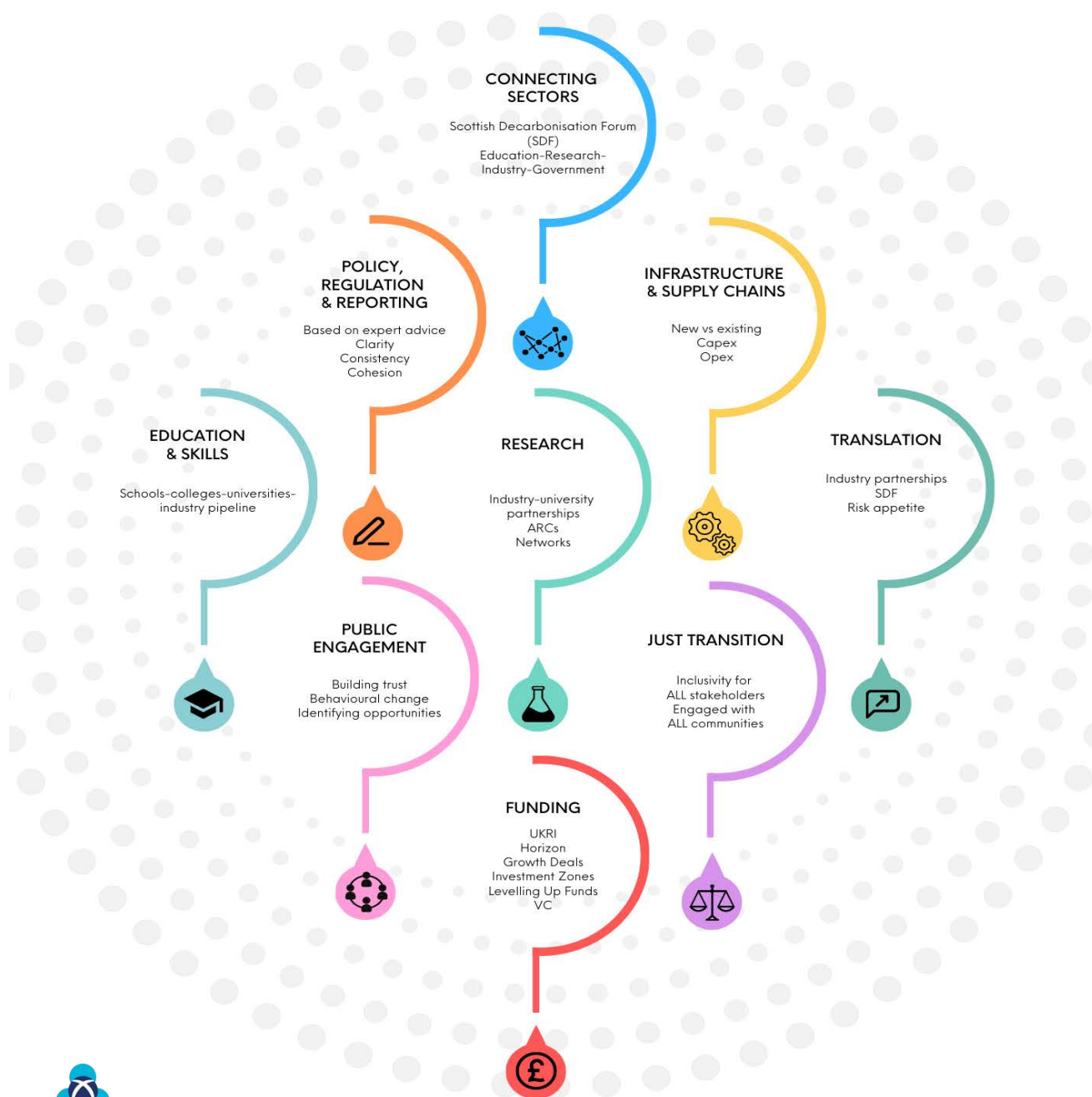




BARRIERS TO DECARBONISING THE CHEMICAL INDUSTRIES



EXECUTIVE SUMMARY

The *Barriers to Decarbonising the Chemical Industries* event (*Barriers* event) was held on 27 May 2022 at Forth Valley College (FVC), Falkirk. The meeting brought together key stakeholders and experts from industry, academia, government and the not-for-profit sectors to discuss:

- The barriers to meeting net zero targets across the industry
- Potential solutions to the identified barriers
- Initial priorities for a roadmap for industry decarbonisation

Key focus areas and priorities were identified. These highlighted a lack of:

- Connectedness between industry sectors and industry, academia and government
- Understanding the criticality of the connection between decarbonisation and renewable energy
- Research focus on areas related to decarbonisation
- Industry-university partnership funding with priorities identified by industry
- Commercialisation from university spinouts due to risk aversion in academia
- The “right” infrastructure to deliver decarbonisation products and processes
- Cohesion and clarity in regulatory and compliance environments
- Articulation of what skills will be required for new “green” jobs
- A seamless education pathway between schools, colleges and universities
- Trust between the public and industry and inclusion of all stakeholders to ensure a Just Transition

It was agreed that there are clear solutions to a number of these challenges, although all will require a complex interplay between multiple sectors and participants.

For example, it would be relatively simple to develop a mechanism (potentially, a Chemical Industries Leadership Group (ILG) and the Scottish Decarbonisation Forum - SDF) to ensure that sectors are connected.

Whilst in the research arena, reaching an agreement on a small number of focus areas (H₂, CO₂ utilisation, biomass waste, and the circularity of products) could be relatively straightforward, using ScotCHEM as a vehicle for bringing all relevant research providers together with industry. A national approach to these areas of research would deliver significant benefits to Scotland, grounded upon our existing world-renown expertise and knowledge base. Using mechanisms such as research networks, together with innovation funding, we could deliver on these focus areas.

In contrast, the lack of cohesion and clarity of policy and regulation requires multi-jurisdictional input and agreement across sectors. This poses significant challenges, although a first step would be to ensure that policy (and regulation arising from the policy) is developed with a greater degree of expert (academic, industry and compliance) input. For example, input to policy regarding the critical need for over-capacity in renewable energy production and ensuring this is a focus area for the Scottish Government.

Similarly, delivering a truly *Just Transition* is not straightforward. A lack of trust between the public, government and industry will require nuanced advocacy and engagement and will require community-specific solutions and a complex interplay between different sectors over a significant period. However, harnessing the specific opportunities (commercial, employment, social) that will eventuate and the skills required to harness these opportunities is a focus for Growth Deals and Levelling Up funding, which itself presents an opportunity for Scotland to access additional UK funding. For example, Scotland could leverage these funding sources to better connect its school-college-university sectors, creating a truly integrated education/skills journey for its citizens and providing access to new employment opportunities for all. This would deliver the talent needed by industry to effect innovation and decarbonisation.

Given its size, existing research expertise and chemical industry base, together with opportunities arising from Brexit, Scotland is well-placed to lead in the decarbonisation of the chemicals industries. Indeed, if we are to reach our Net Zero 2045 target, it is imperative that Scotland’s academic, industry and government sectors work together to remove barriers to decarbonisation. ScotCHEM could coordinate key players through the development of an ILG and the SDF.

IMMEDIATE ACTIONS

Activity	Responsibility
1. Dissemination of Barriers Meeting Report	ScotCHEM
2. Identification of key stakeholders (including stakeholders not present at the Barriers meeting) and map out links with other current/planned initiatives	ScotCHEM & IBioIC
3. Canvas key stakeholders regarding the development of a Chemicals Industry Leadership Group and explore funding options	ScotCHEM
4. Scope the development of a Scottish Decarbonisation Forum and explore funding options	ScotCHEM & IBioIC
5. Finalise MoU with Forth Valley College & develop agreements for joint programmes through the Falkirk Growth Deal National Skills Centre	ScotCHEM
6. Engage with SPICe to develop an advisory role/conduit for Scottish chemicals expertise	ScotCHEM

FOCUS AREAS

Details of the specific issues discussed together with proposed solutions are provided in Appendix 1.

Connecting sectors

There is a current disconnect between the different industry sectors and between industry, academia and government (both national and local).

