CHORA CONNECTION

GO2WOOD

COMPENDIUM

Understanding that teamwork is the secret ingredient of the two man crosscut saw

CHORA CONNECTION

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FOREWORD

The United Nations 17 Sustainable Development Goals and GO_2WOOD

Karen Blincoe
director
Chora Connection

Climate change is here to stay. We need to - before 2030 - become resilient and sustainable to be able to embrace the challenges, climate change is having on our lives. These challenges will increase as time passes and the climate disrupts more and more. It is no longer about 'saving the planet' but making sure humanity has a chance of survival.

17 SDGS

In 2015 193 countries worldwide agreed on a set of goals, the 17 Sustainable Development Goals, designed to curb CO2 emissions, eliminate the extreme effects of climate change and set us on a path towards sustainable development – a transition of our societies from a non-sustainable to a sustainable state.

Similar initiatives, agreements and declarations have occurred before. Every UN COP since the Rio Conference in Brazil in 1992 has produced declarations or statements which some countries have agreed on and

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It is recognised that the Goals are interconnected – e work on one goal we will be working on others as well as they are mutually interwoven.

others not i.e. Agenda 21 (1992) and The Kyoto protocol (signed in 1997 and ratified in 2005). – Declarations that subsequently have not been followed up on and have failed.

The 17 SDGs are different. The goals were developed not only by researchers, scientists and the UN but by representatives of civil society and the business sector. Due to their input the goals have become clearer and more hands-on. Other new aspects of the 17 Goals and 169 subgoals include the following factors:

UNIVERSALITY: The Goals apply to cities, businesses, schools, organizations, civil society - every country, every nation and every sector - all are required to act.

INTEGRATION: It is recognised that the Goals are interconnected – they are systemic. We cannot just achieve one Goal. We must achieve them all. And if we work on one goal we will be working on others as well as they are mutually interwoven.

TRANSFORMATION: It is widely understood that achieving the 17 Sustainable Development Goals involves making radical and fundamental changes in how we live on the planet (www.17sdgs.org).

As this realization reaches a wider and wider audience worldwide the impetus to act strengthens and grows. More and more sectors are engaging in implementing sustainability and resilience measures.

Chora Connection's mission is to further this process and push the sustainability and resilience agenda in Denmark. The aim is to create and test prototypes whether they are models or processes and to upscale, copy and spread the results across regions and borders.
One such result is the GO_2WOOD initiative. An initiative that encompasses a number of prototypes (see pages 18-25).

WHY WOOD?

Wood is a material that is closely connected to the evolution of humankind. Wood has protected us from the environment and climates. It has nourished us through production and use of agricultural and hunting tools, furnished our homes, transported us by road and sea, developed and enhanced our cultures and traditions with musical instruments, arts and crafts. Wood has advanced the body of knowledge through the production of paper. Trees and forests have been an integrated part of most people's lives and are an inherent ingredient in many cultures.

Wood is practical, versatile, sensuous – a living material. It is therefore not surprising that wood is also a sustainable and resilient material, CO2 neutral and of course biodegradable, giving back nutrients to the earth in the process. I wonder, why it is taking us so long to recognize the qualities and potential of wood in a sustainable innovative and future context.

GO_2WOOD

GO_2WOOD focuses on Goals nr. 12 and nr. 15. dealing with sustainable production and consumption patterns as well as the protection, restoration and sustainable use of ecosystems and sustainable management of forests. These aspects impact the other Goals and a wider accumulative effect will be the positive result of the initiative.

Chora Connection's development of the GO_2WOOD initiative is therefore appropriate, relevant and reflects the three factors of the 17 SDGs. The initiative is universal, integrates and combines all aspects of wood as a building and design material.

The GO_2WOOD initiative brought together a diverse field of experts and practitioners: Foresters, researchers, manufacturers, architects, planners, educators, carpenters, engineers and contractors and culminated in a conference held at the Royal Academy of Architecture in Copenhagen, October 2016 in partnership with CINARK – Centre for Industrialized Architecture, KADK. The resulting manifesto is unique and transformational when applied and combined with the latest technology and design thinking (see page 30).

The GO_2WOOD COMPENDIUM is a result of the conference. The chapters have been authored by the wide variety of experts or representatives of experts that lectured at the conference. They have kindly contributed their knowledge, expertise and information of and about wood, forests and forestry and have outlined the inherent and potential qualities for all of us to benefit from. For that we are grateful.

When reading the compendium we can no longer dispute the sustainability of wood and its ability to help us curb CO2 emissions, nor can we dispute the 'importance that forestry has had for the wealth of our Nordic countries', to quote Jonas Rönnberg.

The work of David Goehring, our project leader and developer of the GO_2WOOD initiative, could have a long-lasting effect on our path towards meeting the 17 Sustainable Development Goals.
I hope it does.

WOOD - A MATERIAL FOR OUR TIME

from the introduction of the book TALL WOOD BUILDINGS

Michael Green
architect

Jim Taggart
journalist

As the 21st century unfolds, architecture stands at a crossroads. Until now there has been no reason to challenge the supremacy of concrete and steel for contemporary buildings, but in the past decade our evaluation criteria have become more complex.. The abstract ambitions of 'commodity, firmness and delight' first proposed by Vitruvius 2000 years ago, now fall within a framework of pressing global imperatives that are daunting in both scale and scope. The practice of architecture must now encompass the issues of climate change, population growth, and a global housing shortage.

In the spring of 2015, as we were assembling the material for this book, the National Oceanic and Atmospheric Administration (NOAA) announced that changes in the Earth's climate system had reached a significant and disturbing milestone. For the first time since the NOAA began measuring the concentration of carbon dioxide in the atmosphere at 40 sites around the globe, the average of those monthly measurements exceeded 400 parts per million (ppm).

This milestone is a wake up call that our actions in response to climate change need to match the persistent rise in CO2. Climate change is a threat to life on Earth and we can no longer afford to be spectators.

According to the NOAA, this represents an increase of approximately 120 ppm since industrialization began about 200 years ago. As we know, the rapid rise in CO2 emissions has been driven by technological development, population growth and the commensurate increase in fossil fuel consumption. However, the accumulation of CO2 and other greenhouse gases in the atmosphere has not been linear, as 60 ppm of the increase has occurred in the last 50 years, and 7.5 ppm in the last three years alone.

At 400 ppm, the atmospheric concentration of CO2 is at a level not seen on Earth for millions of years, and the implications are significant. In the words of Dr. Erika Podest, carbon and water cycle research scientist with NASA: "This milestone is a wake up call that our actions in response to climate change need to match the persistent rise in CO2. Climate change is a threat to life on Earth and we can no longer afford to be spectators." Implicit in Dr. Podest's statement is the assertion that we cannot manifest the changes that are necessary to stabilize the climate system simply by fine tuning our current way of doing things - rather we must completely transform our commercial and industrial practices to radically reduce, and ultimately eliminate, their carbon footprint.

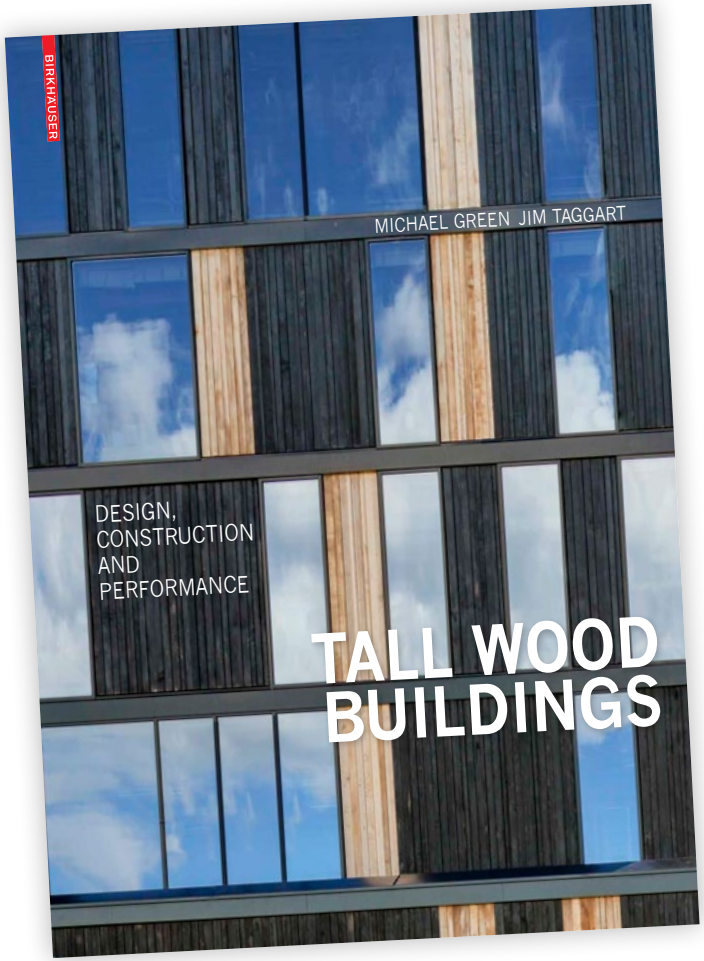
Also in the spring of 2015, two devastating earthquakes in Nepal, resulting in the collapse of hundreds of buildings and the loss of more than 8000 lives, came as a tragic reminder of the substandard conditions in which far too many people in the developing world live and work. As with climate change, the statistics are alarming. UN Habitat has estimated that 1 billion people (1 in 7 of the world's population) currently live in slums, and a further 100 million are homeless.

As the world population continues to increase, it is projected that we will need to construct 3 billion units of affordable housing over the next 20 years. The vast majority of these will be required in the cities of the developing world, where population growth is taking place most rapid-

ly. At first glance the challenges of climate change and world housing might appear to be unrelated. Of the two, climate change receives more attention in the developed world, as its environmental and economic effects are felt directly in the wake of increasingly frequent hurricanes and floods, droughts and forest fires. On the other hand, while access to adequate and secure housing is recognized by the United Nations as a universal human right, it is not a daily concern for most people in the West.

The reverse is true in the developing world, where vast numbers of people live at or below the poverty line, and for whom the overriding concern is the day to day search for enough food to eat and a safe place to sleep. Understandably, for those living in such circumstances, the mitigation of climate change may be nothing more than an abstract concept.

However, thought leaders in the sustainability movement increasingly believe that the solution to the environmental crisis is inextricably intertwined with issues of equity, democracy and social justice - not just within national boundaries, but across the world. This position was eloquently summarized by Andrew Ross in his 2012 book 'Bird on Fire', when he wrote: 'The task of averting drastic climate change might be described as an experiment – a vast social experiment in decision-making and democratic action. Success in that endeavor will not be determined primarily by large technological fixes, though many will be needed along the way. Just as decisive to the outcome is whether our social relationships, cultural beliefs, and political customs will allow for the kind of changes that are necessary. That is why the climate crisis is as much a social as a biophysical challenge, and why the solutions will have to be driven by a fuller quest for global justice than has hitherto been tolerated or imagined.



“The only material we have available to us that could deliver housing solutions on the scale required, and at the same time reduce the GHG emissions associated with construction - is wood.

BUILDING BETTER

To frame these inequities in architectural terms, approximately 20% of global greenhouse gas emissions are attributable to the construction and operation of buildings. However, the 15% of the world's population who live in the 35most developed countries are currently responsible for more than half of the buildings constructed worldwide. Similarly, despite the rhetoric around greenhouse gas reductions, the10 countries that top the list of CO2 emitters, continue to account for fully two thirds of global emissions.

The production of our most widely used construction material - concrete, is already responsible for between 5% and 8% of global GHG emissions. We produce approximately 3 tonnes of concrete per year for every person on the planet. Although this figure also includes concrete used in a variety of infrastructure applications, it nonetheless represents a significant proportion of the 20% of global GHG emissions attributable to the construction and operation of buildings.

While steel is less carbon intensive than concrete, and is relatively efficient to recycle, the production of steel accounts for about 4% of global energy use. If we were to proceed with 'business as usual', the increase in construction activity would generate incalculable quantities of greenhouse gases, and a potentially catastrophic acceleration of climate change.

Clearly construction activity in the developing world will have to increase exponentially to address the housing shortage, but our current materials and technologies cannot deliver this increased volume of construction without grave negative consequences for the environment.

While reducing the operating energy required to heat and cool buildings is dependent on regionally-based solutions that respond to the particularities of local climate, reducing the energy intensity of building construction can be achieved using a universal approach. The typologies of mid and high-rise urban housing are essentially the same everywhere, and currently realized using a combination of load-bearing concrete masonry and concrete or steel frame systems. The only material we have available to us that could deliver housing solutions on the scale required, and at the same time reduce the GHG emissions associated with construction - is wood.

New massive wood products such as cross laminated timber (CLT), together with computerized design and fabrication techniques have accelerated the development of new approaches to building with wood. Calculations have indicated that some of these approaches may be applied to structures as high as 20 or 30 stories. Although research and development of these new approaches is concentrated in Europe and North America, the implications for the global construction industry are profound.

The purpose of this book is to present the arguments in favour of 'Tall Wood' buildings and to showcase completed projects that demonstrate the applicability of this technology to construction across a wide range of building types, and in a variety of physical and cultural contexts. While Tall Wood construction can only ever be part of the solution to the social and environmental challenges we face, its adoption around the world would represent the kind of transformational thinking and cooperative action that will be essential if we are to restore equilibrium to the world's climate system, and eliminate the inequities that have contributed to our current problems.

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http://research.noaa.gov/News/NewsArchive/LatestNews/TabId/684/ArtMID/1768/ArticleID/11153/Greenhouse-gas-benchmark-reached-.aspx, http://climate.nasa.gov/400ppmquotes/

THE GO_2WOOD EFFECT

What is the GO_2WOOD initiative? How did it start and where is it today?

David Goehring
architect
Chora Connection

In the summer of 2015, Chora Connection's first year, the do-tank was in search of an organic resiliency prototype for Danish society. Where was the greatest need? Present day challenges are characterised by a variety of complex economic, environmental and social factors. What was the catalytic action that could move society forward? Something that would have a long lasting and positive impact. The answer was in our own backyard- sustainable wood.

GO_2WOOD GENESIS

There were three significant findings that paved the way for the birth of the what was to become the GO_2WOOD initiative.

First, Chora Connection was active with the early adapters for the circular economy in Denmark and throughout the Baltic Sea Region. Through active networks within the Nordic Council of Ministers and others, Chora Connection entered this forum and soon proactively

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We want to create the purely organic building boldly emanating its inner laws, free of untruths or ornamentation.

Bauhaus architect
Walter Gropius 1920

supported the so-called BIO-ECONOMY- measures regarding regional fisheries, forestry and agriculture, as a key pillar to its regional sustainable development.

Secondly, in the sustainable building platform, Chora Connection was advocating for the Cradle to Cradle DESIGN FOR DISASSEMBLY paradigm, acknowledging the need for flexible, future-proofed buildings. It was through resilient bio-economy measures coupled with the design for disassembly philosophy, Chora identified the ideal prototype for resiliency- sustainable WOOD.

Third, the United Nations 17 Sustainable Development Goals were adopted in September 2015. Goal 15. LIFE ON LAND - Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. This was our validation that we were on track.

DANES LOVE WOOD

Hearkening to the great Danish maritime society of the 800's AD, wood has shaped the culture and environment of Scandinavian people throughout the ages. From the great Viking ships, to the long house, from the Royal Danish forests to the beloved family summer house- Danes appreciate the timeless beauty of this organic material.

Ironically, Denmark shares the unique distinction of consuming the most timber per capita in Europe while at the same time produces the least amount of timber resources. This is due in part to it's only 14% forest coverage and also because Denmark is an agro-economic based country surrounded by the predominently forest-economic based countries of Sweden, Finland and Norway. In recent years Danish forestry has been proportionately unsupported by the state as the forest is often viewed more as a place of recreation, not an engine for

sustainable economic growth. Thus public investment in the concept of the 'production forest' is lacking.

Similarly in the building sector, wood has not been considered the material of choice for public or private development projects. For decades, concrete has been the prevailing means for Danish construction, with a strong emphasis on pre-fabrication. Unfortunately, the production of concrete is carbon intensive and is limited in terms of flexible design. A concrete dominated market has left little room for innovative, bio-based and climate friendly alternatives, like WOOD. Together these two occurrences have resulted in an underutilised natural resource, lost jobs potential and unfulfilled climate solutions. By taking the viewing the whole value chain dynamic, Chora Connection identified a worthy prototype to build a more resilient Denmark. And the GO_2WOOD initiative was launched.

BACK TO THE FUTURE

With climate change related events occurring ever more frequently, municipalities throughout Denmark have initiated new climate plans, demanding both long and short term strategies. Since anthropogenic climate change is caused by GHG green house gases and sustainably managed wood is the only material that dramatically sequesters (versus emitting) CO2, the solution seems clear. The construction industry which contributes nearly 40% of all GHGs, needs a change. Wood seems to have become the material of the future and it is endlessly renewable.

ROUNDTABLES - UNDERSTANDING THE WOOD VALUE CHAIN

In alignment with 5th square methodology, the wood 'problem' was to be viewed from a holistic perspective. A series of structured roundtable discussions were held in October 2015 with experts from throughout the entire wood value chain who were grouped into multi-disciplinary task forces to understand present market dynamics. Participants were organised into three investigative groups- GROW representing the forest, MAKE representing sawmills and wood products and USE representing the building and design industries. Within the focus group were actors from diverse disciplines to engage in a multi-objective discourse.

THE VALUE CHAIN SURPRISE

It soon to be learned the complexity of the value chain in the wood related industries. In the case of industrial design for example, products are conceived and designed in Denmark, raw materials are sourced from abroad, parts are assembled in yet another different country and marketed in a fourth. It was very surprising to see how little one side of the value chain knew of- and much less communicated with the other side.

PROTOTYPES AND SUPPORTING ACTIONS

With the completion of the roundtable discussions, it became evident what was needed to engage Denmark and the bio-region into a deeper, more robust use of sustainable wood. From a consensus, we formally established several new prototypes and supporting actions to define the parameters of the GO_2WOOD Initiative.

PROTOTYPE 1
Multi-story wood structure demonstration project

Our GO_2WOOD delegates considered the profile of a project that would have the greatest impact for innovation in the construction sector. It was determined that a mid rise of 10 stories would create enough change to exhibit sustainably sourced wood as a viable structural building component. During this time-frame, INNOBYG- the innovation cluster for the building industry in Denmark, launched a pre-project (1) year initiative sponsoring Danish companies to prepare and educate our profession for imminent wood design challenges.

PROTOTYPE 2
Wood municipal development project

For this prototype we envisioned working directly with the various municipalities throughout Denmark to encourage the use of wood in development projects, regardless of scale. Schools, urban parks, renovations in municipal properties. In contrast to the first prototype, we would encourage local sourcing for local applications. In this regard, we would simplify the value chain dynamics, stimulate local jobs not only in the construction industry but also within Danish forestry. Several municipalities have started to feature wood projects.

SUPPORTING ACTION 1
Knowledge partnerships

The GO_2WOOD Initiative's greatest asset is that it is a knowledge partnership. By creating a multi-disciplinary platform, members are able to work across ordinary professional boundaries, to learn about the entire value chain and understand how they may be able to benefit from working with more holistic methodologies and making new informed choices towards resiliency.

