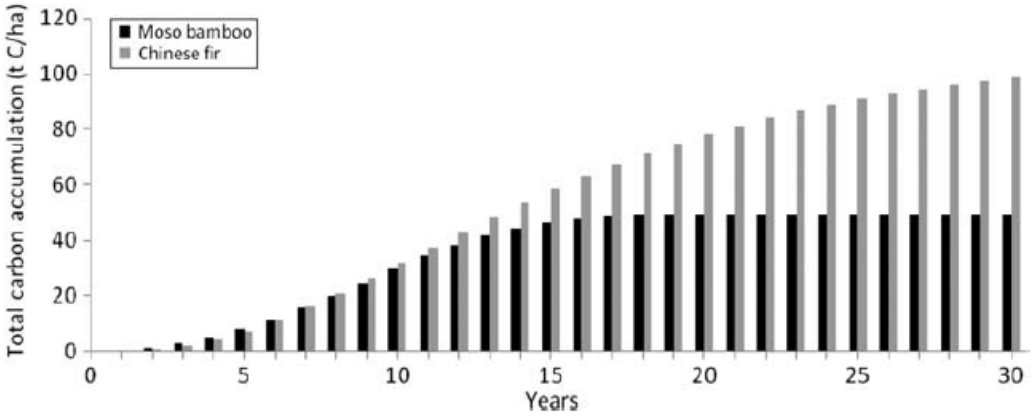

Figure 5. Patterns of modelled aggregated carbon accumulation of newly established Moso bamboo – no-harvest scenario – and Chinese fir plantations.

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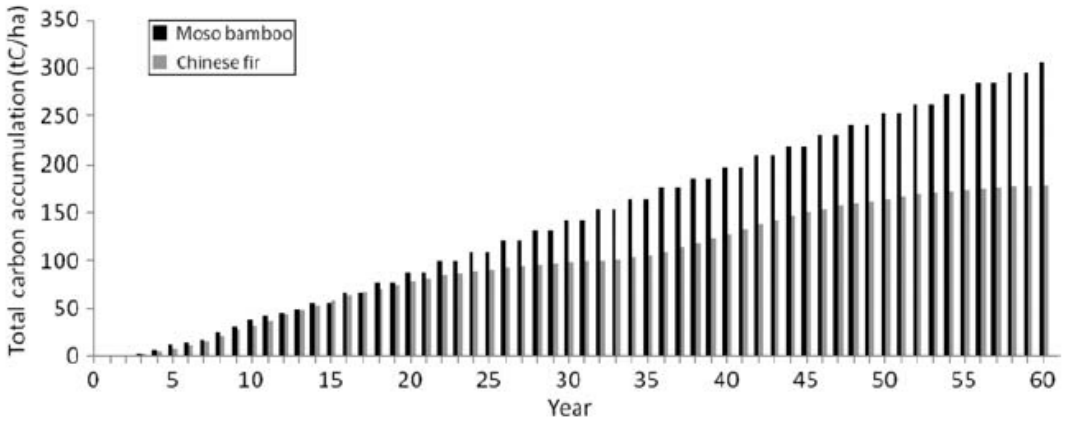


Figure 3. Patterns of modelled aggregated carbon accumulation of newly established Moso bamboo – regular-harvest scenario – and Chinese fir plantations within 60 years.

