BELLONA EUROPA

THE 'POWER TO LIQUIDS' TRAP

A BELLONA EUROPA REALITY CHECK

April 2017

TABLE OF CONTENTS

Authors:

Ana Serdoner; ana@bellona.org

Keith Whiriskey; keith@bellona.org

Photo: Think Stock

In the late 19th century, lighting systems witnessed a true revolution. With the invention of the lightbulb, the electric current was used to turn night into day and the old gas and oil lamps turned obsolete. But what if we imagine an alternate path of history? What if Thomas Edison had invented a way for power to be turned to oil for those outdated lamps?

We don't have to go about finding 10 000 ways to fail in order to find the right solution, as Thomas Edison did when he had invented the light bulb.

The lightbulb of our generation is already here.

EXECUTIVE SUMMARY

With its Clean Energy Package, the EU is on the verge of repeating costly energy and climate policy failures of the recent past. Attempting to provide a low-carbon transport fuel replacement alternative to conventional biofuels, the European Commission in its revision of the EU Renewable Energy Directive (REDII) proposes a 2030 target for 'low-emission and renewable fuels'. The proposed target includes so-called ''renewable liquid and gaseous transport fuels of non-biological origin''. This opens the door for massive public subsidies for synthetic fossil fuels, i.e. renewable hydrogen mixed with fossil CO_2 from emitting industries covered by the EU ETS.

Synthetic fossil fuels will distract from the 2°C goal

This target will, as its predecessor did for conventional biofuels in the past, act as a policy driver for an alchemical production of 'low-carbon' synthetic fossil fuels that are in fact full-carbon, highly energy-inefficient, costly and incompatible with achieving EU climate goals. Like conventional fossil fuels, synthetic fossil fuels emit CO_2 upon combustion. Labelling these fuels as \`renewable\` and \`low-carbon\` only serves to encourage the continuation or even perpetuation of fossil fuelled internal combustion engines in vehicles. Consequently, the EU would distract from actual solutions for the timely development of a low- and zero-emission transport sector.

With synthetic fossil fuels the EU is recreating the biofuel policy fiasco

Synthetic fossil fuel processes are in certain ways analogous to conventional biofuel production: resource intensity, costs and environmental impacts are problematic for both fuel types. The lesson from a decade of EU biofuels policy should be clear enough: flawed climate 'solutions' will not retain their social licence for long, meaning stranded assets for investors and society, and reduced trust in EU policy makers and institutions.

Synthetic fossil fuels will require expensive subsidies

Without subsidies, the business case for synthetic fossil fuels would be inviable; rent seekers would profit from developing a product at a both high societal and environmental cost. From a societal perspective, subsidising production of such fuels entails high risks of wasting resources and funds; mal-investments that should not be encouraged by policy makers, and most certainly not using EU climate policy tools.

Synthetic fossil fuels will devour vast amounts of electricity, renewable or not

CO_2 is a waste-product from energy-intensive processes, e.g. combustion, hence has zero energy value. Converting it into energy products will always need vast amounts of energy input. Production of synthetic fossil fuels will induce massively increased baseload demand for electricity. This would make the entire system less flexible and secure, likely extending use of fossil electricity from coal and imported gas.

Far better options exist to decarbonise EU transport at a lower societal cost

To illustrate, powering Europe's road transport with such fuels would require well more than the entire current EU electricity generation. In comparison, a total shift to electromobility would add just ~24% to current electricity demand and provide flexible grid services, rendering a full and timely shift to renewables far more likely.

Synthetic fossil fuels that dump CO2 in the atmosphere are not a 'circular economy'

The alleged 'circularity' of synthetic fossil fuel production is bogus. The reuse of CO_2 for fuels, with the CO_2 dumped into the atmosphere upon use, is no more circular than throwing all recycled PET-bottles on the street because they were once recycled, calling them 'low-plastic'. The only way to render the process circular would be to capture the CO_2 from ambient air, hence closing the cycle of the CO_2. If the technology is to be treated in any EU policy as relevant to the circular economy, air capture should be mandated to avoid the use and emission of fossil-origin CO_2.

Synthetic fossil fuels 'sneak' transport into the EU ETS, delaying transport and industry decarbonisation for decades or worse

By counting synthetic fossil fuels as 'low-carbon' in the transport sector, claiming the emitted fossil CO_2 has been accounted for in the ETS, the EU would allow car and fuel producers not to decarbonise according to EU transport emission targets. Instead, they could buy industrial CO_2, made 'CO_2-free' with relatively cheap emission allowances. This would delay transport sector decarbonisation. Additionally, it would delay real industry decarbonisation, as it entails a lucrative, perverse incentive for industry to maximise CO_2 production for sale to fuel producers.

To make matters worse, a recent ruling by the European Court of Justice (ECJ) enables industry not to account for CO_2 that is used, provided it's 'chemically bound'. This could open for said CO_2 not to be accounted for at all, effectively rendering the EU ETS completely obsolete.

INTRODUCTION

The reinvention of kerosene for the outdated fossil lamps has taken its modern form. The most recent alternative to the already existing, efficient climate mitigation solutions are synthetic fossil fuels produced by using renewable energy sources. The purpose of this report is to debunk the myths of that so-called climate change mitigation pathway and the promises it claims. Finally, it aims to develop recommendations on how to avoid the pitfalls of *Power to Liquids*.

The EU Renewable Energy Directive

A Science-Policy gap

The structure of current policies will be crucial to the way the future unfolds. The current revision of the Renewable Energy Directive (in continuation RED II) includes provisions on so called *renewable liquid and gaseous transport fuels of non-biological origin*[1],[2] (European Commission 2017a): By providing a leeway for an increase in their production and usage, it risks shifting the focus and resources away from efficient and sustainable climate change solutions, like electro-mobility.

The RED II proposes an array of policy measures to achieve a 27% renewable energy share from total energy consumption by transportation, power and heating and cooling sectors by 2030. It mandates 6,8% of liquid and gaseous transportation fuels to be derived from renewable sources, including advanced alternative fuels and the ones derived

[1] The RED II defines these fuels as ''liquid or gaseous fuels other than biofuels whose energy content comes from renewable energy sources other than biomass, and which are used in transport'' (Article 2).

[2] This report will focus on the drop-in replacement fuels created by using CO_2 and H_2.

with energy coming from renewable electricity. As demonstrated in this report, this production of these non-bio based renewable fuels (in continuation referred to as synthetic fossil fuels and P_2L) for transport will achieve very limited reductions of CO_2 reductions and simultaneously use vast amounts of energy, which can be otherwise used far more effectively by electro-mobility.

