“Barriers and Opportunities for the Implementation of Chemical Recycling within the UK”

Workshop minutes, feedback, opinions and perspectives from the Policy workshop run by CircularChem and WRAP in January 2022

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Contents

List of Figures 1

Breakout Session 1: WRAP Led session 3

Theme 1: Measuring chemically recycled content 4

Theme 2: Measuring impact of recycling 11

Theme 3: End of Waste and quality protocol 16

Overall comments and discussion points raised following breakout session 1 20

Breakout Session 2: CircularChem Led session 22

Theme 1: Perceptions of current policies: positives, bottlenecks, and gaps 22

Theme 2: Funding priorities 28

Theme 3: Measuring impact of current and new policies 31

Conclusions and Recommendations 34

Appendix 37

Screenshots of mural board comments captured during Breakout Session 1: WRAP Led Session 37

Screenshots of mural board comments captured during Breakout Session 2: CircularChem Led Session 40

List of Figures

Figure 1: The three topics and underpinning questions presented to attendees for the first breakout session. 4

Figure 2: How a mass balance approach can be used to introduce greener feedstocks into product supply chains. This image was taken from the ISCC mass balance approach webpage and is used with their permission: 6

Figure 3: The three topics and underpinning questions presented to attendees for the second breakout session. 22

Figure 4: The potential issue of employing a “carbon tunnel vision.” We have to tackle CO_2 emissions, but it must not be our only focus. We need to consider social responsibility, social

impact factors, and other sustainability metrics. This figure was produced and adapted with permission from Jan Konietzko. 26
Figure 4: Comments left on an online MURAL collaboration page during the first breakout session (1 of 3). 37
Figure 5: Comments left on an online MURAL collaboration page during the first breakout session (2 of 3). 38
Figure 6: Comments left on an online MURAL collaboration page during the first breakout session (3 of 3). 39
Figure 7: Comments left on an online MURAL collaboration page during the second breakout session. 40

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On 18th January 2022, a virtual workshop was held by the UKRI CircularChem Centre and WRAP, with a cross-section of individuals from industry, Government, and academia in attendance. Representatives from WRAP, CircularChem, the five CE-Hub Centres, and academics and researchers from the University of Loughborough, University of Sheffield, Heriot-Watt University, Swansea University, and Imperial College London attended the event. Attendees from the RSC, Biffa, E4Tech, Plastics Europe, Plastic Energy, Scottish Water, as well as representatives from DEFRA and the Scottish Government, were also present. The board aim of this workshop was for WRAP to share their findings from their recent "*Barriers and opportunities for the implementation of chemical recycling*" report, and for CircularChem to describe their current policy development and engagement strategy. Two breakout sessions were run to encourage thoughts and discussion, invite feedback and to ultimately help both CircularChem and WRAP shape their policy engagement strategy and future policies targets. This paper provides a general overview of the workshop discussions, thoughts and opinions, which influenced the WRAP publication "*Non-technical challenges to non-mechanical recycling*" by Thomas Baker. This document provides an overview of the thoughts and opinions that were captured during this workshop. Some points highlighted during the meeting have also been addressed and commented on further from the CircularChem team. A MURAL board was used online to capture thoughts from participants, who were more comfortable writing responses rather than orally dictating them, during the breakout sessions. Screenshots from this board are shown in the Appendix, to highlight thoughts captured online during the two workshop breakout sessions.

Breakout Session 1: WRAP Led session

In the first half of the workshop, WRAP gave a presentation on "*Barriers and opportunities for the implementation of Chemical Recycling within the UK*" and their findings (as presented by Thomas Baker). A series of questions and topics were then proposed by Keith James in relation to dealing with plastic recycling and waste, with three key overall themes at the basis of these questions (Figure 1).

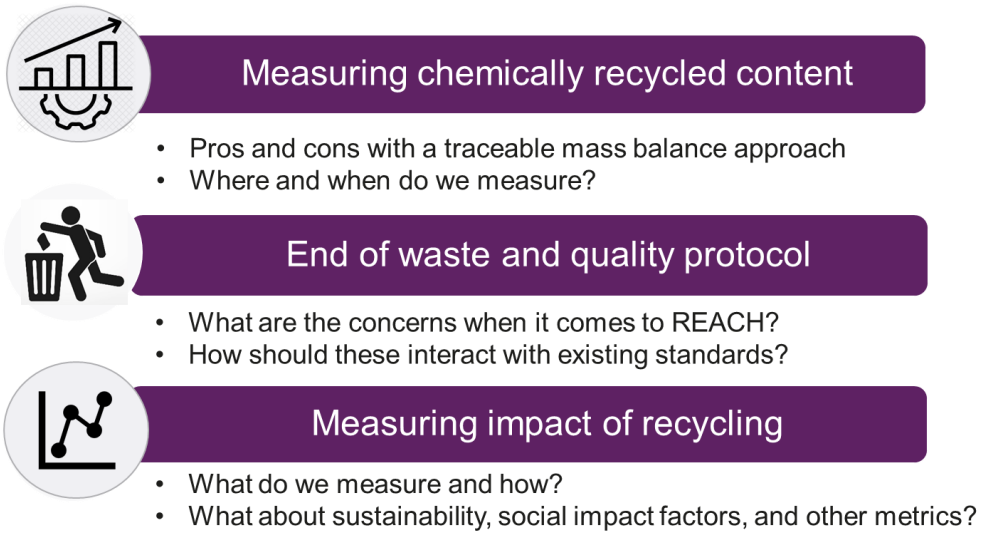


Figure 1: The three topics and underpinning questions presented to attendees for the first breakout session.

Theme 1: Measuring chemically recycled content

- It was generally agreed that all parts of a company production line, including at a site, batch, and product level, need to be measured in terms of recycled content.
- In terms of using mass balance with measuring recycled content, it was agreed that on the positive sides, mass balance can help to save resources and highlight opportunities for re-use. It also helps to trace the use of plastics, or desired chemicals, through the whole system. The ISCC tools, which also calculates greenhouse gases, was highlighted as a useful tool.
- "*Until we have dedicated trackers for chemically recycled substances, such as perhaps fluorescent markers* (currently being researched)*, digital Stock-Keeping Units (SKUs) and/or the Conwy digital deposit return scheme (Polytag) in Wales, we will have to use mass balance".*
- Mass balancing itself is relatively straight forward after materials enter the refining stream, e.g., SABIC can issue protocols on recycled content of refinery outputs. However, many systems need to consider mass balance around recovery processes. In addition, current scale of the chemical recycling market is negligible, and therefore would not make much difference to recycling targets in the short term.
- One issue with mass balance is the number of parties in the supply chain.
    - For example, a chemical recycler will produce pyrolysis oil, which is sent to a petrochemical company for blending in a steam cracker with naphtha. This is then sold to a third party who makes a product. A chemical recycler will provide a batch which is 100% recycled content. The issue then is how do we record recycled content in the petrochemical plant?

- Many felt it would be easier to trace back through the supply chain to identify origins of material, than to trace forward to identify products in which recycled material is used. These identified issues are not unique to plastics, but also apply to materials such as metals. Using a "chain of custody" model in terms of the plastics market was also highlighted as another potential avenue to explore.
- Some participants were wondering whether the best approach, in terms measuring content in the circular economy, is to measure CO_2 emissions or use mass balance. A few standards have been published which used both approaches. The need for the methodology to be harmonised at least between UK devolved regions, and preferably at nation level, was also highlighted.
    - The DEFRA (2011) Anaerobic Digestion Strategy and Action Plan was mentioned as an example.
    - The ISCC PLUS was cited as a certification programme for bio-based and circular (recycled) raw materials for all markets and sectors not regulated as transportation fuels.
- On the other hand, it was highlighted that mass balance is not understood entirely, especially when it comes to those in Government, who need to understand this when weighing up different recycling or policy opportunities. As quoted by one participant; *"We need to get away from viewing things simply as something goes into a supply line or manufacturing plant, and magically something comes out of the end of it. We need to also know more and appreciate the middle stage and stop seeing it as a magical black box."* It was pointed that perhaps one way around this would be to appoint more people in policy and Government with a chemistry or science background, who can understand the science and therefore convey their expertise to others.

Mass Balance

Mass balance is a technique used to gradually increase the use of sustainable and bio-based materials in the chemical sector and to help phase out the use of fossil fuels. Whilst an ideal scenario would be to just completely swap from fossil fuels to renewables, this is not (currently) feasible and could led to unintended consequences, such as creating a higher carbon footprint process, sudden job loses, financial instability, chemical plant closures, product failures, and much, much more. This immediate switch would be extremely expensive to support and could lead to a fossil and renewable parallel system, which ultimately creates more carbon dioxide emissions and does not stop the utilisation of fossil fuels.

Mass balance is the concept of mixing renewable and fossil fuel based materials and feedstocks together, keeping track of the renewable quantity and allocating this mixture to be used to produce certain products (Figure 2).

