Emissions and sensory testing of straw and non-wood fibre based panels

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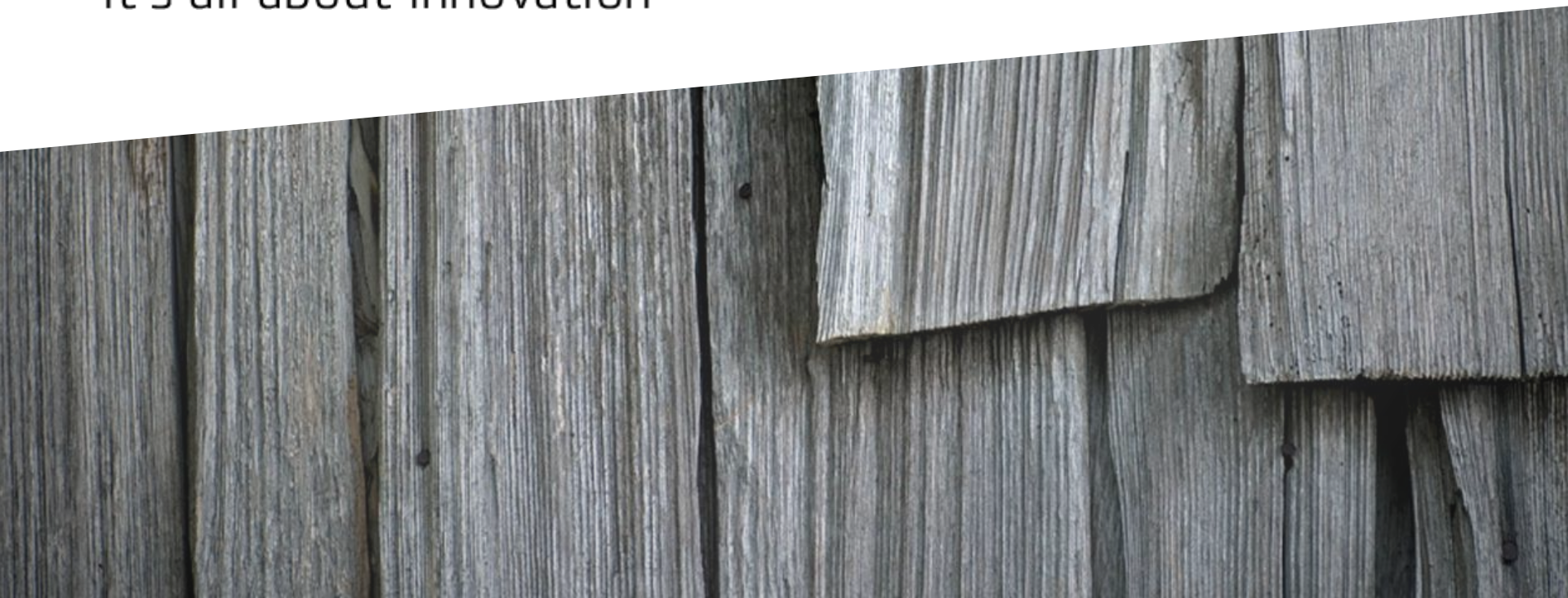
it's all about innovation



Centre for Wood Technology and Bio-Based Materials

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Background

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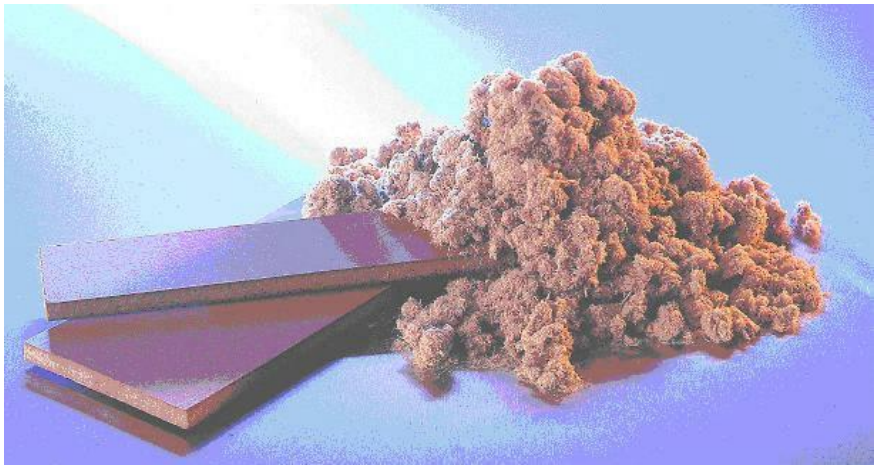
- Increased focus on the use of alternative biomasses as sustainable building materials including incorporation in fibreboards
- Architect interest in new natural surfaces, looks, textures
- Odorous VOCs (volatile organic compounds)
- Compare with wood based panels…….
- Healthy Indoor Environment ?
- Consumer perception ?



