BELLONA EUROPA *brief*

THE CARBON-NEGATIVE SOLUTION: INCENTIVISING BIO-CCS IN EUROPE

The latest report of the Intergovernmental Panel on Climate Change (IPCC 5AR, 2014) issued a stark warning: to stand a reasonable chance of avoiding disastrous climate change, we have to remain within a 'safe' level of CO_2 emissions so that average global temperature rise is limited to 2°C.

Half of the CO_2 'budget' that allows us to remain within this threshold has already been used, and at current rates the remainder will be exhausted within the next 25 years. There are already far more proven reserves of fossil fuels than can be safely burned. Overshoot could lead to uncontrollable and deeply destructive climatic changes.

The IPCC's scenarios therefore now rely on negative emissions to keep temperature rise below 2°C.

Negative emissions are achieved when excess CO_2 is removed from the atmosphere. This is attainable through the combination of Carbon Capture and Storage (CCS) and conversion of sustainable biomass into energy or products, so-called Bio-CCS (or BECCS, Bio-Energy with CCS, when limited to the energy sector).

The message from the IPCC cannot be misunderstood: Bio-CCS is going to be a critical safeguard against disastrous climate change; we must act now to assure its two components, CCS and sustainable biomass supply, are incentivised and widely deployed.

This brief aims to outline how Bio-CCS works in practice and how it can be incentivised.

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What is Bio-CCS

Bio-CCS is the combination of two climate solutions: Sustainable biomass use with CCS. Bio-CCS is, technically speaking, a fairly straight-forward process. It simply means replacing fossil fuels with sustainable biomass in the production of energy and other products, while ensuring those facilities are equipped with CCS technology and infrastructure. **Both technologies exist - we just need to put the pieces together.**

Sustainable bioenergy and -products come from the use of biological material, which is anything that in the process of growing has absorbed CO_2. It therefore encompasses a wide range of materials, including crops, straw, wood, algae and waste. Because biomass absorbs and binds CO_2 as it grows and new biomass can be grown, thus recapturing the CO_2 released when the biomass is burned or otherwise converted, emissions from sustainably sourced biomass are recognised as virtually zero over time: the same amount of CO_2 is taken up as is released. Whether biomass is left to rot or is used for e.g. energy production, its carbon is released back into the natural cycle. This cycle is in theory *carbon-neutral*. If the emitted CO_2 from such a process is instead captured and permanently stored, the value-chain becomes *carbon-negative*: more CO_2 is taken out of the atmosphere than is released into it.

Bioenergy currently accounts for about 10% of world primary energy use, two thirds of which is used for small-scale cooking and heating in developing countries. In industrialised countries, biomass is used for heat in industry and residences, transport fuels and electricity generation.

