**Resource Wood**
National Research Programme NRP 66

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Dialogue field 4: Provisioning and sustainable use of wood

# Focus on wood – opportunities and limits of life cycle assessment

Report on the 60th LCA Discussion Forum at the ETH Zurich on 4 December 2015

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## Content



Further information on the event and documentation:
www.lcaforum.ch

*With the growing interest of consumer society for sustainable products and energy, demand for timber is growing. The issue of how to produce timber and timber products ecologically is steadily gaining in importance. The forum offered new perspectives on this issue, looking closely at various approaches for life cycle assessment and also clearing up a few myths and legends. Life cycle assessment, or LCA, is a tool that allows a systematic analysis of the environmental impact of products throughout their entire lifetime, from exploitation of raw materials through to disposal.*

## 1. About the event

The 60th LCA Discussion Forum at the ETH Zurich on 4 December 2015 was dedicated entirely to the ecological exploitation of wood as a resource (www.lcaforum.ch). The trigger for this focus was the conclusion of investigations into the ecological use of wood in Switzerland in the scope of the Swiss National Research Programme NRP 66 "Resource Wood", funded by the Swiss National Science Foundation (SNSF). The results were presented to a broader public for the first time, with other experts also delivering their talks.

The event, titled "Environmental Use of Wood Resources", was organised jointly by the ETH (Bernhard Steubing, Niko Heeren and Florian Suter) and the EMPA (Roland Hischier) and attracted papers from throughout Europe. The audience was also cosmopolitan, with more than 30 of the 70 delegates having travelled from abroad. The projects that were presented provided insightful glimpses of the issues and innovations currently being studied by experts in Switzerland and across Europe.

Four topic areas considered the LCA of timber and timber products from different perspectives. Alongside databases for LCA (topic 1) the experts also discussed refinement of methods for impact assessment (topic 2). Calculations of the ecological footprint of a range of innovative timber products linked the research to practice (topic 3). The projects in topic 4 considered the entire (or major portions of the) wood value chain. Alongside forest management, this includes the use of wood (in products or for energy).


*60th LCA Discussion Forum at the ETH Zurich on 4 December 2015*

# 2. EXECUTIVE SUMMARY

The environmental use of wood resources was the topic of the 60th LCA Discussion Forum, which took place with around 70 participants from Switzerland and abroad at ETH Zurich on 4 December 2015. The presentations highlighted the climate-protection potential of the wood sector, they detailed the impressive potential of life-cycle analysis (LCA) while also casting light on methodological issues that remain unsolved to date.

The topic was chosen upon completion of several studies into the ecological use of wood in Switzerland, undertaken in the context of the National Research Programme "Resource Wood" (NRP 66) of the Swiss National Science Foundation (SNSF). In tandem with other contributions, the results of these studies were presented to a wider public for the first time.

Divided into four thematic blocks, the forum put the spotlight on four aspects of LCA (Life Cycle Analysis). Block 1 focused on databases for LCA, while block 2 was dedicated to methodological developments in impact assessment. Block 3 dealt with issues related to the calculation of the ecological footprint of various innovative wood-based products, by combining theory and practice; block 4 looked at different approaches to forest management and wood use, as well as their ecological impacts, from a systemic perspective.

## 2.1 Methodological challenges

Each LCA is based on large data sets that quantify the environmental impact of various logging methods or wood-based products. The ecoinvent database, co-financed by the FOEN, has just been updated and will allow for more accurate LCA calculations. There is, however, further room for improvement as not all material flows have been captured yet. Methodological questions include how to draw system boundaries and how to choose the observation period. It is difficult to capture the interaction of natural processes and human interventions; depending on the chosen approach the results can be diametrically opposed: replacing a product with a wood-based product may be deemed climate-friendly according to one approach, while another one leads to the opposite conclusion. The LCA approach is more accurate if the natural reduction of greenhouse gases, i.e. effects of the biosphere, are also considered. The inclusion of this aspect does not make the calculations any easier. But they promise a more precise evaluation of measures to reduce the emission of greenhouse gases and, as a result, reduce the risk of investing in climate-protection measures that have little or no impact. If LCA is used in combination with methods such as species-area models and vulnerability indicators, it is possible to identify how various land management approaches influence biodiversity – at the global, regional and local level. The results of these observations underline the importance of accurately assessing the global environmental impact of wood-based products, which are often consumed far away from the place of production. (*Presentations by: Frank Werner, Environment & Development; Frida Røyne, SP Sweden; Francesco Cherubini, NTNU Norway; Abhishek Chaudhary, ETH Zurich*.)

