



LCA – Carbon Footprint of industrial bamboo products

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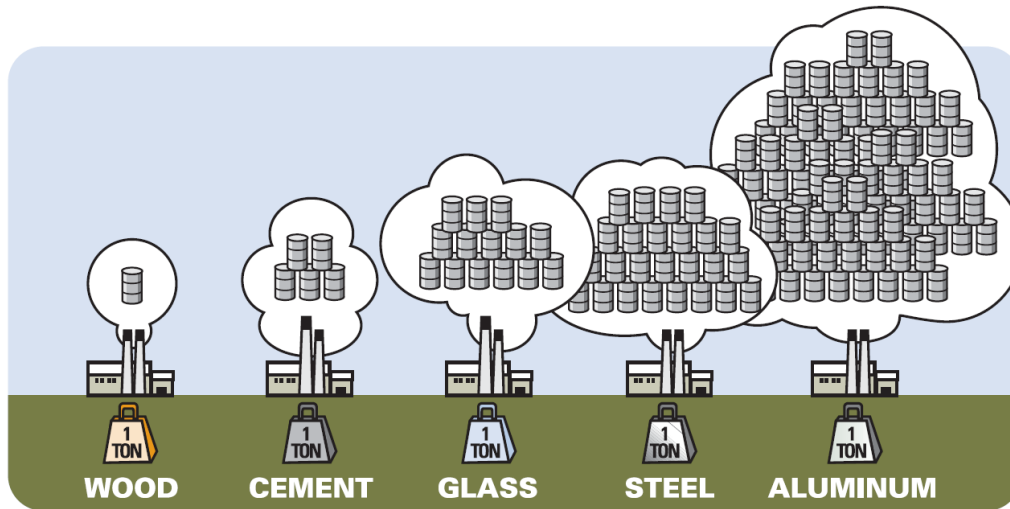


Measuring environmental impact

< Scope of environmental effects >



Energy consumption



Measuring environmental impact

< Scope of environmental effects >


Energy consumption



Carbon Footprint (Greenhouse Gas Emissions)


Kyoto Gas	Potential sources	GWP*
CO ₂	Combustion of fossil fuels: Transport Manufacturing processes Energy generation Direct releases during manufacturing	1
CH ₄	Anaerobic degradation of waste Landfill of waste Digestion of food matter	25
N ₂ O	Nitrification and denitrification in soils Fuel combustion Production of adipic and nitric acid Waste	298
HFCs	Releases into the atmosphere: From refrigerants, During chemical manufacturing Use in foams & aerosols	22,800
PFCs	Releases into the atmosphere during aluminium or electronics manufacture	7,390 12,200
SF ₆	Releases into the atmosphere: during magnesium smelting, electronics manufacturing from high voltage switchgear	124 14,800

Measuring environmental impact

< Scope of environmental effects >




Energy consumption


Carbon Footprint (GHG Emissions)



Life Cycle Assessment

Most complete environmental assessment;

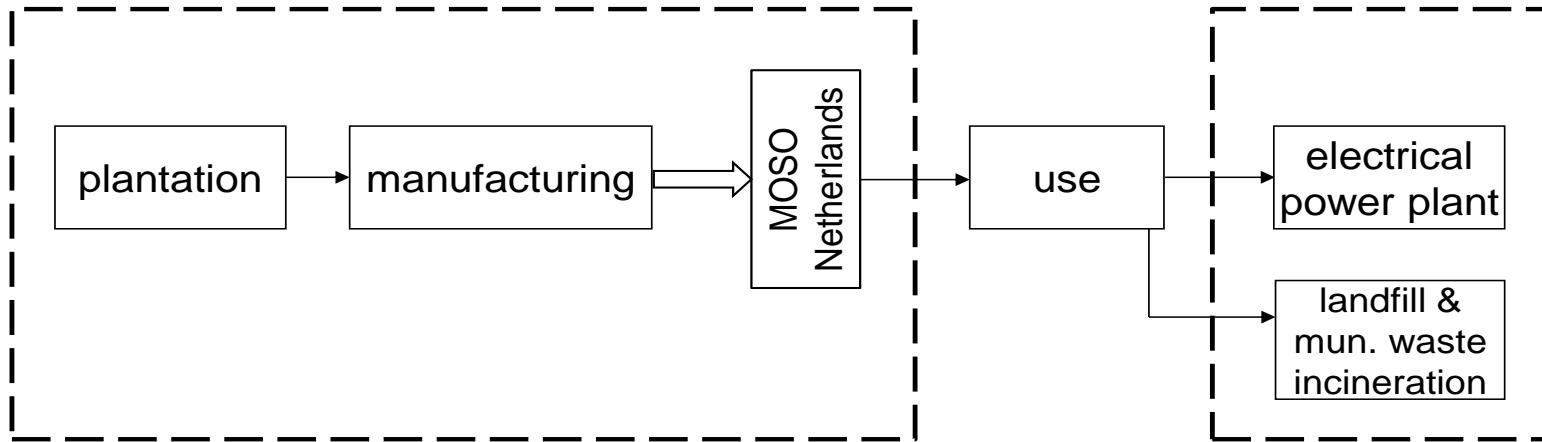
Besides global warming potential includes depletion, acidification, toxicity, eutrophication, etc

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LCA – Carbon Footprint

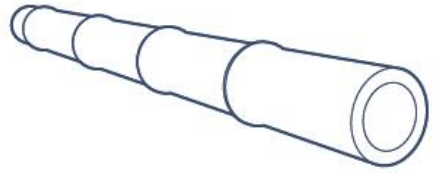
- Delft University of Technology
- Based on PhD research dr.ir. Pablo van der Lugt
- 2011: Update (new products, latest production figures)
- ISO 14040 & 14044 compliant
- Includes carbon footprint
- Focus of this presentation

