Competitive wood-based interior materials and systems for modern wood construction (Wood2New)

FINAL REPORT

Title of the research project	**Competitive wood-based interior materials and systems for modern wood construction (Wood2New)**
Coordinator of the project	Yrsa Cronhjort

BASIC PROJECT DATA

Project period	01.03.2014-28.02.2017
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URL of the project	http://www.wood2new.org/

FUNDING

Total budget in EUR	1 867 700 EUR
Public funding from WoodWisdom-Net Research Programme:	Total funding granted in EUR by source:
Austria Federal Ministry of Agriculture, Forestry, Environment & Water Management (BMLFUW)	259 000 EUR
Finland Tekes – the Finnish Funding Agency for Innovation Academy of Finland (AKA)	402 000 EUR -
France Ministry of Agriculture, Fisheries and Forestry Resources	-

(MAAF)	
French Environment and Energy Management Agency (ADEME)	-
Germany	
Agency for Renewable Resources (FNR)	-
Ireland	
Department of Agriculture, Food and the Marine (DAFM - CoFoRD Programme)	-
Norway	
The Research Council of Norway (RCN)	318 800 EUR (2 646 000 NOK)
Slovenia	
Ministry of Education, Science and Sport (MIZS)	-
Sweden	
Swedish Governmental Agency for Innovation Systems (VINNOVA)	150 000 EUR (1 305 000 SEK)
Switzerland	
The Commission for Technology and Innovation (KTI; in the Federal Department of Economic Affairs FDEA)	-
United Kingdom	
The Forestry Commissioners (FC)	125 000 EUR

Other public funding:

[Name of the funding organization, Country]	-

Other funding:

Aalto-korkeakoulusäätiö, Finland (own funding)	116 030 EUR
AB Gustav Kähr, Sweden (work and materials)	46 000 EUR (401 500 SEK)
European Confederation of Woodworking Industries asbl, Belgium	300 000 EUR
Finnish Log House Industry Association, Finland	10 000 EUR
Laft og Design (formerly Mini Prosjekt), Norway (2.5 PM of work))	72 700 EUR
Massivlust AS, Norway (in kind)	28 000 EUR
Moelven Wood AB, Sweden (work and materials)	19 000 EUR (164 000 SEK)
The Federation of the Finnish Woodworking Industries, Finland	11 600 EUR
(Beginning of project: Finnish Wood Research Oy)	

PROJECT TEAM (main participants)

Name, degree, job title	Sex (M/F)	Organization	Country
Yrsa Cronhjort, MSc Architect Project Researcher, Coordinator Wood2New	F	Aalto University School of Arts, Design and Architecture	Finland
Pekka Heikkinen, MSc Architect Professor of Practice (Wood Architecture)	M	Aalto University School of Arts, Design and Architecture	Finland
Mark Hughes, PhD Wood Science Professor (Wood Material Technology)	M	Aalto University School of Chemical Technology	Finland
Simon le Roux, MSc Architect Project Researcher	M	Aalto University School of Arts, Design and Architecture	Finland
Tomi Tulamo, MSc Architect Project Researcher	M	Aalto University School of Arts, Design and Architecture	Finland
Katja Vahtikari, MSc Technology Doctoral Candidate	F	Aalto University School of Chemical Technology	Finland
Ira Verma, MSc Architect Project Researcher	F	Aalto University School of Arts, Design and Architecture	Finland
Katie Johnson, BSc Environm. Science, Consultant	F	Building Research Establishment BRE	United Kingdom
Katie Livesey, MSc Environm. Forestry, Senior Consultant	F	Building Research Establishment BRE	United Kingdom
Elodie Macé, Diplôme d'ingénieur, Consultant	F	Building Research Establishment BRE Centre for Sustainable Products	United Kingdom
Ed Suttie, PhD Wood Science, Director, Research	M	Building Research Establishment BRE	United Kingdom
Seppo Romppainen, MSc Engineer, Commissioner Senior Adviser	M	Finnish Log House Industry Association The Federation of the Finnish Woodworking Industries	Finland Finland
Topi Helle, PhD, Managing Director	M	Finnish Wood Research Oy	Finland
Bruce Uhler Environmental Ambassador	M	AB Gustav Kähr	Sweden