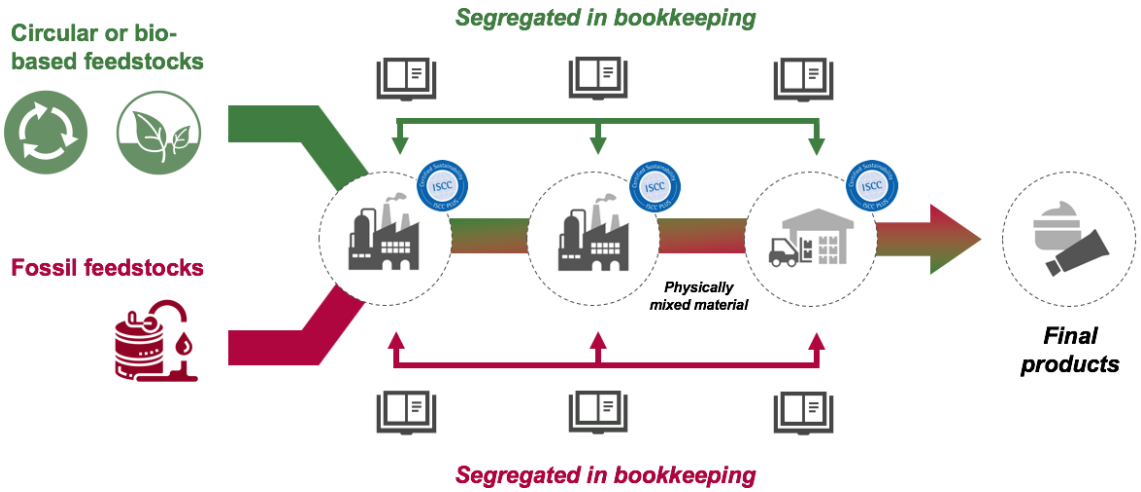


Figure 2: How a mass balance approach can be used to introduce greener feedstocks into product supply chains. This image was taken from the ISCC mass balance approach webpage and is used with their permission:

Whilst this could promote a transition towards using more sustainable resources, it also has its disadvantages, as accurately measuring and quantifying any element of a mixed material is difficult. Some also argue that this mixing may lead to further complications when it comes to waste disposal or treatment, and make it even harder to recycle the sustainable component. Whilst mass balance can be used as a tool to accurately certify products are made from renewable and sustainably sourced feedstocks, and create renewable products with the same quality and performance as 100% fossil fuel based products, mass balance cannot keep track of every renewable molecule or compound that is placed in the mixed material.

Different accreditations exist to award certification to products and companies that use renewable resources from sustainable suppliers with a mass balance approach. For example, ISCC accreditation is often sort by businesses in the chemical sector to verify and certify independently that sustainability sourced materials are used in their feedstocks and/or products. For example, the ISCC PLUS mass balance approach accreditation has been used to certify that packaging material from Unilever, REN Clean Skincare, Aptar, Jindal Films, SABIC, Borealis and Neste are mass balance approved and have used sustainable resources. As part of the Circular Economy 100 (CE100) network, ISCC and BASF sustainability experts (and

others) collaborated with the Ellen MacArthur Foundation to produce a white paper titled "*Enabling a circular economy for chemicals with the mass balance approach*". Overall this paper "*proposes a mass balance approach with clear and predefined rules as a key way to facilitate and encourage the use of recycled materials*".

Mass balance is already used in the creation of biofuels and in the bioeconomy, with examples such as BioLPG from SHV Energy, polyols supplied by PerSTOP, and polymers and plastics from SABIC. BASF have also developed their own biomass balance tool, so that those who purchase biomass based feedstocks from BASF can choose if it comes from fossil fuels, biomass or a mixture of both. Woodfuel supplies in the UK can also follow mass balance accreditation, which combines the Timber Standard with a mass balance approach.

When considering mass balance, carbon footprinting must also be considered. Carbon footprinting is measuring and assessing the amount of greenhouse gas emissions that are produced in the whole supply chain or lifecycle of a product (depending on your area of focus within the supply chain). These numbers are often quoted as carbon dioxide equivalents (or CO_2e). This measurement can be tailored to measure all carbon based greenhouse gases, such as methane and CO_2, and according to the Greenhouse Gas Protocol can also be used to measure non carbon based greenhouse gases. If care is not taken, a mass balance approach may have a larger carbon footprint than simply using fossil fuel derived materials. Whilst mass balance therefore perhaps provides a way to incentivise and encourage the use of renewable feedstocks, it may inadvertently create a larger carbon footprint. Both metrics must therefore be considered when improving sustainability and employing more circular economy principles. Scope I, II and III emissions must all be considered to also avoid misleading carbon footprint measurements.

Whilst mass balance is not completely 100% reliable or perfect, it is arguably one of the only ways to transition away from our reliance on fossil fuels and towards a renewable chemical sector, as this technique offers the opportunity to gradually replace fossil fuels, rather than a sudden and disruptive transition. Using a mixed supply chain approach may also increase product security if supply chains are affected. It can also encourage more accurate tracking of supply chains, chemicals and product manufacturing.

- It was highlighted that the RSC often publish "Explainer" based documents, which are written for non-experts about certain technical fields, to help people understand an area of chemistry more clearly and the current issues surrounding this area. Perhaps a similar approach could be used to tackle poor understanding when it comes to chemical recycling. It was also suggested that perhaps The Environmental Agency could produce an overall arching document to help guide organisations. A common theme of "*Who should set the guidance?*" was also mentioned by many participants.
- Tying in with this theme, it was argued that by some that there are less issues when it comes to chemical recycling on a national level perhaps, but that more issues occur on a local level and perhaps with overall waste harmonisation. There is no UK-wide guidance and no UK-wide education going on to inform plants and local authorities what to do when it comes to waste and recycled content.
- More financial support and guidance for SMEs and others, in terms of dealing with and understanding mass balance and other plastic issues, needs to be given on a national level.
- Extended producer responsibility (EPR) has clear guidance and standards, but chemically recycling is lacking in comparison.

- Packaging recycling evidence (PRN, aka Packaging Waste Recovery Notes) was also mentioned, as a key requirement for issuing PRN is to demonstrate value product. As chemically recycled products may be used for both materials and energy (for example fuels), this value may be more difficult to demonstrate.
    - One participant stated that "*it is imperative that the incineration argument is put to bed and is considered recycling rather than energy recovery.*"
    - Another stated "*we are not measuring materials in terms of mass, but in terms of energy. That is where difficulties come in. For example, it is hard to know where oil from a recovery process ends up.*"

- Another participant also stated that "*mechanical and chemical recycling are too different to compare using LCA analysis, as there are too many differences. This has to be understood.*"
- Public perception around this was also mentioned as a key point, as there is a current bad perception around incineration plants. Educating the public about these methods must therefore be performed, to get the public on board, future investments, and to truly enable people to see the distinction between chemical recycling, pyrolysis, and incineration.

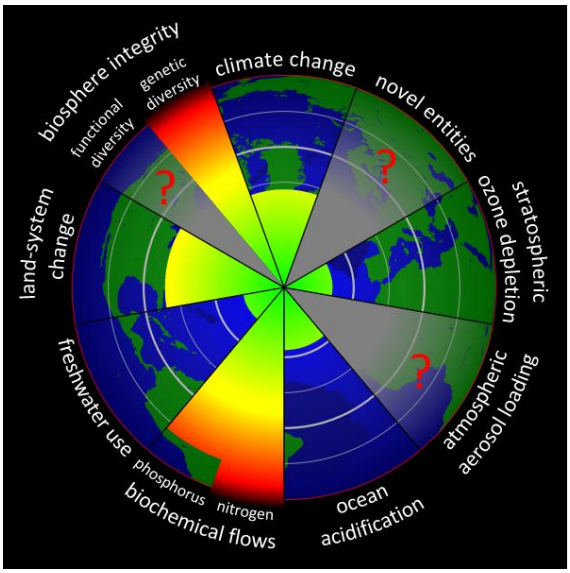
- Using technologies such as blockchain for waste to track waste and verifying recycled content in the future, as well as other new waste tracking tools, could be helpful. These are always difficult to implement though, and this may not happen any time soon.
- Labelling (or lack of it) was seen as a major issue with recycling.
  - This may simply be a binary YES/NO approach to what may be recycled. Could labelling be used on products and/or processes?
  - There needs to be better communication, especially if materials cannot be recycled, as labelling even packaging waste can be misleading and overload the consumer.
  - "*Different supermarkets using different means for other retail elements (chocolate, coffee) is confusing and often overwhelming."*
  - It was mentioned that it is easier to engage with policy makers when doing something practical, such as perhaps proposing a labelling system. This can encourage more informed decisions to be made, reduce barriers to engagement, reduce carbon emissions and so on.

- The lack of transparency from plastic producers also makes it very hard to understand actual composition of packaging. This needs to be addressed.
- We must make sure though that we do not "*Reinvent the wheel*", as there are already similar schemes in place in other industries that could be adapted for plastics, which could be copied for little work or effort. "*The challenges the plastic market faces are identical in nature to fossil fuels,"* therefore we should learn from others and collaborate with other markets"
- **There will always be a loss in the process**, the trick is to understand this and track it as much as possible. "If the recycled **input** is 50%, is the recycled **output** 50%?"
- Whatever we decide to use it much be appropriate, across industry (i.e., mechanical, and chemical recycling) and have an industry agreed standard.
- The UK is at a game-changing point, where it will either now decide whether to fully go down the chemical recycling route or to skip to the old habit of sending waste abroad for someone else to deal with.

Theme 2: Measuring impact of recycling

- It was unanimously agreed that all aspects of a process must be measured to truly monitor the impact of recycling. Measuring aspects such as air quality, water, biodiversity, land-use, and resource efficiency and waste reduction, were all classed as important factors to measure and monitor.
- Some participants noted that we need to look at changing design principles to consider the environmental importance at all stages of the lifecycle: including design, manufacture, use, and decommissioning. This includes the automotive, construction, and textiles industries and is therefore not just a "chemicals" problem.
- One participant highlighted that often if a resource is not respected (e.g. water), then little care is given towards that resource, which in turn will hinder its preservation and protection in the future. "*Until we can truly see water as a finite resource, and therefore give it the respect it deserves, we will continue to see problems with water. No one values wastewater or truly understands the overall journey and importance of water".* By further detailing further aspects that must be considered when dealing with water, such as geography (which affects the availability and abundance of water across the UK), different policies across the UK due to devolution, and distance between water sources and houses, it was highlighted that these are all common issues with other measurable environmental impacts.
- In terms of Biodiversity, it was noted and mentioned that chemical pollution can be incredibly hard to measure and therefore determine. This needs addressing.
- Resilience of the market and cost-benefit analyses can also be used to measure impact. We also need to consider carbon savings, not only in emissions reduction terms but also in monetary terms.
- Despite discussing many different environmental impacts and factors, it was agreed that all measurable environmental factors and inputs should be treated equally.