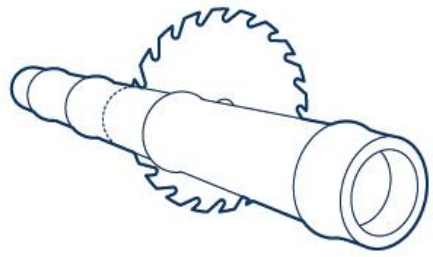
System Boundary

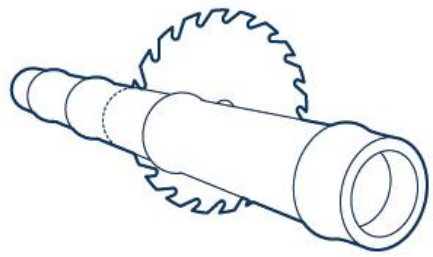


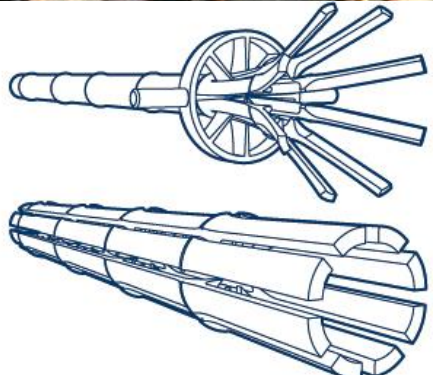
- Based on MOSO Production system
- All solid MOSO Bamboo Products (panels, flooring, decking)
- Use phase (maintenance) neglectable





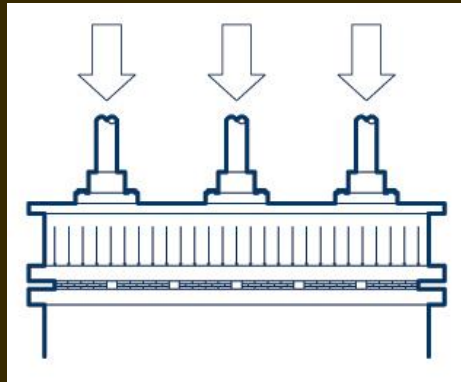
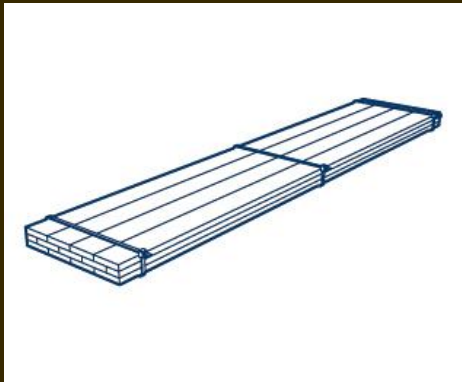