Christina Fuerhapper, DI (FH) Project Researcher, Indoor Air Quality	F	Holzforschung Austria	Austria
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Michael Truskaller, Dipl.-HTL-Ing., Project Researcher, Surface Properties	M	Holzforschung Austria	Austria
Martin Weigl, PhD Head of Unit Chemistry	M	Holzforschung Austria	Austria
Elisabeth Habla, Mag Project Researcher, Indoor Air Quality	F	Holzforschung Austria	Austria
Per Carlborg, PhD University Lecturer	M	Linköping University	Sweden
Tomas Nord, PhD Timber Construction Senior Lecturer	M	Linköping University	Sweden
Thomas Waldhör, PhD, Associate Professor for Medical Statistics, topic Epidemiology	M	Medical University of Vienna	Austria
Roy Sundbye, Architect, Director of Art and Development	M	Mini Prosjekt Norge	Norway
Mikael Axelsson Managing Director	M	Moelven Wood AB	Sweden
Kristian Bysheim, MSc, Researcher, Engineering and Markets	M	Norsk Treteknisk Institutt	Norway
Kristine Nore, PhD Engineering, Senior Researcher, Engineering and Markets	F	Norsk Treteknisk Institutt	Norway
Anders Q. Nyrud, PhD Forest Economics Head of Department	M	Norsk Treteknisk Institutt	Norway
Jörgen Tycho, Architect, Managing Director	M	Oslotre AS / Massivlust AS	Norway
Juha Elomaa	M	Stora Enso	Finland
Karl Dobianer, PhD Chemistry Project Researcher, Toxicology	M	Technisches Büro für Chemie Karl Dobianer	Austria
Steve Cook Sustainability Manager	M	Wilmott Dixon	United Kingdom

DEGREES (if relevant)
Degrees earned or to be earned within this project.

Year	Degree	Sex (M/F)	Name, year of birth and year of earning M.Sc., D.Sc., etc. Degree	University	Supervisor of thesis, supervisor's organization
2015	MSc	F	Katja Kortelainen, 1988	Aalto University (Aalto-korkeakoulusäätiö)	Professor Mark Hughes Instructor: MSc Katja Vahtikari Instructor: MSc Tuula Noponen
2016	MSc	M	Filip Arvola, 900419 2016	Linköping University	[PhD Tomas Nord, Linköping University
2016	MSc	M	Jonathan Hydén, 911106 2016	Linköping University	[PhD Tomas Nord, Linköping University

PROJECT SUMMARY REPORT

Project *Competitive wood-based materials and systems for modern wood construction, Wood2New*, was built around six Work Packages in addition to project management and dissemination activities. These were WP1 Framework, WP2 Wooden Surfaces, WP3 Indoor Environment, WP4 Human Perception, WP5 Wooden Spaces and WP6 Commercialization and Business Models. The work was based on an iterative learning process containing theoretical approaches, laboratory tests, first-hand user experiences and demonstrations. The project partners included six research entities and nine industry partners from Finland, Austria, Belgium, Norway, Sweden, and the United Kingdom. The project was coordinated by Aalto University, Finland.

We spend the majority of our time indoors and this has significant effects on our physical and mental well-being. The importance of the indoor environment is especially important in healthcare and living spaces, and the demand for healthy buildings is growing. To find competitive solutions supporting the further development and use of wood-based products in such contexts, the Wood2New objectives were to:

(1) identify opportunities and limitations for the use of wood in interiors;
(2) assess and enhance the beneficial effects of wood on human well-being;
(3) develop, design and evaluate sustainable, value-added, multi-functional wood based interior materials, products and systems for both new construction and the retrofitting of residential, healthcare, educational and work environments.

The main achievements of the Wood2New project can be summarised thus:

- Work Package 1 published a first overview and compilation work of European building regulations regarding the use of wood in interiors and the key user requirements
- Work Package 2 produced new knowledge on the haptic properties, moisture buffering effects and hygroscopic capacity of various wood species, as well as variations in VOC emissions due to changes in moisture content
- Work Package 3 established a protocol for the long-term monitoring of indoor air quality, delivered and evaluated monitoring data of the indoor air quality in new built, occupied structures over a period of 12 months from 13 objects, and established a calculation model to predict the load of air-borne emissions in timber-built structures
- Work Package 4 published a report on people´s perception of using wood as an indoor construction material based on focus group studies in six European countries. The results are the basis of an original research article investigating the relationship between desired product performance and wood properties. An empirical study in a hospital setting, investigating patients and the impact of visual wood surfaces on well-being and health have also been analysed.
- Work Package 5 published a book of ideas on research results and 25 original designs using wood in wet spaces
- Work Packages 4 and 5 delivered findings confirming earlier reports on the human perception of wood material in spatial design and care environments
- Work Package 6 identified key success factors and processes for sustainable value creation in forest product companies

1.1 Introduction

1.1.1 Background

Interior spaces and indoor air quality significantly affect our physical and mental well-being and comfort, especially in healthcare and living environments. The qualitative performance of buildings depends on several factors.

Temperature and moisture are central characteristics of interior spaces and research suggests that these can be affected by the choice of surface materials. Wood's propensity to interact with moisture can be put to good effect in helping to mediate the interior environment of buildings. As the humidity level rises, wood adsorbs moisture from the surrounding air and, when the humidity drops, the stored moisture is released back into the environment. Associated with adsorption there is a release of heat which can raise the surface temperature of wood; conversely heat is required during desorption. These processes combined with the other thermal properties of wood give rise to the concept of 'hygrothermal mass', which may have the potential to improve the energy efficiency of buildings. These attributes are gradually being recognized.

