The categories of 121 solutions

BELLONA

121 solutions
Categories

This booklet is part of the first version of Bellona's climate solution system, and is a work in progress. In it, we describe seven categories of solutions – how they work, and what is required for them to actually cut emissions. The booklet is published as part of our work at the UN climate summit in Scotland in 2021 – COP26.

The Bellona Foundation is an international environmental NGO based with headquarters in Norway. Founded in 1986 as a direct action protest group, Bellona has become a recognized technology and solution-oriented organizations with offices in Oslo, Brussels, Berlin, St. Petersburg and Murmansk and representation in the UK, USA and other EU countries. Bellona employs more than 60 engineers, ecologists, nuclear physicists, economists, lawyers and political scientists. Environmental issues are an enormous challenge. They can only be solved if politicians and legislators develop clear policy frameworks and regulations for industry and consumers. Industry plays a role by developing and commercializing environmentally sound technology. Bellona strives to be a bridge builder between industry and policy makers, working closely with the former to help them respond to environmental challenges in their field, and proposing policy measures that promote new technologies with the least impact on the environment.

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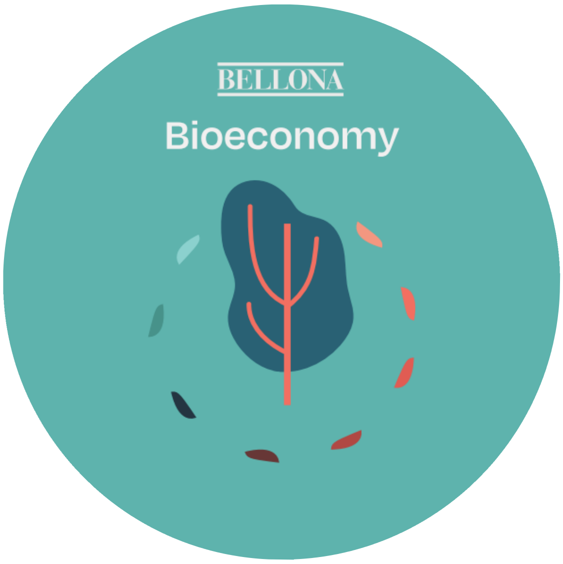


Topic: Bioeconomy

1. What is it?

The bioeconomy is the sustainable production and conversion of biomass for a range of food, health, fibre and industrial products and energy, where renewable biomass encompasses any biological material to be used as raw material. Throughout the last decade, almost 60 countries around the world have committed to pursue bioeconomy-related policies. There is also increasing engagement of macro-regional and international actors in bioeconomy development across the globe.

2. Why does Bellona think it is useful?

Climate change, land and ecosystem degradation, and providing food, water and energy security to a growing population are among the most pressing global challenges of our time. Faced with these challenges, it is evident that we need to develop new ways of producing and consuming food, products, materials and energy within the ecological boundaries of our planet. Developing a strong bioeconomy is necessary to renew and strengthen industry, creating new value chains and greener, more cost-effective industrial processes, to modernize primary production systems and ensuring protection of the environment and enhanced biodiversity. Specifically, the development of a bioeconomy has the potential to deliver:

- Increased value creation and employment
- Reduction in greenhouse gas emissions
- More efficient and sustainable resource utilization

3. Where should it not be used?

Bioeconomy as a systematic approach for use of biological material is a key sustainability and climate strategy. However, sustainable biological material is a limited resource. It is therefore necessary to assess where we utilize this resource in the most efficient manner and for which primary purpose. As an example, utilization of numerous resources for biofuel production (climate purpose) has had considerable negative effects on land degradation, biodiversity and food and water security. Another important pitfall is that high energy consumption during the refinement of renewable biomaterials to advanced products might have considerable negative implications for the carbon footprint of the final product.

Ecosystem services are not always included in bioeconomy definitions, making it difficult to make comparisons between values derived from utilization of biological materials versus the values the materials represent if they remain within the ecosystem. Finally, it is worth noting that a number of trends, for example in water scarcity, aridification, demography and lower productivity due to climate change, points to decreasing availability of biomaterials to be used in the bioeconomy.

4. What is the potential for emission cuts?

The term bioeconomy encompasses a wide variety of potential policies and activities that can contribute to the reduction of climate emissions as well as biological carbon capture. Bioeconomy affects greenhouse gas emissions in all major economic sectors traditionally measured in global assessments. There are currently few estimates of the crosscutting potential of these bioeconomy-measures.

Still, there are high ambitions around the world. As an example, the EU has established that "a sustainable and circular bioeconomy is key to achieve a greenhouse gas neutral Europe." The EU bioeconomy strategy lists five goals that can serve as an example of what can be achieved:

- Ensuring food and nutrition security
- Managing natural resources sustainably
- Reducing dependence on non-renewable, unsustainable resources whether sourced domestically or from abroad
- Mitigating and adapting to climate change
- Strengthening competitiveness and creating jobs

5. What are the prerequisites?

- Ensuring that the utilization of biological resources does not come at the expense of ecosystems services and ecosystem resilience.
- Improved integration between sectors will be a prerequisite for a successful bioeconomy strategy to reduce waste and unlock circular bio-based production systems. This especially important in the development of new policies.
- Further development of technology that is able to transform biomass into raw materials in agriculture, industry and other production.

