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CCU in the EU ETS: risk of CO_2 laundering preventing a permanent CO_2 solution October 2016

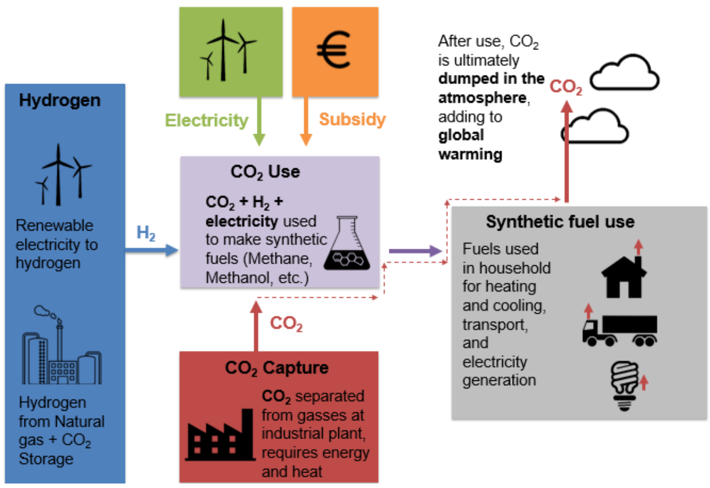
Introduction

Drastically reducing the amount of CO_2 in the atmosphere is necessary to reach the climate goals of the Paris Agreement. The permanent geological disposal of CO_2 captured from industrial facilities, Carbon Capture and Storage (CCS), provides an essential and achievable avenue for reaching this objective.

The usage/utilisation of captured CO_2 (CCU) is incorrectly mentioned to be an equivalent alternative to CCS. While there are methods of permanently storing CO_2 by using CCU technologies, such as mineralisation[1], the usage of captured CO_2 in chemicals and fuels does not contribute to significantly lowering the level of CO_2 in the atmosphere. Synthetic fossil fuels produced by adding captured CO_2 to clean, renewable hydrogen (H_2) is wrongly branded as "renewable natural gas". Fossilising hydrogen to produce synthetic methane merely delays the CO_2 from being emitted.

[1] http://bellona.org/publication/bellonabrief-co2-utilisation-by-mineralisation-much-ado-about-nothing

The distinction between permanent (e.g. CCS and mineralisation) and temporary solutions (e.g. synthetic methane and chemicals) must be made when considering to invest in solutions that are meant to resolve the major challenge of limiting and reducing the level of CO_2 in the atmosphere. Although a CCU infrastructure can be a stepping stone for the deployment of CCS, there is a real danger that governments will boost the profitability of CCU for industries. This will likely form an obstacle that prevents permanent CO_2 solutions from being developed.



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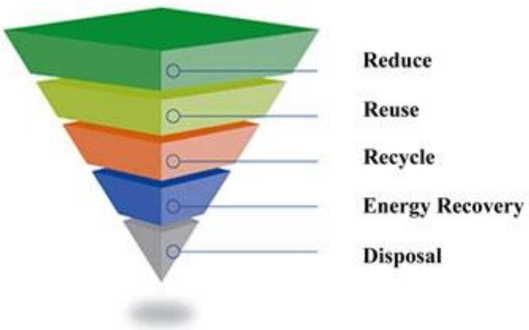
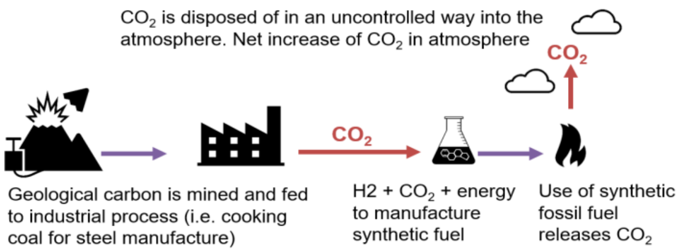
CCU for synthetic fuels is not complete reuse, but delayed atmospheric disposal



Some strong advocates of CCU for synthetic fuels have propose the "simple disposal hierarchy" as providing a clear and logical rationale for the reuse of CO_2 and avoiding CO_2 managed disposal (permanent geological storage of CO_2)[2]. This rational omits the ultimate fate of the CO_2 used in creating synthetic fuels. The use of these fuels will regenerate CO_2 in diverse settings unsuitable to (re)capture of CO_2. **The result being the unmanaged and damaging disposal of CO_2 in the atmosphere.** As the great majority CO_2 generated in the initial industrial process derive from geological feedstocks (limestone, coking coal, fossil energy) the result is potential unaccounted net increase of CO_2 in the atmosphere.