Carbon footprint Bamboo - Results

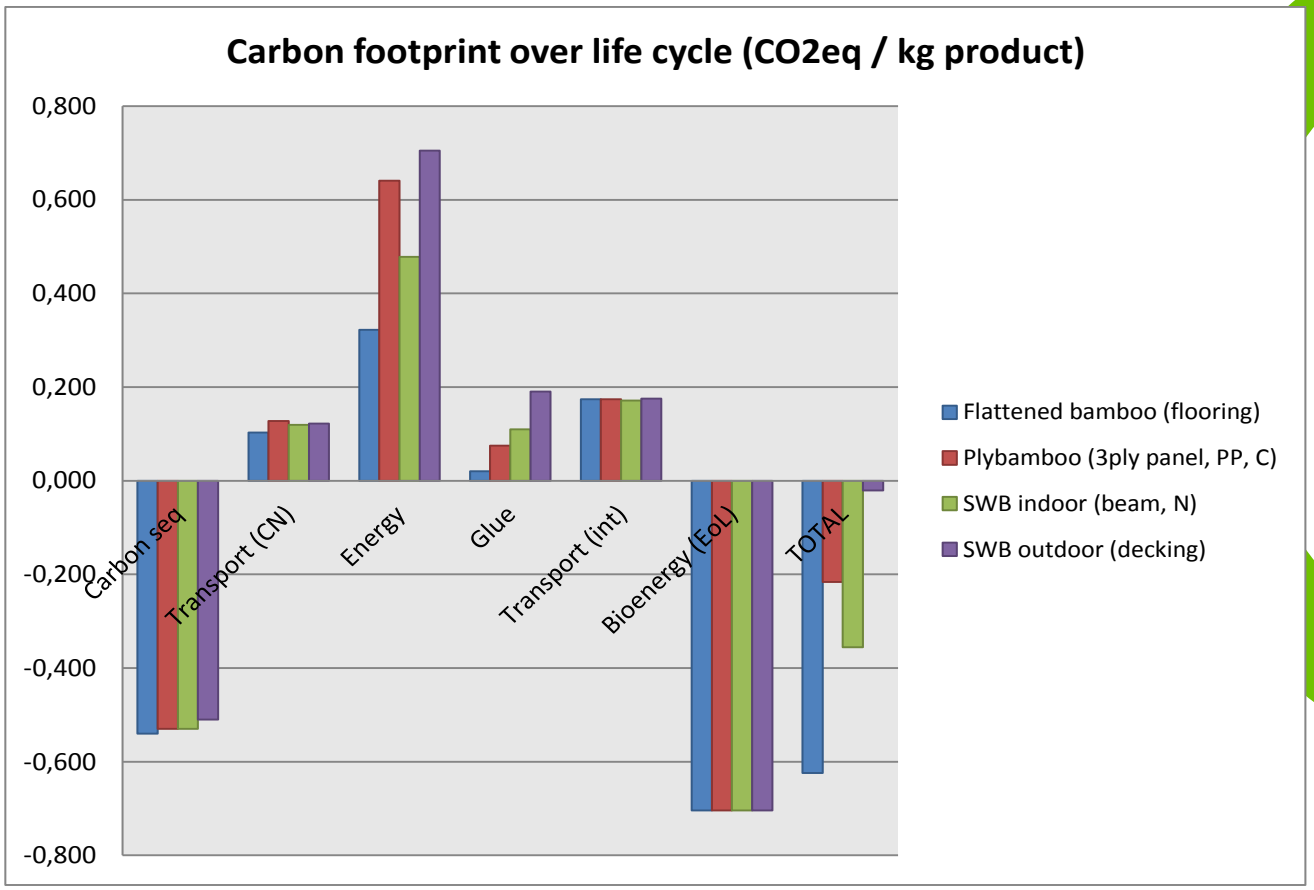
Note: SP = Side Pressed, PP = Plain Pressed, D = Density / Compressed, N = Natural (bleached), C = Caramel (Carbonized), E0 = produced with glues with No Added Formaldehyde (Formaldehyde emission: Class E0, < 0,025 mg/m3).

Outdoor					Carbon Footprint (CO2eq) per kg final product					Eco-costs (€) per kg final product			
	Thickness(mm)	type	style	Color	PRODUCTION cradle to gate CO2equ/kg	EOL CO2 cradle CO2equ/kg	CO2 storage CO2equ/kg	CO2 total CO2equ/kg	CO2 Neutral CO2equ/kg	PRODUCTION cradle to gate Euro/kg	EOL Eco-costs Euro/kg	eco-costs CO2 Euro/kg	eco-costs Total Euro/kg
Decking & cladding (MOSO Bamboo X-treme)	20		DT	C	1.193	-0.704	-0.607	-0.1176	Yes	0.356	-0,132	-0.082	0.142

