IEA Bioenergy

Task 42 Biorefining

The role of industry in a transition towards the BioEconomy in relation to biorefinery

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On behalf of IEA Bioenergy Task 42

Conclusion

- The chemical industry and the biofuels sector are the sectors that a going to drive the development and transition towards a BioEconomy
- The main barrier for developing a BioEconomy is profitability and lack of appropriate policies (political stability to ensure long term planning and commitment)
- Profitability is also limiting collaboration between stakeholders in distinct market sectors – there is a need to see economic benefits and therefore good examples needs to be better exposed and communicated
- It is a competitive market and trust between stakeholders is needed
- Funding programs that facilitates/encourage collaboration across traditional market sectors can stimulate the development
- Cross sectorial networks could facilitate collaboration
- Task 42 can play an active role by monitoring and communicate the progress within demonstration of technologies and highlighting success stories

May 20th 2015

Introduction

In the transition to a future BioEconomy – an economy in which biomass is used for both Food and Non-food applications – the roles of stakeholders currently operating in more or less distinct market sectors will potentially change to a role being an integral part of the development and implementation of integrated sustainable biomass valorisation chains. Within this new role, stakeholders now operating in separate markets have to co-operate in the joint BioEconomy.

Existing industrial infrastructures, i.e. power plants, biofuel facilities, oil refineries, pulp/paper industry, and the food and feed industry, are potentially the point-of-departure for upgrading to high-efficient sustainable biorefineries on the short-term. Promising biomass conversion processes could potentially be integrated directly upstream (power plants, oil refineries) or downstream (biofuel, pulp/paper) of conventional industrial infrastructures, converting these infrastructures to high-efficient sustainable multi-product biorefineries.

The present study has been performed as an activity under IEA Bioenergy Task 42 with the purpose of reviewing the general option among stakeholders of the challenges and their role in the transition towards BioEconomy and to identify factors that stakeholders identify as critical for increased cross-sector collaboration. The outcome of the study will be a knowledge base that can be used by stakeholders intending to initiate collaboration across market sectors and engage in the development of the BioEconomy. In relation to IEA Bioenergy Task42 the study will be used to provide directions for future work, e.g. on focus areas for research and knowledge dissemination.

Methodology

The survey is based on a questionnaire (see appendix 1) that was distributed by the national Task 42 representatives to stakeholders in their respective countries. The direct but also selective approach was used to target key stakeholders in each country and at the same time ensure high degree of feedback. The survey is based on answers from the following countries: Australia, Austria, Canada, Denmark, Italy, Japan, The Netherlands, New Zealand and the USA. A total of 75 stakeholders responded on the questionnaire. Due to limited size of the survey the results have not been analysed on the basis of geographical/country distribution.

Background of the respondents

The background of the respondents is seen from Figure 1 and Figure 2. The survey is dominated by respondents from industry (64%) followed by academia (16%). The aim of the survey was indeed to identify the role of industry and the high representation of industry in the survey is viewed as positive for the outcome of the survey. Because of the limited size of the survey and the large representation from industry it has not been possible to analyse the answers on the background of the respondents. Rather the answers have been pooled into two groups “industry” and “others”, which then represents 64% and 36%, respectively, of the respondents.

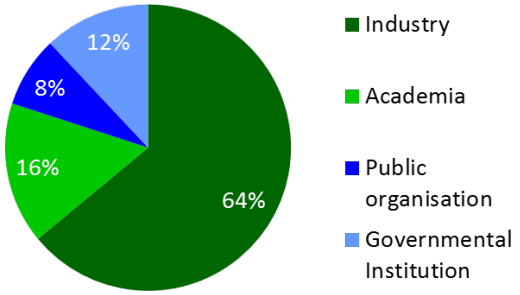

Figure 1: Background of the respondents

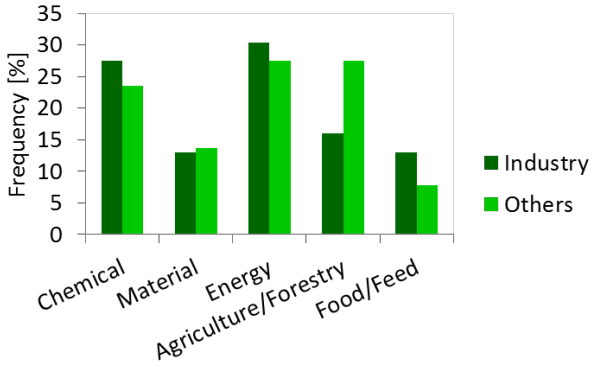

Figure 2: Distribution among market sector based on the background of the respondent. The group "Others" include academia, public organisations and governmental institutions. It is possible to be affiliated with more than one sector.