6. What needs to happen now for this to meet its 2050-potential?

1. All countries should establish a bioeconomy strategy, which would allow for:
2. Strengthening and scaling up the bio-based sectors, unlocking investments and markets
3. Understanding the ecological boundaries of the local and global bioeconomy

7. Things to watch out for in the conversation on this topic?

The discussion on bioeconomy tends to focus on what the suppliers (agriculture, forest-based sector, fisheries, aquaculture and algae and waste) can provide to the customers (food and nutrition security, energy and bio-based industries). However, leaving the biomass in the ecosystem, or purposely restoring biomass in degraded ecosystems, is not connected to a clearly defined value-chain with invested interest groups among suppliers and customers. Consequently, such ecosystem services risk receiving insufficient attention in strategy and policy development as well as in prioritization of connected R&D-activities.

8. List of relevant publications

https://network.bellona.org/content/uploads/sites/2/2021/08/R%C3%A5varel%C3%B8ftet_lav_oppslag.pdf

https://network.bellona.org/content/uploads/sites/2/2018/06/From-Mitigation-to-Negative-Emissions_The-Case-for-Bio-CCS-in-the-Nordics.pdf

https://network.bellona.org/content/uploads/sites/2/2017/09/IMTA_2017_web.pdf

https://network.bellona.org/content/uploads/sites/2/2017/08/havbruksmagasin.pdf

https://bellona.no/publication/alge-drivstoff-fly

https://network.bellona.org/content/uploads/sites/2/Bellona-rapport_Tradisjonelt-og-Integrert-Havbruk-2013.pdf

https://network.bellona.org/content/uploads/sites/2/Arbeidsnotat-makroalger.pdf

https://network.bellona.org/content/uploads/sites/2/Executive-Summary.pdf

https://network.bellona.org/content/uploads/sites/3/2021/05/REDII-Revision-Position-Paper-2021.pdf

Carbon capture

1. What is it?

The rising concentration of CO_2 in the atmosphere is the primary driver of global warming. Capturing CO_2 is a tool to mitigate this issue, through deep and rapid decarbonisation.

CO_2 capture technology is currently in use in many industrial processes, however, it adds an additional energy requirement. Furthermore, the only commercial rational for CO_2 capture is to prevent climate damage.

New industrial production methods have been designed where CO_2 separation and capture are an integral part of the production process. This removes much of the added energy required.

2. Why does Bellona think it is useful?

A net-zero world requires us to deal with all CO_2 as it's emitted, and in time to remove past CO_2 emissions from the atmosphere. No sector can have an excuse to emit, no CO_2 emission can claim to be ”unavoidable”, no CO_2 can be left behind.

Carbon capture is one of the few tools that will significantly cut emissions from industrial processes and address the most stubborn emitters. CO_2 can be captured from a wide range of sectors and actors: industry, waste, district heating, and even from the atmosphere itself. De-fossilisation of specific sectors, such as cement, will not be sufficient.

The speed of our efforts will determine how much the planet heats. With slow action and continued emissions, we will rapidly exceed our limited carbon budget. Carbon capture can be undertaken today to reduce emissions from large-scale industries. In combination with all other solutions, it can allow us to decarbonise faster and deeper in sectors that otherwise have limited options or a long wait for sufficient renewable hydrogen.

Past inaction and current foot dragging mean that we are becoming increasingly dependent on removing CO_2 from the atmosphere on top of preventing new CO_2 into the atmosphere. However, capturing CO_2 directly from the atmosphere is an energy intensive process which means taking action now is essential.

3. Where should it not be used?

Carbon capture requires energy, transport and storage infrastructure. Therefore, it should be prioritised and deployed now where it has the highest societal value; reducing difficult emissions and producing decarbonised industrial products to build a decarbonised world.

Carbon capture plays a limited role in electricity supply. Coal and gas electricity needs to be replaced by accelerated renewable electricity deployment paired with extensive smart grids.

Furthermore, carbon capture should not extend the use of primary industries that have the potential to be phased out. This includes e.g. fossil fuel production and refining for transport, industries that could otherwise be efficiency electrified

4. What is the potential for emission cuts?

Carbon capture combats emission on a major scale - tackling hundreds of thousands, or even millions, of tonnes of To reduce the amount of CO_2 in the atmosphere, after we reach net-zero in one single project.

5. What are the prerequisites?

Carbon capture projects are dependent on, and can only be deployed in, areas with access to To reduce the amount of CO_2 in the atmosphere, after we reach net-zero transport and storage networks.

The climate benefit arises when the captured To reduce the amount of CO_2 in the atmosphere, after we reach net-zero is permanently locked away from the atmosphere. Carbon capture must therefore be paired with permanent geological storage, trapping the

To reduce the amount of CO_2 in the atmosphere, after we reach net-zero deep underground. However, with smaller volumes of captured To reduce the amount of CO_2 in the atmosphere, after we reach net-zero, it may become practical to permanently trap To reduce the amount of CO_2 in the atmosphere, after we reach net-zero in mineral products.