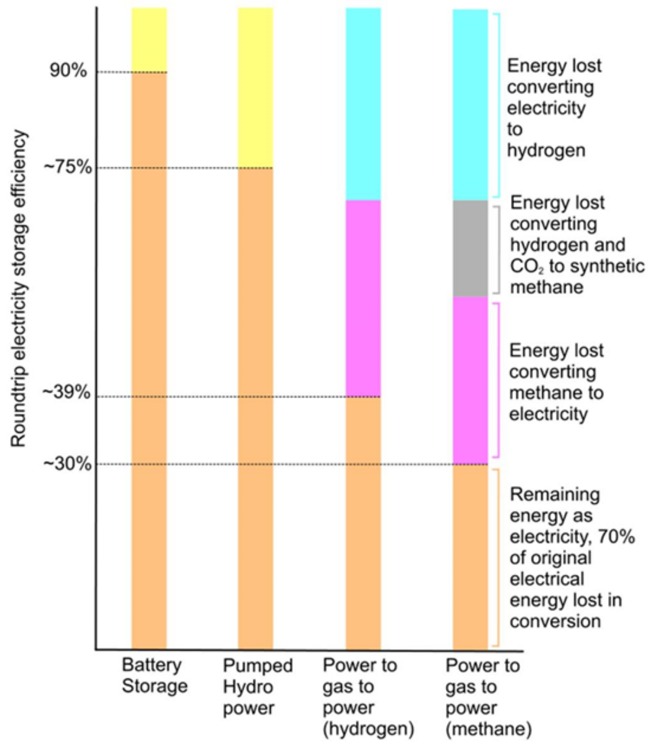
Roundtrip efficiency of electricity storage with power to gas

Battery storage can be very efficient but does not generally provided long term (seasonal) electricity storage. Through the usage of pumped hydroelectric storage, energy can be made available in reservoirs for long preriods of time.

[2] Steven Woolass, TATA Steel, Why CCU? CO2Chem Network, 21st September 2012

Through the principle of 'power to gas', hydrogen can be produced using (renewable) electricity and water in a process called electrolysis. Sythetic methane can be created by adding the hydrogen to captured CO_2. Other gases can also be produced in similar processes (e.g. methanol, ethanol). Such gases are suitable for long-term geological storage.

Converting renewable electricity to hydrogen with electrolysis, however, entails efficiency losses. Conversion is approximately 70% efficient.[3] Adding CO_2 to hydrogen to generate a synthetic fossil fuel entails even further efficiency losses. The Sabatier reaction or microbial methanation is approximately 80% efficient.[4] [5] Generation of electricity of hydrogen or synthetic methane at combined cycle gas turbine power plants has an efficiency of ~56%. The overall energy loss from electricity to electricity thus amounts to approximately 70%.

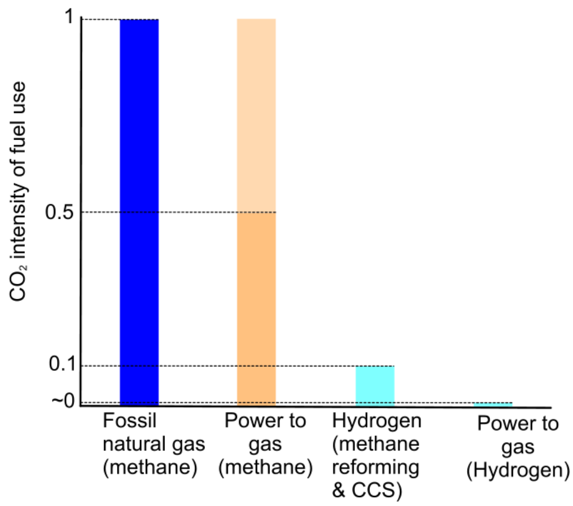


[3] Mazloomi, Sulaiman, Moayedi (2012) Electrical Efficiency of Electrolytic Hydrogen Production. Int. J. Electrochem. Sci., 7 (2012) 3314 - 3326
[4] Dr. Monika (2013) Reuter Power to Gas: Microbial Methanation, a Flexible and Highly Efficient Method
[5] Stephan Rieke (2012) Power-to-Gas technology – the missing link in renewable energy systems SolarFuel GmbH,