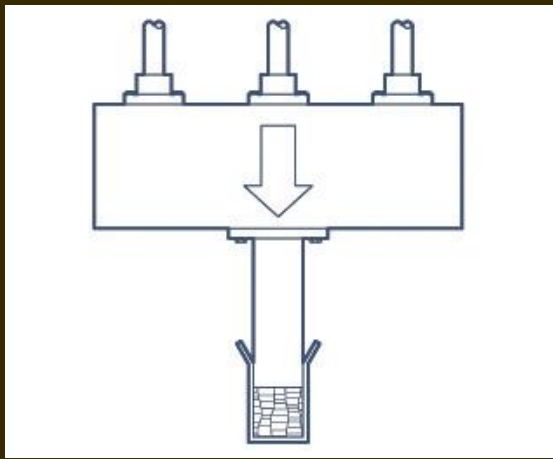


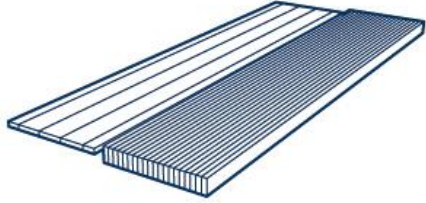








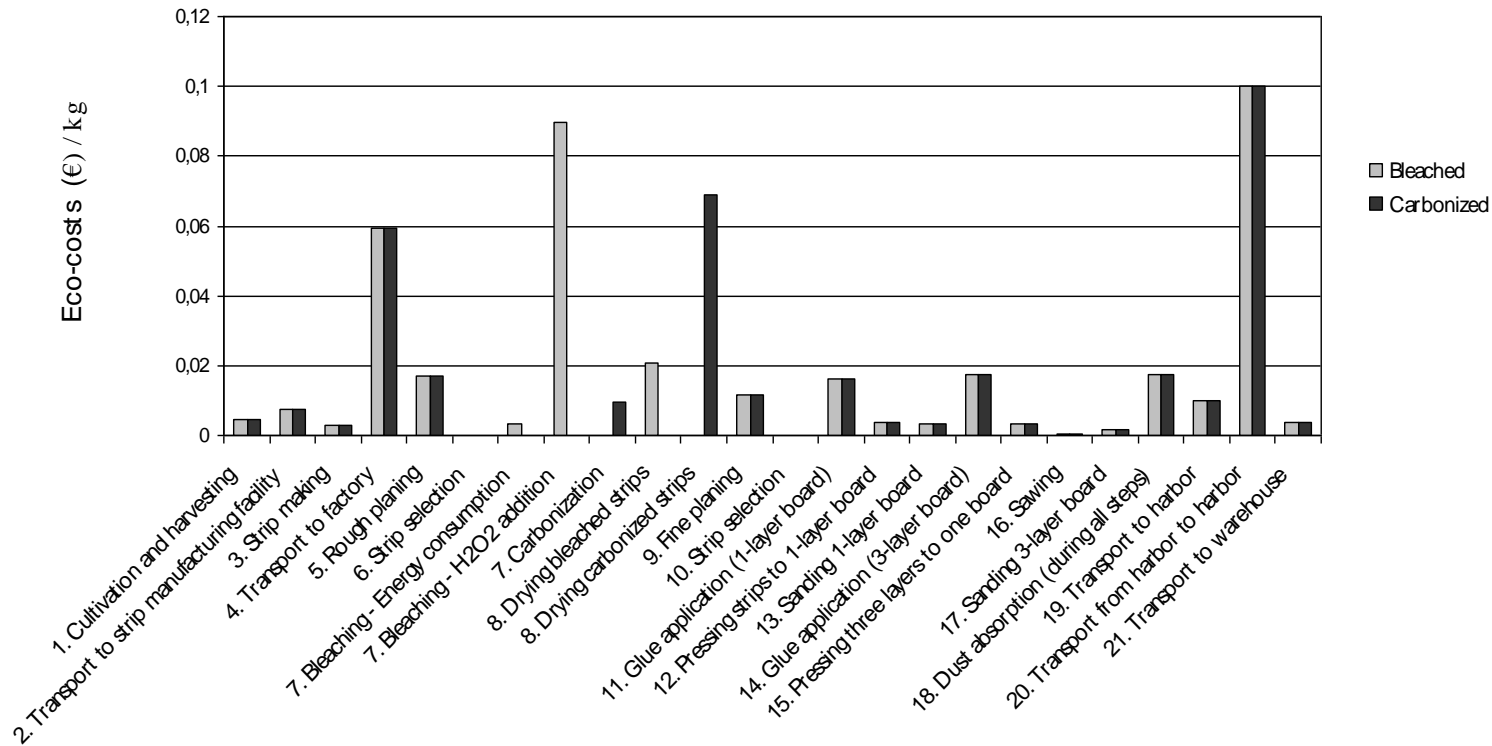




Emissions per Process



- Example: MOSO 3-Ply Solid Panel

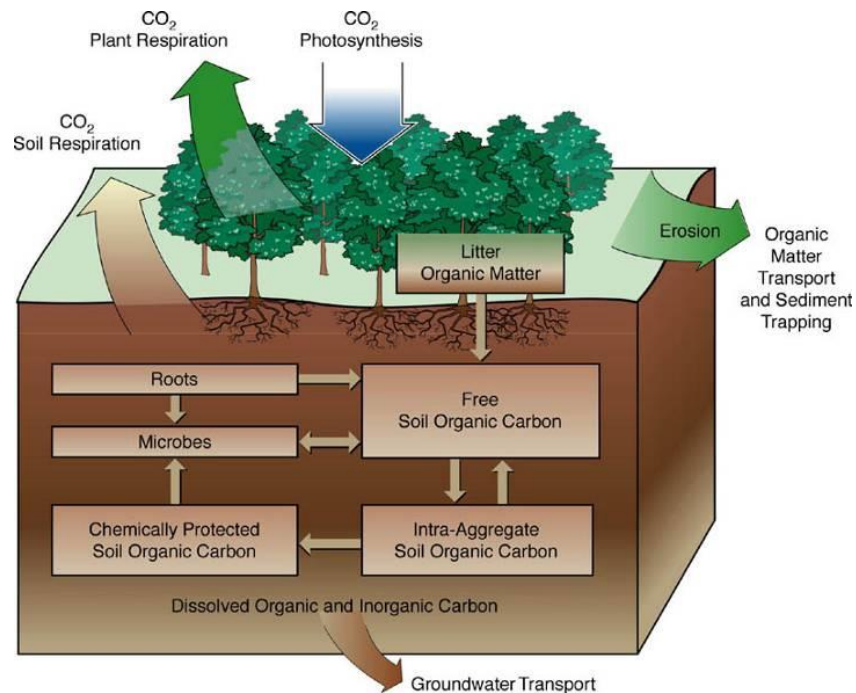


Emissions per Process

Process step	amount	unit	Carbon fp	Carbon fp	Carbon fp	Carbon fp
			kgCO2e/unit	kgCO2e/FU	kgCO2ekg	%
1. Harvesting: Gasoline consumption	0.224	litre / FU	3.895/ litre	0.873	0.0209	1.5%
2.Transport strip manufacturing facility; a 5 ton truck (transport of 23.1 FUs)	30	km / truck	0.63/ km	0.818	0.0196	1.4%
3. Strip making	1.38	kWh/ FU	0.805/kWh	1.111	0.0266	1.9%
4. Transport to factory; a 10 ton truck (transport of 77.6 FUs).	600	km / truck	0.825/km	6.379	0.1530	10.8%
5. Rough planing	8.62	kWh/ FU	0.805/kWh	6.939	0.1664	11.8%
6. Strip selection						
7. Carbonization	4.73	kWh/FU	0.805/kWh	3.808	0.0913	6.5%
8. Drying carbonized strips	9.66	kWh/FU	0.805/kWh	7.776	0.1865	13.2%
9. Fine planing	5.8	kWh/FU	0.805/kWh	4.669	0.1120	7.9%
10. Strip selection						
11. Glue application (1-layer boards)	0.894	kg / FU	2.24 /kg	2.003	0.0480	3.4%
12. Pressing strips to 1-layer board	1.89	kWh/FU	0.805/kWh	1.521	0.0365	2.6%
13. Sanding 1-layer board	1.62	kWh/FU	0.805/kWh	1.304	0.0313	2.2%
14. Glue application (3-layer board)	0.983	kg / FU	2.24 /kg	2.202	0.0528	3.7%
15. Pressing three layers to one board	1.65	kWh/FU	0.805/kWh	1.328	0.0319	2.3%
16. Sawing	0.29	kWh/FU	0.805/kWh	0.233	0.0056	0.4%
17. Sanding 3-layer board	0.86	kWh/FU	0.805/kWh	0.692	0.0166	1.2%
18. Dust absorption (during all steps)	8.67	kWh/FU	0.805/kWh	6.979	0.1674	11.8%
19. Transport from factory to harbour	12.51	ton.km/ FU	0.086/ton.km	1.076	0.0258	1.8%
20. Transport from harbour to harbour	800.973	ton.km/ FU	0.011/ton.km	8.811	0.2113	14.9%
21. Transport from harbour to warehouse	4.7955	ton.km/ FU	0.086/ton.km	0.412	0.0099	0.7%
TOTAL carbon footprint				58.93	1.413	100.0%