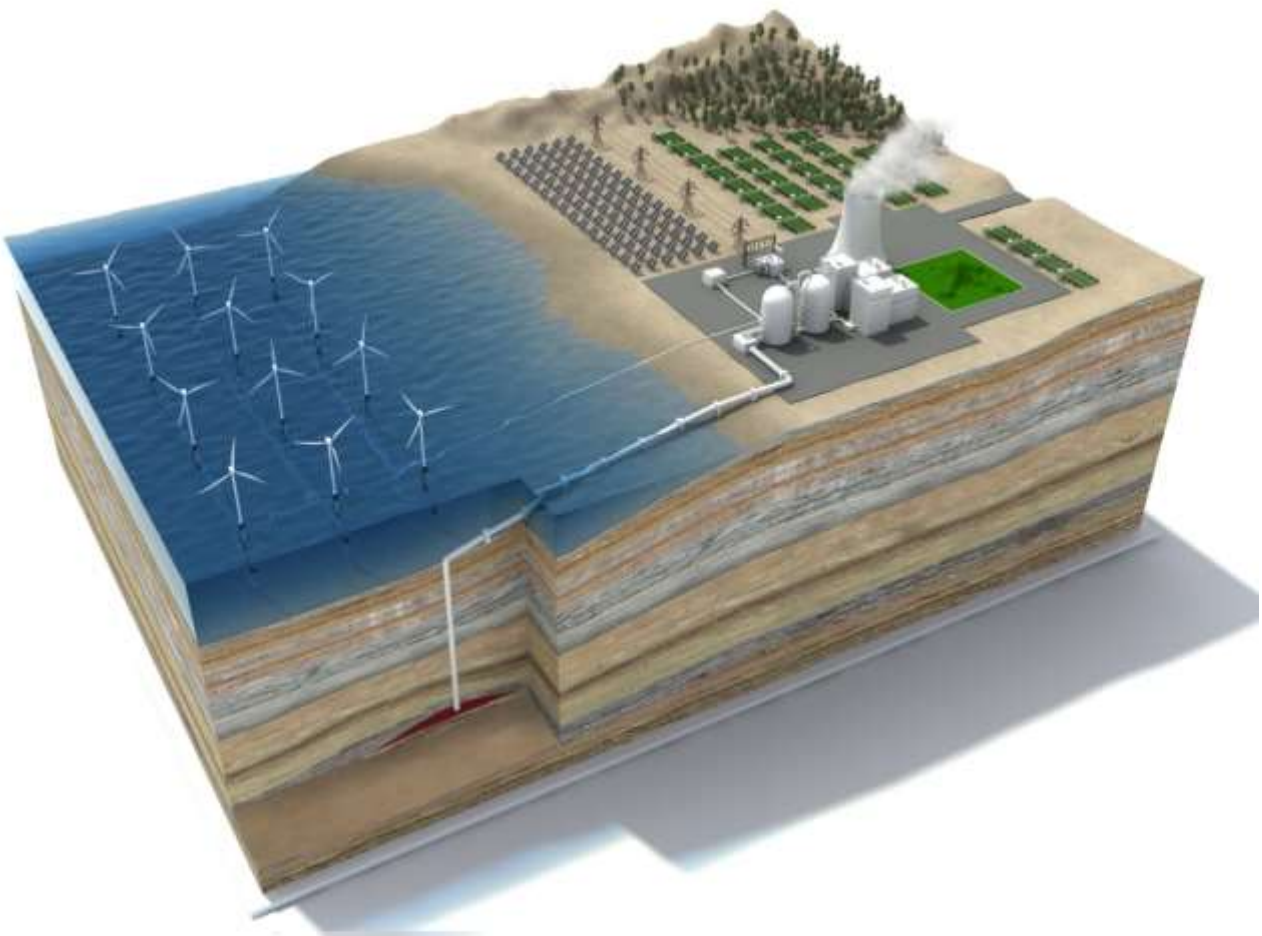
When using biomass for heat and power production, nearly all the related CO_2 emissions can be captured and stored, using similar technology to that used at fossil-based energy production. In addition, as an integral part of the production of e.g. bioethanol through biomass fermentation, as well as advanced biofuels production routes such as Biomass-to-Liquid (BtL), large amounts of pure biogenic CO_2 are released that can be captured at a low cost. These processes, where learnings from CCS in fossil industry are directly applicable and where the purer CO_2 emissions negate a need for expensive equipment to separate the CO_2 from the flue gas, therefore often constitute low-hanging fruits for early CCS deployments. In fact, CO_2 is generally already being captured from such facilities, and is sold to e.g greenhouses to enhance growth or beverage producers. In addition, these facilities increasingly also include the production of other products replacing petroleum-based equivalents, continually expanding the number of facilities where Bio-CCS would be applicable.

The use of biomass in a plant fitted with CCS ideally produces a double climate benefit: emissions from the combustion of fossil fuels are prevented from entering the atmosphere through replacement of fossil fuels and products by biomass, and the CO_2 contained in the biomass is captured and stored, thereby removing CO_2 from the atmospheric cycle.

In Europe: The EU in 2009 committed to sourcing 20 % of its energy consumption from renewable energy sources (RES). According to the latest renewable energy progress report, bioenergy constituted 57%

of the EU's renewable energy mix in 2014. In April 2015 it was decided to put a break on land-based (first generation) biofuels' contribution to EU transport targets. This came in recognition of the need to learn from past mistakes with bioenergy sustainability and to set CO_2 and beyond. The European Commission is expected to suggest new legislation for renewable energy and a new policy on bioenergy sustainability in late 2016.

Bio-CCS is sometimes referred to as geo-engineering: the manipulation of environmental processes that affect the climate. However, geo-engineering is generally associated with dangerous, high-risk interventions with little knowledge of the consequences. Bio-CCS rather combines two concepts that are well-tested and known. In fact, it should be viewed as the opposite of geo-engineering: a correction of the geo-engineering that constitutes excessive extraction and uncontrolled use of fossil reserves.



Why Bio-CCS is needed

There are three core reasons for why the attainment of carbon negative emissions via Bio-CCS is an increasingly sought after and necessary solution, especially considering that actions to mitigate greenhouse gas emissions are already severely delayed, with few signs of catching up[1]:

1. Its capacity to accelerate reductions in atmospheric concentrations of CO_2;
2. Its ability to reduce the overall costs of climate change mitigation by offsetting more difficult to abate emissions;
3. Its capacity to remove or compensate for historical emissions and our inability to undertake sufficient mitigation action rapidly enough.