## 2.2 Ecological footprint of timber-frame buildings and green energy

If wood is used to replace materials that consume a lot of energy, there is a positive effect on the climate – this is the generally accepted opinion at home and abroad. Consequently there is great, quantifiable potential when existing buildings are renovated in Switzerland. According to Norwegian figures, the lighter weight of wood accounts for much of the positive effect: using wood on existing foundations, it is for example possible to replace old buildings with higher structures

(accommodating more storeys). It is therefore important that we consider not only properties such as noise and fire protection when comparing buildings of comparable functionality but that we include weight in our calculations. But the climate-friendly characteristics of wood are not limited to its use as a building material as wood is also a climate-friendly energy source. The canton of Vaud covers 10 to 15% of its energy requirements with wood. Not all heating technologies are equally efficient though: wood to gas conversion receives the best marks if the waste heat is also used. A study from Bavaria confirms the positive climate impact of wood as a source of energy. However, if the analysis considers not only the emitted greenhouse gases but also particulate matter, wood for energy use is not entirely unproblematic. But if Bavaria were to stop using wood for energy altogether, this would result in the emission of an additional 6.4 million tonnes of greenhouse gases. Such figures show that LCA can be used to highlight the impact of political targets. (*Presentations by: Niko Heeren, ETH Zurich; Lars Tellnes, Norwegian Wood Technology; Denis Bochatay, Quantis; Christian Wolf, TU Munich.*)

### 2.3 From lightweight timber construction to bio-refineries – innovative wood-based products in the spotlight

Research is currently developing new wood-based products for the building sector, such as innovative panels and boards displaying a host of desirable properties such as low humidity content and good thermal insulation. An example for such a new product is "holzpur", which does not require chemical treatment or glue of any sort. The life-cycle assessment shows that this product is therefore more environmentally friendly than glulam. The situation is slightly different for the ultra-light panels that were also showcased: they owe their lightness to a biogenic foam core but the ecotoxicity of the currently used foam limits their eco-friendliness. When assessing wood-based products it is key to consider the entire, cascaded life cycle. The positive properties of wood in the use phase are often due to (chemical) treatments in the production phase. This also creates a negative environmental impact in the disposal stage. Labels could help people in the building sector to choose the most environmentally friendly products. Standards for this purpose are currently being developed. LCAs that differentiate between various time spans and different forestry structures could make it possible to quantify the climatic impact of forests and wood-based products more accurately. All in all, this approach, too, confirms that climate change is effectively slowed down by replacing fossil-based energy and products with wood. Bio-refineries open up yet more ways to use wood: in addition to serving as a basic product for the building and packaging sector, wood can be transformed to replace a whole range of oil-based products. However, the necessary chemical processes use a lot of energy and resources and the finished product is generally the result of various reaction chains. For businesses it would be helpful to know which reaction chain is the most economical and allows for the further use of residual materials. The newly developed "Wald-Box" makes it possible to compare potential production processes and to evaluate the efficiency and environmental impact of various bio refinery concepts at the planning stage. (*Presentations by: Philippe Stolz, treeze Ltd.; Christelle Ganne-Chédeville, Bern University of Applied Sciences; Andreja Kutnar, University of Primorska; Merten Morales, ETH Zurich; Antti Kilpeläinen, University of Eastern Finland.*)

### 2.4 Forests as a system and their impact on the climate

Optimised concepts of forestry management that take account of forests all over Switzerland could reinforce the climate-friendly impact of intensified wood use. By casting a systemic look at the entire production and use of wood in Switzerland, it is possible to link management issues to material-flow analyses and LCA. Different wood-based products affect the climate in different ways.

