Decarbonisation of the South West Peninsula's Infrastructure System

Initial workshop findings on the route ahead

Prepared for the **South West Infrastructure Partnership**

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This report summarises the output of two workshops held in Bristol on the 29th January 2020 and Truro on the 6th February 2020.

While it is believed to be a faithful record of the collective discussions held at these two events, it does not necessarily represent the views of the authors, any individual attendees or their related organisations.

The authors and the South West Infrastructure Partnership are grateful to all those who attended the events to share their time and wisdom.

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Executive Summary

Infrastructure systems underpin our daily lives. Their assets and services work together to facilitate the flow of people, resources, energy and information. However, it can also impact negatively on the natural environment and by extension our economies and wellbeing. One significant impact comes from the Carbon emissions associated with the design, construction, operation, use and removal/recycling of infrastructure systems. Engineers have a crucial role to play in adapting and redesigning infrastructure to become more sustainable and to support the activities it facilitates to do the same.

The South West has distinct infrastructure challenges relating to its natural and human geographies. Long-term South West infrastructure challenges hinge around fragmented governance and oversight. The South West Infrastructure Partnership (SWIP) has identified the decarbonisation of the South West as a systemic challenge that depends on the effective integration of the region's infrastructure sector. The challenge of decarbonisation cannot be addressed through decisions taken in regional, operational or political silos. Decarbonisation cannot be achieved by managing one infrastructure system as if it is independent from another.

Two workshops were held, bringing together over 100 infrastructure experts from across the region to explore the decarbonisation challenge. These took place on **Wednesday 29 January** in Bristol and on **Thursday 6 February** in Truro. These workshops sought to explore (1) the perceived purpose of infrastructure; (2) the complexity of the overall infrastructure system; (3) the future of infrastructure; (4) the current and required knowledge for decarbonising the sector; (4) the incentives and barriers to effective collaboration; and (5) the critical actions and next steps to achieve decarbonisation. This document provides a record of the discussions held at those workshops.

The Purpose of Infrastructure

The overarching outcome noted by almost every group at both events was **quality of life**. This is often dependent on reliable public services facilitated by the quality of the infrastructure. Infrastructure also provides connectivity, within the region and beyond. While this is significantly physical in terms of the mobility of people and resources, it is increasingly provided through digital means. The South West has unique challenges emerging from its disperse and transient population. From tourism to agriculture, the environment is a critical factor in its economy.

The Complexity of Infrastructure

Infrastructure services emerge from the interactions of multiple assets and systems. The transport and energy sectors are particularly reliant upon one another. Changes made in one sector can have significant impacts on the operation of other sectors. For example, switching to electrical private vehicles will impact the energy sector, and could even increase use on public transport. Furthermore, sectors critical to the South West, such as agriculture and tourism, can be significantly impacted by and impacted upon built infrastructure. Excluding these from discussions around decarbonisation of infrastructure could result in inefficient or ineffective actions.

The Future of Infrastructure

The idealised South West of 2050 would have a self-sufficient, sustainable, circular economy based on community supported local services. The key diver would be the attainment of valued social outcomes rather than growth in GDP. Decarbonisation should not require the construction of new roads, focusing instead on maintaining existing networks and solutions that reduce demand (e.g. low-cost public transport and flexible working locations). The energy system would include more solar, wind, wave and geothermal sources, and improved battery technology.

In the worst-case scenario a rise in private vehicles would cause congestion while petrol still dominates. The switch to renewable energy sources would have stalled to such a degree that supply could not meet demand. Energy poverty would increase. Climate change would lead to advanced warming, a retreat from coastal regions and an acceptance of greater flood risks. General health and well-being would decline as a result.

Knowledge

There was disagreement at the workshops as to whether there was sufficient information available to get a complete picture of the South West infrastructure sector's contribution to carbon emissions or not. Even where data exists there may be questions over its trustworthiness, accuracy, visibility and consistency. Obtaining a data baseline is essential to delivering a strategy for decarbonisation. Information is required that allows for an agreed and complete measure of embedded and operational carbon through the entire infrastructure supply chain and across the life cycle. Real-time performance data for both lagging and leading indicators would be useful, together with a broader set of metrics that ensures a focus on the ultimate outcomes and not just carbon.

Collaboration

Collaboration is essential to decarbonising the complex interdependent infrastructure system. It requires open channels of communication and can be driven by a clear vision and unified objectives. Collaboration is hindered by a silo-mentality, outsourcing, fragmentation, focus on capital expenditure and related contracting issues. Clear leadership and a change in culture can overcome these barriers. The system needs to appropriately value the environment and involve all stakeholders and delivery partners from the earliest project stages. Intellectual property rights and the distribution of reward and risk can be detrimental. New methods of contracting that avoid short-term individual incentives and provide equality are required.

Actions & Next Steps

It was clear from the two events that there is a realisation of the complexity of the decarbonisation challenge and great deal of appetite for collaborative action across the South West's infrastructure sector to address that complexity. This necessitates a co-created framework for consistently measuring progress towards decarbonisation, a shared vision and a clear collective route map for the way forwards. While this is all based upon a fundamental change in mindset from business as usual, it also requires leadership and a convenor to facilitate collaboration.

Contents

Introduction

Infrastructure systems underpin our daily lives. Their assets and services work together to facilitate the flow of people, resources, energy and information. From roads and sewage pipes to fibreoptic cables and wind farms; the quality of our infrastructure affects our quality of life and the strength of our economy. However, in its current form it also poses a threat to the even more fundamental natural environment. HM Treasury's Infrastructure Carbon Review[1] concluded that the infrastructure industry directly controlled 16% of the UK's total carbon emissions and had an indirect influence over a further 37%. It predicted that the total impact (direct and indirect) would grow to 90% by 2050, largely due to the projected decarbonisation of other sectors. In turn, the resultant changes to our climate can impact the quality of our infrastructure.

The South West has distinct infrastructure challenges, not least the vulnerability of many communities to rising sea levels and flooding. As engineers, we have a crucial role to play in adapting our infrastructure to cope with the impacts of climate change. We also have a moral imperative to go beyond adaptation and redesign infrastructure, whether that's power or transport, to become sustainable and to support the activities it facilitates to do the same. One critical aspect of this is the transition to low carbon technologies.

Long-term South West infrastructure challenges hinge around fragmented governance and oversight. It is fragmented across geographic boundaries and political boundaries. Even looking within these boundaries infrastructure is fragmented by industry. The road and rail networks are managed as largely discrete from the electricity network for example. The result is two-fold. Firstly, the South West does not have a collective powerful voice at national government level and as a result fails to secure as much proportionate infrastructure investment as other regions. For example, it has the second lowest construction spend on highways – around 50% less than the South East[2] despite having urgent strategic highways improvement needs. Secondly, fragmented oversight leads to counter-productive decision making and actions from one sector to another, even though the sector infrastructures are often physically, functionally and operationally interdependent[3] The consequence is ineffective and inefficient infrastructure, which costs more, damages growth and impedes progress towards achieving the Sustainable Development Goals[4] .

