Commercialising Conventional & Advanced Bio-Fuels

Task Meeting Update – Brussels September 2017

Representatives from:
Australia
Austria
Brazil
Canada
Denmark
European Commission (EC)
Germany
Japan
Korea
Netherlands
Sweden
USA

Observers from:
China
India

Highlights:

- EU focussed on trying to get RET II legislation passed which will if legislated:
  - Set EU target for bio-fuels at 8.5% from 2021 rising to 30% by 2030
  - Specific Advanced Biofuels target for first time 0.5% in 2021 rising to 3.5% – rather than double counting
  - Reduce first gen Ethanol production due to Food vs Fuels - very contentious and seen as a backwards step my many due to impact on investor confidence
  - Allow fuels produced from waste fossil processes

- Observers from India and China (looking to join Task 39)
  - India
    - India burns 120-160 MT agricultural residues burnt each year
    - India to make massive investment in Cellulosic Ethanol
      - 12 refineries of $US120-$US150m each to be commissioned by 2025
        - 400-450 tonnes a day
    - GDP growth of 6-7%
    - 11% increase in fossil fuel use
    - 3 X more diesel than gasoline
  - China
    - 2020 target of 10% ethanol
    - Migrating from corn ethanol to 2nd Gen ethanol

- Electrification of vehicles global trends
  - 2 billion vehicles
  - Most aggressive forecasts say 400 million EV’s by 2040 so still high requirement for Advanced Biofuels to help meet de-carbonisation targets
COUNTRY REPORTS

Canada – Jack Saddler
- Change of government – Liberals more interest in renewables & climate change
- Real reductions in GHG emissions proposed
- Focus on projects to reduce C emissions and reduce
- Carbon tax likely to come in Nationally
  o C prices are different depending on provinces
- Also big focus on new policy – possibly like clean fuel tax similar to that in California
- Overall sense – biofuels looking lot more promising at present

Austria – Dina Bacovsky
- Target 5.75% (on an energy basis) rising to 8.45% in 2020 for biofuels in road transport
- Preparing to implement 0.5% advanced biofuels
- 10 producers – 1 ethanol (340,000 tonnes), rest biodiesel (340,000 tonnes) – no HVO
- Biogas facilities for electricity, but few for fuelling vehicles
- B7 and E5 – some exports of biofuels, but also some imports
- Also some pure plant oil used
- ~25% FAME and ~10% are used in higher blends in dedicated fleets
- Biomass gasification CHP closed down – feed-in tariffs ceased
- Have project to do gasification/FT that was using this gasification plant, but will now build a smaller scale pilot gasifier

Brazil- Antonio Bonomi
- 25-30% of transport fuels as biofuels
- Ethanol mandate E27 in gasoline
- Also hydrated flex-fuel cars
- Biodiesel mandates increasing, currently B8 and increasing to B10 by 2019
- Biokerosene production should start by 2020 (Amyris?)
- Stable ethanol production ~25 bn L (ex ~350 plants) – pretty stable production, due to sugarcane productivity 80 t/ha/yr down to 60 t/ha/yr (climatic + mechanisation leading to soil compaction) & economic situation
- Energy cane could be beneficial for combined 1st & 2nd gen plants – but difficulties with making/selling ethanol when sugar prices are good
- To meet Paris commitments will need to double ethanol production
- Biodiesel – lots of spare capacity - largely produced from soy bean oil + animal fats + other oils
- Showed some figures for biofuel production out to 2050 – lots of 2nd gen ethanol & lots bio-kerosene production [FT technology most promising, but also possibly renewable jet using H2 generated from excess electricity produced at sugarcane mills]
- Also current and future costs for biofuels – in short term 2G not competitive, but will improve over time and by 2025 will become competitive (due to reduction of capital & enzyme costs)
  o Basis was to calculate amount of money needed via policy to give incentives for 2G production
- 2 operating 2G plants – early problems, particularly in pretreatment, are being solved
- Also gave information on GHG emissions reductions
- Ethanol produced from mix of sugarcane (~8 months) and corn for rest of year may make sense for certain areas
- Maybe biokerosene from sugars will become economic when C mitigation costs included?
Germany Michael Seiffert