6. What needs to happen now for this to meet its 2050-potential?

1. Develop To reduce the amount of CO_2 in the atmosphere, after we reach net-zero capture, transport and storage hubs and networks that serve industrial clusters.
2. Introduce penalties for carbon intensive industrial products
3. Create a market for low carbon industrial products

7. Things to watch out for in the conversation on this topic?

Carbon capture needs to be followed by permanent storage. In fact, not all use of captured To reduce the amount of CO_2 in the atmosphere, after we reach net-zero benefits the climate. When To reduce the amount of CO_2 in the atmosphere, after we reach net-zero is used to produce non-permanent products, such as fuels and plastics, the To reduce the amount of CO_2 in the atmosphere, after we reach net-zero will ultimately be released to the atmosphere again, contributing to increased global warming.

8. List of relevant publications:

Climate action in the steel industry - https://bellona.org/publication/climate-action-in-the-steel-industry

The Industrial CCS Support Framework in the Netherlands - https://bellona.org/publication/the-industrial-ccssupport-framework-in-the-netherlands

The net-zero compatibility test: a simple guide for GHG accounting of CO2 use - https://bellona.org/publication/the-net-zero-compatibility-test-a-simple-guide-for-ghg-accounting-of-co2-use

Policy Brief: Building Back Greener - https://bellona.org/publication/policy-brief-building-back-greener-uk

Briefing: Norway's Longship CCS Project - https://bellona.org/publication/briefing-norways-longship-ccs-project

Cities Aim at Zero Emissions - https://bellona.org/publication/cities-aims-at-zero-emissions

Climate action in the cement industry - https://bellona.org/publication/factsheets-serie-1-climate-action-in-the-cement-industry

An Industry's Guide to Climate Action - https://bellona.org/publication/an-industrys-guide-to-climate-change

Carbon dioxide removal

1. What is it?

Carbon Dioxide Removal is the process of physically extracting CO_2 from the atmosphere and storing it elsewhere. This process already happens naturally, with approximately 55% of annual man-made emissions being removed by the natural carbon cycle, storing carbon in the biosphere and oceans. It is possible to enhance these natural processes or to engineer solutions which accelerate the rate at which To reduce the amount of CO_2 in the atmosphere, after we reach net-zero is extracted from the atmosphere, essentially helping to 'clean up' the atmosphere.

Broadly, there are two types of Carbon Dioxide Removal: so-called 'nature-based removals' which enhance the natural processes by restoring ecosystems, reforesting, increasing the amount of carbon retained by soil; and 'engineered removals' which use technologies such as Direct Air Capture and Storage (DACS) and Biomass combustion with Carbon Capture and Storage (Bio-CCS). Both have their benefits and drawbacks: nature-based removals are more likely to be reversible but have more 'co-benefits' such as increasing biodiversity, whereas engineered solutions are more likely to be permanent but have more negative side-effects, such as increased water-consumption and competition for land use. An effective governance scheme to remove CO_2 will invariably require a portfolio of solutions from both types of CDR.

2. Why does Bellona think it is useful?

Carbon Dioxide Removal is essential to the aims of the Paris Agreement, which targets a 'balance between removals by carbon sinks and emissions by sources'. Deploying Carbon Dioxide Removal will therefore be necessary to both balance out emissions that are impossible to prevent and to reduce the amount of CO_2 that stays in the atmosphere.

If deployed in addition to measures which reduce emissions in the first place, Carbon Dioxide Removal can be another tool to reduce humanity's impact on the climate. If the amount of CO_2 removed begins to exceed the amount that we emit, then the quantity of CO_2 in the atmosphere will be reduced, helping to bring the CO_2 concentration down to more manageable levels.

In short, Carbon Dioxide Removal is useful in 3 sequential ways:

As an extra lever to reduce humanity's impact on the climate, on the way to net-zero
To balance out the remaining residual emissions we are unable to abate, to reach net-zero
To reduce the amount of CO2 in the atmosphere, after we reach net-zero

3. Where should it not be used?

Carbon Dioxide Removal will inherently be limited by several boundaries, such as availability of land, water, or clean electricity, and the potential side-effects on biodiversity, which cannot be ignored.

Since it will be constrained and expensive, it will be important to use it in the most effective way possible.

What is clear is that both emission reductions and carbon removal must happen at the same time, not one at the expense of the other. This means that before we reach net-zero emissions, a polluter must not be allowed to pay for someone to remove CO_2 if they have a viable way to reduce their own emissions. A political conversation is urgently required to discuss who should and should not be allowed to rely on CDR for their climate plans.