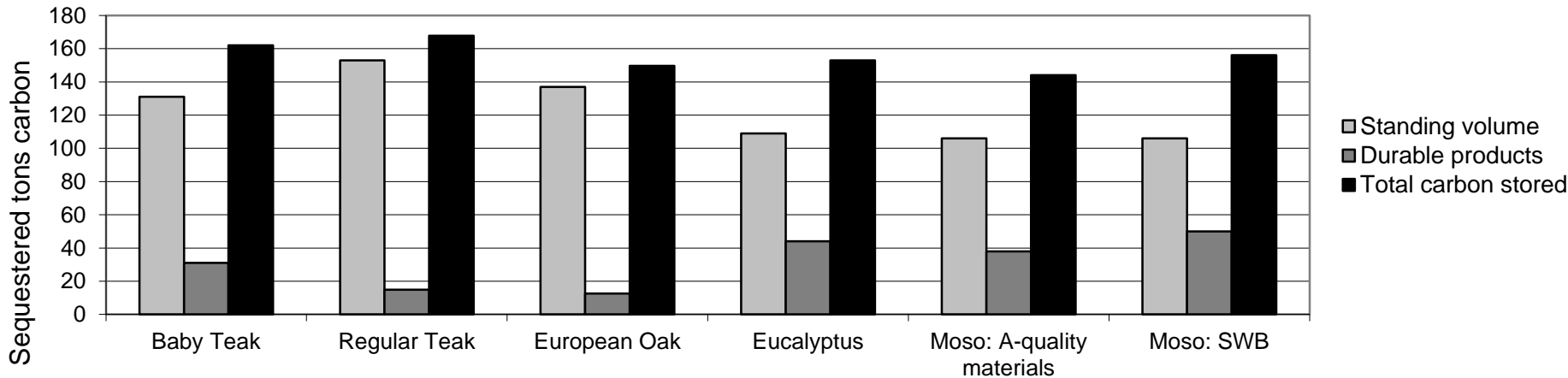
Carbon Sequestration – Product level

- Bamboo absorbs CO₂ during growth
- CO₂ locked in the material during Use phase

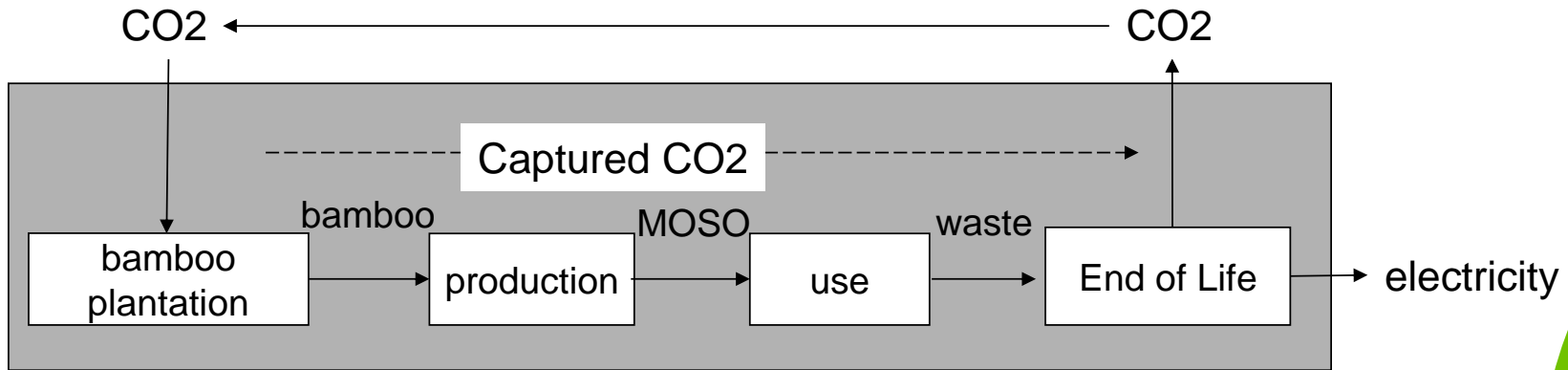


Carbon Sequestration – Product level

- Bamboo absorbs CO₂ during growth – locked in plantation
- CO₂ locked in the material during Use phase
- Difference between wood and bamboo not that big
 - Wood > higher standing volume on plantation / forest
 - Bamboo > higher yield, stored in durable products



Carbon Sequestration – Product level



~~Fossil fuels
(oil, gas, etc)~~



electricity



Carbon Sequestration – Product level

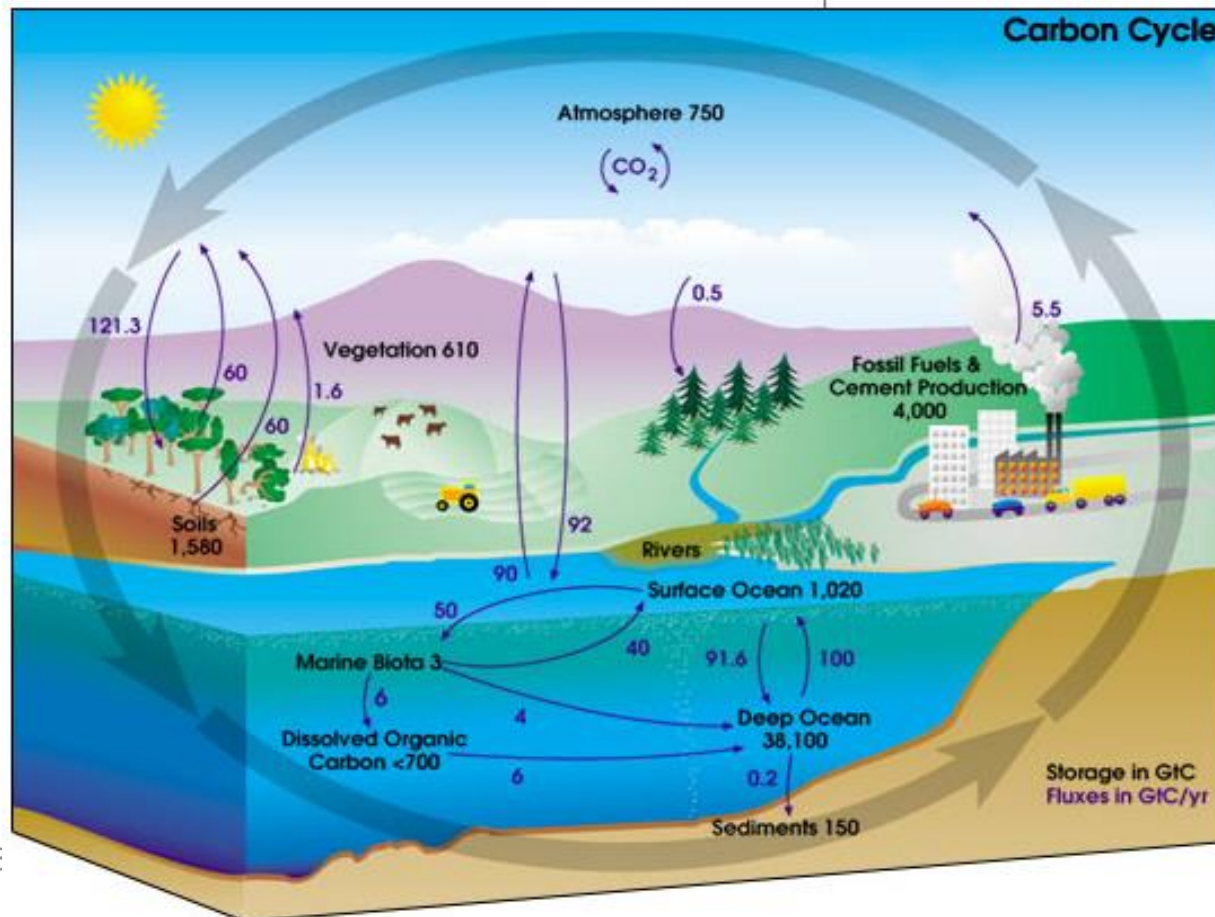
- At end of life:
 - Dump: CO₂ released again
 - Incineration: alternative for fossil fuels > credit



