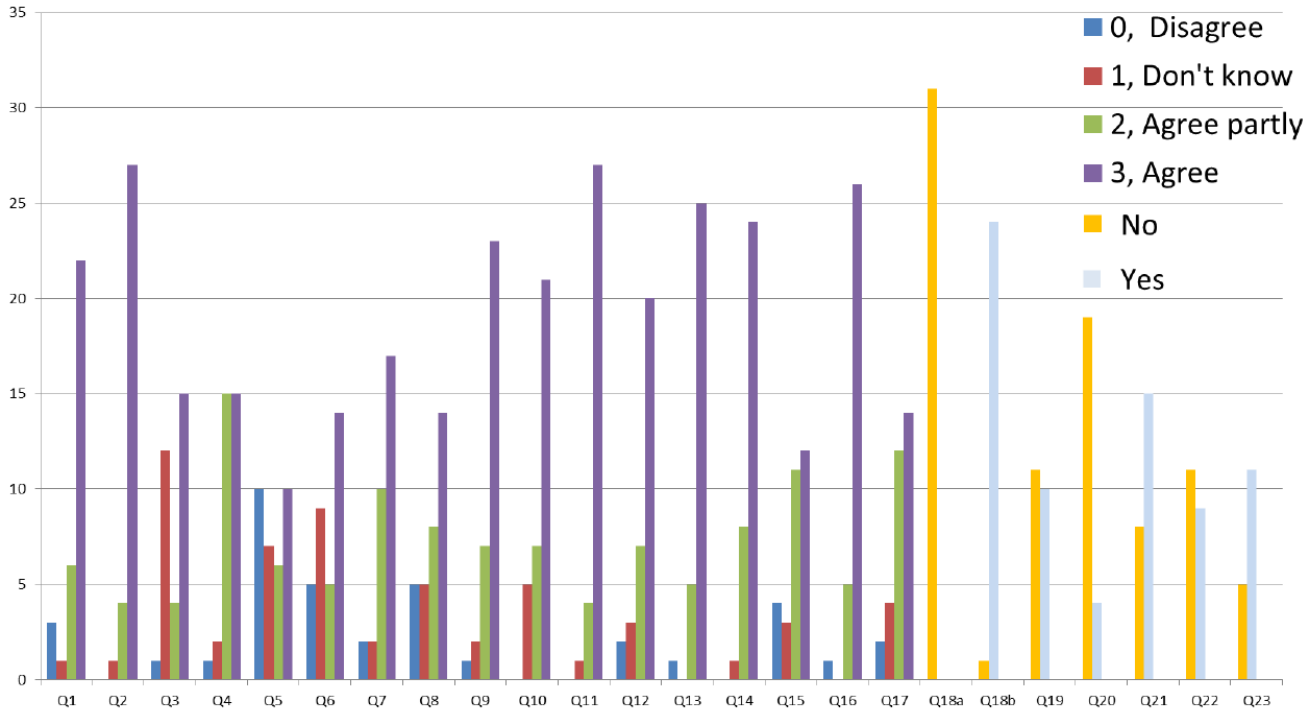
Survey questions and answers

Summary of results:

- 33 responses (>50% of participants)
- Many supporting comments
- Topics for the parallel sessions identified based on diverging views in the survey
- Some key comments used as introductory material for the parallel sessions



Key:

3 = agree

2 = partially agree

1 = don't know/undecided

0 = disagree

Background on forest-based bioenergy and associated climate effects

1. Analysis of climate effects of forest bioenergy needs to consider changes in forest carbon stocks and the full range of forest products, in both bioenergy and counterfactual scenarios.

Q1: 0: Forest = carbon stock; Reference year of Kyoto Protocol = 1990; reporting on carbon stock under 3.3 and in some countries under 3.4. Hence carbon emissions are already accounted for (excluding the amount of fossil fuels required for felling and logistics). I would only agree that in case of long term storage in forest products in e.g. wood construction and high value furniture wood energy may cause some higher emissions. However, to my current understanding, this is only relevant, if these wood products store carbon for more than half the rotation age of the forest from which they originate.

Q1: 3, However, priority should be put on the capacity for CO2 uptake of a forest. Even reduction of the carbon stock by harvesting of (over-)mature trees/stands will increase the positive effects of forests regarding CO2 emissions, as the capacity for CO2 uptake would be maintained/increased.

Q1: 2-Not necessarily as it may be simpler to consider only fluxes to or from the atmosphere. Some terms of the analysis will already necessarily be fluxes (e.g. emissions at the chimney), so using only fluxes would make the analysis more coherent. However, both approaches have to incorporate some modelling with different sources of error and uncertainties and differences can be important.

Q1: 3 = agree, this should be the target of climate impact analysis. However, it might be challenging and significant uncertainties are related to consequential modelling

Q1: 2. Basically yes, but what can be done in practice with sufficient certainty.

Q1: 3 = Agree, in cases where the objective is to understand the effects of increased use of biomass on atmospheric GHGs. But in cases where the objective is to characterize the actual net emissions from the biomass energy system, these need only be considered in the system itself (not the counterfactual system).

Q1: There are dangers in such a generalised statement. It depends on the purpose of the analysis. If the purpose is policy analysis, then the answer is 3. But analyses for certain other purposes may not need to consider all of the aspects covered in the statement.

Q1: 0 – Disagree. The carbon stored in forest is already circulating between the atmosphere and the forest, with carbon being sequestered through photosynthesis and released again in decomposition processes, when litter falls or trees die. Turnover times of a magnitude of a century, maybe less or some centuries. This is not the case for fossils, for which there is basically no natural exchange of carbon between the pools and the atmosphere. The tremendous difference in turnover times between fossils and biomass exists regardless if the biomass fuels are based on stems or residues, boreal, temperate or tropical forests, or if the wood comes from already managed or previously un-managed forest.

The focus should rather be on sustainable forest management – sustained yield, and protection, maintenance or even improvement of environmental, social and cultural services and values, considering also the intrinsic values that un-managed natural forests have.

However, some attention should be given to forest soil carbon pools and the dynamics of this pool. There is only little knowledge about the dynamics of these pools, but some of the soil carbon is probably stored there for millennia. Disturbance or severe depletion of this pool should be avoided.

Including forest and forest product carbon in analysis could also be argued if there is a tipping point and we have alternative renewables to bioenergy, that can provide larger emissions reductions than bioenergy. As far as I understood, however, there is so far not much evidence of a tipping point, and if fossil fuels should be out-phased, probably all renewables must contribute their maximum for a long period of time.

If forest and forest product carbon are anyway included in analyses, much attention should be paid to the counterfactual. There is only little need to including those pools that already have fast decay rates in the counterfactual scenarios (=the biomass is not used for bioenergy).

Probably there is only little reason to include changes in stocks of biomass from managed forest that are residues, or stems already used for short-lived products such as pallets and pulp and paper, while it is more likely relevant to include wood from managed forest that would otherwise have been used for especially long-lived construction and furniture. These products have a relatively long decay rate for the counterfactual. It must be considered, though, that the harvested amounts of large-sized timber for long-lived products do not correspond to the amount of carbon stored in long-lived wood products. A large part of the trunk will end up as saw dust and shavings from the processing, maybe as much as 50-75% of the harvested stem wood. Use of stem wood from currently unmanaged forests may be another relatively more relevant pool, especially in colder climates, that has the slowest decay rates for the counterfactual (natural mortality in the forest). Table 1 was constructed to illustrate these points, but please notice that all values include are not documented, but only for illustrative purposes.

Q1: fully agree. In addition it is necessary to take into account changes in C stocks of long-lived products derived from forest use

Q1: 2 = partially agree. Only partially, because significant questions remain whether this consequential modelling can actually be carried out with sufficient certainty.

Q1: 3, agree: Full carbon accounting is very important in understanding and improving the management and use of forest biomass and other biomass for energy and products. Full carbon accounting does include changes in carbon stocks and allocations to all products.

Q1: 2. I agree that this should be the general approach, but not all of this is always relevant, whilst there are other changes that should also be considered (like the counterfactual energy scenario

Q1: 3: we fully agree. However, if the analysis is aimed at supporting policy decisions, the scope should be enlarged to include all the sectors affected by the policy decision. Beside the forest and the forestry products, also sectors that are impacted by the bioenergy policy (e.g. the energy and competing materials) have to be included in the analysis to internalize what is actually displaced by biomass use for bioenergy

Q1 0; the question to be answered pre-defines the scope of the analysis; the statement is only true for “high level” policy recommendations.

Q1: 3 – Saying that also the production rate/flow of raw material for potential substitution of energy alternatives and materials with large carbon footprints is important. “Don’t get stuck with the stock” since the flow of raw material has much greater climate mitigation potential than the stock.

Q1: 3, provided the analysis is done using a long-term perspective and considering secondary effects on willingness to increase forest biomass production and/or saving/recreating forest at the expense of other land-use. Otherwise the results may be misleading.

Q1: Counterfactual scenarios are generally not needed to assess the climate effects of bioenergy nor any other service or system . However, the difference in climate effects of two scenarios are also generally of interest.

Q1: Yes, forest carbon accounting without considering fate of products is of little use, and vice versa

2. Forest product output and forest carbon stocks are determined by the forest structure (e.g., age distribution, species composition), natural abiotic/biotic forces and character of the associated forest industry (e.g., ownership, management practices, product portfolio). Since conditions vary considerably around the world, analyses must reflect the specific context (e.g. specific growth and decay rates, residues combustion at roadside, expected future forest product markets, etc.)

Q2: 3, Keep analyses of forest management separated from analyses of biomass utilization. (in this case slash burning)

Q2: 2 I think some factors are more important than others and that we can often generalize

Q2: 3- agree but the first statement is not fully correct. The industry is one player but most of all it is local forest management stewardship and policies that control forest product output and forest carbon stocks (yes demand is a driving force but for example setting aside land for conservation has impacts and is not driven by the industry).

Q2: 2 = Partially agree. The sentence suggests the need for perfect information, which is never possible. The data quality requirements for various parameters should be examined using sensitivity analysis so that efforts to obtain site specific information can be focused on parameters where it is important to have such information

Q2: complicated thing, however I strongly support this perception since we need to have a founded analysis of the impacts of our forest-related operations. Agree

Q2: (3) – Agree.

I do not see clear reasons to focus on the short-term, but if it is decided to do so, and include forest and forest product carbon in analyses, it is also relevant to consider the specific context. For example, a skewed age class distribution in a forested landscape may indeed influence the short-term impacts.

Q2: Agree with the need to take the specific context into account. Some of the causal connections mentioned in the first sentence may be weak or fuzzy (go both ways), e.g. that between forest ownership and C balance.

Q2: 2, partially agree: Yes, if you are assessing a particular project with given stands and a land base, but it is still feasible and useful to group and characterize many of these variables and functions into representative conditions, functions, actions, and practices over broader areas, regions, or stand types. The greater the detail, the better is the accounting, but not always practical, feasible, or economic. Yes, product allocation to reflect market conditions are important as well as the other variables.

Q2: 3 – Absolutely. The system is much more complicated than assumed in many studies.

Q2: 3, however it is possible to learn from literature what factors are more/less important from a quantitative and long-term perspective. Such a lesson is that permanent carbon losses from the ecosystem must be greater than what is contained in 6-8 centimeter of peat/pure humus (25-30 ton C/ha) to off-set the substitution value (for the overall GHG

balance of society) of yet relatively low forest production in one rotation period, provided that most biomass will end up as construction material or energy in one form or the other with time.. Thus, various forms of drainage is the only problematic land use in this respect. Also deforestation can be motivated if the replacing short-rotation biomass production is decent. (However, this is based on the condition that general incentives to phase out fossil fuels are in place so that fossil help energy is kept low.)

Q2: Yes indeed, many factors do influence the dynamics of natural resources, their management and markets.

Q2: Yes, the carbon balance of this system must be based on real data and not on assumptions. That can be done at different scale levels, but a global analysis is probably only realistic as a compilation of regional analyses.

3 There is evidence that a fraction of pellets imported into the EU as well as of pellets produced within the EU comes from non-residual wood. Still, there is a lack of statistical data on the type (e.g. lower/higher quality roundwood, residue, wastes) of feedstocks used for bioenergy within and outside Europe, including for domestic and other small-scale uses.

Q3: Fact is that we don't know the origin and type of wood fibres going into the pellet production process. Also this figure is highly variable and may depend on the local and global market situation of upstream sectors (sawmills, plywood producer, veneer producer, etc.) and the price of the forest fibres. Higher quality roundwood may be excluded, due to high raw material costs.

Q3: 1, Poor statistics, yes, but that is the case also for several other forest products. The term "non-residuals" should be avoided as it is highly difficult to define on a general scale. E.g. "non-merchantable" stands or trees or "side-products" in the wood manufacturing process. Potential problems are normally already foreseen and included in the forest or land-use legislation. Thus, no need for any specific additional biomass energy legislation.

Q3 3-agree. However, the definition of what is residual and non-residual wood is also highly dependent on local context, and is therefore not a very useful concept to classify biomass feedstocks. For example, the diameter of a 'merchantable' tree (i.e. a tree that can be used for traditional wood products) varies from one jurisdiction to the other

Q3: 2= Partially agree. In the U.S., there are few, if any, publically available data on the feedstocks used by pellet mills, but the mills themselves have this information.