- Rather than measure chemical recyclers directly, indicators which support a market pull for recycled materials were considered more desirable. "***More indicators should be used that drive circularity***".
- On the note of using LCA and other metrics to measure many environmental impacts, such as water depletion and land use, it was noted that whilst understanding and use of these tools have increased, a lot of people still see LCA as "*a magic number that tells you everything you need to know, and if a poor understanding is used to generate this number, then it will tell you the wrong thing or this number can mask many negative attributes. There is no magic silver bullet, which lot of people wrongly think LCA provides*."
- This ties in with the aspect that a lot of people want a simple yes and no answer when it comes to picking technologies or trying to be more sustainable. It is never this simple, and the large number of impacts to understand and measure can cause issues, but sadly many still do not understand this. *There needs to be a common understanding of how to use LCA, its limitations, and what the boundaries should be when measuring a process. Should we measure all Planetary boundaries? I know when analysing my process, that a lot of things come in that I am not measuring, and a lot of things go out that I am not measuring. Is it the right attitude that I ignore these inputs or outputs? If not, how far do I measure? There is no common consensus as to where the start and end points are.*



- LCAs are also difficult to compare, as each is based on different approaches and often no one understands the comparisons they are making with this data. Defining LCAs is also hard as so many different standards exist. There is also no overall agreed LCA approach to measure recycling, both in mechanical and chemical recycling, which makes it difficult to measure the impact.

- Interestingly, one participant stated that "*We can't compare chemical to mechanical processes as they are doing very different things, the processes are complementing and are not an either/or choice. We need to compare chemical recycling to other options of End of Waste, incineration, landfill and do nothing, but this is still not necessarily a straightforward comparison.*". Whilst this comment is understandable, it is possible to compare the environmental impacts of the whole system. This comment perhaps highlights that this understanding needs to be pushed further.
- Another problem with LCA is how do you change your measuring system if you doing a recovery process vs a circular process? There is a difference also if you use fossil carbon vs carbon from renewable resources. You therefore also need to consider "potential" carbon footprints when products are reused.

- "*There needs to be clear ISO standards so that everyone can approach LCA analysis in the same way*". It must be noted that these standards do exist, such as the ISO14000 series, with ISO 14040 (Environmental management - Life cycle assessment - Principles and framework), and ISO 14044 (Environmental management - Life cycle assessment – Requirements and guidelines). The fact a participant said this perhaps highlights that further understanding of these standards is needed, and that LCA guidelines for particular processes are needed alongside the general ISO standards.
- It was highlighted that RECOUP are currently aiming to create a common methodology for different recycling options. WRAP have also done LCA work into plastic waste hierarchy and best disposal options.

- The overall complexity of measuring many different systems was also discussed and highlighted as difficult to overcome.

- Tying in with this, a main issue is that people do not really know what they are actually trying to achieve. "*Are we trying to increase recycled content, or reduce carbon intensity?*" Current policies are too weak and lack definition.
- SMEs often encounter the issue of how can they afford to measure and reduce their carbon footprints, and accurately? Large companies often have environmental groups and can easily commission LCAs, but SMEs do not have this ability and therefore often hit this barrier.
    - Peter Styring is to take recommendations to DEFRA on behalf of CircularChem on how the financial burden on SMEs can be reduced. As a first measure the Global CO_2 Initiative LCA/TEA Guideline document will be disseminated through CircularChem on the webpage for this event under "Useful Documentation".
- One interesting comment, although perhaps controversial suggestion, was "*would monetising the impacts and metrics enable businesses and others to understand what is more costly?*"
- Carbon dioxide can be a key driver of sustainability and measuring impact, as it is real, relevant, and relatable, but we simply cannot focus on just this variable, and it can be given an overriding importance sometimes.
- One challenge with measuring is the poor quality of available waste data. New waste data tracking tools are being developed, and there has been an increase in data availability, but there is still uncertainty about data reliability. Waste companies are also often reluctant to share what they consider to be market sensitive data and data sometimes "*cannot simply be given away*".
    - Can we implement mandatory reporting and hope true and transparent data is reported? Assurances are need in terms of the quality and reliability of published data as well.

- The issue of who should be measuring impact and the data was also brought up, as well as uncertainty as to who should measure what and how far. There needs to be more clarity and people also need to understand much better that nothing will come cost-free.
    - Is it right for impacts to be solely placed upon the recyclers, rather than prevailing market use of materials, additives, etc.?

- "*We need to shift the onus onto manufacturers and designers, the producers – to remove the composites or other materials.*"
- It is too easy for problems to be pushed down a product line, and to make someone else (for example the recycler) have to deal with the burden?

- Who should also validate the waste data and other data streams, i.e., the Environment Agency? "*Who will police the system? Where does true accountability lie?*" Validation is already practiced and considered in other material streams, such as batteries. Some companies may also work across these multiple streams, so we should ensure that cross-stream learning and consistency of approach is applied across the UK. Lack of funding and resources however often hinder the ability of agencies to validate systems.
- One participant highlighted that one issue in the chemical recycling sector, large companies and SMEs all need to jump through the same hoops, but do not talk to one another in fear of leaking trade secrets. There also is not enough trade organisation in the chemical recycling sector
  - *"If CircularChem can act as a cross-competitors voice in the chemical recycling sector, this will help small companies, developing technologies and also guide small companies to understand policies, and thus grow and develop."* CircularChem will begin the process of setting up a trade association with the aim of acting as the authoritative voice for a circular chemical economy.

Theme 3: End of Waste and quality protocol

- Interestingly, many participants in some groups really seemed to think this area needs vast improvements, with some group members clearly frustrated around current protocols.
- Many participants stated that there is a lack of expertise, investment, and collaboration on End of Waste in the UK.
    - Due to a lack of understanding on the chemical side in industry, there is significant inconsistencies within teams and departments
    - "*The lack of a set of End of Waste protocols in the UK is putting a large uncertainty on the market and stifling investment and business development*"
    - Some participants even stated that "*DEFRA and the Environmental Agency need to truly recognise how poor current protocols are*" and were confused as to why Government bodies seem to expect that businesses are willing to take on high risk and expensive protocols. This overall demonstrated that there is a current distrust or unhappiness between certain industrial partners and Government bodies.
    - The only way to approach and solve this problem is through collaboration, with WRAP themselves highlighting that they are one of several partners looking to see in an industrial set of standard and guidelines can be agreed in terms of End of Waste.
- The UK needs to decide if it would be best to issue end-of-waste pathways for specific processes or use a more general approach.
    - Plastic energy has already achieved End of Waste in the Netherlands and Spain based on case-by-case approach, and in a much shorter timeline (6 months vs the current timeline of 18 months in the UK).
    - Specific pathways may be difficult for small companies and new players. However, for a generic approach, it is unclear what to base quality controls on. Should it be based on a specific technology? Should it be based on substances of concern? Should it be compared against crude oil, which itself is harmful?
    - Each customer also requires different specifications; therefore, some participants were unsure if developing a generic quality protocol would be beneficial.
- There needs to be further collaboration opportunities, investments and more guidance for SMEs when dealing with End of Waste. The ability for SMEs to deal with End of Waste compared to large companies is also different "*Small recyclers are losing out at the end due to scale requirements (10,000s pa).*" Obtaining certain recycling goals, *"such as "30% recycled content for some materials is more than possible, for others impossible."* Because of this *"SMEs are often 'shafted' and pay a premium."* This needs to be addressed.
- Some participants highlighted that quality protocols have been replaced by Resource Frameworks.

  - Undesirable elements in feedstocks are often deliberately introduced into the material in production (e.g., plasticisers) although these are desirable for performance improvement at times). Whilst pyrolysis oil customers do not want these in the feedstock, they were added by the same organisation to the product being recycled.
  - Different customers have different quality specifications for valid reasons (differences in quality of crude processed) and therefore there is not a unified customer specification which can be used to inform a quality threshold against which pyrolysis oil can be said to meet end of waste criteria. This therefore must be developed independently.
  - There is also the need to identify whether screening for additives should take place before or after the oil has reached End of Waste status.
  - Protocols for enzymatic recycling may require pre-treatment for these elements.
  - It was also noted that in terms of hazards, substances of concern will keep changing over time. The market therefore must be ready to adapt when necessary.
- It was noted that we will always have waste, but where does resource recovery come into it? This is always a more challenging issue, and we need to "***keep resources flowing***".
  - A DEFRA participant stated that currently there is a lot of focus in this field driven towards End of Waste or End of Life, but in the future, there will need to be more thoughts on longevity in product designs and measuring the whole life cycle.
  - There are always going to be end-of-life plastics, therefore "*methods, such as chemical recycling, is essential to recover these materials*".
- The main difficulty with quality protocol is that there are so many different technologies and feedstocks to consider and each consumer requires different specifications, therefore it is difficult to have a generic quality protocol that can cover all the different possibilities.
  - The case-by-case approach to tackle this can work but has pros and cons.
  - Business can also try and overcome this complexity by shifting the End of Waste status away from their plants and products onto someone else.
  - *"A holistic approach is needed due to the large number of outputs."*
- The need to address mixed waste and contaminated (e.g., medical) waste was identified as an area for prioritisation, in order to recycle as much material as possible back into the economy.
  - PET trays are often used in medical environments and virgin PET is preferred. Is this something that can be addressed through chemical depolymerisation perhaps?
- One solution to the waste issue is to make sure that companies have appropriate waste acceptance criteria. We need to increase our attitudes pushing towards a simple "*we would accept this waste message*".
- If we really want to reduce waste, we need careful process design and clear policies to push towards low waste goals.

