REACHING CARBON NEUTRALITY BY 2050

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A bioenergy industry perspective towards carbon neutrality and how to address the refining sector.

With the Green Deal, the European Commission has set as target to be climate neutral by 2050, in line with the commitment to the Paris agreement. As the Green Deal is presented as a 'New Growth Strategy', it also offers plenty of opportunities for the European bioenergy industry.
Total greenhouse gas emissions in the EU are in the order of magnitude of 4 billion ton annually[1]. This includes international aviation and maritime, indirect emissions and excludes LULUCF (Land Use, Land Use Change and Forestry).
Parties under the EU-ETS scheme (the 11,000 bigger emitting parties in the power sector, industrial plants and airlines) emit about 45% of the total greenhouse gas emissions in terms of CO_2-equivalents annually[2].
An interesting sector is the oil refining sector, responsible for a significant part of the greenhouse gas emissions.

The European demand for oil products in 2018 was almost 640 million tons and the refinery throughput was about the same[3]. Ten years earlier the demand was about 100 million ton higher[4]. If this trend would be continued, the demand for oil products in 2050 would be about 300 million tons annually. Tens of scenarios show a range from 200 to 400 million ton by 2050[5].

What are the opportunities for the bioenergy industry in reducing greenhouse gas emissions? And how can the refining industry be challenged?

CRITERIA FOR SECURING A STEADY INVESTMENT CLIMATE FOR THE NEXT DECADES

First of all, biomass used for energy generation should be sustainable. So, no clear cuts of forests for the generation of bioenergy or harmful practices in the agriculture conflicting with sustainable food production. This is governed by the RED-II and other directives and may need updates in the future based on new experiences and insights.

To have impact, innovative bioenergy technologies should contribute to a reliable, flexible and cost-effective energy system as the energy transition will require multifold adaptations during the coming decennia.

As the energy sector is a strongly regulated sector, policies are of the utmost importance. The bioenergy industry can prepare itself for the future by anticipating on developing policies and by providing input to the development of new policies. Stimulating policies should secure a steady investment climate for the next decades. A stimulating policy covers a set of measures like increasing ETS-prices or/ and limiting emission allowances, CO_2-taxes, innovation and other stimulating (innovation) subsidies, obligations, etc. while at the same time safe-guarding competitiveness and cost-effectiveness. Clear objectives with penalties for non-conforming parties should be in place.
As an example, figure 1 shows the interaction between policies, oil prices, innovation and implementation for the markets of advanced biofuels[6]. The positions of the blue dots show the changes due to the economic crises in 2008 and the economic crisis as a result of Covid-19. The big difference now compared with the situation in 2008 is that there are very stimulating policies (obligations) for advanced biofuels (at least for 2030) in place. With strong targets set for 2050, innovation will continue and investments will be secured.

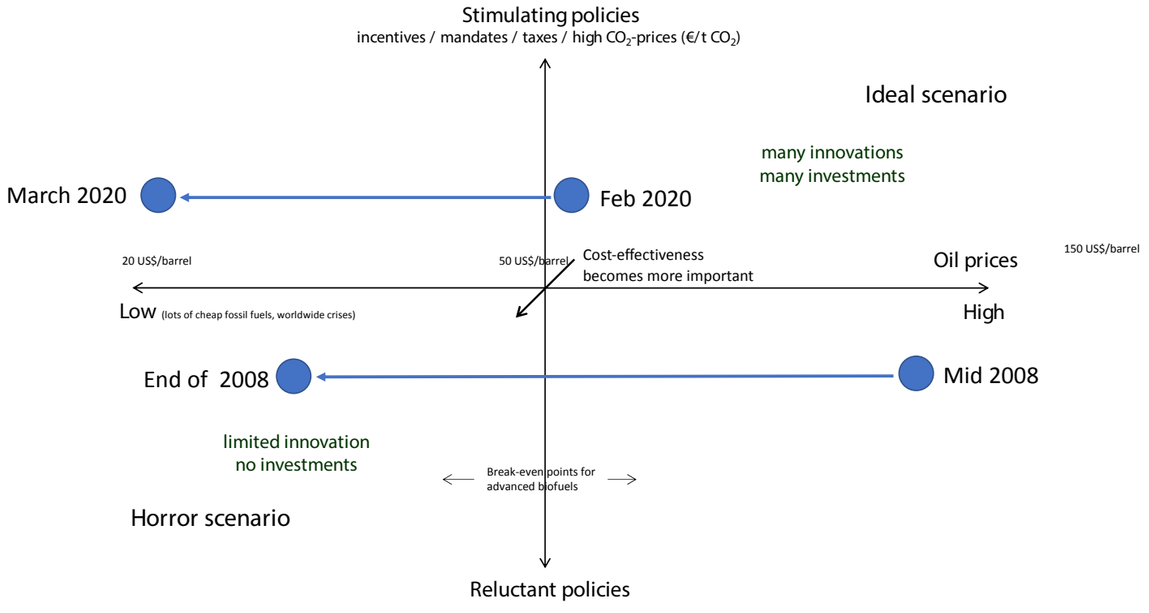


Figure 1 - Scenarios (energy prices + policies) – strong policies needed if energy prices are low

