An energy efficient route to fossil free energy supplies

Biomass role in a sustainable future

The national climate legislation and international goals provide very tough challenges in cutting the net CO_2 emissions towards zero in order to secure a sustainable global climate. Despite growing efficiency and capacity in production of sustainable electricity etc. we are still very far from reaching these goals. An argument often heard, is that the biomass available can only cover part of the global energy demand, and thus technologies like Power2X from CO_2 or nitrogen are needed. The first part of this argument is true, but if the easy electrifiable land based energy consumptions, like industry, heating, and transport were removed from the equation, then there would be plenty of biomass available as energy carrier for shipping, aviation and materials. According to World Biomass Association, at present the global non-food biomass availability is 57 EJ predicted to grow to 150EJ in 2035. Even in a highly populated country like Denmark a recent study ('10 millioner tons planen') showed that we could double the non-food biomass production without reducing food/feed output and environmental sustainability [1] Alone 57EJ corresponding to over 3 Gt of biomass, which via efficient upgrading would produce 1 Gt of biofuel, more than enough for global shipping, aviation and materials.

Looking at international shipping, in April 2018 the International Maritime Organization (IMO) agreed to reduce GHG emissions by at least 50% compared to 2008, but current projections by the International Energy Agency (IEA) show that CO_2 emissions from international shipping is expected to be 50% higher than in 2008, unless something is done urgently [2]. Aviation is another part of the transport sector, where CO_2 emissions are continuing to grow. In 2018 it alone accounted for 2,5% of global energy-related CO_2 emissions, and global aviation activity is continuing to grow rapidly (more than 140% since 2000).

As identified by the IFD Climate Panel in their final report, low-emission or zero-emission biofuels are potential solutions for these sectors. They are currently early stage solutions in need of development in order to become commercialised and exported to the rest of the World. This is supported by the IEA, which finds that the output of biofuels is currently growing with 4% per year, far behind the SDS' target of 10% [2].

Biofuels present their own set of issues. First of all, the most biofuels today are first generation, i.e. made from resources (oils and sugars) that could be used for food and feed as well, which raises both political and large scale availability concerns. Threat to biodiversity from large scale monocultural growth is another argument, but as many new biofuel technologies can accept very mixed feedstocks including mixed agricultural, municipal and industrial biomass 'waste' streams this should be a manageable concern.[1,3]

Another aspect, which is common to most biorefining processes is the decentral nature of biomass, which is in contrast to fossil sources. The logistics of transporting low energy density wet or voluminous biomass often renders huge central facilities less attractive and the complex nature of biomass calls for innovation in the conversion technologies. In order to become a true alternative to traditional fuel sources, biofuels and the process technologies for those need to be developed, taking into account resource efficiency and integration into existing infrastructure.

Conversion efficiency of some selected methods	HHV (MJ/kg)	Yield (kg/1000 kg feed)	Energy yield (GJ/t DM)	Process energy	EROI*	references
CO2 (Capture) to liquid fuel	44	238	10,5	33,6	0,31	4,5,8
Biomass to biogas to liquid fuel:	44	290	12,8	18,2	0,71	4,5,6,8
Biomass to methane via biogas:	56	320	17,8	12,5	1,4	4,8
Biomass to biocrude HTL (B2O)	35	350	12,2	1,35	9,1	7
Biomass to fuel HTL + upgrading	44	300	13,2	3,35	3,9	7,8

)* EROI is the energy return on invested energy in the process

In addition to recovering the energy content of the biomass as a liquid fuel, the recovery of important inorganic nutrients and especially phosphate, which is a very limited global resource, is of key importance. HTL allow separation of phosphate in a bioavailable form as opposed to pyrolysis or incineration processes.

An example of implementation in Denmark :

If we assume that Denmark would start to use biomass including waste biomass for applications where the carbon content is needed and stop the inefficient use of biomass for low value energy generation such as heat, it would be straight forward to get access to 10 mill ton annually (Sewage sludge, MSW, waste wood, garden waste, straw and other industrial/agricultural sidestreams). Danish society is presently burning 8Mt biomass for heating purposes.

10 million ton (10Mt) biomass could be converted to 3.5 Mt biocrude, which could be upgraded to 3Mt fuel corresponding to 132 PJ of liquid fuel (Transport fuel Jet and shipping). Upgrading and process energy would be approximately 45PJ (less than the present production of wind energy).

3 Mt liquid fuel produced by non biobased feeds Power2x (CO2 capture or ammonia) would require 480 PJ. Utilizing 1/10 of the saved electrical energy for heat pumps it would produce more than the district heating use today.

In addition the above HTL, Wetox and Upgrading process would produce approximately 50 PJ excess heat. Assuming 'green' electricity, the fuel replacement would reduce the net CO2 emissions by more than 9 Mt (25% of national CO2 emissions), and provide at least 3000 permanent jobs. In addition it would contribute to solving numerous challenges with WWT, MST and nutrient recovery.

References

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[7] Please note that the efficiencies for HTL to biocrude are based on Bio2oil's present engineering design. (Similar - slightly lower values - can be found in the literature, e.g. [3])

[8] These processes contain to varying degree Power2X conversion