- *"Design for End of Life needs to occur more in the plastic field, on the same level as other sectors".*
- Using a Hub and Spoke model (a distribution method in which a centralised "hub" exists), when designing industrial plants to deal with waste and recycling onsite, was highlighted as a potential positive model to use moving forward.
- Waste crime is a big problem in the UK, and whilst the reality of measuring everything and monitoring waste crime is truly difficult, more must be done.
- There needs to be further honesty and transparency with *"the admission of not meeting recycling targets due to excessive costs*.", without the fear of branding and overall image being damaged.
- One participant stated that "*I believe we are using the wrong word when we say 'waste' and we need to change our wording around the term 'waste'. If we could view 'waste' as a valuable resource, which we could advertise and sell to other companies who are interested in this 'waste', then that would change attitudes completely."*
    - The CircularChem Centre itself wants to change the view that we are not re-using waste, **but instead moving carbon through the economy**.

- There are certain things that can never be avoided with waste though and we must be realistic.
- Discussions must also occur with other country authorities when dealing with End of Waste, especially those who buy and use UK-based products. Authorities (local and national) must also provide more support in terms of developing and approving quality protocols.
- The issue of recycling and REACH regulations was a common topic.

- *"If any substance derived from 'old material' replaces something of virgin, then surely it must be classified as recycled and not waste?"*
- It was noted that changing terminology can perhaps (in a positive and negative manner) get around REACH regulations, for example the aluminium industry can often get around REACH by using the term 'scrap' rather than 'waste'.
- Truly knowing when it is safe to change the term form 'waste' to something else though needs to be considered and could cause issues if approached in an incorrect manner.

- *"Policy needs to come from End of Waste, otherwise we are not going to move forward."*

Overall comments and discussion points raised following breakout session 1

For a true circular economy to be in place, many participants agreed that we need to "*largely*" stop fossil-carbon use. The question was also raised as to whether it was possible to define when we do and do not require virgin polymers, to help reduce waste and encourage a more circular approach to using plastics. Medical and Food Grade polymers were highlighted as an example of polymers that need to be addressed. Automotive plastics are also becoming an issue especially in decommissioning and EV production. We need to plan now for the time when fossil carbon cannot be used. Many sectors are also looking into similar problems, so it was suggested that the opportunity for cross-sector learning may be advantageous.

There was a clear agreement amongst participants that legislation needs to be redefined and current processes often are slow. Lots of legislation is also subject to interpretation, thus representing a high investment risk if companies must rely on case-law. One respondent from DEFRA when asked if they re-evaluate laws mentioned that this is done through a consultation process with stakeholders, which itself is a lengthy process, and public views can be taken and considered at the same time. One participant even noted that they believe there are issues with how DEFRA and other departments in Government focus on policy. "***I feel there is some resistance to having technical expertise in policy roles***".

When the same participant from DEFRA was asked what we all can do to work with policy makers more effectively, the response was given that clear clarification and identification of the issue, is paramount, solution discussions are key, be concise, and aware that DEFRA use an evidence-based and opened minded approach. They stated that they are keen to also deliver outputs that are cross-government and to therefore work with the devolved administrations as well.

Overall, there needs to be ongoing conversations discussions with DEFRA and other government services across the UK. When giving evidence to calls from DEFRA and others, there was a consensus that these calls need to be more specific, as enquiries often struggle with broad statements. If any contradictory statements are made, they must be backed by evidence, with discussion also occurring at high official levels.

Many participants themselves asked the question "*How will the transition to a circular economy be financed?*" There may need to be fiscal interventions with incentives through the Environment Act, which could be achieved through enhanced curb side collections, extending the producer responsibility scheme, and simplified binary labelling. The Plastic Packaging Tax

(HMT April 2022) may also serve as a guiding example. Overall, there should be a monetary incentive to recycle.

We need to find processes that can accelerate guidance, e.g., policy amendments, guidance documents, and we need to be flexible within the rapidly changing landscape and current environment. In the current approach, many different councils and environmental agencies who need to be involved across the UK, require convincing on dealing with waste issues on a case-by-case basis. This method is inefficient, and each council and agency require clear guidance documents to truly understand recycling and best-case scenarios when dealing with waste.

Comments that were submitted by participants online via the specially created MURAL boards for this event during the WRAP breakout session are shown by Figure 5, Figure 6 and Figure 7 in the Appendix.

Breakout Session 2: CircularChem Led session

In the second half of the workshop, CircularChem gave a presentation on their current policy engagement approach and how they plan to develop new policies at the Centre (as presented by Peter Styring and Katie Lamb). Questions related to three key themes were then discussed during the second breakout session (Figure 3).

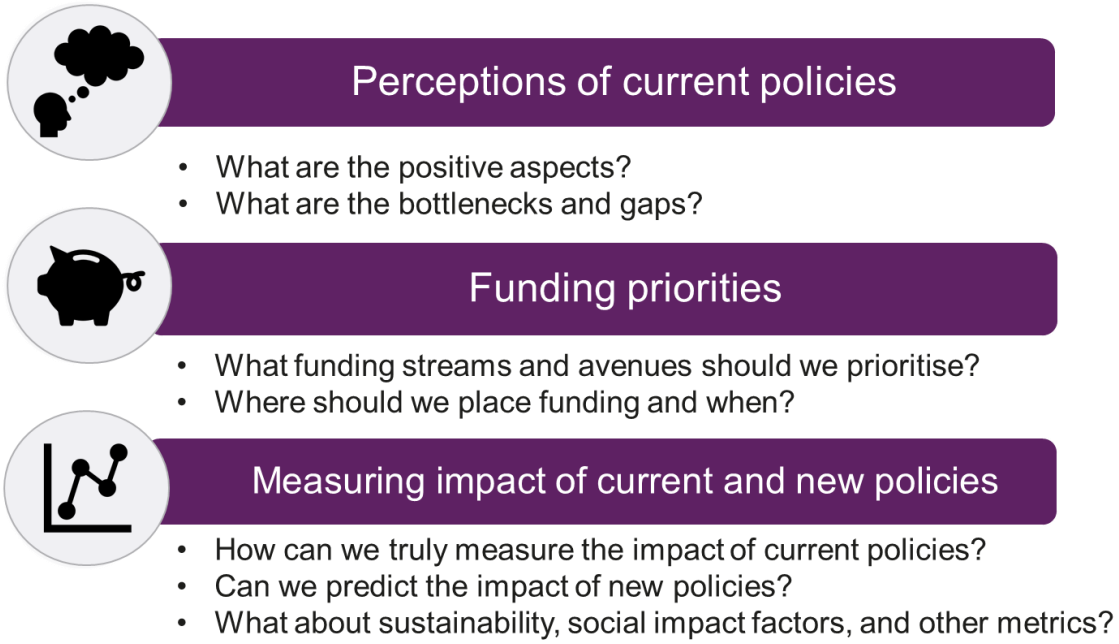


Figure 3: The three topics and underpinning questions presented to attendees for the second breakout session.

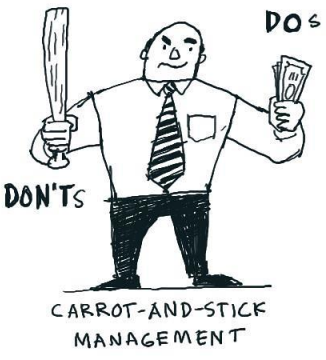
Theme 1: Perceptions of current policies: positives, bottlenecks, and gaps

Overall, people had more negative aspects to list about current policies than good ones, and there was a consensus that more is needed to address problems and gaps with current policies.

- Pending UK Government strategies and consultations, such as "The Biomass Strategy" and the existing consultation on "Towards a market for low emissions industrial products" were seen as opportunities to create incentives for more recycled materials. Current incentives such as Renewables Obligation Certificates (ROCs) are also seen as positive steering tools.
- Tying in with this, the use of policies to encourage markets could positively promote best practices rather than doing the bare minimum (e.g., the plastic packaging tax could have a sliding scale incentivising higher recycled content).
- Waste uniformization in current policies is seen as positive, but there is the risk that most councils will delay adaptation as much as possible. Therefore, a focus should be placed on

accelerating the transition towards waste uniformization, which will increase availability of high-quality materials to feed recycling processes.

