THE USE OF WOOD, A FACTOR IN DEVELOPING SUSTAINABILITY

Joris Van Acker[1]

[1]Laboratory of Wood Technology (Woodlab), Ghent University (UGent), Ghent, Belgium;
Joris.VanAcker@UGent.be

Europe is in general concerned about the adequate and sustainable supply of resources. Timber, wood, lignocellulosic biomass or whatever name we give the material coming from forestry and related sectors, is an eminent renewable resource with high potential for sustainability and surely an excellent ecosystem service for our modern society. Terminology like cascade use and circular economy are surely not new for the forestry-wood chain, but are getting increased attention now. The balance between wood material use and bioenergy use will inevitably lead to higher competition for the same resource and could evolve into critical shortage in Europe even before 2030. Vertical integration alongside a better tree and wood quality concept should lead to a more structured approach dealing with whether some wood products needs to be prioritized and how we could deal with substitution of man-made (building) materials requiring more energy to be produced. This is clearly another option than direct production of green energy based on growing woody biomass. Hence it is unrealistic to focus only on one use of wood when considering a sustainable approach for the silvicultural aspects of forests. For sure the end of life discussion allows to focus on conversion of the embedded energy of wood products and should be optimized through innovation related to combustion and other thermochemical conversions next to biochemical processing, but should remain part of an integrated forestry-wood chain. Even the biorefinery option to produce chemical building blocks and other components for white or green chemistry should not be developed separately. This statement is based on the fact that traditional processing of trees into forest products can meet directly the requirements of a green economy in a highly adequate way. At the moment trees, the derived products and residues are too much used as optional energy resource to solve problems initiated by the deployment of fossil fuels and petrochemical backbones, but focus should be on substituting man-made materials with high embodied energy content. In the overall circular economy approach the end of life assessment is surely related to service life and the impact on life cycle aspects. Wood products have been criticized in this respect. Enhanced quality in relation to service life performance and related stimulation of innovation seems to be a better option than just direct energy conversion of harvested lignocellulosic biomass.

Keywords: resources, material use, bioenergy, embodied energy, embedded energy.
Parole chiave: risorse, uso del materiale, bioenergia, energia incorporata, contenuto energetico.

http://dx.doi.org/10.4129/2cis-jva-use

1. Introduction

This paper is intended to compile some of the critical parameters on the use of wood as an option to develop sustainability in relation to wood production. Topics discussed are availability of the resource, the possibility to improve sustainability throughout the forestry-wood industry chain, vertical integration and cascade use, tree and wood quality options and concerns related to bio-energy use.

2. Wood as a renewable resource

Wood is considered to be the ultimate renewable resource. Trees grow on a major part of the planet and produce wood based on a mechanism called photo-synthesis. Similarly to all biological organisms a maximum level of production has to be taken into account. This maximum potential of wood formation can be seen as a maximum annual growth of volume or dry matter per ha. A forest being (semi-) natural is even under a multifunctional approach limited in increasing the productivity. Extra options are available to produce more woody biomass by having more plantations or even planted forests, but also here available land area and eco-physiological limitations are to be taken into account. Even when we envisage production on arable land as an option for more flexibility the productions systems like timber farming, short rotation coppice and even agroforestry will need to be balanced against food and feed production. There are different ways to typify forest. Jürgensen and co-authors (2014) indicate clearly that there is continuum ranging from natural forest up to trees outside forest all contributing to wood

production (Fig. 1), but the major focus to increase production most likely is linked to planted semi-natural forests and productive plantations as part of the type called planted forest (Jürgensen *et al.*, 2014).
Furthermore there are some trends influencing the potential maximum wood production. Although wood production is a major ecosystem service, societal and economic assessments for several other ecosystem services might lower the priority of this production function. In Europe we agree that in future focus should be more on hardwoods, but this inevitably will have an impact on volume production in many forests. Finally there is also an increasing trend to exclude some forests from wood production through several mechanisms of nature conservation and creation of protected areas.