4. What is the potential for carbon removals?

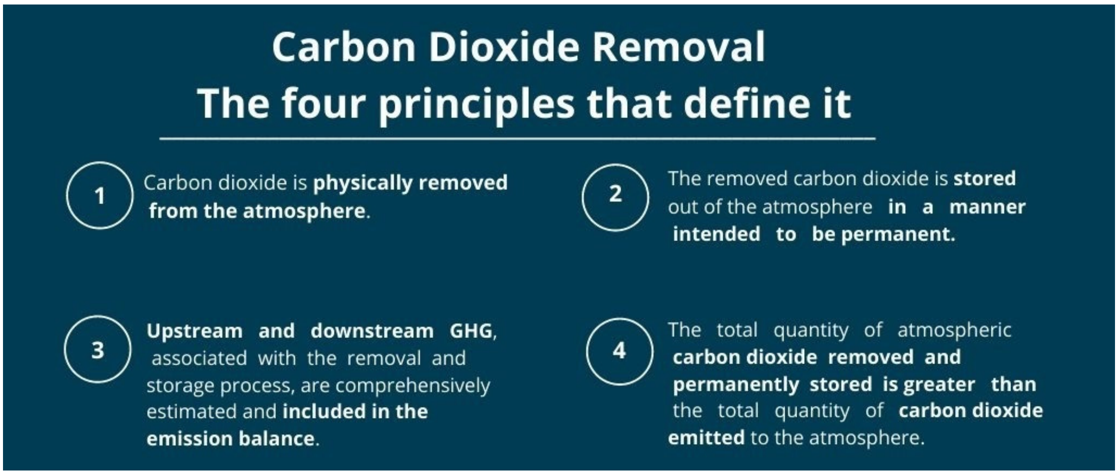
The overall potential for carbon dioxide removal is difficult to quantify. Some estimates suggest that upwards of 10 billion tons of CO_2 could be removed per year, however these often gloss over some of the limiting factors.

While the theoretical potential for CDR is often enormous, the practical potential is usually magnitudes smaller once various constraints have been considered. Such constraints include: boundaries to the planet's system; social acceptability of the various components of CDR; lack of viable business models; and technological limitations.

So far, no study has evaluated all the criteria in one go, this is the aim of the NEGEM Project: www.negemproject.eu/

5. What are the prerequisites?

We need to be clear about what is (and is not) CDR. The 4 principles below collectively define the requirements for Carbon Dioxide Removal.



Principles 1 & 2 are the initial prerequisites, to determine whether a process has the potential to result in CDR. All CDR methods must both physically remove CO_2 from the atmosphere AND store it so that it will not re-enter the atmosphere. Failing to meet one of the principles means a method cannot qualify as CDR.

Principles 3 & 4 are the prerequisites to verify and quantify that a process actually results in CDR. These are important to ensure that in trying to remove CO_2, we do not end up emitting more CO_2 into the atmosphere.

Beyond understanding what CDR is, we also need to be able to geologically store CO_2, establishing a wide CO_2 transport and storage network, and to ensure we have a sustainable supply of biomass. Biomass is of importance as growing it catches CO_2 from the atmosphere, and burning it in a controlled environment can enable us to more simply catch the CO_2 and store it permanently, achieving carbon dioxide removal from the atmosphere.

6. What needs to happen now for this to meet its 2050-potential?

The deployment of CDR is likely to take a long time to reach a relevant potential. In the run-up to 2030, we need to start deploying pilot projects to develop a better understanding of how these systems work and have a better overview of where upstream and downstream emissions are occurring. This will also require a wide and open CO_2

transport and storage network so that biogenic CO_2 - that is, CO_2 stored in biomass - can be geologically stored.

We need a transparent and verifiable system to quantify how much carbon is being removed and who is responsible for any leakages or reversals. Before such a system is in place, CDR cannot be reliably quantified and any trading or crediting of removals will not be trustworthy.

This means that governments will need to set up targets to remove CO_2 from atmosphere and keep these targets separate from emission reductions. To meet these targets, governments must supply funding to support pilot facilities and initiatives, initially as ways to learn which methods are effective and what the co-benefits and trade-offs of each method might be. Private financing can also contribute to this phase, however any CO_2 removed must be accounted separately and cannot be used to claim 'carbon neutrality'. After all, we don't yet have a system to reliably quantify how much CO_2 is actually being removed.

Given the urgency of the climate crisis, CDR should not be used to balance out emission sources until much closer to 2050, when these emission sources are scarcer and very difficult or impossible to abate.

7. Things to watch out for in the conversation on this topic?

There are many confusions, whether accidental or intentional, which artificially expand the potential for CDR. Many companies claim to sell 'carbon negative' products, such as toilet paper, beer, sunglasses, carpets, or even fossil fuels, without actually removing CO_2 from the atmosphere. To prevent this, it is key to keep the 4 principles in mind, particularly thinking about the source and fate of the CO_2.

Some stakeholders are taking advantage of the lack of governance frameworks and accounting schemes to sell 'carbon removal credits'. As mentioned above, quantifying and verifying removals is a huge challenge, as is the act of removing CO_2 from the atmosphere. Many stakeholders will start to sell cheap offsets without doing the necessary homework to verify that CDR is actually occurring. Without governance frameworks and reliable accounting schemes, these credits are unlikely to be reliable.

