Fern submission for EU long-term greenhouse gas emissions reductions strategy

14.8.2018

Key messages

EU long-term greenhouse gas emissions reductions strategy must

- Do its fair share to limit warming to 1.5 degrees (with a 66% likelihood)
- Reduce emissions rapidly to limit the need of negative emissions
- Not use forests to lower ambition on other sectors
- Set ambitious targets to protect and restore ecosystems including changing the way we manage forests (i.e. by logging less intensively, stopping clear-cutting, cutting trees when they are older, encouraging a more diverse mix of species) so as to maximise the amount of carbon they absorb. This strategy would also enhance the resilience of forests to changing environmental conditions and support biodiversity.
- Fully take into account impacts of biomass extraction on carbon sinks
- Restrict public subsidies on biomass energy use
- Not rely on large scale BECCS, nor subsidize the technology
- Take into account co-benefits of mitigation action on the society and our natural environment not only costs

Forest restoration in EU climate policy

The struggle to achieve international climate goals is also a battle to protect and restore our land and forests.

When we degrade them, the carbon dioxide emissions are substantial, but when we restore them they remove the climate changing gas better than any technology currently invented. Each year, forests in the EU remove 10 per cent of the EU's emissions.

The international climate goals were decided in Paris when 195 governments agreed to limit global temperature rise to "well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius." Such wording is important since at 2 degrees warming we lose the coral reefs that directly support 500 million people; whole islands in the Pacific become uninhabitable; water availability is severely reduced; droughts increase; crops are put at risk, and far more. If we go for the stronger and safer 1.5 degree option – and unless we fully decarbonise in the next three years – we will need to remove carbon dioxide from the atmosphere, allowing us to enter a period of 'negative emissions'.2 Relying on negative emissions is extremely risky, so it is essential that we continue to focus on reducing emissions as fast as possible.

Recent EU climate policies, notably the LULUCF Regulation and the Renewable Energy Directive, will not get us anywhere near negative emissions. In fact, their combined effect will likely reduce EU forests' ability to absorb carbon.3 On the positive side, however, the EU has also approved the Energy Union Governance Regulation which aims for the EU to balance emissions and removals as early as possible, before going into negative emissions.

The next important milestone will be EU's 2050 decarbonisation roadmap, which will set out how the EU will meet the international climate goals. This briefing explains why the roadmap should be used to encourage the restoration of land and forests. It proposes steps that the EU should undertake regardless of the need to remove carbon dioxide. These are win-win actions that will remove carbon dioxide, nurture local economies, and make Europe more resilient to climate change.

Why restore EU forests?

To avoid dangerous climate change, the EU's land and forests must remove more carbon from the atmosphere and store it – but with each passing year, they are becoming more degraded and less able to do so. The EU's managed forests are already absorbing 10 per cent less carbon in 2015 than they did in 2009, and according to the EU's projections, by 2050 they will be absorbing less than half the carbon they took up at the beginning of the century.4 This is the opposite of where we need to go.

Cutting down old forests and replacing them with newlyplanted trees – as is the current trend across the EU – is a disaster for the ability of forests to remove and store carbon. When we cut down old forests, we not only lose the huge amounts of carbon they were already storing – we also damage the ability of the forest to soak up carbon, since older trees absorb carbon at a faster rate than younger trees. It takes centuries for new trees to grow big enough to re-absorb all this lost carbon, and to remove carbon at the rate they used to – if they are ever allowed to grow to maturity, which at the moment they generally are not.

Protecting and restoring EU forests will allow them to fulfil their full potential of removing and storing carbon.

It will also achieve many co-benefits.

Helping end biodiversity loss

Globally, forests are home to 80 per cent of the world's plants and creatures. Intensifying agriculture and forestry are the main reasons why biodiversity is declining in Europe, and the situation is bleak. Of those forests with protected status (Natura 2000), only 15 per cent of EU forest habitat types are in favourable condition; the rest are degraded. This is not only a problem for plants and animals: biodiversity loss is as bad for human well-being as the climate crisis.

Improving soil and water quality and carbon storage

More than 20 per cent of EU forests are kept standing for their ability to protect water and soils. Soil is the world's largest terrestrial carbon store. There is about 2.5 times more carbon in European forest soil than in European forest trees. Forest management practices like tilling and lowering the species composition reduce this carbon pool. The soil in mature forests stores significantly more carbon than soils from areas that have been clear-cut.

