



Project no. 723678



“The next Generation of Carbon for the Process Industry”

Coordination and Support Action

Theme [SPIRE 5] – Potential use of CO₂ and non-conventional fossil natural resources in Europe as feedstock for the process industry

**Deliverable 3.2:
*Acceptance and Awareness of CO₂ Utilisation***

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1. Executive Summary

Carbon Dioxide Utilisation (CO₂ utilisation or CDU) is a group of emerging technologies that uses CO₂ as a carbon resource to make products. The growth in the CO₂ utilisation technologies is primarily driven by industry and investors looking for new renewable feedstocks, in conjunction with searching for methods to reduce emissions. However, a wider variety of external stakeholders are interested in CO₂ utilisation. Key stakeholders can include policy makers, non-governmental organisations (NGOs), large and small companies, investors and the general public. It is vital to understand the background and motivation for a specific stakeholder's engagement with CO₂ utilisation; as this can help frame discussions and provide an understanding for their motivation. Key motivations can include reducing CO₂ emissions to the atmosphere, interest in buying products or new business opportunities that are perceived as being greener.

CO₂ utilisation is not a single simple process; it is a whole suite of technologies that utilise carbon dioxide as a resource to make new products. Therefore, creating an effective communication strategy is important and can present unforeseen issues. Research into understanding the acceptance and awareness of CO₂ utilisation process is still in its infancy with only a few published studies available. As more studies are published and more CO₂-derived products are established in the market, both the understanding of how to develop effective communication strategies along with general awareness of the field will evolve.

It is recommended that when communicating about new CO₂ utilisation products the interests and motivations of the stakeholders are carefully considered from the start. Furthermore, there are a range of considerations and misconceptions that should be taken into account when deciding on communication strategies for CO₂ utilisation. In general, it is simpler to convey a single product or product group rather than discuss the whole range of CO₂ utilisation technologies. Careful consideration should be given to explain that the product is made from carbon from CO₂, its properties and the amount of CO₂ emissions that are avoided by manufacturing the product from CO₂. By taking into account these considerations it is hoped that commonly observed pitfalls can be avoided.

This report identifies and discusses a number of key issues that can affect the acceptance and awareness of CO₂ utilisation technologies and products. The report concludes with a simple communication guide, highlighting key aspects that should be taken into account when devising a communication strategy.

2. Introduction

2.1 Objective

This report identifies a number of key issues that can affect the acceptance and awareness of CO₂ utilisation technologies and products. Although CarbonNext is focusing how carbon dioxide (CO₂) and carbon monoxide (CO) can become increasingly used as feedstocks for the process industry, this report focusses only on CO₂. CO is already widely used as a chemical feedstock, but CarbonNext has identified that CO from within the steel industry could be repurposed to create higher value chemicals. As just the source of the CO is changing, it is not anticipated that public acceptance will be an issue and hence it is not discussed here.

CO₂ is a greenhouse gas with a high level of public awareness regarding its effects. Using CO₂ as a carbon feedstock is a new concept and issues have been observed regarding the understanding of how CO₂ utilisation technologies treat CO₂, their environmental impacts and the differences between the CO₂-derived and conventional products. This report identifies key issues and provides guidance on strategies of communication and the audiences that may be addressed.

2.2 Introduction

Carbon Dioxide Utilisation (CO₂ utilisation or CDU) is a group of emerging technologies that uses CO₂ as a carbon resource to make products. In doing this, CO₂ utilisation replaces conventional production methods from fossil feedstocks and creates new opportunities for the process industry utilising alternative carbon sources. These new routes to key products aim to give lower environmental impacts, increase resource efficiency, promote a circular economy, increase sustainability and encourage growth through new opportunities. CO₂ can be transformed into a wide range of products, such as bulk chemicals, polymers, construction materials and fuels. Over 90% of organic chemicals are derived from fossil carbon, which utilises 5-10% of the global demand for crude oil. Confusingly, CO₂ utilisation is known by a range of terms: carbon dioxide utilisation (CDU), carbon capture and utilisation (CCU), and carbon dioxide reuse/recycling (CDR). However, here we will refer to CO₂ utilisation.

The growth in the CO₂ utilisation technologies is primarily driven by industry and investors looking for new renewable feedstocks, in conjunction with searching for methods to reduce emissions. Many of the observed actors in the field are small and medium sized enterprises (SMEs), often spun out of universities (Carbon8, Liquid Light, Novomer (now part of Aramco)) or large companies that have invested resources in the field to look for sustainable products (Bayer/Covestro, Audi, BASF). CO₂ utilisation technologies span a wide range of TRLs (Wilson

et al., 2015) with mineral carbonation, poly-urethanes and methanol amongst the most advanced technologies which have reached the market. A number of processes have reached small scale commercial or demonstration phases in the last few years including synthetic diesel, DME, new fertilizers and ethanol. The products that have reached commercialisation in some cases are exploiting specific, favourable market factors. For example, Carbon Recycling International use the abundant geothermal power in Iceland to manufacture methanol and Carbon8 Aggregates utilise waste fly ash and air pollution control residues which attract gate fees for disposal.