- Complex policy, but clear focus on reducing GHG
- Biodiesel 2.8%, bioethanol 1.2%, HVO 0.7%
- Increasing concern around getting biodiesel cars out of urban areas
- Germany still dominant in biodiesel production – some exported
- Also biomethane production from AD (but lack of infrastructure)
- Recent increase in HVO use (imported)
- 1G ethanol shifting from pure ethanol to a much more biorefinery approach – also selling feed & enzymes
- EV incentives, but still not being deployed at the rate the government wanted
- Increasing interest in hydrothermal treatment to produce fuels which can be integrated with refineries
- Focus moving away from pure fuels to fuels + chemicals
- Lots of interest in using PTx projects (power to x, gas, chemicals, fuels etc)
- Decrease in biofuel funding

Japan – Shiro Saka

- Ethanol use growing up to 2017, mostly used as ETBE – largely imported
- 1G domestic ethanol decreased – previously some production from sub-standard wheat, rice, beet, but terminated now
- 2G projects – one project to produce sugars from construction waste for ethanol – saccharification using dilute sulfuric acid – produce 1.4 M L/yr ethanol (mainly from hemicelluloses) + lignin (+ most cellulose) + electricity: ethanol yield ~7% of theoretical
- FAME – B100 garbage truck, B20 in busses, but now down to B5 from 2014
- Also rapeseed B5
- Biodiesel production 2014 14.9 ML/yr, but might grow to ~20-25 ML/yr
- Hydrogen is stated direction in Japan – Toyota, Honda, Nissan all targeting Olympics for widespread demonstration – 90H2 refuelling stations
- Research projects on production of biojet from algae and cellulosic biomass & fermentation to acetic acid, then hydrogenation to ethanol
- Japan wants to have planes flying using biojet in time for 2020 Olympic Games

Netherlands Timo Gerlagh

- Target 10% renewable energy in transport by 2020
- Dutch Parliament struggling with how to implement iLUC policy, especially double counting and limit on conventional biofuels
- 13 parties in parliament, and still no government from elections in March – making it difficult to see exactly what future policy will be
- Biodiesel moved from single-counted to double-counted feedstocks (UCO – lots imported) + some animal fat
- Also some sugar beet, sugar cane and wheat used for biofuel production
- Neste estimates could increase HVO production by factor of 10 by using up to 30 M tonnes of non-edible fats
- Netherlands producing biodiesel for all of Europe – both HVO & FAME – but production has been decreasing slightly?
- Enerkem hopes to build MSW waste plant in Rotterdam
- Cost of offshore wind has gone down by 50% in 2 yrs – now cheapest form of electricity generation
- Looking at idea of making H\textsubscript{2} from this electricity and using gas pipelines to get to market
Korea – Jin-Suk Lee

- Bio-heavy oil used for power sector (RPS)
- Biodiesel B2.5 (500,000 tonnes), rising to 3% next year
- 10 biodiesel plants in Korea, only ~6 operating due to supply constraints
  - Main feedstocks UCO, PFAD (palm fatty acid distillate), soybean oil
- No ethanol used, but looking at trial of direct blending of ethanol or ETBE at E3 level
- No policy yet for advanced biofuels
- GS Caltex (Korea’s largest oil refiner) - biobutanol plant under construction
  - Developed own technology for cellulosic feedstock to biobutanol using conc H2SO4 hydrolysis (ABE fermentation using GM Clostridium organism – origin is from Bluefire technology improved using acid recovery & improved organisms
  - Feedstock: using municipal wood waste + palm oil wastes
  - Will focus on butanol for chemical market