- Participants overall agreed that the general overarching policies are there, with elements of a circular economy strategy also in place. Major key issues though still need to be addressed, as many policies "*are well intended but fragmented and unclear, especially for recycling*".
- It was felt policy was increasingly taking a systemic approach, using scientific research to make an evidence base, which thus informs policy.
- Many agreed that more policies are being written now with an understanding that behavioural change is needed alongside new policies. More efforts are being made to teach and inform the public why these behavioural changes are necessary, so that the public themselves understand the policies, and are more likely to see the new policies as a driver for good rather than a burden.
- More pushing towards the leasing of products and/or services also needs to be addressed.
- An overall theme of these discussions was that policies often talk about "*ambitions*" rather than "*goals or targets*", and current policies are often out of date (>5 years old) and lack hard targets, especially across the devolved nations.
- Two negative strands or aspects that were mentioned include the fact that "*there is a fundamental mistrust*" between business makers and policy makers, and current regulation issues.
- In general, there is a mistrust as to what recycling actually involves, and how companies can do it, especially on an SME level or new companies that are just starting. It is so difficult for new companies to trial and research how they can be more sustainable, as they to spend lots of money and take more risk to effectively evaluate the circularity of their system. No business will invest £100Ms on technologies seen as intermediate solutions without any guidance or clarity.
    - Should policy "***be the carrot or the stick****? SME's do not have enough money if policy acts like a stick*". On the other hand, the stick can lead to effective change (for example the carrier bag levy although this has had many unforeseen negative impacts) but needs to be managed effectively and the counterfactuals researched thoroughly.



- A lot of IPs are also refused, which means it is often hard to get things trialed at a pilot scale.
- In practice *"there needs to be a consistent delivery of regulation, across SME's and large-scale business"*. The issue of waste crime was again mentioned, as there is no real handle on this and new policies are needed to address this issue.
- REACH, legislation, and the requirement of multiple permits for polymer producers to deal with waste management and incineration was highlighted as a common burden. "*Having policies in place to reduce these barriers would help a lot of projects.*"
- Another current challenge lies around the definition of recycling. We need to ensure that recycling is not limited to like-for-like recycling (i.e., plastic bottle to plastic bottle), but also allows more flexibility. Secondary material use may be favourable from a LCA perspective than enforcing closed loop recycling. This is particularly important within the chemical sector, where the same olefin can be used for a wide range of different products.
- Another hindrance is the fact that there is no overarching policy on chemical recycling. "*The overall lack of policy on how waste becomes a resource shows how there is a poor attitude in Government*".
    - General opinion was that there is scope for all types of chemical recycling technologies, except for those focused on energy (fuel recovery). These need to be assessed on case-by-case basis.
    - There were no perceived problems around the permitting process itself, but major uncertainties still surround how to truly achieve End of Waste.
    - "*How can companies know for sure that their materials are truly being recycled?*"
    - If there is a chemical recycling solution, but you need an incineration licence, you can still be categorised as a recycler. As an example, there is a growing consensus in the UK Government that if you are turning something into an oil-based product, even if it is a mixed product, you can be considered as a recycler. However, there is some concerns around whose responsibility it would be to check and track if refineries are truly recycling.
- There was also considered to be a lack of awareness, and discussions occurring in a wide context, of petrochemicals in non-packaging products (e.g., shampoos). Raising this awareness further with policy makers was identified as a requirement, and there needs to a better understanding of potential recovery of petrochemicals from sewage.
- In terms of current regulation examples, there is the national waste strategy from the UK Government which DEFRA are a huge part of, which involves collecting data and waste information from companies across the UK. However, there are so much data generated, more than one person could ever comprehend, that it is *"truly really difficult to track all of the data*

and to really see everything that goes in and out of a product line". There is also no overall UK-wide waste strategy.

- There was a push in the past for Governments to show that waste strategies were predominantly focussed on protecting human health, and therefore any other aspects such as environmental factors were not given a high priority. The world has moved on now and we need to consider other aspects too. Governments working on problems to increase their good public perception, rather than a matter of urgency, is a current issue with setting up policies.
- It is important to also think about how strict any policy should be. I.e., should it only consider hazardous chemicals or plastics, or be more inclusive? We also need to allow "*a weighing off of different factors*", e.g., increasing carbon circularity and environmental protection vs incremental price increases.
- Should policies also be more legislative in nature, or more advisory and guidance based? It is important to note that voluntary commitments also have impacts, such as increasing interest in recycling technologies.
- There was a scepticism around introduction of plastic tax amongst participants, as there is no guarantee this will be reinvested into the system to increase sustainability. It may also lead to market distortions, and some companies may prefer to just pay the tax than drive towards change.
- It was generally agreed that we need to avoid a carbon tunnel vision, but the issue of how and which metrics to prioritise was raised (Figure 4). Ultimately, we need to slow down the flow of resources, so that we can become more circular. If there are no resources that we can just take and deplete, then the need to become circular increases.

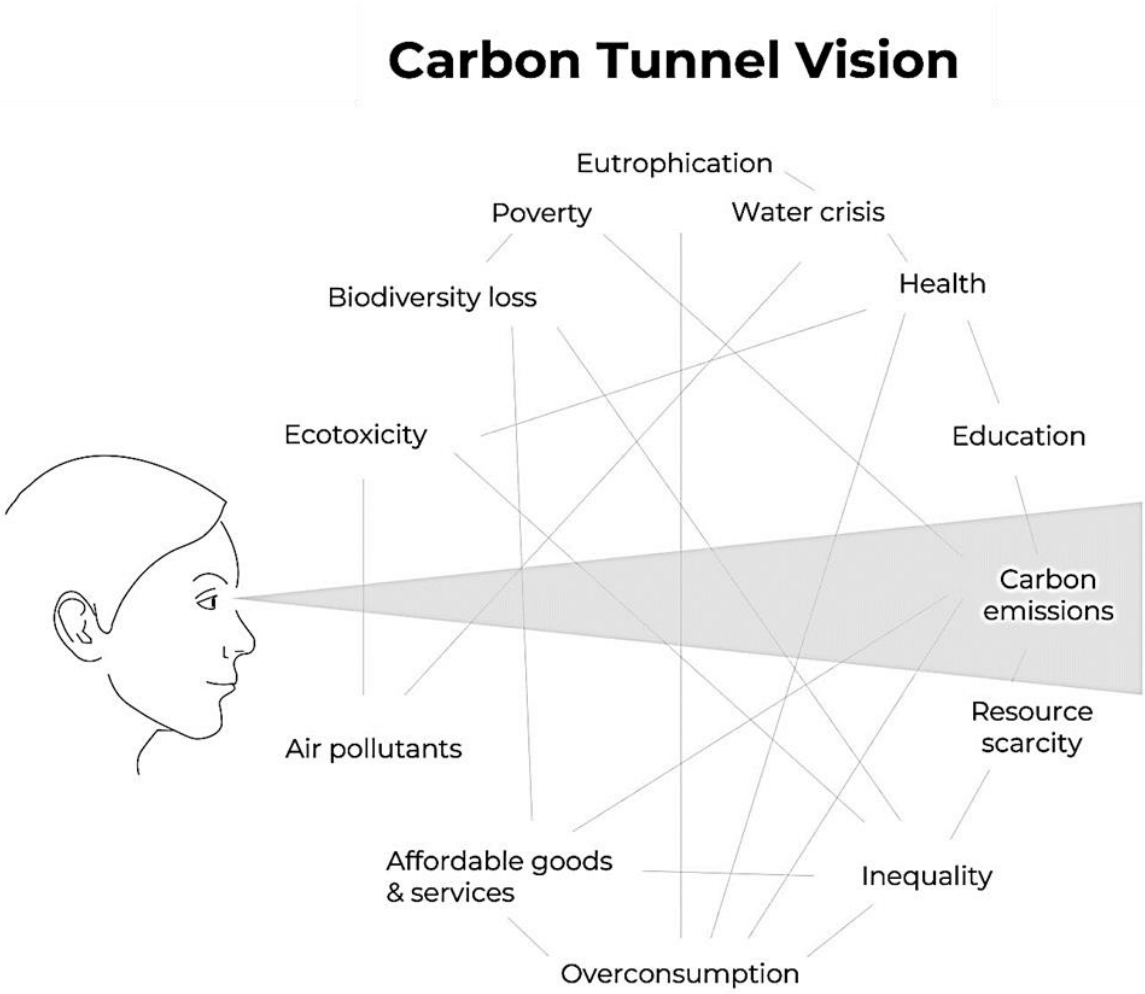


Figure 4: The potential issue of employing a "carbon tunnel vision." We have to tackle CO_2 emissions, but it must not be our only focus. We need to consider social responsibility, social impact factors, and other sustainability metrics. This figure was produced and adapted with permission from Jan Konietzko.[1]

- There also needs to be a better understanding and acceptance that *"recycling should be a last resort and other avenues of circularity should be considered, rather than simply relying on recycling"*. Recycling can also be a barrier, as unless there is an incentive to do it, many people will not address the big change that is needed and stay with what is comfortable.
- One issue that also faces policies is the quickness at which the world is changing, in terms of development, data availability, and the current global issues. This therefore means one weakness of many policies is whether they are still relevant when they are published, with policy publication often taking 18 months.