The route to developing these new technologies to market involves a range of external stakeholders. Kant (2017), identified seven different groups that can play a role: investors, employees, partners, competitors, customers, governments and society. Each of these groups brings different opportunities and barriers, and reflection on how to engage with them to achieve desired outcomes is advantageous. It cannot be assumed that the same strategy should be used on all groups, and therefore careful thought to each group's motivation should be given.

Once market ready, the success of a new technology or product is dependent on the desire of consumers to accept and purchase the product (Ram et al., 1989). As such, the acceptance and awareness of products produced from non-conventional carbon sources such as CO₂ may be a key driver to commercial deployment. A few studies have begun to explore this field for example, Jones et al., 2014; Jones et al., 2015; Jones et al., 2017; van Heek et al., 2017; however, much is still needed to be explored. There is a greater depth of research into the related areas of carbon capture and storage technologies (CCS), renewable energy and the chemical industry in general, as these technologies/areas are more established. Hence, some lessons can be learnt from these fields. The importance of gauging public opinion should never be underestimated, nor the necessity to engage the public at an early stage to give better outcomes (Jones et al., 2014).

As CO₂ utilisation is an industrial process, research on the awareness and acceptance of the chemical industry can provide some insight on how the new technology area may be perceived. A number of studies have been conducted into the public perception of the chemical industry, for example (Castell et al., 2014; TNS BMRB, 2015a; Emily et al., 2016). These studies highlight the attitude towards the industry in general and can help frame broad discussions. The lack of understanding around chemistry and chemicals can hinder discussing products and processes. The Royal Society of Chemistry (TNS BMRB, 2015b) found that only 60% of the public agree that 'everything is made of chemicals' and 19% of the public think that 'all chemicals are dangerous and harmful'. This may stem from the fact that the word 'chemical'

has multiple meanings, one of which is the association with dangerous or hazardous substances as well as in its true sense: the interactions of a substance as studied in chemistry. While the above views relate to the chemical industry as a whole, since CO₂ utilisation will be used to make products within this sector, such findings should be considered, especially as it is known that public awareness of CO₂ utilisation is low.

3. Key Stakeholders

A variety of external stakeholders are interested in CO₂ utilisation. Key stakeholders can include policy makers, Non-governmental organisations (NGOs), large and small companies, investors and the general public. It is vital to understand the background and motivation for a specific stakeholder's engagement with CO₂ utilisation; as this can help frame discussions and provide an understanding for their motivation. Key motivations can include reducing CO₂ emissions to the atmosphere, interest in buying greener products or new business opportunities that are perceived as being greener.

The motivation for policy makers, NGOs and large companies is often observed to be due to the use of CO₂ as a feedstock and climate change mitigation. From a policy maker perspective CO₂ utilisation can often be compared and/or linked to carbon capture and storage (CCS), this is often unhelpful from a stakeholder engagement perspective. This is because these are two distinct pathways, with differing potentials and purposes albeit both involving captured CO₂ (Bruhn et al., 2016). Small companies and SME are observed to be often addressing a specific market opportunity or technology area such as the production of a specific chemical or integrating waste remediation and CO₂ utilisation; their motivation can be based on exploiting research from academic to create a new successful business. Currently engagement with the general public often takes the form of the media reporting CO₂ utilisation opportunities or through academic research to understand public perception of the technologies. Due to the range of differing motivations for those interested in CO₂ utilisation; it is advised that an assessment of interested stakeholder's motivation is conducted before engaging with communication strategies, so that tailored communications can be produced.

4. Awareness of CO₂ Utilisation

As only a small number of products are beginning to emerge on to the market, which are made from CO₂, research into the public acceptance of these products is limited. Initial studies from the University of Sheffield (Jones et al., 2014; Jones et al., 2015) focused on investigating perceptions across the whole field of CO₂ utilisation. The studies looked to understand views on perceived risks, benefits and the preference of specific technologies. These studies were helpful in understanding how people perceived the area of CO₂ utilisation as a whole (general positively) but raised concerns about long-term benefits and whether CO₂ utilisation just shifted the problem allowing more CO₂ to be created just so it could be utilised. The studies highlighted the problems with discussing the whole field of CO₂ utilisation due to the diverse, complex nature of the field. In general, as was expected, the studies found participants had limited knowledge of CO₂ utilisation and therefore explanations of the technology were necessary. This further highlighted that the topic is complex to explain and often left the participants asking for further detailed information or feeling that the information was biased towards positive views. The results gave insight on how 'green' beliefs affected participants' perceptions of CO₂ utilisation when looking at the technology as a whole. This gave rise to the thought that presenting a single product made from CO₂ may have different acceptance outcomes as opposed to communicating the entire field. These initial studies found that people believed that carbon dioxide utilisation would have economic benefits but were wary of the long-term environmental benefits (generally thinking it was just shifting the problem). When asked to compare CO₂ utilisation technologies between methanol, cement production, plastic production, fuel production, enhanced oil recovery (EOR) and a base-case of CCS, it was found that the participants preferred methanol production followed by cement production, with CCS as the least preferred option.