The benefits of Bio-CCS have been acknowledged by a number of influential international institutions, including the United Nations Environment Programme, the Intergovernmental Panel on Climate Change (IPCC), the International Energy Agency (IEA) and the United Nations Industrial Development Organisation (UNIDO).

A report by the JTF Bio-CCS[2] in 2012 found that in Europe, Bio-CCS could remove 800 million tonnes of CO_2 from the atmosphere every year by 2050 using available sustainable biomass. This is equivalent to approximately 50% of current emissions from the EU energy sector. Note that this is *in addition* to the emission reductions that would be achieved by the entailed replacement of fossil fuels with said biomass.

Moreover, in 2011 a Bellona report estimated the significant role Bio-CCS could play in the Romanian electricity sector[3]. A scenario where 10% biomass is used in 2020, rising to just 20% in 2030, would see the removal of 130 million tonnes of CO_2 from the atmosphere. This would only use a fraction of the existing, local sustainable biomass supply available in Romania, and could make Romania the first country in which the entire energy sector would go net carbon-negative.

Extracts from the IPCC 5AR (2014)

- "Many models could not achieve atmospheric concentration levels of about 450 ppm CO_2eq by 2100 if additional mitigation is considerably delayed or under limited availability of key technologies, such as bioenergy, CCS, and their combination (BECCS)."
- "BECCS features prominently in long-run mitigation scenarios for two reasons: (1) The potential for negative emissions may allow shifting emissions in time; and (2) in scenarios, negative emissions from BECCS compensate for residual emissions in other sectors (most importantly transport) in the second half of the 21st century."
- "Delayed mitigation further increases the dependence on the full availability of mitigation options, especially on CDR technologies such as BECCS."

[1] Zakkour, Kemper, Dixon *Incentivising and Accounting for Negative Emission Technologies*, Energy Procedia Vol 63 (2014)

[2] The Joint Task Force Bio-CCS, established by Bellona and composed of the European Technology Platforms for CCS and biofuels (ZEP and EBTP respectively) Biomass with CO_2 Capture and Storage (Bio-CCS): The way forward for Europe (2012)

[3] Our future is carbon negative: A CCS roadmap for Romania (2012)

Incentivising Bio-CCS

Both bioenergy and CCS are complex topics which require a number of well thought-out measures, entailing:

Increasing sustainable supply of biomass: Biomass production is subject to a range of sustainability constraints, including land and water scarcity, biodiversity implications, competition with food production, deforestation and phosphorous scarcity. Large-scale deployment of Bio-CCS requires that we ensure sufficient, sustainable supply. Given the magnitude of the emission challenge, this clearly requires new pathways to biomass supply, including heavily investing in RD&D, development and upscaling of suitable microalgae production, growing and harvesting macro-algae (seaweed) from the seas, and novel methods for growing suitable biomass on lands not currently suited for crops. Both high-tech and low-tech technologies, as well as integrated approaches like Ocean Forest[4] and Sahara Forest Project[5], will be part of the solution.

Deploying conventional CCS: Bio-CCS is an available technology, but still relies on wider and faster deployment of conventional CCS to bring down costs. As CCS requires access to large-scale infrastructure for transport and storage of CO_2, a coordinated, holistic approach to CCS deployment in all relevant industries will hugely benefit societal costs of decarbonisation, and is likely to facilitate the roll-out of CCS in biofuels production in an early stage due to low capture costs.

Strengthening public engagement: Experience with reliance on the ETS to drive low-carbon investments cautions over-reliance on this one instrument. Therefore, it will be important for civil society to create public support and calls for Bio-CCS, as part of the climate solution and as an attractive option for business. There should be an expectation placed on industry to develop carbon-negative power and products for 'its own sake' and not merely to satisfy ETS compliance.

Putting in place supportive policies that incentivise going beyond zero emissions: Today, EU industry is incentivised to replace fossil fuels by biomass through various national schemes and moreover to reduce fossil emissions through the cap-and-trade Emission Trading System (ETS). However, at present there is no commercial benefit of any kind for those companies that go further and attain net carbon-negative solutions. The EU ETS only accounts for emissions from fossil sources, meaning operators of a biofuels production facility or a biomass fired heat/power plant are beyond its scope (as any emissions from biogenic sources are assumed to be neutral). Hence, abating biogenic CO_2 emissions entails no reward/benefit whatsoever. This is counterintuitive, as CO_2 has the same climatic effect regardless of the source, and especially considering that Bio-CCS could often be done at relatively low abatement cost.