Biological House Project

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- Danish, Architect driven project
- Main objectives

-Develop basis for a ”modular house / building”

-Low emission materials, → good indoor environment

-One focal point: biologically derived materials in structural and non-structural panels.

In the project, a number of bio-based fibrous and particulate agricultural residues utilised in panel prototypes: initial screening of “design potential”, alongside technical performance

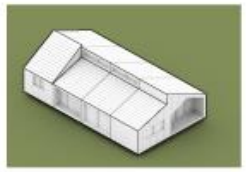
DET BIOLOGISKE HUS

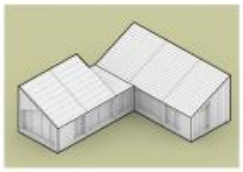
Et nyt bæredygtigt typehuskoncept af sunde materialer

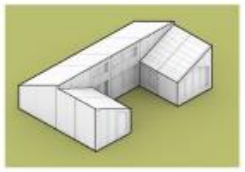
Visionen med 'Det Biologiske Hus' er at skabe et nyt alternativ til det danske typehus; et huskoncept med fokus på arkitektonisk kvalitet, individuel tilpasning og sundt indeklima, somerbyggetaflokalebiologiskerestmaterialer - Et ressourcebevist og fremtidsikret hus for den moderne danske familie.

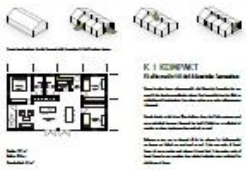
Vision og baggrund

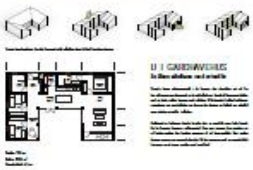
'Det Biologiske Hus' er et bæredygtigt dansk huskoncept med boliger af høj kvalitet bygget af bio-baserede restmaterialer fra landbrugsindustrien. Materialer, der idag betegnes som 'affald' og derfor afbrændes til energi, vil blive oparbejdet til værdifulde byggematerialer baseret på restmaterialer fra produktionen af græs, halm, tomat, tang og ålegræs mm. Projektet anvender Cradle to Cradle principper, materiale 'upcycling' og nye produktionsteknologier i udviklingen af et moderne og økologisk hus med høj arkitektonisk kvalitet. Det Biologiske Hus er et modulært huskoncept der henvender sig til den brede befolkning som en konkret løsning på fremtidens klimatiske og økonomiske udfordringer.