Van Heek et al (2017) conducted the first study into the perception of plastic products manufactured from CO₂. This study was one of the first to look at a single specific end product (CO₂ utilisation for mattresses; referred to as CCU plastics in the study) rather than to examine a range of CO₂ utilisation technologies. Therefore, insights into specific product acceptance can be derived. Their study was divided into two parts, the first looked at a number of acceptance factors and the second included perceived health complaints relating to the product. It was found, once the factor of health complaints was included, this had a significant negative impact on the acceptance of the product. Overall, respondents were quite positive to the idea of CCU mattresses. The key factor in acceptance was disposal conditions followed by saving resources. If the product was perceived to have worse disposal conditions (i.e. more emissions on disposal) the product was rejected. Therefore, the product

was found to need to have at least as good disposal conditions to give acceptance. Saving resources (i.e. carbon avoided by reducing fossil inputs) was found to be more influential than the amount of CO₂ contained in the mattress. In common with other research into CO₂ utilisation acceptance and awareness it was found that perceived and real knowledge of carbon dioxide utilisation was low amongst participants, emphasising the need to communicate clearly and in a way that is seen as unbiased and avoiding 'green washing'. Van Heek and co-workers (2017), conclude that:

“Considering the potential of CO₂-utilization for reduction of CO₂ emissions and fossil resource use, it will be vitally important to consult future users in CCU product development processes and to inform them about CCU in order to reach broader acceptance of CCU products. It should be considered that purely delivering information about CCU is not sufficient, because future users have to feel well informed and have to be able to rely on sources of information.”

5. Key Issues

There are a number of key issues that need to be considered when discussing the use of CO₂ as an alternative feedstock for the process industry. These key issues can affect the understanding of stakeholders regarding how CO₂ utilisation technologies work, their effects on the environment, resource efficiency and other aspects. By identifying common key issues and their possible effect (risk) on the acceptance of the sector, approaches for communication strategies to combat them can be suggested. In this section nine key issues are highlighted and discussed and then a summary of the risk, the stakeholders involved and possible strategies to mitigate the risk are presented. At the end of the section a simple communication guide for CO₂ utilisation products is included. This communication guide does not cover all aspects of CO₂ utilisation but aims to provide a basic starting point for developing clear communication with stakeholders.

1. *Lack of public knowledge on how CO₂ could be used*

Primarily, it should not be underestimated that the public may not understand the basic principle that the CO₂ is being used as a carbon source to create a new molecule and that the gas itself is not trapped inside the product waiting to leak out (Zimmerman and Kant, 2017). The public does in general understand the role of CO₂ as a 'bad gas' and its contribution towards climate change, but doesn't generally understand how it could be used to make a product. This needs to be explained simply and clearly i.e. once the CO₂ has reacted/used to make the product it is not CO₂ any more, it is a new molecule, the CO₂ cannot just escape back out from the product without the product being combusted. Similarities could be drawn to photosynthesis as most people have knowledge that plants use CO₂ to grow. Using the example of a tree that uses CO₂ to grow, then it is released only when burnt to provide heat may help. This lack of knowledge of the conversion of CO₂ to make the product has led to perceived health concerns (van Heek *et al.*, 2017). Combating this lack of knowledge that the CO₂ is being used as carbon source is key to increasing understanding and acceptance.

Risk	CO₂ products are not accepted as the use of the 'C' molecule is not understood
Suggested strategy	Explain that the produce is made from carbon from 'waste CO ₂ ' rather than using carbon from fossil fuels. Explain that the product directly replaces the conventional product it is just manufactured differently
Possible Communicating Stakeholders	Companies, researchers, NGOs
Possible Addressees	General publics, investors

2. Comparing CCS and CO₂ Utilisation

Comparisons between CCS and CO₂ utilisation are common. However, these should be considered as two separate but linked technologies (Bruhn *et al.*, 2016). Commonly CCS and CO₂ utilisation are compared as they both involve capturing CO₂ (Figure 1). CCS is an emissions reduction technology to capture CO₂ from emitters and sequester it in geological formations for long time periods. CCS has the potential to sequester large quantities of CO₂, significantly contributing to emissions reduction targets. CO₂ utilisation, whilst also contributing to a reduction in emissions, is primarily seeking to find alternative sources of carbon as a feedstock for industry. In doing so it is creating new sustainable and economic production pathways that avoid the use of fossil fuels. Both CCS and CO₂ utilisation have an important place in our low carbon future.

