Project no. 723678

ñThe next Generation of Carbon for the Process Industryò

Coordination and Support Action

Theme [SPIRE 5] ï Potential use of CO_2 and non-conventional fossil natural resources in Europe as feedstock for the process industry

Deliverable *3.2*:
Acceptance and Awareness of CO_2 Utilisation

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1. Executive Summary

Carbon Dioxide Utilisation (CO_2 utilisation or CDU) is a group of emerging technologies that uses CO_2 as a carbon resource to make products. The growth in the CO_2 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 CO_2 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 CO_2 utilisation; as this can help frame discussions and provide an understanding for their motivation. Key motivations can include reducing CO_2 emissions to the atmosphere, interest in buying products or new business opportunities that are perceived as being greener.

CO_2 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 CO_2 utilisation process is still in its infancy with only a few published studies available. As more studies are published and more CO_2-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 CO_2 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 CO_2 utilisation. In general, it is simpler to convey a single product or product group rather than discuss the whole range of CO_2 utilisation technologies. Careful consideration should be given to explain that the product is made from carbon from CO_2, its properties and the amount of CO_2 emissions that are avoided by manufacturing the product from CO_2. 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 CO_2 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 CO_2 utilisation technologies and products. Although CarbonNext is focusing how carbon dioxide (CO_2) and carbon monoxide (CO) can become increasingly used as feedstocks for the process industry, this report focuses only on CO_2. CO is already widely used as a chemical feedstock, but CarbonNext has identified that CO from within the steel industry could be re-purposed 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.

CO_2 is a greenhouse gas with a high level of public awareness regarding its effects. Using CO_2 as a carbon feedstock is a new concept for many fossil based chemicals and issues have been observed regarding the understanding of how CO_2 utilisation technologies treat CO_2, their environmental impacts and the differences between the CO_2-dervided 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 (CO_2 utilisation or CDU) is a group of emerging technologies that uses CO_2 as a carbon resource to make products. In doing this, CO_2 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. CO_2 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. CO_2 utilisation is known by a range of terms: carbon dioxide utilisation (CDU), carbon capture and utilisation (CCU), and carbon dioxide reuse/recycling (CDR). Here, we will refer to CO_2 utilisation.

The growth in the CO_2 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). CO_2 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 CO_2 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 CO_2 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 óall chemicals are dangerous and harmfulô This may stem from the fact that the word óchemicalô 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 CO_2 utilisation will be used to make products within this sector, such findings should be considered, especially as it is known that public awareness of CO_2 utilisation is low.

3. Key Stakeholders

A variety of external stakeholders are interested in CO_2 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 CO_2 utilisation; as this can help frame discussions and provide and understanding for their motivation. Key motivations can include reducing CO_2 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 CO_2 as feedstock and climate change mitigation. From a policy maker perspective CO_2 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 CO_2 (Bruhn et al., 2016). Small companies and SME are observed to be often addressing as specific market opportunity or technology area such as the production of a specific chemical or integrating waste remediation and CO_2 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 CO_2 utilisation opportunities or though academic research to understand public perception of the technologies. Due to the range of differing motivations for interested in CO_2 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 CO_2 Utilisation

As only a small number of products are beginning to emerge on to the market, which are made from CO_2, 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 CO_2 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 CO_2 utilisation as a whole (general positively) but raised concerns about long-term benefits and whether CO_2 utilisation just shifted the problem allowing more CO_2 to be created just so it could be utilised. The studies highlighted the problems with discussing the whole field of CO_2 utilisation due to the diverse, complex nature of the field. In general, as was expected, the studies found participants had limited knowledge of CO_2 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 ógreenô beliefs affected participantsô perceptions of CO_2 utilisation when looking at the technology as a whole. This gave rise to the thought that presenting a single product made from CO_2 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 CO_2 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 CO_2. This study was one of the first to look at a single specific end product (CO_2 utilisation for mattresses; referred to as CCU plastics in the study) rather than to examine a range of CO_2 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 CO_2 contained in the mattress. In common with other research into CO_2 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 ógreen washingô Van Heek and co-workers (2017), conclude that:

> *ñConsidering the potential of CO_2-utilization for reduction of CO_2 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.ò*

5. Key Issues

There are a number of key issues that need to be considered when discussing the use of CO_2 as an alternative feedstock for the process industry. These key issues can affect the understanding of stakeholders regarding how CO_2 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 CO_2 utilisation products is included. This communication guide does not cover all aspects of CO_2 utilisation but aims to provide a basic starting point for developing clear communication with stakeholders.