There is evidence that this is taking shape in Denmark today. More often we now see carpenters and architects, students and professionals alike taking study trips to sawmills, visiting production forests to learn how to close the sourcing loop and discover the full potential of wood.

SUPPORTING ACTION 2
Communincation platform

It was determined that GO_2WOOD should have a rapid delivery communication platform to be able to share information across the different actors in their disciplines. By a more fluid exchange of knowhow, innovation, logistics and value- the effect use of sustainable wood will

Hans Christian Andersen House of Fairy Tales Museum, Odense.

expand and adapt to the needs of society. GO_2WOOD developed an independent Facebook page, together with various Chora Connection social media, newsletters and website posts, the members of GO_2WOOD have been keeping updated with the latest applications in Denmark and around the world. In addition, the Danish Wood Federation has developed an information portal www.trae.dk which has been instrumental in delivering timely new developments.

SUPPORTING ACTION 3

Increase the use of wood

It is generally accepted that Danish afforestation- the conversion of non-forest land to forested land and its subsequent sustainable forest management- should be a part of our land use policy. However, this is preconditioned on creating more demand and therefor higher economic opportunities. How do we use wood- past, present and future? We use a large amount of wood in Denmark and it seems to be on the rise. Energy, timber, paper products and wood panels comprise the 20.000.000 m3 of wood consumption in 2015. A rough order of magnitude for the immediate future, it would seem it is the construction industry that has the greatest opportunity for increasing demand. With the growing popularity of CLT cross laminate timber structures, we can now propose replacing whole structural systems of carbon-intensive materials.

SUPPORTING ACTION 4

Wood v carbon intensive materials

An important factor in spatial development and especially architectural design of the future- is be able to calculate the impact of one's decisions when choosing building materials. LCA Life Cycle Analysis is an integral tool to be able to determine a material's source, transport, waste, energy to assemble, and second life potentialities. Typically in buildings, one considers not a single material, but rather

an assembly of parts, to evaluate the effectiveness in the long term application.

Presently, many architects rely on third sources for LCA calculations, and the need for a quick tool to be able to evaluate wood systems side by side with more conventional assemblies such as those of concrete and steel. Træinformation is working on these initiatives to be able to give a rapid reference means to architects to be able to see the full benefits of working in wood.

SUPPORTING ACTION 5

Danish wood engineering

When considering a building structured in wood, there are some perceived obstacles. Many architects and engineers in Denmark lack the proper experience and training detailing in wood, while other means and methods in materials such as steel and concrete required very little learning curve. In simple terms, this has lead to time and again wood options to be abandoned due to an extra time investment on the front end of a project, an investment that is now easily offset during speedy procurement and construction.

Compounding the problem is that there is a curious void in teaching wood engineering in Denmark. With a growing demand for renewable resources in construction, it is difficult to understand how the public can be served by engineering curriculum dominated by the standard bearers of more carbon intensive materials.

LETTER TO MINISTER

In November 2015 Chora Connection addressed Hans Christian Schmidt, the Minister of transport and construction, requesting the state to raise awareness to building more in wood. The letter identified the matter of aligning to EU fire restrictions allowing future wood structures to go beyond present day height limitations of 4 stories. The Minister responded positively that would allow for innovation to allow new tall buildings structured in wood, provided the calculations and documentation can adhere to code. Present positive legislative trends in countries around the world seem to be moving towards similar conclusions that wood is both a great solution for abetting climate change, but also creates at least as many jobs as it replaces.

GREAT GO$_2$WOOD GET TOGETHER

In January 2016 experts from the forestry, the wood products, design and the building industries came together to collaborate on GO$_2$WOOD, the sustainable use of wood in Denmark. Over the past few months, CHORA CONNECTION has launched this inter-disciplinary initiative, which for the first time considers the ecological, economic and social aspects of the entire WOOD value chain.

The diverse group of actors worked on several prototypes which will increase the demand for sustainably managed forests in the region, grow more timber in Denmark, produce new and innovative wood products in Denmark and most importantly fix carbon- which can make a dramatic contribution to reverse the effects GHG green house gases, the primary cause of climate change. This event formalized the GO$_2$WOOD Knowledge Partnership, which will be offered to municipalities, private developers, academic institutions and the general public to promote WOOD, which in turn will create a more resilient and sustainable society.

LET'S BUILD IN WOOD

Rising Live

Focused on the innovative use of sustainable wood in the construction industry. Kim Dalgaard from Tegnestuen Vandkunsten, Ola Jonsson from C. F. Moller architects and David Goehring from Chora Connection presented various innovative and current constructions in wood.

GO_2WOOD delegation in London visiting state of art in CLT buildings.

DAMVAD REPORT

In 2016 DAMVAD Analytics was commissioned by the state to produce a comprehensive study entitled "Potentials and barriers to the use of wood and sustainable wood in the building sector". As a part of the investigation, experts from around the value chain were solicited for opinions and support. In September 2016 a draft was released for review and while the body of research collection was acceptable, the LCA case studies were met with criticism implying flawed conclusions. As a result the report was not published.

LONDON STUDY TRIP

In April 2016 a GO_2WOOD delegation, in preparation for the Danish INNO-Spire wood high-rise project, paid a visit to the world's largest (by volume) CLT- cross laminated timber structured building called Dalston Lane. This new housing development, designed by London's Waugh Thistleton Architects and constructed by B & K Structures, is a ground breaking example of maximising the carbon benefits of sequestration (2400 tonnes carbon from 3000m3 wood) Sustainable timber sourcing coupled with a growing global demand for housing makes a convincing development model for the future.

CONCLAVE '16 WITH MICHAEL GREEN

Wood takes a stand in Denmark The GO_2WOOD Manifesto

October 27, 2016 Chora Connection hosted an ambitious international conference at the Royal Academy of Architecture KADK in Copenhagen featuring sustainable wood. It's goal was to pave the way for more sustainable design and construction while strengthening Denmark's position as an international leader in the development towards the realization of the UN's 17 Sustainable Development Goals.

The conference was entitled GO_2WOOD CONCLAVE'16, and it's main objectives were to bring together representatives from across the wood industry value chain and to direct the spotlight on wood as a CO2-optimal building material that can benefit society in many areas, while fortifying Danish forestry bio-regional resiliency.

The international event was the culmination of a series of workshops held throughout the previous year to catalyse actions, raise awareness and help develop methods for a more robust use of one of the most abundant bio-materials- WOOD. The GO_2WOOD CONCLAVE's goal was to promote Denmark as a sustainable leader in construction and wood production.

The day's program was inspired first by the FOREST - a place for rich bio-diversity and recreation but also a vital production resource of sustainable timber- the workhorse of carbon fixing. The conference was to feature some of the world's front runners in wood construction, industrial design and technologies in wood.

MICHAEL GREEN- renown Canadian architect was the featured keynote speaker. Green presented the virtues of tall buildings structured in cross laminate timber and how his work is inspiring a new generation of architects and engineers. In addition, the CONCLAVE featured experts who presented their views from across Europe in forestry, industrial designers, sawmills operators, architects and the wood products industry, such as: Anne Beim DK, Bastian Kristensen DK, Dan Cornelius DK, David Goehring US, David Rangan DK, Duncan Horswill UK, Emil

Engelund Thybring DK, Frank Erichsen DK, Hening Jensen DK, Jakob Rygg Klaumann DK, Jasper Steinhausen DK, Jesper Panduro DK, Jonas Rönnberg DK, Jørgen Munch-Andersen DK, Karen MacLean DK, Katie Symons UK, Kristine Sundahl DK, Kim Axelsen Dk, Leif Gustavsson SE, Michael Green CA, Mikael Eliasson SE, Mikael Koch DK, Michael Kvist DK, Mikkel Kragh DK, Mikkel Mørch DK, Nick Milestone UK, Niels Elers Koch DK, Nigal Papworth SE, Ola Jonsson SE, Peder Fynholm DK, Pil Bredahl DK, Siv Helene Strangeland NO, Søren Neilsen DK, Vibeke Grupe Larsen DK, Vivian Kvist Johannsen DK.

The GO_2WOOD initiative is an inter-disciplinary, working knowledge platform that is engaged with prototypes to promote sustainable use of wood. In the spirit of collaboration, the morning session featured inspirational speakers focused on the entire value chain and was open to both students and professional delegates. In the afternoon a more engaging and experiential environment was offered where the delegates were invited into (3) expert parallel sessions- INDUSTRIAL DESIGN, ARCHITECTURE AND EDUCATION. These sessions offered exciting and informative cases, which in turn forged new cross disciplinary relationships, a hallmark of the GO_2WOOD initiative.

The outcome of the day was results-oriented - to develop new dynamic actions and methods for promoting wood in Danish production and construction, based on the latest knowledge on WOOD as a valuable and sustainable production material. At the conclusion of the afternoon workshops and before the final session, the staff at Chora Connection led the core group in a closed door session to organise the findings to present to all of the participants.

In the final session, Karen Blincoe chair of Chora Connection delivered the 10 point GO_2WOOD MANIFESTO to close this significant event.

Full program -https://kadk.dk/sites/default/files/downloads/event/full_program_conclave_16_8.pdf

Jonas Rönnberg talking forestry with Vivian Kvist Johannsen

Frank Erichsen on video for the CONCLAVE '16 at craftsman- architecture student collaboration project

MANIFESTO

1 COMMUNICATION

The importance of communicating the value of wood as well as the value-added elements is essential. Establish and maintain a level of awareness with the predominant influencers in wood related industries. Achieve the UN's 17 Sustainable Development Goals and to build a more resilient bio-region. Create an information portal for the public and private sectors to better understand the consumer choices for sustainable wood. What are the short and long term benefits?

2 EDUCATION

Education is the keystone to build and sustain awareness of wood in society. Wood education needs to be enhanced at all levels, kindergarten to A-levels to university. An integrated approach of experiential vocational hands-on training to engineering and architectural tectonics. Create local education with a global outreach, both virtual and most importantly in real life.

3 RESEARCH

Expand the body of knowledge. Build an extensive knowledge platform, with evidence-based data. Main categories to include engineering, forestry and architecture. Measure- comprise a new framework for measuring the impact of wood. Source- co-create an open source data base on wood, across borders. Demonstrate- sponsor demonstration projects based on scientific research and recorded evidence that wood successfully exhibits the triple bottom line of sustainability-social, economy and environment.

4 ROLE OF WOOD

What role does wood hold in achieving the UN's 17 Sustainable Development Goals by 2030? Where does wood fit in today? How may it shape the future?

5 ADVOCACY

Tell the story of wood by creating wood ambassadors. Events like CONCLAVE '16 and action oriented initiatives like Frank Erichsen and the Arhus Architect school design-build wood pavilion, brings wood to life. KILL the negative myths about wood- relating to non-sustainable forest management, climate change, biodiversity threats and the minimal benefit on society. Bring transparency to woods' weaknesses and strengths.

6 PORTFOLIO OF ICONIC MODELS

To inspire and support innovation and give courage to be transformative. It is a collection to exhibit what is possible and how to better understand the great potential of wood. A level of highest quality is paramount- to combat myths and hearsay. Update public awareness that wood is a top grade material.

7 PARTNERSHIPS WANTED

To develop new field partnerships, where various stakeholder types develop initiatives side by side, to accelerate innovation in WOOD. Expand inter-disciplinary methods such as those demonstrated at the GO$_2$WOOD CONCLAVE'16 in cooperation with the many facets of the wood industry.

8 IDENTIFY FUNDING

There are numerous sources of funding for innovation. Funding is needed to create, evolve and spread the message.

9 HISTORY AND A NEW VOCABULARY FOR WOOD

Understand the place wood has in our multi-generational society from the past, present and future; real and received, seen and experienced. Encourage the transformative qualities of wood- from the 'sensual to the sensible'. Wood means a thousand things to a thousand people for a thousand years. Create a robust value based wood vocabulary, to instill change and inspire new ideas.

10 POLICY FRAMEWORK AND ENCOURAGEMENT

Dissemination of updated information to public administrations to promote WOOD. Make annual recommendations and advise the national government for effective Danish applications in forestry, industrial design and urban policy in regard to wood. Establish a best practices guideline for the effective use of wood for Danish municipalities.

FROM THE FOREST RESEARCH PERSPECTIVE

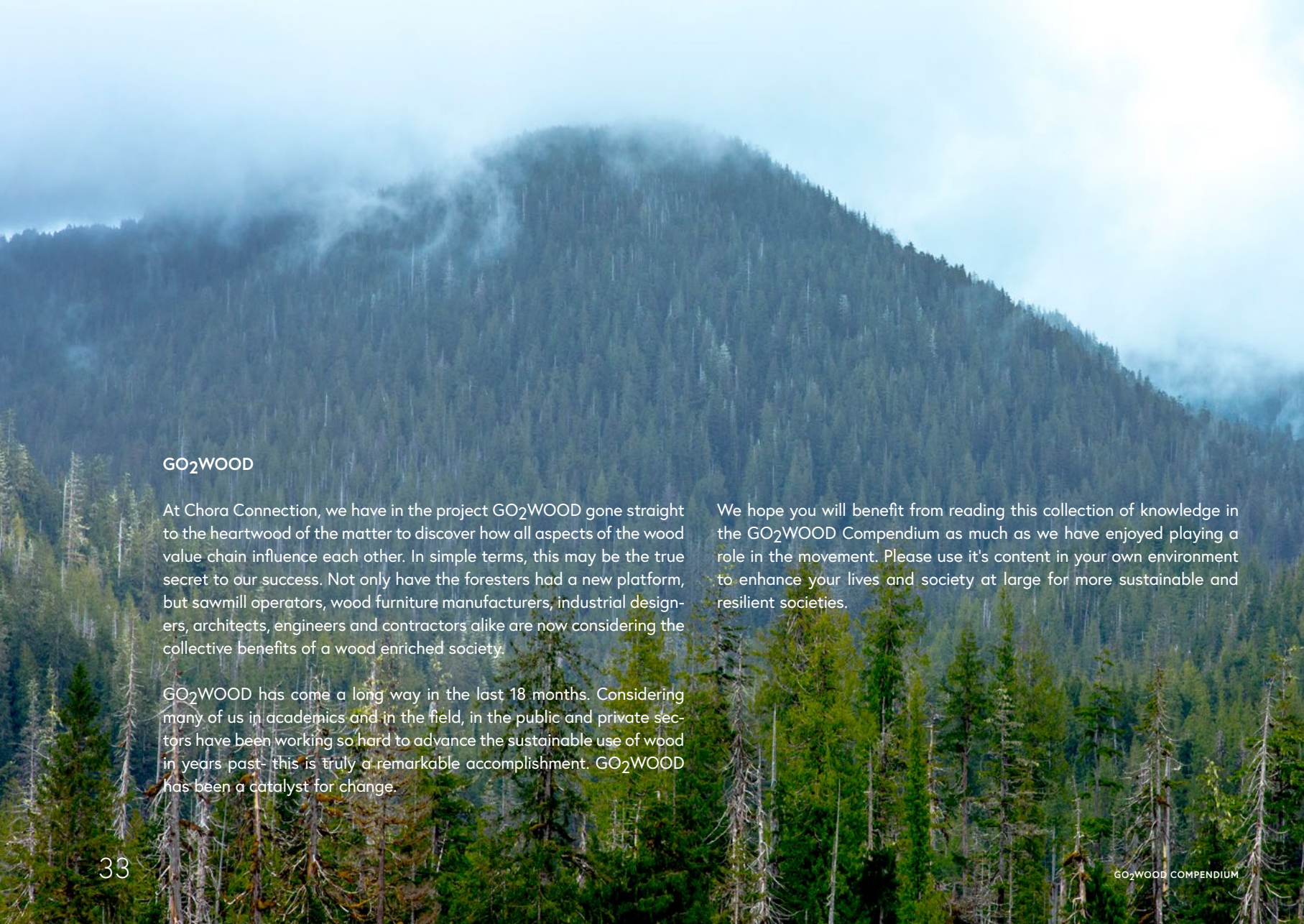
Wood is one of many different products, goods and services from the forests- an important one

Niels Elers Koch
professor dr.dr.
Immediate Past President
IUFRO- International Union of
Forest Research Organisations and
Board Chairman Chora Connection

FOREST RESEARCH COOPERATION

Never before in the history of humanity have so many people demanded so many different products, goods and services from the forests. The main challenges for forest research relate to the interconnections between ecosystems and services for people; climate and land-use; the natural resource-base and environmentally-sound products; biodiversity and human health and well-being; and, ecosystems and global water cycling. Therefore, you need strong forest research institutions and international cooperation.

At IUFRO, creating cooperation between over 15.000 forest researchers in more than 125 countries, I have had the unique opportunity and perspective to be able to see dynamics emerge across borders and cultures- to understand both the opportunities and challenges of sustainable forestry and the management of the many different products, goods and services from the forests.



GO_2WOOD

At Chora Connection, we have in the project GO_2WOOD gone straight to the heartwood of the matter to discover how all aspects of the wood value chain influence each other. In simple terms, this may be the true secret to our success. Not only have the foresters had a new platform, but sawmill operators, wood furniture manufacturers, industrial designers, architects, engineers and contractors alike are now considering the collective benefits of a wood enriched society.

GO_2WOOD has come a long way in the last 18 months. Considering many of us in academics and in the field, in the public and private sectors have been working so hard to advance the sustainable use of wood in years past- this is truly a remarkable accomplishment. GO_2WOOD has been a catalyst for change.

We hope you will benefit from reading this collection of knowledge in the GO_2WOOD Compendium as much as we have enjoyed playing a role in the movement. Please use it's content in your own environment to enhance your lives and society at large for more sustainable and resilient societies.

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DISPELLING THE MYTHS OF WOOD

Sustainable Forest Management, Biodiversity and Society

Jonas Rönnberg
forester
Nordic Forest Research (SNS)

Forests can be used for many things, but whatever they are being used for it seems to be associated with many different feelings. Depending on who you are and from what perspective you look upon, the use of wood will either evoke disturbing or pleasant feelings, and sometimes maybe both simultaneously. Forests are a resource for timber, the home for biodiversity or just a recreational oasis, a place for contemplation or recovery, offer berry picking, providing clean water or preventing erosion.

In the Nordic countries, the right of the commons and strong ownership of the land is complicated by the choice to cut the trees on that land. At the same time, we see that an influx of people coupled with urbanization can lead to alienation from forests and nature. Consequently, this results in a lack of understanding for the same and a fundamental lack of understanding for the importance that forestry has had for the wealth of our Nordic countries.

A lack of understanding leaves room for various interpretations that may be more or less well grounded. It also leaves room for individuals and organisations to have opinions rather than presenting facts which in turn will serve as a seed for germinating myths that will eventually grow into truths. Once a myth has become true it is difficult to question. In a time when alternative facts have become standard, climate change is obvious and forests have the potential to play an even more important role for society it seems prudent to talk about facts rather than opinions based on myths. Of course there are always subjective interpretations behind what we refer to as facts, but as long as they are independently reviewed we have accepted them as reasonable.