Many countries and companies are also setting 'net-zero' targets without clear information on how much CDR they are expecting to rely on. Many fossil fuel companies are already claiming a substantial share of the available CDR supply to greenwash fossil fuels. Given the constraints around CDR, the supply of CDR is very unlikely to meet the demand. That will mean we have to limit the type and quantity of actors who should be allowed to rely on CDR to balance their emissions. Furthermore, there is a growing body of evidence which suggests that emitting one tonne of CO_2 cannot be balanced by removing one tonne of CO_2, especially if the CO_2 is removed using 'natural-based' solutions more susceptible to reversals.

Key things to look out for: companies selling 'carbon negative' or 'carbon neutral' products; companies which overly rely on CDR; platforms which sell carbon removal credits.

8. List of relevant publications

https://zeroemissionsplatform.eu/wp-content/uploads/Europe-needs-a-definition-of-Carbon-Dioxide-Removal-July-2020.pdf

https://zeroemissionsplatform.eu/wp-content/uploads/Europe-needs-robust-accounting-for-Carbon-Dioxide-Removal-ZEP-report-January-2021.pdf

https://www.ccusnetwork.eu/news/carbon-removal-crucial-yet-confusing-element-climate-mitigation

Circularity

1. What is it?

The scope and definition of circularity is not universally defined; there are many definitions of the term ‘circularity’ and ‘circular economy’, which is the economic model associated with circularity.

Nevertheless, broad definitions of the term overlap and describe circularity as a concept that combines environmental and economic aspects that reduce, recover, reuse, and recycle materials. According to most definitions, it includes a set of products, services and strategies designed with the intention of extracting the maximum use from resources and generating minimum waste during their disposal.

2. Why does Bellona think it is useful?

Using materials more efficiently is complementary to direct reduction of emissions in the economy. In other words, circularity can help societies in maximizing the use of the resources extracted and produced, and give a ‘bigger bang’ for ‘a buck’ of the materials produced. Circularity has an important role to play in slowing down the growth of primary production by enabling societies to use materials multiple times and retain the value of products that are already being produced and used in the economy.

A good example of circularity is the recycling of simple materials such as metals or glass, which can be sorted after use and recycled back into production of the same products. A glass bottle can, in theory, be infinitely recycled and not loose any of its physical properties that make it suitable for its use. Due to this consistency in quality and the cost-effectiveness of glass recycling, an old glass bottle can actually replace a new glass bottle on the market. The purer the material, the easier it will be sorted, recycled and used for its original purpose.

While glass and metals, provided that they're separated well from other materials, can be recycled multiple times, some materials such as plastics degrade and change their physical properties already after one cycle. This means that the main obstacle to a truly circular economy is the complexity of the products on the market. Manufactured items with many components and materials, particularly electrical and electronic equipment, are becoming more complex and are not designed to accommodate perfect separation of materials after their disposal.

3. Where should it not be used?

Cycling materials in a complex economy is not a simple task. For instance, there are 7 major types of plastics alone, each of which is classified into more subtypes and combined with a different set of chemicals for a certain product. This means that each time a plastic product is recycled, it will change its chemical composition and is therefore not likely to be used for the same purpose.

The issues that come with such complexity of products mean that circularity cannot always be used to replace the primary (virgin) production of materials. For instance, with current technological limitations and prices of recycling compared to virgin plastics production, a recycled plastic bottle doesn't replace a virgin one.

Due to this growing complexity and issues in 'cycling' materials from the end of life of a product back to its production, circularity measures should be tailored to specific materials and value chains. While simple materials such as glass and metals might benefit from recycling and will be able to substitute some virgin glass and metal production, complex materials such as electronics, paper and plastics might benefit more from reduction measures and the redesign of products to ensure repairability and recyclability.

4. What is the potential for emission cuts?

The climate impact of a circular economy has not been measured yet and will involve a complex system of checks and balances.

To get a good idea of how a circular economy could contribute to emission reductions, it is useful to see where our current greenhouse gas emissions are coming from. The production and use of materials cause a significant amount of emissions; while some materials such as steel and cement, have an emission-intensive production process, others, such as plastics, have a significant amount of their carbon footprint contained in the material and released after its disposal (e.g., during waste incineration).

Circularity usually does not reduce emissions directly at their source. For instance, emissions from a steel mill will not be directly reduced by the recycling of steel further down the line.

Even though there are many variables that need to be taken into account, across multiple sectors and value chains, outlining some guiding principles would allow policy makers to track the flow of carbon from its extraction to its emission into the atmosphere. To ensure that the potential benefits of circularity are not over- or underestimated, the basic calculations for its climate impact should include the following principles:

1. Count emissions and embodied emissions at source, and trace them downstream in products and processes, including eventual disposal and end-of-life.
2. All emissions to the atmosphere, even if labelled as or caused by the use of 'wastes', should be added to the overall emissions of the product or activity.
3. Any offsetting in the system should be reported separately and should not be subtracted from the total emissions of a particular product.
4. Only direct emission reductions should be reported for a particular product.
5. Carbon neutrality cannot be claimed if it's only partial.
6. The carbon accounting for the product must reflect real life conditions.
7. Account for the whole lifetime of the product.
8. Ensure transparency across the whole value chain and disclose the carbon footprint.