The RED II misses the point by focusing on the questionable ''decarbonisation'' of fuels rather than focusing on the decarbonisation of transport.

Even though this 6,8% target includes a sub-target for biofuels, the rest of it comprises of a blend of other fuels, including renewable liquid and gaseous transport fuels of non-biological origin: Article 64 of the Directive states that the use of these fuels would contribute to ''the decarbonisation of the Union transport sector in cost-effective manner'', promote the energy diversification of transport and reduce reliance on energy imports (Article 64).

'Power to Liquids'

An example of renewable liquid and gaseous transport fuel of non-biological origin is a synthetic fossil transport fuel created by using H_2, which is acquired with the use of renewable electricity and CO_2. Collectively, this process is known as «Power to Liquid» (P_2L) and is a form of Carbon Capture and Utilization (CCU) (IEA and IRENA, 2017). The synthetic fuel can then be used, producing and releasing CO_2 to the atmosphere just as a normal fossil fuel. Even under ideal Life Cycle Analysis (LCA) conditions, the maximum effective CO_2 abatement potential of this technology pathway when using CO_2 captured from industry or fossil sources is at best only a 50% reduction compared to normal fossil fuel use[3]. The CO_2 put into P_2L comes out, decarbonising one process at the cost of decarbonising both. Once CO_2 (in the form of synthetic fossil fuels) is distributed it is very difficult to capture it in an economically viable way – if at all (Joode, 2014).

'Power to Liquids', by their inclusion in the main EU policy tool for renewable energy, are implicitly labelled as being 'renewable', due to the assumed use of renewably produced hydrogen (H_2) for their production (Ecofys 2013). Not only will this allow public funds to be spent on expensive initiatives with very limited climate effect, but it could cause irreparable damage to the climate policies of the EU. Wasting vast amounts of renewable electricity to manufacture 'Power to Liquids' will set European policy on a path towards a worsened environmental impact and continued fossil import dependence.

This report explores:

1) current impact assessments of the synthetic fossil fuel production,
2) potential pitfalls of the technology related to the current policy framework and
3) recommendations for alternative paths of climate mitigation.

[3] In contrast to the greenhouse gas emission saving of at least 60 % required for biofuels and bio liquids produced after January 1 2017 (RED, Article 17, paragraph 2), this emission abatement potential is much weaker.

THE 'OVER-SUPPLY' MYTH

Synthetic fuel generation postulates the use of highs in renewable energy generation as feedstock for the production of H_2. The intention is to avoid wasting the surplus green energy created during peak times by storing it in the form of synthetic fuels (Eurogas, 2016). It is argued that synthetic fossil fuel production is a logical solution for the intermittent demand or supply of energy systems on a large scale (ECN, 2013).

REALITY

In the EU, the excess energy production is 10% per year for all member states (Eurostat, 2016). This overshoot of energy supply depends heavily on the geographical location of the renewables: there are only a few areas in Europe where the supply of renewable power surpasses the demand. Even when it does, it doesn't happen on a regular basis.

Here's an example: on the 8th May 2016, the renewable power generation covered 88% of the demand of the largest producer of renewable energy in the EU-28, Germany (Quartz, 2016). The peak only lasted several hours and was considered a rare occurrence. In 2015, Denmark experienced a similar overshoot (The Guardian, 2015). On an uncommonly windy day, renewables were able to meet the national electricity needs – excess power was exported to, Germany, Sweden and Norway, where it was stored in hydropower systems for later use. These examples show that overshoots in renewable electricity supply are too rare to uphold large scale P_2L. Better flexibility options exist for managing increasing renewables in the system.

Instead, the EU should aim for an increase in the flexibility on the demand side and develop electricity applications that can capitalize on low electricity prices and respond to short-term price variations. Power to Heat is one example that meets these requirements and is a cost and socially effective way of using the surplus renewable electricity generation (CE Delft, 2015). Smart charging of electric vehicles can also contribute to the balance of a low-carbon power grid by ensuring flexible consumption patterns on the demand side (E-Mobility Platform, 2015). The benefits of electrifying the car fleet in the EU would be manifold: apart from the flexibility services like valley filling and peak shaving, electric vehicles would mandate far less energy than the conventional, fossil-powered cars (Figure 1). In addition, the reuse of batteries of electric vehicles could provide a storage capacity of approximately 128 GWh, sufficient to provide storage for almost all of Germany's daily capacity from solar power in peak periods. [4]

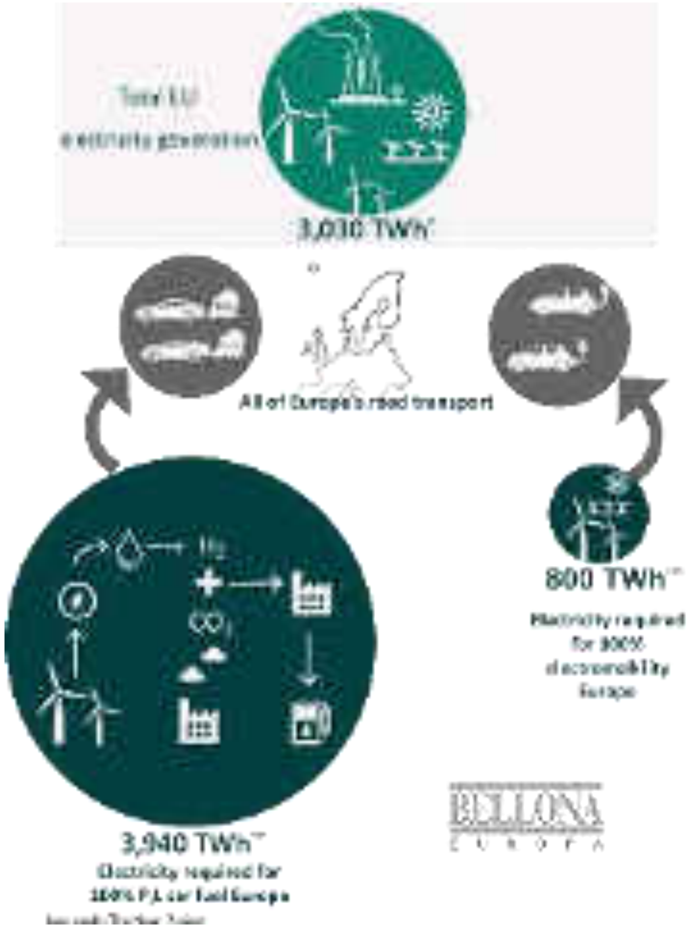


Figure 1: Creating 100% of EU car transport fuels via P_2X would have infeasibly large electricity demand, using more than all current EU electricity generation. Total conversion to electromobility would add just ~24% to current electricity demand and provide flexible grid services. *5 **6 ***7

[4] This estimate is based on an approximation of the number of reused batteries from retired EVs by 2020 and refers to energy storage in electricity supply.