Forests also maintain mountainsides. Mountainous countries such as Slovenia, Italy and Austria have all had soil erosion caused by logging. Forests disturbed by fires and logging have seen soil loss as high as 26.6 per cent. This makes soil less fertile and decreases agricultural productivity in surrounding areas. Monoculture forests also typically have less nutrients in the soil.

Increasing climate resilience to droughts, flooding and fires

Diverse natural ecosystems are an insurance policy against climate change. Scientists have found that forests with many tree species grow at a faster rate, store more carbon and are more resistant to pests and diseases which become more frequent with a warmer climate.

Climate change is predicted to increase flooding. European forests have a key role to play in flood management: 4.5 per cent of European forests are considered floodplain forests which have a significant role in water retention.

As the world gets warmer, forest fires will also get worse. They are a natural phenomenon, to which boreal and Mediterranean forests have adapted, and many species even depend upon, but warming means fires are larger and more intense than before. Severe forests fires have occurred in young dense forests and monoculture plantations – such as the recent spate of forest fires in Portugal that have been linked to the expansion of eucalyptus plantations, tragically killing over one hundred people. Old-age forests are associated with less severe fires.

Good for human health and wellbeing

Forests are good for air quality because they extract a wide range of pollutants emitted by traffic and industry. In Barcelona, green spaces contribute substantially to reducing particulate pollution, and in Florence they have reduced ozone pollution.

Other health benefits include that spending even short times in a forest improves people's mood, cardiovascular health and reduces blood pressure and stress. Green spaces are also linked to increased physical activity, reduction in obesity, and lower levels of crime and violence.

The role restoration could play in the 2050 decarbonisation roadmap

By 2021, we will most likely have missed our opportunity to achieve the 1.5 degree goal through emissions cuts alone, so entering a period of negative emissions will be necessary. The faster the EU moves away from fossil fuels and land-use emissions, the less negative emissions we will need.

The EU has a finite amount of land with a finite ability to store carbon. It is therefore essential to use its limited potential to the maximum effect. The more ambitious our emissions cuts, the more easily we can reach climate targets. Conversely if we allow sectors such as aviation to continue polluting with the promise of forest offsets, it will put the 1.5 degree climate target out of reach.

It is therefore essential not to conflate negative emissions with carbon offsets. One gives us our last chance to meet the 1.5 degree target, the other consigns us to a 2 degree world, or worse.

Scientists estimate that to meet 1.5 degrees, we will need to remove between 450 and 1000 gigatonnes (Gt) of carbon dioxide. The upper end of the range is improbably high, given biophysical limits and the risks of negative social and economic impacts, hence the need to decarbonise as fast as possible and not rely on this volume of negative emissions.

What percentage of the negative emissions challenge the EU – as a historic polluter – should deliver is a political question. Based on cost-optimal models, two scientists, Oliver Geden and Glen Peters, have estimated that to limit warming to two degrees the EU's burden would be 50 Gt of cumulative carbon dioxide removals until 2100. This is on top of the potential need to counteract residual emissions. Obviously to aim below 2 degrees or to 1,5 degrees this share would increase if emission reductions are not more rapid and deep.

But is that achievable?

More research needs to be done, but it is possible to extrapolate what could be achieved through different methods:

1. Restoration and natural forest management

Based on a literature review of existing studies, the Stockholm Environment Institute has estimated that globally, extensive ecosystems restoration could provide 220-330 Gt of carbon dioxide removals.

In the EU, countries such as Germany have been shown to be capable of almost doubling the carbon dioxide their forests absorb (generating 2.4 Gt of additional negative emissions between now and 2102).5 This is not by expanding the forest area, but by decreasing harvesting levels by 25 per cent, lengthening the time between harvests, encouraging more broadleaf species in areas dominated by conifers, and protecting high-biodiversity areas.

Other research has found that allowing forests in Finland to restore by reducing harvesting would allow them to absorb 209 per cent more carbon dioxide, with additional benefits for biodiversity.

There are no figures for the potential of forest restoration for the whole of the EU, but these national figures already give some idea. Peters & Geden's estimate of how much carbon dioxide the EU needs to remove – 50 Gt – translates to roughly doubling the amount of carbon dioxide EU forests currently remove. In Germany, restoring forests would almost double the amount of carbon they absorb, and in Finland it would triple. If figures within this range were possible for other European countries, and they weren't used to offset emissions elsewhere, forest restoration could nearly deliver the carbon removals Peters and Geden say are needed.