Flooring					Carbon Footprint (CO2eq) per kg final product					Eco-costs (€) per kg final product			
	Thickness(mm)	type	style	Color	PRODUCTION cradle to gate CO2equ/kg	EOL CO2 cradle CO2equ/kg	CO2 storage CO2equ/kg	CO2 total CO2equ/kg	CO2 Neutral CO2equ/kg	PRODUCTION cradle to gate Euro/kg	EOL Eco-costs Euro/kg	eco-costs CO2 Euro/kg	eco-costs Total Euro/kg
Solid strip (MOSO Purebamboo)	15		SP	N	0.925	-0.704	-0.629	-0.4084	Yes	0.257	-0,132	-0.085	0.040
	15	E0	SP	N	0.911	-0.704	-0.629	-0.4217	Yes	0.253	-0,132	-0.085	0.036
	15		PP	N	0.951	-0.704	-0.629	-0.3822	Yes	0.268	-0,132	-0.085	0.051
	15	E0	PP	N	0.945	-0.704	-0.629	-0.3884	Yes	0.266	-0,132	-0.085	0.049
	15		SP	C	0.964	-0.704	-0.629	-0.3690	Yes	0.265	-0,132	-0.085	0.048
	15	E0	SP	C	0.951	-0.704	-0.629	-0.3824	Yes	0.262	-0,132	-0.085	0.045
	15		PP	C	0.990	-0.704	-0.629	-0.3429	Yes	0.276	-0,132	-0.085	0.059
	15	E0	PP	C	0.984	-0.704	-0.629	-0.3491	Yes	0.275	-0,132	-0.085	0.058
	15		DT	C	1.048	-0.704	-0.623	-0.2795	Yes	0.301	-0,132	-0.084	0.085
	15		DT	N	1.008	-0.704	-0.623	-0.3194	Yes	0.292	-0,132	-0.084	0.076
Solid wide board (3 ply) (MOSO Bamboo Elite)	15		SP	N	1.015	-0.704	-0.629	-0.3176	Yes	0.286	-0,132	-0.085	0.069
	15	E0	SP	N	0.957	-0.704	-0.629	-0.3764	Yes	0.271	-0,132	-0.085	0.054
	15		PP	N	1.006	-0.704	-0.629	-0.3266	Yes	0.283	-0,132	-0.085	0.066
	15	E0	PP	N	0.952	-0.704	-0.629	-0.3807	Yes	0.269	-0,132	-0.085	0.053
	15		SP	C	1.055	-0.704	-0.629	-0.2783	Yes	0.294	-0,132	-0.085	0.077
	15	E0	SP	C	0.996	-0.704	-0.629	-0.3371	Yes	0.280	-0,132	-0.085	0.063
	15		PP	C	1.046	-0.704	-0.629	-0.2873	Yes	0.291	-0,132	-0.085	0.074
	15	E0	PP	C	0.992	-0.704	-0.629	-0.3414	Yes	0.278	-0,132	-0.085	0.061
	13		DT	N	1.004	-0.704	-0.623	-0.3227	Yes	0.288	-0,132	-0.084	0.071
	13		DT	C	1.042	-0.704	-0.623	-0.2846	Yes	0.296	-0,132	-0.084	0.080