Carbon Sequestration – Global level

The human role of the CO₂ emissions is three-fold:

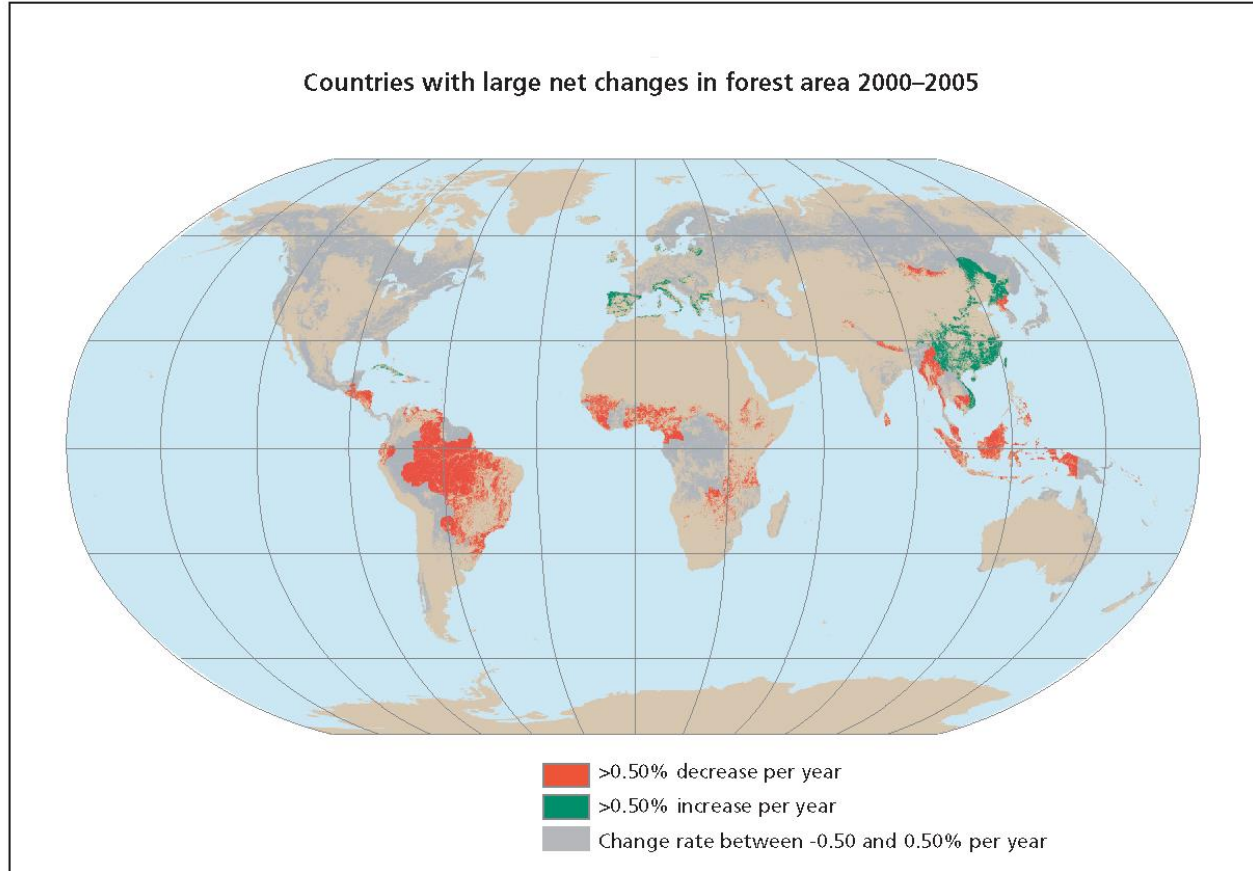
- **5.5 Gt carbon** emissions per year caused by burning of fossil fuels
- **1.6 Gt carbon** emissions per year caused by deforestation
- **0.5 Gt carbon** sequestration per year by re-growth of forests



Carbon Sequestration – Global level

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Carbon footprint - Assumptions

- 5% annual growth of MOSO plantations China
 - Market growth: 20-25%
 - Actual plantation growth 2000-2010: 2.4% / year
 - Carbon store Moso plantation 102 – 288 tC/ha (INBAR TR 32)
 - **Result: credit 0,55 kg CO2 / kg**



Carbon footprint - Assumptions

- At end of life:
 - Dump: 10%
 - Incineration for bioenergy: 90%
 - For Netherlands credible assumption (e.g. Van Gansewinkel)
 - **Result: credit 1,062 kg CO₂ / kg**