The South West Infrastructure Partnership (SWIP) has identified the decarbonisation of the South West as a systemic challenge that depends on the effective integration of the region's energy and mobility (of people and goods) systems; there is no regional governance mechanism for driving this integration and, consequently, little technical action to achieve it. The challenge of decarbonisation cannot be addressed through decisions taken in regional or political silos. Decarbonisation cannot be achieved by managing one infrastructure system as if it is independent from another. Such fragmented approaches lead to unintended consequences and shifting the burden outside of the largely artificial boundary of analysis. As a trivial example it would be regionally sub-optimal to decarbonise Devon's electricity supply if the consequence was drawing more fossil-fuel based power from Cornwall. Under current metrics carbon emissions associated with the road network could be dramatically reduced through a switch to electric vehicles but this would be at best meaningless and at worst disastrous without consideration of the energy system providing the electricity.

The University of Bristol has developed an Integrated Diagnostics Methodology for place-based complex systems challenge as it enables problems to be explored systemically from multiple stakeholder perspectives, modelling the complexity of multiple interacting infrastructure systems, leading to an integrated view of prioritised needs, mutual value and common purpose that can be articulated with a common voice and is backed up by objective evidence. The process commences by identifying high level ***challenge themes*** that, in this case, the South West infrastructure sector needs to address (i.e. decarbonisation). The first stages of the ID methodology attempt to gather evidence to map the problem space, articulate stakeholders' valued outcomes and support the identification of meaningful actions. Recent developments in the application of this method has resulted in the creation of an ***analysis canvass*** that captures and relates ***eight drivers of value and cost improvement*** *(*Figure 1*)*.

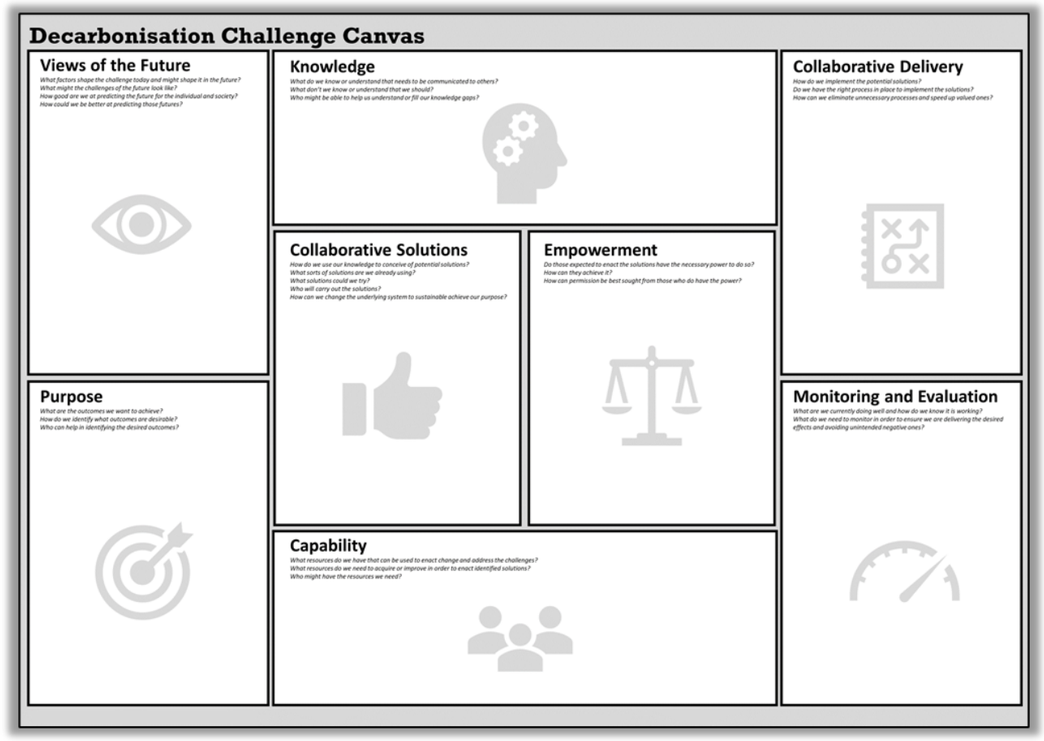


Figure 1 - Challenge Canvas

Two workshops were held to bring together senior engineers, regulators, policy makers and public sector experts from across the infrastructure sectors to complete the canvas and collaborate in exploring the region's infrastructure provision. The workshops took place on **Wednesday 29 January** in Bristol and on **Thursday 6 February** in Truro. Over 100 people attended across the two events. The outputs are shaped by those present and it is notable that the water and communications sectors were less well represented at both workshops. While both sectors were repeatedly noted to be of critical significance, the detail with which they were discussed is not as rich as for other sectors. This should not be interpreted as a reflection on their perceived importance by the attendees or SWIP.

This canvas begins with an exploration of the purpose of infrastructure, and the means by which it achieves this purpose. This is followed by asking stakeholders to imagine what the South West and its infrastructure systems might look like in 2050. The next stage looks at knowledge and capability. It seeks to identify what is currently known, current capabilities, what yet needs to be known and what additional capabilities are required. The canvas then looks at barriers to collaboration and empowerment and how these can be addressed. The final elements of the canvas look at designing actions and the means to monitor their progress (not covered in the workshop). The results of the discussions relating to each of these themes is documented over the following sections.

[1] HM Treasury, 2013, Infrastructure Carbon Review, November 2013
[2] Pregnolato M, Ford A, Robson C, Glenis V, Barr S, Dawson R. Assessing urban strategies for reducing the impacts of extreme weather on infrastructure networks. R Soc Open Sci 2016. doi:10.1098/rsos.160023.
[3] Institution of Civil Engineers, 2016, State of the Nation Report [Online: https://www.ice.org.uk/getattachment/media-and-policy/policy/state-of-the-nation-2016-devolution/state-of-the-nation-2016-devolution.pdf.aspx]
[4] National Infrastructure Commission, 2018, National Infrastructure Assessment [Online: National Infrastructure Assessment 2018. https://www.nic.org.uk/wp-content/uploads/CCS001_CCS0618917350-001_NIC-NIA_Accessible.pdf]

Bristol – 29th January 2020

Truro – 6th February 2020

Understanding the Present: The Purpose of Infrastructure

The purpose of infrastructure is to facilitate the fulfilment of its end users' needs and requirements. While this may seem obvious it is all too easy to forget these overall purposes when focusing on the minutiae of delivery and operation within any particular infrastructure sector. Maintaining the provision of these desired outcomes is central to the decarbonisation challenge. For the first task each table was asked to discuss the sorts of outcomes the citizens of the South West need, value and expect from the infrastructure that serves them.

The overarching outcome noted by almost evert group at both events was **quality of life**. Subsequent discussions explored the factors that contribute to this. General points covered by participants when framing the discussions included considerations of access to clean water, food, healthcare, energy, employment, sanitation, education, recreation and other public services. In fact, as one group mentioned explicit, these considerations could be framed by the sociologist Abraham Maslow's Hierarchy of Needs. These needs are supported by conventional infrastructure assets.

The reliability, resilience, efficiency and affordability of these assets and services became a key theme of the discussions summarised below along with several other recurrent themes.

Some initial framing discussions reflected on the balance between current and future needs, acknowledging that requirements differ between generations and evolve differently within them. Others approached the task by considering the meaning of infrastructure, advocating a broad interpretation which might go beyond more traditional definitions. This was felt to be particularly relevant for the needs of younger generations. One group initially interpreted 'needs' strictly in terms of food, water and housing, questioning whether a "much wider" definition encompassing leisure and recreation was necessary. They concluded that what people need, and what they value are two different things.