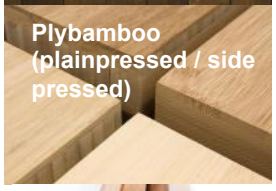
LCA & Carbon Footprint - Results

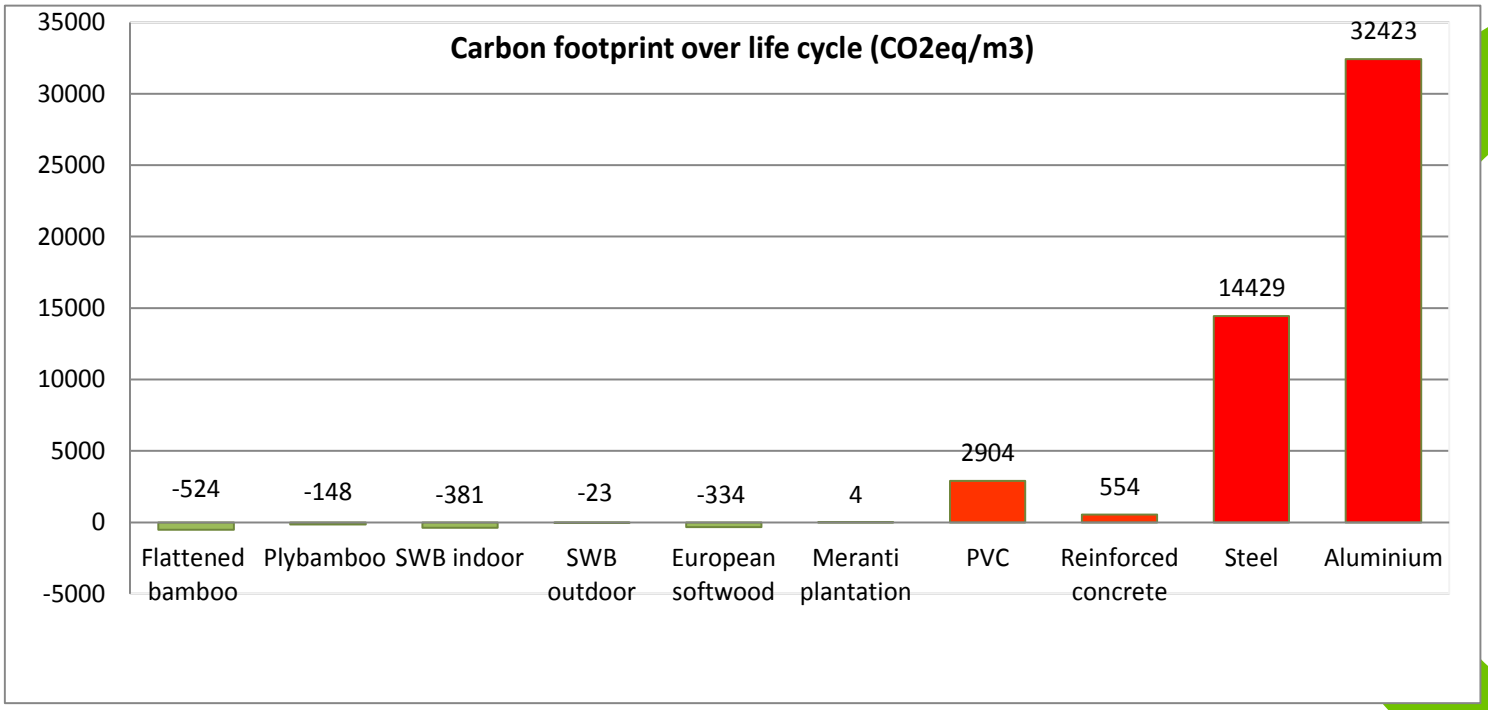
- CO2 neutral over full life cycle (all solid MOSO bamboo materials)
- Credits for carbon sequestration and green electricity production compensate emissions by transport, energy and glue



LCA & Carbon Footprint - Results

- Compared to other commonly used building materials
- Carbon footprint per cubic meter material