Carbon footprint - Results

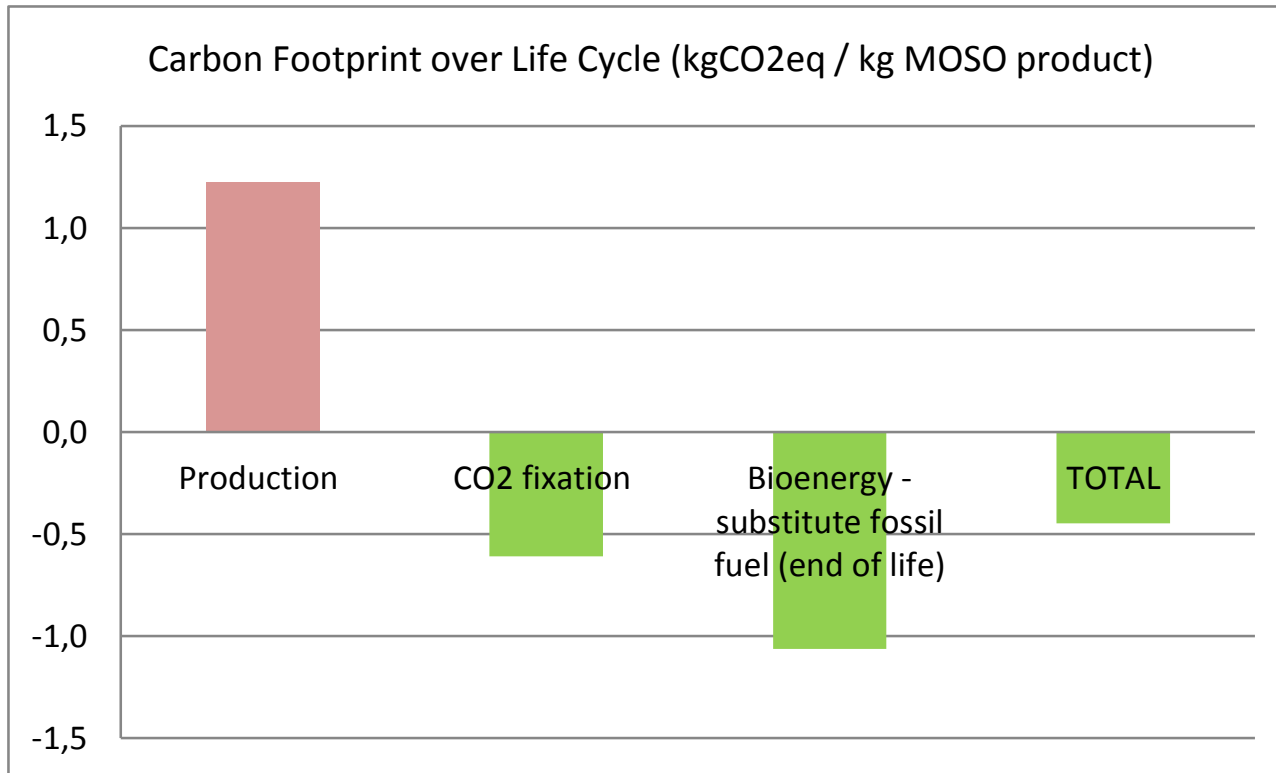
International Bamboo Products				Carbon Footprint (CO2eq) per kg final product							Eco-costs (€) per kg final product					
Plantation growth		5.0%		PRODUCTION		EoL	CO2	CO2	CO2	CO2	PRODUCTION	EoL	eco-costs	eco-costs	eco-costs	
Large biomass plantation		12.17	kg	CO2 footprint	CO2 credit	life cycle	storage	total	Neutral	Eco-costs	Eco-costs	life cycle	CO2 storage	Total		
Bamboo in energy plant		90%		CO2equ/kg	CO2equ/kg	CO2equ/kg	CO2equ/kg	CO2equ/kg	Yes / No	Euro/kg	Euro/kg	Euro/kg	Euro/kg	Euro/kg		
Thickness (mm)		type	Style	Color	CO2equ/kg	CO2equ/kg	CO2equ/kg	CO2equ/kg	CO2equ/kg	Yes / No	Euro/kg	Euro/kg	Euro/kg	Euro/kg	Euro/kg	
1 & Floor covering																
1.1 - Moso																
Bamboo		15		SP	N	1.129	-1.062	0.0672	-0.6085	-0.5413	Yes	0.331	-0.189	0.1419992	-0.082	0.060
		15		PP	N	1.262	-1.062	0.2000	-0.6085	-0.4085	Yes	0.358	-0.189	0.169	-0.082	0.087
		15		SP	C	1.098	-1.062	0.0362	-0.6085	-0.5723	Yes	0.309	-0.189	0.1197536	-0.082	0.038
		15		PP	C	1.231	-1.062	0.1690	-0.6085	-0.4395	Yes	0.335	-0.189	0.146	-0.082	0.064
1.2 - Bamboo Elite		15		SP	N	1.284	-1.062	0.2220	-0.6085	-0.3865	Yes	0.363	-0.189	0.174	-0.082	0.092
		15		PP	N	1.262	-1.062	0.2000	-0.6085	-0.4085	Yes	0.358	-0.189	0.169	-0.082	0.087
		15		SP	C	1.253	-1.062	0.1910	-0.6085	-0.4175	Yes	0.341	-0.189	0.152	-0.082	0.070
		15		PP	C	1.231	-1.062	0.1690	-0.6085	-0.4395	Yes	0.336	-0.189	0.147	-0.082	0.065
		13		D	N	1.269	-1.062	0.2070	-0.6085	-0.4015	Yes	0.360	-0.189	0.171	-0.082	0.089
		13		D	C	1.238	-1.062	0.1760	-0.6085	-0.4325	Yes	0.337	-0.189	0.148	-0.082	0.066
1.3 - Bamboo Supreme		10		SP	N	1.285	-1.062	0.2230	-0.6085	-0.3855	Yes	0.362	-0.189	0.173	-0.082	0.091
		10		PP	N	1.269	-1.062	0.2070	-0.6085	-0.4015	Yes	0.358	-0.189	0.169	-0.082	0.087
		10		SP	C	1.254	-1.062	0.1920	-0.6085	-0.4165	Yes	0.340	-0.189	0.151	-0.082	0.069
		10		PP	C	1.238	-1.062	0.1760	-0.6085	-0.4325	Yes	0.335	-0.189	0.146	-0.082	0.064
		5		PP	N	1.143	-1.062	0.0810	-0.6085	-0.5275	Yes	0.331	-0.189	0.1420775	-0.082	0.060
		5		PP	C	1.112	-1.062	0.0500	-0.6085	-0.5585	Yes	0.309	-0.189	0.1198319	-0.082	0.038
		7.5		SP	N	1.152	-1.062	0.0901	-0.6085	-0.5184	Yes	0.335	-0.189	0.1461108	-0.082	0.064
		7.5		SP	C	1.121	-1.062	0.0591	-0.6085	-0.5494	Yes	0.313	-0.189	0.1238652	-0.082	0.042
1.4 - Bamboo Industriale		10		SP	N	1.141	-1.062	0.0787	-0.6085	-0.5298	Yes	0.333	-0.189	0.144055	-0.082	0.062
		10		SP	C	1.110	-1.062	0.0476	-0.6085	-0.5609	Yes	0.311	-0.189	0.1218094	-0.082	0.040
		15		SP	N	1.129	-1.062	0.0672	-0.6085	-0.5413	Yes	0.331	-0.189	0.1419992	-0.082	0.060
		15		SP	C	1.098	-1.062	0.0362	-0.6085	-0.5723	Yes	0.309	-0.189	0.1197536	-0.082	0.038
		10		D	N	1.200	-1.062	0.1380	-0.6085	-0.4705	Yes	0.346	-0.189	0.157	-0.082	0.075
		10		D	C	1.168	-1.062	0.1060	-0.6085	-0.5025	Yes	0.323	-0.189	0.134	-0.082	0.052
1.5 Panel covering materials																
Panel		16	3,5-9-3,5	SP	N	1.294	-1.062	0.2320	-0.6085	-0.3765	Yes	0.366	-0.189	0.177	-0.082	0.095
		16	3,5-9-3,5	PP	N	1.277	-1.062	0.2150	-0.6085	-0.3935	Yes	0.361	-0.189	0.172	-0.082	0.090
		16	3,5-9-3,5	SP	C	1.263	-1.062	0.2010	-0.6085	-0.4075	Yes	0.344	-0.189	0.155	-0.082	0.073
		16	3,5-9-3,5	PP	C	1.246	-1.062	0.1840	-0.6085	-0.4245	Yes	0.339	-0.189	0.15	-0.082	0.068