General Problems

At both events participants used the opportunity of this first question to also discuss some perceived problems with the South West's infrastructure. This included some general points related to economics and political priorities. There were questions over whether the funding Cornwall received from the European Union would be replaced by national funding when the focus appeared to be on "levelling up" the north of England as opposed to the South West. Funding mechanisms should support CO_2 reduction in the infrastructure decision making process, recognising that better solutions are not necessarily cheaper. Along similar lines there was a need for whole life cycle costs and impacts to be considered.

The challenge of ensuring the infrastructure associated with new developments is sufficient to meet future needs (for example sufficient charging infrastructure for electric vehicles and internet connectivity) was discussed along with the retrofitting of existing built environment assets.

It was suggested that some places within the South West Peninsula suffer from unreliable and expensive public transport, poor internet connectivity (including 4G coverage, 5G roll out, bandwidth and connection speeds), congested roads and expensive parking (particular in the large urban areas). While the reliability of water supplies did not seem to be a problem across the South West, power cuts were more common in rural areas.

Reliability & Resilience

The reliability of public services was perhaps the key topic identified in ensuring the required outcomes were achieved. This was discussed by all groups covering the reliability and resilience of transport links, waster resources, power supplies and waste processing. The reliability of journey times across private and public transport networks was raised by many, suggesting this is valued but not at the level many would like. Some suggested the status quo should be reliably maintained, while others saw a need to improve performance, safety and stability of public service provision.

Connectivity

Travel and communications were frequently discussed together in the context of connectivity, highlighting the increasing relationship between transport and telecoms infrastructure. Citizens of the South West Peninsula expect good communication services and reasonably priced travel services. There is a perceived increasing need for travel. Reliable, high-speed internet connectivity across the region within a system that supports flexible home working could reduce the need for work-related travel. The balance between travel for work and travel for leisure could change dramatically. Digital connectivity must be factored into any future plans for other infrastructure provision. Transport infrastructure has long been acknowledged as fundamental to accessing essential public services, but internet infrastructure is becoming increasingly important for the same reasons.

Geographic Pressures

The South West presents unique geographic pressures also featured heavily in the responses, mostly from those at the Truro event. There is a great deal of variation in geography, population density, economics and demographics across the region. Large urban centres, small coastal communities and isolated villages must all be served. Ensuring an infrastructure system that delivers the desired outcomes of ageing populations in rural locations is particularly challenging. This led to questioning of the equality of costs and benefits across more sparsely populated areas. Travel links within the region, with the rest of the country and internationally are variable. The dispersed communities and peripheral nature of the region creates connectivity challenges with other areas across the UK. It was noted that London to Lille by rail is quicker than London to Penzance. Inhabitants have an expectation that the transport systems are integrated across the region, but the tendency is further towards fragmentation.

In addition to the challenges in operating infrastructure in these circumstances, construction of new infrastructure is also affected. While overall there is a need to reduce over designed structures and construction waste, the dispersed nature means materials often have to be transported over long distances and sites present the need for levelling, retaining walls or take place in difficult coastal conditions.

Tourism & Transient Population

The demographics and needs of the South West Peninsula's population can vary significantly depending on the season. Cornwall's population is unequally transient, seeing a ten-fold increase in population over the summer

months. This has significant implications on the region's infrastructure requirements. Water demand, for example, can be double during the peak tourist season. Not only does there need to be provision for communities that are temporary, but those holidaying communities have different values and expectations from the permanent residents. The visitors themselves are not a homogenous group, and will equally have diverse sets of expectations for their holiday. The cultural identities of the different groups can have an impact on infrastructure requirements. The nature of the economy can change through the year such that even the permanent residents present different requirements and expect different outcomes at different times. Transport links into the region for this transient tourist population are also an important factor.

Alternative Transport

It was felt that public transport will be of increasing importance, and there are important questions as to how the South West can best adapt to serve its varied and unevenly distributed population. The provision of direct cycling infrastructure (e.g. cycle paths) and other infrastructures that serve the needs of cyclists will be of increased importance. The availability of electric vehicle charging infrastructure across the region is also of importance, driven both by its permanent and visiting communities.

Environment

The environment is a key resource in the facilitation of valued outcomes. People across the South West expect access to green space and coastal environments. The preservation of the natural environment is therefore critical. The desirability of the region as a place to live and visit is intrinsically linked with its ecology. These environments have an important value that is not always fully accounted for in infrastructure planning. Those same natural environments can also contribute to extreme conditions which have an impact on the built environment as discussed previously.

Community & Culture

Finally, community and culture featured in discussions at both workshops. There were considerations of the balance between thinking locally and thinking regionally. Those in Bristol indicated an interest in thinking at the neighbourhood level within the city as well as in the regional context. At the Truro event this sense of community could be attached to smaller conurbations. In both workshops there was a widespread interest in considering outcomes and infrastructure provisions at a socially manageable community scale. In Bristol this included discussion of the '15-minute city' concept whereby all of the neighbourhood's core public services could be accessed within a 15-minute walk. Consideration of the community scale was thought to be important for practical considerations such as increased reliance on logistics and home delivery services, as well as broader holistic considerations around CO_2 reduction and other environmental benefits.

Citizen engagement and democracy in infrastructure provision were also discussed, with some suggesting that more community focus could also deliver better ownership of infrastructure decisions. The current system leaves many to feel things are being imposed upon them.

All of the actions necessary to decarbonise the South West Peninsula's infrastructure systems - from food supplies to sanitation, transport to energy – will require behavioural change within those charged with planning, designing, delivering, operating and governing infrastructure, as well as its end users.

Understanding the Present: The Interdependency of Infrastructure

Infrastructure assets and sectors do not exist in isolation from one another. They interact with one another and frequently depend upon one another to function. The state of an infrastructure asset within one sector can impact upon the state of an asset within another. The nature of these relationships and interdependencies can range from the relatively simple to complex networks of resource flows. Frequently, the sorts of valued outcomes that contribute to quality of life are not the simple product of a single infrastructure asset or sector, rather they are the emergent properties of multiple assets and sectors working together.

For the second activity participants at both workshops were asked to identify key infrastructure sectors or individual assets that they were familiar with and map the ways in which they interact with one another using a matrix-based approach.

The matrix-based approach has been developed from the N-Squared (N^2) Chart tool created by Lano[5] for the analysis of interfaces and relationships. It gets its name from the fact that for a system model defined by an N by N dimensioned matrix, then there will be N^2 cells (or boxes) in which to represent the sub-systems and their interactions. Lano describes this as "a visual aid which can be effectively employed to communicate functional or physical interface and interrelationship information to a large group and/or mixed discipline audience in a very short time period" and that "it provides the user with an effective tool for the definition, tabulation, design and analysis of these interfaces."

At its most basic, the N^2 Chart comprises a matrix with the principal system functions represented along the leading diagonal of the matrix, i.e. Function 1 (F1), Function 2 (F2), …to Function N (FN), leaving the remaining off-diagonal boxes to represent the interactions between them. This is demonstrated by the example shown in Figure 2.