[5] Total net electricity generation in the EU-28 was 3,030 terawatt hours (TWh) in 2014, (Eurostat 2016)

[6] Energy use in road transport in 2014 was 289.8 (Mtoe) = 3,370 TWh, (European Union, 2016). Excluding heavy-

Not only can power be better used by more efficient solutions that are already there, but it is not stable enough to allow the economical operation of Power to Liquid plants (UBA, 2016a). Without substantial subsidies and plenty of operation hours, the production of synthetic fuels will not be economically feasible.

With a growing demand for electricity (EEA, 2015), there will be no space for assigning new capacities to the inefficient creation of synthetic fuels.

As can be seen in the Figure 1, powering Europe's road transport would mandate the use of more than the entire current EU electricity generation.

TRAPS

The production of synthetic fuels will only add to the already increasing baseload demand for renewable energy sources. The increase in demand would make the entire system less flexible and secure.

Steelmakers are aiming to turn energy containing blast furnace waste gases into transport fuels. These are currently used to generate electricity emitting CO2 to the atmosphere. The aim is to convert these gases to fuels with P_2L techniques, emitting the same CO2 from the exhaust of cars. This fossil synthetic fuel process is labelled as "steelanol". Blast furnace gases are limited; using a portion of the very large CO2 emissions of a steel mill for P2L will require import of very large amounts of renewable electricity. The steelanol fits in the proposed RED II concept of "waste based fossil fuels", and the process will require substantial subsidies for the fuels to be commercial

The production of the synthetic fossil fuels will also generate a demand for CO_2, since it is a feedstock in their production process. A perverse incentive could develop; instead of being incentivised by CO_2 pricing to actually reduce emissions per tonne of product, EU industries get an incentive to maximise CO_2 for subsidised synthetic fossil fuels production. The CO_2 would be sold at a lucrative price to fuel manufacturers; to them, it would be a minor cost compared to other expenses (Institute for Advanced Sustainability Studies 2016).

The high demand for renewables by the synthetic fossil fuel production process will also provide incentive for producers to avoid feeding that same energy into the grid. Namely, ''electricity obtained from direct connection to an installation generating renewable electricity /.../ that is not connected to the grid, can be fully counted as renewable electricity for the production of that renewable liquid and gaseous transport fuel of non-biological origin.'' (RED II, Article 25, 3.a). If renewables won't have the incentive to go into the electricity grid, but will rather be used directly for the production of such fuels, an electrified energy transition will become far more costly and will stagnate instead of going forward.

Our renewable target will vanish into thin air if power from a wind turbine goes straight to the exhaust of a car.

For the suppliers connected to the grid, this liquid fuel-making process will encourage trading of Guarantees of Origin[8] in order to keep their operations running year round.[9] P_2L will be baseload electricity consumers. During times when renewables won't have an overshoot supply in the system, they will not pause their production. Consequently, they will have to use a potentially fossil source of energy in order to fill in the gaps of the renewable energy supply[10] (UBA, 2016a).

duty vehicles (HDVs) (-30% = 2660 TWh) for direct comparison with Eurelectric 100% EV electricity requirement estimates (Muncrief, 2015). At 60% P_2X conversion efficiency, 3,940 TWh of electricity would be required for 100% P_2X EU car fleet.

[7] 100% electrified fleet will add 802 TWh or a 24.3% increase in total electricity demand. (Eurelectric 2015)

[8] In order to avoid greenwashing, the provisions of the Guarantees of Origin system and the link between the consumers' choice and actual electricity production must be strengthened.

[9] Approximately 5,000 to 6,000 operating hours a year are required for P_2G to realize a positive business case. (Joode, 2014)

[10] For CCU to encompass CO_2 capture and use at an industrial source, synthetic fossil fuel production will be required to follow CO_2 / industrial production (generally

Through the Guarantees of Origin, fossil energy sources could be used to fuel conventional cars, none of which will be beneficial for reaching our climate goals. In addition, baseload operation of P_2L will reduce the flexibility of the grid, not increase it.

THE 'EFFICIENCY' MYTH

It is argued that making synthetic fuels provides an efficient way of converting excess power to other use. This myth is to a large extent connected to the previous one, as it relies on the fact that there is an overwhelming supply of free, non-utilised renewable energy available.

REALITY

In reality, the production of these fuels will mandate a large input of renewable energy sources and will be highly inefficient (UBA, 2016a). The existing mitigation technologies are far more effective in utilising the renewable energy currently being generated. A comparison between fuelling a conventional car as opposed to an electric car provides a vivid illustration of the large efficiency gap between the two transport solutions (Figure 2).

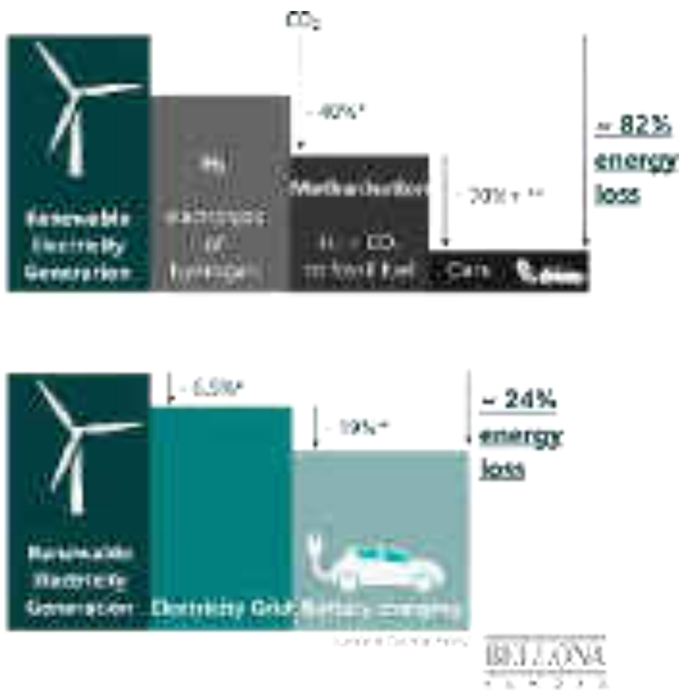


Figure 2: Electric vehicles (EVs) greatly outperform Internal Combustion Engine (ICE) cars using synthetic fossil fuels in the conversion of renewable electricity to kilometres. P_2L invents a new range anxiety. *[11] **[12] #[13] ##[14]

In other words, with the same amount of renewable electricity, you could power an electric car to go more than four times the distance of one running on synthetic fuels.