Currently there is a move towards combining the two technologies under the banner of CCUS – Carbon Capture, Utilisation and Storage. This approach has been observed by the AIChE, DOE, European Commission and Mission Innovation. Whilst the carbon capture stage of both technologies may be common, it is still important to identify the differences in approach that can be taken due to the final destination of the CO₂ (storage or use).

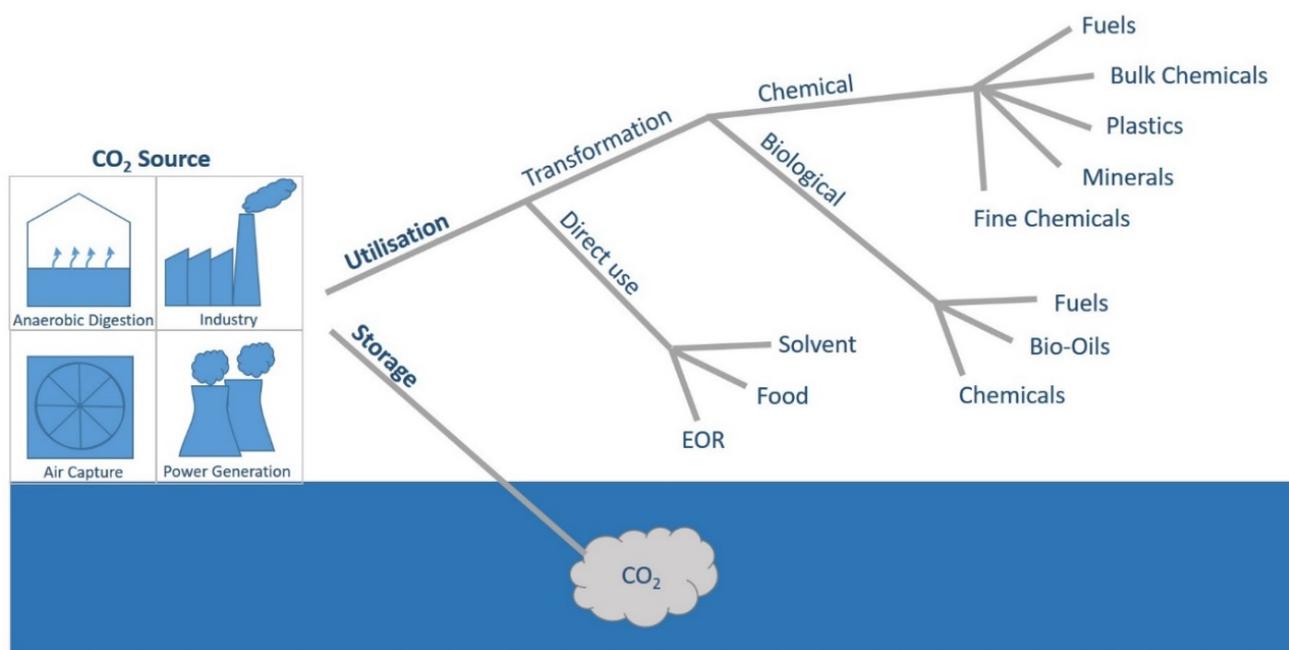


Figure 1. Example routes for CO₂ storage and utilisation. Copyright CO₂Chem Media and Publishing (2017)

Risk	CO₂ utilisation benefits are not fully understood. CO₂ utilisation is only compared with mitigation potential of CCS
Suggested strategy	Understand the motivation of the stakeholder you are communicating with. Explain the advantages of the CO ₂ utilisation technology. Explain all benefits including emissions reduction, resource efficiency, circular economy etc.
Possible Communicating Stakeholders	Companies, researchers, NGOs
Possible Addressees	Policy Makers, NGOs, Investors, General publics

3. *Issues with presenting CO₂ Utilisation as 'the solution' for climate change.*

CO₂ utilisation is not 'the' solution for climate change as no other single technology is. Nevertheless, it is one of a suite of technologies which can be employed to mitigate emissions. The IEA scenarios give many different pathways to decrease emissions and CO₂ utilisation is one option that could contribute by reducing the emissions from various chemical processes by switching to using CO₂ as feedstock. Best projections give the total amount of CO₂ that could be utilised as 1-7 GT per annum, but this reflects the amount of CO₂ used not the total avoided which will be much less once the full life cycle assessment (LCA) is taken into account (see issue 5).