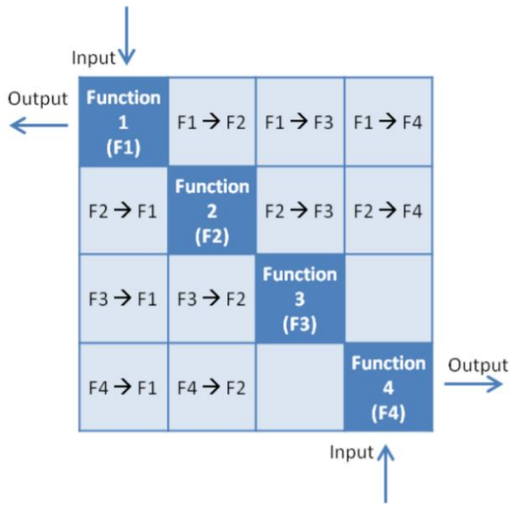


Figure 2 - Example N2 Chart (after Lano)

In this example, the principal system functions F1, F2, F3 and F4 are represented by the darker boxes running from the top left corner to the bottom right corner. These could be services provided by the major infrastructure systems such as public transport or drinking water supply. The off-diagonal boxes show the interrelationships between these functions, and in the implementation of the IPMF these comprise the interdependencies between for example infrastructure systems, the services provided by industrial sectors, or policy objectives. In its original form these off-diagonal boxes are conceived as outputs and inputs, such that the box labelled "F1 -> F2" shows that an output of Function 1 becomes an input to Function 2. The squares in horizontal rows therefore become the outputs of the function in that row. The squares in the vertical columns show the inputs to the function in that column.

The participants were not prompted with which infrastructure sectors or assets to consider, but they were shown examples focussing on the water, transport, waste, energy and ICT sectors. As such many of the example included these. The matrices produced by each of the groups across the two workshops were combined into one single matrix. Duplicate entries were removed, and some terminology amended for clarity. Figure 3 on the following page shows an extract from the combined matrix looking just at the 'core' infrastructure sectors mentioned above. As stated previously, the coverage across the sectors represents the expertise and discussions held during the limited time available, rather than the perceived importance by the attendees or SWIP.

The two most frequently identified relationships were between the Transport and Energy sectors as shown in cell D2, and between the ICT and Transport sectors as shown in cell B5. In cell D2 these include such relationships as the demand in transport affecting the demand for energy and the transport sector providing the functionality to move the raw materials for electricity and other fuel production. Cell B5 includes such relationships as the ability for ICT systems (specifically high-speed internet connections) to affect the need for travel and the ICT sector's provision of GPS functionality to the transport sector.

It is notable that for this extract none of the cells were left blank reinforcing the complex relationships and interdependencies between the sectors.

The full combined matrix is then presented in Figure 4. This adds an additional 8 components identified by various groups across the workshops. Not all of these were considered by every group. In most cases each component was only considered by one group, hence the sparser population of these cells. Some of these, such as logistics and agriculture, could be considered part of the infrastructure; others such as people and tourism provide more of the operational context. It highlights the importance of rigorous boundary selection. Agriculture, tourism and logistics are clearly very important to the unique aspects of the South West's infrastructure. The agriculture industry for example provides land and resource inputs to the energy sector (D12) while also placing critical demands on the water sector (A12). If these sectors were not involved in any future consultation or co-design of decarbonisation pathways then the resultant actions may be ineffective, avoidably challenging to implement or give rise to unintended consequence that may ultimately make the situation worse.

[5] Lano, RJ.(1979) A technique for software and systems design. Elsevier North-Holland Pub. Co.;

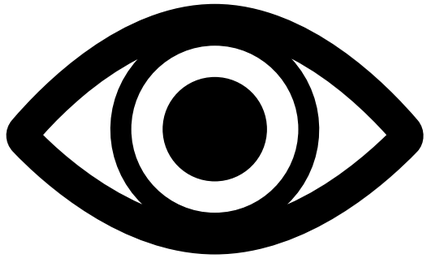
	A	B	C	D	E
	Water	Transport	Waste	Energy	ICT
1	**Water**	Water sector provides drainage functions that prevent flooding under normal circumstances	Water is required for cleaning processes (homes, industry, etc.)	Water provides input to plant cooling functions	Water sector provides flood defences or protect critical ICT systems
		Water networks and coastlines provide an infrastructure for transportation modes (e.g. shipping, ferries etc.)	Water is lost due to leakage	Water provides inputs for Hydro Electricity Generation	Water supply as a basic requirement for personnel in digital infrastructure office
		Water is used in maintenance of vehicles and infrastructure	Water is used to treat sewage by the waste sector	Water required for electricity generation via steam	Water provides cooling function to some ICT equipment
		Water is an input for some transport (e.g. coolant, steam power, etc.)			
		Water is passed to transport sector for distribution			
2	Transport sector uses water networks and coastline	**Transport**	Transportation of waste (domestic, international, industrial, construction etc.)	Transportation of raw materials for electricity generation	Transportation of raw materials used in constructing, maintaining and operating ICT systems
	Transportation sector provides the means to move construction materials, maintenance services and chemicals to point of use in water sector		Transportation of operation/maintenance services in waste sector	Demand in the transport sector induces demand in the energy sector	Transport sector can provide alternative means to access others
			Transportation of chemicals for waste treatment	Transport of fuel to refuelling infrastructure	
				Transportation for maintenance of energy infrastructure	
				Transportation of components for construction of electricity generation facilities	
				Solar panels on transport infrastructure can provide input to energy sector	
				EV batteries can be used to store energy and as input to energy sector	
3	Waste sector outputs water requiring treatment	Waste sector outputs material for use in constructing transport infrastructure	**Waste**	Waste sector outputs biomass for use in energy generation	Waste sector provides recycled materials for use in ICE infrastructure
	Waste sector produces run-off pollution from storage and treatment	Waste sector outputs material for biofuels		Waste sector provides material for incineration with the energy sector	
				Waste sector provides material for anaerobic digesters	
4	Provides energy for water pumps	Provides energy for EV Charging	Provides energy for recycling processes	**Energy**	Provides power to connect diverse assets across area
	Provides energy for water treatment	Provides liquid fuel for transport modes	Energy & Waste assets can be co-located		Provides power to run digital infrastructure
		Provides energy for street lighting, traffic lights etc.	Provides energy for waste processing/treatment		Provides energy for planned or emergency service work
			Provides waste nuclear fuel for reprocessing		
			Provides energy for planned or emergency service work		
5	Provides network management, monitoring and control	Provides functions for Intelligent transport solutions	Provides control and monitoring of waste systems	Provides control systems	**ICT**
	Provides digital information regarding water treatment and distribution networks	Reliability of ICT enables working from home that reduces the need for transport	Provides Internet of Things capability for waste tracking	Provides means for coordination and monitoring of power network	
		Provides communication when transport systems are down		Provides communication functions	
		Provides rail information system, journey information etc.		Provides Asset Monitoring capabilities	
		Provides ability for automation of traffic management		Provides Digital Twinning capabilities	
		Provides GPS function			
		Provides ability to operate Smart Motorways			