2. Forest protection

Increasing EU forest reserves to 7 per cent (up from 2 per cent currently) could remove almost 2 Gt of carbon dioxide by 2050.6

3. Reforestation

Forest carbon can also be increased by reforestation – the active planting of trees on totally deforested land. Reforestation in the EU has the potential to remove roughly 40 Gt of carbon dioxide between now and the 2060s. These figures include reforestation of animal-grazing pastures, but not croplands – meaning meat consumption would need to reduce.

As with all attempts to change land-use, reforestation runs many risks and thus would need to follow the basic principles of good restoration (see graphic on page 3). Reforested areas should not be cut down for short term uses (such as bioenergy), as these emissions are then immediately released back into the atmosphere, negating the positive climate effect. They should be biodiverse (not monocultures), planted only on lands suitable for forests (not undermining other ecosystems), and they should not reduce the albedo effect of the landscape. Studies show that if such issues aren't taken into account, the climate contribution of afforestation/reforestation remains moderate or even harmful.

Safe and **effective** ways to keep carbon out of the atmosphere through forests include conserving old growth and high carbon forests, stopping deforestation, more continuous cover cultivation & natural management methods, letting forests mature, lowering harvesting levels, recycling of wood material, long lasting products (Nabuurs 2013 Bhatti 2012 Pukkala 2016 Peura 2018). These should be addressed in the revision of the CAP ect. EU subsidies.

4. Restoring wetlands and improving farming and grazing practices

Further negative emissions could be generated from restoring wetlands or adopting agroforestry approaches. This briefing note has not investigated these questions. It is clear though that there is an urgent need for EU-wide estimates for the carbon we could remove by taking these steps.

How to restore forests by improving forest management: examples from the EU

Finland

Finland is proud of its high forest cover, but the figures on paper hide a story of old-growth areas being clear-cut and replaced with less biodiverse managed plantations. Rotation forestry based on clear-cutting is the main forest management method in Finland. This is not only devastating to nature and the climate, but also to local people. Social acceptance of clear-cutting is reaching breaking point, with 78 per cent of Finns disapproving of the practice, and a civil society movement calling for state-owned forests to abandon it.

In the same country however, you see forest restoration and natural management approaches that enhance biodiversity (such as increasing tree species diversity or decaying wood).

One promising option could be to swap clear-cutting for continuous cover cultivation. Only 15 per cent of Finnish state-owned forests are currently managed using continuous cover methods. Such management benefits wildlife, but also increases carbon, delivers equal or higher revenues, and benefits local berry picking.

But it is important to keep in mind that no management regime can secure ecosystem services like unmanaged forests.

Ireland

Since the 1980s, County Leitrim in North-West Ireland has slowly become blighted by tall, dark, impenetrable walls of trees. Over the past few decades, the Irish government has provided generous incentives – approved by EU State Aid rules – to encourage the plantation of Sitka spruce trees which now cover 17 per cent of County Leitrim.

The spruce plantations have devastated both the local environment and farming communities in County Leitrim. No birds sing in them and they grow so tall and dark that they block out the sun. Sitka spruce – a North American species – is so acidic that falling pine needles damage the soil, affecting the productivity of the surrounding agricultural land. The fertiliser used to encourage faster growth of trees is poisoning local streams and groundwater.

There is a way to turn this situation around. Some foresters are starting to pursue an approach which involves slowly replacing spruce plantations with a mix including native species and then using continuous cover forestry, rather than clear-cutting them all at once. This practice is better for both the local environment and local people.

The Irish government and EU should stop granting subsidies to the forestry industry – which is already more than profitable on its own – but rather use the money to encourage more protection, enhancement of native broadleaf trees, and participatory and inclusive planning that encourages local livelihoods. With a change of heart, forestry can become a motor for local economic development and job creation, rather than something where benefits flow to outsiders, whilst communities fragment.

Beware of myths and false solutions

Bioeconomy and substitution Some suggest that a growing 'bioeconomy' can contribute to climate change mitigation by replacing more fossil fuels and highcarbon materials with biomass, promoting increased harvesting levels to meet this increased demand. Mobilising more biomass through increased forest harvests can, however, have negative impacts on forests, including their ability to remove carbon dioxide. The trade-offs therefore need to be taken into account.

The reality is that 70 per cent of all wood used in the EU goes to short lived products such as bioenergy or pulp and paper. In such cases the carbon is released back into the atmosphere immediately or within a year, and takes decades to centuries to be re-absorbed. This causes twice the harm because as well as the stored carbon being released into the atmosphere, the cut forests are also no longer able to remove additional carbon.

Allowing forests to be cut for short-lived products therefore risks producing even more emissions than burning fossil fuels.