1. Lack of public knowledge on how CO_2 could be used

Primarily, it should not be underestimated that the public may not understand the basic principle that the CO_2 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 CO_2 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 CO_2 has reacted/used to make the product it is not CO_2 any more, it is a new molecule, the CO_2 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 CO_2 to grow. Using the example of a tree that uses CO_2 to grow, then it is released only when burnt to provide heat may help. This lack of knowledge of the conversion of CO_2 to make the product has led to perceived health concerns (van Heek *et al.*, 2017). Combating this lack of knowledge that the CO_2 is a being used as carbon source is the key in order to increasing understanding and acceptance.

Risk	**CO_2 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 CO_2 Utilisation*

Comparisons between CCS and CO_2 utilisation are common. However, these should be considered as two separate but linked technologies (Bruhn *et al.*, 2016). Commonly CCS and CO_2 utilisation are compared as they both involve capturing CO_2 (Figure 1). CCS is an emissions reduction technology to capture CO_2 from emitters and sequester it in geological formations for long time periods. CCS has the potential to sequester large quantities of CO_2, significantly contributing to emissions reduction targets. CO_2 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 CO_2 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 ï 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 CO_2 (storage or use).

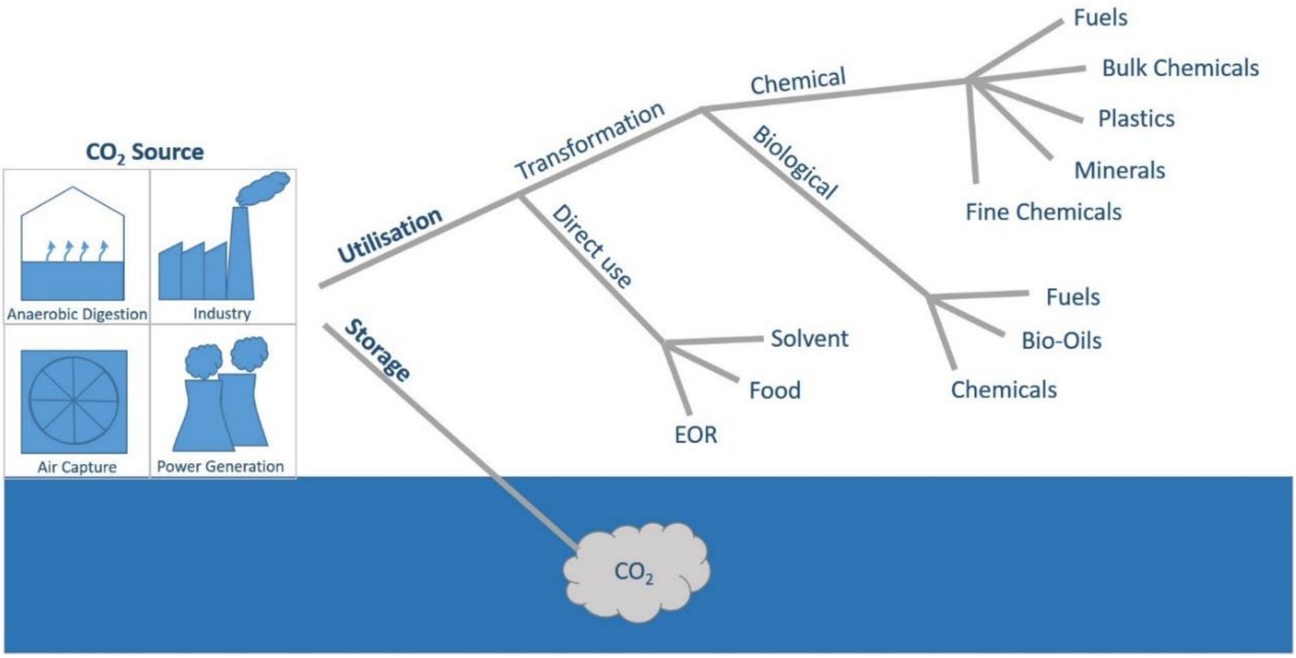

Figure 1. Example routes for CO_2 storage and utilisation. Copyright CO2Chem Media and Publishing (2017)

Risk	**CO_2 utilisation benefits are not fully understood. CO_2 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 CO_2 Utilisation as “the solution” for climate change.