The respondents were able to select among 5 different sectors (Chemical, Material, Energy, Agriculture/Forestry, Food/Feed) to describe their affiliation. It was possible to be affiliated with more than one sector. Overall, the majority of the respondents were associated with the energy sector (29%), closely followed by the chemical sector (26%) and the agricultural/forest sector (21%). As can also be seen from Figure 2, the agricultural/forestry sector is much more dominating among the group "others" compared to industry. The agriculture/forest sector can in principal both include primary production, e.g. farmers or forestry, or processing e.g. forest industry/pulp and paper, which is not clear from the survey.

The role of different sectors in the transition

Existing industrial infrastructures, i.e. power plants, biofuel facilities, oil refineries, pulp/paper industry, and the food and feed industry, can be the starting point of developing biorefineries. These industries/sectors therefore play an important role in the development of future biorefineries and the transition towards a BioEconomy. Based on the feedback from the respondents (Figure 3), the most important market sectors in a transition towards a BioEconomy were the chemical industry (selected by 59% of all) and the biofuels sector (selected by 44% of all). The biofuels sector is already widely regarded as biorefineries, especially in the case of those producing biofuels based on lignocellulosic material. Currently there are also many efforts on making high value chemicals form biomass. It is therefore not surprising that these two sectors ranked high in the survey. The high ranking of the chemical industry and of the biofuels sector can also be attributed to the background of the respondents being largely from the chemical industry or the energy sector (Figure 2). For the group "others", the pulp and paper sector is identified as more important than the biofuel sector, but overall it ranks third (Figure 3). Agriculture/Forestry is overrepresented in the group "others", and given the relative higher ranking of pulp and paper sector and wood industry by this group it seems as Agriculture/Forestry is actually mostly from the forestry sector. In general there seems to be a tendency to rank your own area as more important for the transition.

Although the power and heat sector is currently the largest consumer of biomass for energy production, this sector is interestingly enough not ranked high in their contribution to the BioEconomy development.

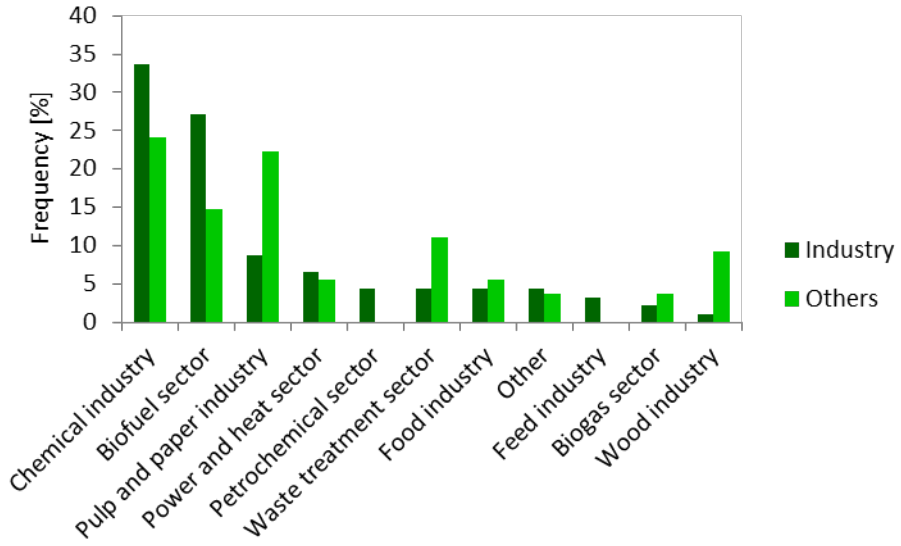

Figure 3: Ranking of the most important sectors in the transition towards a BioEconomy (All possible selection categories listed in figure).

Barriers for the transition

The questionnaire contained two questions related to barriers. Firstly, barriers related to the transition to a BioEconomy in general and secondly the barriers related to collaboration across traditional market sectors.