TRAPS

If we put all of this renewable energy to such inefficient use, the power grid will not decarbonise at the needed rate. On the contrary, it will increase the use of fossil fuels for power generation (German Federal Environment Agency – UBA, 2016a).

The two scenarios below demonstrate the difference between the current policy framework scenario (Figure 3) and an alternative, low-emission pathway (Figure 4). For the same amount of energy, one would get two very different outcomes. In the current scenario, only 3,2% of the road fleet would be powered by synthetic fossil fuels. In contrast, if one used that same amount of energy for electrification, 22 % of cars could be powered with renewable electricity.

The perpetual dependence on fossil fuels, as seen in Figure 3a, would also refer to the type of energy used to manufacture synthetic fossil fuels. In order to run on a daily basis, the production plant would have to compensate for the rare occurrences of renewable energy oversupply by using fossil power sources.

'Power to Liquid' would then become 'Coal/Gas to Liquid'.

Do we really want to turn fossils to fossils?

---

high utilisation) and not follow times of renewable energy oversupply (low utilisation).

[11] Synthetic fossil fuel manufacture with captured industrial CO_2 is ~60% efficient. (Stefansson 2015)

[12] ICE cars have an efficiency of 30%, but generally lower. Driving style and idling can reduce efficiency further. (EPA 2014)

[13] Electric power transmission and distribution losses in EU-28 (% of output) is 6.5% in 2014, (Wold bank, 2017)

[14] EVs have an efficiency of 81%. (Nasjonal transportplan 2018–2029, 2017).

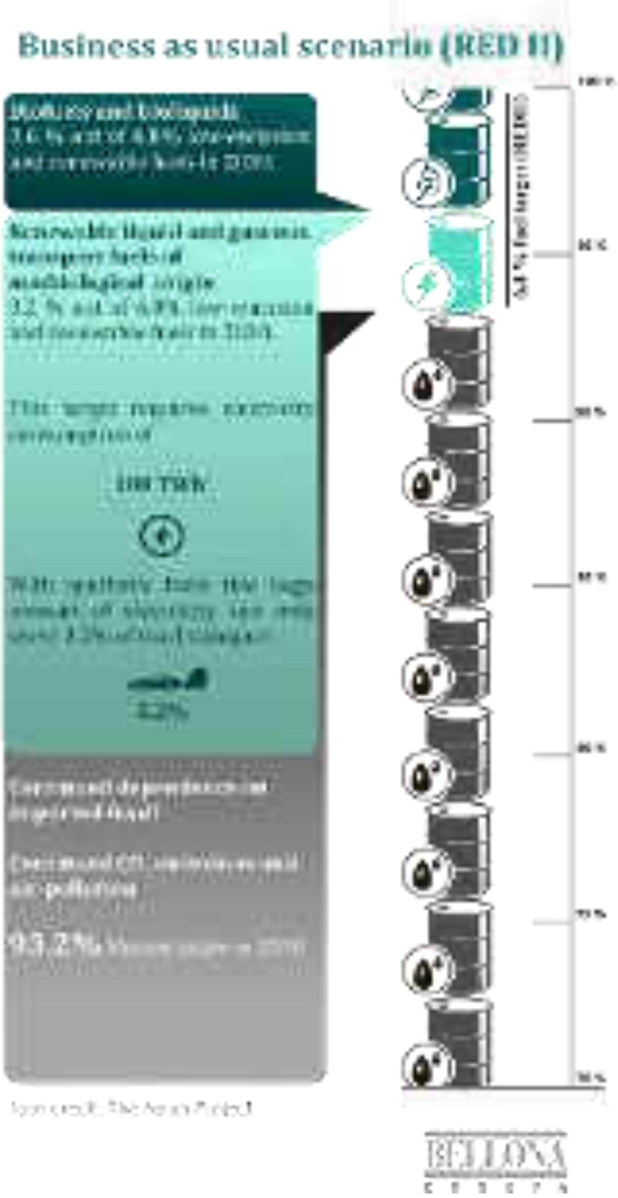


*Figure 3: Current policy framework pathway. *[15]*

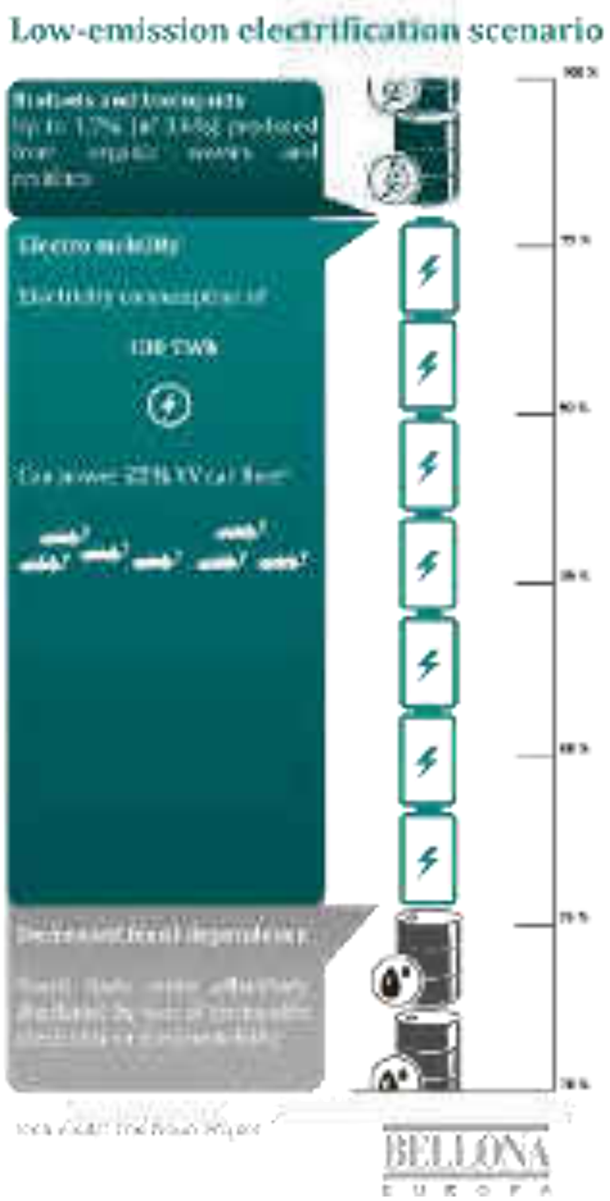


Figure 4: Low-emission electrification policy framework pathway[16] #[17]

This increased use of fossil energy would go against Europe's current decarbonisation goals and would increase the dependence on imported gas, crude oil and even coal.