Interior air quality is affected by, for example, volatile organic compounds (VOC), formaldehyde, air-borne particles and microbes, as well as other factors. The sources of chemical compounds and particulates include human activity, structures, surfaces, furnishings, and the air itself. Reference values for various chemical compounds and particles are defined, and values lower than these usually result from normal use and do not pose a risk to human health. The amount of formaldehyde in wood products has been nationally regulated since 1980, and in 2004 the European Standard EN 13986 established formaldehyde classes E1 and E2 for use in construction. To further the development of indoor air quality regulations, it is now important to quantify the VOCs released from materials, including wood. The odor of wood is widely recognized and used in, for example, air fresheners. However, the amount and long-term development of VOCs released by wood material in a living environment have not yet been clearly identified.

The importance of interior comfort grows with increasingly energy-efficient building. From January 2021 onwards all new buildings within the European Union are to be built to nearly zero energy standards (nZEB). In various pilot projects, wood has so far been used sparingly, even if the characteristics of wood materials support the creation of a pleasant space. Empirical studies have shown that wood is perceived to be a pleasant, warm, breathing, and timeless material. Europe is also aging; future social sustainability requires accessibility and comfort in our living and care environments. Basic requirements concern design for all, good acoustics and good interior air quality. Wood also supports the feeling of a homely environment; it is a familiar material, and the warm surface increases comfort.

Materials and products with environmentally, socially and economically sound values should have an advantage if they can deliver competitive performance. The aim of Wood2New was to reinforce and improve the competitiveness of wood-based interior products and systems based on these values.

1.1.2 Objectives

Objectives of the project were to:

(1) identify opportunities and limitations for the use of wood in interiors;
(2) assess and enhance the beneficial effects of wood on human well-being;
(3) develop, design and evaluate sustainable, value-added, multi-functional wood based interior materials, products and systems for both new construction and the retrofitting of residential, care, educational and work environments.

To reach these objectives the project identified, assessed and developed the following aspects of wood-based materials, products and systems for interior use:

- opportunities for, and barriers to, wood use in interior refurbishment and new construction,
- options to promote the beneficial effects of wood based products on human well-being,
- material and surface properties in terms of improved durability and ease of cleaning, energy efficiency, indoor air quality and human perception of wood based products and systems,
- competitive and sustainable wood surfaces and coatings,
- design solutions that promote human well-being, restorative interiors and energy efficiency,
- design solutions to meet end user expectations in selected market segments,
- demonstrate, test and evaluate solutions in closed test spaces and real life test beds,
- propositions for effective product declarations of wood based materials and systems,
- a basis for market access, including business environment and services.

1.2 Results and discussion

The main achievements of the Wood2New project can be summarised thus:

- Work Package 1 published a first overview and compilation work of European building regulations regarding the use of wood in interiors and the key user requirements
- Work Package 2 conducted laboratory tests producing new information on the haptic properties, moisture buffering effect and hygroscopic capacity of various wood species, as well as variations in VOC emissions due to changes in moisture content
- Work Package 3 established a ground-breaking protocol for the long-term monitoring of indoor air quality and delivered evaluated monitoring data of the indoor air quality in new built, occupied structures over a period of 12 months from 13 objects
- Work Package 4 published a report on the people´s perception of using wood as an indoor construction material, and based on focus group studies in six European countries. The results are the basis of an original research article investigating the relationship between desired product performance and wood properties. An empirical study in a hospital setting, investigating patients and the potential impact of visual wood surfaces on well-being and health outcomes have also been analysed.
- Work Package 5 published a book of ideas on research results as well as 25 original designs on the use of wood in wet spaces

- Work Packages 4 and 5 have delivered new and confirmed earlier findings on human perception of wood material in spatial design and care environments
- Work Package 6 has identified key success factors for market access, and also the internal processes for sustainable value creation in forest product companies
- Wood2New results have been disseminated throughout the project resulting in 4 scientific journal articles, 8 peer reviewed proceedings publications, 18 other publications, 9 project reports and 3 master´s theses – more than 40 publications, 20 of which are scientific. Three newsletters were released during the project. The majority of the publications are available through the website *www.wood2new.org.* Project presentations for the benefit of industry and business, publicly across Europe, have reached an audience of approximately 1000 people.

The results listed contribute new knowledge to research in the field of wood material, wood technology, building physics, indoor air quality, environmental psychology, architecture and industrial economy. The results support the further development and competitiveness of the forest products industry. Vulnerable stakeholder groups, occupants and the end-users of healthcare environments, have been an explicit focal point of the Wood2New project.

Collaboration with industry has been a central part of the project throughout. Activities have included participation in workshops and seminars arranged by industry partners, yearly presentations of the project results for the *CEI-Bois Building With Wood Group of Experts* and individual updates of results to industry partners. The cooperation has also included a press release and blog post, and the Wood2New project is included in the annual *Eco-Management and Audit Scheme report* (EMAS) of Kährs Group in 2016.