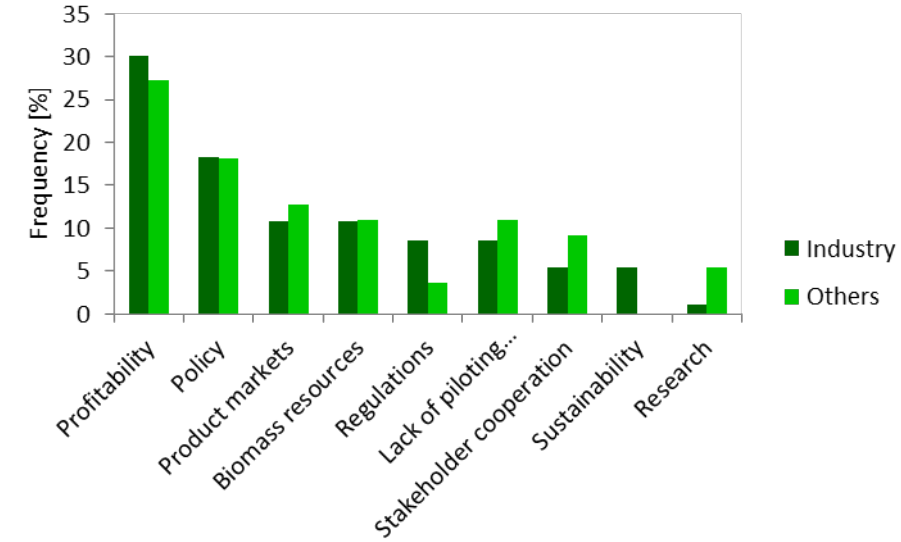

Figure 4: Ranging of barriers for the transition towards a BioEconomy (All possible selection categories listed in figure).

Irrespective of background, industry or others, profitability was seen as the main barrier for the transition towards a BioEconomy (selected by 57% of all respondents), followed by policy barriers (selected by 36% of all) (Figure 4). In general both groups (Industry and others) responded rather similar. Only for the categories “sustainability” and “research” a distinct difference was observed. As

the group others include universities and research institutions the higher focus on research within this group is maybe not unexpected.

When asked about barriers limiting the collaboration across traditional market sectors profitability was again the major barrier (selected by 33% of all), followed by stakeholder co-operation (23%) and regulations (20%). There was some difference between industry and "others" in the perception of most important barriers for collaboration (Figure 5). For the category "Research", this is likely again ranked higher by "others" relative to industry due to the large share of academia in this group.

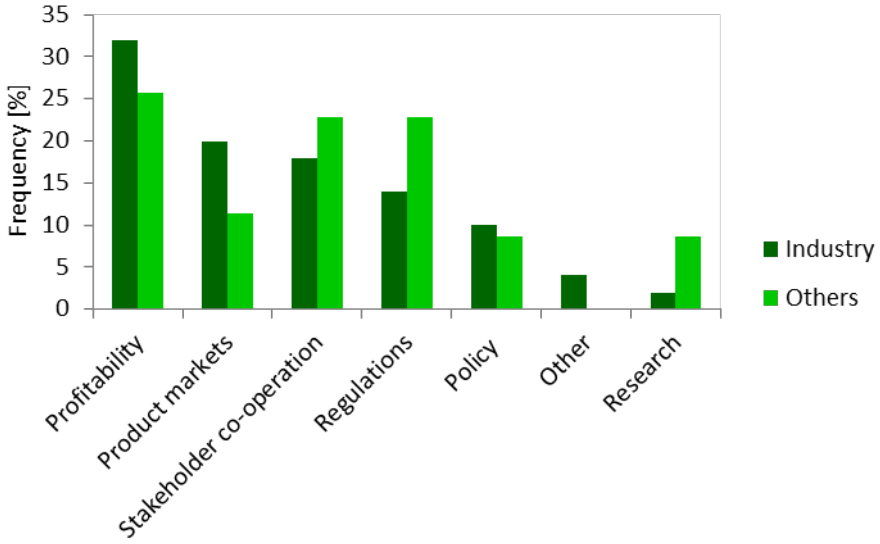

Figure 5: Ranking of the barriers for collaboration across traditional market sectors (All possible selection categories listed in figure).