CO_2 emissions from power to gas

Taking the combustion of fossil natural gas as a CO_2 intensity of 1, replacing fossil natural gas with the use of synthetic natural gas can lead to CO_2 reductions of potential half. This requires that synthetic natural gas displaces the combustion of fossil natural gas. Accurate accounting of CO_2 reductions from fuel displacement is difficult. It should be noted that the CO_2 emissions at the point of combustion of synthetic natural gas will be identical for fossil natural gas (both products are chemically identical). CO_2 saving comes from the reuse of captured CO_2 from industrial processes; this CO_2 is ultimately released at combustion of synthetic natural gas. Releasing the CO_2 after the effort and energy to capture it form industrial process is climactically inefficient. In addition, the use of synthetic natural gas allows blending with fossil natural gas, potential prolonging fossil natural gas imports and CO_2 emissions.

Synthetic natural gas requires the consumption of hydrogen during manufacture. The use of hydrogen directly as a fuel results in much reduced or zero CO_2 emissions. Hydrogen contains no carbon so does not produce CO_2 on combustion. Hydrogen can be used as a zero carbon fuel for the decarbonisation of residential heating and cooling, industrial process heating and freight transport and shipping. The use of hydrogen directly allows for CO_2 captured from industrial facilities to be permanently geologically stored or mineralised instead of being used for gas production. This provides a climate solution compatible with reaching Paris climate agreement.



Roundtrip efficiency of power to synthetic transport fuels

Synthetic transport fuels such as methanol can be used in the transport sector. The value of these fuels in decarbonising the transport sector must be reviewed in contrast to other technologies, the CO_2 abetment potential and the full cycle efficiency, the energy put in to useful work produced.

Direct use of renewable electricity in electric mobility solutions offers by far the highest energy efficiency. Batteries in electric cars and trucks stores energy with little losses and an electric drive motor converts this electricity to movement efficiently. Electric charging stations are 85%-95% efficiency, and the electric drive is 79%-91% efficient depending on how regenerative breaking is accounted.[6] Electric cars already account for ~30% of the Norwegian car sales.[7] Batteries in electric vehicles can also aid decentralised load balancing in a renewable generation systems. Policies are already coming into place, **Norway plans to ban the sale of internal combustion**

[6] Revisiting the Formulas for Tractive and Braking Energy on the EPA Driving Schedules, 2013-01-0766 http://papers.sae.org/2013-01-0766/

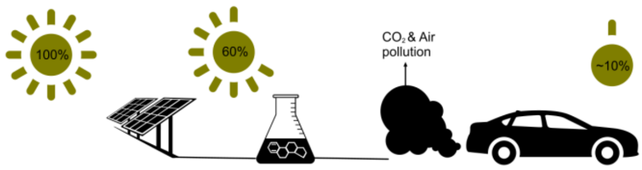
[7] European alternative fuels observatory http://www.eafo.eu/top-5

engine cars from 2025, the German Bundesrat aims for a ban from 2030.[8] [9]

Approximately 75% of the energy captured from the solar panel is used to drive the electric car. Losses include electric motor uses power, driveline, voltage controller and battery charge / discharge efficiency.

Direct hydrogen use in transportation with the use of fuel cells and electric drive offers increased efficiency over synthetic transport fuels. Fuel cell hydrogen propulsion in passenger cars is as twice as efficient end use technology than today's direct injection engines.[10]

The generation of synthetic fuels incurs energy losses, approximately 40% of the initial electrical energy is lost in the manufacture of synthetic methanol.[11] The remaining energy now in the form of methanol can then be use in internal combustion engines of cars and trucks. Combustion is not an efficient process, with only 14%–30% of the energy used to drive motion, with the rest lost as heat and sound[12]. **Of the original electrical energy used to create methanol, only 9%-18% is used to produce useful work**.