The results of Work Package 3 are significant from the viewpoint of VOC measurements and building codes in indoor air quality.

1.3 Conclusions

The Wood2New project delivers new knowledge and scientific data on the behaviour of wood material indoors and human perception of wood-based products. Additionally, the project proposes application models for the results in practice to support new, sustainable business.

The Wood2New project contributes beyond the current state-of-the-art with

- test results on the haptic properties, moisture buffering effects and hygroscopic capacity of a wide selection of European wood species, including coated materials
- a demonstrated case of hygrothermal mass and its use for energy planning in practice
- a protocol for the long-term monitoring of indoor air quality including medical aspects and a calculation model for estimating the load of air-borne emissions over time in timber-built constructions
- new data on the behaviour of VOCs in varying humidity conditions
- data on end-user perceptions of wood material from six European countries, and the use of wood in interiors and care environments from four surveys
- improved knowledge of the beneficial psychological effects and health outcomes from using visual wood surfaces in a healing environments

- 25 original designs proposing new uses of wood in wet spaces
- the identification of key success factors and a business model for sustainable value creation in forest product companies
- over 40 publications on research findings

1.4a Capabilities generated by the project

Outcomes of the Wood2New project include:

- basic research on the moisture buffering capacity of wood, which is to be compiled into a *doctoral thesis* at Aalto University School of Chemical Technology (Work Package 2)
- a *proven new protocol* for surveying and following-up air borne emissions in built environments, as well as a *calculation model* for evaluating the future development of *Total Volatile Organic Compounds (TVOC)* in timber-based buildings based on measurement results of the first few months after building completion (Work Package 3)
- *a strengthening of the evidence* and the opportunity to create new business cases and products for wood in interiors based on health and wellbeing

As a whole, the results of the Wood2New project support the furthering of wood construction especially in the healthcare environments market segment.

1.4b Utilisation of results

Industrial partners have been eager to implement the project results especially in marketing. One example is the Kährs Group with both a press release as well as inclusion of the project in their annual *Eco-Management and Audit Scheme report* **(**EMAS) in 2016.

Research on hygrothermal mass has been directly utilized in Norway as a motivation for four building permits by Oslo Tre Arkitekter and Massiv Lust AS. With the support from Wood2New researchers at Norsk Treteknisk Institutt it was possible to demonstrate an energy saving of 10,348 kWh per year for a CLT building with 675 m^2 visible solid spruce surface reducing the average heating energy demand from the estimated 130 kWh/m^2 to 106 kWh/m^2. The case illustrates the dramatic potential for the moisture buffering effect and concept of hygrothermal mass explored in the project.

Research on hygrothermal mass and the beneficial psychological effects of wood use has also been directly utilized in Norway by Laft og Design, in contributing to the development of an industrialized construction concept of ecological housing. The first project is planned to be completed in the first half of 2017.

The empirical data and research on indoor air quality realized by Holzforschung Austria proves the importance of time in the context of air-borne emissions. In a timber-based building the emissions are initially high as new built but the effect decreases rapidly. Hence regulations on indoor air quality should be based on long-term estimations. To support such predictions, Work Package 3 has developed a calculation model with the ability to forecast the development of interior VOC´s based on only a few months of monitoring. Also this work is transferrable to practice.

1.5 Publications and communication

a) Scientific publications

1. Articles in international scientific journals with peer review

*Kraniotis D, Nore K, Brückner C, Nyrud A. Q. (2016). *Thermography measurements and latent heat documentation of Norwegian spruce (Picea abies) exposed to dynamic indoor climate*. J Wood Sci (2016) 62: 203-209.

(*)Fürhapper C., Habla E., Weigl M., Stratev D. (planned for 2017): *Long-term behaviour of VOC-emissions in prefabricated timber houses* (preliminary title) – holztechnologie, to be submitted in spring 2017

(*)Nyrud, A.Q., Bysheim, K., Bringslimark, T. Forthcoming. *Does elements of nature have a healing effect? The impact of wooden materials and landscape pictures in patient rooms.* Accepted for publication in Arkitektur N.

Strobel, K., Nyrud, A.Q., Bysheim, K. Forthcoming. *Interior wood use: Linking user perceptions to physical properties*. Accepted for publication in Scandinavian Journal of Forest Research

2. Articles in international scientific compilation works and international scientific conference proceedings with peer review

Charisi S, Kraniotis D, Brückner C, Nore K (2016). *Latent heat sorption phenomena in three building materials: Norwegian spruce (picea abies), gypsum board and concrete*. In: Eberhardsteiner J, Winter W, Fadai A, Pöll M 2016, *World Conference on Timber Engineering (WCTE 2016) August 22-25, 2016, Vienna, Austria*.