Q3: I don't have clear evidence but I strongly doubt that there is clear and strictly followed distinction between what we might define as residual and non-residual wood, particularly outside the EU. ? partially agree (due to lack of clear evidence)

Q3: 1 – I am not aware of this but not closely following either. I would be surprised by too much higher value material ending up in pellets do to the economic impact, the exception being where subsidies override market values.

Q3: I have yet to see any hard evidence for this. All I have seen is unsubstantiated claims, based on circumstantial and/or ambiguous data have been made. Perhaps hard evidence may be presented at the workshop? But again, this is a dangerous and also a 'leading' statement - what is meant by 'non-residual wood', and why should it matter if some is being used for wood pellets?

Q3: 1 – I do not know of such evidence even if it might exist. However, I find it relevant to monitor the feed-stock type and origin for many reasons; even those reasons are mostly related to other concerns than climate impacts. From a climate perspective, I find it less interesting if pellets are based on residual or non-residual wood.

Considering other values than climate impacts, it is however important to know if previously unmanaged forest get into management, or if there is a substantial intensification of the forest harvesting and management. This may have consequences for biodiversity and a number of other values that we otherwise wish to protect.

If the market shifts from production of long-lived wood products to using high quality wood for energy it might also be important to know, if it means that more fossil materials are needed to make products that were previously made of wood. The market will normally prevent the use of high-quality wood for energy, as the prices of such wood are generally much higher than what is paid for energy biomass. But perhaps there can be specific circumstances

Q3: : I know next to nothing about the European pellets market, but I agree on the lack of robust statistical data in many fields, and very likely also in that arena

Q3: 3, Moreover, more data are needed not only with regards to the origin of biomass (supply side), but also with regards to their end use. As for non-residual wood coming from US or Canada: imports may be due also to other contingent reasons (slowdown of the housing sector in the US that caused a downturn of demand of wood; pests and storms in Canada).

Q3: 1, disagree. The source of imported pellets is between the seller and the buyer, but that does not appear to be the question. What is the question – it is not clear? There is always a need for more data about forest feedstocks.

Q3: 3 This is true, but it is not clear what is inferred by this statement.

Q3: 2 – There is more than evidence here. Roundwood is used for energy purposes when the situation/market allows it. Pulp and paper is a cyclic industry where demand for pulpwood or the price changes over time. Competition/changed behavior (printing) also nocks out pup and paper industry from some markets. Energy as an alternative for small diameter roundwood is good news for forest owners during such circumstances and helps in the overall forestry economy and the willingness to invest in increased production. An increase that at the end of the day also will increase volumes of saw timber with potentially much larger displacement factors than energy wood

Q3: What is the question? Also stem-wood will die and break down sooner or later if left at site. The use of stem-wood is not a problem from a carbon balance point of view. All forestry must be sustainable, though, i.e. enough natural forest must remain (or for NL, UK, etc - be recreated) to preserve all forest-dependent species of the region.

Q3: We would be happy to see more and better statistics on trade in general

Q3: Agree. In principle, it is no sin to harvest forests for bioenergy purpose, but alternative wood use pathways using cascading will often have a better carbon balance

4. Climate forcers other than long lived GHG (CO2, N2O, CH4) such as albedo, black and organic carbon, evapotranspiration, ozone precursors etc. may also have important influences on climate effects of forest-based bioenergy. Ideally, assessments should include these factors, recognizing regional differences and counterfactuals.

Q4: This is very true and really important, since the highest share of biomass used for energy generation is often used in inefficient applications (e.g. old stoves). In many countries wood based energy generation for heat is reported to be the most important single source for small particle, black carbon and Methane emissions. Only if these factors are well reported, decision makers can make fact based policies.

Q4: 1, Yes, but main-stream factors should have priority in “political messages”

Q4: 3, but we can learn much with more limited considerations nonetheless

Q4: 2-important in some systems but mostly concerns afforestation and has little relevance in the absence of land-use change, i.e. in the case of forest remaining forest, especially if only forest harvesting residues are being used for bioenergy.

Q4: 3 = agree. Also biogenic volatile compounds (terpenes, isoprenes) emitted by forests should be included

Q4: 2, but knowledge on these forcers, their long-range transportation, interaction with other airborne emissions and climate impacts is still poor.

Q4: 2 = Partially agree. First I must disagree with the inclusion of methane as a long-lived GHG. In cases where methane is associated with a biomass energy system or with the counterfactual to that system, methane’s GHG potency and relatively short lifetime in the atmosphere necessitates dynamic modeling to correctly estimate the timing of benefits from the biomass energy system. Second, while “ideally” it would be best to include these factors, the data are currently inadequate to allow them to be addressed in many scenarios. The just-released final draft of the IPCC Fifth Assessment report from WGIII indicates that “There is currently low agreement on the net biophysical effect of land-use changes on the global mean temperature. By contrast, the biogeochemical effects of LUC on radiative forcing through emissions of GHG is positive.”

Q4: little) partially agree; they may have important influences, however there are two points: 1st: we have still low evidence about many of these mechanisms (research needed of course)

Q4: It depends on the purpose of the analysis, and on the significance of the effects of these other factors. Some have variable effects whilst the magnitude of the impacts of others are poorly understood at present.

Q4: 2 – Before setting up requirements that standard climate impact analyses of forest bioenergy should include albedo, black carbon, evapotranspiration etc., it should be examined if these effects are significant in a number of specific settings. If the effects due to changes in any of these factors generally over-rule the effects of, for example, changes in forest and forest product stocks, then analyses of changes in forest and forest product carbon stocks are less important, also in a short-term perspective. If the effects are only important in specific regions, they should only be included for these regions.

Q4: I think it would be absurd to disagree that factors such as albedo changes can influence the overall climate effect of forest bioenergy. Of course any factor influencing the climate

system needs to be taken into account when judging the climate effect of options (and of course we need to be aware of all the uncertainties involved).

However, I think that decisions on forest management, including forest management for bioenergy, need to be based on more criteria than climate effect alone. For example, cutting down forests can increase albedo in regions with high snow cover, and likely that effect may even be bigger than that of the C loss resulting from cutting down the forest, but I doubt that this effect alone should be used to justify cutting down forests: forests are multifunctional ecosystems and supply a plethora of ecosystem services beyond their effect on climate; all of those need to be considered in making sound management decisions.

Moreover, I think we should bear in mind that some of these effects may in itself be sensible to future climate change, e.g. if warming reduces snow cover, the albedo effect of cutting down the forest may vanish

Q4: 3 = We agree. Add biogenic volatile compounds (terpenes, isoprenes) emitted by forests.

Q4: 2 Differences probably arise when a forest is harvested ONLY for bioenergy. Or should we consider all these issues also for forest managed under a "business as usual" scenario? Albedo changes when a forest is harvested, for whatever end use of the wood removals.

Furthermore, the effect on the albedo may be not so relevant when we apply a single-tree cut system, or partial cut system or thinnings. Also consider that about 30% of EU forests are "uneven-aged" and even for even-aged forests, part of the harvest (sometimes the main part) is provided by thinnings. So, this issue of the "albedo" may not be so relevant for many countries.

Q4: 2, partially agree. Yes, it is known that there are many forces that influence the climate changes, but there are several issues concerning their assessments. First, not all can be attributed directly to forest-based bioenergy and separated from other activities on the landscape. Second, these types of added assessment are very costly. More research is still needed before such implementation.

Q4: 2. Agree that these can be important (just like for any other sector or energy source). I strongly disagree with using this to distract from progress on C balances. The C balance is and will remain a crucial issue, it is absolutely vital, and that is where the biggest and most acute problems are. Arranging deckchairs on the Titanic.

Q4 2; yes for "high-level" (consequential) policy analysis, no, for attributive LCA studies (for whatever purpose)

Q4: . 2 – Absolutely, but this further complicates the picture and adds uncertainty when climate effects of different scenarios/decisions are assessed. For the time being it may be better for these additional potential drivers to be a field of research of their own until there is a common agreement of their importance and realistic assumptions of their impact in climate impact models given different scenarios/decisions

Q4: 3, however not in every analysis each time. These factors can be analyzed separately first and then be considered only in cases where they have significant impact.

Q4: Agree but not on the last point. Comparative analysis of different scenarios are generally of interest but so are analysis of individual systems, and states.

Q4: Yes, agree. Other GHGs are due according to IPCC rules. Albedo, evapotranspiration, etc not, but they effectively contribute to the climate effect, so should be considered.

Carbon accounting and policy implementations

5. LCA-based decision support or assessments related to specific products (e.g. product carbon footprint) should follow an attributional modelling approach, i.e., attributional LCA (ALCA).

Q5: 0: I could only agree to some extent, if the framework is correct – In carbon accounting, in particular for forest based biomass in northern hemisphere long timeframe is required – 80-100 years (this will avoid discussion about carbon debt).

Q5: 2 However, many if not most LCA suffer from applications of oversimplified or false assumptions. Forests, and forestry is far more complex than most modellers seem to appreciate

Q5: 3, for project level accounting

Q5: -undecided. We are no specialists in LCA so difficult to comment, but our understanding is that a consequential LCA looks at marginal changes that a new system would cause relative to a reference system, which might be a more appropriate model for studying the marginal impact of bioenergy deployment relative to baseline fossil fuel scenario.

Q5: 0 – consequential effects can dominate in market driven bioeconomic systems and can be empirically based.

Q5: 2 = partially agree. This depends on the decision-support context, where the LCA results are used. (Also, as a general note and according to my experience, the definitions of ALCA and CLCA are still partly under discussion and different experts might have different ideas what is meant by each of them.)

Q5: 2 I do agree with this statement, but only under the condition that broader system analyses (e.g. CLCAs) have already been conducted to establish a reasonable policy framework in which ALCAs can reasonably be utilized. Otherwise the use of ALCAs is a bit like using an un-calibrated model. Generally the term “carbon footprint” recalls assessments for products with well-defined system boundaries and parameters….Having adequate data and input variables is essential. There is a fine line between reducing complexity in the name of operational efficiency/effectiveness, and needlessly ignoring complexity.

Q5: 1. The fundamental question is: should the LCA numbers (ALCA / CLCA) be used in some policy measures (emissions trading, national carbon accounting etc) or not? Or are they just interesting future scenarios about the potential emission or climate impacts of biomass use?

Q5: 3 = Agree, as long as the information is to be used to answer the question “What am I buying?” However, if the question is “What is the consequence of buying this product?” a consequential framework may be necessary.

Q5: This is a very ambiguously worded and confusing statement and it is dangerous to try to answer it. What is meant, for example, by 'decision support' and by 'product carbon footprint'? The choice of LCA method depends on the purpose of the analysis and the question being addressed. It is far from clear what the question is. However, it may be noted that 'decision support' generally implies e.g. deciding whether or not to do something, which implies the application of consequential LCA.

Q5: (3) – This is not my field of expertise, but this seems to be the recommended practice.

Q5: strongly disagree. ALCA cannot incorporate all mechanisms that may affect the full climate effects of deploying bioenergy, in particular it cannot capture market-mediated

effects. These are very important, however. Overall, I am not sure whether such decisions can be built on LCA-type methods alone – I tend to think that LCA approaches need to be complemented by suitable other approaches to understand effects from such feedbacks. I should add that I do not regard myself as being an expert on LCA

Q5: We disagree. It depends, first of all, on how attributional and consequential modelling are determined in practice, but also on the philosophy behind i.e. whether the decision is considered good or bad based on the deontological (the morality of an action based on the action's adherence to a rule or rules) or teleological (the consequences of an act determine whether an act is good or bad) rule ethics (see Ekvall et al. 2005). In addition, it depends on the decision-support context (micro-meso-macro level / scope on changes vs. on-going unchanged activities)

Q5: 3, agree. If the goal is to determine the footprint of a product, then the attributional approach can be used.

Q5: 0. I don't see why decision support in practice (i.e., not policy decisions but those on the ground) would need to follow any modelling approach. Moreover, I do not believe that relevant GHG impacts can be established for "products" as such (in the sense that certain product categories could be assigned a certain GHG value). The land use element is key to the GHG impact, the land use impact is largely independent of the "product" as such, but is very sensitive to the scale of production.

Q5: 3: we fully agree. If the decision is at micro-scale level (does not impact production capacities, see the first sentence in point 6) or is aimed at accounting (carbon footprint, Environmental Product Declaration), the attributional modeling is appropriate. However, the results of attributional LCAs should not be used to support policy decisions aimed at determining large scale changes in the same sector and that would impact other sectors of the economy

Q5: 2 CLCA is always more informative than ALCA but in some circumstances CLCA is impractical. So ALCA should be *allowed* where CLCA is impractical; but not *mandated*. ALCA needs to be adapted to accommodate additional factors: C stock changes in biomass and soil; timing of emissions and removals; albedo; adjustment for indirect effects – ILUC, rebound. (Does the latter make it consequential?? Depends on definitions of ALCA vs CLCA!)

This should not be interpreted to mean that all decisions and all carbon accounting require LCA. Carbon accounting under UNFCCC does NOT use LCA, but rather applies sectoral approach and annual reporting of emissions and removals. Kyoto Protocol accounting compares these with a target, across a compliance period.