In Finland, over a 100-year period, using wood for materials and fossil fuel substitution was shown to be a net source of carbon. The forests' lost ability to remove carbon was not compensated by the avoided emissions. Studies from Canada show similar results.

The EU should therefore be careful about promoting a growing bioeconomy because of the potential trade-offs, notably on the climate and environment.

Bioenergy with Carbon Capture and Storage Although forest restoration has many benefits, it receives far less attention than other carbon dioxide removal approaches, such as Bioenergy with Carbon Capture and Storage (BECCS). BECCS is a controversial option firstly because it is far from clear that it will ever become technologically feasible at scale, and secondly because it has massive social, environmental, biodiversity, climate and financial costs. It is based on the false assumption that the use of forest biomass is carbon neutral. Scientists are clear that bioenergy leads to emissions, which puts into questions whether BECCS has the potential to be a negative emissions technology at all. EU climate models should therefore not rely on BECCS.

Policy recommendations: how can the EU support forest restoration?

The EU and Member States need to set national targets to restore forests. This could begin by setting European commitments under the Bonn Challenge – a global initiative which aims to restore 150M hectares of deforested and degraded land by 2020, and 350M hectares by 2030. Restoration targets should also be enshrined in the EU's climate and biodiversity policies.

Whichever way it is done, the EU should only support restoration that aims for social, economic and environmental benefits, and it should always encourage meaningful participation of local people and civil society. Policy recommendations

The EU 2050 decarbonisation roadmap must

Show ambition

• Reduce emissions rapidly to reduce the reliance on carbon removals as far as possible

• Consider the EU's historical role in releasing carbon dioxide when agreeing its role in achieving negative emissions

• Prohibit the use of forests as offsets.

Ensure strong governance

• Include milestones for what needs to be achieved by 2030, and every five years thereafter

• Propose differentiated and ambitious targets for forest protection, forest restoration, natural forest management, wetland restoration and agroforestry.

Assess potentials

• Include a full analysis of the EU-wide carbon removal potential from forest protection, forest restoration, natural forest management, wetland restoration and agroforestry

• Ensure EU modelling exercises take into account the impact that biomass harvesting has on the EU carbon sink, including the effect of substitution

• Take a precautionary approach when promoting the bioeconomy because of the potential trade-offs, notably on the climate and environment.

Restrict biomass use and reliance on BECCS

• Restrict public incentives for short-lived uses of wood such as bioenergy

• Not rely on BECCS technology to achieve large scale negative emissions.

Read the full Fern briefing and see references at: https://fern.org/ProtectAndRestore

Six problems with BECCS

The climate emergency is on the verge of becoming a climate crisis. Years of inaction have meant that climate scientists are no longer just discussing the need to reduce emissions, they are also talking about having to remove carbon dioxide from the atmosphere. Known as negative emissions, carbon dioxide removals are now at the centre of the climate conversation.

Governments are responding by looking for technological fixes, and one of the most often discussed is Bioenergy with Carbon Capture and Storage (BECCS). But the belief that BECCS would remove emissions is based on the faulty assumption that bioenergy is carbon neutral. This is not the case. BECCS would also have massive social, environmental and economic costs. It offers the false promise of a get-out clause and must not be allowed to distract from the urgent need to stop burning fossil fuels and to protect and restore forests, soils and other ecosystems.

Why climate models rely on negative emissions

The 2015 Paris agreement on climate change has been signed by almost all the world's countries. Its central aim is "to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius."

To achieve the 1.5 degrees aim, we need to keep the concentration of greenhouse gases in the atmosphere below 430 parts of carbon dioxide per million (ppm). This is a daunting challenge given that they are currently at 403 ppm, up from 277 ppm in 1750, and are continuing to rise.

Each year human activity pumps greenhouse gas emissions into the atmosphere equivalent to 37 billion tonnes of carbon dioxide. This means we may reach 1.5 degrees in five years' time.

Against this grim background, researchers have modelled hundreds of scenarios for how to stabilise the climate, taking both socio-economic factors and climate science into account. Most of these scenarios say it is too late to keep global warming below two degrees let alone 1.5 degrees simply by cutting emissions.

Instead, they assume that future technologies will be able to remove more carbon dioxide from the atmosphere than future economies will emit.

Taking carbon dioxide out of the atmosphere is known as carbon dioxide removals or "negative emissions".

Most scenarios for keeping to 1.5 degrees predict that we will overshoot carbon dioxide emissions and then subsequently remove between 450 and 1000 billion tonnes of carbon dioxide by 2100. There are presently no negative emissions technologies that work at scale, and those being suggested have significant risks of damaging environmental, social and economic impacts. It is therefore important to rely on negative emissions technologies as little as possible and prioritise full and fast decarbonisation.