Approximately 10% of the energy captured from the solar panel is used to drive the methanol car. Losses include generation of hydrogen, H_2 + CO_2 to methanol, internal combustion losses, driveline and idle losses.

Generating synthetic methanol requires ~7.5 times more energy input for every kilometre driven when compared to 100% electro mobility

Aside from the very low full cycle energy efficiency of power to synthetic transport fuels, the use of such fuels will continue air (nitrous oxide, ozone, CO_2, particulate) and noise pollution. The European Environment Agency (EEA) estimates that air pollution is responsible for ~403,000 premature deaths every year.[13]

The generation of synthetic transport fuels could have a role in transport sectors where energy density is of great importance, namely aviation fuel generation.

Power to gas is limited by hydrogen and renewable electricity availability

In 2015 the Wuppertal Institute and Covestro proposed using the captured CO_2 from the industrial facilities in the Ruhr region to produce synthetic methane.[14] In order to produce the so-called "renewable natural gas", hydrogen is added

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[8] Norway is going to ban all petrol-powered cars by 2025, Riotta, 2016, http://uk.businessinsider.com/norway-is-going-to-ban-all-gas-powered-cars-by-2025-2016-6?r=US&IR=T

[9] Germany's Bundesrat Resolves End Of Internal Combustion Engine, Schmitt, 2016, http://www.forbes.com/sites/bertelschmitt/2016/10/08/germanys-bundesrat-resolves-end-of-internal-combustion-engine/#26ef6d7131d9

[10] Well-to-wheel analysis of direct and indirect use of natural gas in passenger vehicles, 2014, Curran et al. Energy 75 194-203

[11] Power and CO_2 emissions to methanol, Stefansson, 2015 European Methanol Policy Forum, Brussels October 13 2015

[12] http://www.fueleconomy.gov/feg/atv.shtml

[13] Air quality in Europe, 2015, EEA No 5/2015 http://www.eea.europa.eu/publications/air-quality-in-europe-2015

[14] https://epub.wupperinst.org/files/6010/6010_CO2_ReUse.pdf

to CO_2 captured from industrial facilities. Synthetic methane, it is argued, emits approximately half the amount of CO_2 compared to conventional methane. This effort is, however, a misguided attempt to use the CO_2 as a resource to lower carbon emissions.

The report shows that if the Ruhr region (Germany) were to transition to synthetic methane in order to utilise all CO_2 arising from the industrial sector (iron and steel industry, chemical industry, refineries, cement and lime industry, coking plants), the electricity generation required to produce the hydrogen would exceed that of the entire state of North-Rhine-Westphalia by a factor of six. At the same time, the transition would have to be made to renewable electricity production.

If the main objective of adding captured CO_2 to hydrogen, in order to produce synthetic methane, is to reach the goals set forth in the Paris Agreement, this type of CCU is neither helpful nor practically feasible.

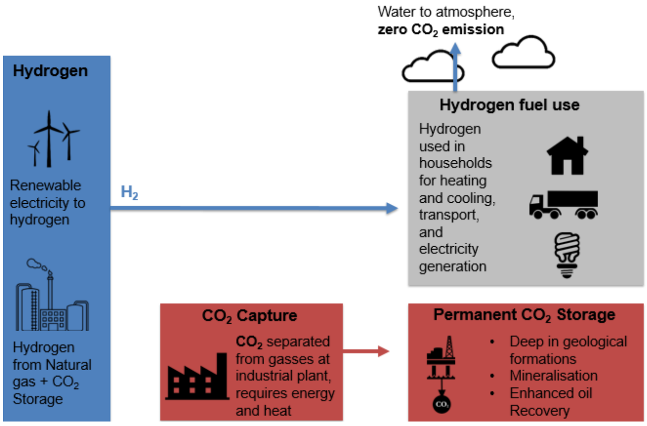
Hydrogen is the key resource, not CO_2

Instead of adding captured CO_2 to hydrogen with the intent to produce synthetic fossil fuels, a much more logical, energy-saving, and non-CO_2 emitting fuel for households and industries is the usage of hydrogen itself.