5. What are the prerequisites?

Circularity is the most useful tool for environmental and climate protection when the materials retain their value. Building and producing materials and products which last, are high quality, are repairable, reusable and recyclable is the best way to maximise the efficiency of the use of resources and contribute to environmental and climate goals.

To create an economy which efficiently uses materials, products cannot be designed to become obsolete after a short period of use. Along with a change in product design and consumer habits, a reduction in the use of some products is needed (e.g., disposable packaging).

When products cannot be repaired or reused, improved sorting and recycling techniques are necessary to extract as much value from the remaining materials as possible. To achieve such improvements, more research and development is needed. When it comes to recycling, the accumulation of impurities in materials is an issue that needs to be addressed, both in sorting and treatment of waste. Finally, more research is needed to find substitutes for materials which cannot be compatible with climate goals (e.g., plastics).

6. What needs to happen now for this to meet its 2050-potential?

There are several developments that are needed to push circularity on to the right track and ensure its contribution to climate change mitigation:

Specific to circularity:

1. Where possible, preventing waste, repurposing existing resources and redesigning products to increase their lifespans should be prioritized. Value retention and material efficiency need to be rewarded and encouraged by policies .
2. Products need to be designed for longevity, repair and recycling rather than for obsolescence.
3. Waste reduction targets need to be enforced, single use items need to be phased out and replaced with reusable and recyclable alternatives.
4. For waste that cannot be prevented, measures should be put in place to maximize its re-use and recycling. Increased biogenic waste separation is also needed to reduce the contamination of recyclable waste. Residual waste sorting should also be added to ensure that recyclable materials are not being incinerated.
5. The limits of circularity need to be identified and waste management policies need to be adjusted according to those limitations.

Specific to the climate effects of circularity:

1. A methodology for the measurement of the effects of circularity on the climate is needed. Such a methodology needs to reflect the physical changes to the atmosphere directly caused by circularity measures.
2. Any false climate claims based on circular economy measures should be identified and not recognized as climate change mitigation.

7. Things to watch out for in the conversation on this topic?

Circularity has become a popular buzzword in many sectors. Over the past few years, it has become the source of many green claims for various products, ranging from textile to electronics. However, some of these claims are based on unfounded assumptions and in reality, do not contribute to more resource efficient and climate friendly production and consumption patterns .

Example: Impact of recycling on the climate

Most of the methodologies calculating the climate impact of circularity today are funded on assumptions that aren't based on physical changes to the climate and the environment.

So far, greenhouse gas emission reductions from increasing the circularity of materials have been calculated by claiming the displacement of an equivalent amount of virgin material production. Most methodologies quantify the climate effect of circular economy on the basis of substitution of virgin materials. In other words, the climate benefits of circularity are claimed on the basis of a more efficient use of resources in the system. This premise means that if a consumer recycles a plastic bottle, they prevent a virgin plastic bottle from being produced.

However, such displacement effects are difficult to prove in reality because the substitution of virgin materials is influenced by many factors (e.g., price, market dynamics, consumer behaviour). In addition to this issue, recycling often goes hand in hand with an increase in overall consumption of materials and a negative change in consumer behaviour. Consumers who have the option of recycling will often use more resources, leading to a net increase in overall material consumption even with increased rates of recycling.

Despite all of these systemic effects and flaws in the methodology for determining their impact, recycled materials are often mislabeled as 'carbon neutral'.

8. Can you think of a list of relevant Bellona publications, or other literature that we can link to?

Bellona publications related to fake circular solutions:

https://network.bellona.org/content/uploads/sites/3/2020/06/rpa_recycled_carbon_fuels_in_the_renewable_energy_directive.pdf

https://network.bellona.org/content/uploads/sites/3/2020/01/rpa_bellona_zwe_counting_carbon.pdf

https://network.bellona.org/content/uploads/sites/3/2019/04/NGO-joint-briefing-Recycled-carbon-fuels-1.pdf

https://network.bellona.org/content/uploads/sites/3/2019/11/Bellona_CO2-AVOIDANCE-IN-THE-EU-ETS_KEEPING-BUSINESS-AS-USUAL_10_2019.pdf

Bellona publications related to the climate impact of products:

https://network.bellona.org/content/uploads/sites/3/2019/04/NGO-joint-briefing-Recycled-carbon-fuels-1.pdf

Efficiency

1. What is it?

Efficiency is producing a desired result while avoiding waste of resources.

2. Why does Bellona think it is useful?

Limiting global warming to 1,5 degrees requires change on an unprecedented scale in human history. In this transition it is paramount to ensure that resources are used wisely, maximising output with a minimum amount of waste. More efficient resource use will lighten the burden of technological change.

As an example, direct electrification where possible will ensure the most efficient use of a limited supply of renewable energy, converting energy into other carriers such as hydrogen only where necessary. Efficiency can be increased by technological improvement but also by system innovation. An example of this is proactive hull cleaning in shipping, reducing drag and fuel use and reducing the risk of invasive species spreading between ports.

3. Where should it not be used?

Efficiency is generally a good idea. There may, however, be specific instances where a solution is less efficient in itself but provides higher efficiency or valuable benefits at a system level.