Figure 3 - Extract from Combined Workshop Matrix

	A	B	C	D	E	F	G	H	I	J	K	L	M
	Water	Transport	Waste	Energy	ICT	Tourism	Environment	People	Logistics	Built Environment (e.g. Housing)	Employment	Agriculture & Food Production	Flood Protection
1	**Water**	Water sector provides drainage functions that prevent flooding under normal circumstances Water is an input for some transport modes (coolant or steam power) Water is used in maintenance of vehicles and infrastructure Water networks and coastlines provide an infrastructure for transportation modes (e.g. shipping, ferries etc.) Water is passed to transport sector for distribution	Water is required for cleaning processes (homes, industry, etc.) Water is lost due to leakage Water is used to treat sewage by the waste sector	Water provides input to plant cooling functions Water provides inputs for Hydro Electricity Generation Water required for electricity generation via steam	Water sector provides flood defences or protect critical ICT systems Water supply as a basic requirement for personnel in digital infrastructure office Water provides cooling function to some ICT equipment				Water sector provides supply for personnel in logistics facilities	Waster sector provides potable, treated water provided for domestic use		Waster sector provides input for irrigation Water sector provides input for uses within food production	
2	Transport sector uses water networks and coastline Transportation sector provides the means to move construction materials, maintenance services and chemicals to point of use in water sector	**Transport**	Transportation of waste (domestic, international, industrial, construction etc.) Transportation of operations and maintenance services within waste sector Transportation of chemicals for waste treatment	Transportation of raw materials for electricity generation Demand in the transport sector induces demand in the energy sector Transport of fuel to refuelling infrastructure Transportation for maintenance of energy infrastructure Transportation of components for construction of electricity generation facilities Solar panels on transport infrastructure can provide input to energy sector EV batteries can be used to store energy and as input to energy sector	Transport sector can provide alternative means to access others Transportation of raw materials used in constructing, maintaining and operating ICT systems	Quality of transport infrastructure affects volume of tourism	Transport sector provides access to natural environment Transport sector outputs pollution to the environment Transport networks require land from environment	Transportation of people to social services (e.g. patients and staff to hospitals)	Transport sector provides the infrastructure through which products are distributed	Quality of transport provision affects housing demands	Quality of transport provision affects employment demand Transportation of workforce to where they are needed	Provides distribution services for food produce Movement of materials for farming	Movement of materials Access to sites for planned and emergency works
3	Waste sector outputs water requiring treatment Waste sector produces run-off pollution from storage and treatment	Waste sector outputs material for use in constructing transport infrastructure Waste sector outputs material for biofuels	**Waste**	Waste sector outputs biomass for use in energy generation Waste sector provides material for incineration with the energy sector Waste sector provides material for anaerobic digesters	Waste sector provides recycled materials for use in ICE infrastructure							Waste sector provides material for composting Waste sector provides material for anaerobic digestion - heat for growing	Waste sector's historic landfill sites can affect flood planes
4	Provides energy for water pumps Provides energy for water treatment	Provides energy for EV Charging Provides liquid fuel for transport modes Provides energy for street lighting, traffic lights etc.	Provides energy for recycling processes Energy & Waste assets can be co-located Provides energy for waste processing/treatment Provides waste nuclear fuel for reprocessing Provides energy for planned or emergency service work	**Energy**	Provides power to connect diverse assets across area Provides power to run digital infrastructure Provides energy for planned or emergency service work		Energy sector outputs emissions to the environment Energy sector's solar farms impact on land use Energy sector's onshore wind farms impact on land use		Provides energy to run logistics servers, data centres etc.	Provides energy for operation of buildings	Provides energy to move raw materials through supply chain Provides energy for machinery	Provides energy for food production, processing, packaging and distribution	Provides energy for planned or emergency service work
5	Provides network management, monitoring and control Provides digital information regarding water treatment and distribution networks	Provides functions for Intelligent transport solutions Reliability of ICT enables working from home that reduces the need for transport Provides communication when transport systems are down Provides rail information system, journey information etc. Provides ability for automation of traffic management Provides GPS function Provides ability to operate Smart Motorways	Provides control and monitoring of waste systems Provides Internet of Things capability for waste tracking	Provides control systems Provides means for coordination and monitoring of power network Provides communication functions Provides Asset Monitoring capabilities Provides Digital Twinning capabilities	**ICT**	Drives awareness of region Provides booking capabilities			Provides communication function		Enables diversity of employment		
6	Tourism increases water demand	Tourism increases the need for transport Tourism creates traffic jams Tourism causes uneven demand profiles	Tourism increases demand on waste functions	Tourism increases the need for energy	Has expectations on communication infrastructure	**Tourism**							
7		Denser land use reduces the amount of private car use					**Environment**	Provides green space that supports wellbeing					
8		Provide funding for transport Provide demand for transport systems			Provide engagement and feedback regarding government investment policy		Output pollution to environment	**People**					
9		Provide function to move goods for manufacturing within the transport sector (e.g. car production)	Provides functions for distribution of chemicals and parts for maintenance		Provides functions for distribution of digital infrastructure equipment				**Logistics & Distribution Centres**				
10	Provides demand in construction and use Waste water for treatment	Provides demand in construction and use	Provides demand on waste system in construction and use Outputs household waste	Provides demand for energy in construction and use	Provides demand for communications in construction and use		Drive changes in land use			**Built Environment (e.g. Housing)**	Drives need for employment		
11	Increased employment opportunities drive need for larger network	Increased employment opportunities drive need for larger network	Increased employment opportunities drive need for larger network	Increased employment opportunities drive need for larger network	Increased employment opportunities drive need for larger network					Increased employment opportunities drives demand for housing	**Employment**		
12	Agriculture and food production creates waste water for treatment Agriculture and food production can create run-off pollution	Agriculture and food production provide materials for biofuels Agriculture and food production output produce for transport	Agriculture and food production produce waste from packaging Agriculture and food production produce green waste for composting	Agriculture and food production provide sources of biofuels and feed for anaerobic digestors Agriculture sector provides land for wind plant Agriculture sector provides land for solar plant								**Agriculture & Food Production**	
13		Flood defence services provide protection for service continuity											**Flood Protection**

Figure 4 - Combined Workshop Matrix

Imagining the Future



The first two workshop activities sought to encourage participants to consider the purpose and complexity of the South West's infrastructure system. Neither the purpose nor the infrastructure is static, both are constantly changing. Therefore, when considering the decarbonisation of the regions infrastructure it is important to also consider what outcomes it may need to facilitate in the future and what technologies may help it in doing so.

There can be a tendency when thinking about future scenarios to simply extrapolate from the past and present towards more of the same solutions. They may be faster, cheaper, more effective, more efficient or have higher capacity than before, but they are essentially the same technologies. This path dependency leads to the thinking behind more roads to combat congestion.

Workshop participants were asked to try to overcome this way of thinking to imagine the sorts of activities and outcomes that would be required and valued in an ideal future. What would the decarbonised South West Peninsula ideally look like by 2050? What is the most probable scenario? What would be the worst-case scenario?

Ideal

Most of the discussions during this section of the workshop focussed on an idealised future for a decarbonised South West Peninsula. Energy and governance, transport systems, well-being, housing, education, the natural environment and energy systems were common topics.

Economy & Governance

The idealised South West of 2050 would be more self-sufficient with an emphasis on a sustainable, green, circular economy. There would be a resurgence of community supported local services. Emphasis on growth in GDP would be replaced by a system that delivers valued social outcomes. This would require sensible regulation as a driver to positive change. A smarter grid, improved storage technologies and greater opportunities for community energy schemes will all be required to maximise the region's ability to generate sustainable, clean energy. Despite the drive towards self-sufficiency it would still require a national government that did not make decisions on narrow political or financial factors. The ideal economy of 2050 would appropriately value natural capital and may require some degree of localised population management, particularly with regards to transient populations. Fundamentally, governance and regulation would make society more equitable, such that everyone has the space and resources to become more self-sufficient and participate in clean energy, local food supplies and other solutions to the decarbonisation challenge.