The positive impact of the current use of waste wood is still marginal even though research has shown that cascaded wood use can alleviate climate change if wood replaces energy intensive materials and is used for energy production at the end of its life cycle. A look beyond Switzerland to Europe sees the positive environmental impact of forests and the intensified use of wood confirmed. The LCA approach allows for differentiated results according to the forest type and management system and it can be adapted to different periods of analysis. On the basis of this, we gain a better understanding of forest dynamics. If we include economic indicators (such as wood price and unemployment figures), LCA-based simulations are effective tools to assess political measures at an early stage and to detect measures that counteract each other or have a negative impact in the long run. (*Presentations by: Florian Suter, ETH Zurich; Giuseppe Cardellini, KU Leuven; Frank Werner, Environment & Development.*)

### 2.5 Conclusion and outlook

The concluding panel debate underlined that a more detailed analysis of spatial and temporal system boundaries of LCA is likely to push the method forward. However, concerns were raised that increasingly complex calculations might be confusing and difficult to communicate. In view of spreading information among practitioners, it will be crucial to break down complex results into simplified messages. It was felt that researchers should be more involved in the dialogue with key stakeholders in order to influence economic and political decisions based on new insights gained through life-cycle assessment.

## 3. New inventory data for the European wood value chain

Industry experts will have welcomed the announcement at the beginning of the 60th LCA Forum that the inventories of timber-specific data in the ecoinvent life cycle inventory (LCI) international database have been updated and significantly enriched in the new version 3.2. The update, which was co-funded by the Federal Office for the Environment (FOEN), covers six different areas of the value chain, from forestry through sawmill products to disposal in incineration plants. Forestry data is no longer only taken from Germany, but now also includes information from Sweden and Switzerland. Compared with the previous version of ecoinvent, the value chain has been modified to differentiate sawmill products, while the area of preservation of stored wood using timber preservatives has also been expanded. In addition, there is now also information on a range of (more realistic) wood densities, allowing shrinkage to be taken into account. This has made the calculations more complex, but also more robust. Finally a number of ancillary products have been added throughout the process chain, which in some cases are more relevant to other countries than to Switzerland. The driving forces are unchanged, but their application in different contexts (including in different countries) is improved thanks to more precise data.

The question and answer session revealed that users still desire further expansion of the data. Those present also felt that it should be an objective to incorporate the new ecoinvent data into the list produced by the Coordinating Conference of Public Construction and Property Authorities (KBOB). (*Presenter: Frank Werner, Environment & Development*)

## 4. Methodological challenges

The issue of how to take account of climate-specific effects in the LCA of timber products was subject to an extended literature analysis. It must be considered whether the assumption that there is climate-neutral consumption only applies in a longer time period due to time-shifting effects. After all, the storage capacity of the forest may change over time, as does the actual land usage at a given site. In addition, the albedo plays a role to the extent that bare ground responds differently to that with plenty of growth. Such factors must be weighed up, but are only covered partially by the existing inventory data. For example, if you compare traditional fuels with bioethanol, this can lead to significantly different LCA results that depend on whether or not climate data (in particular the damage to the state of the soil, albedo and biogenic CO2 emissions) is included. If the frequently used environmental evaluation is compared with a dynamic, forecasting LCA, the differences are even more marked. A study that analyses the effects on the climate of replacing benchmark products with timber-based alternatives reveals that the outcomes can differ significantly depending on which LCA approach is used. In an extreme case, for example, the replacement of methanol acquired from natural gas with biomethanol can produce massive positive climate effects, while an investigation using a different LCA approach concludes that the environmental impact would be immensely harmful to the climate. Depending on the approach, therefore, the outcomes can be diametrically opposite. This is because it is not yet truly clear how the forest interacts with the climate and how this interaction can be realistically modelled in the life cycle assessment. The effects of biomass processing are also uncertain. Accordingly, the existing models are badly suited to replicating this interaction and the question must remain as to how researchers should deal with the existing shortcomings.

The discussion confirmed that the man-made climate impact must be differentiated from natural effects. The point was also made that it is important to be able to set priorities when analysing the impact of carbon from a range of sources and activities. In particular, there is no doubt that there is room for improvement as regards the precision of the existing LCA approaches. (*Presenter: Frida Røyne, SP Sweden*)