Q5 2; for practical purposes of product LCA, carbon footprinting, environmental product declarations, etc., yes. Consequential LCA – unfortunately – is not a standard way of calculating LCA and requires a huge effort in scenario development, data crushing, etc. Current LCA databases and software do not allow for a consistent approach to consequential LCA (although ecoinvent 3.o is trying in this direction).

Q5:). 0 – Considering the complexity in the forest – forestry – forest product system, a consequential LCA (CLCA) is more appropriate even though the complexity in such analyses include more assumptions and thereby uncertainties. Those who are stuck into ALCA have to realise that the factory/production of a product starts already in the forest. Wood can not be handled as finite resources as minerals or fossil fuels since it is renewable and future large market opportunities have the potential to increase both the stock, annual growth, potential annual harvest, and thereby substitution potential. Don’t forget the forest owners and their decisions!

Q5: I am not familiar with the meaning of this term in this context

Q5: It is not either ALCA or CLCA. In many situations ALCA serves perfectly as a decision support tool, in other situations a CLCA approach is also relevant

Q5: Consequential approaches need more attention, but are in a too early stage to implement into rules and policies

6. In ALCA the decisions, actions or products analyzed are assumed to have no consequences outside the decision/action context, i.e. not influence available production system. As decisions or actions of forest managers for forest bioenergy typically concern areas capable of providing a steady flow of extracted/harvested woody material, ALCA should be done at landscape level.

Q6: 0 – There is biological limit of sustainably available forest fibres. Higher demand will cause higher prices and thus the market mechanism will trigger some solution (innovation, substitution, efficiency, etc.) – this might be beyond the scope of an ALCA?

Q6: 2 The sustained forestry concept, and the "landscape approach" should be complemented by influences from the CO2 absorbing curve (early sharp peak, slower but steady decline by age of stands)

Q6: 3 - not an LCA person – but it seems to me that "landscape ALCA" is a type of Consequential LCA

Q6: I disagree (0) because incorporation of landscape level effects increases complexity (e.g. economic/ market impacts and incorporation of dynamic baselines/anticipated future scenarios) which are more akin to consequential LCAs

Q6: 3 = Agree. Especially where increased demand may result in investment responses by landowners, it is critical to perform the assessment over at least a landscape level, and even better, at a level reflecting the market responses.

Q6: This statement is ambiguously worded/expressed and therefore cannot be answered meaningfully. But as with statements (4) and (5), it should be noted that the LCA method (and also the choice of system boundary) should be determined from a clearly defined purpose/question that is being addressed by the analysis.

Q6: (3) - This is not my field of expertise, but it seems reasonable. Stand level approaches rarely give meaningful results (even if it might depend on the question asked).

Q6: Not sure – I tend to think that this does not fix the problem. I rather think the core of the issue are stock/flow relations. I am not against looking at the landscape scale, on the contrary, I think it is necessary to understand what is going on at all relevant scales. But still my suspicion is that moving from the stand to the landscape scale is not the crucial thing we need to do first, nor do I think it will bring the clarity we need because it raises an additional level of complexity. In my view we need to focus on understanding the complexity arising from the stock/flow issues which is aggravated by the fact both ecological and socioeconomic stocks and flows need to be considered which are both nonlinear over time. Once we got that right we can move further to include the complexity arising from the distinction of plot vs. landscape scale.

Q6: 2 In principle we could agree, however the problem becomes setting the boundaries of the landscape.

Q6: 3, agree. Yes, Attributional LCA should be completed across the entire supply area as a minimal and even at larger scales as appropriate.

Q6: 0. It would be easier to reply if I had seen an ALCA reflecting "landscape level" changes. I have serious doubts whether it is possible. I certainly disagree with the suggestion that decisions are "typically" linked to areas capable of providing such a stream. First, a LOT of forest owners/managers have control of too small an area, and this is an issue both in the EU and the US. Second, even for large management units, the key issue is the impact of the change (increase) in demand, which is not "steady". We have to model the impact of change, and ALCA is not suitable for that, no matter how big the landscape is.

Q6: 3 The whole managed forest area should be considered.

Q6 2; attribute LCA is a “descriptive” static approach; attributive LCA does not assume that a decision/action has no influence outside the product system, because attribute LCA does not assess consequences of decisions/actions. However, I agree that impacts on forest carbon pools shall be assessed on landscape level (and not on tree level or per ha level).

Q6: 3 – Still with the opposition under 5 the landscape level is a necessity as well as the policy context, future market opportunity context, and trends in stock and harvest levels over time on a county/country level.

Q6: 3. Seems reasonable

Q6: In a pure ALCA one does generally not model nor attribute any changes in the market equilibrium to the final product. This is relevant for the inter-requirements matrix in an LCA. The characterization of stressors (e.g land use) are generally independent of a CLCA and ALCA approach (E.g Recipe;CML200 etc). I do not quite see the relevance of ALCA in a discussion of characterization of land use impacts. In general valid arguments can be put forth for different approaches to land use impacts. For inspiration see. e.g biodiversity impact models in LCA. Some of these follow a perturbation-return scheme (e.g stand level in this context).

Q6: Certainly better than the stand level

7. To assess impacts of a given action through LCA, accounting should start at the time when the decision for action is taken, i.e. for bioenergy from existing forests this is the time of additional biomass extraction/harvest to provide bioenergy feedstock, or the time that managements was changed in other ways to respond to bioenergy demand (e.g., changed thinning frequency and extent, extra fertilization).

Q7: 1 Also actions taken to sustain, increase or maximize CO2 uptake capacity of a forest should be included

Q7: 1-undecided (accounting starts today or at the time of implementation) again it depends if we value only short term benefits or not.

Q7: 2 – valid arguments on both sides of this issue, but to me these policies only may sense in the long run. So I don’t worry too much about starting point issues. If you are doing assessment over a short enough time that starting point choices can reverse the decision – then in my opinion – you are probably taking a short term view.

Q7: 2 = partially agree. This depends again on the decision-support context. If the aim is to support current decision making, we need to understand the impacts from today onwards (e.g. the impact of harvesting a forests or establishing a new forest for bioenergy production

on abandoned land today). If the aim is to study efficiency of a decision made in past (e.g. the impact of starting a new type of forest management 30 years ago) we can start the assessment at some point in the past to study the long term impacts (but this does not remove the impacts if we harvest the forest today).

Q7: I agree that accounting should start at the point in time the key action takes place, but it is often necessary to incorporate prior and anticipated activity into scenario design, so I am going to go with 2.

Q7: 2, depends on the question what we are trying to answer. What are we looking for? Past actions on enhancing forest growth might be used as reasoning e.g. when negotiating for burden sharing between countries in international climate negotiations. On the other hand, as we cannot influence the past, only actions made from now on can have an impact on the climate impacts in future. Rather a political than scientific issue.

Q7: 3 = Agree, to the extent that the question is limited to studies of the response to increased demand. If the question is related to the attributes of currently produced bioenergy, a different time frame may be needed

Q7: strongly agree; just to get it right: the status immediately previous to the action is started is an implicit part of the assessment of course, as reference case, before/after, LUC …

Q7: 0 – It may be accidental when a decision is made in the long management cycles of a forest. It seems more useful to assess the average change in pools and emissions over a long period of time, when changing from one management system or practice to another.

Generally it also seems more useful to consider sustainable forest management more broadly as the impacts of a management change may be larger for other values than climate

. For example, increased use of fertilization may have only little climate effects, if the additional emissions are small per se, or small compared to the increased biomass production (higher carbon sequestration and substitution opportunities). However, the consequences for, for example, water quality might be significant.

Q7: : Not sure whether I fully understand what that means. With forest ecosystems, the issue at hand is that stock/flow interactions play out over centuries, so I am not sure whether we can get it right without looking at the full range of temporal depths that may be relevant, including the long-term history of the forest we are looking at, which may have a big role to play for its C balance with and without additional forest harvest. See the recent paper by Erb et al. in Nature Climate Change on Austrian forests.

Q7: 2 = partially agree, depends once again on the decision-support context. If one aims to give decision support to guide activities from today onwards, then false decision-support is given if one considers the impact of change in forest management regime 30-40 years ago. One cannot influence the past. It should be noted that the same holds true also to the decision to afforest a land and harvest the forest in the future. If the impact of the harvest decision is considered, then the accounting should start from the decision to harvest. On the other hand, if the overall impact of afforestation and harvest is of interest, then the accounting should start from afforestation. Existing managed forests have been once afforested or reforested to be harvested at some point in time, thus it may be very difficult and possibly pointless to separate between existing forests and “new” afforested forests as regards to impacts of harvest decision.

Q7: 2, partially agree. Yes, conventional wisdom and the current approach are to begin at the time of harvest and contention through re-establishment and growth to the next harvest. This is based primarily on the point at which a decision is made to provide biomass

for marketing. However, for short-rotation, dedicated energy crops, the decision was made at the time of establishment and the LCA should begin at that time.

Q7: 2. Agree on the "decision" bit. I am not convinced that it can be deconstructed like this. E.g., it may not be possible to tell when/where the "additional biomass" is being harvested. There is an increase in the aggregate demand for wood, which will manifest itself in all types of dislocations (increased harvest and/or different allocation between energy and industrial wood and/or increased collection of residue and/or displacement of wood industry or its supply to different regions etc.). "Changed thinning frequency" is not an "other way" but it is additional harvest, and I wonder how often was extra fertilization done in anticipation of increased energy demand as such … Smoke and mirrors?

Q7: 3 The analysis of the effect of a policy to promote bioenergy or a bioenergy project should start at the time that management was altered in anticipation of the bioenergy market, and consider the whole managed forest area.

Starting the clock at the time that management changes is consistent with the approach applied to carbon offset projects, such as under the Kyoto Protocol CDM, in which the project is deemed to start when management changes comparison with a counterfactual without-project scenario.

Q7 3; yes, the economic concept of “sunk cost” applies.

Q7: 2 – Although I’m not totally happy with how it is expressed as “existing forests” could partly be a result of decisions made many years ago. I.e. policies to increase a certain market (why not the energy market) realized in a steady growth in that market over time giving incentives for the forest owners to increase their investment in silvicultural practices that increases forest growth. Again – the factory/production of a product starts already in the forest – not when the tree is bucked into different assortments!

Q7: 2. The bioenergy demand cannot be separated from the general biomass demand for which the biomass production may have been aimed for a long time.

Q7: This is dependent on the research question being posed

Q7: See further remarks. Nice on paper, but unpracticle. This is an arbitrary decision. During the rotation length of a forest, the management strategy and activities are changing continuously. Time zero is arbitrary. Management is a continuum of subtle land use changes, where the concept of carbon debt cannot be easily used for. It is all clear in the case of a single abrupt land use change from rain forest to oil palm for example, but not in a system where the management has evolved through time, but always within a forested context.

8. In the absence of adequate data to fully describe climate impacts of forest bioenergy use, a risk-based approach could be developed as a proxy applicable for policies favoring bioenergy products and systems that give greatest contribution to the specific policy objective, e.g., near-term net GHG emission reductions. This approach would provide a relative assessment of different forest bioenergy products and systems based on the (qualitatively expressed) probabilities and scales of climate impacts (biogenic C included). The approach should be based on clear metrics and transparent background data, taking into account the range of settings for woody bioenergy.

Q8 2 The first priority should be to assess climate impacts based on available information valid for specific programmes/projects. Proxies should be applied only for exceptional cases. (cf. the proxies suggested in the “leaked” EU documents last autumn; values were in some cases more than 10 times too high and misleading)

Q8: 3-agree- given the uncertainties and the long time frame such a practical approach makes sense

Q8: 3 – I agree in principle, but risks are no less value laden than any other tradeoff.

Q8: 2 = partially agree. Some type of risk-based approach could be used to supplement (or partly replace) e.g. the current EU sustainability criteria for biofuels. However, this depends on how the risk-approach would be defined. Also, it might be necessary to list several policy objectives, not just the near term GHG reductions.

Q8: I have some issue with how this statement is worded. I guess I agree that “a risk based approach could be developed as a proxy applicable for policies favoring bioenergy products and systems that give greatest contribution to the specific policy objective, e.g., near-term net GHG emission reductions” Sure, such an approach absolutely could be developed…. But could is different than should, and I am uncertain whether such an approach should be developed. It is worth discussing how such an approach would be structured and what data or lookup variables would be integrated. I agree with second sentence though and general agree that any approach “should be based on clear metrics and transparent background data” I am going with 1

Q8: 2. All kind of analysis of climate impacts is favorable and useful for the players in the field, but do we need additional measures in addition to emissions accounting in climate policy? Future projections of various policy options and their levels of uncertainty are interesting issues. However, emissions accounting should be based on materialized emissions reported in inventories afterwards, not any future predictions on development of biomass stocks with or without increased bioenergy harvest.

Q8: 2 = Partially agree. A “risk-based” approach is a starting point, but it will be inadequate if is not robust to a range of possible technical, market and policy perturbations

Q8: Horst: I think I agree; sounds very reasonable, however I need to see the approach in a concrete case; I am sure whether ”near-term net GHG emission reductions” is clear enough in particular when biogenic C is included.

Q8: From the wording of the statement it is completely unclear what is being proposed. However, it may be noted that a 'relative' assessment implies choices between different actions, which implies the application of consequential LCA.