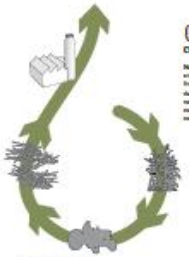


BÆREDYGTIGT TYPEHUS

Ny bæredygtig boltypologi

GRØN VÆKST

Cirkulær økonomi og forædling af restprodukter



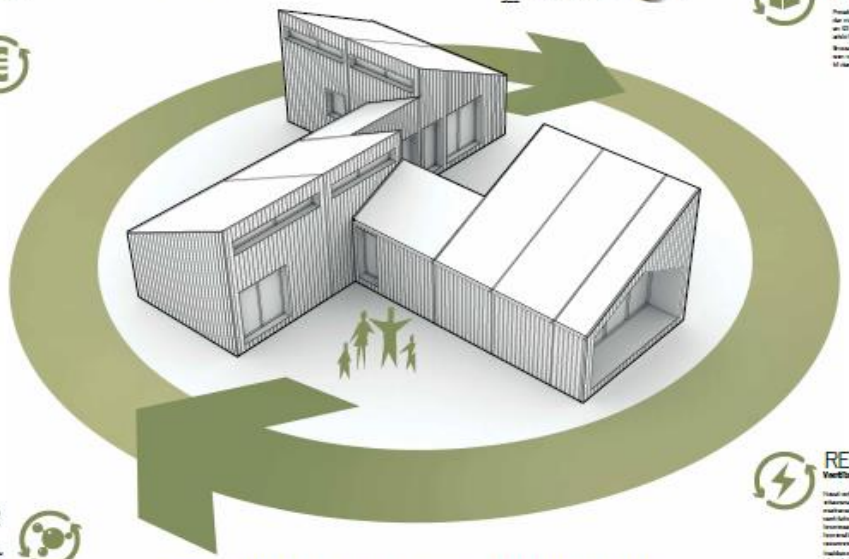
RESSOURCER

Potentialer i restprodukter

BIOLOGISKE MATERIALER

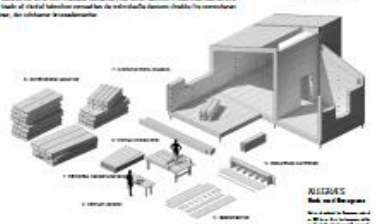
Nye materialer og nyskabende produkter

Byggeriets Bestanddele



FLEKSIBELT BYGGEKONCEPT

Digitalt design og produktion



MATERIALE KREDSLØB

Design for genanvendelse

REN ENERGI

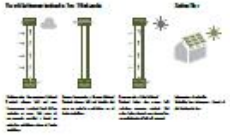
Ventilationsvinduer og solceller

LCA QUICKSCAN

Værktøj til screening af materialer

SUNDT INDEKLIMA

Naturlige materialer uden toxiner



EENTILEEN GXN NCC Deloitte. TEKNOLOGISK INSTITUT

Emissions Testing

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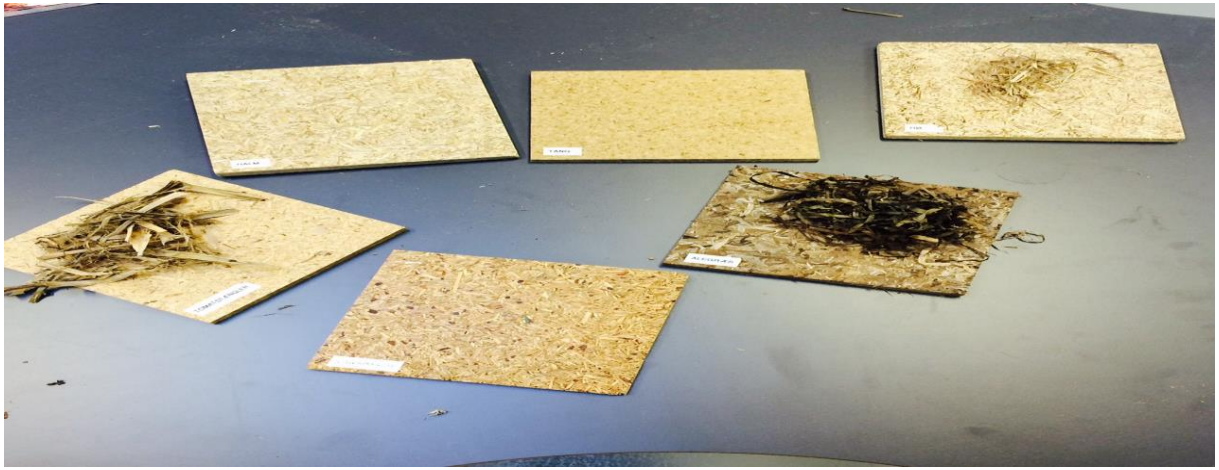
- Straw internode chips
- Tomato stem chips
- Supplied locally (Sjælland, Denmark)

- Boards bonded using Soy-protein thermoset glue
- 10% glue content (dmb)
- 820 – 850 kg m^{-3} boards produced for evaluation



Emission testing set-up

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ISO 16000-9: Indoor Air – Part 9:
Determination of the emission of volatile organic compounds from building products and furnishing
- Emission test chamber method,
The features of the chamber and test conditions:-

Climate chamber:	113 l polished stainless steel
Temperature	23ºC ± 2ºC
Humidity	50 ± 5% RH
Air-change	1 ± 0,05 h^{-1}
Air speed	0,1 – 0,3 m/s
Material loading	0,09 m^2

Straw board

tomato-stem board

Methodology

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- Sampling: after 3 days in the climate chamber.

