

IEA Bioenergy Task 39 business meeting,
Elite Marina Tower hotel
Stockholm, 16 September 2019

Attendance: Leif Jönsson, Adrian O’Connell, Paul Sinnige, Stephen Dooley, Steve Rodgers, Henning Jorgensen, Gluacia Mendes Souza, Dina Bacovsky, Yuta (“Shibby”) Shibahara, Tomas Ekbohm, Jack Saddler, Jin-Suk Lee, Antonio Bonomi, Rubens Maciel Filho, Sune Thomsen, Franziska Müller-Langer, Duncan Akporiaye, Paul Bennett, Jim McMillan

Jim: Welcomed Task 39 members to second T39 business meeting of 2019. Thanks Jack, Mahmood and Tomas for organizing. As always, we have an overfull agenda. We will endeavor to maintain meeting schedule but likely to be challenging.

Tomas (local host/organizer): Overviewed weeks activities, especially first two days comprising T39 meeting and then, afternoon of second day, a study tour to the large Henriksdal biogas production and upgrading plant in Stockholm and to the Scania heavy duty engine manufacturing facility in nearby Södertälje, followed by the Task 39 dinner at Fotografiska restaurant (and museum) in the evening.

Jack: Leads off intros around the room, then reviews meeting agenda. Dina requests adding discussion of IEA B special project on transport decarbonization to meeting agenda.

Jack: Runs through slide deck update on Task 39 activities (this deck is posted on “members only” section of Task 39 site). Highlights include Latest newsletter (Netherlands) published, completed draft on Comparison of LCA models, Phase 2, Part 2 (Brazil), Task 39 profiled in IEA Bioenergy Summary Series piece in IEA Bioenergy Newsletter (focused on Task 39 work on LCA model comparison). Slides 8-11 were used to “encourage” proposed project areas/“volunteer” assignments. One of the main goals of the business meeting was to better define/prioritize Task 39 deliverables.

This motivated discussion around the table regarding ExCo’s expectations for (and the challenges of) T39 contributing to/interacting with many other IEA Bioenergy Tasks and other entities (e.g., AMF, FAO, etc.). It was emphasized that Task 39’s main focus remains on drop-in biofuels, especially interested in advancing biofuels for marine and aviation applications.

TEA / Duncan A. presented (see his presentation slides). Initial ideas for Norway-led TEA project. One challenge with aviation fuels is they have no pull relative to renewable diesel (which is equally good under LCFS and requires less processing/upgrading). General discussion about scope still being rather open-ended, with more definition/specificity desired as to scope of project and what will be delivered.

Duncan will participate in a Feb 2020 workshop planned on biofuel plant TEA (in Milan, Italy?). This meeting might be leveraged to better define focus for this would-be project. Key issues

regarding TEA also include relationship between feedstock sustainability and feedstock cost. It was suggested that, for TEA/LCA of co-processing to quantify costs/sustainability attributes, it would be good to also tie in with other experts like the California Air Resources Board (CARB) folks who have been involved in assessing methods to use to reliably / accurately / cost effectively “track the green molecules.” Jim noted that, while co-processing is highly attractive as means to ramp up production quickly by leveraging massive petroleum refining infrastructure, the bio-oils must be co-processed at high blending levels to reach substantial decarbonization potential in the finished fuels. For example, the 5-20% levels of blending that have been demonstrated / tested for coprocessing to date are insufficient to realize low carbon intensity (CI) finished fuels.

It was suggested (Franziska) to tie in Task 39 activities in this area with Tasks 43 (feedstocks) and 45 (sustainability) to better understand feedstock costs/sustainability and tradeoffs between these. It was also suggested (Rubens) to bring in refineries to prioritize projects/focus as not all potential fuel products are equally attractive (e.g., jet fuel versus Renewable Diesel).

Duncan will prepare more detailed proposal, mentioning the other Task members/entities that were discussed. This will be circulated for further development.