Transport

The journey to a decarbonised South West should not require the construction of any new roads. The focus should instead be on the maintenance of existing networks and the implementation of solutions that reduce the demand placed upon those roads. This could include improved, reliable, low-cost (or even free) public transport solutions with more on-demand car rental and taxi services replacing private ownership. Fundamental changes will have happened within working practices to reduce the dependency on person al commuter travel. This would mean more working from home, greater use of videoconferencing (which would require fast, reliable internet connectivity), and flexibility in working times and locations.

Vehicles based within or visiting the South West would not be electrically powered, with internal combustion engines prohibited. Long-distance mobility solutions and related legislation would be in place to discourage tourists from driving in private vehicles to the South West. This may require improved low-emission rail connections, better integration across transport systems and reliance on previously mentioned on-demand solutions. Expectations around mobility will need to change for this to become reality. Such technologies would make travel time where it was necessary more productive.

Localised supply chains and strategic community hubs for logistics services will also be in place to reduce road freight. Greater pedestrianisation would be implemented in urban centres. Emerging technologies would be embraced such as AI and self-driving vehicles powered by low-carbon sources.

Health & Well-being

Better health and well-being are central to any future vision for the idealised South West Peninsula. The region's economy, culture and infrastructure would support social inclusion, equality of opportunities and lower levels of anxiety. It would serve the lifestyles citizens wanted.

Housing

Affordable housing, while minimising new-build developments, would be widespread across the region. This may require changes to housing expectations and concepts. The existing housing stock would be retrofitted to be more energy efficient, reducing lifecycle costs and emissions.

Education & Culture

Citizens of 2050 would be well educated and capable of holistic, critical thinking. Behaviours would be transformed along with consumer habits. The culture would be open to innovations and experimentation with a desire for continuous improvement.

Environment

The natural environment would not only be preserved, but there would be a reversal of negative human impacts. Reforestation, improved biodiversity, clean air and water would provide attractive, liveable environments with reduced flood risk.

Energy

The South West's energy system would have adopted new technologies to meet demand in a sustainable, affordable low-carbon way. This could include more solar, wind, wave and geothermal sources. A better grid, improved battery technology and community energy schemes would mean the region was not only self-sufficient in sustainable energy, but a net exporter of clean energy.

Most Probable

Discussions over the most probable 2050 state of the South West Peninsula featured some similarities, but also some significant differences.

Environment
While there might be a pause in adverse environmental impacts, biodiversity across the region would nevertheless have decreased. An increased in population would witness coastal erosion, sea-level rises and increased flooding.

Education & Culture
There may be some shifts in diet, consumption and expectations regarding public services, however it was also suggested the South West would likely become more isolated with increased NIMBYism.

Economy & Governance
The economic and governance systems are most likely to maintain the status quo with some steps to transition to a self-sufficient circular economy. The governance system would still see problems in siloed isolation from one another. Some felt that the South West would be lagging the rest of the UK at this point. Climate mitigation and adaptation may have been implemented where necessary.

Housing
Homes would need to be relocated due to coastal erosion and flooding, with an increase in energy inefficient high-rise buildings to house the increasing population.

Transport
Those present at the workshops felt that the most probable scenario would see improved public transport but too many private vehicles remaining on the roads. Improved cycling infrastructure would be mixed with a transition to most vehicles being electrically powered. Despite this, the charging infrastructure might not be ready to meet demand. There would be large investment in major transport links, but a lack of investment in minor transport infrastructures.

Energy
The most likely state would see more renewable energy sources such as ground source heat pumps, tidal power and offshore wind. Some felt that renewable energy sources would form the largest portion of the electricity generation capacity by 2050.

Worst-Case

Finally, the worst-case scenario for the South West in 2050 was discussed. In this scenario both the South West region, the UK and the world would see continued population growth. Most participants started this task with a discussion of climate and environmental changes.

Environment
The worst-case scenario would see climate change out of control, leading to advanced warming. Sea level rises were identified as a key threat to the South West, potentially necessitating a managed retreat from some coastal regions and an acceptance of greater flood risk rather than investing in increasingly costly flood defences. The depletion of natural resources would continue apace causing significant biodiversity loss. Food supplies and agricultural system would be weakened. Some suggested the South West may see a degree of reforesting, even in the worst-case scenario as it is used to become an offset for the Carbon emissions of the rest of the country.

Economy & Governance
The worst-case scenario would see increased poverty, increased inequality and decreased accountability (individually and politically). The regulations and standards governing infrastructure would not be improved.

Housing
There would be insufficient housing for the growing population with poor planning leading to urban sprawl of poor-quality inefficient housing into previously rural areas.

Transport
With diesel and petrol still dominant sources of energy for private vehicles, the roads would become increasingly clogged and some areas less accessible.

Energy
Energy systems would breakdown to such a catastrophic degree that they would no longer meet demand. Prices would rise leading to increased energy poverty

Health & Well-Being
While the workshops took place in January and February 2020 health pandemics were identified by multiple participants as a risk to the South West and a feature of the worst-case scenario. General health and well-being would decline if no action was taken to address the other issues identified in discussing the worst-case scenario.

Knowledge and Capability

Two central segments of the challenge canvas relate to the knowledge and capability required to deliver the ideal vision of the decarbonised future and ensure that the ever-changing purpose of the region's infrastructure continues to be fulfilled.

These elements were considered though six questions posed to the participants:

1) Do we have the information to tell us where we are now?
2) What are the uncertainties?
3) What additional information might we need?
4) How can we get that information?
5) How will we know when we have arrived at our destination?
6) What could we measure or monitor to help inform us along the journey?

The questions seek to understand where key information exists but also what necessary information is missing. This second part is key to developing the first steps in a roadmap to change.

The table below records the responses from each of the workshops. While an integrated view for the Peninsula is sought, the discussions are kept separate here to highlight the similarities and differences between the perspectives of the two locations. They form a snapshot of the discussions and views of those present.

Bristol

Truro

Do we have the information to tell us where we are now?

In Bristol, some participants felt that there is in fact too much information while others felt there was limited reporting of the necessary data. Other suggested that **we don't yet know what data we even need to tell us where we are now**. While huge volumes of data may exist, there is no consensus over what is relevant, no information collective and no platform for accessing large amounts of the data. There are also **questions over the trustworthiness of existing data** due to technical issues, implicit assumptions or hidden agendas. The accuracy and granularity of data varies across sectors. There is a need for a trusted source to assimilate and interpret the data across the infrastructure sector.

Similar differences existed in Truro with some suggesting information useful for decarbonisation was not being calculated while others felt the necessary information did largely exist. The feeling that better data was required was seemingly stronger in Truro than in Bristol. It was also acknowledged that some of the basic assumptions needed for baselining are not yet agreed. There was consensus that **the data is not in a visible, accessible form** and more need to be done to bring it together. A lot of information is published but it doesn't give hard facts. **Consistency is needed in the collection of data across sectors.** There should be a standardised framework for data gathering. General public does not have the information and information is not measurable/understandable

What are the uncertainties?

Building on the previous discussions, **the quality and accuracy of some existing data was identified as an uncertainty**. It is not always known how the data collection methods have been calibrated or the frequency with which it is collected. There can be inconsistencies in reporting leading to confusing or uncertain data. National Grid are an example of best practice in data collection and reporting. The predictive capabilities of current data is unknown. Perhaps in contrast to the response to the previous question, many felt that there were still significant uncertainties surrounding data required for benchmarking the current carbon producing activities across the south west. **Obtaining a baseline is essential to deriving a strategy for decarbonisation.** This needs to exist at a level with sufficient granularity to address the differences across sectors and sub-sectors. There are uncertainties around the strengths and weaknesses of the south west's current economic and energy systems and further uncertainties around their potential future state.