3. Wood availability

Several studies predict that we are heading for a worldwide deficit on wood before 2030 (i.e. Mantau *et al.*, 2010). Recent trends on products like sawnwood (Fig. 2) and wood based panels are still showing a steady increase in wood materials produced worldwide (FAO, 2014), but on a local scale the impact of increased need for biomass resources for bio-energy use is also critical. This might lead to a perfect storm and should be considered critical not only by the forestry and wood sector, but will have wider socio-economic and political impact. It will surely lead to the need to revisit the sustainability of the forestry-wood industry chain. Good governance will become even more relevant and an overall guidance on adequate (eco)systemic forestry management is critical. Through the activities of COST Action E44 on the European Wood Processing Strategy (http://www.cost.eu/COST_Actions/fps/Actions/E44) it became obvious that we lost adequate interaction between forestry and wood industry. Forests are today more than ever approached from a nature - ecological perspective and hence larger open systems like shrub land are included in forests to increase biodiversity. The so-called “close-to-nature” forestry seems to be preferred to intensive evenaged forestry, while both could easily be implemented and as such guarantee more objectives being realised for our society. The role of plantations has been addressed in detail by FAO and has clearly been positioned as a major driver for future wood production (Carle and Holmgren, 2008).

4. Wood and an eco-techno approach

Wood is a renewable resource and is as such a material which can be considered contributing to sustainability also from an ecological perspective. This is however complemented by the fact that technology leads to a balance between traditional and innovative products and hence sustainability also needs to be assessed in this perspective. Wood production through tree growth leads to products that are interdependent and should take into account parameters linked to the following 4 discussion topics: (1) Balance between material and energy use; (2) Vertical integration and cascade use; (3) Tree quality and wood quality; and (4) Service life impact.

5. Balance between material and energy use

Our modern society is constantly in need of new resources for the production of material products (e.g. for construction) and for energy purposes (woody biomass both for residential and industrial energy use). We see a major development of dedicated bio-energy products for combustion (firewood, pellets…), but also research and industrial installations are being implemented, mainly based on thermochemical conversions like traditional charcoal production and new technology based on pyrolysis, gasification…
Furthermore there is a major interest to use a lot of lignocellulosic material for the production of liquid biofuels and white chemistry in biorefineries primarily focussing on biochemical processes. Also here wood is the major resource that is needed to cover the current and estimated future need. Already now this has provoked discussion on international trade and subsidies. Green electricity production, e.g. in the Benelux, requires import of woody biomass from North-America to replace/substitute fossil fuels. On the other hand there is still a lot of very valuable high quality wood spoiled when used simply as firewood to provide enough energy for households, e.g. the case of Kinshasa in DRCongo.
Forest products used as material are low in embodied energy compared to most man-made products, meaning there is a limited amount of energy required for processing. Furthermore the wooden product still has a high embedded renewable energy which can be used at end of life. Hence material use of forest products is an excellent alternative/substitute for man-made materials. Additionally timber and wood products in general are considered to be very positive components for the construction of energy efficient buildings and houses, e.g. passive houses.
Although the above reasoning should be applied on the overall production chain it is interesting to see how this can be implemented in particular for a specific species like poplar/willow. Selection and breeding of poplars and willows has evolved over the last decade to focus more on bioenergy uses. Specific clones and cultivation/harvesting techniques linked to short rotation coppice have been developed with a focus on producing woody biomass on arable land. However this initiated that several decision making processes need to be considered.
There is the option to focus on higher cellulose accessibility to come to better biochemical transformation, however the amount of embedded energy is higher when the lignin content is higher. Also multipurpose plantations can be relevant to increase flexibility. One day a somewhat longer rotation can lead to the production of timber or other forest products and not just biomass for energy, but then the quality of both genotype and phenotype need to be adequate from the beginning.