[1] J. Konietzko; How can we embrace the complexity of the sustainability transition, without getting stuck in carbon tunnel vision?; December 2021; https://www.linkedin.com/feed/update/urn:li:activity:6859418054867083264/; Last accessed 18/11/2022

  - This is a long time for businesses to wait and therefore creates a huge bottleneck for investors, who often simply go to other countries where projects are signed off more quickly.
  - Concern was expressed that the civil service process could be a barrier to urgent action, with frequency changes in personnel meaning expertise does not accumulate with policy makers.
  - A DEFRA representative stated that DEFRA is aware of this issue and highlighted that consultancy processes are required, and that they need to get things correct right at the start of these formal consultations.
  - It was also stated that the UK Government is aware of the difficulty of accessing recycled content, and that if we do not act soon enough, the chemical recycling industry will die, because it will either be done aboard or "*waste incineration will go through the roof*".
- As discussed in earlier conversations, proper cost-benefit analyses must be addressed in policies.
- Abrupt and expected changes in regulation and policy do not help, as often changes in one part of a production line means the whole system needs to be changed, which in turn costs money and can encourage poor management of land, water, waste, and resources.
- "*Better communication and collaborations between industry and academia, and with the Government as well, will lead to better and stronger policies."*
  - Participants reflected that they feel that a very solo based approach is currently used in Government, with each department having its own agenda, pulling in different directions, and not talking with one another, for example "*Waste want to create new plastics and transport wants to burn them for low hydrocarbon fuels. These are potentially two conflicting approaches.*"
  - This is a huge bottleneck, and we must have a more joined up approach, as well as between all the devolved nations.
- **There needs to be better interconnectivity overall in the policy sphere and a national strategy**.
- Current policy often appears to be influenced by opinion rather than evidence. This may result in unintended consequences. There is a risk that the recycling of one material (e.g., plastic) can impact on business models and other materials flows. For example, companies could simply replace part of their plastic packaging with other materials to avoid paying plastic tax, without consider the knock-on consequences of supply chains etc. This may result in both reduced recyclability and higher emissions (from e.g. the transport of heavier materials), and thus no real positive impacts.

Theme 2: Funding priorities

Overall, many participants believed that funding is not currently given to areas of high importance and is often difficult to access. Not enough funding is available, and the clear lack of public funding is a big issue.

- Some participants stated that there needs to be a plastic tax (although participants in earlier conversations stated scepticism about implementing a plastic tax) to fund research and technology development. It is critical to support new technologies through the 'valley of death'.
- We also need to develop clearly defined criteria for selecting which technologies to fund now and in the future. This could be difficult to determine due to the rapidly changing landscape.
    - For example, only 10-15 years ago, most companies did not see any value in chemical recycling or pyrolysis technologies, but now most companies see this as a priority due to factors such as increasing value of recyclate, sustainability concerns and LCA providing evidence for viability of these technologies.
    - The chemical recycling industry was considered by many to have insufficient knowledge of potential funding markets.
- Interestingly, it was questioned whether "*having a committee decide who gets the funding is the best thing to do*"? If they do not understand the challenge or the project, or have expertise in this area, will this stop important projects from getting the funding they desperately desire?
- One big area where more funding is needed is anything to do with public engagement and social aspects. It was mentioned that lots of public and council-based jobs and sectors that dealt with recycling and waste matters no longer exist.
    - *"If a council can't even have people come round to pick up you bins, then there is no money to help engage the public to trust in the council and any Government-based scheme"*.
    - *"If the public do not understand recycling and its issues themselves, with schemes such as clear labelling and simplification (or invisible markers to correct consumer mistakes) we have big problems."*
- More funding needs to be placed into the UK infrastructure and innovation sphere, as if these do not exist, we will not have the right modern technology and infrastructure in place to deal with waste and recycling on our own shores. *"We will continue to offshore our problems, which we simply cannot do anymore"*.
- There is always an issue of thinking long-term about funding streams. For example, in the Horizon 2020 funding scheme, the UK received the most funding compared to any other member of the European Union. The real innovation and outputs from this funding and research

though occurred outside of the UK. One issue that therefore needs tackling with funding is "*How can we make sure that everything gets pasted down the chain?".*

- Brexit also means that we "*no longer have a competitive edge and burnt the bridge*".
- We ultimately need more policies that encourage more innovation and links between academics and industry, so that "*we can narrow the gap between them and all get on the same path*".
    - Early adopters of technology can benefit, but the risk associated with early investment is greater.
    - We must ensure that research from the lab truly transitions from the lab to an industrial scale and "*de-risk academics, and more so industrialists, from taking on new projects and research avenue, and thus innovation, here and now. We are pretty good at funding the development of technology but not at funding the implementation".*
    - More funding is required to take new technologies up to Technology Readiness Levels 7-9. Whilst funding is available for early Technology Readiness Levels, commercialisation requires further support.
- Longevity of funding must also be guaranteed for future innovation. Yes, we must provide funding now and quickly towards circularity, but we have to think in the long-term and ensure that funding is there for long-term projects, so that they have funding throughout the duration of project. *"We need to have funding reserved for the future problems of the world that don't exist today".*

- In contrast, some participants mentioned that if the technology and processes are viable and can be scaled up easily, businesses should not rely on funding.
    - There is a consensus amongst some that funding is one of the biggest issues for companies. To counteract this, private equity companies can raise funds.
    - Perhaps the issue is more about "*smoothing the runaway*" for firms who wish to expand their R&D aspirations, rather than scaling-up barriers.
    - Size matters as well. Larger companies tend to have the money to invest in R&D, unlike SMEs. On the flip side, bigger companies may act as great partners, but they are also slow to change, whereas SMEs can change and respond to opportunities more quickly.

Theme 3: Measuring impact of current and new policies

This is an interesting and difficult question to answer. There needs to be clear guidance on how to measure the impacts, which in themselves may be very difficult to quantify. There also needs to be clear guidance on who is going to verify claims and check on overall progress.

- Tying in with previous conversations, it was agreed by many that policies need clear targets and mechanisms to help achieve these targets, so that the true impact of policies are easily to measure and define.
- It was agreed that LCA and other metrics can be used to measure impact, but all metrics moving forward need to have three pillars at their core: environmental, economic, and social factors.
    - Example factors to measure include social impacts, job creation, diversity, number of new permits granted and new funding allocations, etc.
    - It was suggested that the impact of policy could be monitored by considering plastic littering data, such as existing studies on the amount of plastic recovered from the River Mersey.
    - We also need more socially driven visions. such as a "*Prosperity on a Net-Zero Transition*" vision.
    - Are there new metrics we need to think of to truly measure policy impact?
- It was highlighted that one issue with *"truly measuring a system is that all measures are relative, as unless you compare a metric value with another, you have no comparison or idea of how good the metric value truly is. You also cannot simply focus on numbers and comparisons, without any true goals in mind.*
- It is too easy to simply use National Statistics without any true understanding of these figures. If you also use simple statistics for hard and complex problems, this can often cause more problems. Complex and more detailed statistics also come at a price.
- There is also an existing difficulty in monitoring materials flows. Impact assessments require accurate measurements of material flows, but there is currently a lack of high-quality data.
- Many impacts from policies are also not immediate and can take a long time to become clear, as well as their final impacts. More policies need to be designed with a clear time scale, achievement stages, action plan, and a clear break up of goals, rather than simply listing an end goal and then hoping people achieve this goal by the time the date is reached. "*You can only measure success in targets, as you are held accountable and can be given repercussions if these targets are not met*". Most current policies do not set out measurable targets. By setting policies which you can re-calibrate, predict to some degree, and re-assess, policy can be changed as time goes on to truly have a better impact and lead to better changes. *"You have the chance of therefore being more accurate over longer time periods".*

- The efficiency of policies set up in Wales was brought up and described as a "*beacon*" of circular economy, as the Welsh Government continually monitor the ability to employ circular economy into their policies, and embeds circular economy into the centre of policies, with the UN sustainability goals always in mind. *"By doing this, the policies in Wales are super clear, whereas any policies that come directly from London or the UK Government in England are not so clear."*
- One important aspect that must be maintained throughout is honesty in terms of our data, especially with our levels of precision and degrees of certainty. We must not be afraid to show our policies, data, or figures to everyone so that any errors can be identified, fixed, and improved. It was noted that this *"approach is a double-edged sword, as whilst we need to be honest to avoid misleading the Government or the publics, this can leave us open to attack and people potentially dismissing anything raised in our policies".*
- On talking about using models to predict the future impact of policies, attendees were overall sceptical, as it would be difficult to create models that can predict environmental, economic and social factors of policy. *It would be too easy to miss a variable when such a complex model is created, and thus create misleading information. It also very hard to avoid including a bias in models."*
- LCA based models could be used in this area, but as *"LCA models are challenging, even when dealing with present issues, so it will be even harder to apply these to future systems and challenges. Models are also only as good as your data. This does not mean that we should not look into using future models (for example implementing a change at small scale is easier to predict) but it would be extremely difficult".*

Overall comments and discussion points raised following breakout session 2

The chemical sector should not wait for policy makers to engage with the sector in a systemic way. The sector should engage across the value chain in a systemic way and engage with policy makers in this manner. The UK Plastics Pact Non-Mechanical Working group was identified as one potential vehicle for this. approach

One participant highlighted that as well as looking at the policy perspective, should we also look at this from the business perspective, as would a circular economy create a shortage of feedstocks? Is the drive to a circular economy founded in environmental or economic drivers? Business CEOs may want to make an impact through better environmental credentials, but may ultimately be dominated and controlled by profits.

Every country and industry each set their own different policies and aims to measure the impact of their policies. We need to understand how each sector does this and align approaches as closely as possible. Developing our policies from a best practice approach, for example by analysing and assessing policies from the EU and around the world, would be beneficial and lead to a less insular approach to policy development and global engagement. Even though we have undergone Brexit, we still need to work closely with the EU.

Policy on waste reduction and greenhouse gas emissions should both align, and actions should be considered in the context of both these targets. "*Circularity is focused on materials, efficiency and resources, whereas net-zero is focused on carbon emissions. In the future more dimensions need to be added. At the same time policy needs to be more open for other metrics.*"

Social acceptance and public engagement are also important, as we need to have a clear message down to the individual level. More leadership examples also need to be more openly displayed, with better communication of good news and examples, and less contrasting information from different sources. If people think everything is doom and gloom, they may not even try and give up at the first hurdle.

Overall, there was a consensus that we need to act more quickly and do much more to produce effective policies. *"It will be best to act now and set the foundations for the future than wait before you are penalised"*. One participant stated that there is often a "*Rush ..... into reporting and collating data, which is great, but more efficient connections of all the dots is required. This workshop is an example of that and more workshops like this are needed*."