The accessibility of information is often unknown, providing challenges when it is believed to exist. The complexity of the situation yet to be fully understood. The validity, accuracy and consistency of existing data sets can be unknown. The cost associated with decarbonisation or inaction are largely unknown. T**here is no clear picture on how industries and individuals across the south west are using energy**, even where the headline input figures are known. There are uncertainties over the best way to collect and report data. Local, national and international standards vary. Even units of measurement can vary between sectors or organisations. There are uncertainties over the long-term trajectories of many key input and output indicators.

Bristol

Truro

What additional information might we need?

Information that provides an assessment of the true, holistic life cycle impacts and costs of all activities, current and proposed is essential. That might take the form of a Cost Benefit Analysis or similar, providing environmental, social and other externalities were appropriately accounted for. We need information that allows us to monitor for potential unintended consequences of interventions. **We need information that allows us to measure embedded and active carbon associated with infrastructure projects across their entire supply chains and life cycles**. Some additional production data may be required. This will help provide the benchmark from which to move forward. **We need sufficient information to prepare accurate models of future demand** scenarios and use this with the benchmarking data to develop credible pathways to net-zero carbon. We need information that allows us to identify and model the influences that changes in one sector could have on another.

The consensus in Truro aligned with that in Bristol. **We need information that provides a complete picture of impacts throughout the whole infrastructure life cycle** from which to inform a data baseline. Sufficient information might exist, but it is not standardised or compatible. We need reliable information regarding future trends in climate change, energy use and other infrastructure activity drivers.

How can we get that information?

Relevant carbon data should be **collated locally in a standardised and consistent way** by all involved across infrastructure supply chains before being curated and collated as necessary by higher level projects, operators, and governance institutions.

Collecting the necessary information requires **a transformation in culture, education, and clear publicity of priorities**. Standardisation from over-arching industry bodies and trust between organisations Is essential to facilitate the required levels of data sharing. Some felt that payment would be required to access the necessary data.

How will we know when we have arrived at our destination?

The participants proposed three potential methods. The first, and perhaps most obvious would be to **establish a robust measurement of net-carbon**. While simple to state it may prove complex in practice. The second method looks beyond this to the ultimate outcome, acknowledging that net-zero carbon is means to an end. We would know when we have arrived at our destination **when the rate of climate change was reduced to an acceptable level**, which might mean stopped altogether. Such indicators could considerably lag the interventions. The third method attempts to address this by **establishing a series of targets or leading indicators** at key stages along the journey. The following questions address the form that data might take.

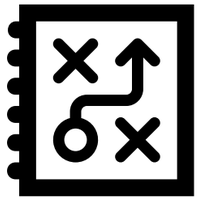
Echoing discussions in Bristol, **a measure of net-carbon** was discussed, multiple groups in Truro suggested **milestones** would be necessary, and some expanding this to concept of **a carbon dashboard** through which progress could be monitored. A short-term destination could be standardised carbon measurement for the infrastructure sector. Global temperatures or other indicators such as sea ice could also provide means to monitor success. While the ultimate planetary condition is key, it is not yet clear what the desired end point for these variables might be. One group suggested that the destination should be continual improvement.

What could we measure or monitor to help inform us along the journey?

It was suggested that the measurement of **performance data should be as automated** as possible and that policy interventions could be monitored as leading indicators of change.

As explored in response to previous questions, there are outstanding questions around how carbon is measured across various industries and the current base line. Without establishing these it will be difficult to progress. Any **performance measures taken along the way should be reported in real time**, or as close to real-time as possible. Power usage and timing would be useful. Individual initiatives -such as the number of new dwellings to Passivhaus standards or other energy efficient ratings - could provide leading indicators of change. **Volumes of other pollutants would also be important to ensure the focus on carbon is not blinkered** to impacts from other mechanisms. **Measures of the natural environment** (e.g. biodiversity, water quality, number of trees, air quality, etc.) could provide useful insights.

Collaboration and Empowerment



Two central segments of the challenge canvas relate to the collaboration and empowerment y required to deliver the ideal vision of the decarbonised future and ensure that the ever-changing purpose of the region's infrastructure continues to be fulfilled. These elements were considered though six questions posed to the participants:

1) What can we do to ensure the collaboration necessary to get us there?
2) What are the barriers preventing that collaboration now?
3) How can we overcome those barriers?
4) What would motivate those we would need to collaborate with?
5) Are there any potential trade-offs that will need to be considered?
6) What should the South West infrastructure sector do to speak-up and act with a single voice?

The table below records the responses from each of the workshops. While an integrated view for the Peninsula is sought, the discussions are kept separate here to highlight the similarities and differences between the two locations. They form a snapshot of the discussions and views of those present

Bristol

Truro

What can we do to ensure the collaboration necessary to get us there?

Collaboration requires **open channels of communication** across industry, government and academia. These must extend nationally and internationally. Specialist consultants and experts can hold knowledge of key resources and should be involved in collaborations. Communities, end-users and those who struggle to have their voiced heard should be included. There may be a role for central agencies to help identify who should be included in collaborations. While collaboration can be rewarding in itself, contracting and regulatory structures should also **reward good collaborative behaviours**. The terms and methods of contracts can be used to facilitate collaboration. It was felt that one of the most impactful things that could be done to ensure collaboration is to **establish unified decarbonisation objectives** behind which stakeholders could align. If they are not convinced in these aims or there are multiple conflicting aims, then there will be additional barriers to collaboration. This requires a clear, co-produced route map with standardised ways of collecting data and agreed metrics.

A plan to bring together communities, local government, central government and specialists around **a clear vision and common agenda** is required to support collaboration. Aligned objectives and simple, achievable goals would encourage this collaboration. Furthermore, the aims and objectives of the collaboration itself must be clear and mutually beneficial to all parties. The process of collaboration would need some **financial resourcing**. The benefit of doing this would need be clear at a local community level. Spreading knowledge throughout the infrastructure sector is important. **Cross-sector reviews** could facilitate this.

What are the barriers preventing that collaboration now?

Contractual arrangements and commercial procurement practices are not designed for collaboration. They have often evolved by incremental change not holistic design. The consequences of this are **boundary problems** or "buck passing" between agencies and competition based on lowest Cap-Ex. The contractual and broader structure of the industry reinforces a **silo-mentality**, vested interests, and lack of understanding over others' issues. It encourages the protection of IP and discourages innovation. The **lack of achievable short-term targets**, conflicting motivations and poorly formulated CO2 targets can prevent collaboration between different entities. **Outsourcing and fragmentation** present barriers to effective working together. It was felt that politics, power and ego could play a negative role. Individuals may feel disempowered to work together and share information.

The industry can be resistant to change, often as a result of **structural and contractual issues**. Clarity and agreement over who pays and who owns the risk are also barriers to collaboration. There is often too little time given on any project to instigate effective collaboration across the stakeholders. Procurement frameworks are purely transactional. **The focus on Cap-Ex** over whole life costing was also highlighted as a barrier, as it was in Bristol. The issues that require addressing lack a clear owner to instigate and manage the collaboration. **Tribalism and trust issues** across the industry can also prevent successful collaboration. The wider economic system does not support the sorts of collaboration required to tackle global environmental crises. **The scale and complexity of the problem** can be a barrier to collaboration despite being the factors that necessitate it. Individual actors and organisations retreat to the certainty of their own silos. There is a general lack of understanding of the problem, no joint policy, no understanding of benefits of difficult decisions. There are no processes to make difficult community decisions.