- VOCs collected using a Tenax tube, and analysed by GC-MS according to ISO 16000-6. Quantification was performed at concentrations above 1 µg/m^3 via comparison with pure reference compounds, or compounds that are comparable.
- Aldehydes were collected by DNPH tube and after elution with acetonitrile were analysed by HPLC (liquid chromatography), using UV detection according to ISO 16000-3.
- Ammonia was collected on a sulphuric acid coated silica sorbent and was then desorbed in water and reacted with indophenol blue reagent and subsequently analysed by spectrophotometric measurement of absorbance at 694 nm.

Emissions tests results

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Substance	CAS-no.	STRAW Conc. (µg/m^3)	TOMATO Conc. (µg/m^3)	Odour threshold Approx conc.[4] (µg/m^3)	Odour impression
Ammonia (NH_3)	7664-41-7	62	380	1800	Sharp
ALDEHYDES					
Formaldehyde[2]	50-00-0	1,4	1,4	60	Stinging
Acetaldehyde[2]	75-07-0	30	40	90	Fruit-stinging
Propanal[2]	123-38-6	4	3	2	Fruit-sickly
Butanal[2]	123-72-8	6	12	1	Fruit-sickly
Pentanal (Valeraldehyde)	110-62-3	4	5	1	Fruit, sickly
Hexanal	66-25-1	5	23	1	Grassy
Propanal, 2-methyl- (iso-Butyraldehyd)	78-84-2	1	2	1	Wet straw
Butanal, 3-methyl- (iso-Valeraldehyd)	590-86-3	10	16	1	Fruit, sickly
Butanal, 2-methyl	96-17-3	2	3	1	Fruit, sickly
Heptanal	111-71-7	1	7	<1	-
Octanal	124-13-0	<1	1	<1	-
Nonanal	124-19-6	1	5	2	-
Decanal	112-31-2	<1	1	3	-
Furfural	98-01-1	2	<1	250	Almond, caramel
KETONES					
Acetone	67-64-1	3	2	4000	-
CARBOXYLIC ACIDS					
Acetic Acid	64-19-7	701	611	15	Acidic, stinging
Propionic acid	79-09-4	9	10	17	Acidic, stinging
Propionic acid, 2-methyl-	79-31-2	3	4	5	Acid
Butanoic acid ("butter acid")	107-92-6	4	5	100	"Sweaty feet"
Butanoic acid, 3-methyl- (isovaleric acid)	503-74-2	2	4	<1	Harsh, acid
Pentane carboxylic acid (valeric acid)	109-52-4	3	3	<1	Harsh, acid
ALIFATIC HYDROCARBONS					
Pinene (terpene)	80-56-8	1	2	100	-
3-Carene (terpene)	498-15-7	2	6	4000	-
Undecane	1120-21-4	<1	1	5600	-
Dodecane	112-40-3	<1	1	770	-
Tridecane	629-50-5	<1	2	42000	-
OTHER					
2-Propanol, 1,3-dichloro-[3]	96-23-1	8	32	na	-
Benzyl alcohol	100-51-6	1	1	na	-
Sum VVOC	-	4	3	-	-
Sum SVOC	-	2	<1	-	-
TVOC (sum af VOCs C6-C16)	-	760	743	-	-

Emissions tests: results overview

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- Both panel types emitted a variety of aldehydes and carboxylic acids,
  - odour can be detected even in low concentrations. Acetic acid was emitted detectably in both board types.

- NH_3 **- <u>below</u>** the recognized odour threshold.
  -Thermal degradation of the proteins, and from the soya glue.
  Higher amounts of ammonia emitted from tomato-stem boards.
  Reflects higher protein content of the tomato stem.

