The Role of the Quality Infrastructure in Scaling Net Zero

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An independent report by the Royal Society of Edinburgh (RSE) commissioned by BSI

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Executive Summary

The British Standards Institution is hosting the International Electrotechnical Commission's (IEC) annual meeting, on behalf of the UK, in Edinburgh in October 2024. In its efforts to engage with local stakeholders to create an impactful legacy for the conference, BSI commissioned the Royal Society of Edinburgh (RSE) to bring to bear the world-leading expertise of its multidisciplinary Fellowship and Young Academy of Scotland to examine the role of quality infrastructure (QI) in accelerating progress to net zero.

Quality infrastructure (QI) refers to the institutions in every country which manage the core functions that underpin the market economy: measurement, standards (assurance), and accreditation. Despite being ubiquitous, in many countries - including the UK - the QI is largely invisible, with a low level of awareness or understanding amongst government, industry, and consumers. If we are to reach net zero by the deadlines that loom ever nearer, scaling up novel technological solutions will be a critical factor to our success. QI can pave the way by speeding up and harmonizing the necessary governance, helping to take promising innovations out of the lab and into the global marketplace in time to make a real difference.

The QI can support innovation in several ways:

Standards as an alternative to regulation

Given the timescales required to introduce or amend laws, developing regulatory systems is by default a protracted process. Stakeholder-led standards can provide an adaptive alternative to regulation that allows for regular recalibration as more evidence becomes available. They can thus evolve alongside the products, practices, and services they are intended to oversee.

Flexibility

In the last ten to fifteen years, there has been a noticeable trend towards more agile, responsive standards. This agility can be capitalized on to fast-track solutions to key societal challenges like net zero. For example, the newly introduced **ISO Net Zero Guidelines** were developed through a formal international workshop process involving over 100 countries and over 1,200 people in record time – four months – illustrating the potential for standards to be developed rapidly without sacrificing rigour. BSI has implemented fast-track processes for many years that are widely used by government and industry.

Securing consumer, industry, and investor trust

The QI transcends political short-termism and provides an enduring link to global markets and the wider economic picture that cannot be undone through changes in domestic policy. This ensures that innovation continues to be incentivized and rewarded. Through procurement, governments can act as consumers and their outgoings can be significant. Given this huge volume of investment, it becomes particularly critical to ensure that appropriate standards are applied to the public procurement of goods and services, including sustainability standards. Consumers are also seeking and indeed deserve peace of mind that the investments they make in green solutions will pay off, both from a financial as well as an environmental perspective. By having the appropriate standards in place, consumers can be assured that new technologies are not only safe and effective, but that they will remain fit for purpose over a reasonable timeframe. Elevating the consumer voice is becoming an increasingly central concern within the standards community. The UK is already regarded as an exemplar in involving consumers in the process of setting standards, and the national quality infrastructure (NQI) is further improving their representation.

Despite the economic, societal, and environmental benefits that can be derived from using QI to its full potential, there remain challenges to applying it to the innovation space.

Lack of awareness

Stakeholders may not even be aware that QI exists. For those that do, they may not fully understand how it applies to them and how to engage with the system confidently and strategically. Government and public agencies may be similarly unacquainted with all the nuances of the standards space, particularly those which are new or emerging.

Industry reticence

When developing or adapting standards, it can be difficult to achieve the necessary consensus, particularly in industries where a few vocal players exert a disproportionate influence on the direction of the sector. Indeed, there can be a strong reluctance among incumbents to accept new standards that threaten to disrupt their business models or whose return on investment is not immediate. Environmental and social standards can often fall into this category of delayed returns.

Applying systems thinking to standards

Developing a system of standards and assurance to govern a particular product, practice, or service can introduce a dilemma: is the optimum solution one that governs the technology itself, or one that covers the overall market framework where that technology is deployed? If a new product is rolled out in accordance with the latest standards, we must ensure that industry is ready to receive it and that its introduction will not lead to any unintended consequences as far as we can tell. Although systems thinking can be a challenge, it is important for the standards community to

face it head on. It would also help to remedy the fragmentation that is often observed across Scotland's policy environment, providing another example where standards may be more suitable than legislation in governing innovation.