Certification schemes review (see Paul Sinnige presentation slides). Paul sees good potential / need for interaction/joint effort with Task 45 as Timo Gerlach (prior NTL for the Netherlands) is now in T45 and can facilitate this. Paul described the fraud case in the Netherlands where Euro 130 million in fraudulent (not legit) biodiesel was “claimed”, due to inadequate certification/checking/verification of certification. The biotickets made by the company were more than were actually allowed. This discrepancy was ultimately identified. Certification scheme change/improvement by using Renewable Energy Units (HBE) that allowed better real time tracking of renewable energy content along the supply chain. This has also motivated the development of an EU-wide database to try to improve transparency and credibility.

The subsequent discussion covered lipid feedstock’s, what we are using today and challenges on supply side (i.e., everyone interested once it’s a waste, no longer virgin/pure oil). Challenges of adulteration of pure lipids to get them categorized as waste, thus big incentive for fraud. Palm oil is leading / lowest cost / most productive terrestrial oleaginous feedstock. However, no one will touch it! We (Task 39) really need to identify/get representation from Malaysia and/or Indonesia (leading cultivators/producers of palm). This is an on-going objective for the Task, although proving difficult to make happen. Can we “recruit” someone from CARB and find out more on how they are doing certification? It would also be good to have other regulatory bodies (Europe, US, etc.) and producers (NESTE? Etc.) involved. Challenges to verification have prompted CARB/CA LCFS and Brazil’s RenovaBio to include 3rd party certification of submitted data. Franziska, Germany also faces similar challenges and we should bring in ISCC. For example, how could existing certification schemes be applied for/to aviation fuels? Glaucia can put Paul S. in contact with Brazil’s certification scheme regulators. Dina: India would also be quite interested in this. We should send them the minutes and emphasize this project. Adrian: Certification schemes need improvement. For example, who is checking the checkers, especially

in voluntary schemes? Biofuels produced in country A and used in country B present challenges to certification schemes / effectively coordinating regulation. Need to tie-in with certification bodies (CARB, ISCC and beyond). Adrian / Paul S.: Discussion of palm oil vs palm oil fatty acid distillate (PFAD); different country regulate these two materials differently, some deeming them fully equivalent (i.e., equally bad / not to be used), others don't see equivalence and OK with using PFAD.

Coffee break

Franziska (see her presentation slides) Successes/lessons learned.

As well as technical/commercial successes, could include policy aspects. JM suggested bringing in US DOE's information about this as well as considering/including policy; e.g., high level findings of implementation agendas. Steve Rodgers, Thomas Ekbom, Glaucia engaged in the discussion. Challenges to getting full details but high-level findings can be discussed. Focus on technical and logistics / policy difficulties / recommendations. Kior (Biofuels digest 3 part series mentioned by Steve R.; Range Fuels as another mentioned by Thomas E.). There are more examples. Glaucia indicated that we should not discuss failures without potentially losing audience/engagement of companies. Paul S.: Cargill doing a great job of segregating wastes and re-valorizing them (e.g, type C starch recovered from waste waste; which gets double counted.) Steve R: is there anything we can learn from Gen 1, i.e., conventional bio-ethanol or bio-diesel? Antonio: Importance of co-products, e.g., sugar in Brazil, animal feed in the US. Now sugar needs the ethanol whereas previously the ethanol needed the sugar (to make for viable economics). Stephen D.: Has there been much activity with joint ventures to reduce risk, conventional vs advanced? JM: POET-DSM plant is one good example of this. JM: Suggest this project be prioritized.