Risk	Overstating the potential of CO₂ utilisation technologies
Suggested strategy	CO ₂ utilisation should be presented as part of the solution to mitigating CO ₂ emissions. Ideally comprehensive LCA should be conducted to clarify emissions reduction before communication of potentials, otherwise limitations of the claims should be presented.
Possible Communicating Stakeholders	Companies, researchers, NGOs, Policy Makers
Possible Addressees	Policy Makers, Researchers, NGOs, Investors, General publics, Companies

4. *Danger of 'green washing' - over-estimating the benefits of a product.*

The lack of transparency and comprehensive guidelines for CO₂ utilisation LCAs can lead to claims of 'green washing'. LCA will provide details of the environmental impacts of each technology, but inconsistency in the boundaries applied in each case can lead to varying results. A holistic approach which takes into consideration all inputs and energy sources is required. Information from reputable external organisations regarding health and

environmental impact assessments may be beneficial to alleviate fears of 'green washing' by the manufacturer by providing an independent opinion.

Risk	Lack of confidence in the potential of CO₂ utilisation due to perceived biased information
Suggested strategy	Conduct transparent, peer-reviewed life-cycle studies before claiming benefits of a product. Clearly state the limitations of the study and include all relevant environmental indicators not just global warming potential (GWP). Using an external organisation to carry out the study can add credibility. All studies should be peer-reviewed and reviewers stated.
Possible Communicating Stakeholders	Companies, researchers, NGOs
Possible Addressees	Policy Makers, NGOs, Investors, General publics, Companies

5. *Confusion between CO₂ avoided, CO₂ used and re-release of CO₂*

Different CO₂-based products have different lifetimes. These can span from hours, to days, to years depending on the use of the product. For mineralisation products the CO₂ can be thought of as permanently sequestered as the products end of life does not necessitate the re-release of CO₂. For many other products, chemicals, fuels, polymers, etc. the end of life for the product often involves combustion or decomposition which results in the release of CO₂. Therefore, the question arises 'does creating the product from CO₂ actually make a difference to CO₂ emissions'? The amount of CO₂ used in the process is not the same as the amount reduced. All processes require energy and other inputs of one type or another and these have related emissions (even renewable energy has a carbon footprint). To calculate the emissions from the process, a complete LCA must be undertaken. This can then be compared with the traditional production of the same material or the material the CO₂-based product is replacing to assess the amount of CO₂ that has been avoided. Figure 2 shows an example of how a CO₂-derived fuel could avoid emissions. Usually, the end-of-life process for a CO₂-based and traditionally produced product would be the same. It is just the production methods that differs. Therefore, it can be concluded that if the CO₂-based product has a smaller carbon footprint to produce than the traditionally based product it does help. An example of this is the Covestro Polyol Dream Process, which has a 15% lower carbon footprint.¹

¹ <https://www.covestro.com/en/cardyon/overview>

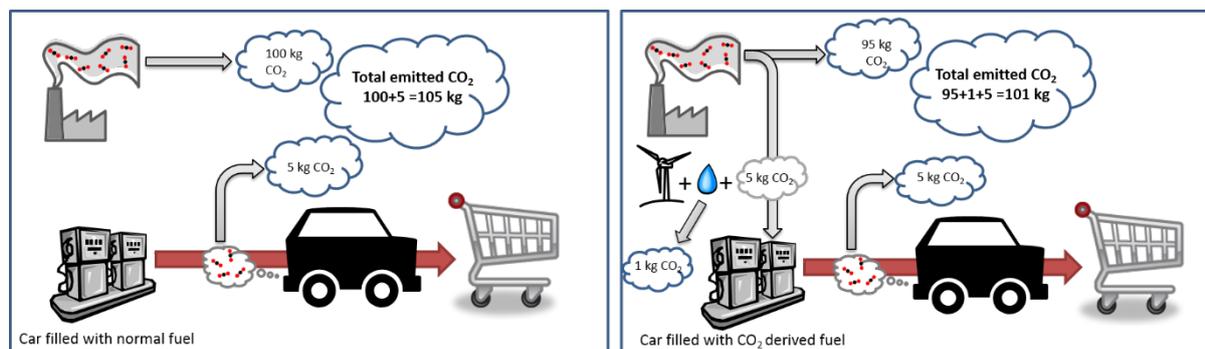


Figure 2. Simplified representation of avoided CO₂ in fuel use. NB this representation does not include the small amount of emissions resulting from carbon capture. (Armstrong et al., 2015)

Risk	Misunderstanding over the CO₂ mitigation potential of a product
Suggested strategy	Conduct transparent, peer-reviewed life-cycle studies before claiming benefits of a product; using an external organisation for this can provide more credibility. Be careful with terminology such as 'carbon negative'. Be clear about what happens to the product at its end of life.
Possible Communicating Stakeholders	Companies, researchers, NGOs
Possible Addressees	Policy Makers, NGOs, Investors, General publics