Energy security, another major goal of the EU, would be compromised by wasting valuable renewable energy sources for an inefficient production of synthetic fossil fuels that will eventually end up being combusted and releasing CO_2 back into the atmosphere.

As synthetic fossil fuels would only replace a small fraction of the current fuels, reliance on fossil fuel sources would remain.

Synthetic fossil fuels can also potentially be converted back to electricity, yet about 80 percent of the energy would be lost in the process (Greentechmedia 2014).

[15] 180 TWh is greater than all 2016 German renewable electricity generation from Wind (77.8 TWh), Solar (37.5 TWh) and Biomass (77.8TWh) (Burger 2017).

[16] The low-emission scenario refers primarily to the more efficient use of renewable sources of energy. It does not include or assess the residual biofuels target, as it is out of the scope of this analysis.

[17] Eurelectric estimate 100% electrified fleet would require 802 TWh, 22% of this could be met for the same electricity in achieving 3.2% synthetic fuels. (Eurelectric 2015)

There are also physical limits to the amount of new renewable energy sources we can add to the system – with electricity demand expected to grow, resources should be used wisely. The integration of large quantities of renewables will require changes to the *modus operandi* of the entire system and substantial investments as is (Egmont Institute, 2014). An added baseload demand from synthetic fuel production will hence lead to an increase in both environmental and financial costs.

THE 'EMISSIONS REDUCTION' MYTH

By using captured industrial CO_2 as feedstock, the process of synthesising such fuels claims to close the carbon cycle. By using CO_2 from point sources, such as cement or steel plants, the fuels use the gas as a resource and thus prevent newly extracted crude oil from being used for transport.

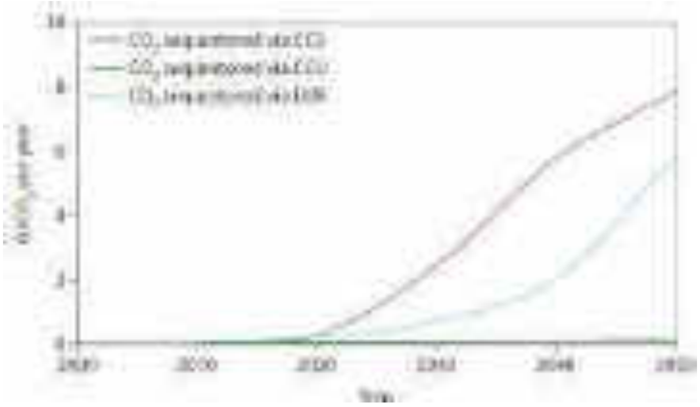
REALITY

Only with fully renewable electricity supply that has low GHG-intensity and feedstock CO_2 from direct air capture or a biogenic source, can life cycle GHG emissions of synthetic fossil fuels be lower than those of conventional technologies (Zhang et al, 2017). According to a recent study, the total CO_2 footprint per distance travelled actually increases when switching from conventional to synthetic fossil fuels (Mac Dowell, 2017).

In other words, the fuel derived from this process can have an even bigger carbon footprint than conventional fuels. A shift to synthetic fuels would hence be a step back rather than a step forward. In terms of emissions reduction, the technology is inadequate for the existing decarbonisation roadmaps (Rockström et al., 2017). As such, it might prove to be a costly diversion from effective mitigation strategies.

Accounting the emissions from synthetic fossil fuels is a matter of time and rate: in contrast to permanent geological sequestration (Carbon Capture and Storage, CCS), during P_2L, the CO_2 is only 'stored' for a short period, amounting to approximately six months.

From a climate perspective, CCU in its various forms is an ineffective way to reduce emissions (Figure 5). In comparison to CCS, the contribution of CCU to curbing climate change is negligible.



[18]Figure 5: Global contribution of CCU to deep decarbonisation is limited. Comparison between emissions reductions of CCS and CCU. (from MacDowell et al., 2017).

TRAPS

Without a thorough analysis of associated opportunity costs and environmental impacts[19], these technologies could substantially water down the EU climate change policy goals. Classifying such technologies as renewable and/or low-carbon without carefully looking into their impacts would render the policies ineffective. Since environmental impacts, particularly in terms of emissions, are not limited to a certain subsystem, the Life Cycle Analysis for synthetic fossil fuels should have a cradle-to- grave scope. Starting from the sourcing of carbon from industrial processes to the final combustion, it should not exclude any emissions the production process could entail.

The inclusion of such synthetic fuels in the RED II will also allow massive public subsidies for renewable energy sources to be indirectly channelled into synthetic fossil fuel production, using fossil CO_2 captured from industrial sources.

In addition, there is a high risk that 'CO_2 laundering' would occur. Emissions could be transferred from one sector to another – industrial emissions could

[18] In this case, CCU solutions are defined as any uses of CO_2, physical or chemical, that prevents immediate release of CO_2 to the atmosphere.

be removed from the Emissions Trading Scheme (ETS) by transferring the CO_2 into the synthetic fossil fuels and thus the transport sector outside the ETS. The CO_2 originally produced by an actor inside the ETS is thus emitted in a sector outside of it, potentially not being accounted for by the ETS.

A recent ECJ court ruling (C-460/15) states that the ETS should not include CO_2 that is subsequently chemically bound and not emitted to the atmosphere in the scheme. The ruling is based in a Schaefer Kalk case, an example of moving the CO_2 emissions from the ETS to the non-ETS sectors. When applied to the production of synthetic fossil fuels, this ruling sets a precedent to allow CO_2 now unaccounted for in the ETS to be transformed to fuels burnt in cars where it counts as 'low-carbon'. The result could amount to legalised, unaccounted atmospheric dumping of CO_2 in the EU.

Moreover, even if the utilised CO_2 would be accounted for in the ETS via surrendering of Emission Unit Allowances (EUAs) by the emitting industry, this would amount to the introduction of transport into the ETS via the 'back door', i.e. by making cars able to meet ever stricter EU emission targets through claiming their fuels' CO_2 is accounted for with relatively cheap EUAs, removing their incentive to actually reducing engine emissions. This could postpone transport decarbonisation for decades, rendering EU climate goals and the Paris Agreement unattainable.

Both EU industries and transport could appear decarbonised on paper. In reality, the CO_2 stock in the atmosphere would keep increasing, while any incentive for real emission reductions would be weakened for both sectors.