As a follow up on the question of barriers for collaboration it was asked if facilitation was needed to stimulate the collaboration or if collaboration could be driven by normal market demands. In total 87% answered that facilitation was indeed needed. Among the possibilities given (Figure 6), funding opportunities that supports cross market sector integration was indicated as the best way to stimulate collaboration (selected by 44%). Networks that connect across market sectors is ranked as the second best option to facilitate cross sector collaboration. Interestingly, teaching and training activities was ranked significantly higher among the group "others" compared to industry. For this question it was also possible to suggest other ways to facilitate the cross market sector collaboration. Only 5 used this option and the comments are listed in appendix 2. No general conclusion could be make on the basis of these comments.

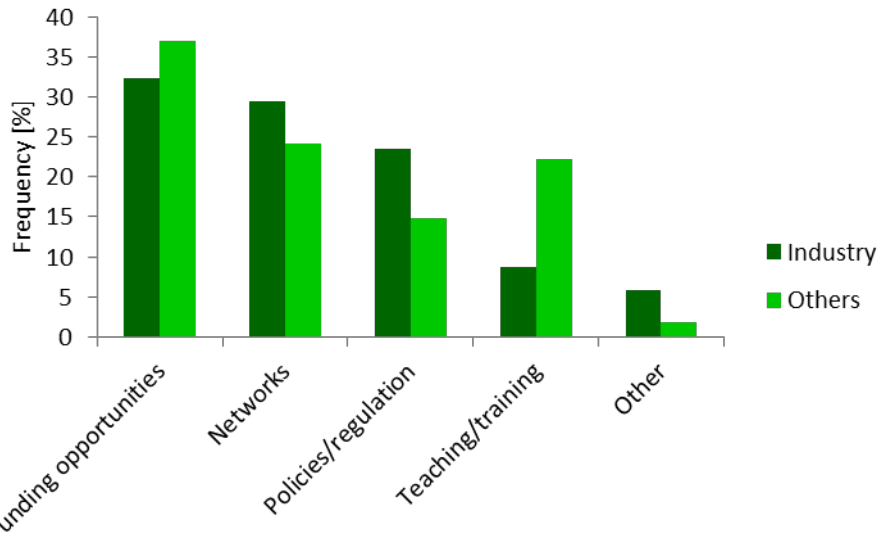

Figure 6: Possibilities to stimulate collaboration between stakeholders currently working in different market sectors (All possible selection categories listed in figure). Full category text: Create funding opportunities that support cross marked sector integration, Create networks across different marked sectors, Policies/regulations to stimulate or ease collaboration, Teaching/ training to increase understanding and awareness of possibilities, Other.

Collaboration to accelerate development of BioEconomy

The stakeholders were asked to give examples of how they see stakeholders currently working in distinct market sectors can collaborate in order to accelerate the development of the BioEconomy. A total of 34 comments or examples were collected. A complete list is given in appendix 4.

Some of the answers were very specific examples of projects or networks that provide good examples of collaboration between stakeholders from distinct market sectors (see appendix 4). In general, the answers showed that the following is needed:

- Creation of networks - many exists already, but usually the participants are from within the same sector. Focus should be on networks crossing traditional sectors (e.g. bridging agriculture and biotechnology) and supply chains
- Support to de-risk research, development and up-scaling
- Need for technology and personnel exchange to build skills across sectors
- Opening and sharing of test sites for pilot/demo scale. Two alternatives suggested:
    - Universities act as hub for to do initial demonstration also for industry
    - Universities could use private facilities for scale-up

Some interesting and important remarks also emphasised some of the barriers or problems associated with collaboration:

- Problem is trust – it is a commercial and competitive market. This is especially an issue related to exchange of knowledge and personel across sectors (and companies) and sharing of test facilities. Exactly in the scale-up phase IPR and knowhow could be very sensitive.
- Long term agreements needed to ensure trust and confidence
- Difficult to engage producing industries (e.g. 1G ethanol) which are focused on production and not testing new innovation

Biomass availability

An important factor in a future BioEconomy is the biomass availability, which was also ranked four among the barriers for a transition to a BioEconomy (Figure 4). Among the possible categories "new collection systems/technology" was ranked first as the key factor to mobilise more biomass for biorefining (selected by 44%)(Figure 7). Policy and regulation ranked second and third. Interestingly, training of primary producers ranked second among the group "others", but only fifth among industry. The possibility to use genetically modified plants as a way to produce more biomass was ranked low. As no analysis was done on the background of country distribution it was not possible to see if there was a general higher perception for GM plants in North America, where the use of GM plants is allowed, compared to Europe, where there is large resistance towards use of GM plants.