So what myths are we talking about? Why are they there and what do the facts tell us about most present-day conditions? That is what this chapter will focus on. This chapter will not focus on other aspects of managing forests, both good and bad, that are not disputed. One such example would be ditching, that has been used to increase productivity but has obvious negative side-effects on downstream water quality. This chapter will not cover all aspects, but will rather try to give insights and food for thought regarding some common misperceptions.

FORESTS CAN'T BE MANAGED SUSTAINABLY?

Quite often it is claimed that forests cannot be managed sustainably. The statement or rather the underlying question is broad and complex. Under this heading we focus only on the basic facts around wood production. All the following statements or myths are highly related and equally relevant to answer the big question on sustainability. It should also be noted that it is not always clear how the term sustainability is or should be defined. With an unclear definition of the key terminology, it is of course impossible to agree or disagree to weather forest are or can be managed sustainably. We will though try to give the reader some facts that should serve as food for thoughts.

Let's go back in time a bit. One hundred and fifty years ago the forest landscape looked very different in most of the Nordic forests. In the south of Sweden forests were basically cut away and heath lands were covering vast areas while further north forest stands had low stocking with few smaller trees. People were talking about the green lines where the forests looked green from a distant but once close one could see there were only few trees in fact. At this time, the end of the 19th century, people started to realize that the forest resource was quickly being depleted, and big plantation projects were started and have since then continued though at a slower pace. Forest laws were created soon after with regulations to safeguard the long term sustainability of the forest resource. In 1923 the National Forest Inventory was initiated in Sweden and the same time era a similar development could be seen in e.g. Finland.

The forest inventories in the Nordic countries are based on long term research at leading research organisations. The research organisations in the Nordic countries rank high in the world. As a consequence we have acquired very good knowledge about the forests, their development and status in the Nordic countries. This basic knowledge on the amount of trees that we have, the growth, health etc. has been used to limit the cuttings so that the growth is always higher than what is being cut. The reporting of the status of the forests to e.g. FAO is not based on the same system as we have, and that is why the figures may not be the same. This is confusing but it is the national forest inventories that can provide the full picture.

With control over harvests, growth and limits to the cutting we now have more forests and trees than we have had in a very long time. In Sweden the standing timber volume has doubled over the last 100 years. The yearly growth has increased from 20-30 million m3 per year to more than 120 million m3 per year. So, from a strict wood production point of view, it seems very possible to have a sustainable forest management. However, this is not the full story...

IT IS BETTER TO LEAVE TREES STANDING, ALSO FOR THE CLIMATE?

Climate change has become politically prioritized due the already evident consequences from the use of fossil carbon and the foreseen effects in the near future. The immediate reduction of carbon emissions in the air is high on the agenda. This can be done in different ways, such as by decreased use of fossil fuels or concrete and by an increased uptake of carbon dioxide by plants such as trees in the forest. It is sometimes said that trees are better in taking up carbon dioxide if left growing and therefore they should not be cut. This is true but only partially. Trees are taking up carbon dioxide when they are growing but once they grow older their potential decreases and eventually trees will die. The picture is complicated by the fact that trees in a forest are growing together and there is a whole ecosystem to consider including other plants, organisms above and below ground, when studying the release and uptake of carbon dioxide to and from the atmosphere. With recent techniques to study the flux of CO2 over forest canopies it can be seen that sometimes the forests take up CO2 and sometimes they release it. It varies also depending on where you are in the world, what kind of soils the forests are growing and when in time they are studied.

The important thing is that to form wood the trees need to take up CO2. If that wood is then used and recycled as long as possible, and at the same time, oil based products are substituted, there would be a positive effect on CO2 emissions and hence the climate. It is also true that managed trees grow faster and will be more efficient in the uptake of CO2 from the atmosphere. To leave trees standing is therefore not always the best thing for the climate. Nonetheless, the system is complex and the management has to be optimized.

Is there an infinite carbon sequestration potential in forests?
Some people seem to have the opinion that there is an infinite carbon sequestration potential in forests. If so, the above is obviously not correct. However, the trees themselves have a limited capacity

to sequester carbon and will only act as a sink while growing. Once trees are on the decline due to age and/or pests and pathogens they start to act as a source instead. In such a case they should preferably have been used to substitute some oil products and leave space for younger trees that are acting as a sink. As indicated above the system is complex and is not only involving the trees themselves but also the other organisms above and below ground. Given certain conditions the above ground biomass is going to be limited by the amount of space, availability of nutrients, water and light. Not even the soils are going to be an infinite sink for CO2 when trees are standing. The system is sooner or later going to reach equilibrium when there will be a balance between release and uptake of CO2. Consequently, it can be good to manage the forests and use the trees to substitute other e.g oil based products. This complexity is evident when unmanaged systems develop a different diversity that enhances the long term storage of carbon in the soils. It therefore seems prudent to keep already old forests with soils able to act as a sink and continue to actively manage the forests that are now growing on land that have been managed for centuries.

WILL THERE ONLY BE MARGINAL EFFECTS ON NORDIC SOCIETIES IF FORESTS ARE LEFT GROWING?

In line with the described myths above, it has been suggested to pause forestry activities and hence the majority of the industrial production dependent on wood from forests. It has been said that the effect on the Nordic countries and its society is marginal and not fundamental for the standard of living and the development of the countries. This statement is interesting but nevertheless hardly based on hard evidence. 2010 the contribution of the forest sectors to the GDP was 4 % in Finland and 3 % in Sweden.

It might seem to be a minor loss to the national economies but would in fact have devastating effects on a lot of people, speed up the urbanization and lead to unforeseeable chain reactions not taken into account in the figures mentioned. In Sweden the forest industries' share of the net export income is huge, at 50-60 %. Sweden is furthermore the third largest exporter of pulp, paper and sawn timber in the world while having less than one percent of the world's forest area. If such a sector would be put on hold for 5-10 years it would have immense difficulties to recover with enormous negative effects on the societies in the Nordic countries.

BIODIVERSITY IS THREATENED BY FORESTRY?

Even if we have more trees and more forests in the Nordic countries than in a long time (several hundred years) forest management is accused of reducing biodiversity. The species information centres in Sweden and Norway can not provide evidence that this is actually the case. Biodiversity is dynamic and what happens is that it is moving and changing. There are only few cases where forest management can be connected to loss of biodiversity, e.g. the wild reindeer. In addition, management is constantly changing and improving as an effect of new information based on scientific findings to provide better methods for producing more of everything. One example of this trend is the amount of dead wood in the forests. Historically, this was seen as a problem but now the increasing amount of dead wood is actually seen as a positive. The effects from changes in management may take time, though. However, it is not correct to claim that forest management and cutting of trees is reducing biodiversity. It may however change it, and perhaps to something we don't want, which should of course be considered.

WHAT IS REALLY THE PROBLEM?

But if all the above myths are not very true or likely to become true, i.e. if forests can be managed sustainably, forests and management of them promote good climate, there is a positive effect on societies and biodiversity is not threatened by forestry – what is the problem?

Some issues, as indicated in the very beginning, are modern urbanized society and the lack of acceptance and understanding, education with its lack of sustainability and students educated in the primary production of fibre from forests, and the lack of proper communication skills in general in the forestry sector.

SOCIETAL SOLUTIONS

In society there is a lack of understanding for and acceptance of the conditions for active forest management. This lack of understanding is of course not only a problem for the urban citizens alienated from nature but also among forestry people who seem to lack the ability to accept the common views of forest management in urban environments and tackle or tactically approach sensitive questions. Not everything is perfectly managed but what this chapter has tried to explain is that things are slowly adjusted to the latest information. Practice is slowly moving in a positive direction, but, everything in the forest this far north take some time. It takes time to grow a forest but it is quick to cut it down. Drastic changes in short time are always tricky to justify and pose a pedagogic problem.

EDUCATIONAL SOLUTIONS

Fewer and fewer students seem interested in studying classic forestry or related subjects. The traditional programs need a drastic make over. They need to be updated to the future both in terms of ability to respond to social and political changes as well as climate changes and advances in pedagogic technologies. Educational programs must be able to attract students at a sustainable level by recruiting from the whole society and not only from male prospects already interested in forestry. Why not explore true cross disciplinary interactions? How often do the forestry students get a chance to study together with architects or physicists, medical doctors or civil engineers? How international are the forestry educations? These are just a few examples of issues that need to be addressed to make forestry curricula attractive again.

COMMUNICATIONAL SOLUTIONS

Communication is an immensely complicated matter. Many of us have very specific expertise and advanced education in something rather technical, but quite often lack the same level of education in communicational skills. There are surprisingly many scientists with poor ability to explain to normal people what their work is about and why it is of public interest. There is a lack of willingness to try to understand the other side's foundation for certain ideas. As long as we lack humbleness to the fact that communication is very complicated there is little chance things will change. With better education in communicational skills at our regular programs and updates in techniques for senior staff there is a chance we will start understanding each other.

The way forward requires political support, innovation and the use of the whole society, reformed educations and improved communication skills. Forests have an underutilized potential where collaboration is key.

Read more (some examples):

Bölscher, T. 2016. Decomposition of soil organic matter under a changing climate. Diss., Uppsala: Sveriges lantbruksuniv., Acta Universitatis agriculturae Sueciae, 1652-6880 ; 2016:85, ISBN 978-91-576-8672-5.
FOREST EUROPE, 2015: State of Europe's Forests 2015.
Grunfelder, J, Rispling, L.and Norlén, G.(eds.) 2016. State of the Nordic Region 20162nd edition July 2016. Nordregio report 2016:1. ISBN 978-91-87295-36-2.
Hadden, D. G. 2017. Processes controlling carbon fluxes in the soil-vegetation-atmosphere system. Diss. Uppsala: Sveriges lantbruksuniv., Acta Universitatis agriculturae Sueciae, 1652-6880 ; 2017:4, ISBN 978-91-576-8781-4
Larsson, A. (red) 2011 Tillståndet i skogen – rödlistade arter i ett nordiskt perspektiv. ArtDatabanken Rapporterar 9. ArtDatabanken SLU, Uppsala.
Swedish Statistical Yearbook of Forestry, 2015.

ECOLOGY, ECONOMY & ENERGY

The three E's of forest production in Denmark

Vivian Kvist Johannsen
forester
Copenhagen University Forestry

ECOLOGY

The Danish Forest Act is based on forest areas being used and managed for multiple purposes: providing growth and health of trees, timber and fuel wood, carbon storage as well as providing basis for work and industry and protecting landscape amenities and cultural heritage, nature conservation and environmental protection. The Danish forests have changed over time from dominating the landscape several thousand years ago, to as little as 2-4 percent 200 years ago and today at 14 percent. The forests today in Denmark are a result of a continuous restoration of forest areas and afforestation during the last 200 years. In this period, many trees have been planted, new genes have been introduced, and native plants have been promoted. The forest area has growing conditions given by soil, climate, and deposition in combination with the mix of tree species and genes of both natural and introduced trees.

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Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

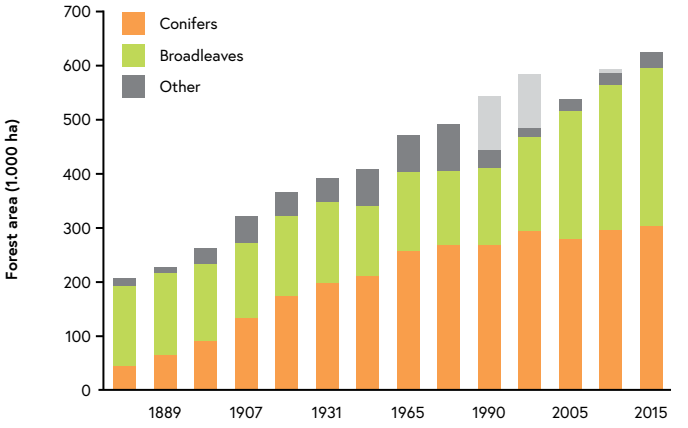
Bruntland 1987

The production and vitality of the Danish forests is the sum of the history and the forest management over time, having effect on current growth, stock and harvest potentials. The structure of the forests also influences the remaining ecology of the forests, the health and stability of the trees, the potentials for protecting ground water, the biological diversity and habitats as well as the recreational aspects of the forest and landscapes. Trees grow in a cycle, as individuals but also as a part of a forest. In the same perspective, harvest is done by single trees, but affects the forests in which the trees come from. The ecology is the core foundation of ensuring forest productivity and stability.

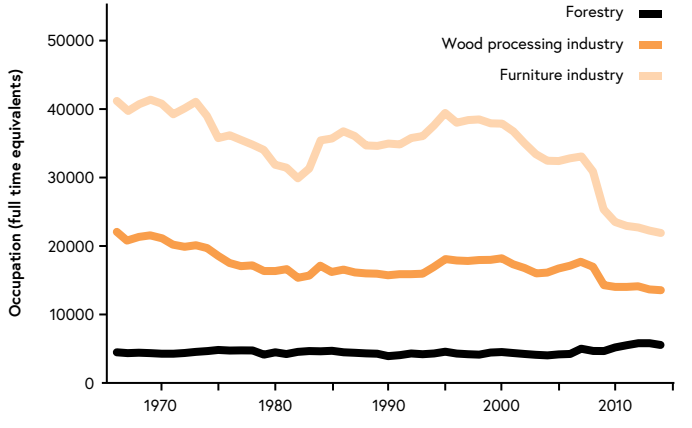
ECONOMY

Forests contribute to the overall economics in the society through direct forestry, as supplier to the wood industry and the paper industry. In the recent decade, the economy and number of jobs in the wood processing and furniture industry have declined in Denmark as a result of the overall financial crisis, while the jobs in the primary production, in the forestry, have remained stable and slightly increased. Recent years indicate an increase in the consumption of wood, in all categories of sawn wood, wood based panels as well as wood for energy, resulting from increasing focus on renewable materials and energy.

Some of the increased use of wood originates from imported wood rather than harvest from the Danish forests. This is a combined result of availability of wood qualities, quantities and prices in conjunction with production and transport costs and options. With Denmark being a small forest country, the international trade and markets highly influence both use and production in the wood based industry. The economics of both the forestry and the related industries give the basis for developing the business cases of production forests in Denmark.



ECOLOGY Development in the forest area distributed to broadleaves, conifers and other. "Other" includes unstocked areas in forests and areas where the species is unknown. Before 2005, the estimates are based on questionnaire surveys. The three hatched areas show the total forest area estimated from satellite imagery in 1990, 2000 and 2011.



ECONOMY Occupation in the forestry sector and associated industry 1966-2014 (Statistikbanken. dk/NABB117: Beskæftigelse og timer (117-gruppering) efter sociookonomisk status og branche).

ENERGY

Wood is produced as a result of the living trees capturing the energy from the sun and storing it in the stem of the tree. When wood is used for buildings or furniture it may substitute other materials with higher energy consumption in the processing phase and in the construction phase such as concrete and steel. This has been documented through multiple studies of full life time analyses.

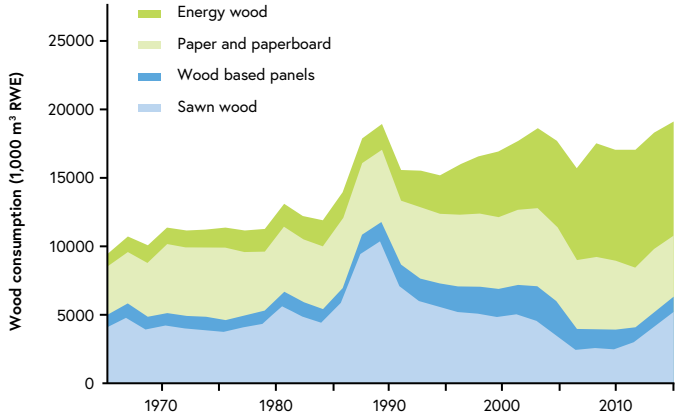
Often wood can be reused/recycled one or more times as different types of products from the sawn wood to wood composites and paper before the fibers finally are utilized for energy by burning. Different energy systems can utilize the energy from wood, with the combined heat and power plants being systems with the highest level of utilization of the energy released by the combustion. New technologies are emerging, utilizing wood in bio-refining processes for a multitude of materials and energy carriers.

The carbon of the energy is a critical element, as it is captured in the wood as long as it is either a living tree or a wood product, but is released to the atmosphere when the wood is burned. The carbon cycle of the wood is, however, very short in time combined with the carbon cycle of fossil sources of energy such as coal or oil, where the time span is many times longer. The use of wood for energy has been a driver for production forestry for many centuries, with fuel wood being one of first products used from the forests, followed by use of wood for a multitude of goods from houses to spoons.

SUMMARY

The Danish forests provide a sustainable production of wood, giving the starting point of the wood value chain in Denmark. The development of the forests in both the short and the long run is important to ensure sufficient amount and a diverse quality and types of wood for the future sustainable use of wood in Denmark. The wood starts as a living tree and can be used for many products and can be reused and recycled before being used for energy.

4Figures from Nord-Larsen, T., Johannsen, V. K., Riis-Nielsen, T., Thomsen, I. M., Suadicani, K., Vesterdal, L., ... Jørgensen, B. B. (2016). Skove og plantager 2015: Forest statistics 2015. Institut for Geovidenskab og Naturforvaltning, Københavns Universitet.



ENERGY Consumption of wood in Denmark distributed to primary wood products and provided in cubic meter raw wood equivalents. The red line illustrates the total consumption of wood without conversion to raw wood equivalents. Sources: Statistics Denmark, FAO-stat, Danish Energy Agency, and Questionnaire on the production in the primary wood processing industry.

WOOD- NATURE'S STROKE OF GENIUS

Wood is the world's most environmentally friendly raw material

Jakob Rygg Klaumann
Danish Timber Federation

Wood is a product of photosynthesis, the chemical reaction that every young person learns about in school. The recipe and ingredients are rather simple: you just mix sunlight, water and atmospheric carbon, CO2. But the output, wood, is so smart. Wood is a natural and renewable material. Wood is the key to a sustainable future.

TACKLE CLIMATE CHANGE – USE WOOD.

There are two ways to reduce CO2 in the atmosphere: either by reducing emissions, or by removing CO2 and storing it. That is: reducing 'carbon sources' and increasing 'carbon sinks'. Wood has the unique ability to do both: It requires very little energy to produce and process wood, so wood can be used to substitute for materials like steel, aluminum, concrete or plastics, which require large amounts of energy to produce.

At the same time wood removes CO2 from the atmosphere and stores it in a product. By using wood, you can lock carbon up in a product, or

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Wood arouses people's feelings, sometimes strong feelings. This is probably because wood activates all of our senses.

in a building. In fact, every cubic meter of wood used as a substitute for other building materials saves the atmosphere from 2 tons of CO_2, through the combined effect of substitution (1,1 t CO_2) and storage (0,9 t CO_2). In addition, wood can be used and re-used, and once wood products are no longer fit for purpose, they can be burned, thereby utilizing their stored solar energy. This replaces the use of coal, oil, and natural gas while resulting in no waste materials.

WOOD FEELINGS

The use of wood arouses people's feelings, sometimes strong feelings. This is probably because wood activates all of our senses.

Wood feels good. It's warmer and softer against the skin than, for instance, metal, stone, and plastic. It is why it is so pleasant to stroke a piece of wood furniture.

Wood sounds good. Concert halls are built from wood because this results in the best acoustics. Wind instruments, guitars, doubles basses, pianos, grand pianos, drums, and xylophones are all made from wood for the same reason.