HOW TO ADDRESS THE REFINERY INDUSTRY AS BIG EMITTER?

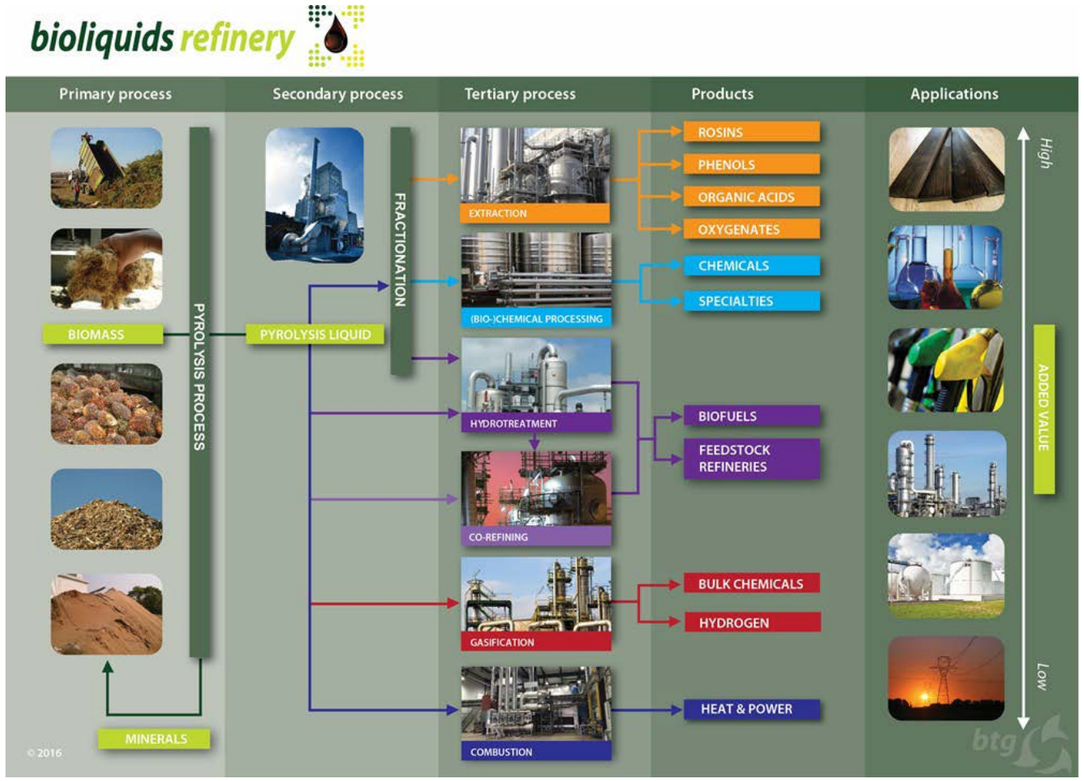
Options for the refinery sector include a shift from crude oil to natural gas, carbon capture & sequestration, forestation, advanced biofuels, hydrogen, etc.
Recently, various oil companies[7] have announced to strive towards becoming net zero carbon neutral by 2050.
A battle might occur: which oil company will become net carbon neutral towards 2050 without losing market share and keeping profits and dividends at the desired level?
Interesting concepts are the retrofitting of energy and industrial plants including the co-processing of sustainable biomass in existing refineries[8]. The latter option avoiding high additional capital costs for the refinery owners and facilitating a step-by-step approach, herewith mitigating risks.
This could also be integrated with the production and use of renewable hydrogen from renewable energy from wind, creating a win-win situation.