Case studies are presented to show how QI has been successful in promoting innovation and where it could be made more adaptable. The case studies are derived from the following sectors and contexts:

- The built environment
- Regulatory equivalence
- Wind energy
- Water
- Hydrogen
- Consumer rights

The paper concludes by offering recommendations for future action and improvement.

Improving visibility of QI and signposting to resources

Businesses and public bodies may not understand how to harness QI to improve their performance and bottom line, particularly smaller organizations. Start-ups and Small and medium-sized enterprises (SMEs) could benefit from accessing road maps or guidance documents (whether generic or industry-specific) that explain how to leverage QI for the purposes of innovation and growth.

Capacity building

As QI looks to raise its profile, it should also consider how it can support the development of associated training opportunities, perhaps in partnership with universities, research institutions, and standards bodies like the BSI. Such training would ideally cover not only the mechanics of QI (including their intersection with international schemes), but it would also explain how to engage constructively with the standardization process itself.

Making standards more agile and adaptive

QI can act as a powerful tool to galvanize international progress towards net zero. However, the system needs to become even more forward-looking and adaptable than it is today. Society cannot conceive of all the solutions that will ultimately be deployed in meeting the climate change challenge and so QI must be able to deal with unanticipated opportunities or hazards. Indeed, standards should be as much a proactive as a reactive tool, one that complements its reputation for effective monitoring and evaluation with greater openness to dynamic experimentation. In this way, standards can form part of a feedback loop that both transmits and collects information, implementing proportionate expectations while also pointing to areas for improvement and helping to suggest a future direction of travel for the sector being considered.

As with regulation, prescriptive, technical standards can serve a valuable purpose, most often in the field of consumer products where safety is paramount and predicated on absolute clarity. Similarly, standards that are too broad run the risk of being inefficient if they are too superficial to accommodate the properties of the technologies they are meant to encompass. New or emerging practices and services can benefit from using a framework of process or outcome-driven standards which focus on performance requirements rather than prescriptive technical specifications.

Where new standards are developed, or existing ones adapted, to deal with the properties of innovative technologies, they will need to have a solid grounding in regular engagement with sectoral innovators and policy makers, citizens and consumers. This engagement should take place at both national and regional levels.

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Foreword

Addressing climate change is one of the most pressing challenges facing the world today. Scotland hosted the UN international conference COP26 in Glasgow in 2021, reaffirming its commitment to achieving a net zero future by 2045. The UK as a whole has made great strides in the development of renewable energy and the reduction of carbon emissions, yet the goal of achieving net zero remains elusive.

In the ongoing debate over how to accelerate progress towards the decarbonization of industry and the transition to renewable energy sources, a valuable tool available to government and industry is the quality infrastructure. This is the ecosystem of regulations, standards, and assurance that can create the right market conditions to promote innovation, investment, and industry transformation at scale and at pace. Conversely, an inefficient quality infrastructure can hold back progress through overregulation or complex business processes.

Products and services emerging from major new innovation platforms like AI, quantum technologies, and engineering biology will play an important role in achieving net zero outcomes. However, much of today's quality infrastructure was put in place to govern the products of 20th century technologies, which were developed in an environment where industry sectors operated in silos. To address the cross-cutting nature and requirements of 21st century innovations (such as the role of digital technologies and sustainability), the quality infrastructure has to evolve. Managing the adaptation of the national quality infrastructure to deliver the degree of scale-up and adaptation needed, on a fast enough time scale to achieve net zero targets, is a major challenge for standards bodies and regulators.

BSI, in its role as the national standards body, is one of the core bodies making up the national quality infrastructure, appointed by government to support industry and regulators to use standards more effectively to simplify the market framework and improve business performance. As part of its commitment to engage with thought leaders and expert stakeholders, BSI commissioned the Royal Society of Edinburgh (RSE) to produce an independent report on the role of the quality infrastructure in scaling net zero, to be published on the occasion of BSI's hosting of the International Electrotechnical Commission's (IEC) annual meeting, on behalf of the UK, in Edinburgh in October 2024.