6. Perception of using CO₂ utilisation as an excuse not to discontinue fossil fuels use.

CO₂ should not be produced solely to be used in CO₂ utilisation, as this is contradictory to the principles of sustainability and green chemistry. We should be taking significant steps to reduce CO₂ emissions to meet and exceed the Paris Agreement targets. However, we will always have to produce some CO₂ for example in fermentation and chemical process and thus CO₂ utilisation can be useful to reduce these emissions whilst making useful products. Technologies to capture CO₂ directly from the air (DAC) before it is used to make products could also help in reducing atmospheric CO₂ levels.

The first research into the public acceptance of CO₂ utilisation conducted by Jones and co-workers, (2014), highlighted that the public feared CO₂ utilisation could be seen as preventing societal change to reduce CO₂ emissions. Participants in this research felt that if there was a recognised use for the CO₂ this would encourage people to continue with a wasteful and polluting lifestyle. It addressed the symptom not the root cause of the problem. This argument can be understood, it can be reasoned that the research participants were predominantly

thinking about CO₂ produced from fossil fuels for energy uses for which there are low carbon alternatives (wind, solar, nuclear), as the wide variety of emission sources is often not discussed. CO₂ utilisation should not be pitched as a solution to the continuous use of fossil fuels. Switching from fossil fuels to renewable, low carbon energy must be the primary aim. However, we need many carbon based products and utilising the CO₂ released from hard to decarbonised industrial processes to produce these is an option.

Risk	CO₂ utilisation is not accepted due to the perception that it inhibits creation of new renewable energy supplies and gives an excuse for producing CO₂
Suggested strategy	Explanation that there are many CO ₂ sources, many of which especially industrial processes are hard to decarbonise and here CO ₂ utilisation may be of benefit. Introduce discussion of direct air capture if necessary. Reference to IEA emission reduction diagrams may be useful to show where emissions originate and that there will still be emissions.
Possible Communicating Stakeholders	Companies, Researchers, NGOs
Possible Addressees	Policy Makers, NGOs, Investors, General publics

7. Risk of underestimating the cost and thus speed of commercial uptake

CO₂ utilisation is a relatively new, emerging technology area; and as with any new technologies, initial costs are high and uptake is slow. Subsequently, an awareness regarding the realistic timescales of deployment and potential of the technologies is useful. In general, CO₂ utilisation products will directly replace products conventionally produced from fossil resources. These processes have been optimised over many years to maximise efficiency and revenue and new CO₂ products must be able to compete with them in the market. However, due to the interest in technologies that can help reduce CO₂ emissions and contribute to developing a sustainable, circular economy, there has been an observed interest from governments to understand the potential of these technologies. The Global CO₂ Initiative (2016) has assessed that at full deployment, five key products have the potential to utilise 7 gigatons of CO₂ per year, creating a market in excess of US \$800 billion by 2030 (Figure 3). However, they state this would only be achievable in optimal conditions which have been created by strategic actions in policy, research and markets. Without these strategic actions, Global CO₂ Initiative (GCI) estimate that 1 gigaton of CO₂ can be utilised. Thus, it can be concluded that the speed of commercial uptake will be dependent on external factors providing mechanisms which make CO₂ utilisation costs lower and hence increase commercial uptake.