Glaucia/Rubens. (See slides). Emerging markets for biofuels expansion, production and use. Suggest that Task 39 funds (\$25,000?) be used to hire post doc to do this work. Leverage FAPESP funding for joint universities-industry projects (PITES program; limited to R&D done within Sao Paulo state. The Task 39/FAPESP funded post doc will look at emerging markets, building off SCOPE project, chapters had focused on Latin America and one on Africa (what about Asia?). Examining potential of converting pasture to cane cultivation across many emerging countries. Shows results of study examining 1% pasture conversion potential to increase cane production and reduce emissions (potential for this). Rubens described the proposed project in more detailed – focus on exergy analysis-based approach to achieve best renewable energy ratio. Corn plants seen as way to stabilize ethanol supply (avoid / reduced seasonal variations). Also as a way to help enable cellulosic ethanol. He mentioned that Vale (large Brazilian mining company) must spend \$15 billion to recover/restore/reforest previously mined lands, nominally by replanting with palm (or another biofuels / lipid feedstock). Antonio: Important to include third leg of sustainability assessment – social impacts – especially for emerging countries. General agreement around the table on this being a good point.

Break for lunch – Ain Laidoja from Estonia joins us @ / after lunch (as observer).

Steve Rodgers/Paul Bennett (Steve presenting – see his slides) on marine biofuels opportunity and challenges. Again, current specs don not enable biofuels and impose lots of challenges. Current approach to removing sulfur is hydrotreating with fossil-based hydrogen. Advantage of biofuels is they are relatively low sulfur, less costly to achieve sulfur limits. Carbon intensity to decline; reduce by 40% relative to 2008 levels by 2030, pursuing 70% reduction by 2050; 50% GHG reduction by 2050. Scrubbers / cleaning up fossil fuels high cost, so big opportunity for biofuels. Steve pointed out challenges to current specifications, e.g., TAN (total acid number) which isn't appropriate measure for corrosivity for biofuels. Other are density, stability. New test method(s) needed. E.g., miscibility with water (versus "density") as well as with the fossil fuel the biofuel might be blended with. Aromaticity Index is another where the test gives incorrect indication of the combustion quality of a given biofuel.

Dina suggests teaming up with AMF, as they have a proposal to study marine fuels opportunity in light of low sulfur requirements coming into force. Adrian O indicated that the European standards body, CEN(?) is also looking at this. Henning/Sune also have proposal in this area (see more on this below). Jack: We should try to engage with Good Fuels as well.

Henning/Sune (HJ presenting; see his slides). They propose updating the marine biofuels report as Maersk shipping in Denmark has a high interest in this area. Previous report by Claus et al extensively leveraged information from Maersk and they are now engaged in evaluating a variety of alternative lower sulfur (and low CI) fuels. Maersk are hoping to offer "carbon-neutral" transport (shipping) services. This project also offers the opportunity to tie in with Tasks 34, 42 and 45. Task 34 member (who?) contacted.

(Duncan also knows him– he's involved in projects that Duncan is also following/part of). The group agreed on a division of labour approach: Sune and Henning would "just" look at updating the 2017 marine report while Steve and Paul will focus on what will be needed to change the standards to enable biofuels to be part of the mix. Tomas: Can you say different things about ports/ferries incorporating biofuels faster/lower hurdle for profitability than ocean going vessels?

The agenda was changed at this time, to ensure we could connect with the participants joining via skype.

Instead, we discussed future Task 39 meetings at this time.

Paul B. briefly discusses ExCo's effort to contact with communications experts to improve our messaging. This is evolving.

In reverse order, it was agreed we would hold our end-of-2021 meeting jointly with the ExCo meeting proposed for Brisbane, Australia late 2021. Denmark (Henning/Sune) offered to host the Task 39 meeting 21-23 April, 2021, Copenhagen. In subsequent discussions, Franziska offered to host Task 39 in the second half of 2020, at a date/location that will be finalized, with the possibility of tying in part of the meeting with another Task. The next Task 39 meeting will

be held in conjunction with the BBEST meeting (30 March-1 April, 2020) in Sao Paulo. The ExCo and Task 45 meetings will also be held at that time, with the hope that Tasks 39 and 45 will share in at least a half-day workshop. The Task 39 meeting will be held after the BBEST meeting on the 2-3 April, likely at FAPESP. A technical tour (two choices) was proposed for Monday, 6 April. However, subsequent discussions (after the Task 39 meeting) indicated that many of the Task 39 members would not be able to stay on in Brazil for that long. Jim and Jack will follow up with Glaucia to see if there are any other options