Delivering consensus on how business and industry could scale net zero through use of best practice, integrating the perspectives of all stakeholders, and considering how this can be delivered through the market are fundamental to meeting our national targets. Particularly in Scotland, there are opportunities to build on a sustainability oriented culture and to reinforce a commitment to meeting net zero targets, and a smart, adaptive quality infrastructure will be a necessary part of that agenda.

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Introduction to quality infrastructure (QI)

Quality infrastructure (QI) refers to the institutions in every country which manage the core functions that underpin the market economy: measurement, standards (assurance), and accreditation. These functions are essential to support the system of market governance at international, national, and local level. Despite being ubiquitous, in many countries - including the UK - the QI is largely invisible, with a low level of awareness or understanding amongst government, industry, and consumers.

Used effectively, the QI will accelerate innovation, support growth, and boost trade through bringing consistent and transparent expectations of performance, interoperability, and safety for goods and services. The system of QI is crucial for governments to deliver efficient and competitive markets in line with governance policy across all sectors, from consumer products and healthcare to the building industry, agri-food, and online services. There is no part of the market economy that the QI does not influence, yet its contribution often goes unrecognized.

Efficient governance of the market requires governments to implement systems that deliver seven vital functions: regulation, intellectual property rights, measurement (metrology), industry standards, accreditation, conformity assessment (testing, inspection, certification), and market surveillance.

Every country has a national quality infrastructure (NQI). In the UK, the core QI is responsible for three of these functions: metrology (the National Physical Laboratory (NPL)), standards (British Standards Institution (BSI)), and accreditation (United Kingdom Accreditation Service (UKAS)). Market surveillance is provided by a combination of regulators (e.g. Food Standards Agency) and Local Authority Trading Standards Officers (SCOTSS in Scotland). Conformity assessment is delivered by the private sector and may be accredited or unaccredited. Products deemed high-risk (such as medical devices) may require pre-market approval by official bodies. Together, these organizations oversee the standards, assurance, and regulatory policies that help make the UK a safe and attractive place to live and do business.

Standards are a set of parameters, or simply information, agreed by relevant stakeholders that relates to the delivery of goods and services by organizations. Standards are not about making things the same. Standards may comprise rules, guidelines, frameworks, specifications, or simply be a set of principles. The main difference between different types of standards is the process by which the consensus was reached.

Although QI standards, which are voluntary in nature, and regulatory standards serve similar functions in overseeing the quality and performance of products, practices, and services, they are in fact very different approaches. Stakeholder standards developed through the QI can be very useful to governments to complement regulation (setting out 'what' must be done in legislation and national policy) and describing 'how' organizations may do it. However, most industry standards that are in use in a developed economy are voluntary. What matters is that the output (product or service) meets the expectations of the associated regulation.

Stakeholder standards have a valuable role to play in governing the development of disruptively innovative products or services in the absence of regulation, or before regulation is fully defined. This could avoid premature resort to regulation that could then be difficult to adapt to their changing properties as they go through the later stages of development. On the topic of disproportionate regulation, this paper welcomes the UK Government's recently launched Regulatory Innovation Office which pledges to tackle regulatory backlogs to expedite decisions on new products and services.

The word 'standard' is used very widely, and this can be confusing. In some industries, proprietary certification schemes (where one organization develops a private standard and offers to certify organizations against it) are described as standards. This type of standard will have a very different governance to the standards of the QI, which are based on stakeholder representation, combined in national delegations in the case of international standards (ISO[1], IEC[2]). Proprietary schemes are common and particularly problematic in the context of sustainability, where claims of compliance to standards are becoming an important variable for consumers and businesses when making purchasing decisions. In the absence of independent accreditation against international standards overseen by the QI, industry claims about performance can easily contribute to greenwashing.

Stakeholder-led industry standards may be developed following government intervention (e.g. through a formal request), industry input, consumer feedback, or any combination of these, and will be maintained as long as the market needs them. These standards may persist for decades, being revised and updated as needed. BSI, in its role as the national standards body (NSB), will oversee the governance process that brings the relevant stakeholders together to prepare drafts and undertake public consultation.