## 5. Biogenic carbon flows and their impact on the climate

For many years, timber from sustainably managed forests was considered to be climate-neutral. New work has shown that this is not necessarily the case, as the harvesting and oxidation of wood to produce CO2, as in the case of incineration, produces a climate effect until the CO2 is once again bound in the form of biomass. Investigations reveal that climatic conditions such as average annual temperature and precipitation volumes significantly influence the relative contribution of used volume of wood to global warming. Of equal relevance in this analysis is the type of tree in cultivation, the rotation period and rate of cleared residue. And the difficulties do not end there. The impact of timber products on the climate also varies according to the length of the products' useful life. As a rule of thumb, the global greenhouse potential is zero when the CO2 is stored for half as long in the product compared with the rotation period of the plant that supplies the corresponding raw material. A range of myths that characterise the debate on global warming are countered by the research: For example, the answer to the question as to whether CO2 that is released by deforestation in one location is offset by the storage of greenhouse gas at another location must be no. This would contradict a consistent definition of system limits. The previous research findings underline the fact that climate-relevant biological-physical factors must

absolutely be included in life cycle assessments, since otherwise there is a risk that money will be put into climate-protection projects that have very little effect or are even counter-productive.
The discussion confirmed the necessity of giving great consideration to the selection of the analysis period in an LCA. (*Presenter: Francesco Cherubini, Norwegian Institute of Science and Technology NTNU*)

## 6. Accurately estimating changes in biodiversity

The methodology section of the forum closed with a paper that quantifies the effects of land usage on biodiversity at various scales (local, regional and global). In the local analysis it shows that the intensity of forestry management affects the number of animal and plant species. Clear-cut land has only around half the number of species that can be found in near-natural forests. For the analysis at regional level, the species -area models were combined with vulnerability indicators. This approach helps to reveal the regions around the world that are under particular threat of reduced biodiversity owing to land usage. Tropical areas and islands in particular are especially badly affected by high biodiversity losses. This is primarily because they are home to a high number of threatened species. Finally, the study investigated how the global production of round wood has an impact on species diversity. Madagascar was named as an example of a country with a high loss of species per cubic metre of harvested timber. In contrast, India risks lower losses since most timber there is taken from plantations, while nearly-natural forests remain largely unaffected. The findings reinforce the need to take a global view in respect of imported timber products, to correctly assess the damage to the environment. A difficulty for evaluation arises due to gaps in data on the worldwide forest exploitation intensity, and taxonomies such as fungi and bacteria. The findings make a significant contribution to the project “Life cycle management of wood in Switzerland: Methods, tools and environmental decision support”, which was carried out in the scope of NRP 66 under the leadership of Stefanie Hellweg at ETH Zurich.

The discussion mentioned studies that show that in some cases similar numbers of species live in extensively managed forests as in natural forests. In a global comparison, Switzerland is in a privileged situation given the harvest revenues are relatively high and there are very few if any native species that could be lost. However, the combination of species often changes to the cost of native species. For example, changing light levels in managed forests may encourage species that require greater levels of brightness to move into an area at the expense of others that avoid direct sunlight. Movements of species are difficult to record. The different scales of biodiversity loss are important for a range of reasons: A global loss of species is irreversible, and should therefore be in the foreground. However, local biodiversity is also important in order to ensure that ecosystems function correctly. (*Presenter: Abhishek Chaudhary, ETH Zurich*)

## 7. The ecological footprint of timber houses

When buildings are in need of renovation or repair, the question arises as to what role wood could play in the construction, and what would be the ecological benefits of increasing the use of this sustainable resource. These questions and others were the prime focus of investigations led by Stefanie Hellweg and her NRP 66 team in the project mentioned above. Linking a range of data sources together allows the researchers to compile an inventory of the existing pool of buildings in Switzerland, which allows conclusions to be drawn about the construction materials used

according to type of building and year of construction. This, in turn, allows the future mass flows arising from new buildings, renovation and demolition to be estimated and assumptions to be made regarding the materials that could be used or reused. In addition, the impact analysis includes assumptions on the requirement for heating energy, determined on the basis of a simulated comparison of solid-built and timber buildings. This shows that solid buildings store heat energy better than functionally equivalent timber buildings, so that a timber house requires slightly more heating energy over the course of the year. However, construction of a timber house results in emission of approximately only half the greenhouse gases in the production of the materials used. According to the sensitivity analysis that was presented, the timber house comes out better over the full life cycle than a similar building built from concrete or bricks, in most cases. The next step is to calculate future scenarios; different renovation and new building rates and a range of insulation standards in housing will be critical in this.