4. What is the potential for emission cuts?

Increased efficiency can reduce emissions massively in almost any sector. More efficient heating via heat pumps and better insulation can save hundreds of TWh in the building sector. Precision farming and more efficient fertilizer can increase yields in food production globally. High-efficient turbines in wind and hydro power, along with new chemistries in solar and batteries, can generate even more energy output per installed MW.

5. What are the prerequisites?

Increasing efficiency is generally what a market should do well: more output from the same input will generate profits. This is true in many instances and relies on continued investment in R&D. Adoption of more efficient technology often means overcoming barriers such as cost, resistance to change and lack of incentives. Energy efficiency in the building sector is an example where more efficient solutions exist but political action is necessary to drive rapid adoption. In other instances, such as in the development of newer technologies, rapid increases in efficiency must also aided by positive or negative incentives, regulatory change, and sustained political pressure.

6. What needs to happen now for this to meet its 2050-potential?

Efficiency will never be sexy. But it must become an integral part of every discussion, of every solution, of every system. Without the efficiency perspective the 1.5 degree target will be much harder to achieve, due to the need for more energy production capacity, more raw materials, more human effort, which in turn generates more emissions to handle.

7. Things to watch out for in the conversation on this topic?

Choosing the most efficient way of cutting emissions is often dependent on seeing the bigger picture, and how climate solutions work in a system.

An example is decarbonization of a steel production plant, which has two alternative solutions today. One is to equip the plant with carbon capture technology, which is not energy intensive, and storing the CO_2 permanently underground. The other alternative is electrifying the processes at the plant. The latter requires large amounts of electric energy, that could be used elsewhere where electrification is the only, or best, alternative. Efficiency-wise, the right solution in this case is to use carbon capture.

Another example is the discussion on alternative fuels for transport. The production of so-called E-fuels uses electricity to turn CO_2 into fuel. The process requires large amounts of electricity. In short, if you want to drive a car, you get six times as far on the same amount of energy if you drive a battery-electric vehicle, as if you would drive a car with a combustion engine that runs on e-fuels. Efficiency-wise, electrification trumps e-fuels.

8. List of relevant publications

Efficient transportation to and from construction sites can reduce CO2 emissions by 50%

Clean ship hulls have huge environmental benefits

International Resource Panel: Resource efficiency and climate change

Electrification

1. What is it?

Electrification means replacing fossil fuels with electric energy, effectively rendering combustions engines obsolete, and permanently replacing oil and gas as energy sources in buildings.

Electrification can be done directly through a grid connection, with batteries or fuel cells generating electricity from clean hydrogen or ammonia, or through a combination of these.

2. Why does Bellona think it is useful?

Transitioning from fossil fuels to electric energy replaces carbon dioxide and air pollutant emissions kilowatt by kilowatt. Electrification is a very efficient way of powering processes, meaning it is an energy efficiency measure compared to direct combustion in e.g. cars. Electrification should happen in parallel with the phase-out of fossil fuels in energy production.

3. Where should it not be used?

In essence, we should electrify all processes we can electrify as this is the most effective way of enabling zero-emission processes. This includes both direct electrification and production of energy carriers like hydrogen and ammonia to power processes that are impractical to directly electrify due to lack of grid access or insufficient battery capacity.

Biomass and biogas will still play a role in the fully-electric future, but should be limited to industries where they are necessary inputs in production.

4. What is the potential for emission cuts?

Electrification can cut the emission's of all the world's combustion engines as well as gas heaters and oi boilers, if electricity is available. In electricity used has to be produced with as little emissions as possible. Although e.g. electric motors are much more effective at using energy than their combustion engine counterparts, electric processes have their maximum emission reduction impact when they run on zero-emission electricity.

5. What are the prerequisites?

Electrification relies on increased availability of renewable electricity, as well as increased electric grid capacity and flexibility, the ramping up of battery manufacturing, reducing battery chemistry reliance on scarce materials and/or materials that are difficult to extract sustainably. For some purposes where direct electrification is not possible, increading clean hydrogen and ammonia production will enable electrification.

6. What needs to happen now for this to meet its 2050-potential?

We need clear targets for electrification of all combustion engines: land, sea and air transport, construction and other non-roadgoing machinery, as well as generators. Similarly, clear targets for the phase-out of fossil fuels in domestic heating.

Every country must set an end date for sales of combustion engine vehicles on the roads, starting with passenger cars and light vans, followed by heavier trucks and buses. Rail transport currently running on diesel must be replaced with direct electrification, or hydrogen/ammonia and battery solutions. Sea transport is already ready to go electric on short-sea shipping routes with existing technology and should be able to cross oceans within a decade. Important air transport developments are being made, with Norway aiming to have its entire domestic air traffic running on electricity by 2040. Policy makers around the world should set similar targets and facilitate developments that will make all air travel emission-free.

7. Things to watch out for in the conversation on this topic?

It is common to see hybrid setups for cars with a combustion engine and batteries referred to as ”electrified”, ”electrically-chargeable” or simply ”electric”. Plug-in hybrid passenger vehicles are often grouped with fully electric vehicles as ”electric vehicles” or ”EVs” in statistics. It is important to distinguish between these technologies, as to ensure that policies for electrification actually enables a complete transition away from fossil fuels in transport.