Q8: 0 – If near-term policy goals are steps on the way to a long-term solution, this proposal sounds reasonable. However, more often it seems that the near-term policy goals block solutions that are beneficial in a longer time perspective. In a longer term there is less doubt about the climate benefits of bioenergy, and less need for risk-based calculations related to GHG emission reductions.

However, risk-based approaches to see if the biomass is from sustainably managed forests are very relevant.

Q8: Well, if we can’t get the full picture we will be tempted to use proxies. But I see a substantial risk that flawed decisions may result from oversimplified proxies. Given the very large C stocks in forests, and the poor understanding of the drivers of the C cycle (human vs. natural vs. feedbacks from climate change), this risk is in my view substantial and may result in policies that support options which do in fact not help to reduce GHG emissions at all (or even result in higher emissions than would ensue in their absence).

Q8: 1 = We do not know. We did not fully understand this question, so we cannot agree or disagree. If policy implementation refers to RED-type accounting / sustainability certification to be carried out by actors in value chain (i.e. micro-level management), then we maybe disagree. If implementation refers to macro-level management in steering policy targets, then we maybe agree.

Q8: 0, disagree. First, probabilities and other proxies can be used when clear and transparent. However, the term "risk-based" is not clear and relatively comparisons can lead to wrong or misconstrued results.

Q8: 2. Agree that a full description of impacts is unlikely to be feasible (or even necessary) and simpler approaches are desirable. I am not sure what the approach mentioned would entail. In any case, the starting point for assessing the risk should be that the only thing that we know for certain in all cases is that burning biomass releases more C/unit energy than burning anything else, and that for any savings to materialize it has to happen where the biomass is sourced (typically on the land). Therefore direct emissions will increase, and benefits are indirect. The burden of proof to show the benefits is on those who claim reduced emissions

Q8: 3 In the absence of complete quantitative understanding of the effects of every bioenergy system the responsible approach is not to dismiss all bioenergy, but to develop a risk-based assessment to discern those bioenergy systems that are most likely to be beneficial (in relation to the stated objectives).

Q8: 0 – This approach is to narrow both in terms of forest products included and in terms of time and space. Avoid making comparisons restricted in time and space when it is obvious that it matters i.e. short-term effects direct decisions in one direction and long-term effects in another. Long-term effects must be more emphasized unless Armageddon is around the corner due to climate change. And if so – the priority list for measures taken is unlikely to start with avoiding the use of renewable resources with a limited carbon footprint.

Q8: 2. The idea that near-term GHG emission reduction is important is based on the assumption that another alternative to fossil fuel will be used if the bioenergy alternative that give full GHG effect (and then a really good GHG effect) first after 40-50 years is kept out of market. This is not the case – of simple economic reasons.

Q8: I'd say the answer is to do the job properly. Not search for short cuts.

Q8: Better than nothing, but good LCA approaches, based on realistic inventory data are underway

Q8: agree, but methodology must be developed

Policy planning context

9. ALCA (e.g. product life cycle GHG emissions) or calculation of payback times is inadequate to support broader long-term policy decisions (such as setting bioenergy production targets), as it does not internalize effects of bioenergy demand on the forest sector and on other sectors of the economy.

Q9: 0 This perspective is useful as a complementary knowledge in the scenario development of future potential forest biomass demand and utilisation

Q9 1 The problem seems to be primarily "academic".

Q9: 2 partially agree- it depends on the level of confidence that you have in futuristic predictions. ALCA should be just one the tools that could be used to support policy-making, along with others such as economic and social assessments.

Q9: 3. By the way, do we need any specific bioenergy targets, or should we just have emission reduction targets and let the players decide how to meet these reduction targets?

Q9: 2 = Partially agree. It depends on what specific "broader long-term policy decisions" are being addressed. ALCA may be the most appropriate for certain policy decisions (e.g. emission factors for point source emissions of biogenic CO2) and inadequate for others (e.g. identifying qualifying biomass for renewable energy targets).

Q9: certainly agree; unfortunately the world of CLCA is still very undetermined; the setting of the external consequences is somehow finding the philosopher's stone … however we need to go that way. It's like with ILUC. It doesn't make sense to promote some biofuel policy by closing the eyes for indirect effects.

Q9: 1 - This is not my field of expertise, but it seems that ALCA is seen as inadequate by those working with support for broad long-term decisions.

Q9: ALCA can be useful as one among several tools, but it is clearly not sufficient as a basis for sound decisions.

Q9: 2, partially agree. Attributional LCA provides the footprint under the assumptions given which may include market demand. To understand policy and market effects, a consequential LCA may be more appropriate.

Q9: 2 Broader long term policy decisions should be based on a range of methodologies. Long term policy decisions (whether to support bioenergy; what instruments to apply) should not be based solely on product-level ALCA. Product-based analyses based on average rather than marginal data, that exclude indirect effects and/or the impacts of timing of emissions and removals, are inadequate for evaluation of alternative policy options. (This applies also to any decision with a substantial impact – eg by a large company; ie not only to government regulations.) However, ALCA in conjunction with information about likely consequences, and careful sensitivity analysis to discern the important factors that influence the results – which may relate, e.g., to the bioenergy technology, or the energy system displaced – can help to decide the best use for biomass in a specific context, and the best application of specific bioenergy technologies.

Q9: 3.. A general demand for forest biomass may have increased the land owners and society's willingness to maintain the forest, save it from fire and improve wood production over the past century or more.

Q9: The larger challenge at hand is how to manage our land for climate change mitigation. To support development of policies to this end, research in the interface of climate modeling and agri/forest science is needed. This, in order to enable models with adequate resolution in representation of land use and bio resources as well as climatic forcing and feedbacks. LCA based approaches may then support the implementation of these policies.

Q9: Somehow true but the best we have for the moment. Consequential is immature, and also has limitations (the limitation of economic theory ceteris paribus).

10. Climate and energy policies aim at change in the energy and other sectors, e.g. agriculture and forestry. When LCA is used to support policy development (e.g. raw materials strategies, technology scenarios, policy options) a consequential modelling approach should be used (CLCA).

Q10 1 "the chart in front of the horse". The leading issue is climate mitigation, not changing forestry or agriculture.

Q10: 3. Basically yes, but the analysis could be cumbersome in practice.

Q10: 2 = Partially agree. Only disagree to the extent that CLCA will often not be adequate unless it is integrated with economic modeling to capture investment responses and their impacts.

Q10: I think it is necessary to include the feedbacks usually considered in CLCA, as far as I know that approach. I am not sure whether CLCA is necessarily the best option to move forward. Perhaps we need to think about that from a totally different perspective (but perhaps I just do not know enough about LCA). I tend to think that we need a nested scenario approach that evaluates effects of different policies within a comprehensive framework that considers the whole land surface of the planet and all sectors with substantial land requirements.

Q10: 3 = We agree (bearing in mind that it is never possible to capture all the related consequences and significant uncertainties may be involved

Q10: 3 We agree, but also realize that it is an enormous effort to include all the consequences that a policy may have on other sectors. Again, setting the boundaries of the analysis becomes a main issue.

Q10: 3, agree. Consequential LCA is used to compare technologies and policies.

Q10: 3. To the extent modelling is used. It would not hurt to use common sense also. As mentioned in 8 above, the benefits are likely to be mostly indirect and need to be substantiate with modelling or otherwise.

Q10: 2 The distinctions between ALCA and CLCA are not entirely clear ie not universally agreed. Therefore it is not helpful to be prescriptive about when ALCA vs CLCA should be applied. It is more useful to describe which data should be used (eg marginal vs average) and where the boundaries should be drawn (eg whether to include indirect effects).

Q10 2; in theory: yes; however, CLCA is currently not operational to support this kind of decision support. The expected changes in the energy system will not be marginal but be incremental, meaning that CLCA will cover changes beyond the ones that are currently covered in respective methodological guidance and data(-bases).

Q10: I find this survey to too much set in an LCA perspective. This is not about ALCA or CLCA. There is an evident need to analyze and compare scenarios to meet the regional and global final demand of goods commodities and services as a whole. For this purpose we have IAMs, MRIOs,EIOs etc. A common approach is to analyses different individual development pathways and compare outcomes.

Q10: A nice recommendation, but not possible to take as a rule, because immature, in fundamental science stage

11. In elaborating policy scenarios, the range of possible market-mediated impacts should be analyzed (diversion of wood from other energy and materials sectors, land use changes, changes in forest management practices, etc...) and related consequences considered in the analysis.

Q11: 2. The point above seems to imply that bioenergy means a risk for shortage of raw material for other uses. In reality, the opposite may occur, but some changes would take place. Increased biomass production opportunities exist within Europe, but primarily in other regions with ample growing conditions and land availability.

Q11: 3-agree. It is important to consider confidence intervals around estimates.

Q11: 2. Might be useful, but not necessarily needed for regulation purposes.

Q11: Probably this is generally the case, but be careful. The actual details of the choice of system boundary will depend on the specific purpose/question being addressed by a particular study, and should be derived explicitly from the purpose/question.

Q11: 3 = We agree (bearing in mind that it is never possible to capture all the related consequences and significant uncertainties may be involved

Q11: 3 We agree, but also realize that it is an enormous effort.

Q11: 2, partially agree. This is an open-ended statement that appears to be, “when comparing policies, everything should be included in the analysis.” Good boundary conditions should be set in order to ensure a good policy assessment, but they need to be feasible and practical.

Q11: 3. Yes, not the least because these "impacts" must include the benefits we seek. Given that the combustion of wood can only increase emissions, most benefits will be indirect and need modelling to show.

Q11: 3 Where there are several alternative likely scenarios, the impacts of these should all be considered, in a sensitivity analysis.

Q11: 3. In the analysis, OK.

Q11: Models of different mitigation pathways must evidently exogenously or endogenously describe changes in intra or inter sectorial trade. E.g Partial equilibrium models of the forest sector and industries offer relevant capabilities on the market side today. The attribution of any impacts due to changes in equilibrium, to specific products, is though another question.

12. Policies promoting specific energy options based on their near-term GHG balance may prevent investments in systems that are considered compatible with longer-term climate stabilization targets.

Q12 2. True for wind and photovoltaic; fail to find examples for bioenergy.

Q12: 3-agree. The recent IPCC report (AR5-WGIII mitigation) recognized that efforts to reduce GHG emissions are needed by 2050 and that additional efforts are also needed by 2100. It should be acknowledged that a change in energy system will likely take several decades to take place, therefore it is important to also consider longer-term targets. Policies should aim at promoting energy options which include a balance between short-term GHG-reduction benefits and longer-term climate stabilization.

Q12: 2. It depends…The magnitude of departure from near-term to when the option should be considered long-term likely matters

Q12: 3. That might be problem in regulatory policies based on emission inventories as well.

Q12: 3 = Agree. As the statement infers, a focus on near-term GHG balance may lead to a “lock-out” of infrastructure needed to meet long-term stabilization targets. This is the inverse of, but directly analogous to, the “lock-in” problems identified by IPCC as being associated with delayed emissions reductions (i.e. IPCC notes that delays in reductions result in lock-in of higher emitting technology and infrastructure).

Q12: This may happen, but there are many other risks, including a risk to promote bioenergy that does not help to reduce GHG at all, or over very long periods of time. Moreover, there is a risk of promoting bioenergy use in manners that do not help to reduce fossil fuel use, e.g. due to rebound effects. A relatively recent panel analysis (York, NCC) concluded that 1.0 additional unit of renewable energy supplied reduced fossil energy use by just 0.1 units (10%); if we do that with bioenergy that has just 20% of the GHG emissions of fossil fuels (which is lower than most current bioenergy carriers), the net effect is a doubling of GHG emissions.

Q12: 0 It maybe true, however from a broader point of view, policies should not promote any specific technology. The market should decide, on the basis of costs, carbon mitigation and other factors.

Q12: 0, disagree. This is a poorly worded statement that seems to indicate that short timeframes are wrong in LCA. The timeframe should be appropriate.

Q12: 2. Yes, but the opposite is also true. Ignoring the near-term balance (or ghg balance at all, as is the case today) is likely to increase emissions without ANY guarantee that those increases will ever turn into savings. It is irresponsible to knowingly and significantly increase "short-term" emissions (meaning decades) when the eventual savings are indirect, speculative and depend on assumptions that are simplistic at best or even incompatible with the policy itself. E.g., if "future savings" are predicated on the assumption that coal would remain the marginal fuel to be replaced by biomass for centuries into the future, then the assumption itself makes us doomed and the policy irrelevant.

Q12: 3: we totally agree. It is actually true that investing in technologies that do not deliver GHG saving in the short term may prevent investments in technologies that deliver GHG saving in the long term.

However, we think that it is positive to prevent investments in systems that deliver GHG savings only in the long term. The reason for this is that there are technologies, e.g. PV and wind, which deliver GHG savings in the very short term (few years), do not impact the environment as much as bioenergy (in term of biodiversity and pollutants emissions) and are more resource efficient (reduced land occupation and primary resources appropriation).

The technological issues presented by such non dispatchable renewable energy sources may be overcome in the next few decades with investments and political support in research and development focused on smart grids and energy storage.