Susan van Dyk (via Skype – see her slides). Susan updated the group on the UBC co-processing work, motivated by the need to decarbonize aviation and marine sectors. The UBC group proposes to follow on / update the drop-in report. This will be subject of IEA Bioenergy's webinar that will be broadcast, Wednesday, 25 Sept, 2019. High capital cost challenges have hindered the development and expansion of stand-alone drop in biofuel production (as demonstrated by Alt Air/World Energy). Co-processing is seen as an easier way to ramp up production although this is still technically challenging and needs to be supported by the refiners who would co-process. Strength in leveraging existing petroleum infrastructure including hydrogen production. (See slides). Some of challenges include what additional infrastructure or increased cost of maintenance, increased hydrogen demand, changes to fuel blendstocks. Refineries are typically risk adverse and need to know such information before committing. But incentives or compulsory reductions in GHGs offer reasons / value for refiners to engage on trying to do this. While many refineries are testing coprocessing, this information is generally not available publicly. There is a lack of standards for bio-based intermediates, what levels of heteroatom, etc., contaminating content can be tolerated within refinery while maintaining positive economics and LCA. Both "conventional" feedstocks (lipids) and advanced (bio-oils from HTL, pyrolysis) are being evaluated. Insertion into FCC lower risk than insertion into hydrotreater, although the primary product is gasoline blendstock. Hydrotreater poses greater risk of damaging catalysts, increasing maintenance frequency. Tracking of the bio-component is not yet standardized, with the C14 isotopic method the preferred standard by some. However, relatively time consuming and costly versus alternative mass or carbon mass balance methods. Some key questions: what is the impact of feedstock variability on coprocessing performance (product yields, H₂ consumption, etc.) and how might we collaborate with other Tasks/entities on this? For example, coprocessing of FT liquids (Task 33); with biomass supply chains (Task 43), etc.

Rubens: Brazil's experience with pyrolysis oil has been challenging. Susan/Jack: Refiners prefer zero oxygen content, which makes for expensive oils. Duncan: FCC trials underway, trying to go further. Key is stabilizing py-oil. Paul B.: BTG press release today on progress scaling up py-oil production. Steve R.: Smaller refiners likely more willing to work with us versus big players who will only consider material that meets current (fossil-based) specs.

Duncan: Stadtkraft has historically not been interested in coprocessing; had experience with it but weren't interested in implementing. Recently this has changed. He's optimistic about them being able to contribute good information in this area. Tomas: Co-processing is a good report, essential to get plants built. He has been talking with Preem which needs to make \$2 billion investment to modify refinery to last for next 40 years. Susan/Jack: Walk before we run. Scale

up challenge is huge. It's only one of many approaches. Difficult to supply even a small refinery (like Parkland in BC) with sufficient biocrude for co-processing.

Coffee break

Mahmood Ebadian (via Skype – see his slides). Mahmood provided an update on Implementation Agendas report which also included China and India (beyond T39 member countries during last triennium). Jim is polishing before being released to public by Dec 2019. LCFS policies are proving most effective to date, providing best incentives to continue to improve (reduce) the CI of biofuels. Different countries have different drivers for biofuels. Energy security is a main one with food security another in some jurisdictions (e.g., Japan). Mahmood showed exemplary market pull and technology push tables from Ch 18 (which focuses compare and contrast of policies across countries), as well as strengths and limitations of types of policies currently being implemented. Plans to do two updates during this triennium. First in later 2019/first half of 2020. Second in second half of 2020 through 2021. Mahmood asked the group which new elements need to be considered. What changes are needed in the updates, e.g., adding section on compliance mechanisms used to enforce biofuels policies, recommendations re: optimal policies for international sectors like aviation and marine. Anticipate continue to grow emphasis on LCFS policies, as they are proving to be especially effective for driving innovation and increased more efficient / lower CI production. Mahmood will be sending an updated questionnaire and soliciting feedback/updates in October. JM: We should consider a chapter on limitations/challenges posed by current specifications/regulations – largely specific to petroleum and all too often inappropriate for biofuels. This is another area greatly hindering implementation – it's not JUST biofuels policies – current fuel specifications are also a major limitation. Steve Rodgers: it would be good to improve consistency in units we use to report out – volumes versus energy content or carbon intensity. However, this may be difficult to deliver. Franziska suggested delaying schedule as we don't want to submit updates until we can report on 2019 production/consumption statistics. General agreement to do this.