Absolutely key to chemistry decarbonisation is cheap renewable energy. This will require >>100% overcapacity in wind power to decarbonise the chemical industry, and unless this happens, the chemical industry will burn gas because it is cheaper. If cheap renewable wind power is available, it will be used by the energy-intensive industry as a direct replacement for gas (and with much of the energy being converted to hydrogen) since the cost of this power could be very low and may even be a negative cost for grid balancing.

Scotland is in a unique position here – we are better placed than almost any other European country to exploit renewable (wind) energy¹ coupled with relatively low demand due to a sparser population. This would deliver a compelling unique selling product for Scotland, massively reducing costs for industries (including chemicals) and driving inwards investment with new companies located in Scotland using cheap, clean electricity. It would also deliver the benefit of reducing/eliminating dependence upon foreign gas supply and, therefore, price uncertainty).

- The Scottish Government will need to prioritise >>100% renewable capacity, which is not currently addressed in policy
- Renewable electricity supply is fundamental to sustainable chemicals industries, and therefore infrastructure and supply companies must be part of the knowledge exchange

There is also an opportunity to fill the knowledge exchange gap, providing a mechanism for communication and collaboration leading to decarbonisation solutions. Priorities in this area are:

- A mechanism for knowledge exchange
- Agreement on national challenge areas (in which to focus for greatest need/return on investment)
- Identification of expertise in particular challenge areas
- A mechanism for connecting “user” and “supplier” of expert input (advice, research, policy/regulation)

Research

There is considerable expertise in compound/product development, but key challenges were identified:

- Focus on a small number of viable product/process categories. For example, H₂, CO₂ utilisation, biomass waste, the circularity of products (such as enzymes to turn waste plastic back into chemicals)
- Improving efficiencies in sustainable processes
- Identifying sustainable compound characteristics/specifications

Funding

Current funding is not driving industry-academic collaboration, lacks focus, and is not of sufficient scale to tackle key issues. Priority areas were identified:

- Horizon scanning and bringing together consortia to secure large-scale funding. For example, Challenge Funds, Growth Deals, Levelling Up Funding, EU/international funding
- Coordination of research activity to ensure complementarity to and expansion of existing projects/programmes and facilities
- Develop an agreed methodology to articulate the return on investment (ROI) into research by industry (i.e. overcoming the profit vs investment challenge for shareholders)

¹ <https://www.ft.com/content/a37d0ddf-8fb1-4b47-9fba-7ebde29fc510> - see map and note Scotland’s position with respect to wind-power generation

Translation – moving up the TRLs

Numerous industry challenges will have a solution in research. However, although universities are good at ideation, they are less successful at spin-out. In addition, venture capital (VC) funding is plentiful, but there is a significant lack of SMEs in which to invest. There is a need to focus on:

- Encouraging greater acceptance of risk in commercialising research ideas
- Deliver/build upon university training – both entrepreneurial skills and overcoming the fear of failure (targeted at Early Career Researchers (ECRs))
- Better understanding and acceptance of intellectual property (IP)/data ownership
- Working with Business Development Managers (BDMs) at each university – ensuring the Research Commercialisation Directors Group (RCDG) is part of the knowledge exchange
- Generate collaborative bids for University Innovation Fund (UIF) Challenge funding

Infrastructure & supply chains

New, more efficient and sustainable processes will require new infrastructure. Priorities should be:

- Capitalise/build on existing infrastructure and funding. For example, Falkirk Growth Deal (FGD)/Falkirk and Grangemouth Investment Zone (F&GIZ), Wilton small-scale carbon capture and utilisation (CCU) plant.
- Embrace new ways of doing things, especially in the wake of Brexit and other current disruptions
- Identify funding for major infrastructure projects (CAPEX and OPEX)

Regulation & Reporting

There are considerable barriers to deploying sustainable solutions and processes across all industries due to policy/regulatory uncertainty and/or contradiction in policy/regulation across different jurisdictions and levels of government. Priorities include:

- Map out UK vs Scottish policy and regulations, identifying where there are clear gaps/contradictions in the system and work with government to find solutions
- Ensuring that the right knowledge and skills are available to policymakers and regulatory authorities to provide policy clarity and certainty, and a more consistent approach to deployment
- Understand what the “right” incentives would be for industry to adopt new processes that balance profitability with sustainability
- Explore how sustainability can be articulated as ROI

Education & skills

The lack of clarity on what new “green jobs” will be (including building new infrastructure) and the skills required for them is a major concern. Priority focus should be given to:

- Industry identification of future job demands
- Working across schools, colleges and universities to provide a seamless, national approach, allowing students to enter/exit at various points along the education/skills pipeline and with industry-ready skill sets – this could be a focus for the FIZ National Skills Centre of Excellence
- Better articulation of what studies/qualifications/courses can lead to which career paths (addressing a current lack of clarity between course/subject descriptors and potential careers)

Public Engagement

There is the ongoing challenge of public perception about “dirty chemical companies” being the route of environmental problems. There is, therefore, an urgent need to change the narrative to the chemical industries providing the solutions. One-off events and messages will not be successful, and it will require a combined effort to build a new level of trust with the public.

Priority focus should be given to:

- Engaging with the Royal Society of Chemistry (RSC) to mount a national campaign
- Focus on recycling in conjunction with government messages
- Involve social sciences in understanding behavioural change and best practice communication
- Look for local solutions with the involvement of local communities

Just Transition

Achieving a truly “Just Transition” may not be feasible, but it should be the aspiration. The challenge is to be truly inclusive, but current approaches do not involve all stakeholders, especially marginalised groups. Equitably engaging with a broader range of stakeholders and better valuing their diverse insights will be essential. Priority areas on which to focus include:

- Undertake an expanded stakeholder mapping exercise
- Identify experienced facilitators with expertise in cross-sector stakeholder engagement on complex and contested issues
- Involve expertise from the social sciences and humanities – and particularly interdisciplinary ‘systems thinkers’ – as well as other land-use stakeholders (for example, communities, poverty and climate/conservation NGOs, and other areas of the bioeconomy that have their sights on using arable land in Scotland)
- Map local solutions and examples of best practice
- Connecting directly to the education and skills focus, ensuring that everyone can benefit from future employment and investment opportunities
- Examine how circularity costs can be articulated as positive social impact as incentives for investment by industry

WAY FORWARD

There is clearly a gap across the sectors in connecting key stakeholders and identifying and/or driving the various initiatives and activities needed to assist our chemical industries to decarbonise. We propose that ScotCHEM could provide this connecting role, working across Scotland’s research and innovation ecosystem and in partnership with IBioIC and other key sector entities.

Across the challenge areas, thought experiments will help map out challenges and specific barriers. The “thought experiment” below is an example of how to identify key challenge areas and best practices in overcoming these challenges (in this case, biobased polyethylene made from ethanol from sugar beet). This is a summary of the report published by IBioIC and Scottish Enterprise² where the data and full calculations can be found.

As in the sugar beet example, breaking down the challenge will be pivotal in understanding where barriers exist, which potential decarbonisation solutions are practical and achievable, and which key stakeholders will need to be engaged to effect change and deliver solutions. However, to ensure that the most efficient and effective routes to decarbonisation are harnessed, a central coordinating role would be highly advantageous.

ScotCHEM could coordinate the ILG/SDF, with the aim of:

- Identifying key issues, stakeholders, expertise, potential solutions and potential funding in each decarbonisation focus area
- Promoting investment, research and development, and academic-industry collaboration in each focus area
- Engaging all stakeholders to create a compelling, sustainable, competitive position in chemicals manufacturing, assisting in achieving net zero whilst significantly expanding the Scottish economy

² SUGAR BEET: A Just Transition for the Chemicals Sector and a Net Zero Solution for Manufacturing

<https://www.ibioic.com/publications-database/sugar-beet-a-just-transition-for-the-chemicals-sector-and-a-net-zero-solution-for-manufacturing>

THOUGHT EXPERIMENT:

Decarbonisation - Biobased polyethylene example – approximate (rule of thumb) numbers