Wood is beautiful and is available in a variety of colors and grains. Wood smells good, especially when it's fresh. Scents vary widely by species.

Wood tastes good, for instance when wine is matured in oak barrels. The feelings that are associated with wood are sometimes conflicting because when you use wood, you need to fell a tree. And that creates a paradox since most people love wood but hate to fell trees.

THE USE OF WOOD BENEFITS THE FORESTS

Trees are harvested in nearly all forests in Denmark and Europe, which is benefits the forests. Young forest stands need to be thinned for the

remaining trees to reach maturity. Forests are replanted when trees are felled. Using more wood creates a greater incentive for planting new forests and to increase the forested areas. The forest area in Denmark and throughout Europe is growing and has been growing for many years. In 1989 it was politically decided to double the forest area in Denmark within a tree generation. More and more trees are growing in the forests of Denmark and Europe. Over the course of centuries, only a fraction of the forests' annual growth – as measured in cubic meters of wood – is harvested. Sale of wood generates income for forests, making it possible to promote the forests' other values, such as rich flora and fauna. Forests and wood are simply key to the green transition.

WOOD CAN BE CERTIFIED SUSTAINABLE

Forests can be managed to meet the needs of our and future generations- economically, ecologically and socially. Forests can be managed sustainably and we have systems, like PEFC and FSC, in place that can document sustainability and traceability of wood. How many raw materials can actually do that?

Certified wood comes from forests that can document sustainable forestry techniques, for instance the replanting after logging. Not all forests are managed sustainably though. Some parts of the world are challenged with deforestation. On a global scale the forest area is decreasing due to clearing of tropical rainforests, often by simple burning. The primary drivers are often linked to poverty: Forests are transformed into agricultural land used to produce palm oil, beef cattle, soy and maize.

One way of preserving rainforests is to make them more valuable to the local community than the agricultural land in the same area. This will happen if the rest of the world purchases sustainably produced wood from rainforests.

OLD-FASHIONED V INNOVATIVE

Many people have a perception that wood is old-fashioned. Wood is indeed one of the oldest materials known to man, but old-fashioned it is not. We are constantly taking wood to new heights: researching, getting new insights, innovating and pushing the material to its limits – and beyond. Today wood is considered an innovative and extremely versatile material. When you break down the fibers of wood to chemical building blocks, the opportunities are endless and you'll find wood in many unexpected applications:

Wood for smart packaging, healthcare products, bicycle helmets, bicycles, cars, textiles, windmill towers higher than 100m tall, CLT for tall buildings, transparent wood for windows, and wood for asphalt. And this is just the beginning. ANYTHING we can make from oil we can. in fact, make from wood through bio-refinery processes.

WWW.TRAE.DK

As a sector, we strive to communicate better and to capitalize on all the virtues of wood in the creation of a new wood culture. We have a fantastic material between us. Www.trae.dk offers a platform for communication where we can share news and information about the use of wood, share knowledge and best practice and strengthen the network. We need to be consistent and keep telling the same story and using the same arguments forward. Let's work together to change the agenda about how we communicate about wood.

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3D PRINTING IN WOOD

The new concrete?

Nigal Papworth
senior interaction designer
Interactive Institure Swedish ICT

Concrete has been an established, trusted building material since Roman times, while the use of timber has an even older history. These two materials, and the techniques for utilising them, are polar opposites to each other. For example, timber is subtractive in nature, while concrete is additive. Concrete is a fluid, pliable material and thus has no natural form, if not controlled and conditioned by the building contractor. Also, once set, it cannot be reused. Timber can be manipulated in two different ways. Firstly, with professional respect and understanding for the natural form, as in the way trees were picked for specific supporting pieces in the age of oak war ships. Or, as a base material that can be manipulated by standardising its use, for instance, as in plywood forms that can be steamed and bent. It can also be reused when needed.

Along with the humble brick, these two materials dominated the building trade, up until and through the industrial revolution. Their use has remained stable, with small advancements, for most of the history of construction.

As these techniques become established as viable alternatives in the construction process, focus inevitably begins to shift away from the use of environmentally hostile plastics and concrete and turns to wood based materials.

All this is now changing. Recent advancements in additive manufacturing techniques are poised to turn this situation on its head. The combination of computing power and 3D printing has removed the practical barriers that have dictated the rift between the search for standardised simplicity and the desire for customised complexity. This new freedom opens up a world of innovative possibilities for the designer, the architect, the construction engineer and the builder. As these techniques become established as viable alternatives in the construction process, focus inevitably begins to shift away from the use of environmentally hostile plastics and concrete, and turns to wood based materials. The irony in this is that in order to create a viable filament that can be fed into and utilised by a 3D printer, we must throw away practically all of the natural features that make wood such an exemplary building material.

In its natural form, wood is pliable, it has an amazing weight to strength ratio and is aesthetically pleasing to the eye, coming as it does in a wide variety of colours and grain. None of these qualities can be retained if the material is to adapt to current 3D printing techniques, an essential step if it is to be effectively used in such an environment. While at first sight this might seem counter productive, destroying a natural and valuable material to make an unnatural and more flexible material, it is a viable alternative. There is a ready source of wood based materials that have already been robbed of these properties.

Substances such as lignin are left over when, for instance, a material such as viscous is created for the clothing industry. If the right ecologically viable binders can be found then there is a huge potential to create 'earth friendly' printable wood-based substances.

SO WHY TRY TO USE WOOD AT ALL?

The building materials industry is, more and more, about standardisation. Trees, especially in Scandinavia, are being grown to closely match

a standardised target form, the right height and girth, as straight as possible and planted in neatly distributed rows. All this is intended to enable efficient conversion into predetermined lengths of building timber.

This makes sense in a construction world where repeatability and predictability create the basis for commercial viability. However, as we have already stated, 3D printers simply don't know the difference between a simple box form and a highly intricate irregular organic one, or if they know, they don't care. This opens up a huge, new, exciting palette for the creators of tomorrow's building solutions.

Endeavours such as the +Project, based at Umeå University's 'open' innovation centre, Sliperiet, in Northern Sweden, are tackling this challenge head on. Their focus is not just on the potential of the material itself, but very much about looking at how it can be used and the effects this will have on us socially, practically and emotionally. With new forms suddenly being possible and desirable, design research is beginning to tackle, through some startling and surprising techniques, what these new spaces might look like and, above all, why they might look like.

One approach already prototyped by RISE Interactive within the + Project is to use motion capture technology and Virtual Reality tools to allow experts in movement, in this case dancers and choreographers, to redefine what a living space could be. By tracking their exploitation of the space, while performing a series of 'living' tasks, volumetric forms are created along a time line. Further cutting-edge technologies can then be used to interpret this and create tangible 3D forms from the data stream. These, in turn, can be rendered from the virtual to the physical, using readily available 3D printers.

To be clear, these exercises are not intended to short cut the design process of future houses, but should be seen as probes that can help us redefine the language of architecture. With great freedom comes not only great responsibility, but also the potential for great confusion. We have to create a language with which we can make and communicate these new embodiments of living. New approaches and new sensory descriptions of what is both possible and desirable have to be made tangible. All this has the potential to not only affect the visible manifestation of dwellings, but to redefine what we will do within them and how we will do what we will do. It is quite possible that by radically changing the inherent form of our domestic space, we will change the social fabric of the lives that we will live within them. With these new possibilities, the question arises as to what should inform what; should our new social and behavioural desires create the templates for our material framework, or visa versa.

Inevitably, old ideas fade or die, new concepts emerge and evolve. 3D printed buildings are not the stuff of dreams, they are already happening, in adobe, in concrete and in plastic. It is inevitable that our oldest building block, timber, will also adopt to these brave new shapes and meanings…it's just a matter of time.

WHY WOOD MATTERS IN DESIGN

Wood is a material we associate with the natural

Pil Bredahl
Pil Bredahl Design

Wood and the forests are essential for life on earth. Wood is a source of history but also a resource for our future cultures. Man has always found sustenance in trees both physically and spiritually. For millennia, artists have found inspiration and motives in this organic material.

Wood is associated with the natural. We can read the trees' life in its oar and we can count the time it has taken it to grow into a state where we begin to associate it with a useful material. Often wood is not associated with modern. Denmark is known for high quality wood cabinetmaking. Since this remarkable cabinetmaking has been part of what is defined as the Danish-Modern style and Danish design internationally, we must consider wood a material with qualities that can contribute to the definition of the latest ideas in a design context.

Danish-Modern is known as the minimalistic furniture and housewares associated with the Danish- design-movement. Kaare Klint embraced principles of Bauhaus in the 1920s, creating clean lines based on an un-

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Wood might seem a traditional material, but technology has changed the way we use it, our attitudes towards its production, conservation and re-use.

Freja Chair,
Henrik Fredriksen

Leggy Cabinets,
Ditte Hammerstrøm.

derstanding of classical furniture craftsmanship. With designers such as Hans Wegner, Arne Jacobsen and a group of cabinetmakers, Danish furniture thrived from the 40s to the 60s and contributed to the history of design. But wood has always been noticed in the history of design, often objects in wood have either announced a new era or even been the carriers of a new technology of the ideas for the future to come.

Wooden artifacts have created design history, like the Shakers furniture, a distinctive style of furniture developed by the United Society of Believers in Christ's Second Appearing, commonly known as the Shakers. Their beliefs were reflected in the well-made furniture of minimalist designs. The Shakers' dedication to perfection has resulted in a unique range of architecture, furniture and handicraft styles. Shaker craftsmen made most things out of pine or other inexpensive woods and hence their furniture was light in color and weight. Their attitude towards wood as a material, developed in the early 19th-century, still inspires designers around the world today.

The groundbreaking production-model of skilled craftsman Michal Thonets embodies the transition from workshops to factory production. Created in 1859, the No. 14 chair is the most famous chair made by the Thonet chair company. Also known as the Bistro Chair, it was designed by Michael Thonet, using a unique steam-bending technology, known as bentwood, which required years to perfect. With its affordable price and simple design, it became one of the best-selling chairs ever made. The chairs could be mass-produced by unskilled workers and disassembled to save space during transportation, an idea similar to flat pack IKEA furniture.

With the technology and possibility of producing plywood, Finnish architect, Alvar Aalto, was the first to deliberately implement the natural spring effect of the material when creating his "Piamio" in the 1930s. Marcel Breuer created the Long Chair in 1935-1936, and five years later the designers Charles Eames and Eero Saarinen won a furniture design competition in New York with a three-dimensionally shaped wooden shell. In Denmark, Arne Jacobsen made the Ant (chair) in 1952 where the seat and back are self-supporting, connected by a narrow waist. These million-selling classics are still in production today and still defining a part of the design branch that is dedicated to shape giving of everyday objects.

Plywood and other lightweight forms of timber brought wood into line with 20th-century science and technology. Wood might seem a traditional material, but technology has changed the way we use it, and our attitudes towards its production, conservation and re-use. MDF may be synonymous in many people's minds with cheap catalogue items, yet it can be produced in an environmentally sound way and provide affordable, reliable furniture.

Although wood has ancient roots and has been used in every culture in the world from before the Stone Age it is experiencing a revival in use. In part this is because of the newly discovered health and wellbeing benefits of exposure to wood, which produce similar effects to those created by spending time in nature.

Wood has some unique properties compared to most materials in design and architecture. The beauty of wood is that it engages all of our senses being warm, rich and affecting. The surface has a tactile and sensuous strength and the material delights the eye, ear and nose - these are intrinsic values. Wooden structures effortlessly combine aesthetics and strength, thermal protection and environmental benefits to create optimal spaces or objects. With these positive tactile properties and with the immediate understanding of origins, wood appeals to us as an important and valuable material in constructions and design.

That's why wood matters in design.


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WHY WOOD BUILDINGS IN DENMARK?

Mikael Koch
Træinformation

WHY ARE WE SO FAR FROM OUR NEIGHBOR-COUNTRIES, WHEN IT COMES TO BUILDING IN WOOD?

First and foremost, it is rooted in tradition. After World War II, the Marshall Plan help supported use of concrete and steel. Accordingly, Denmark became good at producing cement and concrete as well as concrete element systems. But now we need to break with habit with the intention of a fossil-free society in 2050 – an ambition that requires a better means to achieving this goal.

REDUCTION IN ENERGY CONSUMPTION

As we know the building industry contributes 40% of the total energy consumption in Denmark. Measured over 50 years, 50% goes towards operation and 50% goes towards producing the materials and construction of buildings. Further reduction of energy use for operations is not economically viable. It is a challenge to get below the 2020-targets

if you do not include the VE-production. The 50% that goes into producing materials and construction is a completely unregulated area. But why make the effort if there are no requirements?

TOOLS FOR REDUCING ENVIRONMENTAL IMPACT

In Denmark we have the knowledge and the opportunity to reduce this environmental impact significantly. COWI has recently developed a tool to optimize the use of steel in concrete element, so that the environmental impact of production can be reduced by 40%. Therefore, we can optimize both the way we build and use more materials from renewable sources – even materials that store CO2. The question is- why aren't we already doing it?

VOLUNTARY SUSTAINABILITY CLASSES IN THE BUILDING CODE

One suggestion is to introduce voluntary sustainability classes in the building regulations, where we test and learn from it. Even volunteer sustainability schemes are woefully behind, as today you can

> *I have never seen people walk into a building and hug a steel or concrete column, but I have seen that happen in a wooden building. I have actually seen people touch the wood and I think there is a reason for that- just like snowflakes, no two pieces of wood can ever be the same any place in the world.*
>
> Michael Green 2013

Press for curved glue-lam wood beams. Moelven, Norway

super-optimize all parameters, earning a DGNB Platinum level rating on a conventional concrete element building. Platinum is for so-called Gazelle projects and should, if anything, support optimization of structures.

WASTE IS GENERATED IN THE USE OF CONCRETE

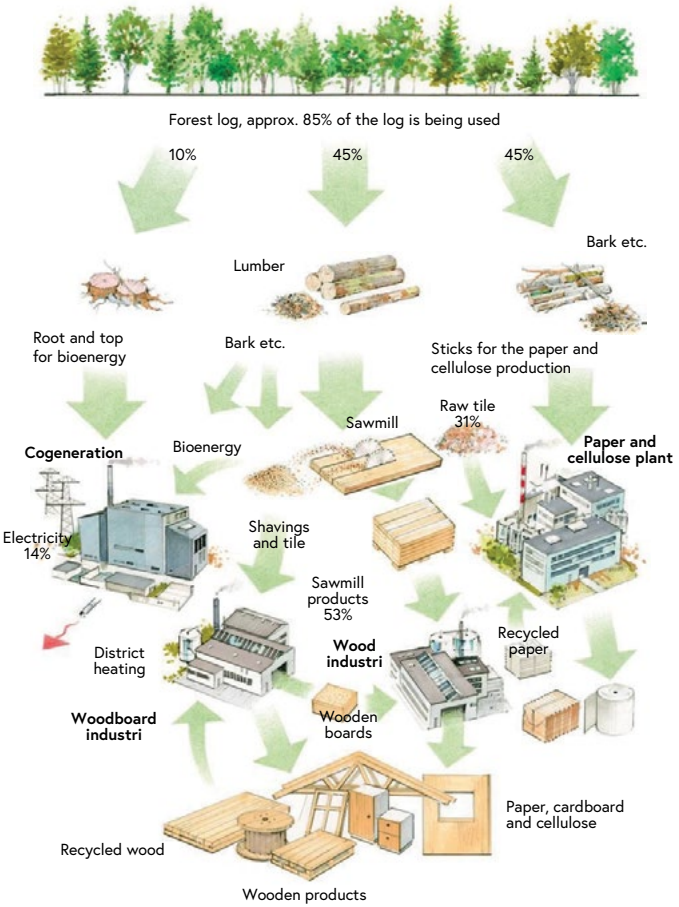
Today's concrete is dimensioned with considerable margins because it is easier than making optimal construction calculations. A large percentage of the concrete is also used for rust protection of the reinforcement steel. Even low three-story buildings are built using concrete while most of the strength required of concrete is used to carry itself.

LARGE ECONOMIC ADVANTAGES IN LIGHT-WEIGHT CONSTRUCTION

Light-weight building for example in wood, requires less foundations, reduced transport and fewer crane lifts and provides substantially quicker build-time. Modern wood systems can be fully industrialized with a high degree of variation. In comparison, it takes a day's work to rebuild a concrete cast if, for example, a window opening requires modification. Concrete is an excellent material for many purposes, especially for infrastructure. But even for infrastructure wood materials are being used for bridges in our neighboring countries because of the large lightweight elements that can be placed over railways without interrupting the train traffic.

LACK OF ENGINEERING MASTER DEGREES IN WOOD CONSTRUCTION

Engineering degrees needs to have more focus on construction optimization and alternative materials. It is unfortunate that there are no engineers being educated in wood construction at a master's level at the Danish Technical University. We are forced to have building curricula that include subjects like sustainability, construction optimization, dimensioning and material choice.



The use of wood varies from country to country, depending on the country's forestry and industry. Of the net outcome from the forest log, approx. 25% become sawmill products, while the rest is used for energy production, paper and cellulose. Illustration: Træinformation

CIRCULAR ECONOMY AND RECYCLING WOOD

The circular economy and recycling of construction waste have started to dominate the agenda. Waste and landfill are physical and easy to observe, and recycled material can be visible with its own aesthetics. But will this aesthetic survive in the long run when the "fashion" changes? Many recognize this agenda and even politicians can spot it. We should take care not to cut corners and believe that just because the material is circular, everything is good and sustainable.

Reusing something 1:1 is sometimes seen as true recycling. If wood is to be reused in a 1:1 relation, then it must be sorted by strength and be CE-marked to be legal, but also so that you can calculate the strength. The wood must be stored dry and there cannot be any old nails or screws, or else tools will be damaged. It must be sorted by dimensions and length and will therefore present a bigger logistical challenge while also making it difficult to make it economically sound. But why does a material have to be reused 1:1 to be acceptable? Because it is easy to understand!

VAPOR MEMBRANE MADE FROM RECYCLED PLASTIC

Another example we have is the vapor membrane, created in a "green version", made from recycled plastic. The data is based on average values, but the raw material of used plastics is so variable that each batch is different, so that all batches ought to be declared individually. This has already led to failure and fracture in these "green" membranes. Is it sustainable that an important component that is very costly to replace, can fail? Perhaps recycled plastics might be better used in other contexts. Does it have to be in the building sector?

CATASTROPHE THAT WOOD IS USED AS A CO2 NEUTRAL FUEL?

The fact is that the average Dane throws out 50 kg of wood each year. Of this, 38 kg are made into chipboards, where the wood is crushed. All metal, screws and nails are sorted and remolded into new CE-marked products. The chipped wood is mixed with 30% new wood, reducing the need for glue, so that boards can be made with half the amount of formaldehyde allowed by environmental standards. These particleboards are used in all IKEA's kitchens, amongst other things. Is this bad? All recycling stations collect used wood but if any of the used wood should end up burned as CO2 neutral fuel - is this a catastrophe? The reality is that half of all the trees felled in Denmark end up directly used as chips in power plants. Let's instead use recycled wood and utilize the wood industry's capability of automatically cutting and sorting wood in the dimensions that are actually in demand. Wood also has the dynamic advantage, unlike most other agricultural products, that although it has the need to be harvested when ripe, it can be saved for when in demand. This is yet another unique selling point of WOOD-inventory control.