Bio-CCS needs to be rewarded by accounting for negative emissions in the EU ETS. This must be done through the modification of the ETS Directive (Directive 2003/87/EC) to recognise (negative) emissions from biogenic sources and the **establishment of a mechanism in the ETS for the issuing of EUAs on the basis of such emissions** (see box: *Bellona's proposal for crediting of negative emissions*).

[4] http://bellona.org/projects/ocean-forest
[5] http://saharaforestproject.com/

At first thought, in a cap-and-trade system with a set cap, this would mean adding more allowances to be awarded where CO_2-emissions are actually reduced beyond zero. However, in an already flooded market, this would be a counter-productive, not to mention extremely controversial, measure. Moreover, by adding a new reward it would further fuel the entrenched debate about the sustainability and assumed carbon neutrality of current EU biomass utilisation, rather than focus on solutions. There are two main options to do this: Bellona fears that industry and governments might then treat Bio-CCS as a strategy to postpone necessary action elsewhere, which would be a bad signal in face of a global crisis. The main purpose must be to ensure that capturing and storing emitted CO_2, regardless of the source, is rewarded in the same way.

Bellona's proposal for crediting of negative emissions

How: Dedicate a number of existing EUAs in the ETS for rewarding of carbon-negative solutions. These EUAs would be given to operators that achieve negative emissions, to sell to the market (or surrender for any fossil emissions if relevant), thus providing a direct monetary incentive. Rather than adding more EUAs to an already flooded market, a dedicated fund should be established, either from unallocated permits or from a set-aside specifically created for Bio-CCS. For instance, 50 million EUAs from the Innovation Fund could be dedicated to Bio-CCS operations in the next trading period.

Pros: Administrable within existing scheme; using a reserve rather than adding new EUAs maintains the scheme's integrity as there are no 'additional offsets' created; dedicated number of EUAs provides clear market signal; the limitation in scope to cover early movers prevents worries about possible unforeseen perverse effects, yet allows low-hanging fruits for CCS deployment to proceed.

Cons: Risk of low yield from the dedicated ~50 million EUAs due to low and unpredictable carbon price (however, this is true for any emissions covered by the ETS today); timely CCS deployment in Europe is dependent on capital for infrastructure being made available through other EU funding programmes (e.g. the Innovation Fund and the Connecting Europe Facility (CEF)) as well as from Member States.

Sectors for Bio-CCS application

Power: The Drax coal power plant in the UK has (co-)fired increasing amounts of biomass for a number of years. The White Rose CCS project, which is currently in planning stages, would see CCS applied to Drax and could thereby render this a Bio-CCS facility. However, the lacking incentive for capturing biogenic CO_2, may mean a lost opportunity for proving Bio-CCS on a large scale in the power sector. Depending on the amount of co-fired biomass and the assurance of its sustainability, White Rose can provide carbon negative electricity for up to 630,000 homes.

Industry: CCS is critical should industry survive in a carbon constrained economy. Energy-intensive industries such as steel mills, cement factories, chemical plants and refineries emit CO_2 in their production processes. This means that if they were to reach their theoretical efficiency limits (which they are already close to), CCS is the only technology that can reduce their inherent CO_2 emissions. Bio-CCS is a natural first step at pulp and paper factories, where at-site wood waste is already being used to power production. In addition, some of those facilities offer Bio-CCS opportunities also for the process emissions. Use of Bio-CCS in industrial processes can give us not only carbon neutral, but carbon negative products - which would be a true industrial renaissance.

Biofuels production and bio-refineries: The cost of CO_2 capture from biofuels production, such as ethanol fermentation, is generally very low, as the CO_2 by-product streams are of high purity. The pure stream of CO_2 eliminates the need for additional separation equipment, with only driers and compression units necessary to prepare the CO_2 for transport to a storage site. The ADM Industrial CCS Project in Decatur, Illinois, USA is already producing such carbon negative biofuels, capturing more than a million tonnes of CO_2 annually for permanent storage in a saline aquifer. Such biofuels production with CCS is the low-hanging fruit for Bio-CCS.

A closer look at the case of Norway

Norway does not currently have targets or policy for Bio-CCS or carbon-negative solutions. The Climate Agreement (2012) states that Norway should develop one full-scale CCS demonstration plant by 2020. This commitment was confirmed by the current government. There are no commitments to CCS development in Norway beyond 2020.

Norway and the other EEA-EFTA countries joined the EU ETS at the start of phase two (2008). Making CCS a commercial reality in Norway is therefore dependent on the positive development of the EU ETS.