One suggested technology to deliver negative emissions BECCS has attracted the bulk of the attention. Most of the Intergovernmental Panel on Climate Change (IPCC) scenarios for mitigating climate change assume a major role for BECCS. Even those scenarios that rely on large scale electrification, energy efficiency, limiting non-carbon dioxide emissions and large-scale lifestyle changes often have a limited role for BECCS.

This briefing note is based on a literature review of studies on BECCS. It outlines six reasons why policy makers planning decarbonization pathways for 2050 or beyond must not rely on BECCS to achieve negative emissions.

*****

What is BECCS?

BECCS is a geo-engineering technique to remove carbon dioxide from the atmosphere. Plants such as trees or agricultural crops naturally remove carbon dioxide, they are then burnt to produce energy and the emissions are captured and stored in geological formations underground.

The theory is this can be considered negative emissions if the plant growth is *additional* to existing or foreseen plant growth as the carbon dioxide removed is also therefore additional.[1] As the carbon dioxide from biomass combustion is not released, but captured and stored, the extra plant growth removes emissions already in the atmosphere. It is touted as a win-win which provides an alternative for fossil fuel energy while removing carbon dioxide from the atmosphere. In practice there are no operational BECCS facilities claiming to produce substantial negative emissions anywhere in the world, and many scientists have highlighted feasibility constraints that would make it unlikely to ever work, at least not on the scale foreseen.

******

1. BECCS may not deliver large scale carbon dioxide removals

BECCS is proposed as a solution based on the assumption that bioenergy is carbon neutral.[2] This assumption is flawed, notably because of emissions from land use and forestry.[3]

Even in a best-case scenario where bioenergy was made from 'additional biomass sources', carbon capture and storage (CCS) only captures emissions released from burning biomass. No mention is made of the indirect and supply chain emissions related to biomass growth, transport, refining, capturing and storing. These could considerably reduce the positive impact of the capture and storage of the combustion emissions.

There are four main types of emissions to consider:

A. Harvesting a forest reduces the carbon stock in trees and soil. There is a significant time lag between the moment of harvest or combustion and the assumed regrowth. The general rule is that if you cut a forest down, it takes the same amount of time it took to grow for it to return to its previous level of carbon storage. On average this would be between 50 and 120 years, but there is also the possibility that a forest is never able to host as much carbon as before. In addition, while a forest left standing continues to remove carbon, the moment it is cut down sequestration stops. The lost sequestration of a harvested forest is known as foregone sequestration.

   Increasing demand for biomass can lead to intensification of forest management and higher harvesting levels, which can reduce future growth and hence the ability of forests to sequester carbon dioxide. If forests are continually harvested more intensively due to bioenergy, they will never be able to recover the loss in carbon stock or the emissions released during combustion.

---

[1] Additional carbon dioxide removals mean an increase in the amount of carbon stored in ecosystems annually.
[2] Carbon neutrality refers to a concept where a measured amount of carbon released is balanced with an equivalent amount sequestered.
[3] The European Academies Science Advisory Council, UK government agency Forest Research, Chatham House and 800 scientists have highlighted that burning forest biomass is not carbon neutral. Read also Fern briefing on the energy use of woody biomass.

If bioenergy is to reduce emissions, biomass growth must be additional to what would have happened without the bioenergy use.[4] The potential for additional biomass sources, such as biomass grown on degraded land or (industrial) residues and wastes, is extremely limited.

B. Land-use change such as forests being converted to agricultural land is one of the largest drivers of climate change. Growing bioenergy crops could add to this problem and accelerate warming. In addition to direct land-use change, increasing demands for land can drive *indirect* land-use change (ILUC). For example, if an energy crop such as willow is planted to meet demand for wood chips, and it displaces agricultural land for food production, the food producer needs to find other land, which could drive deforestation.[5]

   The rapid growth of wood for energy could also increase indirect emissions from material displacement. This is when competition for wood leads to the use of more carbon intensive materials, such as concrete or metals.

C. There are also 'opportunity costs' to consider. Without bioenergy demand and the associated production of bioenergy crops, there could be larger climate benefits from alternative land and biomass uses. Examples are the restoration of natural forests and the use of biomass for 'long lived products', such as durable wood construction.