- **<u>None</u>** of the substances emitted at harmful concentration levels.
  - With passage of time, the emission levels will reduce. ✓✓✓

Sensory Evaluation

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- Straw chips,
- Eel-grass / reed
- Wood chips
- Tomato stem chips
- Chopped hay

- Boards bonded using Soy-protein thermoset glue
- 10% glue content (dmb)
- 750 – 850 kg m^{-3} boards produced for evaluation

Sensory Evaluation

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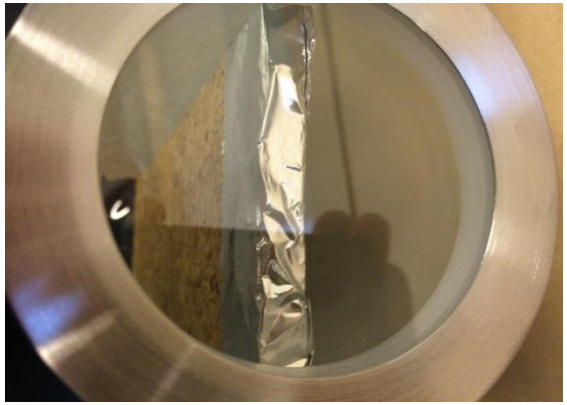
Glass containers with samples for sensory evaluation



Glass seen from above. Lid lifted

Untrained panel of 20 persons evaluated the intensity and the acceptability of the air.

ACCEPTANCE		INTENSITY	
-1	Clearly unacceptable	5	Overwhelming odour
		4	Very strong odour
-0,1	Just unacceptable	3	Strong odour
0,1	Just acceptable	2	Moderate odour
		1	Weak odour
1	Clearly acceptable	0	No odour

Sensory Results

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	1 day		28 days	
Material	Acceptability	Intensity	Acceptability	Intensity
Straw	-0.15	2.2	-0.10	2.0
Eel-grass	-0.15	2.3	-0.13	2.3
Wood chips	-0.20	2.5	-0.18	2.0
Tomato stem	-0.25	2.0	-0.15	2.3
Hay	-0.40	3.0	-0.23	2.2

Results of sensory evaluation of odour after conditioning periods of 1 and 28 days

Sensory Findings summary

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- In general, wood and straw boards have the most acceptable smell with little perceived difference in the intensity of the odours.
- "Relative acceptability rankings":

  Wood > Straw > Eelgrass > Tomato Stems > Hay.
- In terms of perceived Intensity, rankings are:

  Wood = Straw < Hay < Eelgrass = Tomato Stems.

Data shows:

- all of the panels fall outside the accepted ranges of sensory impact at the first testing day.

- After time, both wood and straw boards almost fall below the accepted moderate intensity (< 2.0), the other materials have moderate to strong odour intensity.

Summary Comments

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- Boards produced from straw and tomato stems do not give rise to hazardous levels of emissions
- However, odorous compounds are released. In the case of agricultural residues, the odours are, not surprisingly, indicative of "an agricultural" base material
- Sensory testing has shown the raw materials to be labelled as "just unacceptable" by panelists and this remains after a 4 week period. Further testing is needed to determine if these sensory values decline over a longer time-period.
- The data is useful to designers of interior spaces in which there is often an "aesthetic" wish to show natural materials within that space and to "sell" a design concept on that basis. However, if unacceptable odors linger long term, this needs to be considered at an early design phase.

www.fiberties.dk

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Invitation

FiberTies - Nordic Network on biofibers

- Financed by Nordic Forest Research (SNS) and Nordic Joint Committee for Agricultural and Food Research (NJK)

The network cordially invites you to a joint **symposium on October 22nd 2015 and workshop on October 23rd 2015** with the aim of establishing ties between sectors and across borders.

- With focus on sharing knowledge on sustainable **utilization of plant fibers** from the forest, agricultural and food sectors in building, textile and packaging industry.

Participation is free of charge

Thanks to…..

DANISH TECHNOLOGICAL INSTITUTE

Co-authors

Biological House project

Danish Environmental Protection Agency: for project funding

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Thank you for staying Awake !!