CO_2 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 CO_2 utilisation is one option that could contribute by reducing the emissions from various chemical processes by switching to using CO_2 as feedstock. Best projections give the total amount of CO_2 that could be utilised as 1-7 GT per annum, but this reflects the amount of CO_2 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 CO_2 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 CO_2 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 ögreen washingôby the manufacturer by providing an independent opinion.

Risk	**Lack of confidence in the potential of CO_2 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 CO_2 avoided, CO_2 used and re-release of CO_2

Different CO_2-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 CO_2 can be thought of as permanently sequestered as the products end of life does not necessitate the re-release of CO_2. 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 CO_2. Therefore, the question arises ödoes creating the product from CO_2 actually make a difference to CO_2 emissionsö? The amount of CO_2 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 CO_2-based product is replacing to assess the amount of CO_2 that has been avoided. Figure 2 shows an example of how a CO_2-derived fuel could avoid emissions. Usually, the end-of-life process for a CO_2-based and traditionally produced product would be the same. It is just the production method that differs. Therefore, it can be concluded that if the CO_2-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

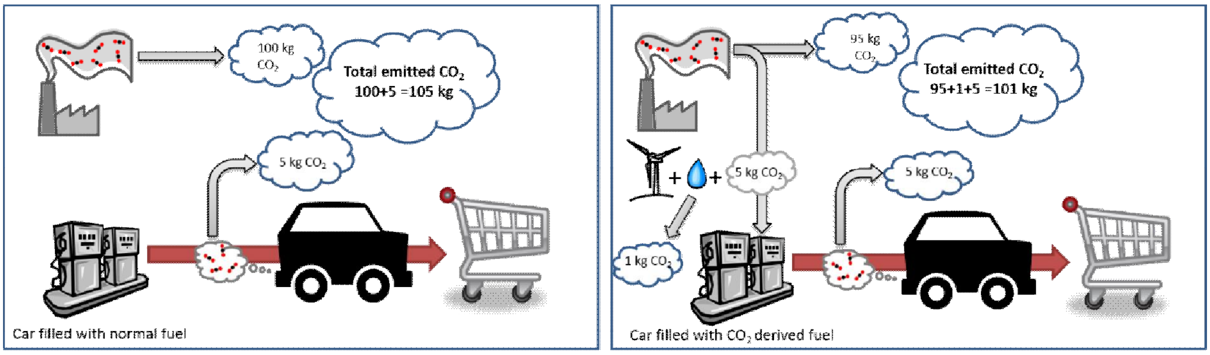

Figure 2. Simplified representation of avoided CO_2 in fuel use. NB this representation does not include the small amount of emissions resulting from carbon capture. (Armstrong et al., 2015)

Risk	**Misunderstanding over the CO_2 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 ócarbon negativeô 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 CO_2 utilisation as an excuse not to discontinue fossil fuels use.

CO_2 should not be produced solely to be used in CO_2 utilisation, as this is contradictory to the principles of sustainability and green chemistry. We should be taking significant steps to reduce CO_2 emissions to meet and exceed the Paris Agreement targets. However, we will always have to produce some CO_2 for example in fermentation and chemical process and thus CO_2 utilisation can be useful to reduce these emissions whilst making useful products. Technologies to capture CO_2 directly from the air (DAC) before it is used to make products could also help in reducing atmospheric CO_2 levels.

The first research into the public acceptance of CO_2 utilisation conducted by Jones and co-workers, (2014), highlighted that the public feared CO_2 utilisation could be seen as preventing societal change to reduce CO_2 emissions. Participants in this research felt that if there was a recognised use for the CO_2 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 CO_2 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. CO_2 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 CO_2 released from hard to decarbonised industrial processes to produce these is an option.