6. Vertical integration and cascade use

A tree is traditionally subdivided for different transformations. The first processing step could be slicing/peeling, sawing, chipping… Traditionally the forestry wood industry has always been very concerned to focus on vertical integration. Additionally we can state that waste is not really generated since all residuals are used. Technically recycling and reuse are key elements in the traditional cascade approach allowing the production of different wood based panels, eminent example being particleboard (chipboard). Linked to that a consortium ECAMOB has started to interact under the EU Strategic Implementation Plan - EIP on Raw Materials. Finally at end of life we still can generate energy or allow composting, both being close to ecosystem processes.
The traditional integrated processing is even based on subdividing trees. The lower part of the tree (e.g. a plantation poplar tree) was always considered to be a log for the production of veneer, plywood, timber... (Fig. 3). The top and residues from sawmills / veneer peeling are more included in bulk products like panels, pulp/paper, bio-energy... Future integration leading to even better sustainability could involve making more loops in the chain of products and hence work towards higher quality products (e.g. loadbearing beams) based on recycled materials.

7. Tree quality and wood quality

Trees are suitable for many different products/materials and might be assessed on quality and performance in respect to the typology attributed. Aesthetics are often prioritised when producing or envisaging sliced veneer, parquet, music instruments. Mechanical properties are critical for construction timber and many engineered wood products. Durability against decay, both biological and physical (weathering, fire…) are relevant for many construction uses, but anyhow requires specific attention when dealing with exterior uses and related options for wood protection. Creating large surfaces like wood based panels and paper/paperboard have since mid of last century been of major importance for our modern society. New in the quality approach is the level of suitability as building block for chemicals and biopolymers.
Wood has technological assets. Is has a beauty that always have been key for applications like furniture and interior design. It remains the ultimate multi-level natural composite making it very suitable for constructions and many load bearing applications especially due to its specific strength/stiffness. It is a renewable resource with an interesting and abundant chemistry. Even less favourable material characteristics like fire and decay resistance have been turned into advantages through modern approaches and innovation.
Our wood industry seem to be able to upgrade this renewable resource and make it toady even more competitive not only economically but surely when sustainability criteria are considered. Even when focussing on the case of plantation poplar, surely tree quality, but also wood quality are very relevant for the production of plywood and other engineered wood products. Besides the general use for packaging products (food, transport…) it remains valuable to increase flexibility in available construction products and provide complementary ones to those based on softwoods.

8. Service life impact

Wood and moisture can hardly be neglected in any wood product and this leads to issues related to dimensional changes and even fungal decay. Service life is important for most items humans use, but in particular for wood the word “durability” is very critical and is even in many languages the same word as “sustainability”. Since energy efficient housing and green building are now established goals for the future, we need to asses performance fully in line with the European construction products regulations. Service life estimation, prediction and costing also link with sustainability and environmental parameters like the LCA approach and impact on CO_2 sequestration. In relation to long lasting wood products there are surely positive aspects to sustainability when focussing on a fit for purpose approach, but there remains a need for technology to enhance service life.

9. Forestry – Wood research

All above topics to some extent underpin the need for dedicated research both in the forestry sector and in the wood sector. Research should try to bring together both and networking like the InnovaWood network (http://www.innovawood.com/) should be an option to facilitate this.
Also cross national interactions both through collaborative research in EU projects and several interactive networking like COST Actions, should focus on bridging between production of wood and end use. A chain approach is critical both related to quantity and quality aspects and the forestry-wood industry chain (FWC) requires improved linkage between forestry and wood technology. Although we are dealing with a traditional sector, both forestry and wood industry need to focus on innovation and cutting edge research techniques.