Allowing the labelling of such fuels as 'renewable' and/or 'low-carbon' would therefore lead us down a path of both more emissions and higher costs.

THE 'BETTER-THAN-BIOFUELS' MYTH

The production of conventional biofuels, notably biodiesel, has been labelled unsustainable due to its resource intensive production and effects on indirect land use change (ILUC), both within and outside of the EU. With the production of one drop-in fuel decreasing, there is a need for another 'renewable' alternative. Synthetic fossil fuels are often presented as the option that could fill the biofuel-gap in the EU renewable energy goals. REDII includes provisions on synthetic fossil fuels to supplement biofuels in meeting the EU renewable transport target of 6.8% by 2030.

REALITY

There are several crucial similarities between synthetic fossil fuels and first generation biofuels that discredit the alleged status of the former as the lesser of the two evils (Figure 6).

Biofuels production has analogies to synthetic fossil fuels in its complexity. Biofuels link diverse markets such as land use, food commodity markets and fuel users. Such complexity can entail undesirable social and economic outcomes if the underlying policy framework is poorly designed.

As drop-in substitutes for petroleum and diesel, synthetic fossil fuels and biofuels work in the same manner when it comes to their thermodynamics. Both raw materials are processed and refined to their final form that upon combustion releases CO_2 emissions. Due to these CO_2 emissions and their high resource intensity, neither type of fuel will achieve limiting warming to 2°C or below (Rockström et al. 2017). As an ineffective deep decarbonisation strategy, the production of synthetic fossil fuels could lose its social licence in the same way conventional biofuels largely have. This time, the point of contention would not be land-use change as with such biofuels, but wasting renewable electricity and forestalling effective industrial and transport decarbonisation.

As was the starting point for most biofuels, synthetic fossil fuels are currently far from being competitive on the fuels market (Institute for Advanced Sustainability Studies, 2016). To reach economic viability, they need to be produced with tax-free electricity and can't be taxed once they're sold on the market. This implies they would need heavy financial backing from public institutions in order to be competitive.

From the resource perspective, synthetic fossil fuels are, despite their higher gross area-specific yield, resource intensive products. The accumulated environmental impact of synthetic fossil fuels could end up being higher than the one of conventional biofuels (Mac Dowell, 2017). Compared to renewable biomass, the feedstock for the production of synthetic fossil fuels is intended to come from CO_2 made by burning fossils: whereas growing biomass can ideally provide a carbon sink.

Figure 6: Biofuels and synthetic fossil fuels – substituting like-for-like 'drop in' fuels will likely lead to like for like policy headaches.

TRAPS

The outlined similarities between conventional biofuels and synthetic fossil fuels could entail similar unexpected and unfortunate effects.

The risks of unforeseen consequences deriving from the policy framework currently being developed bear clear parallels to EU biofuels policy over the last decade. When EU biofuels policy was defined in 2007-2009, largely in the context of the current EU Renewable Energy Directive, there was widespread enthusiasm about the 10% RES mandate for transport by 2020 which served as the key driver (Kanter, 2008)

In the years to follow, the debate about unforeseen consequences, notably those related to ILUC, have led to subsidies being reduced and removed for many processes. This has been a painful exercise as several sectors, including EU agriculture, have been incentivised to shift production toward energy crops. The resulting risk of stranded assets makes it politically highly challenging to backtrack.

It is paramount to avoid a similar effect deriving from a flawed synthetic fossil fuel incentive policy, which would involve a wide set of key EU CO_2-intensive industries, representing jobs with a high impact on the economy and welfare. Hence flaws are likely to be even more challenging to rectify once the climate and financial consequences become clear. Getting P_2L/CCU policy and LCA boundaries right from the start is key to sound policy-making in this space.

THE 'CIRCULAR ECONOMY' MYTH

One of the arguments supposedly favouring the production of the fuels in question is the fact that they claim to 'recycle' the CO_2 being emitted from various sources and therefore supposedly close the loop of the carbon cycle.

REALITY

With its action plan, the Circular Economy Package of the European Commission sets out to minimise waste and resource use by "closing the loop" of the circular economy and ''tackle all phases in the lifecycle of a product: from production and consumption to waste management and the market for secondary raw materials.'' (European Commission, 2017b).

As Figure 7 below shows, the life cycle of synthetic fossil fuels is anything but a closed loop. In reality, the CO_2 stock in the atmosphere keeps increasing and is not accounted for. The fossil CO_2 that is captured is emitted at a later stage, prolonging its life cycle only until the fuel is combusted. This short lived re-use of the CO_2 lasts for, at best, 6 months (Mac Dowell, 2017), after which the CO_2 is released back into the atmosphere as it would have been months before. Synthetic fossil fuels are on the far end of the storage when compared to other utilisation options.

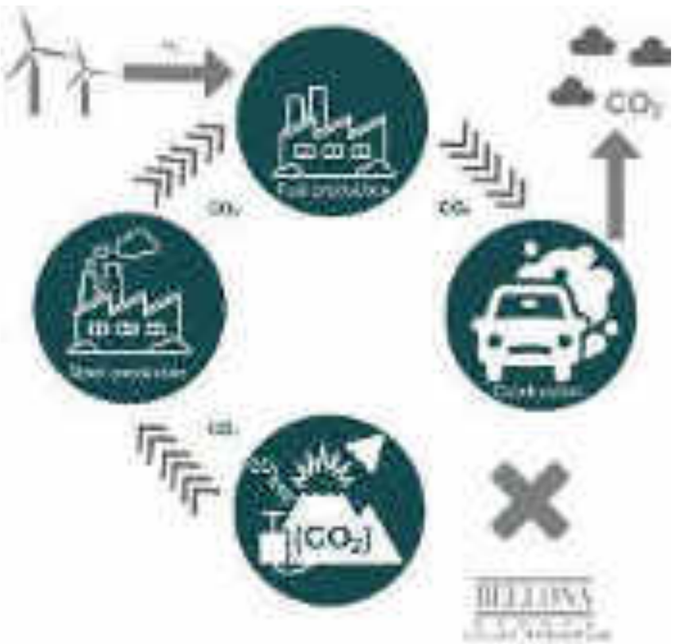


Figure 7: The non-circular life cycle of synthetic fossil fuels. Synthetic fossil fuels contribute to growing stock of CO_2 in the atmosphere.

Only if CO_2 were to be captured from ambient air would the resulting fuels not increase the concentration of CO_2 in the atmosphere. Yet, air capture system costs will amount to approximately $1,000 per ton of CO_2 (House, 2010): many times more than capture of CO_2 from point sources that are readily available (Schmidt et al., 2016). Depending on the industry, CO_2 capture could be anywhere from 100 to 10 times cheaper than air capture.