A SCENARIO FOR 2050

Let's assume the following scenario: 45 out of the around 90 refineries existing nowadays in Europe still remain in 2050, but only a limited amount of fossil fuels is used (in a ratio of less oil and more gas). CO_2-emissions are compensated by CCS and large scale afforestation.
This half of the former existing refineries is not necessary anymore, as 2/3 of the personal cars are electrically driven, which makes part of the refineries abundant. The electricity needed for all these personal cars is obtained from renewable sources, mainly hydro, wind and solar. But from biomass and some nuclear power as well, as Europe can't rely on hydro, wind and solar only.
The remaining 1/3 of the passenger cars are hybrid, of which the high energy density liquid fuels are based on advanced biofuels. There is a number of hydrogen powered cars, but very limited, as the refinery sector has replaced its fossil based hydrogen completely by green hydrogen, and thus contributing to the direct greening of the refinery sector (greening of the transport fuels indirectly).
In the remaining refineries, fuels for transport are still being produced, but mostly for the heavy-duty road transports, the maritime and the aviation sectors[9].
The liquid fuels are not fossil based any longer, but are advanced biofuels from sustainable biomass residues. The renewable hydrogen available on the market, is mainly produced by wind power.

Part of depreciated refineries has been retrofitted into 100% biomass-fed refineries, another part of the still existing refineries is co-refining biomass intermediates to a significant amount, and the newly constructed refineries are 100% stand-alone biorefineries.

In the above scenario, hundreds of million tons of sustainable biomass would be needed for a sufficient production of advanced biofuels[10]. The production will take place in biomass-rich areas around the world, including Europe, that would have increased its capacity due to large scale forestation.
The products of the forest are used firstly for construction purposes in the biobased economy, herewith storing CO_2 for a long term and replacing energy-intensive materials like concrete. Only biomass residues are used for advanced biofuels production in a responsible manner.



Co-processing 2050	70 billion €	Flexible
22 Mtoe/yr	40.000 jobs	Scaleable
Advanced Biofuels (flexible mix of diesel and kerosene)	80 mio t CO_2/yr	Using existing infrastructure

Figure 2 - Pyrolysis as platform technology (BioLiquids Refinery)

An example of what co-processing could offer in this 2050 scenario with just one platform technology (fast pyrolysis) is presented in figure 2. By using this flexible and scalable technology in the existing infrastructures a potential of 22 Mtoe/yr of advanced biofuels could be achieved, saving 80 million tons of CO_2 emissions every year and generating up to 40,000 jobs.

A PORTFOLIO MANAGEMENT APPROACH TO TRACK TECHNOLOGICAL DEVELOPMENT

It may be clear that innovation will be key for the coming decennia, as a complete renewal of the industry has to be established and new technologies will have to be integrated with existing infrastructure wherever possible.

For both the industry as the European Commission it will be important to keep track of technological developments and to have insights in the critical issues relevant for the innovation routes. One way to track is the concept of Portfolio Management.
This could be done as part of the Integrated Strategic Energy and Technology Plan (SET-Plan) of the European Commission[11].
For bioenergy and advanced biofuels this is taken care of by the European Technology and Innovation Platform[12].
With portfolio management a number of innovations are being monitored and policies will be modified if needed. This approach offers many advantages because:

1. it is a proven method for successful project development and an economic principle used by many project developers, private equity parties as well as multinationals
2. it is very useful in case many projects are listed and critical success and fail factors are difficult to recognize
3. it allows for bundling of projects
4. it can facilitates risk mitigation
5. it avoids the re-inventing of the wheel over and over
6. it can facilitate the reduction of costs and the acceleration of successful innovations
7. it offers a way to learn from failed innovation routes
8. it helps to achieve the targets in a well-managed manner

The first action is to list all projects and technology developments ongoing, expected and completed. New projects are placed left in the pipeline (low TRL), almost completed projects (high TRL) to the right.
Dropped out and failed projects are listed as out of the pipeline. Successfully completed projects have left the pipeline at the right. A successful innovation starts left with low TRL-projects and leaves the pipeline right as it is commercially adopted by the market.

Critical success- and fail factors are determined by observing the developments of the innovation routes.
Examples: technological developments can be too expensive, no market, no incentives in place, not matching the market demand, not matching biomass supply and energy demand, too complex, no adequate legislation in place, weak organization, not scalable, no business case, or whatsoever. Figure 3 shows a simplified example of Portfolio Management.