- Biobased polyethylene (PE) can be made from ethanol (see [Braskem “I’m green polyethylene”](#))
 - o Each tonne of ethanol made from sugar cane in Brazil **captures** ~2te CO₂
 - o This is likely to be a higher number from Scottish-grown sugar beet due to higher emissions in Brazil from land use changes
- Current PE production in Grangemouth is estimated to be 200,000te per year
 - o Each tonne made from fossil carbon **emits** ~2te CO₂
- So, switching from fossil to biobased PE results in an **800,000te drop in CO₂ emissions** for Grangemouth
 - o This is approximately **20% of Grangemouth emissions**
- Ethanol could be produced in Scotland from Scottish sugar beet
- 200,000te biobased-PE would require ~400M litres of ethanol (coincidentally this is the optimal size of a bioethanol plant)
- 400M litres ethanol requires 3.5Mte sugar beet from approx. 60,000 ha of land. This is about 10% of available east coast arable land per year (but since beet grows on a 6-year rotation 60% of the total land needs to be engaged with the programme).
- At £0.5/L ethanol, the cost contribution to the final biobased PE is about £1000/te PE

PE is the largest volume chemical both in Scotland and globally. The above outlines a path to decarbonisation of this section of the chemical industry (~25% of the industry by weight). Understanding why this is not happening is key to understanding the barriers to decarbonising the chemical industry.

The two main barriers to the above are:

1. Lack of an investor to build / operate sugar beet to ethanol process
2. Limitations on land use – it is difficult to conceive that 60% of farmers/land will engage. Beet is a break crop used in wheat / potato / oilseed rape rotations, so this is not to suggest that it takes 60% of output of the land. It would likely replace oilseed rape in the rotation at up to 10% of the total land per year.

This is a very high-level proposal to show feasibility (i.e. this can be done) as opposed to viability (i.e. this can be done profitably).

Mitigation for the final challenge around land use is to develop a mixed-feed plant that would run on sugar beet for half the year and (imported?) wheat for the rest of the year. This would reduce the land demand to something more manageable in Scotland (and probably Northeast of England). It also provides a better return on CAPEX investment as the plant can run year-round.

Appendix 1

Key points arising from the discussions

Connecting sectors			
Challenge		Solution	Suggested path forward
1	Significant lack of communication between sectors	Develop a knowledge exchange where all players are involved	Develop a knowledge exchange where all players are involved (ILG/SDF)
2	Within sectors, some sectors have “industry bodies” but rarely encompass research and/or policy	Knowledge exchange academia-industry	Filling the Chemical Sciences Scotland (CSS) gap – ScotCHEM to bring together an Industry Leadership Group (ILG) and Scottish Decarbonisation Forum (SDF)
3	Lack of chemical industries in Scotland	Having clear and more consistent regulatory frameworks will, ultimately, encourage new industry investment into Scotland A clear linking mechanism between industry and research will also encourage new inwards investment	Engagement with Scottish Development International
4	Obsession with competition at all levels		
5	There are collaborative groups but no funding	Build networks using network grants	ScotCHEM to assist in developing relevant networks Develop an ILG that can feed into research networks
6	Academic vs industry – capacity and funding to deliver large-scale projects	Leveraging growth/levelling-up funding	ScotCHEM to assist in developing relevant research networks Develop an ILG that can feed into research networks
7	Innovation Centres (ICs) are successful <u>when</u> they have flexibility to deliver		Ensure ICs have full involvement in ILG/networks

Research/technology			
Challenge	Solution	Way forward	
1	Land area is an issue – cannot produce enough from plant-based feedstocks. Hydrocarbons too useful to burn	Need to develop a directory of feasible feedstocks Understand properties; usability; recyclability	Based on existing Scottish chemistry assets – identify the research priorities- focussing on existing expertise and infrastructure Look at examples overseas for best practice/what works
2	We already know how to use emerging feedstocks but the processes are not efficient	More research on improving process efficiencies	Develop a research focus group/area; possible RSE/UKRI network funding
3	Move from fossil fuels is not a short-term option	Need to understand the timescales and develop a prioritised list on which to focus	Engage with ILG
4	Lack of focus on realistic solutions e.g. feedstocks	Need to focus on H ₂ CO ₂ utilisation, biomass waste. Enzymes to turn waste plastic back into chemicals – circularity of products	Look at examples overseas for best practice/what works
5	Current manufacturing processes are very efficient – it is going to cost more to move to decarbonised processes – govt and public will need to understand this	Clear understanding of whole-of-life costs of materials, processes and recycling	Potential role for ILG
6	Current approach is too scatter-gun:	Focus should be on recycling	Develop a research network with recycling focus