Stephen Dooley – Advanced biofuels supply chain assessment, CAPEX and OPEX (see presentation slides). Stephen highlighted prior literature, especially ART fuels forum reports. Adam's report and Dina's decarbonization report will build on this. Bottom line: Many different feedstock x process x fuel options to explore. Thus, we need to narrow scope. See slides.

Adrian O'Connell – LCA work, cont'd. See slides. (Don O'Connor also skyped in for this.) Past work shows models performing similar when same input data used. Why are there differences in input data? There are many reasons such as different assumptions, different time periods used, different geographical locations with different energy grids. See longer list on slide titled 2. There are also data gaps and the different models address these differently. Propose project to develop complete high-quality data sets (for EC and beyond). Make these data sets available to model developers/users to incorporate into their assessments. EC looking at Brazilian sugarcane ethanol, north (and south?) American soybean-based biodiesel, and also EU and NA (or Brazilian?) corn ethanol. However, public data on renewable diesel plants is

scarce. Propose developing sample set and seeing if industry can update/improve on it, with some type of 3rd party verification of accuracy / reasonableness of supplied data. Propose white paper (or peer reviewed?) on implications of using different allocation methods. Glaucia recommends contacting Annette Cowie (T45 WP leader) to build on / leverage what they've already developed. Franziska raised the issue of "good" versus "bad" CO₂, depending upon what the source of the CO₂ is (i.e., biogenic or fossil-derived). Other possible work areas include definitions for wastes and how to deal with wastes, modeling of other "unusual" or newer feedstocks (e.g., tall oil); etc. Adrian suggested that Task 39 become the "go to" experts for LCA issues related to biofuels. Don O'Connor (via Skype) indicated that T39 is organizing a biofuels LCA session at the BBEST meeting March/April 2019 in conjunction with next T39 business meeting. Related to this, he indicated he recently held a webinar with Haldor Topsoe on biofuels and that they remain interested in working with T39. The webinar content will become available to see/listen to next quarter. Haldor Topsoe are very interested in co-processing while CARB is expected to publish the first CI for a coprocessing pathway. Canada is also interested in this area. Don proposed developing a position paper on the best practices for doing an LCA for co-processing applications.

Jack thanked Antonio and his project team for developing T39 expertise/awareness in this area. This work has been critical and we want to extend it. Feedstocks are a key issue. Don indicated that the challenge with palm is land use as a large proportion of plantations have been developed on peat soils with huge detrimental emissions when the peat soils are drained and oxidize. A related issue is that a large portion of the new/on-going plantation expansions have encroached into virgin forests. On the topic of corn ethanol versus Brazilian ethanol, Don indicated that some US plants are as efficient as Brazilian plants. He thinks that 5-10% of plants in US are moving/have moved away from fossil-based energy inputs.

As the meeting was running into a time-crunch the topics below were covered quickly.

Glaucia gave an overview of the BBEST 2020 conference and possible Task 39 participation (See slides). The BBEST meeting will be held in Sao Paolo March 30-April 1st, 2020. This meeting will be held jointly with biofuture platform, in which 20 countries are participating. The 1st day is all plenary, with more political / high level focus. Parallel sessions on March 31st and April 1st, with final session being plenary biofutures platform summit. Financed by FAPESP, which allows only certain types of financial support. Registration fee to all IEA members will be greatly discounted (by 40%) for all IEA Bioenergy members; US \$420. 70% discount on hotel too (5 star hotel). Preregistration required; speakers must be registered by Nov 2019 (see slides). The Task 39 LCA session on April 1st 9-10:30am; Task 39 overview 11:30-13:00, Task 45 14:30-16:00. Private Task / exco meeting April 2-3. After weekend, there could a Monday study tour, either Iracema Mill or Sao Martinho Mill. See link for more info: <https://bbest.org.br/scientific-program/bbest-tours>.