10. More wood and wood products in the EU

Forestry requires eco-economical investments, technology and know-how beyond nature conservation… Forestry might need even more foresters in future and hence academic and technical education should support this. We should not forget that sylviculture (the practice of controlling the establishment, growth, composition, health, and quality of forests to meet diverse needs and values) is critical for the link forest – society. The fact that forest certifications systems like FSC and also PEFC were established underpins the need for forest management. Wood production outside the forests is viable and we probably need to focus on more than just energy

crops: tree farming, agroforestry, polycyclic plantations… Even the production of high quality trees and precious wood species is feasible. Greening of agricultural area might be an excellent opportunity to create some necessary opportunities. Wood industry most probably does not only require economics of scale. Stimulating SME's and craftsmanship will allow to enhance potential of quality wood products and underpin local and general resource management of woody biomass is respect of adequate forest management. This is to some extent illustrated by initiative like 'Grown in Britain' (http://www.growninbritain.org/). With a future heading for more energy efficient and green building and even tall buildings we will need fit for purpose quality wood products. But there is an increasing potential to use also high volumes or quantities of bulk like products with an innovative technology upgrade. We will need to focus also on new pulp and paper products as well as on engineered wood products (EWP) and wood based panels (WBP). This could also be strengthened through SME based innovation related to quality and allow specific wood modification options being explored. There is a need for thorough reflection when increasing the impact of producing chemical building blocks through tempting developments using new types of bio-refineries and new materials. Similarly the discussion on 2nd generation biofuels is ongoing, however the full potential of thermochemical conversion as planned is not feasible. Alongside steering strategically the expected increase in focus on and in demand for wood products there is also a need to work even more intensively on the flow of selection - breeding - forestry - agriculture - ecosystem services to enhance quantity and quality of the raw material. In this respect countries like China and Brazil have invested considerably in planted forests. Also the increased interest in hardwood seedlings for high quality timber production is key for future eco-economic strategic options combining nature conservation, biodiversity and wood production to come to an overall sustainability.

11. Climate perspective and sustainability-concluding remarks

Climate change is a major challenge and trees and wood products can be considered key in this respect. There is a need to deal with climate change mitigation and at the same time remain sustainable at higher production levels. The forestry-wood industry chain will need to enhance and combine cascade use and service life approaches. The forestry-wood industry chain should not become a victim of the renewable energy boost in search for replacing fossil fuels. It might be better for sustainability to focus on low energy transformation processes and to substitute man-made materials by e.g. stimulating timber constructions. Sustainability in a climate perspective should also stimulate growing more trees, producing more long-lasting high quality forest products based on timber and in more general (lignocellulosic) woody biomass. This should be based on locally organised model forestry units that link directly with local wood industry. In an overall SWOT analysis the major strength is the fact that using the renewable resource wood is highly compatibility with the principle of sustainability. Compared to both man-made materials and fossil fuels advantages are evident but also lead to the need for strategic decision making.
The major weakness remains the production capacity. When the whole world would consume similarly as Europe or North-America we might need 2 to 3 times earth. In the analysis we can see either as opportunity or as threat the role of changing towards a bioeconomy. Do we need to embrace the creative destruction (revolutionizing the economic structure from within) this could initiate and decline from some wood products or should we focus more on creative innovation in line with the development of (nano-) fibres, 2nd generation biofuels, EWP's like CLT as complementary to the current situation?

Acknowledgement

The content of this paper was also presented in part as: "Advantages of using more wood products for the EU from a climate perspective" during the Wood Action Days on 23/09/14 to the EU Parliament in connection with the presentation of the Woodworking Industries' Manifesto, co-organised by CEI-Bois (European Confederation of woodworking industries; http://www.cei-bois org/, EOS (European Organisation of the Sawmill Industry; http://www.eos-oes.eu/), EPF (European Panel Federation; http://www.europanels.org/) and the European network on research and education Innova-Wood m (http://www.innovawood.com/).