Q12: 3 It is important that decisions about bioenergy (and any other significant infrastructure investments) should consider the long term. In the context of meeting the 2 °C target by 2100, there is capacity in the atmosphere for additional GHGs; society needs to decide how to use this capacity. Investment in bioenergy is a legitimate option.

Q12: 3 – Therefore short term effects should never be used as the only source of information for decision/policies with the intention to mitigate climate change/convert the energy supply system.

Q12: 3. YES! Which is a crime against future generations.

Q12: Yes, rules should not be based on near term metrics alone

Q12: this must be further detailed/analysed

13. Development of climate change mitigation strategies in the forest sector needs to recognize the possible C sink/source function of growing forests and the full range of forest products, since other forest based industry sectors (biobased materials, biochemicals, building sector, pulp and paper, panel industry) may provide better GHG balance per unit wood used.

Q13: 0/3: It is less the carbon storage in these “other” products which will make wood the preferred raw material for e.g. modern fibres. Rather important is the substitution effect, which makes wood fibres so attractive from a carbon point of view. – E.g. wood based plastics instead of fossil fuel based plastics. Similar to above, I would like to highlight, that when comparing the long term effect on carbon stored in products, it really depends, how fast the natural resource will regrow (9 years for Eucalyptus in BR or 100 years in northern Sweden). Somewhere I read, that accounting for HWP only makes sense, if these store the carbon for at least half the rotation time of the forest which they originate from…

Q13: 3. (C tax or emission trading based regulation including the LULUCF/AFOLU sector might be a solution to the problem (information comes across through price signals).)

Q13: 2 – It will only make a difference in a shorter term if wood is substituting fossil materials or fossil fuels. The store carbon will be release sooner or later. Decisions should consider where it is most likely to find a climate friendly alternative to fossils in the long term.

Q13: Agree. In addition, accumulation of C stocks in long-lived products needs to be considered

Q13: 3 All forests, not only growing forests. All the forests are “growing”! In the LULUCF context (UNFCCC and EU level) there is already this recognition: it is now mandatory to estimate the C stock change in the harvested wood products pool. Furthermore, the substitution effect (of both materials and energy) should be accounted for.

Q13: 3, agree. It is considered good practice and within given protocols to include carbon sinks/emissions in inventories and LCA.

Q13: 2. Yes in general, but unclear to what extent it is for the "forest sector" to consider. The "forest sector" cannot create a demand for more reasonable products, neither can it prevent its production being wasted by others (just like agricultural crop production cannot prevent biofuels being produced or food being wasted).

Q13: 3 It is important that the whole managed forest area, and the wood products pool – in service and in landfill, where relevant, is considered. Usually a range of products is produced from a forest – high quality sawlogs are of course generally used for high value solid-wood products, which can continue to store carbon while in service, and may then be used for energy. Composite products are a possible use for lower quality logs. This option - followed by bioenergy at end of service life - should be compared with immediate use for bioenergy. Regulation should not mandate/prevent specific uses of forests (C sink/bioenergy / wood products) on basis of simplistic categorization, but should encourage consideration of all effects, and promote uses with greater mitigation benefits in the long term (considering the mitigation per unit biomass, and the total potential mitigation contribution as bioenergy implementation is expanded).

Q13: 3 – Absolutely. This also includes indirect effects on the flow of raw material for other forest products with better displacements factors. Since forest biomass for energy is a low

priced commodity incentives to substitute non-wood products with a large carbon footprint with wood-based products could be a good policy option to mitigate climate change and low quality wood and residues for the energy sector will come out of the potentially higher flow of wood as a result of future marked expectations and thereby investments in forest growth. Market opportunities on the energy market will have an equal effect – but maybe at a lower rate. Anyhow, all future market opportunities are good news for the raw material factory and bad news will work in the other direction. Focus on flows and end-use rather than on stocks as long as annual harvest levels equals or are lower than annual growth on a landscape/country level.

Q13: 2. Yes, however with general negative incentives on fossil C emissions in place, market forces can solve that equation better than technocrats/politicians in most cases. Normally bioenergy cannot compete with a high-value product such a lumber if only there is a buyer out there.

Q13: 0. I agree that other forest based industry sectors may provide better GHG balance, but the main comparison should be between energy production using forest biomass and other fossil fuel sources it replaces. If we compare C sink/source function of growing forests and forest based industry sectors this would most likely lead to one answer that C sink is the winner and no economic activity should involve forests.

14. A better understanding of resource competition and synergies within the forest and between other sectors is needed. Cascading use of forest biomass often has favorable GHG balances: if forest products such as paper, board and construction wood are used as bioenergy feedstock at the end of their service life, the storage of carbon in these products contributes to climate benefits of the whole systems.

Q14 3 Yes, but cascading should not become a strait-jacket for development. Both the energy and the forest industry sectors are truly international and are used to find pragmatic local models for their raw material acquisitions and handling.

Q14: 3 – better understanding is hard to argue against, but the induced innovation of major climate based policies can cause unforeseen structural changes in competition and synergies. For example I think current CGE models are inadequate to address these issues.

Q14: 2 = partially agree. The carbon stock benefits from short-rotation products such as paper are not very significant.

Q14: 2. The significance of C stock of short-lived products minor, construction wood relevant. More important might be the savings in fossil GHG emissions in case wood products in the cascading use can displace fossil C emissions (e.g. construction wood less energy intensive than competing non-renewable materials). So there is cascading displacement of fossil fuels.

Q14: strongly agree; however we have to take into account what is written under point 11 to 13 very thoroughly. The time scale is a complicated issue even more when it comes to highly diverse markets differing in product requirements and potentials. One small example: if we store wood in shape of longer living products or apply a real good cascading use, we will bring up this wood to be burned as fuel in future times, when (hopefully) fossil fuel substation will be done. If someone performs an LCA in a very suborn way the conclusion may be: better burn it today when you still can substitute fossils, and not in the future when you will substitute wind/solar … What I want to say is: we need to set up such systems very wisely.

Q14: 2 – It is important for a short-term perspective. But it will always be better for the climate if recovered wood substitute fossils, instead of just letting it decay e.g. in a landfill. In the latter case, you will have emissions from fossils in addition to the emissions from the wood in the landfill.

Q14: 2 However, some wood products undergo chemical treatments that make the materials unsafe and harmful for energy production (combustion) at their end life.

Q14: 2, partially agree. This statement infers that "only biomass from other products" and "only products used for energy at end of life" provide climate benefits. In truth, biomass that without another original first use or products without ever being used for energy are both sequester and offset carbon emissions. The linkage to resource competition is unclear.

Q14: 1. I don't understand: if these products are burned, then there is no more storage. How could they then contribute?

Q14: 3: we fully agree. However, on top of the storage of the carbon in the products, the substitution of other materials, often more GHG intensive than biomass, provides an even higher contribution to the GHG emissions reduction of using biomass for products.

Q14: 2 The option of landfill should also be examined. Wood products in landfill are a carbon reservoir. Possible methane production, that would negate this benefit unless captured and used for energy, should be considered also.

Q14 0; the use of post-consumer wood as bioenergy feedstock provides a climate benefit because fossil fuels can be substituted; this benefit is not related to carbon storage. However, a cascade use of wood products, i.e. reuse and recycling, prolong the storage effect of wood products, enlarge the material basis for wood and pulp & paper industries and might lead to beneficial substitution effects when additionally energy intense products can be substituted.

Q14: 3 – We need to remember that the bioenergy market start where biomass in the form of residues are piled up close to the market i.e. industrial residues comes first before there is a need to increase harvest intensity in the forest (logging residues, stumps, small diameter treea etc). Policies promoting recycling/cascading will ad to the industrial residue piles on the market.

Q14: The potential to reach a higher, yet sustainable, production of woody biomass is still so high in Europe and in the world so that all products that are economically viable in themselves can find enough resources. The most competitive refined biofuels are produced together with higher-value products. Cf Q 13 also.

Q14: Cascading has definitely a positive effect, but it is mostly theory. There is a lack of good data on the actual and potential cascading level in Europe, as well as on policies, which could stimulate cascading without market distortions

15. Availability of residual wood streams (forest logging residues, secondary and tertiary forest products, manufacturing residues and unmerchantable wood) is dependent on non-energy forest products markets, which are small compared to anticipated bioenergy demand.

Q15: 0: According to EFSOS II these categories from other sources could account for up to 48% of the wood raw material supply in Europe!!!

See: http://www.unece.org/fileadmin/DAM/timber/efsos/data/Country_profiles.pdf

It is a big challenge that not enough information about their current role already today is widely available (Mantau in Germany, Probos for the Netherlands or the GESBOIS questionnaire from the European Panel Federation all indicate that these volumes already are a significant source at present already) – The official reporting (HS/CN) does often not capture these volumes due to low unit values and small size enterprises involved. European waste statistics only report a fraction of the real values, since they do not look at the availability, but rather those volumes of wood waste, which are report being recycled.

Q15: 0/3 Depending on geographical perspective, e.g. global perspective or individual forest-rich countries

Q15 2 Avoid referring to fuel biomass as residues. Forest management regimes should regard fuel biomass as integrated products. That also means that local/site structures and economic conditions should determine the output. For example, energy plantations and harvesting of "pulp wood trees" for energy are carried out irrespective of other forest operations.

Q15: 3-agree. The profitability of using residual wood streams for bioenergy production is also highly dependent on the vitality of non-energy forest products markets (this factor currently overcomes any effect of bioenergy demand). It is at least the case currently in many jurisdictions (e.g. Canada), and will likely stay so in the short- to medium- term.

Q15: 2 – "small" isn't always the problem, sensitive to business cycles for example may be more important than size.

Q15: 1 = I do not know. This probably depends on the region, may be true for Europe.

Q15: I agree with the first part of this statement but strongly disagree with the second part related to wood product markets being small as compared to anticipated bioenergy demand.

Q15: . 3. (Global roundwood production in 2000 about 3 billlion m3/yr = 0.7 GtC/yr = 25 EJ/yr??)

Q15: 2 = Partially agree. It seems that this is almost true by definition (i.e. a residual does not exist without a primary activity). Whether the supply is small depends on the size of the incentives to bioenergy.

Q15: (partially) agree; these markets are always cross-wise dependent, and mostly the non-energy forest products markets are smaller than the vast energy market; however in many cases the availability of residual wood streams is already consumed by the (small) given markets. It depends strongly on the region and the vulnerability of the forest systems.

Q15: 2 – they do rely on them but I think these product demands and uses are increasing as well

Q15: This is a 'leading' question. Also, it is unlcear what is meant by residual wood streams. Furthermore, it is not clear that non-energy markets for wood are necessarily 'small' (e.g. EUwood study?)

Q15: 3 – It is my impression that this is the way it is.

Q15: Agree, but that is not sufficient as an argument to increase wood harvest in order to have more fuel wood available if such a strategy does not help to reduce overall GHG emissions

Q15: 2 = partially agree. We do not know whether the market for non-energy forest products will be small compared to anticipated bioenergy demand, as this depends on the scenario assumptions.

Q15: 2 Maybe it is the other way around: future bioenergy demand is too large with respect to residual wood availability. However, it is quite difficult to estimate what the forest contribution to bioenergy will be.

We do not completely agree with the above statement because the availability of “forest logging residues” is also related to the technical possibility of extracting the residues from the forest. It is possible that an increase in the demand for "wood for energy" in the medium term will also result in an increase in the collection of residues from the forest. These residues might now be left in the forest just because it is not economically viable to collect them. Therefore their availability is not related to the "non-energy forest products markets” alone.

Q15: 0, disagree. This statement is not clear. First, wood residues are limited as indicated. Second, forest products markets are not small, especially as compared to bioenergy markets using wood. Future forest products might become small compared to all bioenergy usage from all biomass sources, but in this statement, this is not an absolute.

Q15: 3: we fully agree. This is the reason why the bioenergy demand, that is in most cases artificially created with policies and subsidies, should be set to a level compatible with the amount of residual wood available. Alternative policies stimulating demand for primary wood products (with their associated residual streams) would simultaneously increase bioenergy feedstocks availability and increase the specific GHG emissions reductions. Also, stimulating cascading use and re-utilization would increase the residual feedstocks available for bioenergy use.

Q15: 3 The implication is that to implement bioenergy at climate–relevant scale will require dedicated bioenergy production and harvesting.

NB its no longer “unmerchantable” if used for bioenergy. Need to clarify that this means unmerchantable in conventional markets.

Q15: 3 – There is a need to give the message that forest biomass is not the solution for future energy supply – but part of it. Perspectives on the forest potential is needed – not the least since the forest industries are struggling with new products potentially within the biorefinery concept with the potential to compete with the energy industry for forest biomass of all qualities.

Q15: 2. That will show out. Also other bio-product markets will grow when fossil C emissions are being disincentivised. And also energy savings, electricity and other renewable energy production will compete on the energy market. Let it grow - let the problems show out - and solve them successively (in a slightly more pragmatic manner).

Q15: There is a problem of mobilization of wood energy from the forest in Europe. Wood energy as a byproduct from other wood industries is still the major part of forest bioenergy. There is however a decreasing trend in the production volume of paper and particle board sectors, which could in the short term lead to a decrease rather than an increase in forest bioenergy production.