The discussion revealed interest in the fact that the method used would allow the researchers to reach differentiated conclusions on the use of timber in buildings overall. A further objective is to determine the availability of used timber from existing buildings for subsequent material or energy requirements. (*Presenter: Niko Heeren, ETH Zurich*)

Research work from Norway reinforces the positive effects on the environment of timber in building construction. In Bergen this year, a 14-storey building was constructed from wood. The CO2 stored in the building is the same as the volume that would be emitted by 10 million cars as they drove over the nearby Puddefjord Bridge. Even when comparing multiple types of flooring, concrete emits more than twice as much CO2 as timber. The low weight of wood is a particular advantage; timber buildings weigh only a third as much as buildings made from concrete and steel. This allows old foundations to be used when replacing buildings, which considerably reduces the CO2 emissions. Therefore, when comparing functionally equivalent buildings it is necessary not only to take account of fire protection and noise insulation, but also weight and volume of materials and buildings themselves. However, binding standards are required to allow materials research to be used in practice. Currently these are paid little attention in the construction process, and new timber buildings are therefore difficult to evaluate. However, due to their low weight, components made from wood have significantly more environmentally friendly potential when they are used to replace concrete elements. (*Presenter: Lars Tellnes, Norwegian Institute of Wood Technology*)

## 8. Bioenergy: Verifying impact assessments

A study looking at the canton of Vaud is dealing with the energy potential of existing wood reserves. Consumption of timber in the canton of Vaud is constantly rising but the stock is limited. In the implementation of the energy strategy, timber could still play an important role as a renewable resource, as long as it is used as efficiently as possible. The calculations have revealed significant potential: currently 10% of the energy requirement in Vaud could be covered by wood, and this could rise to 15% with the new energy policy. Admittedly, the technologies used to convert timber into energy (mobile pellets manufacturing, pre-dried pellets, conversion to gas, pyrolysis) are not all equally effective. Conversion to gas produces the best results and, in comparison with conventional heating with wood chips, it produces 26% more yield. However, this does require that the residual heat from the conversion process is also used. Conversion from of wood to gas is also beneficial in respect of environmental consequences. LCAs show their value for well-founded political decisions; accordingly, wood should be converted to electricity as a priority and the

residual heat be used for heating purposes. The investigation will now continue and focus on the issue of how many of the existing heating systems in the canton of Vaud should be replaced by other heating technologies. (*Presenter: Denis Bochatay, Quantis*)

Optimisation in respect of environmental consequences of the use of wood as a source of energy is also being investigated in Bavaria. Solid biofuels, i.e. wood, are responsible for 83% of the heat from renewable resources in Bavaria. If the entire life-cycle of different types of wood energy is considered, the split wood traditionally used in wood ovens is advantageous in terms of greenhouse gas emissions. This is because preparation is less complicated and transport distances are short, as consumers are mostly covered by suppliers in the direct proximity. On the other hand, when focusing on the emission of fine dust particles, traditional wood ovens with split wood produced the worst result. Overall the LCA shows that the wood used for energy in Bavaria is responsible for only 1.7% of the greenhouse gases emitted in heating processes, but for 80% of fine dust emissions. The Bavarian energy concept now proposes to increase the use of wood for energy by 15%. The consequence of this would be to release 2% less greenhouse gas. However, fine dust emissions would increase by 11%. Nevertheless, completely avoiding wood as a supply of energy would mean increased use of light heating oil, natural gas and electricity. The environmental impact of this would be an additional 6.4 million tonnes of greenhouse gas compared with the current situation. The study clearly shows that wood can make up at the most one quarter of energy from renewable sources if all available sources are mobilised.

In addition, the study demonstrates that LCAs are extremely useful in assessing political objectives. The discussion highlighted the limits on intervention options, however. While traditional wood ovens that use split wood are not particularly efficient and emit a lot of fine dust, they are particularly widespread in rural areas and it would take a generation to replace them. In addition, switching from split wood to pellets would be a major technical task. When it comes to making political decisions, time is a major factor generally. Therefore, the best short-term measure is to retain the existing solution. Most people have a local supply of wood for burning, while pellets, whose production is more complex, would potentially need to be imported from Canada or Russia. (*Presenter: Christian Wolf, TU Munich*)