Kraniotis D, Langouet N, Orskaug T, Nore K, Glasø G (2016). *Moisture buffering and latent heat sorption phenomena of a wood-based insulating sandwich panel*. In: Eberhardsteiner J, Winter W, Fadai A, Pöll M 2016, *World Conference on Timber Engineering (WCTE 2016) August 22-25, 2016, Vienna, Austria*.

Nyrud A Q, Strobel K, Bysheim K (2016). *User perceptions of naturalness and the use of wood in the interior environment*. In: Eberhardsteiner J, Winter W, Fadai A, Pöll M 2016, *World Conference on Timber Engineering (WCTE 2016) August 22-25, 2016, Vienna, Austria*.

Vahtikari K, Noponen T, Hughes M (2015). *Moisture Buffering Properties of Various Hardwood Species.* In: Horáček P., Wimmer R., Rademacher P., Kúdela J., Kolářová V., Děcký D. *InWood2015: Innovations in Wood Materials and Processes*. MENDELU – Mendel Unievrsity in Brno. 2015.

Vahtikari K, Noponen T, Hughes M (2016). *The effect of wood anatomy and coatings on the moisture buffering performance of wooden surfaces*. In: Eberhardsteiner J, Winter W, Fadai A,

Pöll M 2016, *World Conference on Timber Engineering (WCTE 2016) August 22-25, 2016, Vienna, Austria*.

Verma I, Cronhjort Y E, Kuittinen M (2016). *Design for care - use of wood in public buildings*. In: Eberhardsteiner J, Winter W, Fadai A, Pöll M 2016, *World Conference on Timber Engineering (WCTE 2016) August 22-25, 2016, Vienna, Austria*.

Weigl M, Medved S (2015). *Impact of blue stain infected spruce wood on particle board properties*. International Panel Products Symposium 2015 joint conference with COST Action FP1303, At Llandudno, Wales, UK.

*Weigl M, Stratev D, Fürhapper C, Habla E, Nohava M, Niedermayer S (2016). *Wood borne emissions in a real room environment- a modelling approach*. In: Eberhardsteiner J, Winter W, Fadai A, Pöll M 2016, *World Conference on Timber Engineering (WCTE 2016) August 22-25, 2016, Vienna, Austria*.

3. Articles in national scientific journals with peer review

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4. Articles in national scientific compilation works and national scientific conference proceedings with peer review

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5. Scientific monographs

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6. Other scientific publications, such as articles in scientific non-refereed journals and publications in university and institute series

*Burns J, Garvin S, Johnson K, Lennon T, Livesey K, Macé E, Suttie E (2016). *Building Regulations, EU and National.* Building Research Establishment Ltd. 22 January 2016. Project report. Available at: www.wood2new.org

Bysheim, K. 2015. *Effekten trebaserte produkter har på mennesker i innemiljø*. Treteknisk Informasjon 2/2015.

*Bysheim K, Nyrud A Q, Strobel K (2016). *Building materials and well-being in indoor environments A focus group study Byggematerialer och velvære I innendørs miljø*. Norsk Treteknisk Institutt. Rapport, 88, 2016. Project report. Available through: www.wood2new.org

Bysheim, K. *Økt konkurransekraft for trebaserte interiørprodukter*. Treteknisk Informasjon 2/2014.

Bysheim, K. 2016. *Wood Forum Nordic 2016*. Treteknisk Informasjon 1/2016.
Cronhjort Y, Dobianer K, Hughes M, Livesey K, Nord T, Nyrud A Q, Weigl M (2014). *Using wood based interior materials to promote human well-being: project Wood2New.* COST Action FP

1303, Performance and maintenance of bio-based building materials influencing the life cycle and LCA, Slovenia 23-24.20.2014. Poster.

Cronhjort Y (ed.), *Competitive wood-based interior materials and systems for modern wood construction*. Project report. Available through: www.wood2new.org

*Cronhjort Y., Hughes M., Paakkanen M., Sahi K., Tukiainen P., Tulamo T., Vahtikari K. (eds.) (2016). *Functional Wood*. Aalto University publication series CROSSOVER 3/2016. Project report. Available through: www.wood2new.org

Cronhjort Y., Tulamo T., Verma I., Zubillaga L. (2017). *INTERIOR DESIGN AND CARE ENVIRONMENTS End-user Perceptions of Wood Material*. Technical project report. 70 pages. Available at: www.wood2new.org

Fürhapper C (2015). *Häuser zum Wohlfühlen Wood2New – Internationales Forschungsprojekt zur Wohngesundheit.* HOLZFORSCHUNG AUSTRIA MAGAZIN FÜR DEN HOLZBEREICH. 4/2015.

Fürhapper C (2017). *Statement report WP3 – Indoor Air Quality in prefabricated timber houses*. Technical project report. 8 pages. Available at: www.wood2new.org

Fürhapper C (2017). *Statement report WP3_4 – Influence of moisture buffering and latent heat exchange on the emission behaviour of wood*. Technical project report. 7 pages. Available at: www.wood2new.org

Hughes M, Vahtikari K, Noponen T (2015). *Moisture Buffering Properties of Various Wood Species.* COST FP1303 Action Management Committee Meeting, 04-05.03.2015.