Risk	**CO_2 utilisation is not accepted due to the perception that it inhibits creation of new renewable energy supplies and gives an excuse for producing CO_2**
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

CO_2 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, CO_2 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 CO_2 products must be able to compete with them in the market. However, due to the interest in technologies that can help reduce CO_2 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 CO_2 Initiative (2016) has assessed that at full deployment, five key products have the potential to utilise 7 gigatons of CO_2 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 CO_2 Initiative (GCI) estimate that 1 gigaton of CO_2 can be utilised. Thus, it can be concluded that the speed of commercial uptake will be dependent on external factors providing mechanisms which make CO_2 utilisation costs lower and hence increase commercial uptake.

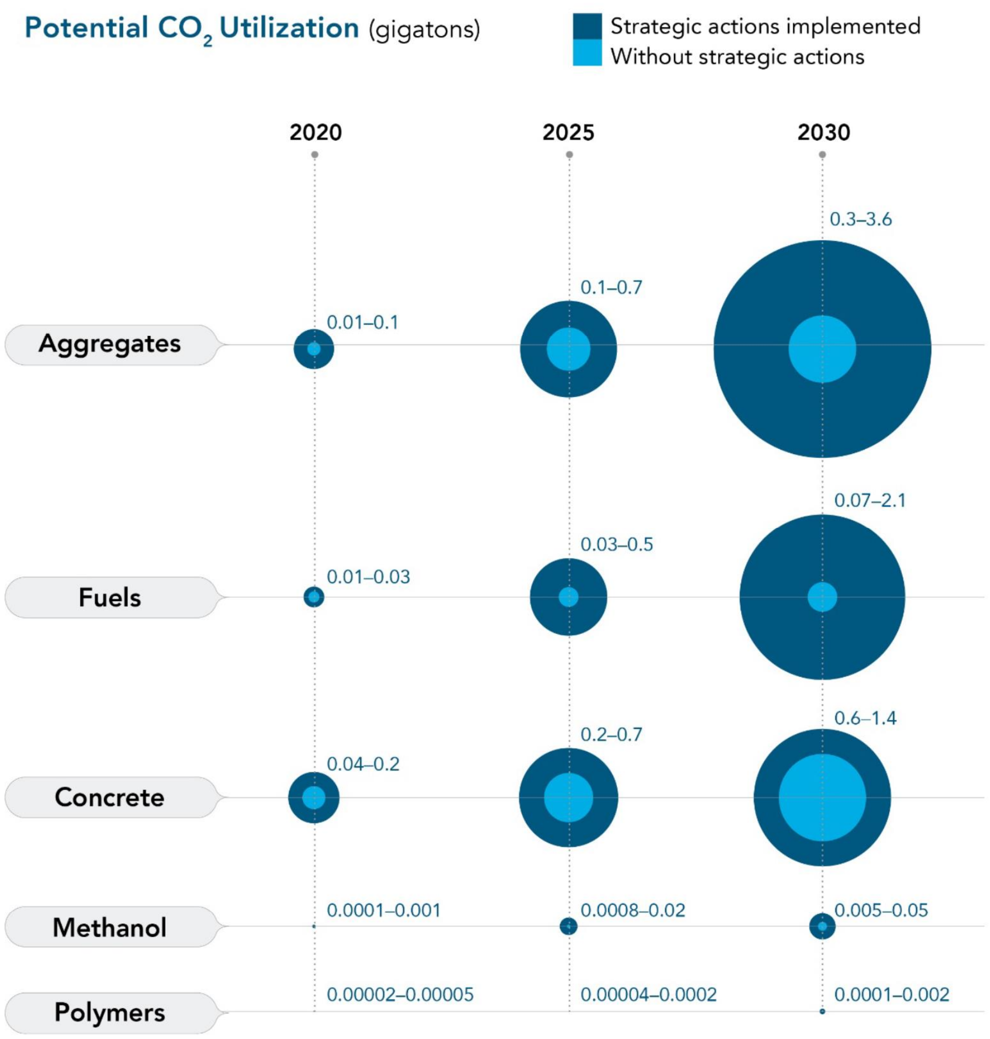

Figure 3 Potential increase in market size due to implementation of strategic actions. Global CO_2 Initative. (2014)

Risk	**CO_2 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 CO_2 product properties compare with normal product.