Sweden – Tomas Ekbom

- 70% reduction in transport emissions by 2030 is likely. Separate quotas for petrol & diesel – will be introduced in annual increments
- Biofuels 20.4% of all transport fuels, but 27% of diesel, mainly as HVO
- Strong development for HVO, especially in heavy transport where it can replace fossil diesel or biodiesel
- Ethanol declining, biogas stagnant
- HVO100 larger than all other biofuels combined – made from slaughter wastes (38%), UCO, PFAD, tallow- no palm oil
- Many small biogas plants
- Ethanol still blended at E5 & no sight of E10
- E85 now difficult to market, so ED85 for heavy vehicles & buses – E85 may last only 2 more years, as only 1 new E85 car
- HVO capacity has increased, largely based on tall oil & will build plant to produce 800,000 tonnes in 2021
- ST1 plans for 200,000 tonnes HVO production
- HVO results in a bit more volatile fractions, so some blended into petrol
- SCA & Renfuels – solvent liquefaction of lignin at pilot scale. However, deposition of products is an issue here
- Sodra – 5,000 tonnes methanol from pulp mill
- All fuels taxed equally
- May have environmental zones by 2020, e.g. EV & biomethane at airport vs biodiesel, so could see diesel cars banned in Stockholm. Could mean folks will stop buying diesel vehicles...and then no market for HVO?
- So perhaps more development of EVs & hybrids?
- In iLUC, PFAD classified as a waste not by-product, so PFAD is likely to be removed... which might mean palm oil back again
- Observation that current policy supports biofuels, but does not encourage domestic production
- HVO 100% exempt 70 euro cents/L from carbon tax
- Currently for Neste, 10% of its production is renewables. But this is responsible for more than half of the company profits

Denmark – Claus Felby

- Country hopes to switch away from fossil fuels by 2050
- Proceeding well for electricity and heating
- Wind is growing, but bio is growing even more
- Biofuels: E5 & B5 are sourced from overseas
• Avedore Power plant is biggest consumer of biomass 1.15 M tonnes biomass 0.95 tonnes wood pellets and straw – mix of electricity and heat – main demand is for heat for district heating
• Biofuels production – FAME and DAKA based on residues from livestock industry (22 m pigs, 800k cows)
• Maabjerg large-scale biorefinery - still on hold
• Renescience [Part Of Dong] – use enzymes to liquefy MSW, then convert to biogas – plant built in UK separates out plastics for recycling
• Inbicon plant mothballed
• Biogas sector going well & expanding
• Technology development on reforming of CO₂ to methane - over pressure of hydrogen shifts equilibrium to higher methane - Could substitute ~40% of natural gas
• Renewables to cover 35% of total energy consumption by 2020
• Renegotiation of energy policy will occur in 2018
• Research - Funding for energy research cut by 50%. However, private foundations are making up for part of this reduction. Some areas of focus:
  o Looking at separation of lignin from biogas processes (it is essentially unmodified)
  o Thermal liquefaction
  o Light-driven enzymes
  o Lignin to diesel
  o Marine fuels
  o Lignin building blocks

EU – Kyriakos Maniatis

• No single market for biofuels in the EU
• Within the EU, bioenergy has negative connotations
• REDII 8.5% to 10% increase by 2030
• If reduce food-based biofuels then will make it difficult for advanced biofuels producers to invest
• CCU – essentially the Lanztech process
• Alternative & Renewable transport forum (~100 participants)
• Eni and Total – moving to HVO to keep two of their small refineries operating
• Pyrolysis – Ensyn, Fortum, BTG
• ST1 plant is still being commissioned
• Use algae from wastewater cleanup and then convert to biogas
• Has industry-based information on biofuel production costs
• Believes significant progress in all technology types & some close to commercialisation
• But need stable long-term policies if investment is to occur

USA- Jim McMillan

• Energy efficiency & renewable energy research proposed in DoE for 69% cut. At moment keep funding for 1st quarter from 1 October, then not clear what will happen
• Hard to tell what is coming at the moment given the political climate
• Positives
  o RFS2 and California LCFS driving everyone to put biofuels into California
  o Cellulosic ethanol plants still coming on stream
  o Existing dry mills starting to convert distillers grain fibre into cellulosic ethanol (incremental capital)
• Negatives
  o Petroleum prices
  o High policy uncertainty
  o Transitioning to chemicals
  o Abengoa, etc
  o US DoE going back to more basics – wants Natl labs to focus at TRL 3 and below
Bioenergy held to uniquely high standard

- Just got over 10% renewable energy in US and 14% of this is in the transport sector
- RFS2 targets – corn ethanol and biodiesel have met this, but advanced and cellulosic ethanol have not
- Expect that production of 1G ethanol will increase, but will depend on exports
- Lots of biogas RINs being generated
- Big growth in ethanol production from corn fibre – but lots of different approaches to doing this
- Cars after 2001 approved for E15 - some E15 stations are opening
- Biodiesel – still continuing to increase (still includes renewable diesel production), but limited by feedstock supply – lots of different feedstocks, soybean (~50%) rest wastes & some canola – also imported biodiesel
- Co-optima (Co-optimisation of fuels and engines) project with 9 national labs
  - Finding that high octane fuels in high compression engines is a good fuel and it might be best to get up to 30% blends of ethanol for optimal efficiency
- US policy uncertainty makes things difficult