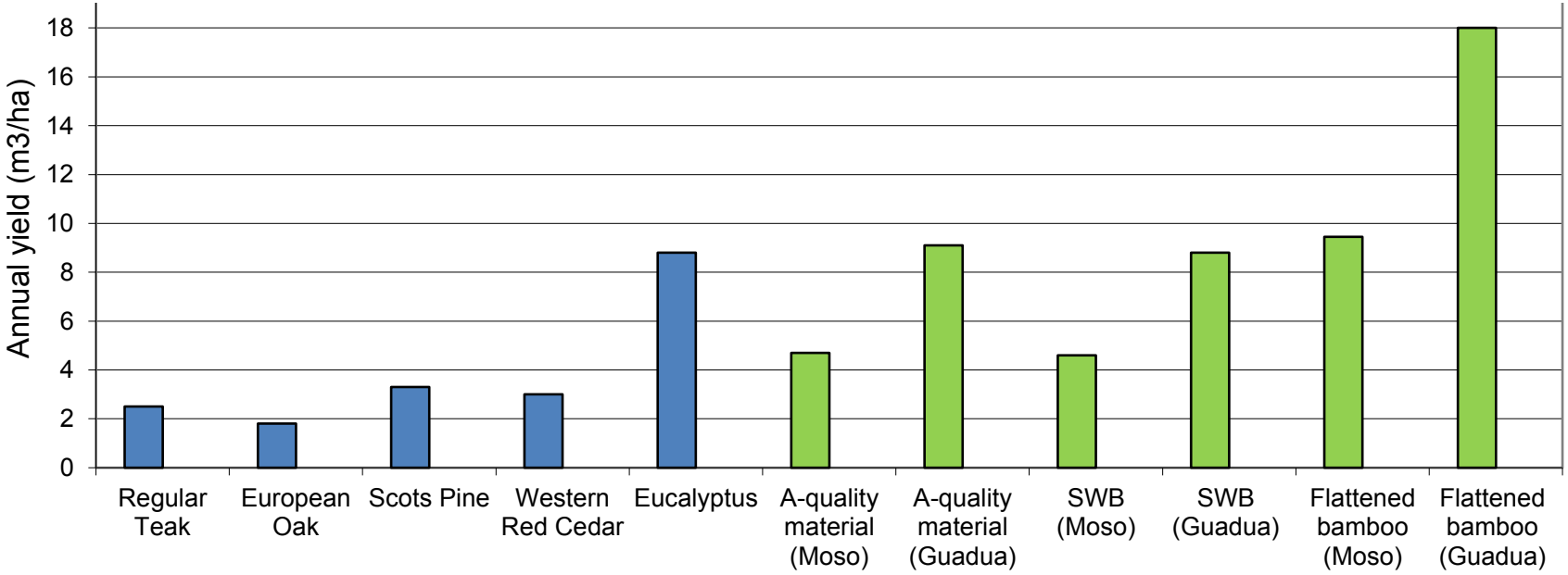




- Bamboo materials & softwood outperform hardwood, plastics & metals
- Flattened bamboo most sustainable option available

Carbon footprint - Excluded

- Annual yield = additional benefit excluded in LCA



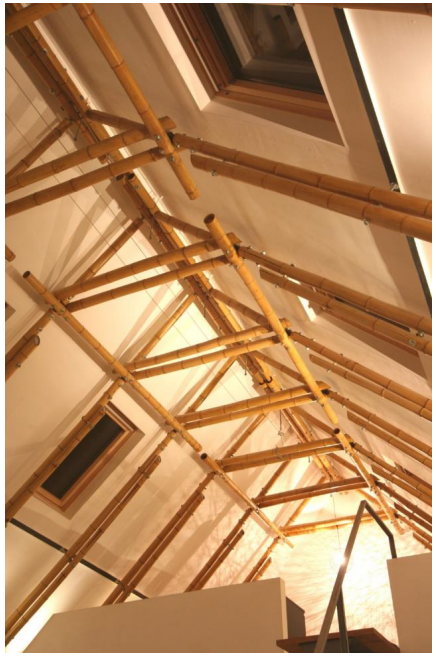
- Additional growth related environmental benefits vs wood:
  - annual harvesting provides better growth > no deforestation
  - reforestation on degraded land possible
  - short establishment time

Points for improvement

- Energy (52-63%):
  - Higher energy efficiency; e.g. co-generation electricity & heat
  - Sustainable energy; e.g. PV panels on factory
- Transport
  - International (15-25%): closer sourcing (e.g. Africa, Latin America)
  - National (10%): larger and more efficient trucks (e.g. EURO 5)
- Resins (3-16%)
  - More formaldehyde free resins (e.g. EPI)
  - Use of fully biobased resins

Some final thoughts (i)

- Bamboo stem interesting only in the countries of harvest
  - From market perspective
  - From carbon footprint perspective due to inefficient seatransport:
    - Bamboo stem used locally: 0,19 kg CO2 / kg stem (cradle to gate)
    - Bamboo stem used in Europe: 1,45 kg CO2 / kg stem (cradle to gate)



Some final thoughts (ii)

- Sell the green story well, but only when it is complete and correct (no copy – paste)

Some final thoughts (ii)