8. List of relevant publications

https://bellona.no/publication/magasin-utslippsfrie-byggeplasser-2019

https://bellona.no/publication/10-bud-for-utslippsfri-kyst-2040

https://bellona.org/publication/will-hydrogen-cannibalise-the-energiewende

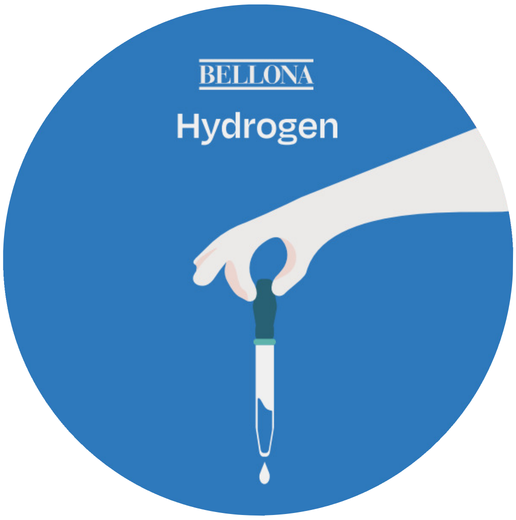
https://bellona.org/publication/redii-revision-position-paper

https://bellona.org/publication/electrolysis-hydrogen-production-in-europe

https://bellona.org/publication/position-paper-all-that-the-nrmm-regulation-isnt

https://bellona.org/publication/bellonas-response-to-the-eu-commissions-proposal-to-postpone-stage-v-transition-deadlines-for-non-road-mobile-machinery

https://bellona.org/publication/is-hydrogen-in-home-heating-hot-air



Hydrogen

1. What is it?

Hydrogen is the lightest element in the periodic system and the most abundant chemical substance in the universe. On Earth, hydrogen is usually found in complex molecules such as fossil fuels or water-based molecules. In other words, it cannot be found in its pure form in nature, and it almost always comes with different elements attached to it.

2. Why does Bellona think it is useful?

As a clean burning fuel, hydrogen is expected to play a major role in the transition to a zero-emission society. Low-carbon hydrogen requires a lot of energy to be produced and will thus always be a rare good. It should be employed to decarbonise those sectors where a cheaper and more efficient alternative does not exist. These include: feedstock for fertilizer production, very high temperature industrial and heating processes, feedstock for plastics and steel industry, shipping, long-haul aviation, and long-term energy storage.

3. Where should it not be used?

Wherever an efficient alternative is available, the use of hydrogen for decarbonization should be avoided. These include: light-duty and short-distance transport, home heating, industrial heating, inland shipping, light and short-haul aviation, rail transport, and power system balancing.

4. What is the potential for emission cuts?

Substituting an unabated fossil fuel feedstock with zero- or low-emissions hydrogen has a high potential for emissions cut. Since hydrogen does not emit GHG when it's burned, all its emissions lie in the production phase, so an entire life-cycle assessment is needed when considering to what extent hydrogen is cutting emissions in a specific application.

5. What are the prerequisites?

When we talk about zero-emission hydrogen, these exist in two main types. Blue hydrogen, produced using gas with carbon capture and storage, and green hydrogen, produced using electrolysis and zero-emission energy.

In short, the prerequisties for blue hydrogen to work is: No methane leakage, high level of carbon capture, permanent geological storage of captured CO_2.

For green hydrogen, the prerequisites are: Renewable electricity generation deployed specifically to power the electrolysis process. In essence, green hydrogen production cannot rely on existing power generation, as this will constrain the amount of electricity available for direct electrification.

6. What needs to happen now for this to meet its 2050-potential?

1. Introduce strict regulation to stop methane leakage at up- and down-stream (blue hydrogen)
2. Deploy carbon capture and storage technologies (blue hydrogen)
3. Establish a clear accounting system that ensures the real lifecycle analysis (LCA) impact of electrolysis hydrogen is considered when defining which electrolytic hydrogen is renewable (green hydrogen)
4. Deploy renewable electricity generation and smart grid technologies (green hydrogen)

7. Things to watch out for in the conversation on this topic?

For hydrogen to be a tool for decarbonisation and not a massive drain of existing renewables, we need to make sure new hydrogen electricity demand is matched with new, extra renewable generation. If renewable generation is scarce, then renewable hydrogen production, and the broader energy transition, will be constrained.

Without deploying additional renewables when electrolysers are deployed, and matching the hydrogen production with electricity generation, hydrogen production will cannibalise the renewable electricity being deployed to phase out coal and gas electricity. Moreover, if hydrogen gobbles up the existing low-priced renewable electricity production, this will inevitably increase scarcity, driving electricity prices up, at the expenses of direct electrification.

8. List of relevant publications

From Pollution to Solution chapter 1 on Hydrogen

Electrolysis Hydrogen Production In Europe

Will Hydrogen Cannibalise the Energiewende?

Fit for 2030 series: Hydrogen enters center stage in RED