THE FUEL VALUE OF WOOD- NOT COUNTED IN THE MINISTRY'S LCA BYG TOOL

In the recycle discussion- it is paramount to distinguish between renewable and non-renewable resources. As such, some materials are more important than others for reuse. Even though we recycle most of our wood waste, it is presumed burned and the burn value is not counted in the LCA-Byg calculations, despite being a CO2-neutral fuel. It is well within reason to allow wood to remain in the building for hundreds of years as CO2 storage, which is a much more effective and economically viable solution, versus artificial CO2 storage- pumping into empty gas reservoirs.

A HOUSE OF WOOD DOES NOT NEED TO BE COVERED IN WOOD

Can wood last for several hundreds of years? Won't it burn or rot and require endless hours of maintenance? This is the normal reaction. Let's look at the Danish cities and suburbs, where all the roofs have been construction from wood for centuries, and where the wood walls also exist. A house does not need to be covered in wood, to be a wood house. Of course, it helps with being sustainable if it is.

ECONOMIC ADVANTAGES

There are many opportunities in main construction for light-weight facades in a wide variety of materials- including brick tiles, slate, and sheet goods. Many wood solutions fit this category and include more species of trees and treatment methods, as well as non-toxic modifications with up to 50 years of durability. For example, the Danish architecture firm Tegnestuen Vandkunsten has made a complete economic calculation of untreated pine covering on one of their projects, where a required year 20 replacement has been included. It is an economical solution that makes sense, and the project will be interesting to follow. Finally, a long lifespan is not always necessary. If the lifespan of a building is assessed as being short, then it needs to be designed for ease of disassembly. Wood is characterized by the fact that it must be assembled, and can therefore also be intentionally designed to be disassembled.

WOOD AND FIRE SAFETY

Fire safety in wood buildings can be solved, and BR 2018 with certified building permits should ensure a knowledgeable and uniform building case management in the future. There exists a widespread myth that you cannot construct wood buildings more than four stories high. This is not the case. Most likely this occurs because the fire examples only include examples up to four stories high. To be certain of an approval of a building more than four floors high, the necessary documentation must be in order. But it is achievable. The course of the fire in wood is very predictable. That there are no sudden static failures is a gradual process. Besides wrapping the constructions, low pressure fog sprinkling is an overlooked solution in Denmark. It is used often in other countries, and is cheaper to install, and uses less water than the conventional methods we use today.

OTHER COUNTRIES BUILD IN WOOD – AND BUILD HIGH

Municipalities abroad are not hesitating to build in wood, and there is an ongoing competition to build the highest structure. Denmark can also participate in this. Building in wood is a very industrialized process, which is comprised of wood box elements up to 6 stories, and if higher, a column girder system in laminated wood or CLT elements can be used. Building with CLT elements is not unlike building with concrete elements, and therefore it will be an easy transition for contractors to adapt to CLT means and methods from that of building in concrete.

ACHIEVE SUSTAINABILITY ON ALL PARAMETERS

So why hesitate? By constructing with wood, we can achieve sustainability on all parameters: financial, social and environmental. Besides all of the above-described factors, wood construction also leads to less transport to the construction site, because the weight of wood is 80% less than concrete. Concrete elements are usually transported on a truck two at a time, but a corresponding truck can carry the timber equivalent of up to 16-meter-long wooden facade elements, that can also be lifted by a smaller crane at the construction site. It is also faster and less noisy to work with wood, because installations happens without drilling, avoiding noise and quartz dust. The high degree of industrialization, less transport and less foundation, as well as shorter construction time, provides a sustainable financial result. Many social housing companies have realized the possibilities and are building with

Signe Wenneberg private residence made from all FSC wood.

wood to a large extent, leading to a rent achievable for lower income groups. Besides, wooden buildings also score high on indoor climate, a tremendous positive social aspect.

HOW TO ACHIEVE THE CLIMATE AGENDA?

The building sector can easily contribute to Denmark reaching its climate goals. There are several solutions available and wood is easy to approach. But it demands that we begin setting limits for how much buildings can impact the environment. The challenge must be solved as part of the bigger picture, and not sector by sector. Therefore, it might not be a wise decision to set demands for recycled materials in construction materials, as per the example with plastic above. Instead we must look at resource cycles in a wider context, and distinguish between renewable resources and final resources. We cannot ignore that sustainability is an overarching approach, and that circular materials are a partial element that must be seen in a wider context, and not just sector by sector.

IS THERE ENOUGH WOOD?

The answer is YES! We just must distinguish between cultivated trees and replanted forestry on land that is unfit for agriculture, in contrast to endangered exotic types of wood and uncontrolled logging. In the Scandinavian countries, the increase in forests is larger than the timber used, and there is a large potential in increasing use. European wood is regulated by EU timber regulations, and large parts are also FSC and PEFC certified. If you buy wood outside of northern Europe, you must look for FSC or PEFC certification.

So let's get this show on the road and start making demands for construction. Træinformation is happy to help and guide.

AFFORDABLE HOUSING DRIVING INNOVATION

Kim Dalgaard
architect
Tegnestuen Vandkunsten

A search for improved quality and sustainability combined with increasing prices and long delays on conventional construction has led Danish social housing companies towards timber construction.

Current timber technology takes off in manifold directions with promises beyond lower costs and shorter erection time. Compared to concrete, wood also provides a cleaner environmental footprint, reduced overall energy consumption, curbing of climate change, a healthier indoor climate and support for circular economy (recycling), as well as seamless integration between BIM and computer aided manufacturing.

This has put the spotlight on timber construction to produce energy efficient and truly affordable housing, which also supports political ambitions to further advance responsible environmental and social values as well as city-central housing for the average civil servant, such as policemen, school teachers and hospital staff.

Lisbjerg Housing

How much does your building weigh? The question can be seen as a measure of the poetic elegance of a lightweight construction as well as a rough measure of the environmental footprint of a building.

- Buckminister Fuller asking Sir Norman Foster

Lisbjerg housing wood floor slab.

The big questions for architects are: can we design good, sustainable and socially cohesive housing schemes at low cost? Do we still believe in 'the good life' for the average middle class worker, as well as for a growing class of 'urban poor', such as unskilled migrants and unemployed? Together with non-profit housing administrator, KAB, Domea and Al2bolig, Vandkunsten Architects are trying to provide positive answers to these challenges, without making claims to final truths.

While the traditional construction industry has not produced many new answers to such contemporary problems, it appears that relevant innovation is happening in the timber industry, which is booming with inventive spirit, excitement, as with the entry era of reinforced concrete 100 years ago.

Incentives to look for new options are further provided in the current building boom. Considerable delays in the pre-fab concrete industry, which dominates the Danish construction sector, make room for alternatives. To show the span and current trends in affordable timber construction we will here introduce three current building cases from the office. All are social housing schemes and display different use of timber .

ALMEN+ MODULAR HOUSING CONCEPT. 5TH GENERATION

The housing concept Almen+ (Non-profit Housing Plus) keeps the rent low by optimizing efficiency and architectural quality. The concept uses traditional light frame timber prefabrication, based on factory-line module assembly.

Each of the new Almen+ concepts are based on evaluation of the former generation, changes to building regulations, new energy requirements, as well as improvements in construction, logistics, architecture and HVAC technology.

The concept is inspired by one of the most popular Danish working-class housing models, 19th century three-story townhouses, a.k.a. 'the potato rows', high-density living with a nice degree of social interaction. The average rent in Almen+ developments is about 23% less than in other, comparable non-profit housing.

This is made possible in part by means of energy optimization - by using durable low-maintenance façade materials, and by replacing traditional but also costly craft methods with pre-fab wood-based units.

The box module construction system is cheaper than conventional concrete structures – and has also cut resource consumption in half.
The three-story homes are simply three modular timber boxes, placed on top of each other, creating a minimum of three rooms plus bathroom.

The homes are delivered partly as empty 'lofts', with few walls, minimal kitchens and without built-in domestic appliances. This to keep building costs low - and allowing DIY residents to exert their own influence on the interior design. The 5th generation Almen+ challenges the basic genericness of 'the box' (which has a tendency to make all rooms look the same) by protruding the ground floor level, creating a better functional hierarchy between living and sleeping areas, and a better overall sunlight distribution.

The newest settlements are mixed with 25-30% 'micro-apartements' (30-45 m2), of one and two rooms, reserved for financially poor inhabitants, but prepared to merge into 90 m2 family units - which is made easy by the light frame construction.
The urban dwelling concept is very popular with long waiting lists. There are currently four new settlements of the 5th generation Almen+ houses under way.

THE THYME GARDEN. AFFORDABLE ROWHOUSES IN SOLID TIMBER.

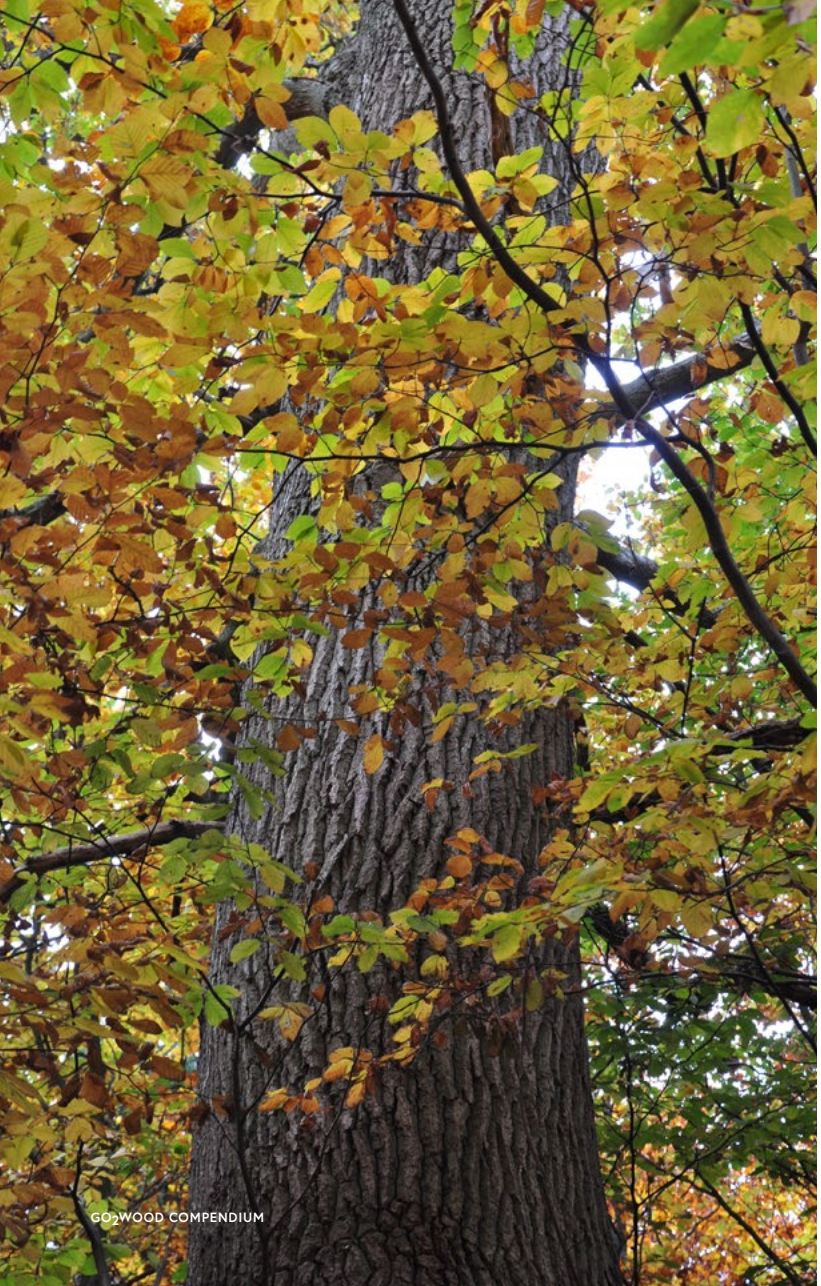
'The Thyme Garden' (Timianhaven) is a simple two-story rowhouse project in greater Copenhagen. The apartments are family units built for the Domea non-profit housing cooperation. Interestingly the decision to use solid CLT-timber construction derives from the contractor. The contractors at Adserballe and Knudsen have stated that they fell for timber's extremely fast and accurate erection, which allows different teams to work simultaneously on the building site, thus saving time and money.

But the contractor also emphasized that the building site 'smells good' compared to a concrete based site and that it is unusually quiet, dust free and clean. The building components can be worked with simple tools: 'two guys and a drill' - bringing greater satisfaction to the workplace. The ambition is to build housing that is as simple and affordable as possible; without vapor barrier, leaving parts of the interior solid timber panels exposed, making the walls breathable, and thereby creating a warmer and healthier interior climate.

THE WOOD STOCK BUILDING SYSTEM.

Buckminster Fuller once asked Norman Foster 'how much does your building weigh?' The question can be seen as a measure of the poetic elegance of a lightweight construction as well as a rough measure of the environmental footprint of a building.

The American writer and ecologist Stewart Brand nuanced this in the book How Buildings Learn (1994), asserting that there exists no correlation between a buildings durability and the use of heavy materials (such as brick, steel or concrete), because building durability is always a function of 'weak links' - and it's inherent adaptability to changing circumstances over the course of its lifespan. Therefore any building should be built with 'shearing layers', separating the struc-



tural layers according to their individual lifecycle.

The Wood Stock building system invented by Vandkunsten Architects and Moe AS, takes its cue from Stewart Brand. This system devises a multi-story building concept for three to eight stories, optimized in terms of weight, but also in regard to adaptability of the primary structure and its connected subsystems, such as facade panels.

The multi-story building is inspired by current trends in hybrid building construction, and consists of 90% timber and approximately 10% of steel and concrete, using each material to its best advantage. This allows for an extremely fast and lightweight building system that is both internally flexible and easily adaptable to future needs, thereby reducing lifetime costs. The building system is put to the test in the Aarhus suburb Lisbjerg where six individual building types are currently erected with a program mix of social housing for students as well as families.

As one of the first housing projects in Denmark, the settlement will be certified in the DGNB system to 'gold standard.' Approximately 50% of certificate points are provided by the environmental credentials of certified timber and the affiliated adaptability and cost-efficiency of the structure.

As a point of notice, both interior and exterior cladding consists of easily replaceable and untreated spruce boards. Untreated wood on the interior will allow the walls to breathe and improve the interior climate. On the exterior the wooden facade is allowed to weather naturally, without any treatment.

Row houses Ørestad Syd

TALL CLT

The building blocks of the FUTURE

Ola Jonsson
architect
C.F. Møller

The Nordic countries have the means to improve the way we design our cities and our approach to the use of available resources. This includes the importance of resourceful design and the way we build to enhance the value chains and lifecycle performance over time. The renaissance and innovation of engineered wood provides architects and city planners with the possibilities to change from a grey to a green building industry. Changing the way we build is part of an evolutionary and innovative approach that is essential within a worldwide movement towards a stronger circular bio-economy. Urban metabolism is a figurative way to describe the development from cities producing CO2 to future cities preserving CO2. The possibility of realizing tall timber buildings highlights an important change in the way we are designing our future.

ENGINEERED WOOD - INNOVATION AND IMAGINATION

The creative processes in which architecture comes into being goes beyond historical and technical knowledge; its focus is the issues of

Hybrid CLT and concrete high rise Västerås, Sweden.

“The vision and ingenuity of architects and engineers today is a response to the challenges and possibilities of our time that include strong urbanization and threatening climate change.

Örnsro Timber Town, Sweden, entirely built from solid timber.

our time. The positive reaction and worldwide interest in the winning proposal for HSB competition in 2013 showed a longing for a new direction. The proposal of a wood skyscraper pushes the physical boundaries of engineered wood and the boundaries of our imagination. Exemplifying the high performance lifecycle qualities of tall wood buildings reveals the potential of engineered wood. Architects and city planners all over the world share the same curiosity of feasible, sustainable solutions. The fascination of tall timber structures is similar to the wonder of early steel skyscrapers of the 20th century. The vision and ingenuity of architects and engineers today is a response to the challenges and possibilities of our time that include strong urbanization and threatening climate change. The race for tall buildings is only the tip of the iceberg. What matters most is the shift from an energy consuming and carbon intensive building industry towards resourceful and carbon sequestration ways of building our future cities.

TALL TIMBER BUILDINGS – MULTIDISCIPLINARY RESEARCH

C.F. Møller is part of a multidisciplinary research project titled "Tall Timber Buildings" in collaboration with researchers from the Linné University in Växjö and RISE, The Swedish Research Institute. The development is a cooperation between representatives from different parts of the field including developers for timber buildings, housing developers and engineers. The research project was granted in 2015 and is financed by the Swedish Research Council, Formas. The aim is to develop feasible concepts for planning and designing timber buildings taller than 20 stories according to present regulations and identify issues that need more research.

The TTB research project studies the HSB jubilee project, a 26 story CLT (Cross laminated wood) building Stockholm designed by C.F. Møller and DinellJohansson. The approach for the research is holistic in exploring the possibilities and challenges of using only engineered wood. The incitement is to force new innovations and refined solu-

tions when pushing timber structure to its limit. The challenge to design buildings taller than 20 stories will create more resourceful ideas and solutions that can also be applicable for small-scale and mid-rise buildings in wood. The investigations cover construction, wind load, compression, connections and installations, fire-, noise-, water- and damp-resistance, durability, LCA, etc. The research has already taught the team that the design of modern buildings demands a new attitude toward design.

Over the last 40 years cars have been designed to survive crashes, but in the last decade cars are instead designed to avoid crashing. Similar to this evolution, buildings of the future should focus on the potential to limit risks of damage and thereby achieving safer buildings for people. The 22 story tall Flat Iron building with a steel frame construction was possible through inventions including elevators and sprinkler system. The Tall Timber research team aims to develop innovations and building techniques that make tall wooden buildings durable and safe.

RESOURCEFUL DESIGN AND SMART HYBRIDS

Engineered wood provides architects with new design possibilities that include high precision, lightness, acoustic qualities and parametric design solutions. Wood is a renewable building material with proven advantages for health and the environment. Timber provides a large variety of products and options along the value chain within a regenerative design. Refined wood for buildings is both tactile and aesthetic, and each component comes with a fingerprint, not a footprint. Tall timber buildings add another layer to the value chain, stretching the peripheries in the overall cradle to a cradle of wood. The word of the future is "resourceful" and the best building materials are the materials never used at all.

The future includes smart hybrids with the aim to reach valuable synergies that optimize our use of resources. Resourceful hybrids include using the most suitable materials and combinations, taking in consideration a complete sustainable screening and lifecycle perspective. C.F. Møller recently won a competition for a tall hybrid building in Västerås, Sweden. One third of the volume of the building is constructed of CLT and two thirds are made from concrete. The synergy between the two components results in a balanced carbon footprint. Investigations show that in order to produce one cubic meter of concrete approximately 700 kg CO2 (Svensk betong) is released into the air, one cubic meter of wood absorbs approximately 900 kg of CO2 (Svenskt trä) during its growth. The top seven floors are designed with CLT, which reduce weight and reduce the volume of the load bearing concrete base.