National standards bodies from around the world will be nominated by their governments to represent national interests in the international standards system as represented by ISO and IEC.[3] This integration ensures that national and regional standards are aligned (i.e. non-conflicting) with international equivalents. Many countries pursue a policy of international first, preferring to work in ISO and IEC and then adopting the resulting standard in their own country as a national standard (BS in the UK). Any conflicting national standard is then withdrawn. This is a mandatory requirement for the NSBs of the 34 countries that make up the European regional system (EN). A well developed and sophisticated NQI is often reflective of a nation's or region's prominence in the global market.

The use of standards to streamline the market

[1] International Organisation for Standardization

[2] International Electrotechnical Commission

[3] The third of the three international standards bodies is the International Telecommunications Union (ITU) which is a UN Treaty organisation and in which national governments participate directly.

economy dates to ancient times, when authorities recognized the importance of standard systems of weights and measures in trade. During the Industrial Revolution and particularly during the transition to mass production, it became evident that companies needed to exchange information with each other (and with their clients and regulators) defining the technical requirements of their goods and services. This type of standard continues to form the bulk of industry standards used worldwide and has underpinned the growth of the global economy. Simple examples that we are all familiar with include the dimensions of a credit card (ISO/IEC 7810:2003), or the specifications of a 'standard' ISO shipping container.

During the second half of the 20th century, the concept of quality emerged as a vital element driving business performance, and standards of best practice in management processes were recognized as strategic tools for organizations across all industry sectors. In the last decade, with the recognition that people are the most important resource in any company, standards have been used to agree sets of principles as a consensus of what good looks like - for example, the principles of risk management, good governance, or the principles that corporations should follow to achieve net zero.

Metrological standards describe methods of measurement. The definition of time or weight (kg) are prime examples. Without reliable standards of measurement, market trading will be open to abuse. In the context of QI, metrology ensures that measurements are consistent and reliable across different environments and contexts, and that test equipment for products and services is consistently and reliably calibrated.

Accreditation is a process of 'checking the checkers' whereby an organization that is seeking to certify others against a given standard is itself audited by a third party (such as UKAS, the UK national accreditation service) and accredited to perform that service. A good example is the accreditation of hospital laboratories to perform tests on clinical samples and issue certificates.

Market surveillance is the policing of the market to ensure substandard, dangerous, or counterfeit goods or services are not being offered to consumers. Market surveillance authorities include Trading Standards officers employed by local authorities and regulators, who employ inspectors. Surveillance may involve randomized product testing to ensure regulatory compliance.

If we are to reach net zero by the deadlines that loom ever nearer, scaling up novel technological solutions will be a critical factor to our success. QI can pave the way by speeding up and harmonizing the necessary governance, helping to take promising innovations out of the lab and into the global marketplace in time to make a real difference. The following chapters consider just how QI can act as a catalyst to innovation and how it can be further improved to remove remaining barriers.

Examining Scotland's progress towards net zero

Although this paper is intended to have general resonance, it uses Scotland as a case study to highlight a common challenge that nations face in delivering emissions reductions: the implementation gap. Despite progressive policy, political will, and impressive science and technology capability, Scotland, like many countries, has fallen behind key milestones in its race to decarbonize in line with the expectations of the Paris Agreement. Unless its present course can be altered, it is doubtful that Scotland will be able to reach its 2045 net zero target. This is where standards can make significant positive interventions.

The Climate Change (Scotland) Act 2019 was groundbreaking for its time and positioned Scotland at the forefront of the global fight against climate change. Unfortunately, reflecting concerns raised by the Committee for Climate Change (CCC), Scottish Government has since conceded that the 2030 target of a 75% reduction in emissions is no longer tenable. This in turn makes the target of reaching net zero by 2045 seem even more daunting. In addition, in 2021, it was reported that Scotland had missed eight of its last twelve annual targets, further highlighting Scotland's struggles to live up to its aspirational climate rhetoric. As the CCC also noted in its report to Scottish Parliament, many of Scotland's key indicators of delivery progress are off track.[4] Certain sectors – namely, domestic transport, agriculture, buildings and product use, industry, and fuel supply[5] – continue to release large quantities of carbon, despite a wealth of legislation aimed at curbing emissions (Scottish Government, 2021).