There were 400 attendees last meeting, and more are expected this year, especially with new RenovaBio policy kicking off in 2020. There is also attractive sponsorship packages (see web site). Deadline for speaker registrations is Nov 1 to submit a presentation or poster abstract. Also seeking start-up companies to present/attend. Paul B. asked for clarification if the potential site visits are also open to IEA B ExCo / other Task members. They could be

Dina B – Update on advanced biofuels demoplants database. (See slides). Shows what's up and operating as well as what is no longer operating. Seeing on-going global interest in accessing database. Shows list of top ten countries accessing the site recently. 208 active entries in database now, spanning T33, T34 and T39. Re-activating entries related to HVO and would like to also be following co-processing. However, recognizes that it will be difficult to access good information.

Dina B – Special project/report on decarbonization of transport. How much can advanced renewable transport fuels contribute (see slides). This is another IEA ExCo special project (funded through EC rather than IEA ExCo). The goal is to identify hurdles, policy gaps, make recommendations. Dina showed an overview of the work package elements and contributors (see slides). Looking / projecting up to 2030. Will culminate in a workshop in 18 Nov 2019 in Brussels (<https://iea-amf.org/content/news/TD-WS>). We are all invited to attend and also requested to spread the word about this workshop to energy analysts who might be interested in attending. Tomas mentioned the recently published Swedish Energy Agency report that projects that, for Sweden by 2030, 25% of transport energy will come from electricity. Although much lower than previous projections, still ambitious.

Ended day 1 meeting at 5.45PM, gathered for T39 dinner at Fotografiska museum/restaurant. Taxis will arrive @ 6:10pm in front of hotel to take us there. Tomorrow start at 8:30 with presentations from Swedish government energy and transport.

Day 2, Tuesday September 17, 2019

Tomas Ekbom, welcome/kickoff intro to meeting day 2
Introductions around the room

Professor Joakim Lundgren, Lulea University of Technology (see slides)
Status of Swedish gasification and pyrolysis. He is also a member of IEA Bioenergy Task 33. Historical development since 1970s prompted by oil crisis and expected petroleum shortages, focus on gasification to biomethanol and pyrolysis to replace fossil oil. In 1980s, shifted focus to electricity production, less focus on pyrolysis. In first decade of 2000s, decreased interest in gasification-based electricity, renewed interest in gasification for biofuels production. During this decade, new large projects started including Pyrogrot, BLG, BoBiGas, Bio2G. Large market uncertainty for all biofuels proved a challenge, as are ongoing low oil prices. Currently, drop-in biofuels stimulated, pyrolysis liquids for upgrading in petroleum refineries, with gasification routes de-emphasized. Setra & Preem project outlined, focused on pyrolysis of sawdust. New company created to commercialize this technology (see slide). Also, project on pyrolysis liquid from old car tires. No physical plant(s) yet, but they are expected to be coming. SFC center of excellence coordinating gasification R&D, as they still see gasification playing a role. He discussed the GoBiGas Phase 1, 1800 h continuously 2017-2018. A technical success as all performance targets were reached. However, economics proved challenging plus it is difficult to be economical at the pilot scale. Also LTU Green Fuels (former Chemrec technology), another

technical success on gasification for methanol and DME. Several projects also on development of bio-jet fuel plus co-gasification for black liquor with extended feedstock base. Coertus Energy's WoodRoll technology, focused on biojet fuel from forest biomass and alcohols for Arlanda airport's needs. A literature review looked at cost reduction potential for advanced biofuels. Currently, pyrolysis to drop-in biofuels favoured under new obligation scheme with several projects initiated. Gasification ready for scale up.