## 9. From lightweight timber construction to the biorefinery – innovative wood-based products in the spotlight

Currently, research is being conducted in various laboratories into wood fibre boards and wall-lining elements, and therefore it is worthwhile investigating the impact on the environment. The presentation introduced the “holzpur” product – a board made of spruce and fir that uses no glue or preservatives in the production (presented by Philippe Stolz, treeze GmbH) and an ultra-lightweight particle board with a biogenic foam core (presented by Christelle Ganne-Chédeville, Bern University of Applied Sciences). This latter product is currently under development by Heiko Thoemen and his group in the scope of NRP 66. Investigations confirm the climate-friendly potential of both products. The LCA result of holzpur wall elements is significantly better than that of conventionally glued boards. In particular, the comparably low land usage in production of the raw materials and the low amount of energy required for the drying process are beneficial. In respect of the ultra-lightweight boards it is important to weigh up various factors. For example, while their greenhouse gas emission potential is lower than that of conventional particle boards, the ecological toxicity is greater since polylactic acid (PLA) is used in the manufacture of the foam.

When wood is treated to improve its resistance against the effects of weather, this also has an impact on the environment. A range of processes could be used (thermal, chemical or methods involving impregnation). While the positive effects of the treatment will general be seen during the use of the product, the modification of the wood itself occurs during the production phase and the environmental impact may not occur until disposal. When attempting to calculate the environmental consequences of treated wood, therefore, it is important to take account of the entire utilisation cascade. For practical applications – i.e. for use in construction – it would be important to have recognised labelling to allow selection of products that have been treated using the most environmentally friendly processes possible. Discussions are currently ongoing on the development of corresponding standards to allow uniform certification of products. (*Presenter: Andreja Kutnar, University of Primorska*)

Wood is not only used as a construction material or energy source, but can also be used as a base material for other substances, such as chemicals. Such approaches are referred to as bio-refineries. The trick is that the conversion of wood into the end product can be done via a range of reaction chains. This can be seen in the example of sugar, which can be produced by the use of acid (wood saccharification), or via the enzymatic decomposition of wood. In comparison with the production of sugar from sugar beet, it is evident that the different methods for sugar production from wood are far from as economically effective. Therefore, it would be advantageous to have an instrument that would allow an early comparison of the different reaction chains in transforming wood into a range of desired outputs. Most companies will not find it feasible to simply manufacture a product, so therefore it would also be necessary to consider how the by-products of the reaction can be used for other purposes. LCA could be used to improve the bio-refinery approach. The recently developed "Wald-Box" concept – a tool to assess different wood-based chemical production chains – also allows the efficiency and environmental impact of various bio-refinery concepts to be assessed in the planning of the corresponding plants. (*Presenter: Merten Morales, ETH Zurich*)

Wood is used intensively in Finland, and LCA could help in the simulation of biomass production under various conditions, modelling of biogenic and man-made greenhouse gas emissions and calculate the climate impact of various forest usage concepts. The calculations could lead to recommendations on matters such as the most climate-friendly age distribution of the tree stock. Information on CO2 emissions in the biosphere and anthroposphere contributes to improved understanding of the role of the forest in reducing climate warming. LCA findings show that the replacement of fossil-based energy and products with timber is an effective option for reducing climate change. A great stock of timber or the use of fertilisers could help further strengthen the positive effect of the use of wood on the climate. However, the climate effects change over time and according to the forest structure. (*Presenter*: *Antti Kilpeläinen, University of Eastern Finland*)

## 10. The forest ecosystem and its effects on the climate

Timber is a multifunctional resource and can be used for various energy and material purposes. Thus, sustainable forest management can counter climate change, and the use of wood can reduce demand for energy-intensive materials. Currently, the timber stock in Swiss forests is increasing, and new strategies for forest usage are needed to achieve the biggest possible reduction in climate warming. To develop optimum forestry management and timber usage concepts, there needs to be

a system-wide overview of Switzerland's entire timber production and usage. This has been enabled by the project run by Stefanie Hellweg and her research team in NRP 66, through a combination of material flow analyses and LCA. Around 50% of the wood currently in use is used for energy, while a quarter is used to manufacture paper and another quarter for furniture and building elements. Statistical data has been used to determine the total volume of goods produced and their environmental impact. The large volume in respect of paper manufacture and wood-based energy generation is particularly important in the calculation, although the various evaluation approaches apply very different weightings. The effects of different origins of the timber on the environmental impact of generated products have also been investigated. The current use of reclaimed wood in Switzerland has barely any positive climate effects as currently it is largely replacing fresh wood. Cascading wood use can have favourable environmental effects, however, where energy-intensive materials are being replaced and the wood is used in energy generation at the end of its life cycle with no major restrictions. Therefore, increased use of wood in Switzerland would have positive effects on the environment, but only if all effects are considered in the assessment (e.g. fine dust in addition to greenhouse gas emissions), if wood replaces resource and energy-intensive materials like concrete, and if it is used in such a way that its final use is in energy production. (*Presenter: Florian Suter, ETH Zurich*)