Kortelainen K (2015). *An investigation into the surface temperature changes of solid wood during sorption*. Aalto University School of Chemical Technology. Master's thesis for the degree of Master of Science in Technology submitted for inspection, Espoo, 19 May, 2015.

Kraniotis, D, Nore, K. 2015. *Treoverflater – et gratis naturlig varmegjenvinnende panel*. Treteknisk Informasjon 2/2015.

Macé E, Taylor S, Vivien T, Suttie E (2017). *Space and End-user Requirements, Past and Future.* Building Research Establishment Ltd. 10 January 2017. Project report. 43 pages. Available at: www.wood2new.org

*Nord T, Carlborg P, Backman T, Ekerå M, Hallbert S, Järvenhag J, Nordlund J (2016). *Work Package 6 Business Environment and Market Segments*. Linköpings Universitet. LIU-IEI-RR—16/00239-SE. 11 January 2016. Project report. Available at: www.wood2new.org

Nore, K. 2015. *Glem varmekabler. Velg heller trepanel på badet*. Bergens Tidende 19. oktober 2015. http://www.bt.no/nyheter/lokalt/Glem-varmekabler-Velg-heller-trepanel-pa-badet-287517b.html

Nore, K., Nyrud, A.Q. 2016. *Fukt i bygninger kan være en ressurs. Bygg og bevar april 2016*. https://www.byggogbevar.no/pusse-opp-gammelt-hus/tre/artikler-trehus/fukt-i-bygninger-kan-vaere-en-ressurs
Nore, K., Nyrud, A.Q. 2015. *Kronikk: Stor interesse for hygrotermisk masse*! Arkitektur N 7/2015.

Nyrud, AQ. 2016. *Tre i innemiljø, psykologiske effekter*. Treteknisk Informasjon 1/2016.

Vahtikari K, Cronhjort, Y, Verma, I, Hughes, M (2017). *Functional properties of wooden surfaces in real indoor environments.* COST Action FP1303 Performance and maintenance of bio-based building materials influencing the life cycle and LCA: A technical workshop focusing on: "Design, Application and Aesthetics of biobased building materials"Bringing new functions to wood through surface modification, Bulgaria 28.02-01.03.2017.

Vahtikari K (2015). *The effect of coating on the moisture buffering properties of pine.* COST Action FP1006, Bringing new functions to wood through surface modification, 07-08.04.2015.

Weigl M (2014). *Emissionen die mit uns wohnen*. HOLZFORSCHUNG AUSTRIA MAGAZIN FÜR DEN HOLZBEREICH. 1/2014.

Fürhapper C. (planned for 2017): *Innenraumluftqualität in neu errichteten Holzhäusern* (vorläufiger Titel), HOLZFORSCHUNG AUSTRIA MAGAZIN FÜR DEN HOLZBEREICH 3/2017

Truskaller M. (planned for 2017): *Einfluss von Oberflächeneigenschaften auf die subjektive Wahrnehmung von Nutzern* (vorläufiger Titel) HOLZFORSCHUNG AUSTRIA MAGAZIN FÜR DEN HOLZBEREICH 5/2017

b) Other dissemination

Publications

Cronhjort Y, Vahtikari K (2014). *Koe Puu! Experience Wood!* PUU WOOD HOLZ BOIS. 3/2014. Article. Available at: https://issuu.com/puuinfo/docs/puu_3_14_web

Cronhjort Y, Vahtikari K (2016). *Puulla myönteisiä vaikutuksia sisäilman laatuun.* Blog post at the website of the Federation of the Finnish Woodworking Industries.
Available at: puutuoteteollisuus.fi/puulla-myonteisia-vaikutuksia-sisailman-laatuun/

Suttie E. *Is wood good for your health?* A feature article in the TRADA Timber Yearbook 2017

Kährs Group i banbrytande forskningsprojekt om träets påverkan på inomhusmiljön.
Press release by Kährs Group. 19.10.2016.

Newsletters – 3 releases during ongoing project including one feature article each and separate contributions from all Work Packages

Trähus kan spara energi. Skog & Industri Nr 1/2016, p. 9. Article.