Funding – research			
Challenge	Solution	Way forward	
1	Too reliant on funding at Uni level especially for innovation – need to get industry more involved	Push funding through industry then on to universities – will focus innovation on industry-related challenges Building UK capacity and capability not duplicating	Horizon scanning to see what industry-academia collaborative funding is available e.g. Challenge Funding Look at existing infrastructure to ensure no duplication of investment e.g. Wilton has already got a CCU small plant – so build on this at F&GIZ
2	ROI for industry investing in research is not clear - How to articulate ROI		Engage with the ILG
3	Lack of co-academic-industry funding programmes		Engage with the ILG to lobby government/funders
4	Too high reliance on Innovate UK funding		Engage with the ILG to lobby government/funders

Translation - Moving up the TRLs		
Challenge	Solution	Way forward
1 Universities good at ideation but not so good at translation	Look at success stories and develop series of case studies – what works	<p>Research spin-out -> encouraging risk; IP/data ownership – who do we pitch to, to get the money? How can we work with Business Development Managers at each Uni? Research Commercialisation Directors Group (RCDG) – part of Universities Scotland – could ScotCHEM partner/work with them to find solutions?</p> <p>Challenge funding – collaborative bids – University Innovation Fund (UIF) challenge network – part of RCDG Training people in how to be entrepreneurial – fear of failure – especially for ECRs Could ScotCHEM run an entrepreneurship course? What is currently available – where are the gaps? How do you take a research idea and build it into a commercial idea? Speak to academics who have developed successful commercial ventures (Prof Rebecca Goss, Prof John Storey) – what made it possible for them? → VC funding</p>
2 Industries have challenges that could be solved but don't connect with the right research		Knowledge exchange – Carbon Capture & Storage (CCS) gap
3 Issues of propriety data/IP		
4 Plenty of funding (VC, start-up, etc) but not enough SMEs in which to invest		
5 Need to get over the “fear of failure” culture in universities (cf USA where there is a much better understanding and acceptance of risk with start-ups)	Access to funding to translate – funding into Dev rather than Research with risk understood and acknowledged	

Infrastructure & Supply Chains			
	Challenge	Solution	Way forward
1	Will need new processes therefore new infrastructure	Infrastructure exists elsewhere – look at best practice, costs, etc and decide where Scotland can focus	Continued discussions between all supply chain actors – CSS2.0
2	Don't have the skills to build new infrastructure	Need to include skills for infrastructure building	FGD National Skills Centre (FVC)
3	Lack of capital funding for new infrastructure	Economies of scale used to drive capital funding	Do not duplicate e.g. CCS and F&GIZ
4	Supply Chains have been disrupted – op to think about doing things differently	Opportunity to do things differently – map out potential new supply chains	CSS2.0

Education & Skills			
	Challenge	Solution	Way Forward
1	Industry not good at communicating what skills/jobs will be needed in the future	Critical skills identified by industry – feed into school, college & university curricula More industry involvement in College/Uni courses - MSc with mentoring, placements, etc	Interaction through FGD National Skills Centre/Forth Valley College (FVC) – initial identification with industry
2	Potential careers and jobs are not well described (some are not yet known) so need to promote careers in the industries better	Industry and academia to come together to identify the skills and jobs needed for the future	Work through the FGD National Skills Centre/FVC to develop a national framework
3	Where will the future workforce come from? Especially F&GIZ	Need to engage with schools and the public to understand what future jobs will be	Industry willing to fund promotion of careers? Work with RSC
4	Better joined-up between school -> college -> university	Role of: Curriculum needs to recognise STEM as critical, not opt-in; FVC & FGD National Skills Centre; Greater involvement of industry at all levels; Universities delivering industry-specific MScs Mentorships; Industry placements at all levels	Work through the FGD National Skills Centre (FVC) to develop a national framework
5	Disconnect between disciplines at college/university – choices not clear for students – poor “obvious” links to careers/jobs	Integrate chemistry and biotech Clear articulation of potential careers/jobs from the different disciplines	Communication – see above