Forests have a key role in the fight against global warming from a European perspective too. This has been revealed by scenarios that have been developed in the international FORMIT project (FORMIT stands for FORest management strategies to enhance the MITigation potential of European forests). The calculations use dynamic LCA. The starting point comprises an inventory of 49 different forest systems mainly prevalent in Europe, with a range of species groups (from unmanaged forests to plantations with short rotation periods). On this basis, a comprehensive survey was used to investigate the spatial distribution of the different forest management systems. The survey asked questions on various aspects of management, such as the machinery used, fuel used, method of wood harvesting, etc. The data that has been gathered allows calculations to be made of the environmental impact (in terms of CO2 equivalent) per hectare of each forest management type. The findings can be broken down by country (and therefore by head of population). A time-differentiated LCA allows better understanding of the forests. It also reveals that it is primarily the storage effect of the wood that is relevant for the climate, while the influence of the forest management system is comparably less important. (*Presenter: Giuseppe Cardellini, KU Leuven*)

A study aimed at discovering the future importance of the forest and the use of wood for reducing the greenhouse effect looked at four scenarios, each comprising a different level of intensive wood usage (and therefore also increased CO2 storage in Europe's forests) and differentiated wood usage (wood for energy vs. production of goods). The focus is on the question of what consequences on the climate these scenarios would have leading up to 2030. It emerges that forestry or the use of timber-based products as required in the EU objectives for bioenergy would have clearly positive effects on the environment and in particular on climate change. Over the full life cycle, timber products come out better than functionally equivalent CO2-based goods. While it at first seems surprising that an increase in the wood stock – and consequently heavily reduced use of wood – comes out best of all the scenarios in terms of greenhouse gas emissions in the short to medium term, this scenario also involved increased emissions outside the EU and a doubling of the price of timber by 2020, and increased unemployment in forestry. The greatest dynamic for the forestry and timber sector would come from an approach that prevented the combustion of freshly

harvested timber for energy purposes first. The study confirms the complex interaction between the storage capacity of the forest, the climate effects of the produced goods and the ecological consequences of substituting raw materials, since these can have contradictory effects. Political measures to protect the climate must therefore be developed with utmost care in order to avoid unintended consequences. It must also be considered that the forest as a carbon store is subject to a different time dynamic than the substitution effect arising from the replacement of goods with wood-based products. In the long-term analysis, the reduced forest usage entailed unfavourable consequences for the climate as the substitution effect of CO2-based goods disappeared and the mortality of unused forests increased. Therefore, it is equally important to be heed to the time scale over which the analyses are considered. (*Presenter: Frank Werner, Environment & Development*)

## 11. Conclusion and outlook

In the concluding panel discussion, the participants – Stefanie Hellweg (ETH Zurich), Klaus Richter (TU Munich), Martin Riediker (President of the NRP 66 Steering Committee), Hansueli Schmid (Lignum) and Frank Werner (Environment and Development) – were united in the opinion that it would make sense to replace oil-based materials and fuel with wood as long as the products were intelligently designed and used the least possible amounts of chemicals, and were also acceptable to the engineers. In addition, it was agreed that it is necessary to look beyond national borders and to verify the consequences of reducing wood cultivation and the generation of products elsewhere. It is also important to consider the time scales of these processes. The LCAs that have been used enable a more comprehensive view to be taken of the situations. Such models are difficult to calculate, however, and the panel expressed their concern that the complex calculations could lead to confusion in the population. Indisputably, it is the job of science to model our complex reality as accurately as possible. However, it must also be capable of breaking down its findings into more simple take-home messages. Not least, researchers should invest more in dialogue with the key stakeholders, to understand how decisions are made in business and politics. Only in this way will they be able to actively influence decision-making with new findings from LCAs.