TRAPS

Due to the substantial price difference between ambient air and industry carbon capture, the probability that the CO_2 utilised in synthetic fossil fuel production will come from industrial sources is very high. As previously mentioned, this could cause 'CO_2 laundering', as it would take out CO_2 from an ETS sector to be subsequently emitted to the atmosphere in a non-ETS sector. In addition, it would reduce incentives for real decarbonisation measures in transport.

In the current data requirements for calculating the life cycle GHG intensity of novel transport fuels (European Commission 2017c), the LCA methodology of the synthetic fuels in question doesn't account for the entire life cycle relevant for the environmental impact assessment of the fuels.

In the calculation of default values for novel transport fuels, the carbon content of the synthetic fossil fuel is not counted as an emission during its combustion.

As the accounting in the LCA excludes the emissions caused by combustion of the fuel, it ceases to exist on paper. Since the CO_2 from the industry is no longer counted as emissions either, there is a real danger of it not being accounted for any step of the way. Ultimately, the current policy framework could result in an endless viscous circle of pointing fingers, rather than a real climate change mitigation solution. At best such a situation would allow for the partial decarbonisation of one sector at the expense of decarbonisation in another.

In order to retain a social licence into the future and avoid repeating the mistakes of the past, the LCA should include full chain accounting of CO_2 used, CO_2 emitted on reuse, potential additional external effects, such as renewable energy displacement, and all of the energy input for the production process

Labelling the synthetic fossil fuels 'circular' would also encourage the continuation of fossil use in ICEs vehicles, which are much less efficient in converting energy into movement than for instance electric vehicles. Meeting the EU's target of reducing CO_2 emissions from transport by 60% by 2050 will necessitate significant and immediate efforts to transition to a low- and zero-emission transport sector and the usage of synthetic fossil fuels could prove to be a costly distraction from reaching them. In addition, an electric shift would aid the EU in meeting other key policy targets, such as air quality.

P_2L – MAKING IT WORK

It is clear that there are many pitfalls to tend to when it comes to synthesizing fuels for the transport sector. Even though substitution pathways must be explored, particularly for sectors such as aviation and shipping, a gap between science and policy should by all means be avoided.

Despite the potential traps, there are some instances when Power to Liquids could be a beneficial climate mitigation strategy.

There are two types of conditions that would enable P_2L to be a successful climate mitigation strategy. Firstly, the inputs to the process would have to be acquired under certain circumstances:

- in areas with high potential for renewable energy and no clear electricity demand, where there is little infrastructure, industry or vehicles to power

An example of such a case would be solar photovoltaic in the desert. In those cases, some forms of P_2L could possibly be beneficial.

The second condition for successfully reaching CO_2 emissions abatement with P_2L is the physical property of the final product:

- producing liquid fuels that do not require nor emit CO_2, such as ammonia

CONCLUSIONS

Current state of play

The EU policy framework proposed in late 2016 (RED II) sets out to support a demanding climate change mitigation measure via CCU for renewable fuels of non-biological origin with very high input intensity and very low emissions abatement potential. According to RED II,

> *"/…/ renewable liquid and gaseous transport fuels of non-biological origin /…/ can contribute to **low carbon emissions**, stimulating the decarbonisation of the Union transport sector in a **cost-effective manner**, and improving inter alia **energy diversification** in the transport sector /…/ and **reducing reliance on energy** imports. The incorporation obligation on fuels suppliers should encourage continuous development of advanced fuels /…/."*
>
> *(Article 64, Directive on the promotion of the use of energy from renewable sources (recast))*

Previous analysis shows that the effects of synthetic fossil fuel production and usage as described in the above article in RED II should be questioned.

Declarations of intent for other policy measures, such as the Strategic Energy Technology plan (SET-Plan), also include such assumptions:

> *"Given the positive contribution to both energy security and climate mitigation goals, advanced renewable fuels can strongly justify the short-term high economic cost that their production implies /…/."*
>
> *(Targets 6.1, SET-Plan – Declaration of Intent on "Strategic Targets for bioenergy and renewable fuels needed for sustainable transport solutions in the context of an Initiative for Global Leadership in Bioenergy")*

Even though they are yet to become legally binding, these types of provisions are a manifestation of the current consensus on producing synthetic fossil fuels.

Not only do the policy proposals reflect this consensus: the aforementioned ECJ court ruling (C-460/15) demonstrates that the 'shift' of emissions from one sector to another is already underway and has legal backing.

Rent seekers in the private sector have already developed a range of synthetic fossil fuels and are actively lobbying for policy support:

> *''Audi e-fuels can make a large contribution towards achieving CO_2 neutrality.''*
>
> *(Audi, 2016)*
>
> *''Steelanol can cut greenhouse gas emissions by over 80 per cent compared with conventional fossil fuels.''*
>
> *(Arcelor Mittal, 2017)*
>
> *''By turning waste carbon from a liability to an opportunity, we are accelerating the reduction of harmful emissions while creating new economic opportunities /…/.''*
>
> *(LanzaTech, 2017)*
>
> *''The resultant fuels and products represent an opportunity to increase the environmental friendliness of long distance /transport/. What would be a huge step forward is nevertheless dependent on the creation of a political framework, which supports the profitable large-scale production of synthetic fuels.''*
>
> *(Sunfire, 2017)*
>
> *"Latest assessments clearly prove that rCCU fuels and chemicals show very high GHG emission reductions compared to fossil- and bio-based fuels (…) CO2 -based fuels and chemistry have to become crucial parts of a renewable and circular economy"*
>
> *(Nova-Institut GmbH, 2016)*

This combination of both public and private support suggests that the costly business as usual pathway will perpetuate.

In order to construct a decarbonisation pathway that is of the lowest cost to society, both market and policy players need to shift their efforts towards more attainable mitigation pathways. The current state of play suggests that the policy framework is about to enable private actors to close a business case for an investment that could increase the societal cost of reaching the climate goals.

Instead of reinventing the outdated technologies of the past, the focus should be put on the existing deep decarbonisation solutions.

The analysis of synthetic fossil fuels as a climate change mitigation solution shows that it is not an effective way of using the resources that are currently at our disposal. Renewable electricity used directly to power electric vehicles is incomparably more effective at decarbonising transport, while power-to-liquid utilises energy inefficiently, hence maintaining fossil fuel dependency.

Efforts should be focused on developing sufficient infrastructure for electric vehicles and supporting interoperable policy development such as public procurement to facilitate the transition towards electric transport, instead of wasting resources on creating alternative synthetic fuels with limited decarbonisation potentials.