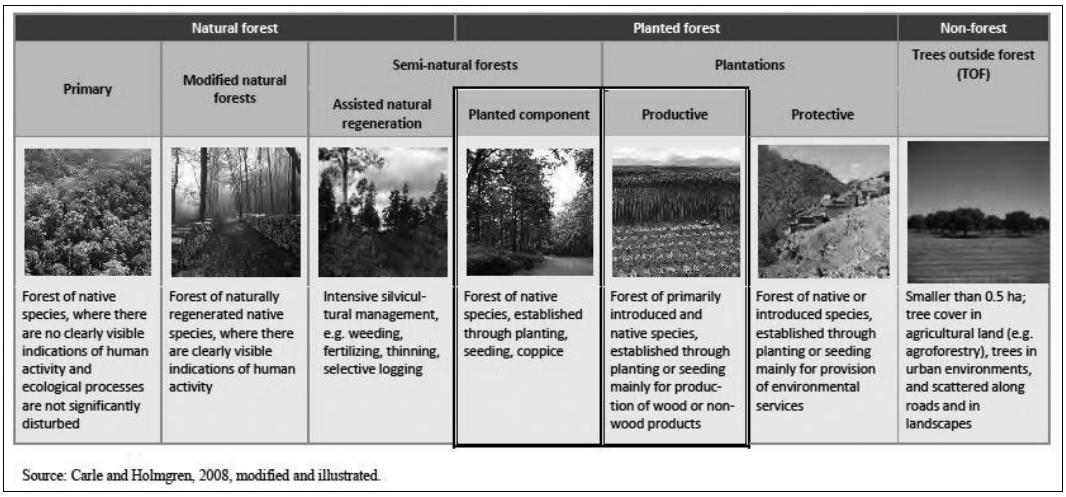

Figure 1. Continuum from primary forest up to trees outside forest (Jürgensen *et al.*, 2014).
Figura 1. Passaggio continuo dalla foresta primaria agli alberi fuori foresta (Jürgensen *et al.*, 2014).

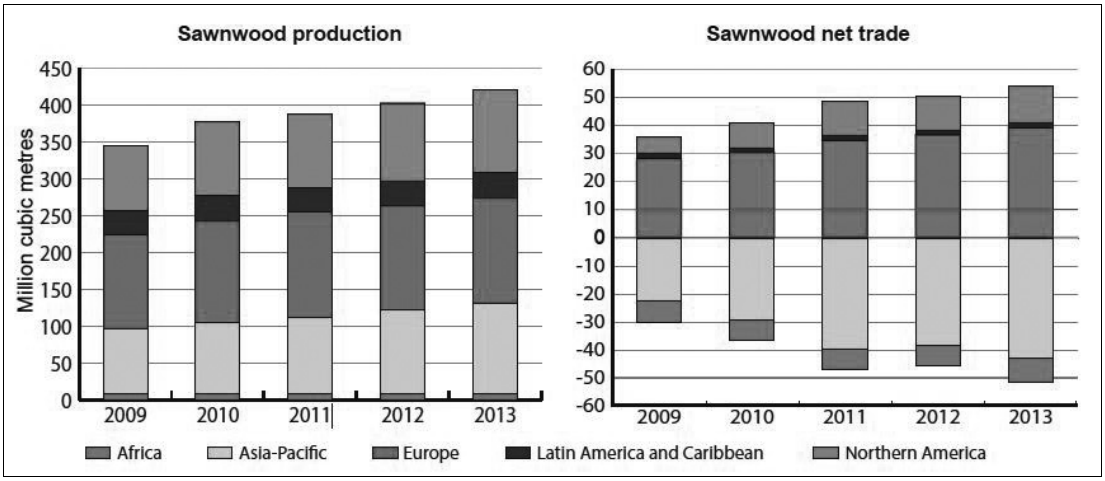

Figure 2. Sawnwood production and net trade (FAO, 2014).
Figura 2. Produzione e commercio netto di segati (FAO, 2014).

Figure 3. Scheme of the possible uses for the different tree portions (Castro and Zanuttini, 2008).
Fgura 3. Schema dei possibili usi delle diverse parti dell'albero (Castro e Zanuttini, 2008).