D. Finally, additional emissions from the production of biomass, the supply chain and Carbon Capture and Storage (CCS) can negate the potential climate benefits of BECCS. The growth of biomass can lead to a large increase in fertilizer use. This is particularly problematic as nitrous oxide (N_2O) (which is released in fertilizer creation, storage and use) has a global warming potential up to 300 times higher than carbon dioxide. Scientists trying to quantify the global warming effect of increased use of N_2O have shown that it can be equivalent to between 75 and 310 per cent of the carbon stored in trees. Fertiliser use alone could turn bioenergy into a source of greenhouse gas even before harvesting and combustion take place.

   Other concerns include that the CCS technology itself requires large amounts of energy (the additional fuel required when CCS is applied is up to 31 per cent for coal fired installations), which will increase the requirement for biomass or other energy sources. There is also a risk of carbon dioxide leaks from carbon storage sites.

   The supply chain emissions can be significant. In the case of dedicated bioenergy crops, emissions from transport, processing and using carbon capture and storage technology already represents 64 per cent of all carbon stored in the first place. For

[4] This is the principle of additionality, which means that to reduce emissions, the feedstock must not already be performing a function as part of the terrestrial carbon cycle.

[5] Land use change can also lead to climate warming due to a change in 'albedo' – whereby light-coloured or less densely vegetated surfaces which reflect more light to space are replaced with darker surfaces and thus absorb more warmth.

one tonne of carbon dioxide sequestered and stored underground, emissions from the supply chain would amount to 1.11 tonnes of carbon dioxide.

In conclusion, the assumption that BECCS at scale can provide a significant amount of additional carbon dioxide removals from the atmosphere, is flawed. Even more disturbingly, a report by the European Academies science Advisory Council recognises the risk of BECCS worsening climate change and recommends the climate impacts of BECCS to be assessed case by case.

2. BECCS has technical barriers and is expensive

Most of the scenarios for keeping global warming to 1.5 degrees require BECCS to be available and functioning on a gigantic scale from mid-century onwards. There is an implicit assumption that BECCS can be deployed at an extremely rapid pace, but it faces significant questions about feasibility, scale and cost.

Costs for BECCS are difficult to estimate as they depend on the price of biomass feedstock, CCS components, infrastructure, operations and the price of electricity. A synthesis of different cost estimates gives BECCS a price of 86-172 € per tonne of carbon dioxide (tCO_2).[6] As a comparison, during the first half of 2018, the carbon price in the EU Emissions Trading System was 8-17€/tCO_2.[7]

As the cost of biomass feedstocks rise, so would the cost of BECCS. Even in modelled scenarios which include a high level of biomass availability (100 exajoules per year),[8] costs would quickly increase to a level where negative emission technologies such as direct air capture (DAC) become financially competitive. In comparison to these little tested options, forest protection, restoration and natural management are already in operation. Their costs depend on the price of land and other elements, but estimates range from <8.5-85 €/tCO_2.

Technical barriers include the safe storage of carbon dioxide. The security of these sites is a great concern to public safety, ecosystems and the climate as leaked highly concentrated carbon dioxide would have very damaging impacts. As with nuclear waste, storage would need to be permanent, which has significant cost implications. Thus, public concern may form a significant barrier to large scale use of CCS, even more so considering at least part of the costs would be billed to the taxpayer for thousands of years to come.

3. BECCS would require a huge amount of land and push up the price of food

As the human population increases, more land is needed for food, animal feed and other biomass uses. This is made even more problematic by the increase in meat-eating, as rearing animals takes more land than growing pulses. In addition, climate change and land

[6] Equalling 100-200 US$ per tonne of carbon dioxide (tCO_2).

[7] Carbon price is the amount that must be paid for the right to emit one tonne of carbon dioxide into the atmosphere.

[8] This amount of availability is unlikely considering that in 2000 the total amount of energy in all the crops, plant residues, and wood harvested by people for all applications (e.g., food, construction, paper) and in all the biomass grazed by livestock around the world was roughly 225 exajoules (EJ). See Searchinger and Heimlich, 2015.

degradation are reducing the extent of areas suitable for biomass production.

Climate modellers looking at scenarios for staying below 1.5 degree include options for devoting less than 10 million hectares (Mha) to bioenergy, (the size of South Korea) to more than 1000 Mha (the size of Canada). A conservative yet highly unlikely estimate would be that 100 EJ/year of bioenergy could be provided in 2050.This would take the equivalent of 31 per cent of existing cropland (500Mha)[9]. These estimates do not include an assessment on the social, climate or other environmental impacts of this amount of biomass and land being used.