Project presentations at public conferences and seminars
(including dissemination to industrial partners)

10.04.2014 *Annual WoodWisdom-NET Seminar*. Stockholm, Sweden.
- Cronhjort Y. *Competitive wood based interior materials and systems for modern wood construction (Wood2New),*

27.11.2014 *Puupäivä 2014*, 1315 registered attendants. Helsinki, Finland.
- Cronhjort Y., *Energiatehokkuus ja puiset sisäympäristöt - Wood2New ja WoodLife*

22.01.2015 *Aalto Wood Winter Seminar*, 100 registered attendants. Espoo, Finland.
- Cronhjort Y. *Project Wood2New*

23.04.2015 Feeling Good Foundation – event. London, United Kingdom.
- Livesey K. *Project Wood2New*

23.06.2015 Seminar *Fremtiden Bygges iTre – Treets påvirkning på inneklima og helse, ny forskning*. Bergen, Norway.
- Cronhjort Y. *Presentasjon av forskningsporsjektet Wood2New.*
- Weigl M. *The contribution of wood products towards indoor air quality Emisjoner fra trematerialer – omfang.*
- Nore K. *Hvordan forbedres inneklimaet ved bruk av tre - hygrotermisk masse.*
- Truskaller M. *Haptics of wooden and non wooden elements Gåkomfort - forsøk med ulike typer tregulv.*
- Nyrud A Q. *Brukers perspektiv på byggmaterialer av tre - Fokusgrupper i Findland, Norge, Sverige og Østerrike.*

15.09.2015 *Annual WoodWisdom-NET Seminar*. Zürich, Switzerland.
- Cronhjort Y. *Competitive wood based interior materials and systems for modern wood construction Wood2New*

15.01.2016 *Aalto Wood Winter Seminar*. 89 registered attendants. Espoo, Finland.
Following presentations:
- Nore K. *Hygrothermal Effect: A New Standard?*
- le Roux S. *Towards Eco-efficiency: The Future of Eco-labelling*

17.03.2016 *Puuidea 2016* seminar. Vantaa, Finland. Organizer: Puumiesten Liitto ry.
- Cronhjort Y. *Energiatehokkuus ja puiset sisäympäristöt*

31.03.2016 Yearly meeting and seminar, the Finnish Log House Industry Association. Seinäjoki, Finland.

- Cronhjort Y. *Wood2New tutkimushanke; Puun termodynaamiset ominaisuudet*

16.06.2016 *Forum Wood Building Nordic 16*. Espoo, Finland. 400 registered attendants.

- Fürhapper C. *Indoor Air Quality in Prefabricated Timber Houses.*
- Bysheim K. *Interior wood use: Linking User Perceptions to Physical Properties.*
- Truskaller M. *Tactile Perceptions of Wood-Based Materials.*
- Arvola F, Hydén J. *Human well-being – the Road to Sustainable Business Models in the Wood Products Industry.*
- Vahtikari K. *The Effects of Wood Anatomy on Moisture Buffering Properties.*
- Nore K. *Hygrothermal mass – potential improvement of indoor climate by building materials.*
- Tycho J. *Feeding on Knowledge, a Holistic Approach to the Building Process.*

07.07.2016 The British Woodworking Federation *Members Day*. London, United Kingdom.

- Suttie E. *Growing the use of wood in interiors*

24.08.2016 *World Conference on Timber Engineering WCTE 16*. Vienna, Austria.

- Charisi S, Kraniotis D, Brückner C, Nore K. *Latent heat sorption phenomena in three building materials: Norwegian spruce (picea abies), gypsum board and concrete.*
- Kraniotis D, Langouet N, Orskaug T, Nore K, Glasø G. *Moisture buffering and latent heat sorption phenomena of a wood-based insulating sandwich panel.*
- Nyrud A Q, Strobel K, Bysheim K. *User perceptions of naturalness and the use of wood in the interior environment.*
- Vahtikari K, Noponen T, Hughes M. *The effect of wood anatomy and coatings on the moisture buffering performance of wooden surfaces.*
- Verma I, Cronhjort Y E, Kuittinen M. *Design for care - use of wood in public buildings.*
- Weigl M, Stratev D, Fürhapper C, Habla E, Nohava M, Niedermayer S. *Wood borne emissions in a real room environment- a modelling approach.*

31.08.2016 *Research Day*, organized by the Federation of the Finnish Woodworking Industries. Presentation and facilitation of workshop on the topic of *Interior Air Quality*.

- Cronhjort Y. *Puu ja sisäilma*

17.10.2016 *Timber Expo UK 2016*, Seminar: Pushing out the envelope of what is possible in wood. Birmingham, United Kingdom.

- Suttie E. *Interior wood use delivers health and wellbeing benefits*
- Suttie E. and Cronhjort Y. Panellists at the closing discussion

08.11.2016 *Syysseminaari 2016*, Hirsitaloteollisuus ry. (Autumn seminar 2016, The Finnish Log House Industry Association)

- Cronhjort Y. and Verma I. *Hoivaympäristöjen viihtyvyyteen vaikuttavat tekijät*

24.01.2017 British Woodworking Federation Interiors Group. London, UK.

- Suttie E. *The biophilic office, wood and health and wellbeing*

26.01.2017 Seminar *Påverkan av interiört trä* (Wood2New). Stockholm, Sweden.
Organizers: Sveriges Träbyggnadskansli, Trä- och Möbelföretagen. 20 participants.