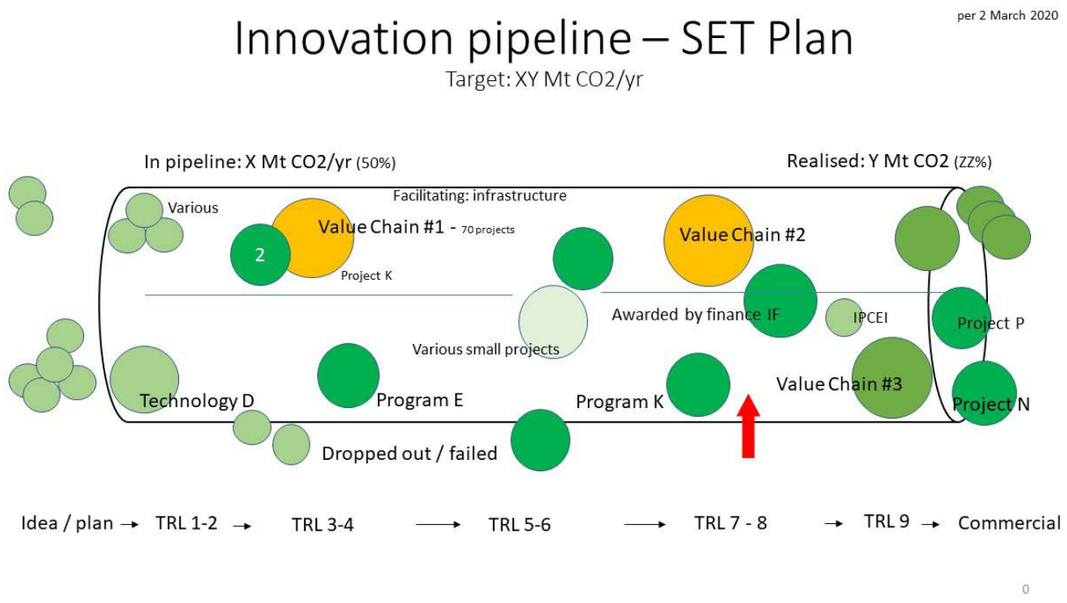


Figure 3 - Portfolio Management (also as tool for managing the portfolio of SET Plans)

Conclusions

There is no silver bullet for replacing crude oil in 30 years, while the sector has been practicing current operations for almost 150 years. Europe will need multiple options and the most cost-effective and appropriate ones will emerge in due time.

Investment security for the industry is of utmost importance and long-term policies need to be in place. Especially in economic crises, like the present one as a consequence of the Corona (Covid-19) virus, it is important to enforce investments in innovation and sustainability, herewith enabling a competitive edge for Europe as well.

Energy storage and renewable energy carriers will become of key importance. Biomass intermediates can play an important role in this.

Keeping track of the technological developments and accelerating the best developing ones through portfolio management may help to achieve the targets cost-effectively.

1 Eurostat, Statistics explained – Greenhouse Gas Emission Statistics, Table 1, 15th April 2020, data from June 2019. See the link: https://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics

2 https://ec.europa.eu/clima/policies/ets_en

3 European Petroleum Refiners Association - FuelsEurope Statistical Report 2019, Figure 5, page 11. Link: https://www.fuelseurope.eu/wp-content/uploads/FuelsEurope-Statistical-Report-2019-2.pdf

4 European Petroleum Refiners Association - FuelsEurope Statistical Report 2019, Figure 7, page 13. Link: https://www.fuelseurope.eu/wp-content/uploads/FuelsEurope-Statistical-Report-2019-2.pdf

5 David Chiaramonti, Alternative and Renewable Liquid & Gaseous (ART) Fuels Forum, 2nd Plenary Meeting, Brussels, sheet 7-9, 10-11 February 2020. Figures have been rounded by the author. See also: http://artfuelsforum.eu

6 These scenarios have been developed by the author during the economic crisis after 2008 and were updated recently by the author due to the Corona crisis

7 Among others companies like Total, BP, Shell. See for example https://www.worldoil.com/news/2020/5/5/total-pledges-to-be-carbon-neutral-by-2050)

8 See for example https://www.biofit-h2020.eu

9 Tens of scenario studies have been carried out during last years. Compare for example with the key findings of so-called 'Ricardo Study': https://www.fuelseurope.eu/wp-content/uploads/Key-findings-Ricardo-Study.pdf

10 Listed amounts of advanced biofuels for the various scenarios varying from 13 – 134 million tons oil equivalents. See: David Chiaramonti, Alternative and Renewable Liquid & Gaseous (ART) Fuels Forum, 2nd Plenary Meeting, Brussels, sheet 7-9, 10-11 February 2020. See also: http://artfuelsforum.eu

11 See for example: https://ec.europa.eu/energy/topics/technology-and-innovation/strategic-energy-technology-plan_en and https://www.setplan2019.fi/content/uploads/2019/11/SET-Plan_2019-Outcome.pdf

12 ETIP BioEnergy, see https://www.etipbioenergy.eu