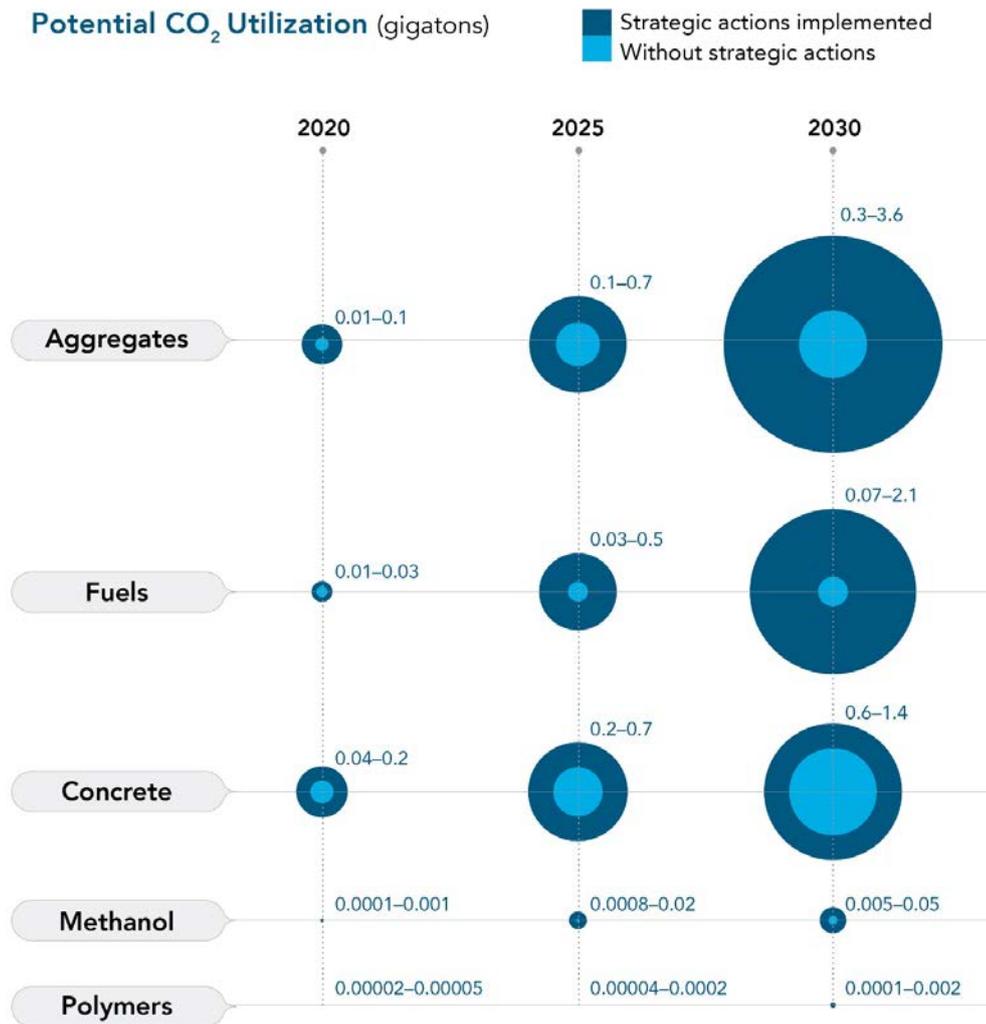


Figure 3 Potential increase in market size due to implementation of strategic actions. Global CO₂ Initiative. (2014)

Risk	CO₂ utilisation costs and the time needed for market penetration are underestimated. The speed of impact of technologies is exaggerated.
Suggested strategy	Understand the motivation of the stakeholder you are communicating with. Techno-economic assessments (TEA) should be used to predict costs and future deployment scenarios. Use references to other new start-up green-technologies and their speed of deployment. References to deployment scenarios for CO ₂ utilisation should take into account all assumptions, market conditions and mechanisms employed to create the scenario
Possible Communicating Stakeholders	Companies, researchers, NGOs
Possible Addressees	Policy Makers, NGOs, Investors, General publics

8. *Lack of understanding regarding how the CO₂ product properties compare with normal product.*

There can be a confusion about the differences between the CO₂-based product and the product it replaces. All similarities and differences should be clearly explained. If it is a direct like for like replacement it should be clearly stated, for example methanol or DME. For polymer products, both Covestro (cardyon™) and Saudi Aramco (Converge™) report some properties of their products to be superior. This enables the consumer to make informed choices especially if the CO₂-based product has a higher price point. Here it is also important to explain any end-of-life disposal differences as highlighted by van Heek and co-workers (2017), as it has been found to be a major contributor to acceptance of the product.

Risk	CO₂ utilisation products are not accepted and consumers not willing to purchase them
Suggested strategy	Clearly explain how the product is produced using carbon from 'waste' CO ₂ and that it directly replaces the conventional product. If it is chemically identical state so. State any superior properties to the conventional product. Use independent verification if necessary.
Possible Communicating Stakeholders	Companies, researchers, NGOs
Possible Addressees	Policy Makers, NGOs, Investors, General publics

9. *Awareness regarding the integration with low carbon, renewable energy*

All CO₂ utilisation products should have a lower carbon footprint than the product that they are replacing, so they are avoiding CO₂ emissions. As we move towards a decarbonised electricity supply most of these processes will need to utilise low carbon or renewable energy and this potential dependency should be understood. Furthermore, the ability to seasonably store or utilise excess renewable energy at times of oversupply will be critical as the share of low-carbon renewable energy increases in the energy mix and the creation of CO₂-fuels or chemicals could provide one such method.

Using renewable energy for CO₂ utilisation processes for needs careful consideration, and questions arise to be best use of the available renewable energy. Although 'guarantees of origin' can be provided to prove that renewable energy has been used, this may just cause renewable energy to be diverted from one application to another. Hence, these may not actually provide an emissions' reduction when the whole system is taken into account. To ensure this does not happen, it may be necessary to create new sources of renewable energy

or utilise 'excess or surplus' renewable energy supply which is produced in excess of consumer demand.