16. In assessing policy options, scenarios should include forest management changes which may result from policy decisions to stimulate bioenergy production (e.g., fertilization, intensified thinning). Assessment of the effects of policies should be performed at landscape, regional or global scale (as opposed to stand level) depending on the expected geographical relevance of the policy.

Q16: 3-agree. But one has to stay realistic in scenario-building about the actual impact a policy decision can have on forest management activities and on forest productivity, e.g. case study examples from Scandinavia may have very little relevance in Canada.

Q16: 3 – but of course the course of intensive management is likely to be affected by the carbon policies, e.g. carbon friendly nutrient management.

Q16: 2 It all depends. The assessment should be based as close to reality (and possible future realities) as possible . I generally think policy analysis works well at a regional scale BUT depending on the policy intervention, stand-level dynamics may be important to consider. So in this context a stand level analysis could be useful. So long as an entire policy did not rest on the outcome of a stand-level study.

Q16: 3= Agree. Without doing this, you miss potentially important investment responses to increased demand.

Q16: (3) - It is important for analyses of the short-term perspective. Changes in the forest management may have more severe impacts for other values, such as biodiversity and water, compared to climate, especially in the long term.

Q16: agreed, but we also need to consider the ecological and GHG consequences of such management changes which are seen quite critical by many ecologists. Moreover, we also need to consider potential issues related to adaptation/vulnerability against climate change. - See my answer on stand vs. landscape scale above.

Q16: 2 = partially agree. As the impacts are very typically global, the consequences should typically be assessed using global system boundaries

Q16: 3 We have doubts related to the fertilization policy option to increment bioenergy production.

Q16: 2, partially agree. The first part of this statement is unclear but seems to indicate the need to include changes in management practices. Yes, a good LCA does include sinks/emissions associated with management practices. Yes, the spatial scale should be appropriate.

Q16: 2. Fine to assess these. However, it needs to be realistic. Also, it is one thing how these could contribute to more bioenergy being produced, it is quite another thing whether/how they can reduce GHG emissions, which is why the policy is ostensibly promoted.

Q16: 3. O reasons already mentioned. However, still the stand level perspective must be somehow considered, otherwise also new drainage may “slip through“ if it concerns only a small percentage of the area.

Q16: See response to 9. Models should ensure to have an appropriate system response behaviour. This can be obtained through a stand/age class level basis. Also, Important insights can be obtained from stand level analysis.

Q16: The stand level is definitely not the good scale level to evaluate effect of policies. Regional level is a good approach to start from realistic age class distributions, and understand effects of management changes on regional carbon balances.

Q16: 2 partially agree, but these forest management changes should be documented by sound data; thinnings contribute to increased biomass growing stock

17. Besides Global Warming Potential (GWP), Global Temperature Potential (GTP) and/or other metrics should be considered, and should reflect the time horizon of climate targets (e.g. “limit to 2 °C increase by 2100”).

Q17: 1, but time is clearly important

Q17: 1 – not my area, but it’s hard to argue for one dimensional performance metrics.

Q17: Depends on what we are talking about:

3 = agree, if we talk about research, it is useful to consider different metrics and viewpoints.

0 = Disagree, if we talk about the metrics used in the policy making. It is not necessary to confuse the current climate change mitigation discussions by introducing new metrics; more important is to make real decisions. Also, e.g. the use GTP100 might lead to significantly higher costs for reaching the 2°C target, when compared to the use of GWP100 (Ekholm et al. 2013: Robustness of climate metrics under climate policy ambiguity. Environmental Science & Policy. Volume 31, August 2013, Pages 44–52).

Q17: ”). 0. Can involve interesting mathematics (!), but discussion on metrics to be applied is related to international climate policy in general and should be avoided in this specific bioenergy context. (Highly political issue.)

Q17: 2 = Partially agree. At a minimum, where the timing of benefits is important, emissions and radiative forcing should be modeled dynamically.

Q17: Partially agree; important stuff; for now I would hesitate or even disagree to take this up for the “basic LCA tool”; keep it for “further considerations”, “extended analysis”

Q17: Well, probably, but this is a bit presumptuous. The choices of metrics will depend on the specific purpose/question being addressed by a particular study, and should be derived explicitly from the purpose/question.

Q17: (3) – This is not my field of expertise, but generally it seems that different indicators give different information, and that it is useful to have more indicators to see different aspects of the consequences of planned action.

Q17: Considering more metrics is good, but of course it will not speed up the process. Using bad proxies in the meantime may result in adverse outcomes.

Q17: a) 0 = Disagree. Yes, the applied metrics should reflect relevant time horizon for decision-makers, and this can be applied with any metrics. But why introduce new metrics to the policy arena, especially ones that have found out to potentially lead to economically non-optimal burden sharing in between sectors in climate mitigation (Ekholm et al. 20xx)? Additionally, cumulative change inferred to the energy budget (CRF -> GWP) depicts impacts to all safeguard objects (sea-level rise, changes in climatic patterns, accumulation of heat in the whole global climate-ocean-land system), while GTP depicts only one of the safeguard objects (surface temperature change) and, more importantly, aims to describe that safeguard object only in one moment in a passing by moment in the distant future. The fact that discourse around International Policy has adopted surface temperature change in 2100 as the main indicator for mitigation targets does not imply that it should be applied as the main indicator in science around climate impact assessments.

Q17: The issue here is if it is realistic to use 2100 as a time horizon. It is way too far in the future, we are not able to project future behaviours of any sector (economy, energy, forest…) with meaningful results on such a long time scale.

Q17: 2, partially agree. The appropriate timeframe for the LCA should be used.

Q17: 2. Always open to consider alternatives, if they are reasonable. However, we should consider the overall climate policy framework. It makes little sense to set a "climate target" for bioenergy that is not consistent with the climate target at large. Alternative metrics should not be used to hide the inability of biomass to contribute to climate change mitigation in policy-relevant timeframes.

Q17: 2 GTP focusses just on the target year – this is a narrow perspective, though informative for policy purposes. For research purposes, a range of metrics should be applied – eg direct calculation of radiative forcing. It should not be expected that LCA for routine applications (eg product labelling) will include multiple metrics. (The policy development process will need to determine which metrics will be applied in implementation, and provide guidance and tools for the required calculations, as it cannot be expected those involved in policy implementation will have expertise to apply and interpret these metrics.)

Q17 2; this depends on the scope of the analysis

Q17: 2. Yes, but there is no reason to “let the best be the enemy of the good”. It is better to keep below 3 °C in 150 years than fail completely. Lost carbon stocks in forest (as an initial prize for near-time fossil-fuel substitution otherwise not obtained) also form a potential for carbon stock build-up in the far-off future when it may be more needed

Q17: Agree, follow the metrics of the IPCC.

Q17: Indeed, several metrics have to be explored (beyond IPCC guidelines), looking both at nearby thresholds and long-term evolutions

Further questions – (simple “yes”/“no” answer is also possible)

18. At the point of combustion, burning wood emits more GHG per unit heat released than burning fossil fuels (except lignite). Whether burning wood emits more GHG per unit useful energy than burning fossil fuels depends on the efficiencies of biomass and fossil fuel conversion.

18a Is it adequate to assess climate effects of forest bioenergy considering just the point of combustion?

18b Or should the whole forest systems, including products pools, and energy system responses be considered?

Q18b (Or should the whole forest systems, including products pools, and energy system responses be considered?) : Yes – including the preparation of the different fuels (refinery, extraction, transportation, etc.)

Q18: The statement above is oversimplified and therefore not relevant. The reality is much more complex. “Wood” has to be defined according to its moister content; coal, oil and fossil gas must be burdened also with their leakage of CO2 and methane (the latter have got increased relevance with tar sand processes, fracking and the recent finding of leakage of methane from mined coal). And in addition, all fuels should carry the emissions from their transport and handling.

18a: No, not without considering the points above.

18b: If harvested from sustained forestry, the biomass is carbon neutral. In that case, the analyses could be limited to the combustion.

Q18a: ? No, the GHG balance of LULUCF/AFOLU sector should be included in the accounting

Q18b: I am still convinced that biomass systems are working in a cyclic way. Whether biomass is decomposed or rapidly burned is a question of time scale and integral. Of course the dynamics of sinks and sources is the major question and also of short-term accumulation of CO2 in the atmosphere (due to prompt and large scale increase of biomass burning).

Q18a: There are no obviously interesting or relevant purposes/questions for which it would be appropriate/relevant to select such a restricted system boundary.

Q18b: Probably this is generally the case, but be careful. The actual details of the choice of system boundary will depend on the specific purpose/question being addressed by a particular study, and should be derived explicitly from the purpose/question.

Q18: 2 - It is not a simple 'yes' or 'no'. However, the efficiency of the conversion is always crucial not to waste resources, and have additional impacts also on other values than climate.

Q18b: Yes, but as far as I see the point is that we don't have agreement on how to draw the system boundaries, which is one of the core issues in my understanding

Q18b: In which decision-support context? In Policy planning context, 3 = we Agree. In micro-level decision support, partially disagree.

Q18b: Yes, but we need to set the boundaries of the system. If the boundary is set at the combustion chamber it is certainly too narrow. But if we set the boundary at the forest systems + product pools + energy system responses, then the boundary may be too wide.

In general, we think that the statements above are misleading. Indeed, when comparing fossil fuel emissions with wood fuel emissions, we have to consider the different origin of the CO2 emitted by these fuels. In the wood-fuel case, the CO2 released to the atmosphere comes from the biosphere-atmosphere system, i.e., from a short cycle, 20-30 years long for coppices and maximum 120-150 years long for high forests (generally used for timber production). In the second case, the CO2 released into the atmosphere will be added to the biosphere-atmosphere system. If, our purpose is to reduce the amount of GHGs in the atmosphere, this action will go to the opposite direction.

Of course, this is only true for "managed forests", such as the majority of the EU forests (i.e., excluding deforestation and other specific cases). Furthermore we should also account for the emissions related to harvesting and transporting harvested wood, in order to provide the "life cycle" emissions of the final fuelwood product.

We think that a better approach should be to analyze the carbon stock and carbon flows in all the forest pools and over a timeframe as a consequence of different management practices and for a set of alternatives (such as, for example, more bioenergy vs more wood products). By comparing the results of these scenarios, it is possible to frame the problem and understand what are the best practices to reduce GHG emissions.

Finally, as for the counterfactual, it is needless to say that the same boundaries that we apply to the bioenergy system need to be applied to the fossil fuel systems as well in order to evenly compare different systems. This also introduces complexities to the analysis. For example, recent data of energy consumption patterns indicate not only an increase of the

use of coal (also in Germany), but also of the worst kind (from the environmental point of view) of coal, coming from opencast mining. [1]

Q18a: NO, but it should be the starting point, as this is the only thing that is certain and direct and under the control of the energy sector operator (simply using a dirtier fuel). All the "benefits" are more or less indirect and distant (even speculative).

Q18b: These must be considered if any GHG reduction claims are to be made

Q18a: No, that is an unbalanced assessment. You need to consider the difference between the with- and without-bioenergy cases in terms of average carbon stock in the forest and wood products pools, to determine the impact on biospheric C balance. That will tell you whether there is additional carbon added to the atmosphere in the with-bioenergy case. Of course you also need to include non-CO2 GHGs in each case, and impacts of energy system infrastructure; and albedo and black carbon effects should be considered.

Q18a no

18b this depends on the scope of the analysis; at least the upstream emissions including impacts on forest systems should be covered.

Q18a: No, the whole chain needs to be taken into account, from the primary biomass source production, harvesting, logistics, pre-treatment, conversion and end-use delivery.

Q18b: Yes, to the extent possible

Q18: Except lignite, peat, natural gas with high losses, oil sand, etc. The problem with high use of fossil help energy at conversion is a problem of using the wrong kind of incentives (such as the US blending obligation and various subsidies, i.e.not general, cf above).

Q18a: no

Q18b: See answers above. It is possible to generalize strongly if only there are systems in place to safeguard sustainability (economic, ecological and social) and if sound incentives are used (cf above).

Q18: Yes, conservation of mass, and the first law of thermodynamics still holds.

Q18a: No, but the total climatic effect can be characterized and multiplied with the point source emission

Q18a: No. It is not very clear for me what is this concept referring to “the point of combustion”. Important is what kind of fossil fuel the wood replaces.

19. If burning wood emits more GHG per unit useful energy than burning fossil fuels, must then the feedstock production improve the GHG balance, i.e. reduce GHG emissions or increase forest C stocks compared to the counterfactual (no bioenergy) scenario, to achieve a net climate benefit from the forest bioenergy system?

Q19: No, only level carbon stocks since 1990 should be required.

Q19: I am not clear of the question, but time and cumulative effects come in.

Q19: No, Stocks may go down and a bioenergy scenario may still generate GHG benefits in the long term (as long as the changes in carbon stocks do not negatively affect ecosystem functioning and forest growth). In fact the higher C stocks in the deadwood compartment of

[1] The Economist, Apr 19th 2014. Coal. The fuel of the future, unfortunately. http://www.economist.com/news/business/21600987-cheap-ubiquitous-and-flexible-fuel-just-one-problem-fuel-future

forest ecosystems in the fossil fuel scenario is a source of GHG. i.e. the stock goes up and it causes more emissions relative to the bioenergy scenario.

Q19: Confused by this question, the system should improve the GHG balance – independent of the role of individual components of the system.