Comments that were submitted by participants online via the specially created MURAL boards for this event during the CircularChem breakout session are shown by Figure 8 in the Appendix.

Conclusions and Recommendations

Overall, numerous opinions were captured during this January workshop event, in terms of creating a circular economy when it comes to recycling, chemical recycling and also the current impressions of policy development within the UK.

Accurately measuring and tracking chemically recycled content is still being refined, with mass balance and carbon footprinting both with positive and negative aspects. Many argued that a deeper understanding of mass balance, as well as other guidelines such as PRN and EPR, across

all stakeholders is needed. Labelling of recycled products also needs to improve. The UK is at a vital turning point where it needs to decide whether to perform more onshore recycling, or to send waste abroad for other countries to manage

The whole lifecycle of materials used to make products, including those that are recycled, must be measured, regardless of the challenge and complexity. Further understanding of the metrics employed, and those that promote circularity, is also needed, to avoid falling into the trap of seeing metrics as providing a 'silver bullet' answer. An appreciation, transparency and honesty regarding the data used to produce these metrics is also essential.

End of Waste and quality protocols need to be improved across the UK, with policy and Government deciding whether to set broad rules or refined rules for each individual process. General understanding again could be improved in this area, with an appreciation of when resource frameworks come into play, and keep REACH regulation and future policies in mind. We will never eliminate waste, but we need to keep materials and resourcing flowing regardless.

Policy development was deemed as too slow to respond, performed too often in "a bubble" and occurs with low engagement with the public and other stakeholders. Whilst this in reality may not be the case, and current policy making processes in the UK cannot change overnight, it is undeniable that those in attendance felt that improvements are needed. This indicates that more communication and understanding between the policymakers, academia, industry and finance (and all stakeholders) is required.

Prioritising decisions when it comes to funding will always be difficult. Create funding resources that are resilient and provide longevity for new innovation, SMEs and other research avenues are vital. Measuring the true impact and efficiency of policies is no easy task, with some impacts resulting in qualitative data rather than quantitative data. Creating long-term policies with clear targets and goals (during the whole lifetime of the policy rather than simply at the end), which can be adjusted in line with data growth, global issues, global policies, and technology development, are needed. Policies must also be written with honest and transparent evaluations occurring within timely intervals during the development process.

In terms of recommendations, it is clear that more guidance and knowledge across all stakeholders is needed, in order to truly implement a circular economy across the UK and global chemical sectors. Further collaborations and discussions are also needed across all stakeholders, with an appreciation of all stakeholders and views, without pushing the blame

into one area or simply stating this sector must provide the answer. This inadvertently just pushes the problem further down the road, as it creates a sense of “This is not my problem” if care is not taken. Social impacts and public understanding is required for both chemical recycling and policy development, in order for both to develop and to have success.

A general consensus was conveyed at the workshop that the circular economy is slowly being used more and more in policies, but is still fragmented and disjointed across different sectors. The CircularChem Centre may be looking (currently) to address olefins in the UK chemical sector, but it is clear that more guidance and direction is needed for all stakeholders when it comes chemical and non-chemical recycling and policy development. A future aim of CircularChem (in conjunction with WRAP) will be to set up an association, in order to and address the points and issues raised by participants during this workshop.

Appendix

Screenshots of mural board comments captured during Breakout Session 1: WRAP Led Session

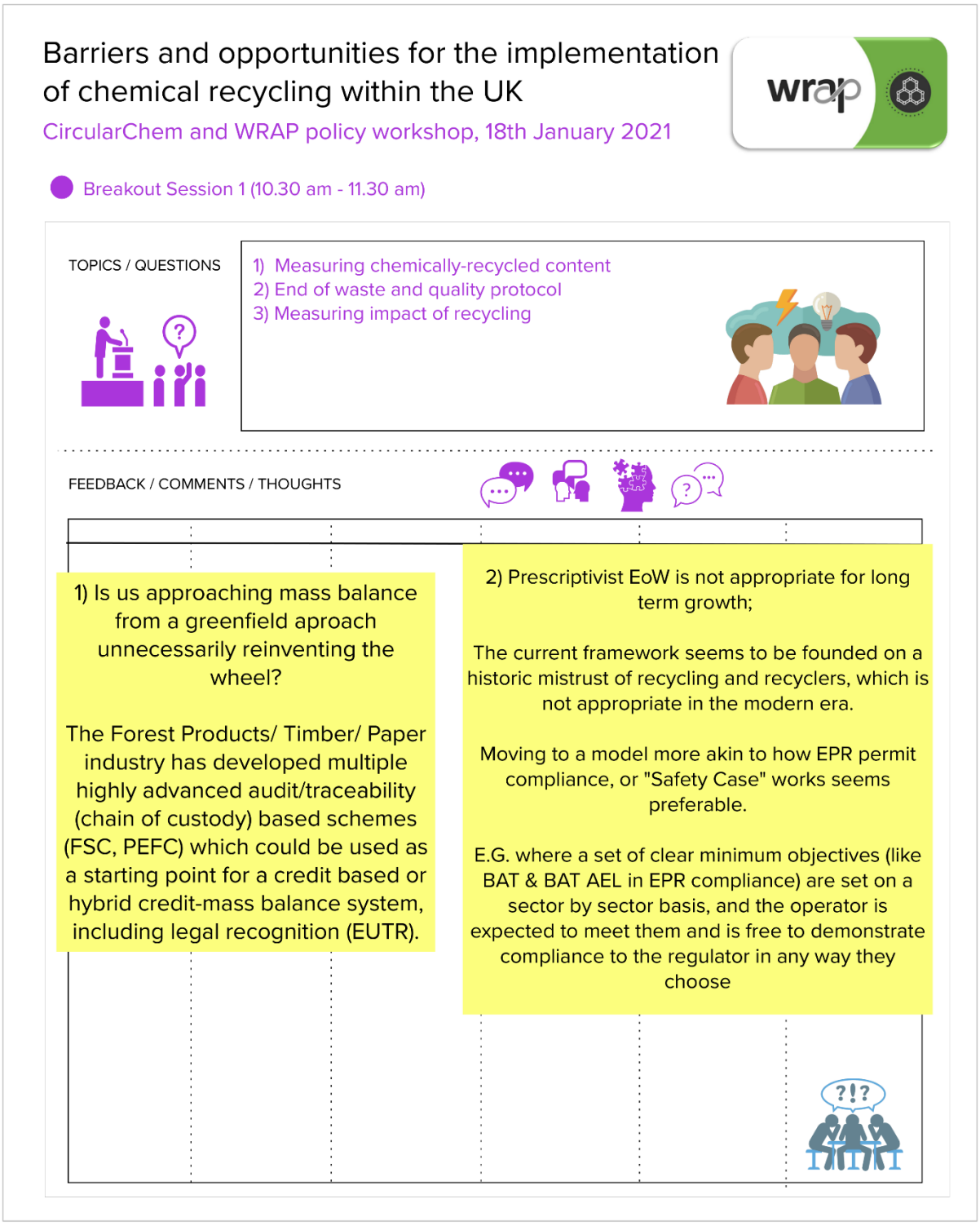


Figure 5: Comments left on an online MURAL collaboration page during the first breakout session (1 of 3).