RIASSUNTO

L'uso del legno, fattore dello sviluppo della sostenibilità

In generale l'Europa è interessata a una fornitura adeguata e sostenibile delle risorse. Legname, legno, biomasse ligno-cellulosiche o qualunque sia il nome che diamo al materiale proveniente dal settore forestale e da quelli correlati, si tratta di una eminente risorsa rinnovabile con un elevato potenziale di sostenibilità e sicuramente un eccellente servizio ecosistemico per la nostra società moderna. Termini come uso a cascata ed economia circolare non sono certo una novità per la filiera legno-foreste, ma attualmente stanno ricevendo attenzione crescente. L'alternativa tra l'uso del legno come materiale e la bioenergia porterà inevitabilmente a una maggiore competizione per la stessa risorsa, e potrebbe evolvere in una grave carenza in Europa ancor prima del 2030.

L'integrazione verticale, congiuntamente a una migliore concezione della qualità dell'albero e del legno, dovrebbe portare ad un approccio più strutturato riguardo alla questione se alcuni prodotti derivati dal legno debbano costituire una priorità, e come si possa affrontare la sostituzione di materiali artificiali per l'edilizia che richiedono più energia per essere prodotti. Questa è chiaramente un'altra opzione rispetto alla produzione diretta di energia verde basata sulla coltivazione di biomassa legnosa. Quindi non è realistico concentrarsi solo su un utilizzo del legno quando si considera un approccio sostenibile per gli aspetti selvicolturali delle foreste. Di sicuro la discussione riguardante la fine del ciclo di vita permette di mettere in evidenza la conversione dell'energia contenuta nei prodotti legnosi, e deve essere ottimizzata attraverso innovazioni legate alla combustione e ad altre conversioni termochimiche simili al trattamento biochimico, ma deve continuare a far parte di una catena integrata foresta-legno. Anche l'opzione bioraffineria per produrre "mattoni chimici" e altri componenti per la chimica bianca o verde non deve essere sviluppata separatamente. Questa affermazione si basa sul fatto che la tradizionale trasformazione degli alberi in prodotti forestali può soddisfare direttamente le esigenze di un'economia verde in misura molto adeguata.

Al momento gli alberi, i prodotti derivati e i residui sono troppo usati come risorsa energetica alternativa per risolvere i problemi iniziati dalla diffusione dei combustibili fossili e dei *backbones* petrolchimici, ma è necessario concentrarsi sulla sostituzione di materiali artificiali che presentano un alto contenuto di energia incorporata.

Nell'approccio globale dell'economia circolare la valutazione del ciclo di vita è sicuramente correlata alla durata in servizio ed al suo impatto sul ciclo di vita. In questo senso i prodotti legnosi vengono criticati. Un miglioramento della qualità in relazione alle prestazioni durante la vita in servizio, e lo stimolo di innovazione che ne deriva, sembra una scelta migliore rispetto alla semplice conversione diretta in energia della biomassa ligno-cellulosica raccolta.

REFERENCES

Carle J., Holmgren P., 2008 − *Wood from planted forests: A global outlook 2005-2030.* Forest Products Journal, 58 (12): 6-18. Available at: http://www.undpcc.org/undpcc/publications/details.php?id=656&t=1359682760

FAO, 2014 − *2013 Global Forest Products Facts and Figures - Highlights for 2009-2013.* p. 16. http://www.fao.org/fileadmin/user_upload/newsroom/docs/FactsFigures2013_En.pdf

Castro G., Zanuttini R., 2008 − *Poplar cultivation in Italy: history, state of the art, perspectives.* In: Van Acker J. and Fioravanti M editors, Proceedings of the COST Action E44 Conference on 'A European wood processing strategy: future resources matching products and innovations', pp. 141-154.

Jürgensen C., Kollert W., Lebedys A., 2014− *Assessment of industrial roundwood production from planted forests.* FAO Planted Forests and Trees Working Paper FP/48/E. Rome. Available at: http://www.fao.org/forestry/plantedforests/67508@170537/en/

Mantau U. *et al.*, 2010 − *EUwood - Real potential for changes in growth and use of EU forests. Final report.* Hamburg/Germany, p. 160.