URBAN CONTEXT - BUILDING FUTURE CITIES

Another project by C.F. Møller is "Örnsro Timber Town", a visionary residential quarter in Örebro including tall and midrise buildings entirely built from solid timber. The winning proposal in the competition from 2016 includes a generous integrated landscape design. The buildings are 4 to 11 stories tall, shaped to enhance urban and social qualities. In the city of Norrtälje C.F. Møller are developing three city blocks including 30.000 s.q.m. including more than 450 housing units. The project will be one of the worlds largest housing project made in CLT, with a positive lifecycle performance that shows the positive environmental impact of solid timber.

C.F. MØLLER ARCHITECTS

C.F. Møller is an international architectural practice with quality design based on experience and innovation. Tall wood buildings are already part of our city skylines and we are determined to continue our commitment to open-source research and develop sustainable and resilient solutions for the future.

THE CLIMATE CASE FOR COPENHAGEN 2025

With structures in WOOD

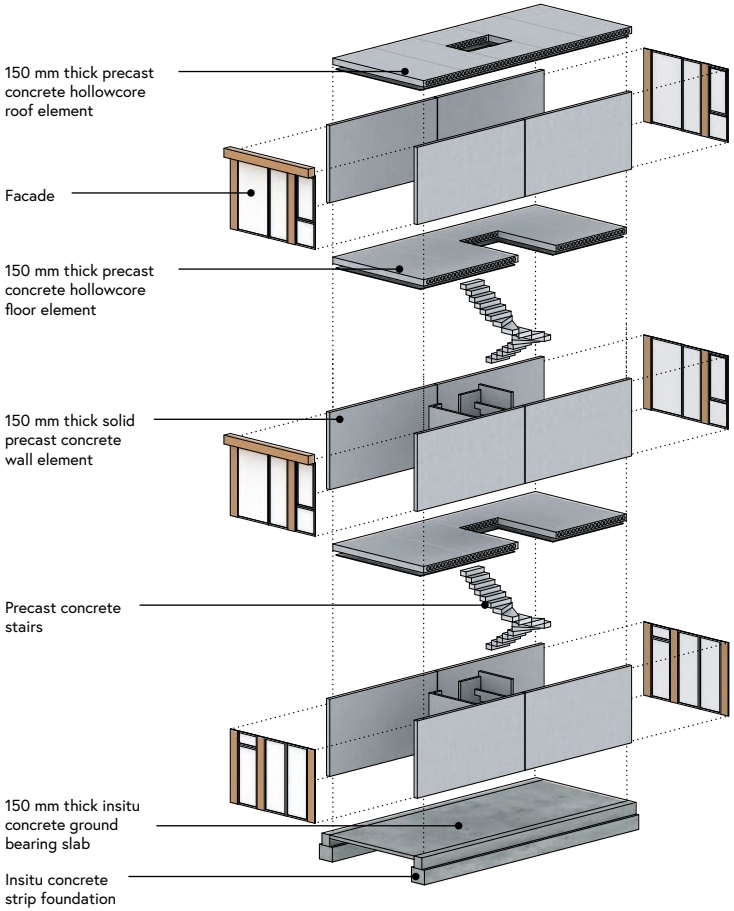
Duncan Horswill
engineer
BIG Engineering

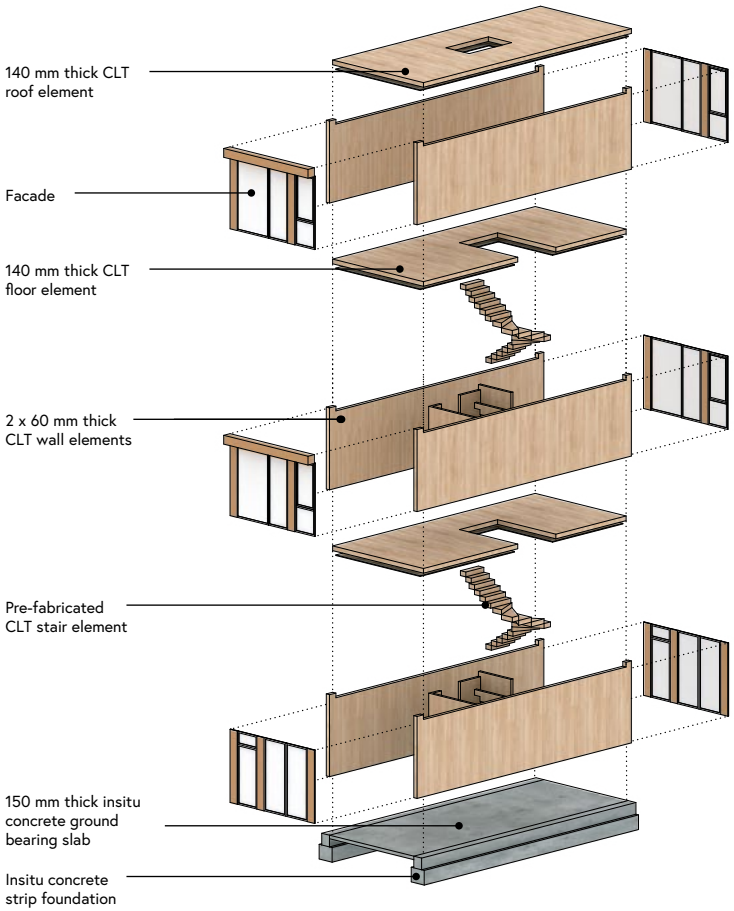
Today, our planet is experiencing an environmental crisis. We mine the Earth's natural resources for minerals which we process into materials and in doing so consume vast amounts of water and energy. This process produces gases which are slowly heating up the planet, raising water levels and turning our seas acidic. Natural habitats on land and sea are being destroyed and animal species wiped out. The construction industry has a significant role to play in this process. According to the UN Environment Programme, buildings use 40% of global energy, 25% of global water and 40% of global resources. Furthermore, they produce one third of greenhouse gases.

Climate change and the increasing migration of people away from the country and towards cities are two of a number of global megatrends which are challenging our political leaders around the world today.

In 2009, Copenhagen made a commitment to be carbon neutral by 2025 and, if successful, it would be the first carbon neutral city in the

The wood advantage. Carbon calculator- concrete (+)12 tons produced, wood (-)17 tons extracted.





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Putting this into the context of the climate plan, we can see that if only 1 in 6 new residential buildings were to be built using CLT construction, the saving in CO_2 would be approximately equivalent to the contribution from solar cells.

world. To quantify this ambition, Københavns Kommune published a document entitled 'CPH 2025 Climate Plan'. This describes the various initiatives the city hopes to implement over the coming years in order to save the 1.2 million tons of carbon per year required to become carbon neutral by 2025.

According to the report, the large majority of the carbon savings are expected to come from the ways that we produce and consume energy. For example, nearly 400,000 tons per year will be saved by using wind turbines. A similar amount will come from using biomass. Smaller contributions will be made by encouraging more people to use their bikes and public transportation or to use green fuels for private transportation.

Many of these initiatives are already manifest in the city. For example, as a visitor approaches the city by air, it is easy to spot the wind turbines in the harbour. They might also see the 1400 solar panels which sit on top of the UN building in Nordhavn. As they travel north to the city center from the airport, they might pass the Amager Bakke Resource Centre which will turn 400,000 tons of the cities' waste into hot water and energy each year. As they approach the city center they will notice the large concentration of cyclists who commute to and from work by bike – either their own or one of the 2,000 city bikes which are widely available.

At the same time as making this environmental commitment, Copenhagen is also experiencing a boom in building activity – especially in the residential sector. According to Københavns Kommune, the city is expected to receive 110,000 new residents by 2025 demanding the construction of 45,000 new residential units. However, the CPH 2025 Climate Plan does not refer to the effects that different construction systems might have on achieving carbon neutrality.

Since the end of the Second World War, Denmark has invested in the development of pre-cast concrete elements for the construction of much of its housing stock. This was a result of financial aid from the US to help rebuild Europe's bombed urban infrastructure combined with a local supply of sand, cement and aggregate. Today, pre-cast concrete makes up an estimated 80% of the construction market and is considered a dominant industry.

Timber is a natural construction material and is used in many parts of the world for various building structures. Cross-laminated timber (CLT) is an example of engineered timber in which small individual timber elements are glued together to form large-format timber elements with specific engineering properties. Over the past 20 years, CLT construction has grown in popularity, especially for residential building, to the point where it is being used in many parts of Europe, the UK, the US, Canada and Australia.

Concrete uses large quantities of non-renewable resources, water, and energy in its manufacture whereas timber has a far more sustain-

able profile. It is the only construction material grown by the sun and can be considered renewable if harvested from managed forests. As it grows, a tree will absorb carbon dioxide and release oxygen. When the tree is harvested, and used for construction, that carbon is locked away in the buildings' fabric. At the same time a new tree is planted which absorbs more carbon dioxide. This process is known as carbon sequestration.

In order to quantify the benefits of CLT construction over pre-cast concrete construction with regard to carbon, a parallel design study was carried out on a typical three story residential building near Copenhagen. The building would typically be designed with pre-cast concrete floors and roof spanning between pre-cast concrete walls. In terms of structural principles, CLT elements are very similar in nature to pre-cast concrete elements therefore, to develop the CLT scheme, the pre-cast elements were simply replaced with CLT elements.

In order to assess the amount of carbon associated with each solution, a carbon calculator was developed. This tool quantified the amount of carbon produced by each material at each stage in its life – rom cradle to grave – by combining Environmental Product Declaration (EPD) data with material volumes derived from the structural schemes. The results of this assessment showed that for a typical 115 m2 apartment, pre-cast concrete produced over 12 tons of carbon whilst CLT saved over 17 tons of carbon. In other words, that is 17 tons of carbon extracted from the atmosphere and locked away in the fabric of the building whilst the harvested trees are replaced with young trees which continue to extract CO2. This is enough to offset the CO2 emissions produced by six average cars per year.

Putting this into the context of the climate plan, we can see that if only 1 in 6 new residential buildings were to be built using CLT construction, the saving in CO2 would be approximately equivalent to the contribution from solar cells. Furthermore, the use of timber would mark a significant milestone in the development of Denmark's construction industry from one that uses natural resources to one that supports the world's environmental goals.

The work for this research was carried out during my tenure at Søren Jensen Rådgivende Ingeniørfirma. It is my ambition to continue to develop this work and apply it to new opportunities in my new role at BIG.

Gammel Hellerup Gymnasium

NCC EXPERIMENTS WITH WOOD

Dome of Visions

Vibeke Grupe Larsen
Head of Sustainability
NCC Building Denmark

When we built the first dome on Krøyers Plads in Copenhagen back in 2013, we called the building an experiment in scale 1:1. The same is true today, where a 3.0 version of the dome can be found at Pier 2 on the harbour front of Aarhus, right next to one of the most ambitious city development projects in Scandinavia, Aarhus Ø. Dome of Visions on the harbour front is NCC's contribution to the debate over wood as the building material of the future and at the same time, it is our tribute to the use of wood in construction.

LIGHT WEIGHT AND SLENDER

The stature of the dome makes it possible to experiment with both the structure of the building as well as with the use of materials. Consequently, the materials used to construct the dome have been chosen from a desire to use as little steel as possible.

The architect of the dome, Kristoffer Tejlgaard, developed a design

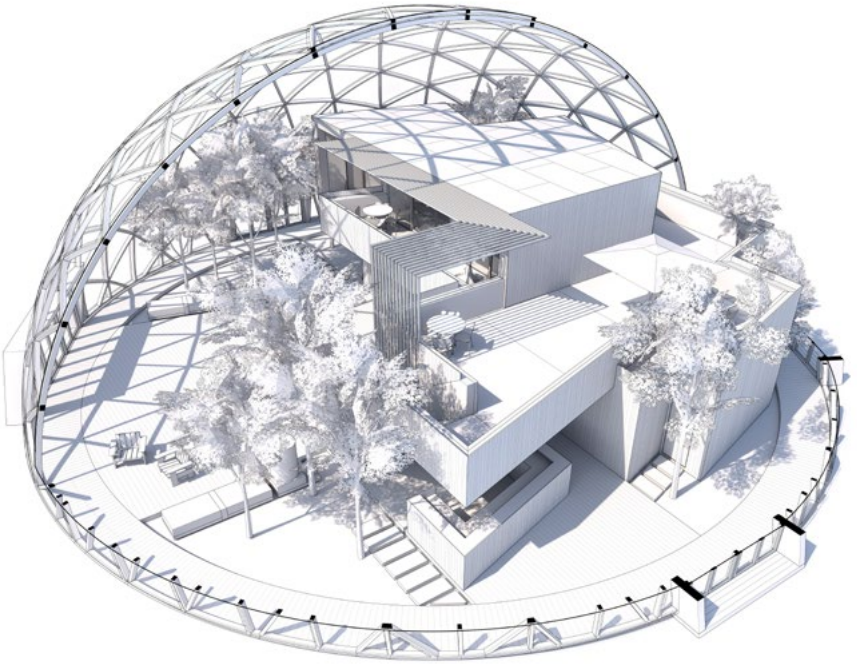
Dome of Visions, Aarhus

that makes the skeleton of the dome both light weight and slender. Curved laminated veneer lumber (LVL) is used for the beams that are joined in nodes consisting of five millimetre steel sheet. The wall plate consists of six large, curved glue-laminated components that shape the circular base of the building. The doors are made of waste wood treated with linseed oil. The wooden house inside the dome is built from CLT (Cross Laminated Timber), where the dimensions of the timber plate have been fully utilized. For instance the house has been designed to fit the maximum load of a 16x3 meter CLT-plate, and the house exploits the potential span of the plate 100 pct. FSC-certified wood has been chosen for the entire building, because this certification system ensures that the wood comes from well-managed forests and/or recycled materials.

PREFABRICATION

We chose to work with CLT, Cross Laminated Timber, mainly because of its potential use in modern-day pre-fabricated construction. CLT components can be prefabricated, which can speed up construction practices or allow for off-site construction. Unlike concrete, timber structures can be joined with screws and bolts, which is a fast way of stabilising a building. Wood also has the advantage of being a very dry material, which helps minimise waiting periods at the construction site e.g. for concrete drying time. Prefabrication also means a more orderly construction site, because much of the preparatory work has been carried out off-site, such as or in engineering workshops or in plant sites, before the elements are transported to the construction site.The entire structure of Dome of Visions has the advantage that all CLT-components can be disassembled, moved to a different location and re-erected again- paving the way for more flexible construction. There are strong indications that CLT is a material well suited for recycling into chipboards, wood fibre insulation, MDF and many other things. This is something that we will study further.

> *On a very pragmatic level wood weighs a lot less than concrete. This paves the way for new kinds of foundations, which means that construction cranes can be designed and built with a diminished lifting capacity compared to the current need.*



CO2

As new constructions in Denmark are becoming more and more energy efficient, the construction industry is focusing on other areas where a conscious effort can benefit the environment. Previously the day-to-day operations accounted for 80 pct. of total energy consumption of our buildings. Thanks to energy efficiency, the equation looks completely different today, and when it comes to the construction industry, most of the CO2 emission today comes from the energy being used for manufacturing and processing building materials.

From this viewpoint the use of wood in construction is very interesting, because such a development could lead to a number of immediate environmental advantages. Wood binds carbon dioxide and contributes to the absorption of greenhouse gases. Furthermore, the production and use of wood components is easier on the environment than any other building material. It takes less fossil fuels and less energy to produce wood products than alternative materials such as steel, concrete and building bricks. So using wood as a construction material will lead to lower CO2-emissions in the production phase.

In overall terms there is general consensus of the environmental advantages of using wood in construction – not least based on numerous life cycle analysis and other research. On a very pragmatic level wood weighs a lot less than concrete. This paves the way for new kinds of foundations, which means that construction cranes can be designed and built with a diminished lifting capacity compared to the current need. In itself the amount of wood used in the dome weighs about 83 metric tons and binds 124.5 metric tons of CO2.

THE AGENDA

In NCC we have an unerring eye for what the surrounding world expects of a company that assigns as high a priority to sustainability, circular economy and design for assembly, as we do.

NCC's understanding of the concept of sustainability is based on Brundtlands three pillars: environmental-, economical- and social sustainability. NCC has two ambitions within the area of environmental sustainability: We are climate neutral. We close the loop.

NCC will reach these goals by focusing on optimizing the use of resources in the construction industry, both in terms of consumption of energy as well as material use. This means that we will perfect our knowledge of using components that are either recycled or recyclable.

The use of CLT makes it possible to design with the intention of making the wooden construction relatively easy to disassemble with the intention of re-erecting it again later on - circular thinking 1:1. By incorporating sustainability at a very early stage in the design process, we have the opportunity as a leading construction company to influence the agenda and inspire innovation.

WORKING ACROSS BUSINESSES

NCC is very concerned about constructing (and refurbishing) buildings without leaving a big carbon footprint. Knowledge about materials and recycling possibilities is crucial, and calls for the entire construction industry to work together and share each other's experiences. In an overall perspective we need to ensure desirable framework conditions in order to use our resources as effective as possible.

We need to show where we can build bridges between different interests. The objective is to ensure a green and more sustainable development for our society. Dome of Visions is an example of how, in a scale of 1:1, we can think green, be innovative and cross disciplinary.

LEA

RN

WOODWORKING DEFINES WHO WE ARE

The tree

David Rangan
carpenter
faculty at NEXT Copenhagen

Like us, the tree is a natural part of the life that covers the surface of the earth. The planet from which we spend our lives has arisen from organic life, and we are a part of this organic evolution, not unlike trees.

The tree came before us and from the start we have received much from our relationship with trees. We have sought shade when it was too hot, climbed up in trees when we wanted to see far and to pluck its fruit. Later we learned to make tools from its strong branches and fire if the branches were dry. Before television and the internet, we might have been spending the evening looking at our surroundings, leaning our back against a tree. We might have seen how its branches stretched up towards the stars, pondering our place in the universe. Later we learned to build houses of the timber the trees provided. We also have come to understand that forests provide the very air we breathe. Without a doubt, air is our most valuable element to life.