India Sandeep Poundrik

- In India petroleum industry looks after biofuels as oil companies 60% owned by the Govt.
- Crude oil consumption +11% in past year
- India dominantly a diesel economy
- GDP growth +7% last year – linked to energy consumption
- Energy mix dominated by coal and oil (28%)
- Renewables to grow from 2.2% to 9.8%
- Rising import dependency a concern in India
- 3 ministries, renewable energy, power and fuel sector (look after biofuels)
- 98% of fuels sector is controlled by public sector companies
- 1G ethanol based on molasses (no grains used) – total potential 3 bn L, but ~1/3 taken by potable alcohol
- Now about 3.1% of gasoline consumption as bioethanol
- Interest in 2G ethanol as a way of getting to E10 in petrol – primarily from agricultural waste
- Government has asked to put in place 12 pre-commercial 2G plants at 400 – 450 t/day & offtake agreements from private sector producers
- Biodiesel – not produced/used very much because edible vegetable oil cannot be used (lots already imported) - production only 45 M L
- Important focus is on reducing imports to reduce dependency
- Used cooking oil – consume 23 MT of cooking oil, then recycled, leading to health issues, so trying to collect UCO to produce biodiesel
- Shell has a demo plant at 5 t/day to convert any feedstock to direct drop-in fuels (will start up this month)

Technology – RD&D

- 500 R&D scientists, within 7 centres of excellence for biofuels research
- Also a number of industries engaged, including oil companies - and a large number of extramural-funded projects
- Significant number vehicles running on CNG
  - Discussed current limitations:
    - Biodiesel – no edible oils
    - Bioethanol – inadequate feedstocks
    - Biogas – technology limitations
- Work on developing non-edible oil crops & macro and micro algae technologies on coast
- Also potential use of agri-waste and industry wastes for conversion to biogas – (but how to collect in short timeframe & store?)
- There are two 2G ethanol demonstration plants being built
- Includes Praj Industries 12 t/day demo plant
• Will have a pilot plant for anaerobic digestion for converting all wastes to biomethane in 24h – involves liquefying the biomass first, then anaerobic digestion within 24 h
• Three plants for 2G ethanol from rice straw or soy husks permitted and under development

China – Huili Zhang

• Biomass in China – presented data from 2010
• Country wants to transition from corn-based ethanol to 2G
• E10 in 3 provinces, production now 2.3 million tonnes/yr, but only in some parts of the country
• First plants used corn, but after this all using cassava and 1 using sweet sorghum
• Bioethanol production and use completely controlled by government
• Feed-in tariff have decreased to essentially zero, but still some tax refunds for producing cassava
• However, big announcement on 13 September – Implementation plan for deploying ethanol – full document with details still to be released
  o By 2020 all petrol vehicles will need to contain 10% ethanol from corn, including regional and schedule strategy – will be very ambitious
  o The establishment of an economically operational mechanism
  o By 2020 want 2nd gen demo plant in operation and industrial production by 2025
• A fast development is foreseeable in the near future

Biorefinery at BUCT (National Energy R&D Center for Biorefinery)

• Lot of work on sweet sorghum to produce ethanol and butanol
• Pilot facility for ABE fermentation to produce 1,000 tpa ethanol + acetone and butanol
• No private diesel sold to cars in China – only diesel in trucks
• Biggest oil companies not involved in biodiesel
• Research on converting fatty acids into biodiesel using enzymes and demonstrated at demo scale (30,000 tonnes/yr)

• Also lots of EVs being deployed, but thinks that biofuels will be dominant due to limited range of EVs

End of country reports.