Jonas Lindmark, Swedish Energy Agency, will become Sweden's rep to IEA Bioenergy ExCo. He presented (see slides) that the Swedish situation is unique in that they import a huge amount of HVO. They don't see this as a viable solution for the longer term. Pure biofuels and renewable portion of high level blends (e.g., E85) are exempt from CO2 tax and energy tax reductions/exemptions possible. More details on reduction quota, the new policy introduced 1 July 2018, starting with gasoline 2.6% reduction quota, diesel 20% reduction quota. This will be re-assessed after 1 year, revisiting important assumptions/uncertainties regarding future transport demand and level of electrification of transport. Ambition for 70% reduction in GHG by 2030 compared to 2010. The Swedish Energy Agency funds biofuels projects at 4 M euro / year. Example projects include TEA and paper studies, less heavy experimentation, allows many projects to be carried out with relative economy. R&D infrastructure at pilot/demo scale. Biorefinery pilot focused on pretreatment and biological conversion, two others shown (see slide). Jonas highlighted Renfuel and Suncarbon, which are developing innovation in lignin valorization. Jonas's conclusions indicated strong demand for drop-in fuels (both diesel and gasoline), uncertainties on policy for pure biofuels after 2020, several investments to build HVO production capacity, but mostly from imported (oleaginous) feedstock.

Nanna Wikholm, (Nanna.Wikholm@Naturvardsverket.se/klimatklivet) heads up Klimat Klivet initiative, which is a \$800 million climate support program with the goal of achieving the "climate leap" required to achieve fossil free energy (see slides). They support company initiatives to reduce emissions, e.g., Pyrocell and Lignol. Biogas production is big, filling stations, LBG fuels trucks, etc. Expect funding to increase significantly, from 6 to 10 billion kroners (for the period 2015-2020). Average grant is 47% of investment. 6200 applications 2015-18, with 3200 granted totaling 4.7 billion kronor, mostly to private sector. Not only biofuels, also includes charging stations, filling stations, biogas production and energy conversion including Coertus project (see earlier presentation). Review criteria used to judge/evaluate proposals and the restrictions of the program. Learning regarding biofuels include, must work with EU and state aid rules, markets and partners using vehicle fleets, what might be an alternative scenario, e.g., feedstock is not used / project not pursued, where will feedstock go otherwise? What fuel is being replaced? Need a mix of policy instruments. Investment supported need to complement carbon tax. They have seen several application withdrawn after they have been approved, pointing to challenges. Observations include long-term policy / investments can have a long life-span. P. Sinnige indicated that "state rules" prevent many projects from being supported. For example, he cannot support all the projects he would like to (in the Netherlands). Aid is to defray capital costs for new investments, i.e., not operating costs.

Coffee break

Sven Lochen, CEO RenFuel AB. (see slides) Other major players in company include Prof Joseph Samec, founder and Chm Mats Odell. Sven is entrepreneur who has started half a dozen companies previously. The focus of RenFuel is lignin-based bio-oil. Patented catalytic process that energy efficiently converts lignin from Kraft black liquor into lignin oil, "Lignol" (registered trademark or copyrighted?) see slide. 15 patent families in over 40 countries and 15-20% of R&D spent on IP annually. Feedstock is lignin-recovered from black liquor, not virgin forest. 1/3 of forest biomass is lignin (softwood). Kraft process same today as it was 70 years ago, primarily recovering cellulose which is only 45% of woody biomass. Paper mill has high efficiency power boiler as well as recovery boilers, but these are focused on chemical recovery and are not high efficiency. His process is atmospheric pressure, (under boiling temperature) so relatively low cost and a possible way to evolve a pulp mill into biorefinery. He suggests that their bio-oil can be used as a feedstock for HVO (converting bio-oil in petroleum refinery). Key attributes include energy efficiency, high yield (~99%), low T & P, no waste products. This eliminates the need to invest in a new recovery boiler to achieve increased pulp production, as black liquor recovery not required, creating more capacity for otherwise limited recovery boiler. Biocrudes require hydrotreatment/hydrocracking to make fuels (drop-in) with potential to achieve 90% CO₂ reduction. Biocrudes are potentially miscible with petroleum oil. Typically blended with HVO or gas oil to reduce viscosity to allow processing in a refinery. Lignol are partnering/working with Preen (among others?) have tested their bio-oil in 7 refineries so far and all have found this oil to be an acceptable feedstock. The first biorefinery in collaboration with Rottneros pulp mill completed basic engineering phase work in 2019. Although the technical results were good the ROI was too low (4-5 year payback; companies want it to be 3 years or less). Thus, need greater scales of economy to be attractive. Lesson learned is to focus on pulpmill with capacity of >300 kton pulp, larger than Rottneros plant. They want to identify a large plant with a commitment to further increase production. His slides outlined the company vision for integrated production in pulp mills as well as taking on lower grade woody feedstocks. His presentation ended with a short video.