As of late, we have been very busy with all the technologies we have

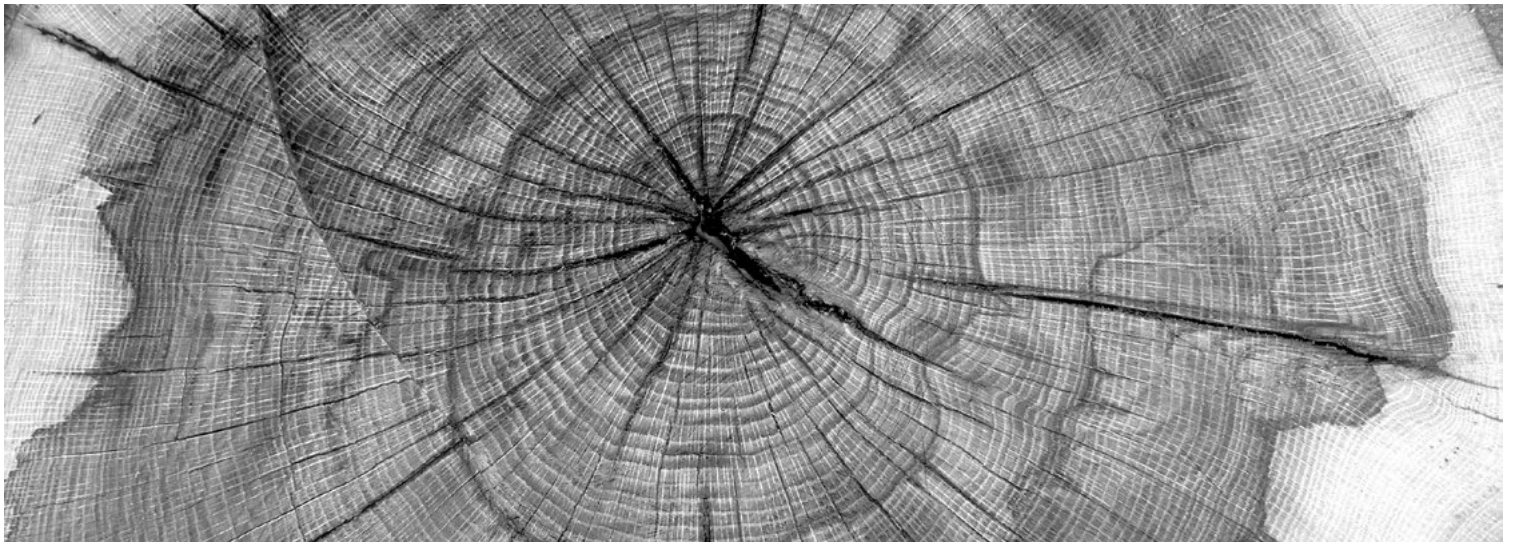
When I went from being a carpenter in practice to become a teacher of carpentry, I realized just how much embedded knowledge my hands, arms and my entire body had about cutting after a line with a saw.

discovered. In the future, the stories we tell will be about these technological inventions. Nevertheless, in the times we live in now, the stories that are passed on to us, seem to involve nature as an important part. Trees might have holes that we crawl into and experience other wondrous worlds.

Trees have special meanings to different cultures around the world. The tree of life is a central symbol among the Native American people, also with the Yggdrasil here in the Nordic countries. In the Hebrew tradition, there is the tree of wisdom- in India it's a sign of water. Trees are a living part of our culture in such a way that when you ask a child to draw a house, they will usually draw a tree next to the house. As we study our society and the way we live, we refer to culture. We describe culture as the contents of codes that embody the way we do things. Symbolically, how do we comprehend our connection within our surroundings? Of these cultural codes, some are more fundamental and have been with us longer than others.

One of the most fundamental codes is the tree. It tells us of the changing seasons and how it affects life for all of us on the planet. When one builds with wood, we learn that the layer that grows in summer is soft and flexible. The layer that grows in the winter gives wood its strength and hardness. We discover that one cannot do without the other.

When we consider these cultural codes, the doctrine not only relates to the tree itself, but we also recognize ourselves in it. The tree strives to keep a foothold with its roots well-grounded in the soil while simultaneously stretching its branches and twigs as far as possible towards sky. As humans, we are reminded of things we do not understand, hoping to get a small grasp of the great mysteries.



THE STATE OF CRAFTSMANSHIP

As a society, we propose new ideas in the direction we need to develop. In this regard, research has an important role. In research, we examine our lives, our surroundings and forge new pathways. In this manner, we adapt and teach one another. This is the essence of education. Education and research are closely tied together. What both disciplines have in common is that they transform a change that moves things forward. We describe the change as "learning" when it is at the individual or social level and "development" when it defines structures in our society.

In the field of carpentry, which tools do we use in this transformation? Mostly we use both our spoken and written language. Thereby it's mainly through linguistic forms that we research and develop our society. This is perhaps one of the reasons that craftsman education stops at the apprenticeship and the development of the craft is mainly driven by innovation that is within the manufacturer's range of materials.

When I went from being a carpenter in practice to becoming a teacher of carpentry, I realized just how much embedded knowledge my hands, arms and my entire body had about cutting after a line with a saw. From years and countless hours of wood working, I instinctually knew the sound of a well-seasoned piece of wood as it came in contact with a well-sharpen saw. I could distinguish wood of different qualities with my nose. The saw in my hand, I could cut after the markup I had drawn and lovingly respond to each piece of wood peculiarities such as knots, checks, cracks and beveled edges. Somehow this knowledge I had, I just could not explain why or how.

This special knowledge relating to sawing was what we describe as tacit knowledge. In the classrooms of the next generation of sprouting carpenters, I could not tell them how to do it. I could not write it for them in the curriculum. All I could offer was to show it to them and hope they caught it, or it caught them. Over the next few years as a teacher, I slowly developed a language that could support my body's silent instructions concerning cutting after a markup with a saw. By using my voice, I could direct the attention of my students cutting instruction, to the relevant topics of my act.

Today, I reflect on my many years in the traditional craft of carpentry. I find myself as a trusted keeper of the craft, as the modern world evolves past me and carpentry. Engineers develop new materials and methods. Medical science is finding new ways to cure disease. I see space science develop ways in which we can get to Mars and stay there. However, with all the wonders of these innovations, craft science is not developing. Such a phenomenon is nearly non-existent.

There are no master candidate programs today, no one is writing a dissertation in carpentry professional development. Perhaps this is because the craft is inherent to both the body and the mind. For the development of the craft of carpentry relates to skills that we have in the body, and which unfolds on the other side of the language. It's a form of knowledge that is beyond our strong linguistic research traditions that develop society. In present day terms, craftsmanship is not in tune with the development of society, but has over the past century been more shaped by the technical developments taking place within tool-engineering and the development of increasingly synthetic and energy-intensive materials.

An example of true craftsmanship is the Copenhagen kitchen staircase, one of my most rewarding teaching segments. In it, the students learn how to build the staircase with 5-7 treads that wind around a square corner. The steps have the same height and where the foot enters, the step length will be the same otherwise the person will stumble. All the steps are tapered to both fit in the room size and the staircase center. This is done with few calculations, but a lot of mathematical relationships that are built into the markup technique.

The Copenhagen kitchen stair is a winder stair and is cut and planed in advance so when carpenters sample them, they fit not only into the very narrow high shaft, but all the sloping steps and the curved beams in a manner adapted to suit individual for each story floor level. Amazing.

I often have wondered how this craft technique was invented? It is a technique without much language and very little calculation, but it manages to create contexts in woodworking which, to me, appears equal to a brilliant scientists' invention. This is the height of true art. I ask this question every time I teach staircase building, all the while I marvel at the craft and art. Every time I carry down the trash on a Copenhagen kitchen staircase, I marvel at its ease of use and simplicity of idea.

I could stop here at the joy of this and other genius craft techniques that until now have been discovered and has become a part of the thousands of years old carpenter craft tradition. But I am also curious about all the craft techniques that have yet to be invented. I believe that there is potential in exploring the crafts to develop in the same way as we explore medical science and space travel. We should be able to further educate society in the craft of carpentry. Perhaps craft schools not only teach the doing, but also research. The question is an extension of mine and other craftsperson's curiosity of their crafts' capacity as a development potential.

A promising step in the direction of the development of the craft, is the new initiative of the Danish Ministry of Education and Research to create a national knowledge center for crafts and design, for which NEXT Copenhagen may perhaps be able to house the center. Also mentionable is the center for building conservation (Raadvad) that over the time has preserved ancient craft techniques. Although there are great initiatives, we have created a society that's managed to separate the logical and rational abilities inherent in the language from the rest of all the qualities we hold as humans, and to attribute language skills more value than others. As I write this article, I see our craft- what we can create with our hands- is left behind when we move on with society.

MOVING WOOD EDUCATION FORWARD

In wood education, it is important to remember that wood is not merely a plant, nor only a building material. Wood is an aspect of defining who we are. It is a basic cultural symbolic form, representing not just our connection with nature, but also embodying the development we have made as a species and is an important part of our culture's DNA. Likewise, it is important when planning for future wood education to remember that woodwork is not a form of knowledge you read in a book or a scientific report. Wood artisanship is something we do. It contains a bodily-anchored knowledge that expresses itself through our own body's interaction with its surroundings.

There is a great need for targeted development of wood education. At present we have a poor breeding ground in our linguistic research practice. There is a need to develop artisanal research methods, which count tacit knowledge and interdisciplinary cooperation. One example is the cooperative project that my co-author Jens Kjartan Mortensen is in the process of developing. This project isbetween design students and apprentices from NEXT Copenhagen in the Danish "Skud på stammen", and is a cooperation between the Royal Architect School, the carpentry students. Woodwork is an embodied cultural action. Keeping wood education alive is an important part of the cultural remembrance of who we are.

BIBLIOGRAPHY
Austring, Bennye D & Sørensen, Merete(2006) : Æstetisk og læring-Grundbog I æstetiske læringsprocesser, Hans Reitzels Forlag
Erhvervsskolernes forlag (2009) 3.udgave,Trapper. Erhvervsskolernes forlag
Illeris, K. (2015). Læring I konkurrencestaten- Kapløb eller bæredygtighed. Samfundslitteratur.
Merleau-Ponty, Maurice (2009). Kroppens fænomenologi
Sennett, Richard (2009) ; Håndværkeren, Forlaget Hovedland.
The Holy Bible, The national bible society of Scotland
Thøgersen, Ulla (2004). Krop og fænomenologi
Træinformation: http://www.traeinfo.dk/ set 27-03-2017
Tzu, Lao (2000): Tao Te Ching, Aschenhoug Dansk Forlag.
UN. (2016). Harmony with Natur. United Nation
Argyris, Chris; Putnam, Robert; Smith, Diana McLain (1985). Action Science: Concepts, Methods and Skills for Research and Intervention

CREATIVE RESISTANCE

What wood teaches us

Karen MacLean
founder
Green Free School

At the Green Free School we love learning tools and activities that multitask. We like it when an activity teaches more than one thing at once. That's why we love working with wood; it is the ultimate multitasking learning material.

So what does wood teach us? Well, first of all, it teaches us how to wield the tools of the trade, from saws and hammers – the ones we all know – to jigsaws, planes, chisels and mallets, various rasps and files and grades of sandpaper. What an incredible diversity of functions these tools represent and what a wide array of ways to shape wooden reality!

This kind of knowledge is useful but underrated by many parents and others in the teaching community. These skills are taken for granted by earlier generations who picked them up from hanging out with grandpa or from woodworking classes, back when these were actually taught in school. It's the stuff that comes in handy for the rest of one's life. Or the stuff one misses for the rest of one's life, if one hasn't learned it.

NOT EVERYTHING IN LIFE COMES PACKAGED BY IKEA.

Not coincidentally, learning to wield these tools with skill is good for the brain. We know that fine motor work supports cognitive skills often viewed as unrelated, such as reading. But there is little acknowledgment that cognitive skills can be continuously supported and further developed – even after the basic ability to read has been achieved, for example. Working with wood is one way to do this. There is a fine-tuned feedback loop between motor and cognitive development and it doesn't stop at a certain age or stage.

BUT WHY CHOOSE WOOD OVER BEAD PLATES, SAY, OR LEGO?

The first reason is that working with wood strengthens kids' ability to plan and design. Some years ago, one of our teachers picked up a truckload of wood scraps from a construction site, and for a couple of weeks, all the kids at our school hammered and sawed and had a wonderful time. My daughter, who was eight at the time, came home

> *Having a picture of something in your mind's eye – something you really want to make, to solve a problem you experience or to serve a function you personally see a need for, manipulating materials to create that something, and checking back and forth between your internal idea and external reality. That process is the prototype of planning and design.*

with a strange assortment of nailed-together boards, and explained that these were furniture for her dolls. She proudly showed off the bed, the table, the stairs to the basement, the highchair, etc. Now these objects showed little resemblance to objects in the real world; they were clearly receiving a powerful assist from her imagination. But conceiving of them – I want to build a bed for my doll – selecting the pieces and putting them together was a first, entirely self-directed object lesson in planning and design.

Having a picture of something in your mind's eye – something you really want to make, to solve a problem you experience or to serve a function you personally see a need for, manipulating materials to create that something, and checking back and forth between your internal idea and external reality; that process is the prototype of planning and design.

It is important for children to experience this process in the physical realm, preferably many, many times. Later on, when they turn their interest to planning or designing non-material projects – such as an essay, for example – the cognitive work is the same. This is the project I intend to produce, this is the external reality I've managed to get down on paper or on the screen, and I check back and forth between the two, adjusting the force of my rhetorical tools the way I would adjust the pressure I apply to the plane. I can't stress enough the importance of children experiencing and learning such processes materially, with their hands and their eyes in real life, in preparation for executing them in the abstract later.

Lastly, working with wood develops children's will power and their patience and perseverance. Wood offers up a unique creative resistance that is of increasing importance today. Children need to experience the resistance of the world to their efforts to shape it, and they need to develop internal characteristics such as perseverance and patience to assist them in exerting their will on that external world.

Children today experience lots of resistance; at no time in history have children been as restricted as school children in the first world are today. Because that restriction is often diffuse and difficult to counter, children have few opportunities to develop their willpower. Many children experience great release and comfort in playing virtual games, because exerting their will on the obstacles in the game is so effortless and successful. But these games do not adequately develop children's will nor their perseverance and patience for use in tangible, real-life situations.

Working with wood develops children's will. The process of creating a useful or pleasing object out of wood offers children the opportunity for a unique sort of collaboration. The wood offers up an organic resistance to the creative efforts of the young craftsperson. Its hardness or dryness, the direction of the grain, the variation in hardness that comes with the variation in the grain; these characteristics offer a wide array of resistance to the process of turning a block of wood into an artifact.

Striving to impose their will on a piece of wood develops children's persistence and patience. There is no shortcut to the roundedness of a bowl, or the silkiness you want to feel as you rub your fingers over the wood. If it doesn't look or feel the way it should – the way you want it to – it's back to chiseling or sanding.

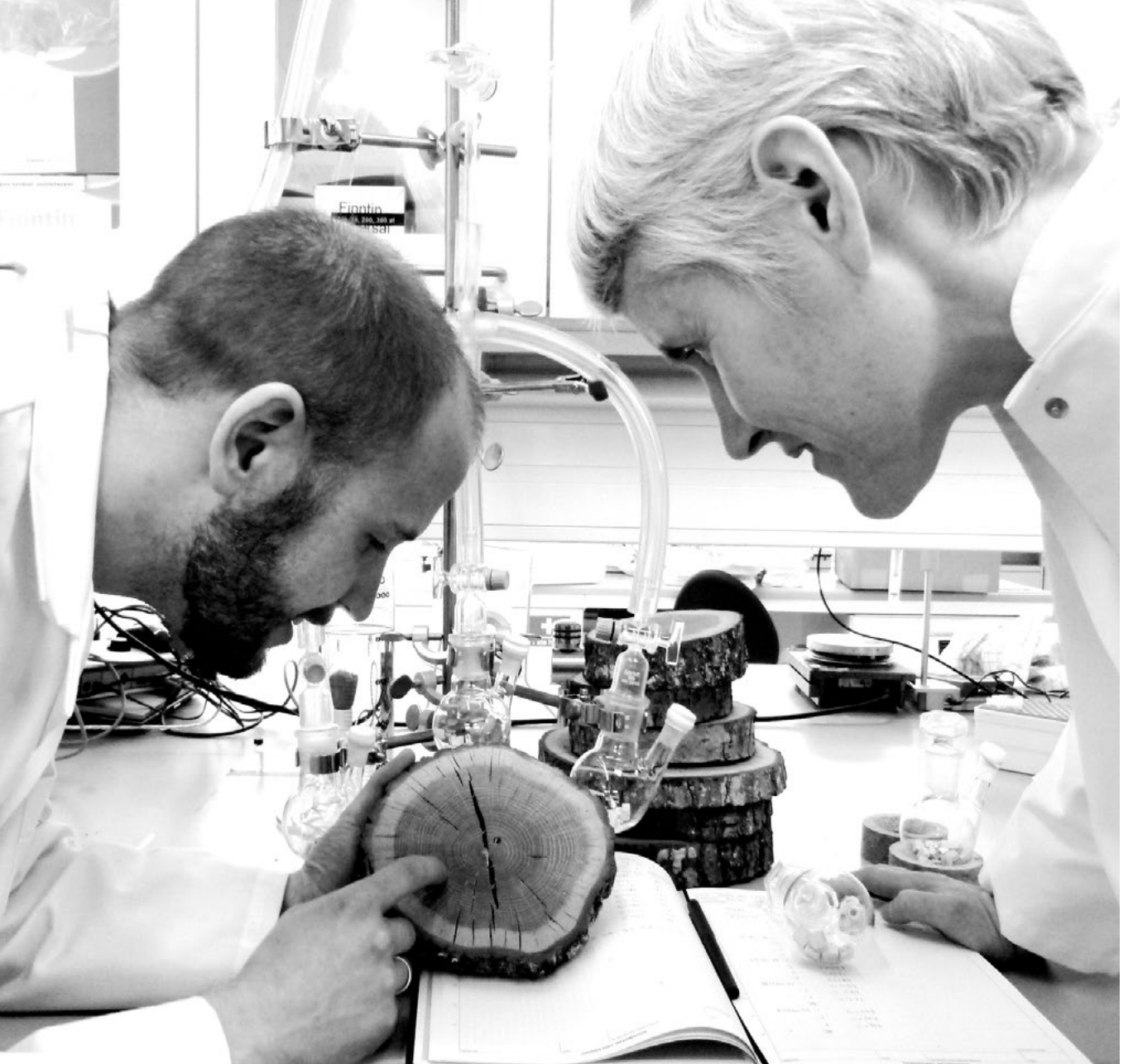
The goal of our school is to prepare children to participate actively and purposefully in the transition to a sustainable future. This will require great willpower, patience and perseverance. Working with wood teaches our students practical, everyday skills. It trains them in planning and design and serves as a scaffolding for cognitive skills. Finally, it develops their willpower, their patience and their perseverance. We hope this will help them succeed in making transition happen.

WOOD SCIENCE IS BACK!

Emil Engelund Thybring and Lisbeth Garbrecht Thygesen
Copenhagen University Forestry

The transition to a sustainable society requires an increased use of renewable resources due to their markedly better environmental profile than man-made materials. For structural purposes, wood is without doubt the most abundant and economically important renewable resource. Despite the importance of wood for buildings, furniture, energy, etc. the last few decades has seen a diminishing Danish wood research environment and subsequently a reduction in academic courses on the use of wood in society.

This trend is highly problematic for the part of Danish industry using wood, especially the construction sector where lack of knowledge about fundamental wood properties and behaviour can lead to disastrous results such as building collapses. Moreover, if structural engineers are uncertain about inherent challenges related to any given construction material, they are prone to go for materials they know better. Since no academic courses on wood have been offered in recent years, newly graduated engineers are predisposed to use other



If structural engineers are uncertain about inherent challenges related to any given construction material, they are prone to go for materials they know better.

less-sustainable constructions materials than wood. In those cases where the use of wood is required by architects in line with the trend in society towards more sustainable buildings, engineering competencies for building with wood will most likely be brought in from neighbouring countries. This constitutes an alarming problem for the Danish construction industry in terms of loss of jobs and know-how, especially as the demands for reductions in environmental footprint for the construction sector continues to increase. Therefore, there is an urgent need for a thriving Danish wood research community that can supply updated knowledge about wood to academic educations of engineers, architects, foresters, and everybody else who needs training in using wood for structures.