Risk	CO₂ utilisation is perceived as being in conflict with renewable energy deployment
Suggested strategy	Explain how CO ₂ products could provide solutions for seasonal energy storage. Clearly state the energy sources used in production. If possible, LCA and TEA studies should be performed to show renewable energy impacts.
Possible Communicating Stakeholders	Policy Makers, Companies, researchers, NGOs
Possible Addressees	Policy Makers, NGOs, Investors, General publics, Companies

6. Simple Guidance for Communication of CO₂ Utilisation

- Know your audience. Different audiences have different backgrounds and motivations for their interest in CO₂ utilisation.
- The motivation for CO₂ utilisation is not the same for each product. It is simpler to focus on specific products rather than the whole field of CO₂ utilisation
- Explain that the product is made from carbon from 'waste CO₂' rather than using carbon from fossil fuels.
- Explain that the product directly replaces the conventional product, it is just manufactured differently. If it is chemically the same, explain this.
- Explain that in the manufacturing process, the carbon in the CO₂ is used and is no longer CO₂.
- Explain the carbon footprint – this product has X% lower carbon emissions than the usual product across its whole life span. If necessary, include the end of life process (recycling, burning of fuels), how could CO₂ be re-released and whether this differs from the conventionally made product. It can be helpful to use a diagram such as figure 4.
- Explain product properties – this product has the same/improved properties than the conventionally made product or alternative.
- CO₂ utilisation is not a replacement for CCS. Both can contribute to reducing CO₂ emissions. CO₂ utilisation focuses on adding value to CO₂ by using it as a carbon source to create new products.

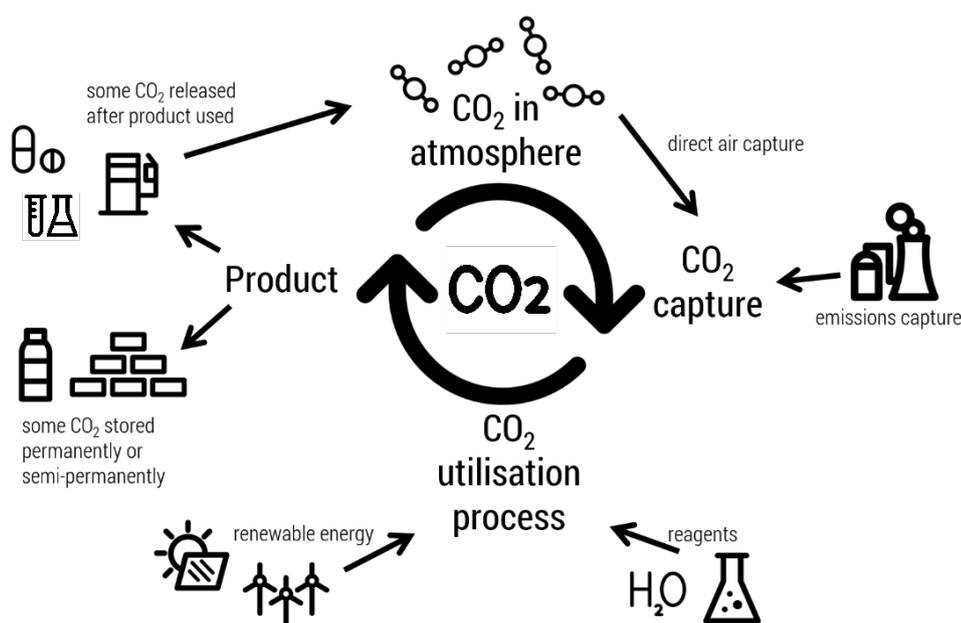


Figure 4. CO₂ utilisation Cycle. CO₂Chem Media and Publishing, 2017

7. Conclusions

CO₂ utilisation is not a single simple process; it is a whole suite of technologies that utilise carbon dioxide as a resource to make new products. CO₂-derived products are diverse, as are the processes to make them. Therefore, creating an effective communication strategy is important and can present unforeseen issues. Research into understanding the acceptance and awareness of CO₂ utilisation process is still in its infancy with only a few published studies available. As more studies are published and more CO₂-derived products are established in the market, both the understanding of how to develop effective communication strategies along with general awareness of the field will evolve.

It is recommended that when communicating about new CO₂ utilisation products the interests and motivations of the stakeholders are carefully considered from the start. Furthermore, there are a range of considerations and misconceptions that should be taken into account when deciding on communication strategies for CO₂ utilisation. In general, it is simpler to convey a single product or product group rather than discuss the whole range of CO₂ utilisation technologies. Careful consideration should be given to explain that the product is made from carbon from CO₂, its properties and the amount of CO₂ emissions that are avoided by manufacturing the product from CO₂. By taking into account these considerations it is hoped that commonly observed pitfalls can be avoided.

8. References

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