Biofuels in Shipping and Marine – Claus Felby

Report issuance being delayed to add definition of low sulfur fuels in Introduction before public version of report is released

• Ships minimum scale of interest for biofuels 100,000 tpa
• Ships 8 major bunkering ports globally for 70% of fuel consumption (global demand 330 MT/yr in 2014) – main consumption by bulk carriers (coal, wheat etc) and container ships
• Tried to write report from shipping sector and biofuel producer perspectives
• Essentially fuel wants carbon – take anything - pumpable slurries: 2-stroke diesels operating at constant revolutions (high efficiency ~60%)
• Low quality requirements, but low prices
• HFO ~75%, MDO, MGO ~20%, LNG ~5%
• MDO and MGO not usable either in the environmental control areas
• SOX and NOx emissions regulated and now reporting CO2 emissions – now tools to monitor CO2 emissions during shipping
• IMO working goal – 50% reduced CO2 emissions – slower sailing will give a lot of this
- Challenge for biofuel developers is large amount required for test runs 20 – 200 tonnes
- Marine users don’t like pyrolysis oils – too acidic and not stable
- Can run emulsions of water and lignin as fuels (silica or sulfur an issue)
- Says thermochemical conversion routes most appropriate
- Could use new multi-fuel engines which can use methanol and ethanol, e.g. on methanol carriers
- Goodfuels – Claus thinks main fuel are UCO-based fuels (HVO). He notes they are also starting a business in Port of Singapore.
  - But challenged by supply
- “Low carbon transport is a commodity sought by shipping customers”
- **Claus will draft and add a less-than-10-page executive summary that will indicate why biofuels will be important in the marine sector. It was recommended that unlike our normal 6-month embargo, this summary go straight into the public domain to help influence the current RED II debate and demonstrate their potential and relevance.**

**IEA Bioenergy Roadmap (Transport fuels part) – Adam Brown (IEA HQ)**

- Roadmap to be published at the end of November in Ottawa (Joint Mission Innovation/IEA event)
- Exploring what it would take to make emissions below the 2DS possible, particularly by pushing more energy efficiency and more CCS (including bioenergy & CCS)
- Bioenergy RFS to 2DS required for ~1/5th of the emissions reduction required, i.e. very important for a low carbon future
- Roadmap is based around how this bioenergy might be best used
- By 2060 – big growth of bioenergy (up x4), but largely in transport sector (x10) and some growth in other sectors – biofuels ~30% of transport and electricity a little less – but they are complementary
- Suggests little hydrogen by 2060 – might have a role, but not in a widespread deployment (talks about emissions from industry. However, by then, price of renewable H2 could match cost from gas
- Model has a bioenergy input constraint. Bioenergy is only used in sectors where other options don’t work
- Mix of biofuels needs to change, especially focussing on the diesel pool, biojet, but also some growth in biogas and ethanol is predicted
- Need the new drop-in biofuels
- Currently 85% of biofuels used in US, Brazil and Europe, but growth in use (up to 30 EJ) must be propagated more widely globally
- Current progress slow and needs to move ahead much more quickly
- 4 major classes of actions are recommended
  1. Promote short term deployment of mature technologies (e.g methane in sewerage works)
  2. Further stimulate the already first and second generation biofuels deployment
  3. Catalyse geographic diversity of bioenergy deployment
  4. ???
- All these actions still need the right policy/regulatory framework
- Ideal policy landscape
  - Level the playing field
  - Provide low risk investment climate
  - Catalyse and support innovation and commercialisation
  - Fair, stringent and stable sustainability regime
- Continuing need for RD&D
  - To continue to reduce costs and improve GHG performance
  - Demonstrate reliable performance of existing “novel biofuels” plants
  - Need to develop routes to diesel and jet substitutes
  - Identify potential development paths for cost reduction
  - Broaden options with better understanding of non-bio low carbon fuels and BECCU
Comparison of LCA models – Antonio Bonomi

Comparison of 4 biofuels models

- Greet
- BioGrace
- GHGenius
- Virtual sugarcane biorefinery (VSB, Brazil)

- For sugarcane in Brazil – can harmonise by changing the different assumptions
- Paper submitted to Biotechnology for Biofuels
- Paper 2, led by NREL, under preparation

Phase 2 proposed (using all models, including updated VSB):

1. Preparation of paper with NREL to review representative LCA studies of commercial ethanol production
2. LCA of biodiesel from FAME and HEFA biojet from soybeans (US & Brazil), animal grease (Brazil), rapeseed (EU) and macaw (Brazil)
3. LCA of developing industrial processes for the conversion of biomass to advanced biofuels from short rotation eucalyptus and sugarcane (in Brazil) and corn (in the US)
4. Prospective LCA of technologies for cellulosic ethanol (2G) production integrated with corn ethanol in the US and sugarcane in Brazil
5. Preparation of paper prospective LCA examples for 1st of kind plants and projections of learning curve
6. Detailed report of this work