There can be confusion about the differences between the CO_2-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 (cardyonÊ) and Saudi Aramco (ConvergeÊ) report some properties of their products to be superior. This enables the consumer to make informed choices especially if the CO_2-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	**CO_2 utilisation products are not accepted and consumers not willing to purchase them**
Suggested strategy	Clearly explain how the product is produced using carbon from ówasteô 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 CO_2 utilisation products should have a lower carbon footprint than the product that they are replacing, so they are avoiding CO_2 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 CO_2-fuels or chemicals could provide one such method.

Using renewable energy for CO_2 utilisation processes for needs careful consideration, and questions arise to be best use of the available renewable energy. Although óguarantees of originô 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 emissionsô 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 óexcess or surplusôrenewable energy supply which is produced in excess of consumer demand.

Risk	**CO_2 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 CO_2 Utilisation

- Know your audience. Different audiences have different backgrounds and motivations for their interest in CO_2 utilisation.
- The motivation for CO_2 utilisation is not the same for each product. It is simpler to focus on specific products rather than the whole field of CO_2 utilisation
- Explain that the product is made from carbon from ówaste CO_2ôrather 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 CO_2 is used and is no longer CO_2.
- Explain the carbon footprint ï 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 CO_2 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 ï this product has the same/improved properties than the conventionally made product or alternative.
- CO_2 utilisation is not a replacement for CCS. Both can contribute to reducing CO_2 emissions. CO_2 utilisation focuses on adding value to CO_2 by using it as a carbon source to create new products.

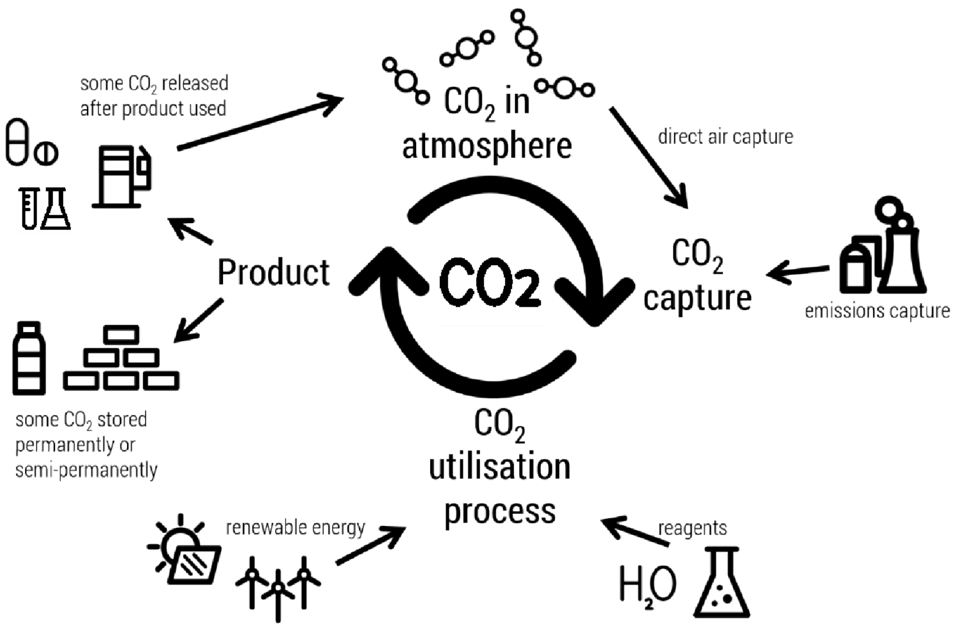

Figure 4. CO_2 utilisation Cycle. CO2Chem Media and Publishing, 2017

7. Conclusions

CO_2 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. CO_2-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 CO_2 utilisation process is still in its infancy with only a few published studies available. As more studies are published and more CO_2-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 CO_2 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 CO_2 utilisation. In general, it is simpler to convey a single product or product group rather than discuss the whole range of CO_2 utilisation technologies. Careful consideration should be given to explain that the product is made from carbon from CO_2, its properties and the amount of CO_2 emissions that are avoided by manufacturing the product from CO_2. By taking into account these considerations it is hoped that commonly observed pitfalls can be avoided.

8. References

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