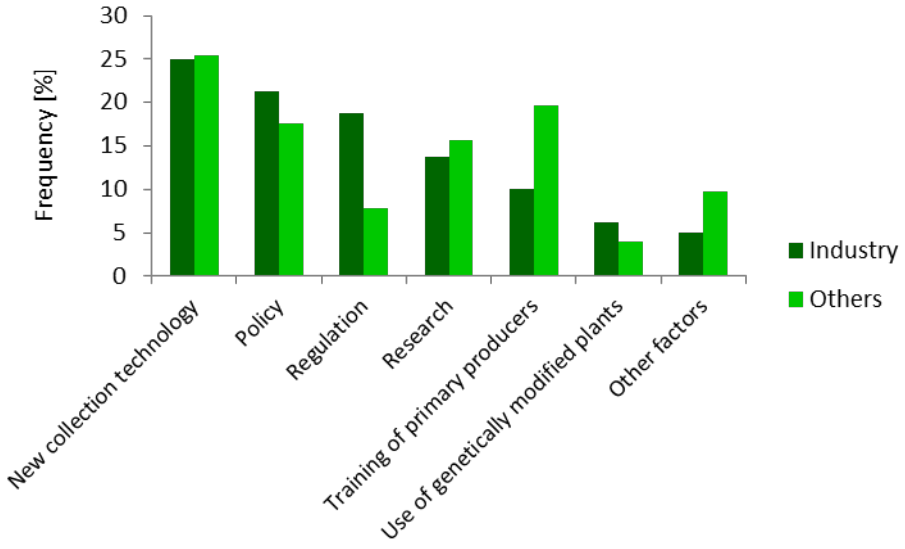

Figure 7: Key factors to unlock and mobilise more biomass (All possible selection categories listed in figure).

It was also possible to add comments or suggest other factors. A total of 18 comments were collected (see appendix 5). From the collected comments the general message was that it is important to ensure optimal use of the biomass in the whole value chain, i.e. use of cascade systems and system integration. As was also commented, in view of sustainability and food security no substantial increase in biomass production/availability should be expected. Otherwise, the comments were that it is needed to create a market, which can be facilitated either by imposing clear policies measures or by price incentives. However, also pointed out by others, feedstock costs are critical.

IEA Bioenergy Task 42

IEA Bioenergy Task42 Biorefining was started in 2007 and the mission is to facilitate the commercialisation and market deployment of environmentally sound, socially acceptable and cost-competitive biorefineries, and to advise policy makers and industrial decision makers accordingly based on facts and figures of biorefinery systems assessed in the whole value chain. The strategy of Task 42 is to provide an international platform for collaboration and information exchange between industry, SMEs, GOs, NGOs, RTOs/universities concerning biorefinery research, development, demonstration, and policies based on technic and scientific information.

Based on this it was therefore relevant to investigate if Task 42 was known among the stakeholders contacted in this survey. In general 56% replied that they had prior knowledge of Task 42 and the work done by the task. There was a large difference between the two groups "industry" and "others" - 46% and 74%, respectively. It is therefore clear that Task 42 in the future should have more emphasis on reaching the industry.

In relation to the overall subject of the survey, it was also possible to provide feedback on how Task 42 could support the BioEconomy development. A total of 23 comments were collected (see appendix 5). Based on the comments the following summarizes the recommendations:

- Communicate better progress within demonstration of technologies world wide
- Stimulate business thinking related to local circumstances
- Case studies of best practice
- Show techno-economic data
- Interactive techno-economic model to calculate feasibility in relation to individual specific sites
- Report on price and production volumes of biobased products
- Report on economic viability and sustainability on long term perspective

Some of these suggestions are very ambitious and in general detailed techno-economic data or models are not within the scope of Task 42. Furthermore, good models will require detailed data that are typically very sensitive for the companies/industries involved. Other good suggestions will be used to formulate the future work program of Task 42. However, some of the suggested topics are already partly covered by reports and brochures produced by Task 42:

- IEA Bioenergy Task42 Biorefining Report
- Biofuel-driven biorefineries Report 2013
- Biorefinery Fact-Sheets