13-8-2013



Carbon Footprint - Results

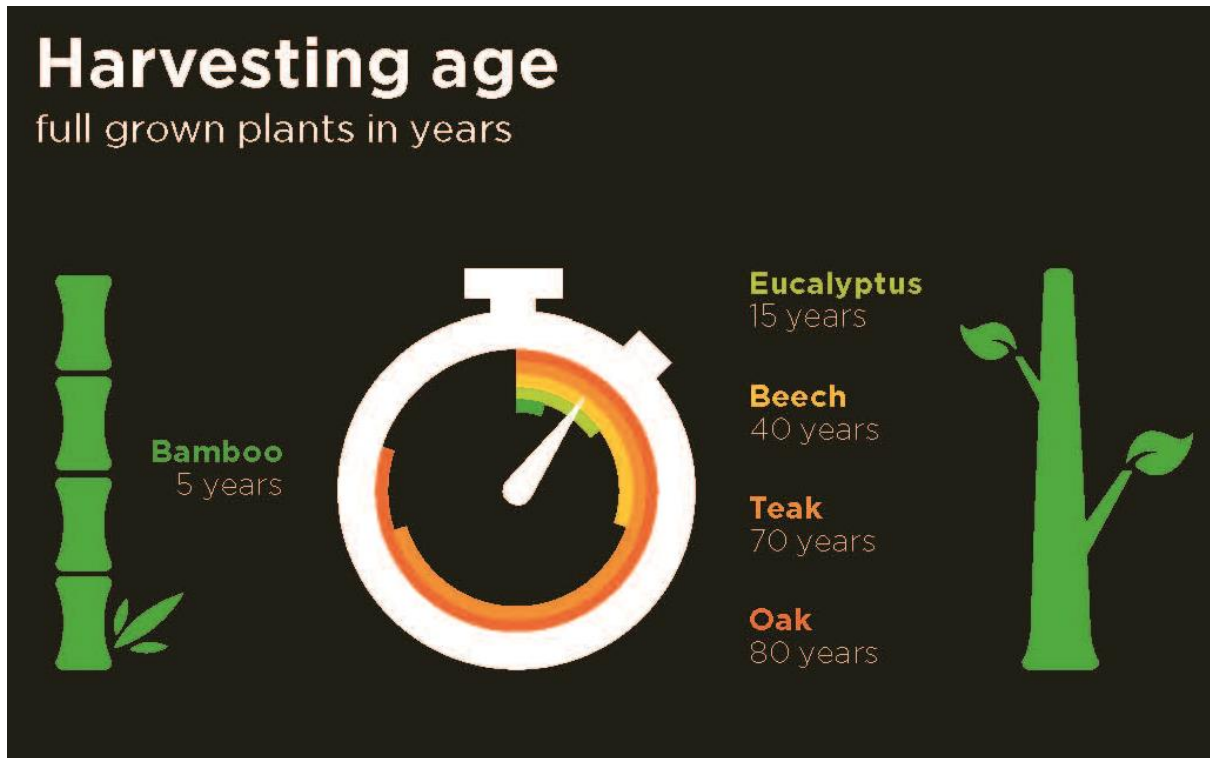
- Example: MOSO 3-Ply Solid Panel



- CO₂ neutral over full life cycle
- Also applies to other assessed solid MOSO products