Phase 3, not really discussed, would likely run into next triennium

It was emphasised that GHG studies have a purpose – which dictate the choice of model

A comparison of diesel alternatives - Matt Hermann (REG)

- REG currently operates 13 multi-fuel biodiesel plants
- 1 HVO (75 M gal per year plant) – in addition to HVO, the plant makes renewable naphtha and renewable LPG
- Isomerisation to reduce melting point depends on cold weather spec – more isomerisation means lower yield and more co-products (this product called RHD renewable hydrotreated diesel)
- Also one sugar fermentation platform to make speciality fatty acids
- The GHG emissions of Renewable diesel depends on the level of unsaturation in the feedstock (more saturated the better) and decarboxylation and level of triglyceride vs free fatty acid
- UCO has to be collected from restaurants (they are paid for the UCO, but less than virgin oil). The UCO is cleaned up before it can be converted to fuels – only after this has been done does the price become similar to the cost of virgin oil

Overview of current global LCA work on biofuels – Don O’Connor

- Don’s presentation gave an overview of the development of biofuels LCAs
- 10 yrs ago LCA moved from informing policy to regulatory compliance, e.g EU RED, US RF2 programme
- California LCFS – plant-specific CI [carbon intensity] now used for most fuels (except or gasoline and diesel) – fraud is an issue
- Primary data – this is the “gold” data
Secondary sources – from databases, literature etc & things change all the time – these are major sources of variability

Challenges around LCAs:

- Challenge for regulators relying on LCAs: they should represent the process being modelled, be fair and don’t contain biases
- A lack of good quality secondary data, e.g. fuel use on farms
- USDA publishes regional farm energy use by major crop every 5 years or so – not transparent and lot of geographical variability – and global variation
- Also issues around changes in carbon stocks – This exclude palm oil from most biofuel programmes
- Definition of waste vs residue vs co-product – no generally accepted rules
- Allocation approaches – displacement vs mass vs energy
- Model differences

It was recommended that an Action Steering group of Antonio, Don, Jacopo and Mark Staples [MIT] to have a discussion on what Task 39 should do in the LCA area in the next year and next triennium and make recommendations – and tie-ins to Task 38 and 43 within 4-6 weeks.

Recommendation: Don to look at condensing down a short primer on LCA of biofuels, based on the previous work he did for AMF (which is already in the public domain)

India

- Interested in principle in joining Task 39 but needs a number of ministries to agree. Plus, would need a formal invitation to take to the appropriate ministries before they could get a decision.
  Jim, Jack or Luc will arrange for this letter of invitation to be set out

Offered to host the next meeting if China falls through.

Drop-in Biofuels Report Update

- Jack gave an update on the report – As it will build on the first report, it should be shorter and complementary to the first report
- Projecting an 80 page update (review of technologies) – with new sections including 1) drop in integration with oil refineries 2) a section on policy to encourage production and use of biofuels in the air, marine, rail and long distance trucking sector and, 3) section on LCA (as decarbonisation of long distance transport is the main motivation)
- Hope to have a rough draft ready before Beijing meeting

Luc Pelkmans – IEA Bioenergy Survey results

Luc gave an update on the recent IEA Bioenergy Survey results – which will be discussed at the upcoming ExCo meeting in Switzerland

3 surveys – general (358), ExCo members (22/24), Task Leaders (10/10)
Top 3 priorities for IEA Bioenergy TCP activities (from general survey)

- informing the public debate
- discussion platform
- central information source

but all others important as well

Future areas of work (Luc’s groupings)

- Bioenergy in future energy systems
- Circular economy – including using wastes and residues
- Mobilisation of biomass (in sustainable way) T43
- Environmental impacts of bioenergy
- Biomass conversion: business models and techno-economics
- Biogas/biomethane
- Transport biofuels
- Deployment of bioenergy
- Social impacts, acceptance and dialogue

Next Task Meetings

Beijing, 7,8 April 2018 – subject to confirmation

Week of 5 November 2018, San Francisco, around end of triennium conference