- Nord T. *Welcome and introduction*
- Suttie E. *WP1 - Framework*
- Vahtikari K. *WP2 – Wooden surfaces*
- Nore K. *WP2 – Hygrothermal mass*
- Truskaller M. *WP2 – Wooden haptics*
- Dobianer K. *WP3 – Indoor air quality*
- Nyrud A. Q. *WP4 – Perception of wood*
- Cronhjort Y. *WP5 – Interior Design with wood*
- Nord T. *Summary*

26.01.2017 Seminar *Låt Landet Bygga Staden*. Stockholm, Sweden. Organizer: Trästad. 90 participants.

- Nord T. *Aspekter med interiöra träprodukter och boendes välbefinnande*

27.01.2017 Seminar *Påverkan av interiört trä* (Wood2New). Linköping, Sweden.
Organizer: Linköping University. 45 participants.

- Nord T. *Welcome and introduction*
- Suttie E. *WP1 - Framework*
- Vahtikari K. *WP2 – Wooden surfaces*
- Nyrud A. Q. *WP2 – Hygrothermal mass*
- Truskaller M. *WP2 – Wooden haptics*
- Dobianer K. *WP3 – Indoor air quality*
- Nyrud A. Q. *WP4 – Perception of wood*
- Cronhjort Y. *WP5 – Interior Design with wood*
- Nord T. *Summary*

28.02. – 01.03.2017 COST FP1303 Meeting
Design, Application and Aesthetics of biobased building materials. Following presentations:

- Vahtikari K (co-authors: Cronhjort Y, Verma I, Hughes M)
  Functional properties of wooden surfaces in real indoor environments

Dissemination of results to industrial partners (and within companies)

- Yearly presentations for the *CEI-Bois Building With Wood Group of Experts*
- Wood2New included in the annual *Eco-Management and Audit Scheme report* **(**EMAS) of Kährs Group in 2016
- Individual annual updates of results to industry partners
- 9 Advisory Board meetings, Finland
- Presentations at events organized by Puuinfo Oy, the Federation of the Finnish Woodworking Industries, and the Finnish Log House Industry Association, Finland (see above)
- Blog post at the website of the Federation of the Finnish Woodworking Industries
  Cronhjort Y., Vahtikari K., *Puulla myönteisiä vaikutuksia sisäilman laatuun*, 26.04.2016
  Available at: http://puutuoteteollisuus.fi/puulla-myonteisia-vaikutuksia-sisailman-laatuun/
- Press release by Kährs Group
  Uhler B., Johansson H. *Kährs Group i banbrytande forskningsprojekt om träets påverkan på inomhusmiljön*, Kährs Group, 19.10.2016,
  www.kahrsgroup.com/sv/media/cision-detail-page/?cisionid=2336985

LinkedIn Discussion Group

- 95 members with global spread
- approximately 120 conversations

1.6 National and international cooperation

The Wood2New consortia is a new collaboration that has evolved into a close network of researchers, companies and establishments around the topic of wood material. Work has been supported throughout the project via short-term research visits between project partners, common dissemination activities in all partner countries as well as cooperation in research to produce material covering several European countries, such as the report on European building codes published by Work Package 1. Common dissemination events include Forum Wood Building Nordic 2016 and the World Conference on Timber Engineering 2016 attracting attendants with a global spread.

The network has also expanded to include single people and entities worldwide like FPInnovations Canada and the University of Primorska. Outcomes include a planned research visit from Aalto University to the University of Primorska in 2017 and collaboration in future projects.

Industry partners have been active in furthering the work by offering case objects and test material. Such support has been valuable for the demonstration of results in Work Package 2, for the monitoring scheme in Work Package 3, and case studies in Work Packages 4, 5 and 6. Collaboration has additionally included common dissemination activities and the production of individual communications like the press release by Kährs Group on October 19th 2016.

The project has also been active in parallel networks participating for instance at several COST Action events with conference papers and presentations but also in industrial initiatives like the Feeling Good Foundation UK.

Wood2New has attracted general attention to the topics and served as a starting point for further research. For example, in Finland *LUKE the Natural Resources Institute in Finland* is getting more involved in the field and *The Federation of the Finnish Woodworking Industries* has raised the topic of indoor air quality of wood-based products on its agenda. In the UK the sector through trade associations and companies are coalescing to look at opportunities with BRE in the industry funded biophilic office project for occupant health, wellbeing and productivity, a component of which focuses on interior materials and will build on learning generated in Wood2New. In Norway, three projects related to the monitoring of the interior environment in CLT student housing projects and supermarkets have been initiated, and several new projects are being planned. Additional new projects are planned in residential environments (apartment buildings) and schools.

The Wood2New collaboration has overall been productive and fruitful, creating new knowledge and connecting people worldwide beyond the project consortia. Work goes on; several initiatives for follow-up projects are on the table and research continues concurrently in parallel projects. Scientific dissemination is expected also after the project period.