A Norwegian bioenergy strategy was presented in 2008. The strategy aims for a 14 TWh increase in bioenergy production by 2020. The strategy confirms that conditions in Norway are favorable for a significant increase in the use of bioenergy. According to the Norwegian Water Resources and Energy Directorate (NVE) the realistic potential for bioenergy is estimated to approximately 21 TWh. This includes forest resources, industrial and organic waste, micro- and macro-algae and biomass for biogas.

The current government aims for Norway to be a frontrunner in environmentally sound energy use and production. The following targets were set in its declaration:

- Develop a biogas strategy
- Increase renewable power production in Norway
- Develop a white paper on energy policy, connecting energy supply, climate challenges and commercial development

Today, Norway has support schemes for bioenergy production under the Enova enterprise (investment aid directed at heating centrals, biogas district heating, biofuels and new technology) and Innovation Norway (investment aid directed at production, use and supply of bioenergy in the form of fuel or heating, tile production).

CO_2 capture in Oslo: Over the last year the potential for CO_2 capture at the Klemetsrud plant in Oslo has received increased attention. **Klemetsrud energy recovery** is a thermal power and waste incineration plant. It is the largest industrial waste energy recovery plant in Norway, with an annual capacity of 310 000 tonnes of waste, recycled from households and commercial waste from Oslo and neighbouring communities.

Today CO_2 emissions from Klemetsrud represent 21 per cent of Oslo's total emissions, making it the capital's largest point emission source by far. Gassnova estimates possible capture of about 400,000 tonnes of CO_2 per year at Klemetsrud. A CO_2 capture plant at Klemetsrud would be the first carbon negative facility in the world.

The heat energy from the incineration of waste is used to produce hot water, which is utilized in Oslo's district heating systems and in the production of electricity. Klemetsrud has an annual production of about 600 GWh of heating and around 160 GWh of electricity.

The plant operation is stable and will remain so for 40 years. It therefore provides a good base for technology development. CCS in energy recovery systems is of great global interest, and use of CCS will enhance energy recuperation's role as an essential component of a lifecycle-based waste system.

Bio-CCS in six steps

1. Biomass growth / absorbtion of CO_2

Biomass is any source of organic carbon that is grown and is derived from plant materials and animal materials. All biomass binds CO_2 from the atmosphere through photosynthesis as it grows. When biomass rots or is combusted for power production, this carbon is released back into the natural cycle. This cycle is therefore carbon-neutral. If this carbon is instead captured and stored, the result would be a net removal of CO_2 from the atmosphere. Use of biomass in a plant fitted with CCS has a **double climate benefit**: Emissions from fossil fuels are prevented and the CO_2 contained in the biomass is removed from the atmosphere.

2. Identifying sustainable biomass feedstock for Bio-CCS:

The use of biomass in a plant fitted with CCS produces a double climate benefit: Emissions from combustion of fossil fuels are prevented from entering the atmosphere and the CO_2 contained in the biomass is captured, thereby removing CO_2 from the atmosphere. This benefit is however, reduced (often dramatically) if the biomass is not sustainably grown, replaced and transported through life cycle emissions or indirect land use change (ILUC). To avoid such impacts, we should focus on advanced sources of biomass, such as forest residue, agricultural and municipal wastes, waste oils, seaweed and algae.

3. Biomass conversion

Fuel for transport: Especially aviation where electrification is not an option.

Combustion for electricity: Biomass can be used at many CCS equipped power plants. It may be gasified for use in natural gas CCS power plants or blended with coal and combusted in existing coal power plants (co-firing).

Powering industry: Energy-intensive industries such as steel mills, cement factories, chemical plants and refineries are reaching theoretical efficiency limits and CCS is the only technology that can substantially reduce their emissions.

4. CO_2 capture and compression

Capture entails the separation of CO_2 from other components (mainly steam and nitrogen, but also particles, sulfur, etc.) from total emissions to get the smallest possible volume and purest composition for transport and storage. The cost of CO_2 capture from biofuel production, such as ethanol fermentation, is generally very low, as the flue gas is often of high CO_2 purity. Beyond this higher simplicity, the process is the same as for capture from combustion. Prior to transport, however, the CO_2 must be dried and compressed to reduce the volume of the CO_2, as this makes it easier to transport.

5. CO_2 transport

Most storage sites are below an ocean, offshore CO_2 transport can be made via pipelines or ships.

6. CO_2 storage

CO_2 storage can take place both underground on land and offshore. Following transportation the CO_2 is stored in geological formations located far below the earth's surface.

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