Q19: I'm not sure if I understand the question right. Is it about the climate parity point, where the bioenergy would be carbon and climate neutral?

Q19: It depends on the timeframe being considered. A forest based system will provide substitution benefits repeatedly, essentially forever, whereas a counterfactual forest can only grow to saturation once. At some point, the substitution benefits from a renewable forest-based system overcome the lower efficiency of the combustion process and the foregone sequestration of the counterfactual.

Q19: No question, it is always best to have the maximum of GHG emission reduction, but referring to my answer above: as long as on 99 ha the C is incorporated, which I emit from burning the wood from 1 ha within a specified period, I would ignore the direct comparison of CO2 emission factors of fuel A, B, C … I would agree to introduce payback times as a politically implemented metric with the objective to enforce efficiency. I would not feel comfortable to introduce that into basic LCA calculations

Q19: This question is rather ambiguously worded. The answer depends on the purpose/question being addressed. However, probably it is generally the case that what is of interest is producing wood energy feedstocks that avoid adverse impacts on forest carbon stocks (rather than a requirement to improve forest carbon stocks) and/or reduce GHG emissions when compared to the counterfactual.

Q19: 0 – No. The counterfactual to using the emissions from conversion of wood to bioenergy should be fossil emissions + emissions from the wood decay that occur otherwise,. In a long time perspective, this will always favour biomass over fossils.

Q19: Not sure whether I understand that question, perhaps I am too tired after answering so many others

Q19 : Yes, feedstock production should always be improved.

Q19: Carbon stocks should be counted to show that the carbon is released from stored stocks and then re-sequestered by the forest and removed from the atmosphere. The GHG balanced is improved by offsetting the release of carbon from fossil fuels and not adding additional carbon to the atmosphere.

Q19: Yes. But the counterfactual generally does not mean "no bioenergy", as in the majority of the cases and over human history at least some of the wood always ends up as energy. If we promote bioenergy, then the counterfactual would generally include a certain (lower, unsubsidized) bioenergy use. The impacts of promotion may include the cannibalization of the unpromoted use by subsidized operators.

Q19: No. As indicated at Q18a, to determine whether there is a net climate benefits from the forest bioenergy system you need to compare the net effect of change in C stocks in forest and product pools over the long term; changes in life cycle non-CO2 GHGs; albedo and black C if relevant; difference in GHGs from fossil fuel combustion (scope 1,2,3), for the bioenergy vs fossil energy systems.

Q19 no; the production of bioenergy emits BIOGENIC carbon as compared to fossil fuels which emit fossil carbon; sustainably managed forests can provide a steady flow of wood without contributing to climate change (i.e. the forest carbon pools remain stable). Under

such conditions, the use of bioenergy is considered carbon-neutral as emissions are balance with the uptake.

Q19: If the burning of wood emits more GHG as compared to the fossil alternative then one should not put wood into bioenergy but search for other alternative RES sources and leave the forest standing to increase the C-stock

Q19: No – the long-term effect is more important (unless Armageddon is around the corner – if so is avoiding renewable energy options the first action on the priority list??)

Q19: If only forest C stock is largely maintained (i.e. permanent losses are kept below 20-30 t C/ha), then burning wood is always better than burning fossil fuels, provided fossil help energy is kept below 10 % of total energy consumption

Q19 The key rationale for bioenergy is that the turnover times of regenerative biomass are on the order of a human life time and less (1-100 yrs) while the turnover times for fossil carbon reservoirs are of geological timescales. It is important to not lose sight of the physical timescales of the problem when applying conventional metrics and assessments etc.

Q19: The assumption is not necessarily true, it depends on the type of fossil fuel the wood replaces

20. Converting forests into bioenergy supply systems can cause loss of carbon stock in forests that needs to be compensated by avoided fossil fuel emissions before the system delivers net GHG savings. Should "acceptable" payback times be less than 20 years?

Q20: Never, the payback time should reflect the challenge we are facing. I personally would suggest long term payback time, 100 years.

Q20: No (Should consider the actual rotation period in the forest plantations)

Q20: Irrelevant statement, see comments above (If harvested from sustained forestry, the biomass is carbon neutral. In that case, the analyses could be limited to the combustion.)

Q20: Time, time, time, how do we deal with time?

Q20: No (perhaps use discounting)

Q20: No to 20 year payback unless science suggests that 20 years is the appropriate temporal scale.

Q20: Depends on the context, acceptable for whom? Of course we can make assessments by using whatever timescales we decide. But to understand the total picture, both short and long time scales should be used.

Q20: No, no general or scientific answer exists.

Q20: No. IPCC's Fifth Assessment Report clarifies that CO_2 emissions are primarily a long-term issue. IPCC's concern with CO_2 emissions increases in the short- to intermediate-term is related primarily to the inferred "lock-in" of high emitting technologies and infrastructure associated with delays in reducing emissions. Some short-lived GHGs however (e.g. methane) can have temperature impacts in the short term that are greater than those associated with CO_2.

I would agree to introduce payback times as a politically implemented metric with the objective to enforce efficiency. I would not feel comfortable to introduce that into basic LCA calculations

Q20: I am not sure whether a generalized threshold value is fair taking the strongly differing dynamics of forest growth in different climatic zones into account. Just understanding payback time thresholds as a political metric.

Q20: Statement made in first sentence: This is a very 'leading' statement and very ambiguously worded. What does 'converting forests into bioenergy supply systems' mean? If the wording of the question is improved, I might be able to agree with it and give the answer 3, e.g. "The increased extraction of wood from forests for use as bioenergy is generally associated with reductions in forest carbon stocks, which need to be allowed for when assessing whether, overall, GHG emissions are increased or decreased as a result of the bioenergy use. Question posed in second sentence: "Payback times" (requires careful definition) of 20 years or less may or may not be appropriate, depending on what it is you are trying to achieve. We cannot assume that the objective is always the same, or that reducing GHG emissions is always the principal objective for forest management.

Q20: 2 – Using an acceptable payback time of 20 years might ensure that the wood that would anyway have decomposed quickly is used first. However, if the alternative is fossil fuels, that have payback times of millions of years, wood with payback times larger than 20 years will be preferable (unless there is violation of other values, such as biodiversity, soil quality, water, and other principles for sustainable forest management etc.).

Q20: Agreed. But about payback times: Not sure, but I doubt there are many, if any, forest-based bioenergy systems with so short payback times.

Q20: 0 = Disagree with the question. Acceptability of risk level or adequate/inadequate level of climate mitigation is the choice of the decision maker, not the choice of the impact analyst. From research only interesting question is to see which energy portfolios/scenarios can deliver the mitigation target (levels of radiative forcing, W/m2 over chosen timeframe).

Q20: No, it is not possible to provide one figure that can be valid for a wide range of options (management practices, high stands, thinnings, coppices, time horizon, geographic location, and so on). A better approach is provided, for example, by the table included in the 2013 IINAS report (see below). This table clearly shows where the criticalities are, and at the same time it gives an idea of the complexity of the issue.

In any case, the sentence is not clear, what do you mean by “converting forests into bioenergy supply systems”? Do you mean deforestation? Or do you mean converting the forest into short rotation forestry? In the first case the forest carbon stock is lost (or moved in the harvest product pools if the biomass is not converted into energy). In the second case, there will be a new system with a different equilibrium. However, if you mean managing forests to produce also biomass for energy then there is a C stock change at the time of harvest. Afterwards, there are C flows into the atmosphere, when wood is converted into energy. However, with sustainable forest management practices, the C stock is built again in the harvested area and, at the same time, the fact that only a fraction of the forest area has been harvested guarantees a balance.

Q20: No, it should be the appropriate length of time for the rotation, but more importantly within the temporal and spatial framework of the forest and not a specific stand.

Q20: I disagree with the statements. First, forests have been "bioenergy supply systems" throughout history, there is no need to convert. This "conversion" only makes sense if we are talking about an unmanaged (primary) forest brought into production. If so, this is what should be stated. Second, if the only impact on forest is the C stock loss, then the system as a whole can never result in savings. E.g., for the mentioned primary forest, the benefit would be that the increment would increase (from zero to whatever is consistent with the management regime introduced). For that to happen there has to be a benefit, such as an

increase in increment, which should provide the eventual savings and which must be part of the equation. Third, the mentioned compensation ("how long shall we increase emissions compared to baseline") is not a particularly relevant point for any purpose, but it should be short enough to allow us to make reasonable assumptions (even 5 years seems like a lot nowadays). But what matters more is what happens later: will there be any savings? How big, under what assumptions (likelihood, etc.).

Q20: Yes. 20 years is a reasonable amount of time, but the calculation of the payback time is not a standardized methodology. The results of payback times calculations are very dependent on the choice of the system boundaries, assumptions and of the counterfactual system to which the bioenergy systems are compared. Furthermore, the market mediated impacts are extremely difficult to internalize in the analysis. However, for the implementation of a policy, once targets for bioenergy production are set according to scenarios built with a consequential approach (internalizing also the impacts on other sectors), in order to prioritize the use bioenergy that provides GHG saving in the short term, the calculation of payback times with a coherent and uniform methodology and a standard and common counterfactual, may provide a good proxy to identify the most beneficial feedstocks and pathways.

Q20: Acceptable payback period cannot be prescribed. Biomass for bioenergy is part of an integrated forestry system that addresses multiple environmental, social and economic objectives. In addressing climate change, the critical need is to develop a low-carbon sustainable energy system. Bioenergy can deliver this. Society needs to determine how much of the available “emissions space” should be used in developing this renewable energy system.

Q20 The context of this question is not clear to me. In any case, it is not desirable to convert forests into “bioenergy supply systems” because it is against the cascading principle of a climate beneficial use of wood.

Q20: No 20 years is acceptable although bioenergy/RES systems mitigating more GHG should be supported/stimulated more strongly.

Q20: No – but the payback time could be part of the information needed (together with other environmental impacts and economy) for decisions on which resource to exploit first.

Q20: 1. No, it should be 50-60 years “Policies promoting specific energy options based on their *near-term GHG* balance may prevent investments in systems that are considered compatible with longer-term *climate stabilization* targets.” > YES! Which is a crime against future generations.

Q20: Seen 19 and also note that carbon payback time is not a good metric in an of itself since we have target-based climate policies. Again, fossil emissions cause warming for millennia., a TH of 20 is too short compared to the physical timescales involved in the problem.

Q20: In principle, a payback time caused by the creation of a carbon debt must be as short as possible, and 20 years might be a reasonable proposition. This is clear in situations of abrupt land use change. But in the practice of subtle changes like in European forestry, the problem is the reference year. You can tell a forester that he/she caused a carbon debt by harvesting the forest, but he/she will tell you that he/she is not creating any debt, but is only using a credit built up in the past by his/her effort. So the reference time is arbitrary but decisive to conclude if a debt has been created or not. Also we need to remember that payback times are only possible to calculate for systems that reduce greenhouse gas emissions. If we decide to change management for a service which is not doing that, there is never payback, but we might still want to perform that change, even if it is causing emission.

So imposing payback time rules on bioenergy might be interpreted as discriminatory compared to other land uses

Q20: Since the idea is to use LCA, the proper boundaries should cover the entire life cycle. The use of payback time is irrelevant.

21. In large managed forest estates, management activities in one stand are coordinated with activities elsewhere in the landscape with the purpose to provide a steady flow of harvested wood. While carbon stock decreases in stands that are harvested, carbon stock increases in other stands resulting in landscape-level carbon stock that fluctuates around a trend line that can be increasing or decreasing, or remain roughly stable. Do you agree that forest biomass can - for simplicity - be considered CO2-neutral (with regard to biogenic carbon) if stemming from a managed forest landscape that is harvested on a sustained yield basis, i.e. if the whole forest carbon stock is not decreasing?

Q21: Absolutely! Kyoto reporting is on the landscape level at its biggest extent – i.e. at country level. The country level should be the geographical unit for accounting for carbon stocks.

Q21: Yes, of course. Stop thinking of a forest as a pool of carbon, instead accept a forest as a mechanism absorbing CO2.

Q21: I think that “carbon neutral” is a troublesome phrase that we probably need to move away from. I think that the forest described above can be described as a sustainable fuel source but that we ultimately need to consider the fuel required for forest management and harvest.

Q21: No, the counterfactual does not seem to be considered in the question

Q21: No from a scientific perspective – I do think there may be cases where the system is clearly carbon better and therefore could be treated beneficially from a policy perspective without each case being evaluated separately.

Q21: Depends on the context. NO, if we want to understand the total climate impacts, as then we should compare the forest use to a counterfactual baseline. YES if we think about the actual balances (e.g. for GHG inventory)…

Q21: Yes. But the key word is forest biomass…we’re not talking combustion emission in bioenergy.

Q21: 2. Depends on the baseline, which is rather a political than a scientific issue. For instance, have a country negotiated a baseline sink in international climate policy (e.g. Kyoto Protocol)?

Q21: Depends on the baseline scenario, maturity of the forest etc. One could argue that the answer is yes, if carbon leakage/ILUC is taken into account.

Q21: If the management described in the question was specifically 'business as usual', then I could have answered yes/3. However, it is the case that, in some situations, additional wood may be harvested/extracted from forest areas, and this is achieved on a sustainable yield basis, but there will still be reductions in forest carbon stocks associated with the additional harvesting/extraction.