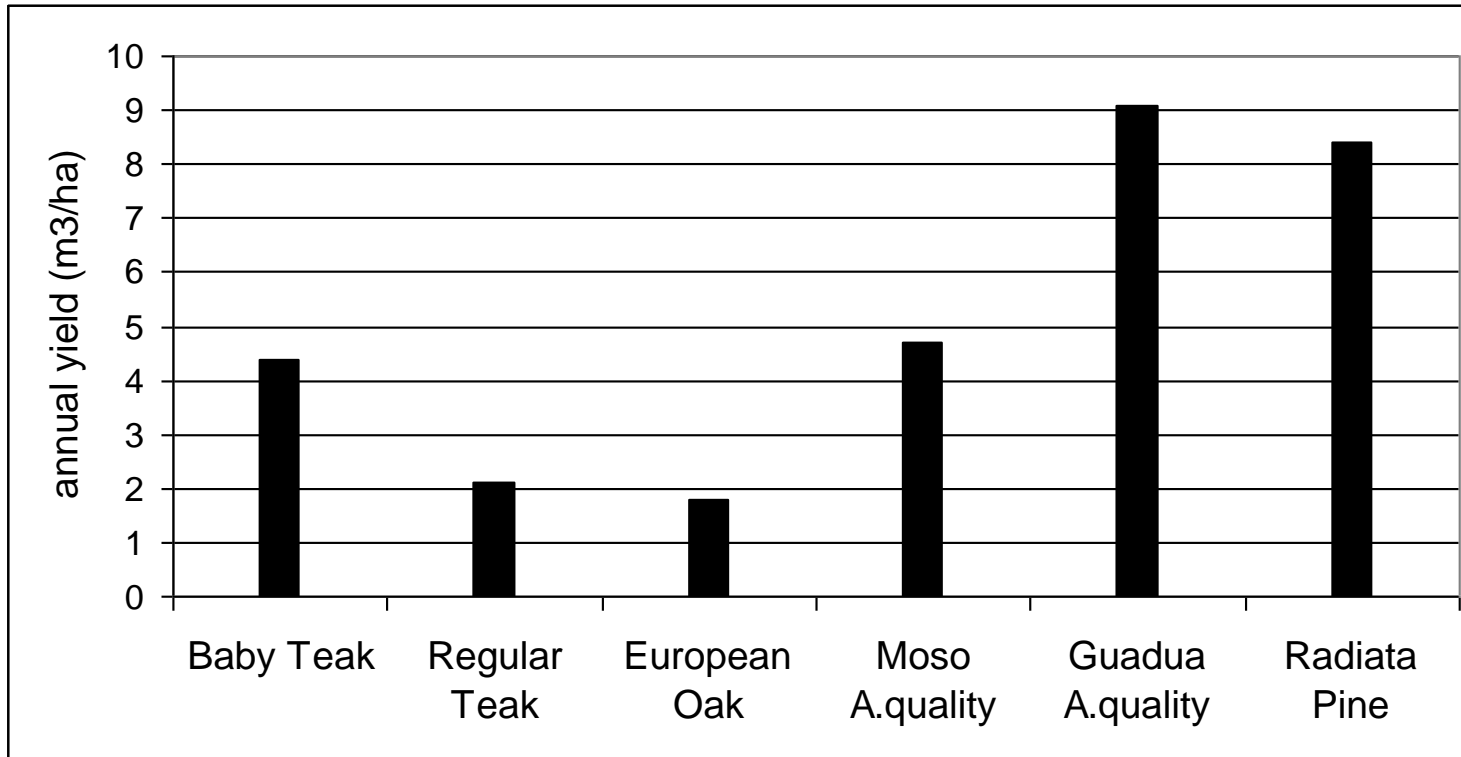
Carbon footprint - Excluded

- Not included in LCA / Carbon footprint:
 - Social Aspects (People)
 - Annual Yield > additional green credential



Carbon footprint - Excluded

- Environmental Sustainability Balance
 - LCA / carbon footprint > Debit side
 - Annual Yield > Credit side



Landuse: Annual Yield #1

- Growth on degraded land (e.g. slopes)
 - Erosion control
 - Water table restoration



Landuse: Annual Yield #2

- Growth on degraded land (e.g. slopes)
- Short Establishment Time
 - 5- 10 years
 - Wood: 15 – 80 years



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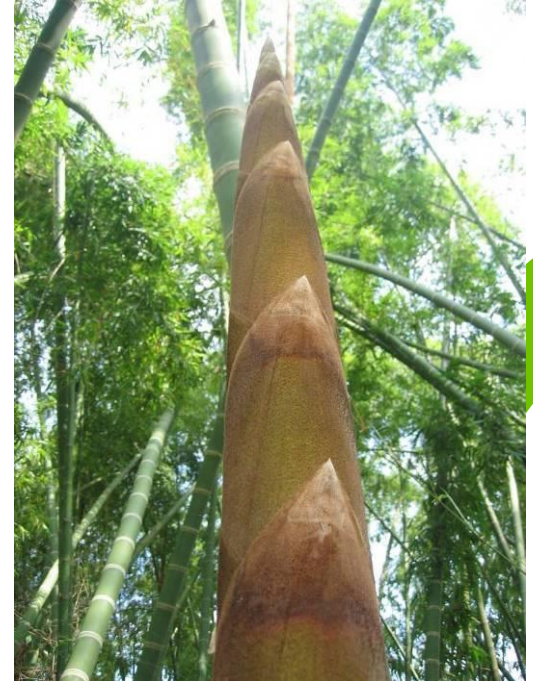
Landuse: Annual Yield #3

- Growth on degraded land (e.g. slopes)
- Short Establishment Time
- Flexibility / Applicability
 - Fiber / Pulp
 - Paper, Composites, Textile, Biofuel
 - Earlier harvesting (Age 1-2)



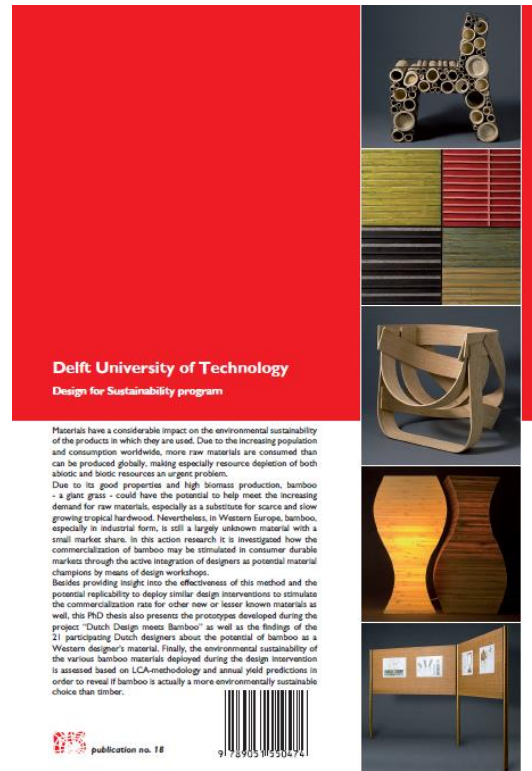
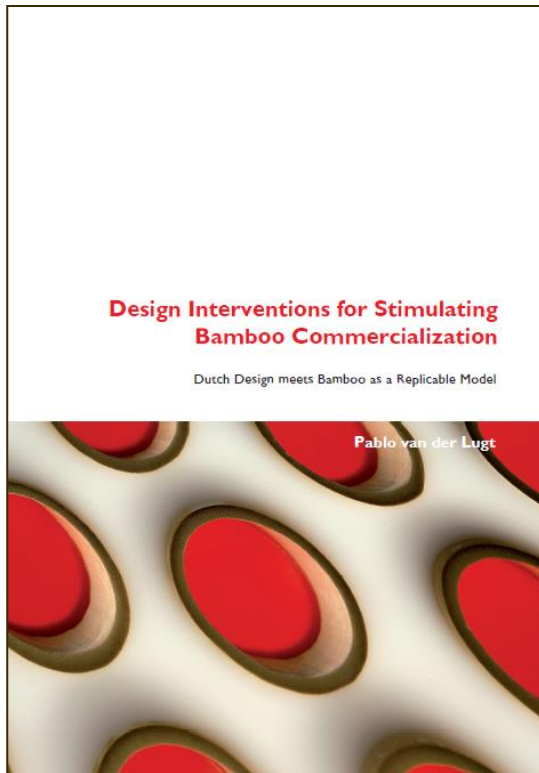
Landuse: Annual Yield - Conclusion

- Giant bamboo species (e.g. Guadua)
- Similar yield as fastest growing tree species (Eucalyptus)
- High applicability
 - High end (e.g. terrace decking) vs. low end (e.g. MDF)
 - Also for other industries (paper, textile)
- Hardwood properties (especially SWB)



Want to know more?

- PhD thesis Pablo van der Lugt (ISBN 978-90-5155-047-4)
- Bamboo, a Sustainable Solution for Western Europe - Design Cases, LCAs and Land Use (ISBN 978-90-6562-196-2)
- Dutch Design meets Bamboo (ISBN: 978-90-74009-49-2)
- www.bambooteam.com/pablo



Dutch Design meets Bamboo

Tomorrow 10:00 AM