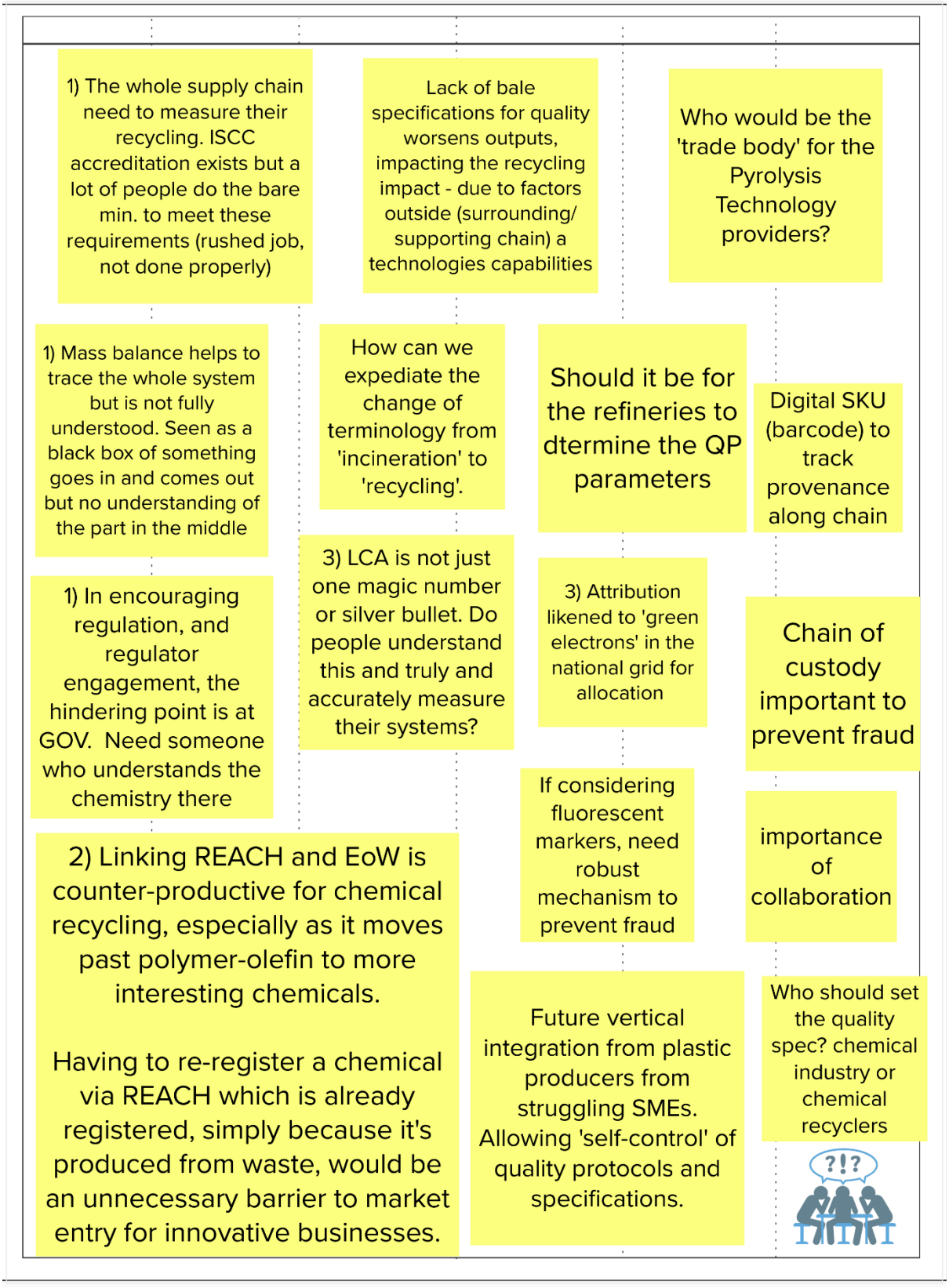


Figure 6: Comments left on an online MURAL collaboration page during the first breakout session (2 of 3).

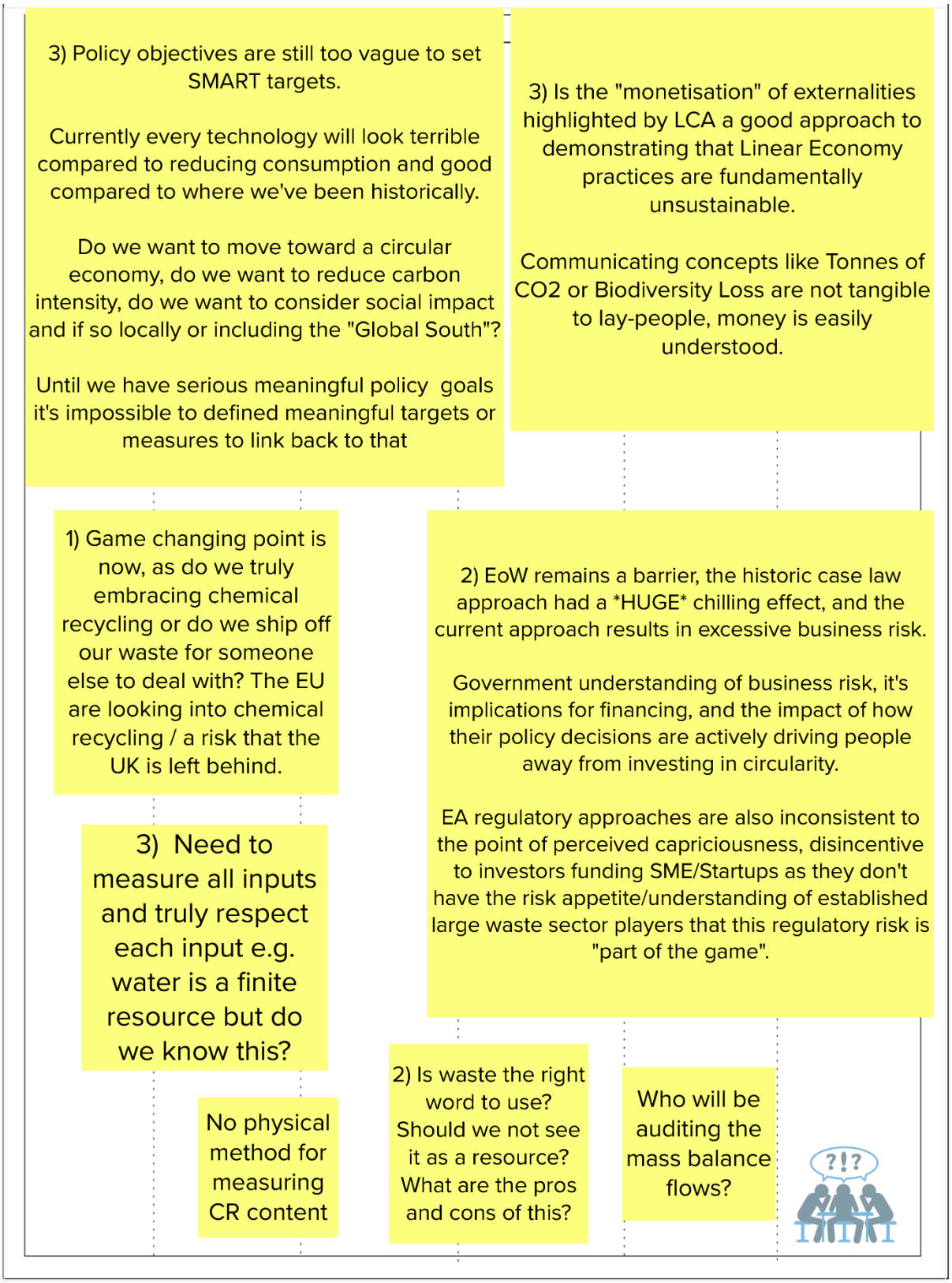


Figure 7: Comments left on an online MURAL collaboration page during the first breakout session (3 of 3).

Screenshots of mural board comments captured during Breakout Session 2: CircularChem Led Session

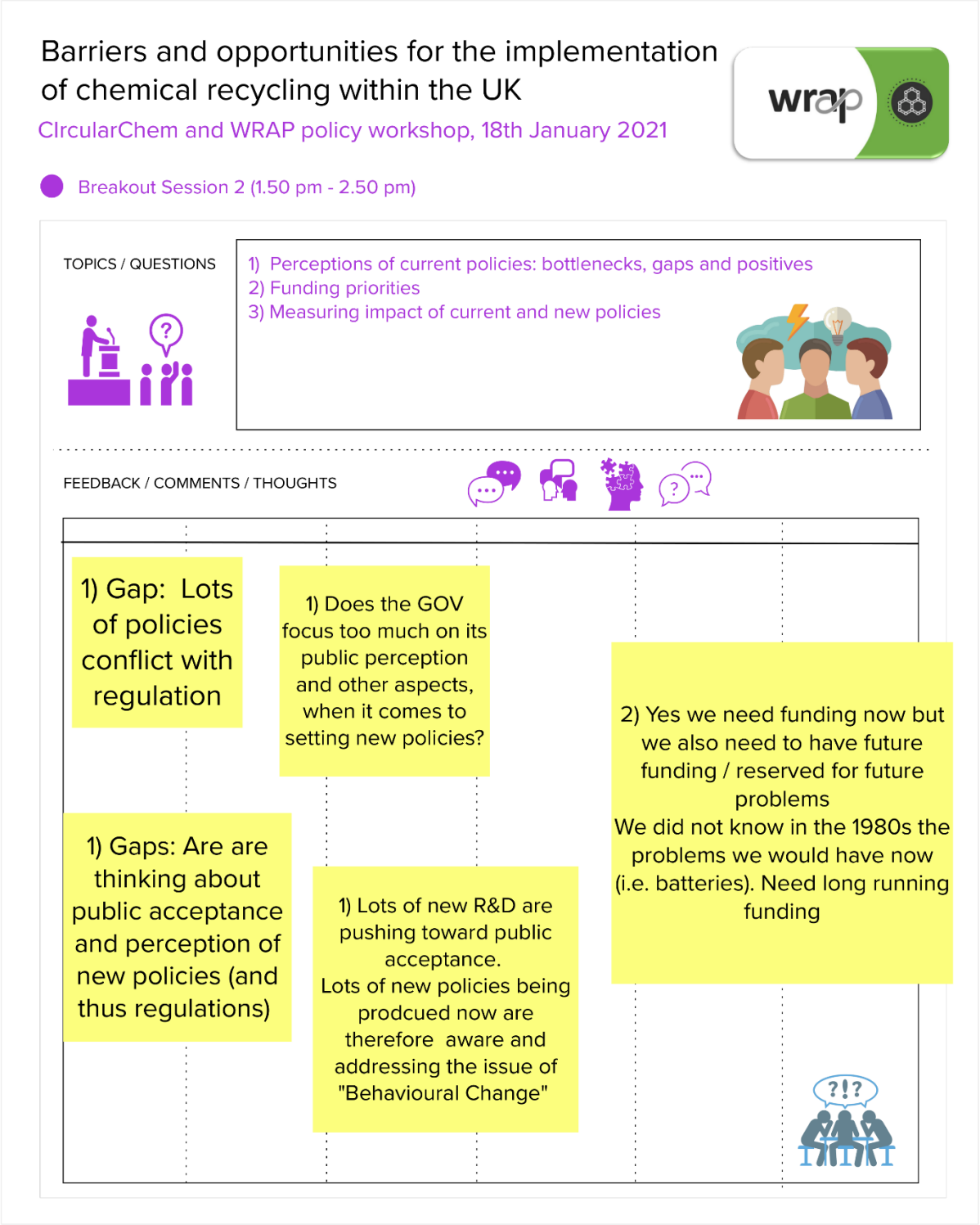


Figure 8: Comments left on an online MURAL collaboration page during the second breakout session.