For further information and latest information please visit the website of IEA Bioenergy Task 42 on: http://www.iea-bioenergy.task42-biorefineries.com/en/ieabiorefinery.htm

Appendix 1: Questionnaire

IEA Bioenergy
Task 42 Biorefining

Questionnaire IEA Bioenergy Task 42 Biorefining
The role of industry in a transition towards the BioEconomy (BE)
in relation to biorefinery

1) Background: ◯ Industry ◯ Academia ◯ Public organisation
◯ Governmental institution

2) Market sector: ☐ Chemical ☐ Material ☐ Energy
☐ Agriculture/Forestry ☐ Food/Feed

3) What are in your view the two most important market sectors in a transition towards the BioEconomy (BE) in relation to biorefinery?

☐ Power and heat sector ☐ Biofuel sector ☐ Petrochemical sector
☐ Pulp and paper industry ☐ Wood industry ☐ Biogas sector
☐ Chemical industry ☐ Waste treatment sector ☐ Food industry
☐ Feed industry ☐ Other

4) What do you identify as the two most important type of barriers for the transition towards the BE in general?

☐ Policy ☐ Product markets ☐ Biomass resources
☐ Stakeholder co-operation ☐ Regulations ☐ Research
☐ Lack of piloting & demonstration ☐ Sustainability ☐ Profitability
☐ Other

5) What do you identify as the most important barrier for the collaboration across traditional market sectors (for example synergistically co-producing Food and Non-food ingredients)?

◯ Policy ◯ Product markets ◯ Stakeholder co-operation
◯ Regulations ◯ Research ◯ Profitability
◯ Other

6) Do you think there is a need to facilitate collaboration between stakeholders currently working in different market sectors in order to accelerate the development of the BE or will it anyway be driven by normal market demands?

◯ No need, collaboration will be driven by normal market demands
◯ Yes, facilitation is needed to stimulate collaboration
If yes, how could this be done?

☐ Policies/regulations to stimulate or ease collaboration
☐ Create funding opportunities that support cross market sector integration
☐ Create networks across different market sectors
☐ Teaching/ training to increase understanding and awareness of possibilities ☐ Other: ...

7) How do you see that stakeholders currently working in distinct market sectors can collaborate in order to accelerate the development of a BE? If you are aware of good examples please provide links or references that can be used for follow up.

8) What are the key factors to unlock and mobilise additional biomass resources for the BE?

☐ Policy ☐ Regulation ☐ Training of primary producers
☐ Research ☐ New collection systems/technologies
☐ Use of genetically modified plants ☐ Other:...

9) Have you previously heard about IEA Bioenergy Task42 and are you familiar with our work?

◯ Yes
◯ No
What information on biorefineries deployment is lacking in your view, and what can IEA Bioenergy Task42 do to fill this gap?

Please return the questionnaire to Henning Jørgensen
heir@kt.dtu.dk before December 31st

www.IEA-Bioenergy.Task42-Biorefineries.com

Appendix 2: Comments provided to question 6 – How to facilitate collaboration?

List of comments to question 6:

- But it is difficult to establish and a slow process
- understand where inertia is created by having the wrong incentives in place, for example.
- Governments must be seen as attaching a priority to development of the bioeconomy - not a reality in Canada
- End user education and make products available to end users. For example filling station roll-out for bio-diesel bio-ethanol transport fuels. Encourage auto manufacturers to fast track materials developments etc.
- Third party facilitators (e.g. NISP)

Appendix 3: Comments provided to question 7 – How do you see that stakeholders currently working in distinct marked sectors can collaborate in order to accelerate the development of a BE?

List of comments to question 7:

1. BE has to be large scale for efficiency/ low costs so very high capital costs are encountered for emplacement of necessary new technologies. Need long term supply/ demand agreements between collaborators essential to provide confidence to invest
2. Alliance between paper companies and chemical companies. Paper company to have insufficient skills and knowledge related to organic chemicals, chemical companies biomass handling + water system of technology is not good. Need to do technology exchange and personnel exchanges.
3. Effective networking cross sector and across supply chains. Working groups are a good idea.
4. There are good examples, MicroBiogen and Agritechnology are examples of successful product development and commercial success - however there is a lack of awareness of the capability available in the region. For example, how many publicly funded research institutions would (or could) consider utilizing private scale up facilities to get their technologies to the market?
5. With the agriculture sector being a key to biomass production, showing the impact of bioproducts to increasing profitability, and financial resilience to farmers will help the ag sector be more interested in collaboration. Some examples explored in Australia relate to woody biomass, such as co-planting mallee species in broadacre farming (Western Australia), and harvesting unwanted native species on cattle grazing land in Central Queensland. Neither of these experience the food versus food challenge.
6. Often a complete chain from raw material to product is needed to get profitable processes. In this case we often need to look at less traditional collaborations to be able to generate enough value.
7. Provide support in piloting and DEMO
8. Joint research program and demos
9. Feedstock --> Sugar (cellulosic), Sugar (cellulosic) --> Chemicals. E.g. conversion of a side stream from wood pellet production (hemicellulosic sugars for chemical production) requires bridging the gap between wood pellet producers (feedstock) and the sugar to chemicals industry, which is primarily a matter of different cultures and approaches. In general it is very difficult to engage a producing industry, e.g. add-on to 1G production, which are focussed on production and not testing new innovations, even though the feasibility has been accounted for, but it has for obvious reasons a longer horizon.
10. BBE Park Cuijk, in development, is a clear example of cross-industry collaboration to reach BE goals (green power/heat, manure drying, (biogas), feed/chemicals through biorefining), using different biomass input streams and generation various products for various markets.
11. We have an alliance in Denmark between stakeholders (www.biorefiningalliance.com) who all have an interest in biorefining. This has created a common platform from where we can

contact politicians, central administration, science etc. - and a platform for public communication.

12. In order to accelerate the development of a BE a good way is to cooperate with stakeholder from district marked sectors to make use of their expertise and already available infrastructure for biomass sourcing
13. Government support and funding to de-risk the initial research and development work. Access to expertise and collaboration facilitation from the university sector who can act as hub and also perform initial demonstration work
14. www.nede.go.jp/activities/zzJP_100058.htlm
15. www.marcopolo.e.com; info@marcopolo.e.com; www.novamont.com
16. Organise joint meetings such as the "Agro meets Chemistry" meeting recently organised in the Netherlands.
17. Development of biomass for multiple market sectors
18. Market needs, whether driven by customers or policies, will ultimately drive innovation to move the bioeconomy forward
19. Projects will have to be a win-win for all participating companies. The right companies will find together when the right opportunities are identified
20. Work of Bioindustrial Innovation Canada in bringing groups together
21. There has to be a benefit to both industries; cooperation should increase their respective long term competitiveness; thre is a cost (lost opportunity) for not colloborating
22. Networks of stakeholders at the company level, like the FPAC'sBiopathways Partnership Network, or association level, like the BioEconomy Network. Cluster initiative are also useful
23. Create cross-sector working teams: Biomass production Biomass partitioning Primary products Final product
24. Significant collaboration has already occured (e.g. Agriculture & biofuels, forest sector & bio-products). The petroleum and petro-chemical sector are often seen to be opposing transition to lower carbon/renewable products. A mix of regulatory (stick) and market-pull (carrot) policies may assist bringing these sectors into BE alignment with agriculture, foresty, bio-refining.
25. This is difficult as it is a competitive and commercial market. Development of trust is a key aspect between parties and a mechanism that ensure both parties profit fairly from their contribution.
26. The CRFA and BEN Network are curently working together to create a national voice on the bioeconomy.
27. I think this should be a second stage cooperation once viable business models and value propositions are defined within the market sectors
28. Development of biomass for multiple market sector
29. There are good example - Ontario BioAuto Council, Bioindustrial Innovation Canada
30. Specificic and relevant goals for the collaborative project need to be set and the right partners across all facets of the supply chain need to be identified and engaged. Due to the immature nature of the research and industry, this needs significant goverment support but with the appropriate level of commitment from the private sector.