To produce hydrogen in large enough amounts to serve industry and households, and without emitting CO_2, either electrolysis with renewable electricity or the conversion of methane with subsequent CCS needs to be employed. Since it is currently impossible to acquire large enough amounts of renewable electricity for this purpose, the usage of methane in combination with CCS is the only viable option.

The City Gate project in Leeds is an example of the structural transition of the gas grid from methane to hydrogen, by using H_2 attained through the conversion of methane and CCS.[15] It has shown that this is both possible and cost-effective. Whereas synthetic methane may cut the emissions of CO_2 in half depending on fossil fuel displacement, the combustion of H_2 produces nothing but heat and water.

With relatively limited changes to the gas grid, Leeds could thus transition to a deeply decarbonised city, in line with reaching Paris climate goals. Instead of producing synthetic methane by fossilising hydrogen, hydrogen should be used directly as in the case of Leeds.



CCU and the ETS

The Emissions Trading System (ETS) of the EU is the primary avenue taken to limit the emission of CO_2. Although this system has been mentioned to be ineffective, in part due to the free allocation of certificates to industrial actors and the low price of such certificates, it will be required to play an important role in the attempt to lower CO_2 emissions.

Seeking to include CCU methods that do not provide permanent storage of CO_2 into the ETS would undermine the purpose of the system itself. A briefing paper by the Scot Project recommends that the ETS should include methods such as the

[15] http://www.northerngasnetworks.co.uk/wp-content/uploads/2016/07/H21-Report-Interactive-PDF-July-2016.pdf

mineralisation of CO_2, but not those that only allow the temporary storage of CO_2.[16]

Although one industrial actor may pass on captured CO_2 to another actor as feedstock, the CO_2 will inevitably be disposed of in the atmosphere. If the CO_2-producing industries would receive financial benefits within the framework of the ETS, it would potentially be more lucrative to produce than to limit the production of CO_2.

CO_2 Laundering

Moreover, including non-permanent storage methods of CCU into the ETS could institutionalise 'CO_2 laundering'. Industrial actors covered by the ETS could pass on captured CO_2, for instance in the form of fuel, to another actor outside the ETS. When this fuel is used, the CO_2 will be released into the atmosphere without being accounted for by the ETS.

An existing example of a remedy to such a situation is the accountability, within the ETS, of the producer of urea products (ammonia + CO_2) for the end-of-pipe CO_2 emissions caused by their usage in the agricultural sector.

Recommendations

CCU is a stepping stone towards CCS

The development of a CCU infrastructure should serve as a stepping stone towards the deployment of CCS. Although CCU can be used to prevent CO_2 from entering the atmosphere in the case of mineralisation, CCS will be required to deeply decarbonise industry and households, as in the case of Leeds. Furthermore, usage of CO_2 arising from biogenic sources (i.e. sewage) should be preferred to the utilisation of CO_2 from fossil sources.

[16] http://www.scotproject.org/images/Briefing%20paper%20EU%20ETS%20final.pdf

Synthetic methane should not be called "renewable"

Synthetic methane should not be referred to as "renewable natural gas". This name gives the false impression that the burning of the gas does not increase the levels of CO_2 in the atmosphere. The CO_2 emitted from a facility using this gas is still CO_2, and it will contribute to global warming.

Use H_2 directly as a zero-emissions fuel

Hydrogen should be used directly in industries and households. Industrial complexes should not have the ability to claim the available hydrogen in order to convert it to synthetic methane. Fossilising it by adding CO_2 in order to produce synthetic fuels offsets the positive characteristics of H_2, namely that it does not emit anything but water at combustion.

Exclude non-permanent CCU from ETS

It is imperative that CCU methods, except for those allowing for permanent storage of CO_2, are excluded from the ETS of the European Union. Including non-permanent CCU in the system could not only incentivise industries to produce more CO_2, as this would become a commodity, but it could also allow the CO_2 to be emitted without being accounted for by the ETS.

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