Circular CO_2

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Last weeks we were calculating on renewable energy. What do we have to do to truly become climate neutral? We also looked at the payback period for these mitigation measures. Some solutions save net CO_2 after a short period of time (wind turbines and solar panels), for other solutions it takes considerably longer. A sudden large-scale implementation would then result in a substantial increase in CO_2 in the short term. We have also seen that a large part of our carbon footprint is in the products (food, clothing, stuff, etc.) that we use[1]. To our surprise, it turned out that the raw materials themselves do not even make the biggest contribution, apparently the processing of raw materials into end products is also an energy-consuming process[2]. What we have also seen that it is almost impossible to make some products or services CO_2-free. This mainly concerns transport on longer distances such as shipping and flying. That does not seem to be possible on electricity yet. Hydrogen is possible, but because of the low density it is difficult to efficiently store and transport it, while you have to do both in getting the transportation sector greener.

In summary, you can therefore state that it is not yet possible to live climate-neutral at this moment; our activities ensure that CO_2 is produced. At the moment this CO_2 is released into the air, and then causes global warming. In addition to preventing the production of CO_2, we will therefore also have to do something about dealing with the CO_2 produced. There are roughly two ways for this. The first is to collect the CO_2 and store it separately. In the Netherlands a project was started for this (CO_2 storage Barendrecht[3]), but protests have ultimately helped to stop this initiative. The idea was (with the disaster of Lake Nyos in our minds[4]) that CO_2 storage is very dangerous if a leak occurs, because CO_2 stays and then everything in its environment can suffocate. Technically, this turned out to be not so bad (a leaky pipe is a bit different than a lake that buzzes like a Mentos in a bottle of cola[5]) but the tone was set. In fact, the Dutch coalition agreement has put a lot of effort into CO_2 storage as a means of reducing emissions. Technically this can also be done very well, especially if you have a fairly high concentration of CO_2, such as in the exhaust gases of a power station, an industrial stove, blast furnace or cement factory[6].

The disadvantage is that you have to burn more fossil fuels to get the same net output. That does not sound very sustainable. What is possible is to use the sustainably produced energy to capture CO_2[7] however it feels weird. Just pay attention: a kWh not taken from a power station saves 0,6 kg per kWh, while with 1 kWh also 2,5 kg of CO_2 can also be put underground (see footnote 6). For this you do not have to burn more grams of fossil fuels. If you then reach the point where virtually no more CO_2 is emitted, you can slowly start the transition, where the power stations close and the renewable electricity is used immediately. The concentrated CO_2 may still be used as raw material in some processes. With a surplus of electricity you can even convert the CO_2 into fuel again, in order to limit the use of fossil fuels.

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[1] Statistics Netherlands (CBS) has just published a message that the CO_2 footprint of the Netherlands has risen in the past year due to the extra import of goods: https://www.cbs.nl/nl-nl/nieuws/2018/20/nederlandse-broeikasgasvoetafdruk-in-2017-gestegen
[2] This inevitably raises questions about the effect of recycling. If the raw materials are only a small part of the footprint, you can not earn much. It is different of course when the product is re-used (via i.e. a recycling shop), so that you spread the production costs over several years of use. Unless of course you drive from Groningen to Maastricht (400 km)
[3] https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/publicaties/2017/01/27/co2-opslag-barendrecht/CO2-opslag+Barendrecht.pdf
[4] https://nl.wikipedia.org/wiki/Nyosmeer
[5] https://www.youtube.com/watch?v=LjbJELjLgZg
[6] A study by MIT shows that the removal of CO_2 directly behind a plant costs about 0,4 kWh per kg of CO_2. An average of 0,6 kg of CO_2 is produced per kWh. Thus, 1-0.4 * 0.6 = 0.75 kWh net of a produced kWh remains.
https://sequestration.mit.edu/pdf/David_and_Herzog.pdf
[7] This may also solve the balancing problem of renewable energy by using CO2 storage as a buffer

This technology only does not work with distributed production of CO_2, such as cars, airplanes, and currently also the heating of our houses. For CO_2 that once escapes to the air, the concentration rapidly decreases from something like 10-20% in the exhaust gases to the basic level of 400 ppm in the air. Of course, 400 ppm sounds like a lot (and compared to the pre-industrial level it is also a lot more), but ppm stands for parts per million. It is therefore 0,04%, and that is very little. The fact that catching these lonely molecules is much more difficult than most people think it is. But the crucial question is whether it can also be done climate-technically. It is difficult to find good information about it, but what you find is very clear: it is not possible. It takes about 3 kWh to get 1 kg of CO_2 from the air, while it costs an average of 1,8 kg of CO_2 to make that 3 kWh[8]. If you have real sustainable energy left it can be climate-technical, but as long as electricity is produced with fossil fuels, this is a nonsensical way. The costs of this measure are estimated at something like thousand dollars per tonne of CO_2, *prohibitively expensive* as they say so beautifully across the water.

What is still possible in terms of costs is CO_2 capture with biomass. You can capture about 5 tons of CO_2 per hectare per annum. For agricultural crops, this can amount to as much as 20 tons per hectare, but it does require artificial fertilizer and diesel. But, and that is a very big one, with one hectare of solar panels plus windmills (which can be on the same ground at the same time), you can produce around 1000 MWh per year[9]. So you can get around 300 tons of CO_2 from the air. Although plants grow freely in nature, the use of sustainable energy is winning when it comes to use of space. And we did not have a lot of space because of the rise in sea level (see the column "regret regretter regrettest" of 20 April).

This comparison of CO_2 sequestration via plants or industrial, places the whole discussion about biomass in a different light[10]. One of the arguments for biomass is that some applications simply need fuels (also our observation). But in Iceland there is already a factory that produces methanol with CO_2 (concentrated though) and electricity[11]. About half of the electricity that is put into this product is released during the burning of the methanol, a yield of 50%. This process can also work with CO_2 from the air, even though the efficiency decreases to 40% because energy has to be stopped in capturing the CO_2. A solar panel has an efficiency of about 20%, and that leaves 8% in the form of methanol, which is easy to store and transport. That is much better than biomass does, because in that case you talk about a return that is 10 times lower. Biomass can therefore better be eaten than using it as fuel. After all, making food with electricity is not easy. We are now both eating and burning, the barbecue is already on. On a fire of biomass (charcoal!) we roast other products from the sun: asparagus, mushrooms, peppers, zucchini and green burgers. If these are more or less black, we throw them in the fire, because for grilling meat it can not be hot enough. In the context of sustainability, we only eat vegetarian animals today. We wish you a nice long weekend.

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[8] See https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3251141/. The direct costs are estimated at about 400 kj / mol, or 3 kWh per kg. You can therefore retrieve 0,3 kg from the air per sustainably produced kWh, or s ave 0,6 kg of emissions
[9] Average production 10 MW per km^2, 10000 hours in a year, 100 ha per km^2
[10] https://nioo.knaw.nl/sites/default/files/downloads/150112%20Visiedocument%20biomassa%20KNAW.pdf
[11] See http://www.mefco2.eu/references/power-to-methanol-2.php, and then Keep Reading: http://www.mefco2.eu/pdf/2.%20Application%20of%20Power%20to%20Methanol%20Technology%20to%20Integrated%20Steelworks%20for%20Profitability,%20Conversion%20Efficiency,%20and%20CO2.pdf