References

Arcelor Mittal, 2017. Sustainability. http://europe.arcelormittal.com/europesustainability

Audi 2016. Synthetic fuels: Audi e-fuels. https://www.audi.de/corporate/en/sustainability/sustainability-at-audi/product/synthetic-fuels-Audi-e-fuels.html

Bellona (2015), Where will the energy storage mega trend lead us?

Bellona (2016), Bellona response to the consultation on the preparation of a new renewable energy directive for the period after 2020

Burger (2017). Power generation in Germany – assessment of 2016. ise.fraunhofer.de. Freiburg, Germany: Fraunhofer Institute for Solar Energy Systems ISE. https://www.ise.fraunhofer.de/content/dam/ise/en/documents/publications/studies/power-generation-from-renewable-energies-2016.pdf

CE Delft (2015), Potential for Power-to-Heat in the Netherlands

Ecofys (2013), Implications of the Reuse of Captured CO2 for European Climate Action Policies

ECN (2013), Re-use of CO2 and intermittent renewables

EEA (2017), Overview of electricity production and use in Europe

EE publishers (2016), Power to liquids and power to gas: closing the carbon cycle

Egmont Institute (2014), Renewables: the great uncertainty of the EU energy strategy

E-Mobility Platform (2015), The Energy Union Strategy - a plug-in plan for making Europe the world's leader in electro-mobility

Energy Innovation (2016), http://energyinnovation.org/wp-content/uploads/2016/05/Grid-Flexibility-report.pdf

EPA (2014). Drive Cycle Powertrain Efficiencies and Trends Derived from Vehicle Dynamometer Results http://papers.sae.org/2014-01-2562/

Eurelectric (2015), Smart charging, steering the charge, driving the charge. http://www.eurelectric.org/media/169888/20032015_paper_on_smart_charging_of_electric_vehicles_finalpsf-2015-2301-0001-01-e.pdf

Eurogas (2016), Elusive energy: How to keep it

For when we need it - A brief look into the problem and solution of energy storage

Eurostat (2016) http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_105a&lang=en

European Union, (2016) Statistical Pocketbook 2016, EU transport in figures.

European Commission (2011), White Paper on transport

European Commission (2017a), Proposal for a recast of the Renewable Energy Directive

European Commission (2017b), Fact Sheet -Circular Economy Package

European Commission (2017c), Fuel Quality

European Commission (2017d), Energy security strategy

European Commission (2017e), Renewable energy directive

Eurostat (2016), Renewable Energy Statistics

Greentechmedia (2014), Does Using Excess Renewable Electricity to Create Hydrogen Make Sense?

IEA and IRENA (2017), Perspectives for the energy transition investment needs for a low-Carbon Energy System

IEA (2008), https://www.iea.org/publications/freepublications/publication/Empowering_Variable_Renewables.pdf

Joode, 2014, The role of power-to-gas in the future Dutch energy system, ECN. https://www.ecn.nl/publications/PdfFetch.aspx?nr=ECN-O--14-030

Janter (2008) Europeans Reconsider Biofuel Goal, New York Times, July 8, 2008 http://library.wur.nl/WebQuery/file/cogem/cogem_t49e1165a_001.pdf

Lanzatech (2017), Company. http://www.lanzatech.com/company/

Muncrief, Sharpe (2015), ICCT, Overview of the heavy-duty vehicle market and CO_2 emissions in the European Union www.theicct.org/sites/default/files/.../ICCT_EU-HDV_mkt-analysis_201512.pdf

Nasjonal transportplan 2018–2029, (2017) Meld. St. 33 (2016–2017). Norwegian national transport plan https://www.regjeringen.no/no/dokumenter/meld.-st.-33-20162017/id2546287/sec1

Nova-Institut GmbH (2016), Petition for Integration of renewable CCU in the RED

The Guardian (2015), Wind power generates 140% of Denmark's electricity demand

MacDowell et al. (2017), The role of CO2 capture and utilization in mitigating climate change

McKinsey & Co. (2010), Transformation of Europe's power system

Rockström et al. (2017), A roadmap for rapid decarbonization

Schmidt, Patrick R., Werner Zittel, Werner Weindorf. Tetyana Raksha (2016). Renewables in Transport 2050 Empowering a sustainable mobility future with zero emission fuels from renewable electricity, Ludwig-Bölkow-Systemtechnik GmbH.

SET Plan Secretariat (2016), SET-Plan – Declaration of Intent on "Strategic Targets for bioenergy and renewable fuels needed for sustainable transport solutions in the context of an Initiative for Global Leadership in Bioenergy"

Sunfire (2017), Applications http://www.sunfire.de/en/applications/fuel

Stefansson (2015), Power and CO2 emissions to methanol, European Methanol Policy Forum, Brussels October 13 2015

UmweltBundesamt (2016), Integration of Power to Gas Power to Liquids into the ongoing transformation process

Quartz (2016), Germany had so much renewable energy on Sunday that it had to pay people to use electricity

Worldbank, 2017, Electric power transmission and distribution losses (% of output)

Zero Emissions Platform (2017), ZEP ME5 Report

Zhang, Bauer, Mutel, Volkart (2017), Life Cycle Assessment of Power-to-Gas: Approaches, system variations and their environmental implications, Applied Energy 190 (2017) 326–338.

The Bellona Foundation is a multidisciplinary international environmental NGO based in Oslo, Norway. Founded in 1986 as a direct-action protest group, it has since blossomed into one of the world's most recognized technology and solution-oriented environmental champions with offices on two continents. There are altogether some 40 ecologists, nuclear physicists, engineers, economists, lawyers, advisors and journalists working at Bellona.

The Bellona Foundation is financed by industry, business and individuals as well as through project-orientated grants from philanthropic organizations and the Norwegian government.

Throughout our offices, located in Brussels, Murmansk, Oslo, St. Petersburg, Bellona works with relevant governments, experts and other NGOs in achieving sustainable solutions to the world's most pressing environmental problems. These include fighting global warming, the clean-up after the Cold War legacy in Russia and the safety of the oil and the gas industry in Europe. The work is carried out through information dissemination, lobbying and campaigns directed at local and governmental levels. Bellona publishes its findings on the Bellona web site in order to inform and educate the public about the environment in which it lives.

Contact

Jonas Helseth, Director, Bellona Europa
jonas@bellona.org
Keith Whiriskey, Policy Manager Climate Technologies
keith@bellona.org

Bellona Europa, Brussels, Belgium, 2017

www.Bellona.org Bellona International @Bellona_EU