Growing dedicated crops for BECCS would require 0.1-0.4 hectares of land per hypothetical tonne of carbon removed. The amount of land needed differs depending on the climate scenario, but one example which would give us a 50 per cent chance of meeting the aim of keeping global warming below two degrees would require the growing of biomass on a land area 1-2 times the size of India (380–700 million hectares).[10] This would correspond to globally converting 25–46 per cent of arable land and permanent crops to biomass. The land requirement rises dramatically if the aim is to limit warming to 1.5 degrees, or if irrigated bioenergy production was excluded, so there would be a trade-off between water and land requirements if bioenergy is implemented at a large scale.[11]

Such huge land-use change could also cause serious deterioration of soil accompanied with degradation of vegetation productivity. This would have further dramatic impacts on food, water and biodiversity.

Studies show that as a result of decreasing land availability BECCS would likely increase food prices, but all such scenarios remain highly speculative because the impact of climate change on yields is still unclear. BECCS would put pressure on limited natural resources, and thus increase conflict for land, biomass and water.

4. BECCS would harm biodiversity

Between 1970 and 2012, vertebrate biodiversity declined by 58 per cent, mainly due to the rising human population and intensification of land use.[12] Increasing demand for land for BECCS is therefore an additional threat to biodiversity. The areas considered to have good potential for dedicated bioenergy crops overlap with protected areas, especially in central Europe, the Mediterranean, the United States of America, Central America, South-East Asia and Central Africa.

When biomass comes from harvesting existing forests, biodiversity is harmed during the harvest and this is even worse if the forest is converted to a monoculture plantation. In a synthesis study on the impacts of different carbon removal technologies, the conclusion was that BECCS would almost certainly reduce biodiversity if implemented at scale. Large scale BECCS would reduce as many terrestrial species as a 2.8°Celsius temperature rise.

---

[9] This calculation draws on information from two sources: National Research Council (2015) and FAO land data 2010

[10] This is expected to sequester 12 billion tonnes of carbon dioxide annually

[11] Also, another study by Yamagata et al 2017 arrived to similar results.

[12] This is based on the Living Planet Index that measures average change in population abundance over time.

The Convention on Biological Diversity adopted a moratorium in 2010 on "any technologies that increase carbon sequestration from the atmosphere on a large scale that may affect biodiversity".

5. **BECCS would take a huge amount of water and threaten planetary boundaries**

When climate modellers talk about 'additional biomass' requirements, it is important to consider the large amounts of water it would require. As well as increasing the price of land, biomass demand is expected to increase the price of water by the end of the century, especially in Asia Pacific (by 330 per cent) and Latin America (by 460 per cent). Irrigation is the leading cause to groundwater depletion globally. Already nearly half of the world's population live in areas with water scarcity and this is expected to increase to five billion people by 2050.

It is estimated that to produce biomass crops for enough BECCS to meet the two degrees aim would require more than a doubling of the amount of water used currently for irrigation globally for food production.

As well as pushing us beyond the limits of our freshwater use, BECCS is likely to push us beyond other planetary boundaries[13]. Researchers have calculated that if regional environmental limits are adopted as precautionary measures the potential for negative emissions from bioenergy plantations is marginal – less than 0.1 billion tonnes of carbon out of the atmosphere per year – a tiny amount given that the amount needed is expected to be between 0.6 and 4.1 billion tonnes carbon per year in 2050.

6. **BECCS is a barrier to energy transition**

BECCS is presented as a fossil fuel-free source of energy, but there are various ways in which it encourages continued use of coal and oil in particular.

Bioenergy without CCS is already offering a life-line to coal, as many coal power plants are being converted to allow the co-firing of biomass and coal. BECCS power stations that allow for co-firing of biomass with coal would be no different. Co-firing with coal is envisaged as the way to make BECCS facilities economically and technically more feasible. Demonstration projects in the UK and Norway are already testing the CCS of co-firing biomass with coal.

Even more worrying is the prospect of using the carbon dioxide captured from BECCS plants to extract oil from depleted oilfields through a technique known as enhanced oil recovery (EOR). It involves pumping gas at high pressure underground to drive oil to the surface and currently allows a further 5 -15 per cent of oil in some reservoirs to be exploited, which could in effect double the potential of these oil fields.

Carbon dioxide captured from the current generation of CCS applications (mostly fitted to

[13] The concept of planetary boundaries is based on the idea that once human activity has passed certain thresholds there is a risk of irreversible and abrupt environmental change. Other planetary boundaries that would be passed include land-system change, biosphere integrity and biogeochemical flows.

coal power stations and high emission industrial plants) is already being used on a considerable scale for EOR, partly because CCS is an expensive technology and selling the captured carbon dioxide to oil companies to help them extract more oil is a way of financing the investment. For example, a recently completed largescale retrofit application of CCS to a power plant at Petra Nova in Texas is expected to pay for itself in less than 10 years as a result of carbon dioxide being piped for EOR.