- Sell the green story well, but only when it is complete and correct (no copy – paste)
- Make bamboo more mainstream → inclusion in standards for quality, health, environment (CE, ISO, FSC, IPCC)

CE

FSC
The mark for products from well managed forests.
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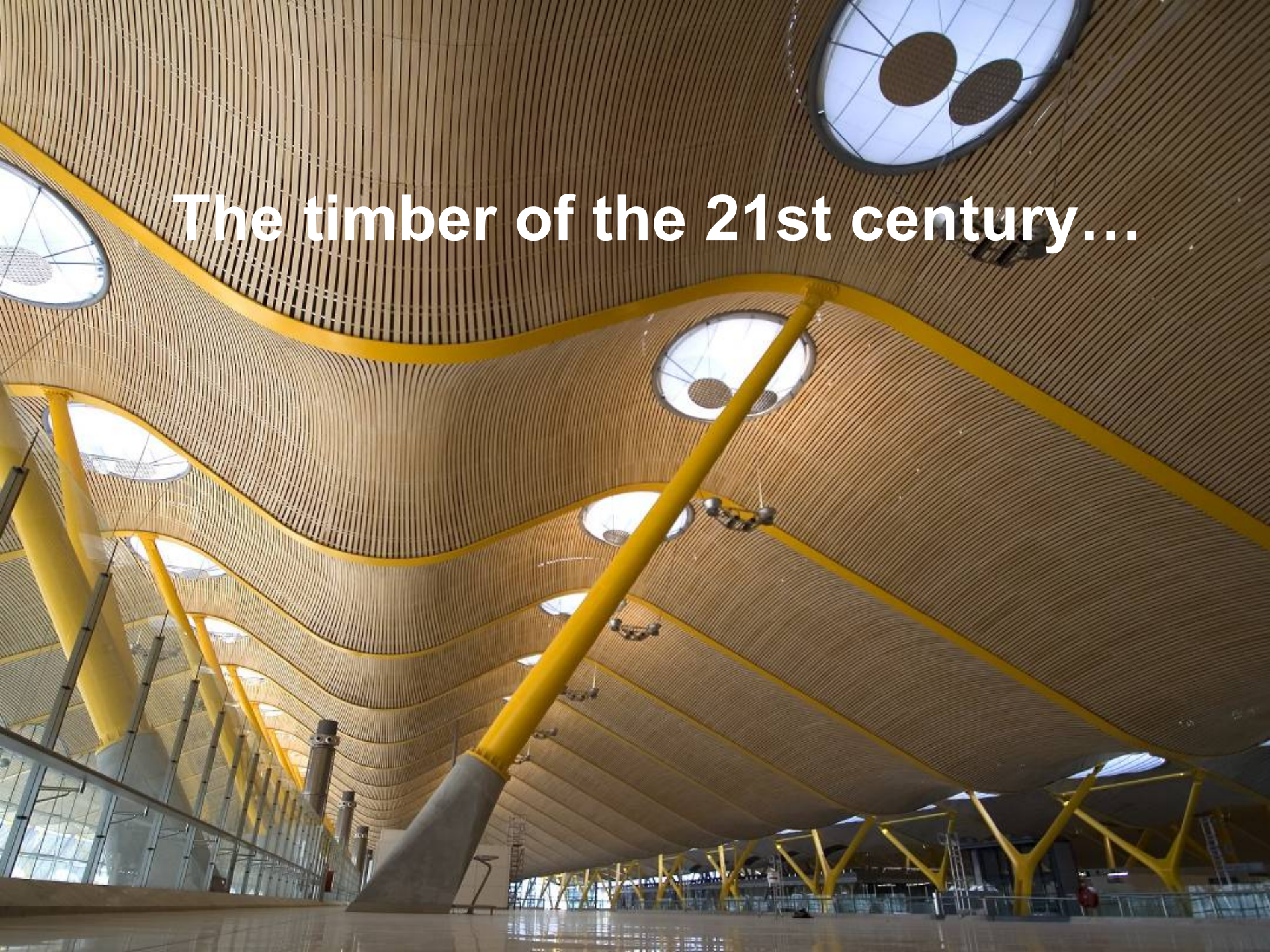
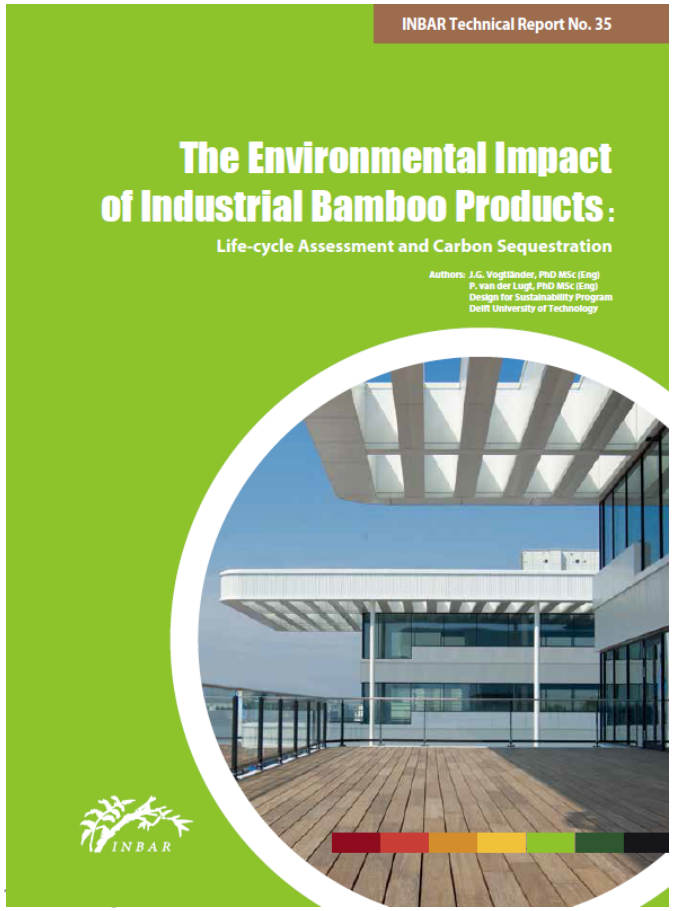
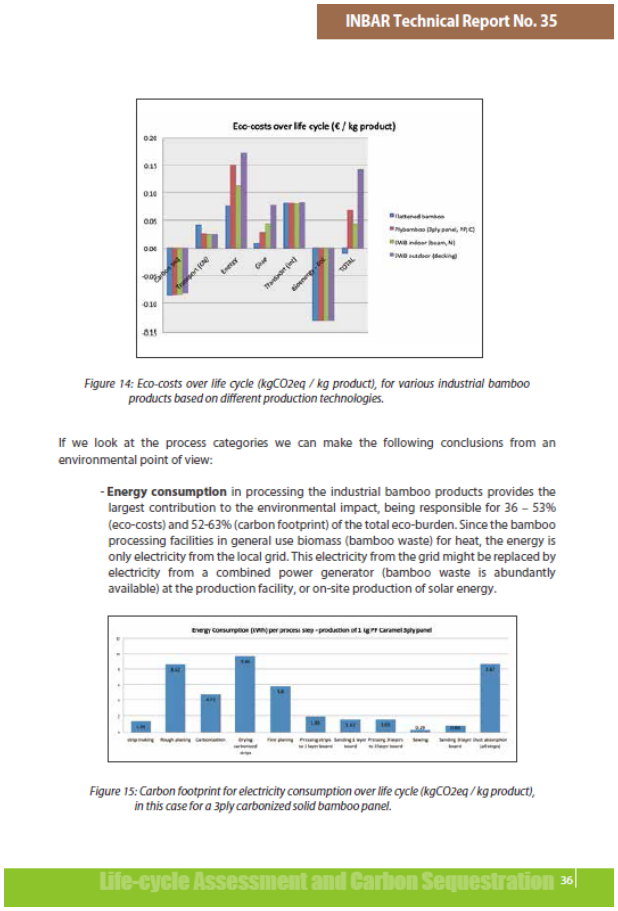

The timber of the 21st century…

More information?

- INBAR Technical Report no. 35






Questions?
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