31. Waste heat and industrial gases as inputs in other processes (e.g. Vegetable greenhouse or CO2 to chemicals)
32. Petroleum and agriculture for ethanol. Sarina as Biohybrid Cluster
33. For instance, the Industrial Bioproducts Value Chain Committee in Canada (facilitated by Agriculture and Agri-Food Canada) and clusters such as the one in Sarina, Ontario
34. Bioindustrial Innovation Canada; Sustainable Chemistry Alliance Investment Fund, Canada; BioProduct Agrculture Science Cluster, Canada

Appendiks 4: Comments provided to question 8 – Other ways to unlock biomass or comments

List of comments to question 8:

1. Collaboration of primary industry sector and chemical company.
2. Price incentives
3. policy = policy stability
4. Better understanding by processors (who currently use biomass fibre for electricity production in boilers) to ways of better utilization of the biomass for bio-industrial products that also can generate surplus heat for power or residue suitable for boilers.
5. In view of sustainability and food security no substantail increase should be expected.
6. Market value known for primary producers
7. There seems to be much reluctance towards utilisation of local biomass (e.g. Denmark) which drives the prices up and limit the chances of local feasibility for biorefineries. This limits the geographical locations somewhat. In other words; feedstock cost is critical. This can be mitigated by policy and at least we should not create obstacles by enforcing regulation.
8. Clear sustainability criteria and consequently acceptance of NGOs/public for import of biomass; incentives for primary production of biomass
9. Optimal use of biomass value chain (material use first, energetic use second)
10. Create a market demand for biomass, for instance through regulations that accellerate transition to BE.
11. Improve the whole value-chain of the biobased economy
12. Use of casade systems
13. In Canada, land tenure policy of forest industry
14. System integration; integration into existing infrastructure
15. Economic profitability of the conversion and outputs will unlock additional biomass resources. Furter research to improve economics of the technology is key
16. Creation of networks (see 7)
17. Profitability as compared to other cropping opportunities
18. Financing derisking; collaboration between farmers, biomass converters and bioproduct customers.

Appendiks 5: Comments provided to question 9 – What information on biorefineries deployment is lacking in your view, and what can IEA Bioenergy Task42 do to fill this gap?

List of comments to question 9:

1. Influence government policy to support and encourage new technologies through advantageous financing - real direct action
2. Energy use of biomass is nonsense from the viewpoint of overall CO2 emission. The retain of biomass as solid useful industrial goods is the most effective strategy to suppress CO2 emission.
3. Primary product and the final exit product, each of the players, and coordination of technology
4. We would like to know the prices and amounts of bio-based products consumed by end-user all over the world.we wouid like to expect such an investigation and a report.
5. comparative techoeconomics and the idea that biorefining is an existing deployable industrial opportunity not an academic exercise.
6. contact forum between biorefinery actors
7. Any additional information will increase my knowledge of the work around Task 42 and I look forward to participating in the working group.
8. Clearly feasibility data is essential information for making projects look viable, however the challenge is the individual specifics to each site. Hence it might be worthwhile to develop an interactive techno-economic model that allows one to input data (eg cost of site, salary costs etc) showing the final cost per litre of producing the output product.
9. communicate success stories more prominent
10. Progress of demonstration plants worldwide not widely known; but there are wide definitions of a biorefinery and the resources vary with location (eg Pinus radiata enzymatic conversion to ethanol problematic for NZ)- so a demo in Norway (eg Boregaard) might not be relevant here. So aim should be to stimulate some business thinking relating to local circumstances by showing what has been achieved elsewhere - but needs cost/profit analysis so not so easy to do in practice. Examples based around anonymous case studies might work
11. Economic viability and sustaibility aspects long-term should be spotlighted - but it requires technology maturity (not there yet), feedstock cost at at reasonable level and a willingness to initally pay a premium for "biobased" products. The benefits of BE should be crystal clear for policy makers and industry players, but right now it's still a bit muddy.
12. It will be most usefull with an overview of residues on a regional basis
13. IEA Bioenergy Task 42 include enough information on biorefineries
14. Development of practival use for industry by companies led
15. Understanding of time lines to commercial development
16. Need to promote smaller distributed biorefineries that can be located in rural areas
17. Tell the stories of successful biorefineries (conditions that have enable their development)

18. I have heard of IEA Task 42 but I am not familiar with its work
19. The ideal role of goverments (and agencies such as IEA TF42) is to develop and promote stable policies and programs to promote and guide long term industry development. To attract capital to build and operate plants successfully, policie.
20. Have not identified any as yet. Newly acquainted to the organization and learning. This indicates visibility is an issue againts the backdrop of other organisations in the same field.
21. Capitalization relative to other potential uses e.g. Drug development
22. Case studies of international best practice of both bio-refiniries and bio-clusters (related yet distinct concepts)
23. More info on moving to a diverse faciolity -biofuels and chemicals and other products