Magnus Lindgren, (see slides) Swedish Traffic Administration (Trafikverket) and also a member of AMF. Wants to develop even greater interaction/collaboration with IEA Bioenergy. He described the policies/goals that included increased use of walking, cycling and public transport (already reached the 25% target!). He described a "sticks-and-carrots" approach. Bonus (carrot) side: provides bonus to buy new energy efficient vehicle (focus on tank to tailpipe). Malus (stick) side: annual vehicle taxes (for first three years after purchase) increase if car emissions exceed 95 g CO₂/km. 82 SEK for each g in range 95-140 g CO₂/km, and 107 SEK per g above 140 g CO₂/km. One loophole is that an individual can get credit for E85 compatible vehicle even if you don't fuel it with E85. He emphasized that the only solution for heavy duty transport is biofuels. Three key principles: Transport efficient society; efficient vehicles and operation; renewable energy. Emissions from infrastructure and vehicles need to reach net zero by 2045. To meet 2030 targets for passenger transport Sweden must use less passenger cars, especially within cities. (See slides). The 2030 target for freight transport depends upon several factors such as, improved logistics and modal shift (to more rail and maritime), shared urban transport (companies not having independent delivery fleets for example), fuel taxes, eco-bonus for rail

and marine, km tax, modal shift subsidy, etc. Challenge is that trends are not in this direction, with the number of vehicles/total distances driven still increasing across all sectors. Showed excellent comparison of how EU vehicle efficiency has improved substantially since 2001. Norway leads, but via electrification; Sweden has made great progress using biofuels. 2030 target for light duty vehicles is 50% more efficient fleet by 2021; will require significant electrification – see slide 14. 2030 target for heavy duty is 30% more efficient; only biofuels can play here. For public transport, target 80-90% electrified public transport; high potential in urban delivery. Additional 10-15% achievable through eco-driving (slower speeds, etc.!) – see slide. Nice plot showing the high level of renewable energy being used in transport) – see Slide 16 (or 18) – albeit still heavily dependent on imports (e.g., HVO). Target overall 50% reduction in total energy demand for transport by 2030; forecast 10-15 TWh bioenergy (biofuels) will be required, plus another >20 TWh bioenergy for marine, aviation and non-road mobile machinery. Q&A: What about engine side efficiency improvements (AFAE); he agrees great improvements possible on an engine dedicated to a specific fuel and sees it as a market challenge not a technology issue. Example being higher cost of filling station infrastructure while fuel demand diminishing due to higher efficiency usage in engines. A to SRodgers Q: Can get subsidy/bonus if modal shift to improve efficiency, e.g., moving what is now transported by road to be transported by marine. Key to increasing share of public transit is to make it more attractive, i.e., relative to driving a vehicle. Many cities have created “no private vehicles” zones where only walking/cycling and public transit are possible; can still use cars but limited to periphery so less direct which makes the public transit/personal mobility (cycling/walking) alternatives more attractive.

Wrap meeting for day; join conference study tour to see 1) biogas upgrading plant in Stockholm and 2) Scania engine manufacturing/assembly plant (in town where tennis great Bjorn Borg grew up).