Q21: No because this line of reasoning neglects that the same landscape would absorb a lot more C if not harvested, and would continue to do so usually for many decades, perhaps even centuries (counterfactual).

Q21: 0 = disagree with the question. Once again, in which context? Yes, in annual GHG accounting for Kyoto etc. reporting the forests are managed in a CO2-neutral way. But in terms of impact assessment of activities, the C evolution in the management activity needs to be compared to the counterfactual baseline. In impact assessment context the CO2/climate neutrality is very unlikely.

Q21: No, a carbon neutrality assumption is probably not valid a priori in any case. However, in cases like the one depicted above, where sustainable forest management is in place, where a long time horizon is assumed (steady flow of harvest), and where a large forest estate is considered (thus only a small part of the forest is harvested) it is probably quite safe to say that the balance is close to zero. It should be kept in mind that we are talking about forests that would be managed in any case. Of course other GHG emissions have to be accounted for (harvesting machineries, transporting, processing, …).

Finally, answering yes/no to this question is difficult: the answer in fact depends on many factors (such as management practices, timeframe and so on), and specific analysis is needed.

Q21: Yes, conceptually, but only after accounting for the fossil fuels used in the production of the biomass. Sustainable forest management can be used to ensure that the stocks are not decreasing.

Q21: It depends, but the example in the question is irrelevant in the context of promoting bioenergy. Suppose one has such a system in steady-state, working on a 100-yr rotation. That must mean that the harvest level has been unchanged for about a 100yrs and could continue indefinitely without a change in C balance. I could agree to an accounting convention that would consider its output "carbon-neutral". However: 1) This would only apply to the preexisting production level. Should the demand for biomass increase, the system would be perturbed and significant GHG emissions would occur. Therefore, the increase cannot be C neutral. 2) It is not certain whether a higher rate of production would be possible to sustain, and even if so, it may take a very long time to reach a (new) equilibrium. 3) Even if the energy production is maintained at steady-state, it still carries a significant opportunity cost. Let's assume that a C free energy source becomes available that can replace this wood. If we use the new source and stop harvesting, the forest will start accumulating carbon until it reaches a level similar to what it contained before it was taken into management. That is the cost of maintaining production.

Q21: No. The carbon neutrality assumption is simply not valid because without bioenergy production the forest would either continue to grow and store the carbon out of the atmosphere, or the wood would be used for the production of materials. Not even residues can be considered carbon neutral, as a matter of fact, if residues are left on the forest floor, they constitute a carbon pool alternative to the atmosphere. The same applies to waste-wood if landfilled instead of combusted.

Q21: Partially yes, particularly for routine assessments, eg for policy implementation, this may be appropriate. For research purposes, and to confirm the assumptions of policy, the balance of growth and extraction should be assessed, to confirm the assumption of stable C stocks. If there are significant fluctuations in C stocks over time, compared with the reference forest system, these may have a climate impact that should be included.

Q21: Yes/no – I would like to introduce an growth parameter over time to this concept, since it is the amount of annually harvested wood the has the real potential to make a difference for the climate. Don't focus to much on the stock unless it is rapidly shrinking.

Q21: 3. Yes. (provided new drainage is largely prohibited)

Q21: It is not either or. both stand level and landscape level provide important insights. The turnover time of different carbon pools, within the global carbon cycle, are of relevance for understanding climate impact of utilizing different resources. (E.g see respons on 19.)

Q21: From experience we know that this is very dependent on the age class structure and thus on the history of the forest in a given landscape. The normal forest is a desired state, a theoretical concept, which is never reached in practice. Inventory data give us a good view on age class distributions, and allow us to perform time and space explicit LCAs.

22. If bioenergy systems use biomass from managed forest landscapes where harvest does not exceed the annual increments, can one for simplicity exclude biogenic carbon in LCA studies?

Q22: Yes, however, the amount of carbon emitted during harvesting, processing and transporting should be added in any case.

Q22: 2 (Should also describe positive indirect effects of increased biogenic C stocks)

Q22: Yes, but often "sustained forest management" leads to improved CO2 uptake. In those cases biomass would have a positive value.

Q22: Yes, but I think we need to discuss spatial scale.

Q22: No, the dynamics of atmosphere-land GHG exchanges is not captured by such an approach

Q22: I don't think so. If LCA studies are for gaining knowledge, then nothing should be excluded. However, for making policy it is possible that exclusions could be permitted based on this knowledge.

Q22: NO. To understand the total climate impact we have to include the counterfactual. (E.g. if we used the same logic in the case of using peat for energy, could we then say that if the use of peat globally is lower than its annual increment, peat is carbon neutral?)

Q22: No. natural disturbance should also be included. What about the effect of black carbon, etc.?

Q22: Depends on the baseline in LCA.

Q22: It depends on the objective of the study. If one is studying the GHG implications of an increased demand for biomass, a consequential framework is needed which includes biogenic carbon. If the objective is to characterize the actual net emissions from the system, a simplifying assumption (excluding biogenic carbon) might be appropriate in the circumstances described.

Q22: Changes in biogenic carbon should ideally be included

Q22: No, because in some situations the additional harvesting/extraction of wood from areas of forest may be achieved on a sustainable yield basis, but will involve associated reductions in forest carbon stocks. It's more pertinent to consider whether levels/patterns of harvesting are consistent with 'business as usual' (or historical levels/patterns), or involve increases in overall harvesting/extraction.

Q22: 3 – They can be excluded in GHG-LCAs, but not in full LCAs that also consider other environmental values than GHG emissions.

Q22: No, for the same reason (Q21). In fact that's one of the core problems, in my view.

Q22: 0 = again disagree with the question. One, unfortunately, can do whatever they opt in LCA studies, but what is the decision-context they are trying to give climate impact information to? If the practitioner aims to give information on impacts endogenous to the studied activity to some decision maker, then no. Counterfactual is always needed in impact assessment with any decision-support relevance, whether it is framed "attributional" or "consequential". Cf Milá i Canals et al. 2007; Koellner et al. 2013 and Houghton in Lal et al. 2012. For traditional fossil comparators in "attributional" perspective the counterfactual just happens to be zero-level equalling actual (observable) net emissions

Q22: No, a carbon neutrality assumption would not be valid.

Q22: One can assume that carbon stocks do not significantly decrease and this can be a cost-effective method for measuring stock changes.

Q22: Certainly not if the purpose is to assess GHG impacts. The "harvest does not exceed annual increment" condition is largely irrelevant and grossly misleading. First, there is nothing magic in harvest=increment as such. The question for management is at what level they are equal. H=I may mean total devastation (nothing grows, nothing harvested) or unmanaged (virgin) forest. Neither is good for bioenergy, but that does not mean that anything in between is good, let alone optimal. Second, many key wood supplying regions have a significantly higher increment than harvest, meaning a forest sink. Making them equal by increasing harvest would mean the liquidation of the forest sink, which would be roughly equal to the GHG cost of this policy. A roughly 10% increase of total GHG emissions (in EU and US). Third, the impact is not just in the C stock, but any displacement of pre-existing uses.

Q22: As for 21: if the studies are for routine assessments that is fine eg for product labelling; if studies have a research focus it is important to document any forest C fluctuations compared with the reference system, which could have climate impacts.

Q22: Hmm – uncertain. Probably better to have it included provided that the LCA approach capture the complexity of the system

Q22: 2. Depends on the purpose of the LCA.

Q22: DISAGREE. The atmosphere is part of the global commons, thus all sources and sinks of CO2 ought to be considered, including in LCA studies.

Q22: No, all should be accounted

23. Would the decision to exclude biogenic carbon in such LCA studies need documentation showing that the implementation of the bioenergy system is not expected to significantly alter the trend line for landscape-level carbon stock? What type of documentation - e.g., forest data at appropriate scale, compliance with SFM principles, information about relevant national legislation including its effectiveness in promoting sustainable use of forest resources?

Q23: – Every country conducts national forest inventories (with differing methodologies and periodicities). Remote sensing may provide information to extrapolate trends until the next assessment on the ground (sampling).

Q23: Yes – verified forest data at appropriate scale is most suitabl

Q23: Do not focus on the carbon stock, but on the ability for CO2 uptake. In most cases, all relevant information would be covered in existing forest legislation and policies.

Q23: A suitable topic for discussion, including of “appropriate scale”. I think that “significantly alter the trend” is also subject to discussion, i.e. appropriate baselines.

Q23: No, an approach focusing solely on stocks can be misleading.

Q23: Ideally, a statistically robust carbon stock assessment (Forest inventory, Landsat data, LIDAR, etc.) could be provided. The US private landowner/non-regulatory context presents more challenges than Canada.

Q23: For instance, yes. However, negotiation of correct trend line (i.e. baseline/reference level) is still mostly a political issue.

Q23: Again, whether the baseline is stocks at a point in time or stocks compared to a trendline depends on the purpose of the analysis. In any event, the assessment of impacts on forest carbon stocks needs to be done at a scale, and over a time frame, that captures investment responses to increased demand.

Q23: YES. In fact, if we accept that mode, we will need a compliance scheme. SFM principles are the right way; however we should have clarified in advance on a scientific way, which specific management activities lead to which C effects. Though SFM as such has a lot do with C conservation, not all activities might be automatically addressed in the adequate way by just following a SFM endorsed standard. E.g. I am doubting whether PEFC would be protective enough.

Q23: Sufficient data could for instance be regional or national studies.

Q23: Yes, generally, it would seem that evidence would be needed, if such an assumption were to be made as part of an assessment. However, the evidence needed is, very explicitly, evidence that supports the view that implementation of a bioenergy system should not significantly alter the trajectory of forest carbon stocks (more specifically, cause reductions in carbon stocks compared with business as usual). The types of information listed in the second sentence would appear inadequate as supporting evidence - they could be viewed as 'necessary but not sufficient' criteria for forest bioenergy production. However, this depends on what is implied by 'forest data at appropriate scale' - it really depends on what the data are (e.g. carbon stocks?). Finally, be careful again. The answer to this question is likely to be context-specific, i.e. what specific purpose/question is being addressed by a specific LCA study?

Q23: 3 – To be excluded from analyses, documentation is needed that principles of sustainable management are followed. There may be several fluctuations in forest management carbon stores that do not express the climate impacts of forest management actions. Sustainable forest management is a better ‘measure’, which immediately considers other values than climate benefits .The documentation may be the existence of national legislation and documentation of its efficient enforcement, or sometimes supplementary measures may be needed, see e.g. suggested CPET methodology category A and B.

Q23: I think what one needs to show is that burning the biomass for energy is part of a strategy that has lower overall GHG emission than an alternative strategy (counterfactual) that does not include that.

Q23: Excluding biogenic carbon would not be correct.

Q23: A whole new set of procedures are not needed. In most cases, such as in the U.S., there are national inventories with regional information. Also there are state governments that have in place systems to monitor forest operating for sustainable management practices.

Also, in many cases the forests are under sustainable certification. In summary, there is often sufficient documentation concerning sustainable harvest levels that can be used to reduce additional assessments.

Q23: I don't understand the question. If one can document all that, why not include the impact in the LCA? It is not just the C stock that counts, but also other uses of the biomass (in the baseline). E.g., we can increase bioenergy production from a given forest without any impact on the forest by simply diverting all its output to energy use, and leaving the previous users of the biomass stranded. The question then becomes whether they would use wood from elsewhere, or whether their products would be replaced with non-wood alternatives (presumably worse) or whether people would just use so much less of something (welfare loss). Whatever the case, the trend in the forest itself may be secondary or even irrelevant (e.g., in cases where production is linked to management objectives that are not oriented towards the market).

Q23: The decision to exclude biogenic carbon from LCA would not be scientifically correct.

Q23: Yes. Would require combination of inventory data (growth, extraction) and modelling.

Q23 yes, sourcing from countries that account for Art. 3.4 of the Kyoto protocol could also be an option.

Q23: Forest data at appropriate scale collected at a yearly/2-yearly basis and accessible to the public at the highest spatial resolution and compliance with SFM (which could be accommodated through national legislation).

Q23: Yes – documentation is always good and national forest and forest soil inventory data and trends provides strong evidence on the direction.

Q23: IPCC NIR for annex I countries in the Kyoto protocol and crude figures about deforestation from FAO FRA statistics for remaining countries. -> In problematic cases perhaps combined with independent satellite image analysis on changes in forest cover and density over time

Q23: Current SFM rules cannot guarantee steady forest carbon stocks. Inventory data will be needed to demonstrate that. When such information is available, we can as well perform an LCA.

FINAL REMARKS: While we support the use of life cycle approaches we are uncomfortable that this survey focusses on LCA as the sole basis for decision-making for forest-based bioenergy, and that it categorizes ALCA as the relevant tool for policy implementation and CLCA as the relevant tool for policy development. There are other important approaches that should be considered: GCMs, CGE models, IAMs that are dynamic and that model environmental and human-environment, and socioeconomic processes. These broader, dynamic, process-based models, especially those that model human-environment interactions are important for developing understanding of factors such as ILUC and rebound which determine the true net effects of bioenergy policies. Perhaps a very broad definition of CLCA would encompass at least some of these, but it is misleading to class these approaches as elements of LCA.