Bristol

Truro

How can we overcome those barriers?

Two actions emerged from the Bristol workshop as central to overcoming the barriers to collaboration. The first was to **establish agreed measures for determining success**. These must be translated and embedded into different disciplines and industries within the infrastructure sector. **Shared targets** must align with the route map to the ultimate destination of net-zero carbon with a clear strategy for achieving milestones along the way. The second action was much more fundamental. The industry requires **a change in culture**. This means a removal of the win/lose competitive mentality and replacement with structures that support attainment of the ultimate decarbonisation and sustainability goal. In practise this might mean the establishment of a statutory basis for inter-agency collaboration. It might require new frameworks for risk sharing across projects to reduce individual cost exposure and barriers to innovation. CDM-style regulations for carbon reduction could be introduced. Formal partnering and changes to economic models may be required. All of this would require **leadership from those that recognise the severity of the environmental crisis**. The involvement of contractors and those with relevant social science skillsets early in the design process could help overcome barriers to collaboration. The harmonisation of language across sectors and organisations could also support better collaborative working as could some technological innovations such as those related to Building Information Modelling.

Many of the same actions were suggested at the Truro workshop, albeit with a slightly different emphasis. Related to culture change, the strongest message related to **education** within the industry and beyond. Identifying key innovators in this area, sharing best practice and promoting emerging technologies such as 5D BIM were suggested. Second to this was the need **to re-value the environment** alongside more traditional commercial valuation. This should be based on improvements to specification, contracting, regulation and risk as well as proactive incentives like sustainability awards and other forms of recognition. These also help with the education of best practice. **Earlier engagement with contractors** and more time/focus in earlier stages of projects where savings and impacts can be maximised. Frameworks such as Project 13 can help to change the landscape to focus on overall goals rather than short-term individual incentives. The need for an agreed **shared vision** with short, medium and long-term targets was also recognised as being essential to overcoming the barriers to collaboration.

What would motivate those we need to collaborate with?

Motivation can come from a **shared vision, seeing the rewards/benefits and regulatory incentives**. Reputational, legal, and financial factors will always be strong motivators. Infrastructure needs to be de-politicised. Education is also essential.

Financial incentives will always be the biggest motivator under current systems. **Public engagement** and a clear understanding of the long-term benefits of collaboration can help. Good example and **case studies of successful collaborations** would motivate some into action. A carbon reduction and collaboration champion for the region could work to unite organisations, individuals and groups. There would be success until collaboration is a part of business as usual.

Are there any potential trade-offs that will need to be considered?

Nimbyism is often a factor that necessitate trade-offs. Across the region there may be trade-offs and conflicts between the rural and the urban. **Addressing social inequality** presents a need for important but difficult and complex trade-offs. Unforeseen environmental impacts and **short-term carbon solutions leading to other negative long-term impacts** would need to be carefully managed. In any project, under the current systems cost, speed and efficiency present trade-offs. The quickest or cheapest solution may not be best. We need to move away from a culture of 'more'

The economic cost of action versus the risks of inaction present a fundamental trade-off. There is a reactive mindset that is willing to pay to defend against something that has happened recently, but less willing to pay for the prevention of future hazards of which there is no current experience. Equally there is a mindset of 'cost' rather than 'investment'. There is a tendency to only see one side of the balance sheet. Spending on infrastructure and infrastructure resilience can be seen purely as a cost and expense rather than an investment in creating better services or preventing catastrophic environmental impacts. The cost of action is being judged against a poorly understood and uncertain cost of inaction. The protection of **intellectual property rights and the distribution of rewards and recognitio**n can also introduce the need for trade-off decisions.

What should the South West infrastructure sector do to speak-up and act as a single voice?

The South West infrastructure sector must **act in a professional, informed and holistic way**, to speak with one voice and lobby on a regional and national level.

The sector should build on the South West Infrastructure Hub and **grow the South West Infrastructure Partnership**. It should identify and **create best practice**. It needs to embrace and table the difficult trade-offs and articulate the decisions to broader stakeholders. For example, the inconvenience of new sewerage infrastructure versus the benefits of clean beaches/seas/fish stocks /tourism etc. It should promote the opportunities decarbonisation offers and **involve everyone** (academics, public, private sector etc.). The sector should **co-produce an agreed vision and clear targets** around which everyone can collaborate.

Actions and Next Steps

During the final session participants were asked to identify important actions for the South West infrastructure sector to successful progress towards a net-zero carbon future. Each participant was also provided with two stars with which to vote for the one or two actions they felt to be the most critical.

The following list documents the actions receiving the most votes across the two workshops. Some can be achieved in the short term while others require more resources and time.

1. **Develop a framework for consistently measuring progress towards decarbonisation.**
2. **Set achievable and measurable targets that provide a clear route-map to the overall goal of decarbonisation by 2050. This must be developed by, and accessible to, multiple groups including small and large businesses, the Health and Safety Executive, regional and national governance institutions and the public. It should combine any existing pathways into a single credible route map with collectively agreed priority areas that can be monitored by the framework above.**
3. **Encourage a fundamental change in mind-set regarding waste and CO_2 production to underpin the route-map and all emerging actions and behaviours.**
4. **Educate and inform all regarding total lifetime CO_2 production and the costs of inaction.**
5. **Expand the South West Infrastructure Partnership to include as many representatives from relevant sectors across the region as possible.**

= **Co-produce and establish a clear definition of 'net-zero carbon'.**

= **Ensure carbon-neutral housing and green-villages.**

In addition to these five actions, the following related actions were also identified across the two events as being of importance. A single project lead should be appointed/identified to collate information/data currently available and promote the case for action. This should be used to influence the establishment of ambitious centralised carbon targets, including incentivisation mechanisms. A simple, consistent means to calculate the whole life cycle associated carbon should be produced, showing the cost/benefits of action and inaction. A system of pledges for the public, businesses, schools and governments was also recommended.

Industry should find a way to share best practice via partnering, shared targets, early contractor involvement and national databases. It will be necessary to address the equality of costs and impacts between different communities.

The South West Infrastructure Partnership should provide an integrated strategy with other professional bodies to inform and influence regional and national authorities. It should provide better collaborative links to these authorities. It should detail to government the South West infrastructure industry's co-designed roadmap to reach net-zero carbon.

Information regarding progress and other contextual changes should be tracked and reported on an annual basis. This should inform improvement strategies.

Net-zero carbon should be incorporated or elevated in the various guidance and regulatory documents that are used within the industry, for example, Building Regulations, Codes of Practice, Standards and Specifications and HM Treasury's Green Book. Locally supplied resources (materials and skills) should be encouraged or incentivised.

Organisations, individual departments within those organisations and individual projects should seek to work with carbon specialists, embedding them in their day to day operations. There is a need to understand outstanding barriers and upskill providers to deliver against the net-zero carbon route map.

It was clear from the two events that there is a realisation of the complexity of the decarbonisation challenge and great deal of appetite for collaborative action across the infrastructure sector to address that complexity. This requires a neutral convener to facilitate the co-production of a regional industry route-map, the collection and sharing of data to monitor progress and support the collaboration necessary to enact the required change