Policy, Regulation & Reporting			
	Challenge	Solution	Way forward
1	UK vs devolved nations	Smart regulation -	
2	Big disconnect between policy/legislation (done at a national govt level) and regulation compliance (which is rolled out at a local authority level)	Provision of accurate and consistent information to support government departments Work with SPICe	Policy briefings and providing expert advice – ScotCHEM to work with SPICe to ensure that relevant expertise is involved
3	Different policies often sit within different government departments so often contradictory	Provision of accurate and consistent information to support government departments Work with SPICe	Single, unified voice providing a conduit for research-based information and advice ScotCHEM could act as a connector/provider to/of expert advice
4	BEIS – not enough capacity		
5	Govt reporting is not aligned		
6	Policymakers/Regulators may not know enough to make right decisions e.g. Carbon Capture and Storage (CCS), biotechnology	Need to get policymakers who are better educated in the science/research/roll-out Colleges/Universities could roll-out courses for govt/policymakers in particular fields – “the basics of...”	CSS gaps – role for ILG advisory role
7	Self-regulation is not the solution	Incentives vs disincentives – needs open discussion with industry, and national and local government.	Develop ILG to provide advice/input to government
8	Not the right level of incentives for industry – too much emphasis on industry and not progressing in the right direction. Need to get the balance right – industry still needs to be able to make money. GM Crops – England agreement in place but not in Scotland Brexit has introduced uncertainty	Need to get clarity from Scot Gov Create a credit system within ETS Incentives – make it sensible	Develop ILG to provide advice/input to government
9	Complicated interplay of policy-regulation-legislation with contradictory requirements across jurisdictions and sectors; Confused signalling;	Need more policy cohesion Map out Scottish vs UK regulatory jurisdictions	
10	Regulators often seen as inflexible		

Public Engagement			
	Challenge	Solution	Way forward
1	How to change the message from “dirty chemicals that have been the cause of the problem” to solutions	Public campaign not individual messages/events	Engage with RSC etc to change the message.... Chemistry’s Brian Cox?
2	Govt & public need to think about recycling in different ways	Need social scientists involved - Consumers adapting to new practices Look at circular economy centres – mainly England	Need social scientists involved - Consumers adapting to new practices Look at circular economy centres – mainly England
3	Not listening to locals – too many centralised decisions	Learn from locals – many decisions are taken centrally	
4	Lack of trust		

Just transition			
	Challenge	Solution	Way forward
1	How to be truly inclusive; not currently involving all stakeholders How to engage with ALL stakeholders (particularly marginalised groups)	Equitably engaging with a broader range of stakeholders, and better valuing their diverse insights. Crucial to bring in expertise from the social sciences and humanities – and particularly interdisciplinary ‘systems thinkers’ – as well as other land-use stakeholders (e.g. communities, poverty and climate/conservation NGOs, and other areas of the bioeconomy that have their sights on using arable land in Scotland).	An expanded stakeholder mapping exercise could be very valuable here Identify experienced facilitators, with expertise in cross-sector stakeholder engagement on complex and contested issues
2	Sense of ownership and pride but still energy poverty e.g. Orkney	Look at best practice – what works?	Look at local solutions – best practice; case studies
3	Very aspirational	Is it achievable? Be honest and realistic Need real costs for green materials – whole-of-life cycle must be considered	FGD National Skills Centre (FVC) could be instrumental in developing messaging and engagement with local stakeholders which could provide a blueprint for a national approach
4	Supply chain – don’t have the workforce to build the required manufacturing equipment	National Skills framework	Work with FGD National Skills Centre (FVC)
5	True costs of circular products need to be fully articulated – it will cost more ££	Circularity cost must include social aspect (positive) Accounting system to take social capital into account	Incentives for positive social impact