Establishing a community dedicated to advancing our knowledge on wood and providing research-based education in our universities is a challenge in a country the size of Denmark without a large forest industry as in neighbouring countries. Previously, academic wood-related education was typically the responsibility of a single researcher in each institution offering courses on wood. The basic problem, as we see it, is that research has shifted towards collaborative efforts, so such lone research positions scattered around Danish academia are no longer attractive for highly skilled researchers. Further, such isolated positions are not, as the development has shown, robust against short-term university priorities in times of limited funding. Therefore, to establish a thriving and long-lasting wood research environment a substantial investment in people and advanced infrastructure for doing experiments is required.

As the last resort for academic wood research in Denmark, University of Copenhagen has within the last two years made a dedicated effort to re-vitalise Danish wood research. Supported by several grants from both public and private foundations we have successfully stopped the decline and initiated the development of a research group aspiring to become internationally recognised within wood materials science. Being at the forefront of our research area is necessary for attracting some of the most talented researchers and expanding the Danish wood research community. To fast-track this development motivated by the urgent need for action, we have teamed up with leading wood research institutions in countries with large forestry sectors such as Sweden, Norway, Switzerland, and Germany. For us to get support from these institutions, we have benefited from the fact that University of Copenhagen is already at the forefront of research related to degradation of biomass for production of biofuels. Since wood degradation by fungal decay is a major research focus for long-term application of wood in structures, we wish to use existing expertise at our institution to studying environmentally benign ways to prevent decay inspired by wood species with a long natural durability. This will help wood remain an attractive construction material and expand its applicability in structural design.

With the expanding research group well underway, we are now focusing on re-introducing research-based teaching in academic courses on wood. On the one hand, we intend to collect, write, and publish updated Danish-language teaching material for bachelor level courses, while at the same time tailor our current course curricula to fit into the education system at neighbouring academic institutions. All of these developments described above could not have taken place were it not for support from our colleagues at the University of Copenhagen as well as generous grants from VILLUM FONDEN and Innovation Foundation Denmark. They have collectively helped us re-vitalise the Danish wood research community. While it was hanging on the edge two years ago, we are happy to announce today that Wood Science is Back.

Impact Farm, by Human Habitat. Vertical hydroponic greenhouse, made for dis-assembly, with all FSC wood structure.

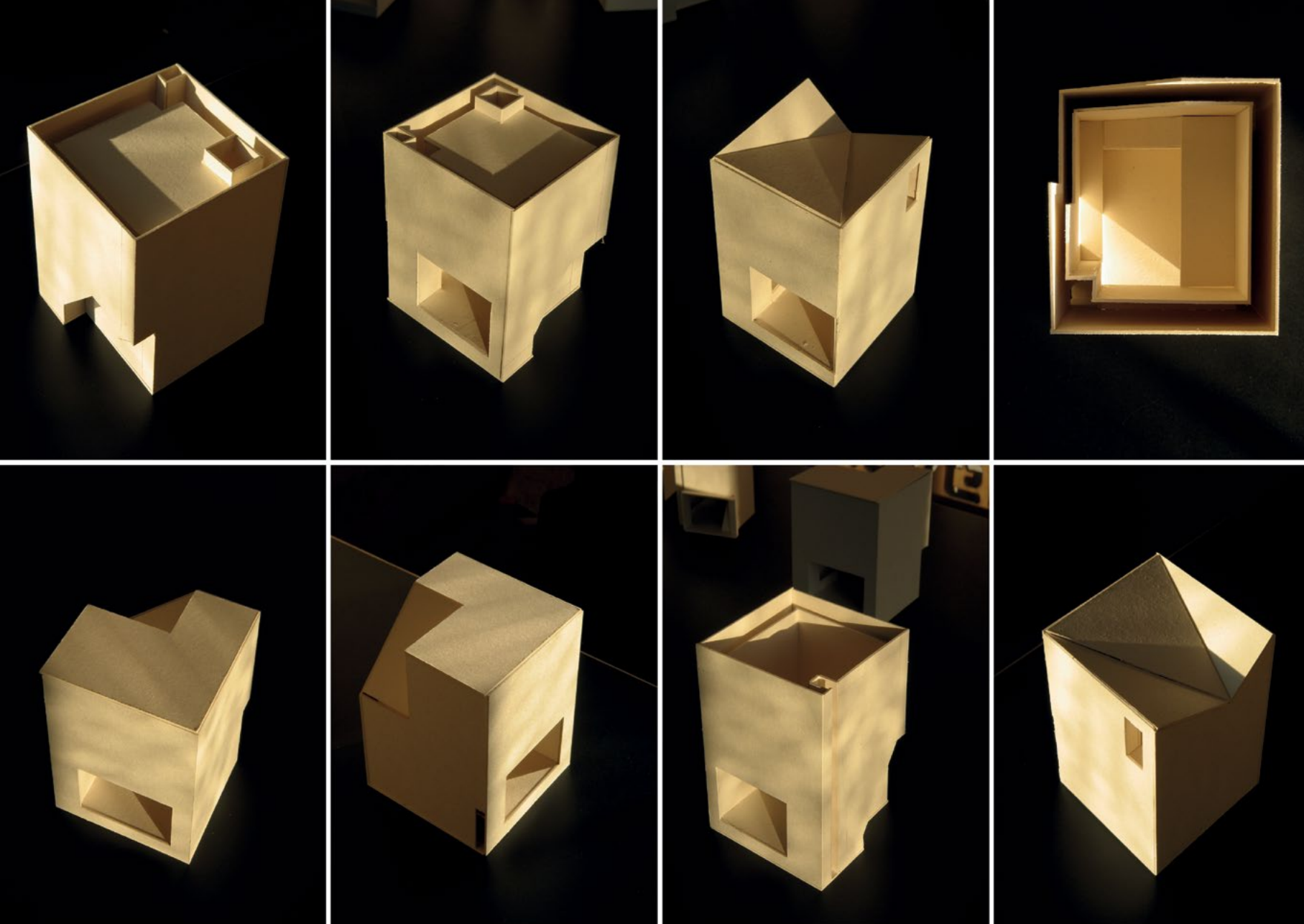
A MATERIALS APPROACH TO WOOD

A material trajectory

Anne Beim
professor PhD
CINARK
Centre for Industrialized Architecture, KADK

As part of the Royal Danish Academy of Fine Arts School of Architecture, Institute of architecture and Technology (IBT), CINARK's approach to materials – and in this case to wood – builds upon an understanding of architecture that has been cultivated through generations of affiliated teachers, researchers and practitioners. Scholarly traditions have been formed by reflections and experiments on how materials can be applied in architecture in new ways and how to both compare and challenge specific properties across various materials. How can we learn from historical structures and by which means can we explore the aesthetic dimensions of the material properties?

Subjects like these have been developed into different courses and projects continuously informed by both academia and architectural practice. Over the years, professional organisations and construction guilds have requested collaboration with CINARK and IBT in order to approach various technical problems from an architectural angle, challenging the students to come up with new ideas through student competitions.



The historical connection to the Fine Arts may have provided a complementary understanding of materials, where they are not only perceived as pure physical entities, as means to an end – but also as subject matters in itself that create particular meaning and that can be studied and engaged with from multiple perspectives; aesthetically, technically, socially, environmentally etc. In that sense, 'materials' are brought into a larger all-encompassing conception that also links them to cultural dimensions, societal or commercial institutions, and value systems.

In the research and educational activities connected to CINARK this understanding of materials including wood is also connected to a fundamental definition of tectonics that forms a synthesis compiled by the aspects; FORM-MATERIAL-TECHNIQUE. A plain explanatory model may outline tectonics as a subcategory of the Vitruvian triad; venustas/ beauty, firmitas/durability, utilitas/ usability. By reference to this basic conceptual model, it has been possible to structure and assess which sorts of teaching elements or research problems to focus on, but also, most importantly, it has provided a methodology through which materials can be understood and described to the students or to collaborative partners.

EXPERIMENTAL STUDIES INTO MATERIALS

Experimental studies into materials – where students and teachers have worked in close collaboration with external partners - have proved to be very productive. These set ups have been part of the educational activities and courses offered by IBT and CINARK in a period from 2005-2013. In the case of wood, they have included: The former Danish Museum for Hunting and Forestry in Hørsholm, Wood.dk, and Træinfo.dk. A full month course (TEK1) gave the students a true hands-on experience with the specific material properties and the architectural design potentials, and for two years the assignments focused on how to use and design with freshly cut 'raw wood'. This called not only for different sorts of tools and crafting techniques, but also for con-

struction designs for full scale wall structures that had to be fully considered from a perspective where assembly methods as well as physical and aesthetic aspects of weathering were thought as integrated. Similar teaching activities have been executed at 1:1 wood workshops at Virserum Art Museum in Sweden that particularly focuses on wood as part of their artistic strategy, and who invited CINARK to be part of the Architecture of Necessity Triennial. The first time was in 2013 for the WOOD Summit with a full-scale section model of the AUTARKI Pavilion and the second time was in 2016 with the Industrial PhD project; Materiality of Wood and Fire in Architecture.

MATERIAL INVESTIGATIONS THROUGH INDUSTRIAL PHD'S

Since CINARK was established in 2004 one of the primary tasks of the center has been to bridge the gaps between architectural education, the research environment, and the construction industry – in particular the material industries of brick, concrete, wood and plastics. With CINARK's overarching interest in sustainability, the projects have looked into how to benefit from the efficiency of industrial manufacturing, optimizing the use and quantity of materials, but not the least the environmental profile of the materials themselves.

Very conveniently the Innovation Fund Denmark opened for new disciplines (eg. architecture, structural engineering and construction management) to apply for funding for industrial PhD projects in 2005, which turned out to become an important source of research funding for CINARK. Over the years four Industrial PhD's have completed their studies focusing on block-bricks, new masonry constructions, fabric formwork for in-situ concrete and robot manufactured concrete formwork.The latest industrial PhD-project that is running from 2014-19 focuses on wood and fire, under the title; Materiality of Wood and Fire in Architecture. The project is supported by the Danish Institute of Fire and Security Technology, (DBI), who asked for an architectural scientific perspective on the new challenges given by a growing interest in building multi-story houses in wood. How does technical demands (e.g. new types of wood materials, fire-protection) meet the aesthetic dimensions, and which sort of tectonic strategies can be developed as feasible scenarios across architectural practice, construction regulations and wood industries – are some of the questions that are being addressed.

EXPERIMENTAL RESEARCH INTO MATERIALS

The AUTARKI Pavilion was an ambitious research initiative of experimental nature which was developed from 2011-2013 in order to test a series of tectonic aspects in full scale. This included the physical properties of a 100% wooden construction of CLT elements, their thermal efficiency and the indoor comfort, the rationality of assembly principles, and the longevity and weathering of the un-cladded construction elements of wood.

The pavilion also tested for the first time a ventilation shaft system that is based on natural ventilation principles including heating and cooling – and as such the pavilion was supposed to work as a self-sufficient entity that needed no additional heating supply. AUTARKI was monitored for a year and proved to perform along the lines of the initial intentions, however the temperature fluctuations were difficult to control due to the 'passive systems.'

This initiative was included as part of the International Symposium on WOOD – in a sustainable building culture (2013), where central players across governmental politics, the wood industry, architectural practices and research came and shared their ideas and anticipations for the future use of wood in architecture. CINARK intend to carry on with these collaborative experimental projects focusing on materials and the dissemination of the various results – having seen how the outcome can inspire the industry with alternative ideas and qualify the next generations of architects.

DO YOU KNOW ANGELIM RAJADO?

Lesser Known Timber Species

Loa Worm
director
FSC Denmark

Did you know that there are more than 50.000 tropical timber species in the world? Yet we only make use of a few of them! We must learn to think smarter and more holistically if we want to care for the planets forests. Every day tropical forests are destroyed or degraded. Forests are cut down in an effort to gain fast revenue or whole areas are converted into other land uses. It's time to search for new ways to end this destructive development.

One way is conservation by fencing of human activity and guarding nature - physically or by law. This seems to work in some cases but cannot be set as model for all of the tropics. We cannot deny the need for natural resources and economic development.

IMAGINE MANY MORE SPECIES – IT IS EASY IF YOU TRY

Part of the solution is to broaden the way we source timber. Tropical forests contain a multitude of wood species – in fact more than 50.000


MADERA
FSC-100%

- and a great number of these are potentially of commercial value. But still we ask for the same five-six species again and again. We ask for Azobe, Cumaru, Teak and Maghogany and not for Angelim Rajado, Gombe, and Tauari. This has led to overexploited of the few well-known tropical timber species.

Bringing this unfulfilled potential of Lesser Known Timber Species (LKTS) to the market will relieve pressure on the most commonly used species and at the same time, sourced sustainably with FSC, make it possible for the forest owners to earn a living from managing their forests in a beneficial way for nature. In other words, we could provide forest owners with a better incentive to manage their forests responsibly.

The thing is, in a sustainably managed forest, you don't just cut down the popular species. You don't just grow the popular species. You manage and grow a selection of trees that would naturally be there and you protect the ones there are endangered. You protect the biodiversity hot-spots and the wildlife. And naturally this means that you get a selection of trees aren't amongst the five most wanted. There is nothing wrong with these species – they just happen to be the ones we don't know. But how will we ever know, if we don't try?

USE IT OR LOOSE IT

Some think that using wood from tropical forests is a bad thing and entails destruction of forests. But in fact the opposite can be true. Some of the biggest and most influential environmental organizations is working to ensure a commercial – but sustainable – use of the tropical forests as a way to mitigate deforestation in the southern hemisphere. Amongst these are WWF Worldlife Fund for Nature, Greenpeace and Forests of the World.

The logic is to create economic incentives to manage the forests and maintain them instead of cutting them down. This incentive is created

through access to Western markets and price premiums compared to local markets because the wood is sold with an FSC label on it.

Often smallholders will be some of the providers of lesser known species. Being able to sell these species to a developed marked could mean the difference between being successful in maintaining certification and sustainable forest management or struggling to make ends meet. The sourcing of LKTS timber helps people and forests in the tropics towards a more sustainable business model with a higher likelihood of long-term success and effective maintenance.

COULD LKTS BE GOOD FOR BUSINESS?

If we manage to teach wood-based industries to use a broader selection of species, it is likely to be a beneficial business strategy for all.

Some industries are already experiencing soaring prices and price premiums on well-known and highly used species. Some are also finding that species known for their excellent properties no longer meet expectations simply because of the limitations on quality logs. This is seen both in terms of quality and the size of available logs. Overexploited species may face future trade restrictions. All of the above can be avoided through a diversified purchasing strategy that includes prices selected on the basis of technical quality and not solely on name.

LET'S TAKE IT TO THE NEXT LEVEL

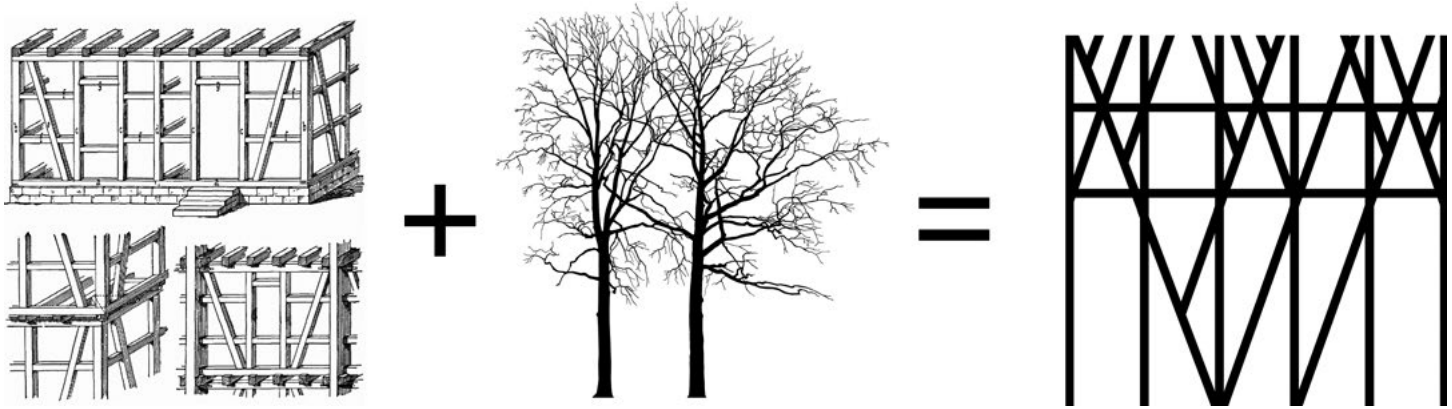
The FSC system is globally highly involved in creating background data and communication on alternative species. These years we are going door to door to architects, designers, constructors and decisions makers to teach them about lesser known timber species (LKTS).

That is also why we've developed a LKTS-database. The main purpose of the website is to inspire and guide timber and wood users to look for a more diverse selection of timber species as supplements or alternatives to the well-known ones. The aim is to develop a more diverse timber market to support sustainable forestry, improving pricing and regional development through the commercialization of a greater variety of wood species.

We need to teach everyone that there is another way – and we need to learn about these species and their performance lives as we go along. Only by daring to explore together will we be able to take it to the next level and ensure Forests for All Forever.

> *Our goal to create a more diverse timber market and break with the conventional thinking that dominates the industry today. It is okay to use well-known timber species like teak or cumaru- as long as they come from sustainable sources. However, if we can supplement some of it with lesser known species, it will make sustainable forestry much more profitable for the forest owners.*

design diagram for H.C. Andersen,
House of Dreams Museum, Odense, DK



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CONNECTION

If wood didn't exist, we'd invent it.

Bio-regionalism, job creation, sequestering carbon, multi-disciplinary, endlessly renewable. This is the language of sustainable wood, an old idea revisited. Never before in history has a material re-evolved that can positively influence the needs of our planet. Unfortunately, illegal deforestation remains a major threat to climate change today. Ironically, the solution lies within the problem; sustainable forestry management is the antidote. With whole value chain thinking, we understand that by selective harvesting of young forest growth, storing this timber in the structure of buildings and carefully replanting the forest- we can effectively and significantly remove carbon from the atmosphere.

The Go2WOOD Compendium is a collection of insights from international practitioners from the whole value chain of the wood industry. In the chapters GROW, MAKE, USE and LEARN- carpenters, industrial designers, foresters, and architects alike, eloquently describe the value of working with this timeless material.

Join the Go2WOOD movement, to promote the use of sustainable wood in Denmark and the Nordic bio-region. It's the right time, the right moment.

Chora Connection is a Danish non-profit organisation established in 2015 with the vision of creating sustainable and resilient societies. Chora Connection's mission is to meet the UN Sustainable Development Goals before 2030 by driving concrete behavioural change towards a sustainable society in Denmark as well as challenge the way we think, live, consume and produce. Chora will achieve its mission by creating interdisciplinary and innovative partnerships across sectors, disciplines and organisations, with the purpose of developing new experimental prototypes within the framework of the 17 UN Sustainable Development Goals.

Read more at www.choraconnection.dk

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