Another concern is the possibility of carbon dioxide leakage which undermines the climate value of sequestering it in the first place. The US oil industry estimates that about 30 per cent of carbon dioxide piped to an EOR site is directly emitted back into the atmosphere. Another problem is that old oil fields are sometimes not capped properly which means carbon dioxide held underground may find a way out.

Finally, reliance on negative emissions and especially BECCS can come at the cost of measures to reduce emissions, like energy efficiency, solar and wind energy. The promise of BECCS also deters us from looking critically at our levels of energy and resource consumption.

What alternatives do we have?

As we have seen, BECCS is unworkable at scale and even in a best-case scenario it is unlikely to achieve negative emissions. It would also be extremely costly both financially and in terms of its environmental and social impacts. The trade-offs also fly against the Sustainable Development Goals for zero hunger, clean water, affordable and clean energy, responsible consumption and production, life on land and climate action.

Another often raised proposal to remove carbon dioxide is large-scale afforestation, but this also requires huge amounts of land, fertilizer and water. The impacts on the climate and biodiversity are context specific, but bad practices such as creating monoculture plantations on lands not suitable for forests that are then harvested for short-lived products, would make afforestation no more environmentally sustainable than BECCS.

So what could work?

The answer is surprisingly simple. Protecting and restoring natural forests would benefit biodiversity and also bring climate and social benefits.

Unlike BECCS, restoring natural forests' climate benefits are tried and tested. Forests already store large quantities of carbon and they have been sequestering carbon for hundreds of millions of years. If protected and managed with the full inclusion of the people that live in and depend upon them, they can help us achieve the targets of Paris Agreement and the Sustainable Development Goals.

But first we must reject a heavy reliance on negative emissions and rapidly reduce emissions from fossil fuels to zero, stop destroying ecosystems, and reduce the overconsumption of natural resources.

Recommendations

Policymakers must:

- Agree climate policy that limits warming to 1.5 degrees
- Reduce emissions as fast as possible in all sectors so as not to rely on negative emissions
- Protect and restore natural ecosystems in ways that respect the people who depend on the land
- Restrict public subsidies for the use of biomass for energy production
- Not include large scale BECCS (or other unproven) technology in climate models nor subsidise the technology

Further reading

Risks of negative emissions are outlined in Fern's report Going Negative

Fern's report Return of the Trees shows the global benefits of forest restoration for people and the climate

Fern's briefing Burning trees for energy is no solution to climate change

DECATUR PROJECT IS NOT CARBON NEUTRAL

The first and only industrial scale BECCS project started operations in 2017 at Decatur in the US state of Illinois. It does not claim to be carbon neutral, let alone a producer of negative emissions. Only 16.5 per cent of the carbon dioxide is captured.

The project, run by the agribusiness giant Archer Daniels Midland (ADM), involves capturing and burying up to 1.1 million tonnes of carbon dioxide a year emitted as a by-product of fermenting corn into ethanol. Carbon dioxide, which would otherwise have entered the atmosphere, is converted into a "supercritical" fluid and injected into layers of sandstone below the plant, two kilometres underground, for long term storage. The ethanol plant is located within a massive multi-purpose corn processing complex powered by coal.

The corn to ethanol fermenting process produces an almost pure stream of carbon dioxide as waste. This makes capturing and processing the emissions cheaper and easier than other forms of bioenergy. US$208 million has been invested in the Decatur project with most of the funding (US$141 million) coming from the US Department of Energy.

Carbon storage requires a particular geology: porous rocks, such as sandstone, that are capped by an impermeable layer. According to ADM, the Mt. Simon Sandstone which lies underneath the Decatur plant has the potential to securely store "billions of tonnes of carbon dioxide". However, it has been suggested that some of the carbon dioxide captured could be used for enhanced oil recovery in South Illinois.

While the Decatur project is the world's biggest use of BECCS, the 1.1 million tonnes a year sequestration target is a pinprick in the context of industrial emissions. A single large sized (500 MW) coal-fired power station typically emits three million tonnes of carbon dioxide every year.

The biofuel inputs of choice for future BECCS projects are more likely to be biomass from trees or high yield grasses than corn. Carbon dioxide emissions from these fuels are harder, more expensive and more energy intensive to capture, which makes the process less efficient than capturing emissions from ethanol fermenting.

Read the full Fern briefing at: www.fern.org/beccsbriefing