Although Scotland has announced it will be changing its approach and adopting five-year carbon budgets rather than measuring annual emissions reductions - which it argues are prone to fluctuation - critics believe this will only mask the uncomfortable reality that Scotland is no longer a world-leader in climate action. Scotland clearly faces an enormous challenge in living up to its 2045 target. Ambitious policies are not always being translated into action.

Scotland has a very clear vision of where it wants to go and the reputation it wants to build and sustain as one of the world's first nations to reach the increasingly elusive target of net zero. This needs to be backed by actionable delivery plans that make the most of new and emerging technologies. Scotland is fortunate to play host to a brilliant and internationally connected research and innovation community who are making significant strides in solving the many decarbonization challenges that remain. How can their cutting-edge research be scaled up and commercialized safely, quickly, and efficiently, both in Scotland and around the world? We will clearly need adaptation of current policies, but they will need to work this time.

> Standards and the NQI, if intelligently mobilized and developed in parallel with policy adaptation, could regain some much-needed ground in Scotland's journey to net zero.

[4] Progress in reducing emissions in Scotland – 2023 Report to Parliament: https://bit.ly/4h19iYl
[5] Scottish Greenhouse Gas Statistics 2022: https://bit.ly/4f2m7zF

How QI can support innovation and achieving net zero

The Earth is facing a collective climate emergency, and nations must rapidly rally their respective research communities and economies to develop cutting-edge solutions to replace or complement existing approaches. The QI concept needs to be a better understood and utilized dimension of business, industry, and academia within the UK, emphasizing its role as a supportive framework for innovation. This is the reality in many other countries, including Japan, Korea, the US, Germany, and France, where there is a much stronger appreciation for QI as a critical tool in securing business advantage and promoting economic growth.

An initial question might be: is there a standard for net zero itself? The answer is yes, by some metrics, such as the ISO Net Zero Guidelines.[6] However, climate change is a complex phenomenon made up of many variables which can interact in unpredictable ways. Even the most agile standards could not possibly account for these constant variations, nor would it be useful for them to do so. It is therefore more practical to frame standards as providing a blueprint towards reaching net zero, rather than demanding precise compliance with what is ultimately a temporary definition of net zero. Despite this caveat, there is some debate as to whether QI could go further in capturing the full carbon impacts of a product, practice, or service, as discussed further in section 6. The following sections highlight some of the ways in which QI can support innovation, including in the quest to achieve net zero.

Securing business and innovative advantage through standards

There is a continuous interplay between national and international standards. While nations can be obliged to incorporate international standards within their own regulatory frameworks (such as entrenching the principles of the Paris Agreement within corresponding national targets), they can also influence standards upstream by participating in the international negotiations where prospective standards are scrutinized and ratified. In doing so, nations can ensure their economic and industrial interests are reflected in these emerging standards. They can also take back learnings from countries and adapt them to their own contexts. If nations can be proactive in developing standards that are eventually rolled out to other jurisdictions, they stand to gain a competitive advantage by meeting these standards before they become mainstreamed. If domestic companies can become early adopters of these standards, they effectively get a head start on scaling up their innovations and capturing majority shares of international markets by outperforming competitors who have yet to adapt. These competitors then have a powerful incentive to incorporate and perhaps even challenge these standards within their own operations, potentially sparking a chain reaction of innovation of which society is the ultimate beneficiary by gaining access to better tools in the fight against climate change.

What kind of standards can confer business advantage? As one example, a company that is

[6] ISO - Net Zero Guidelines: https://bit.ly/4dQvy4i

shown to be embodying sustainable practices will likely be perceived as less risky for investors, more attractive to governments (given the presumption of compliance, which reduces the need for external inspection), and more ethical to consumers who increasingly look for evidence of corporate social responsibility. Another example is cost savings. In the telecoms sector, one-third of the total operational cost comes from the electricity required to power these systems. If companies can make the switch to more energy efficient alternatives (as enabled by the applicable standards), they stand to improve not only their environmental performance but also their bottom line.

Standards as an alternative to regulation

Regulation is grounded in legislation and therefore prone to inertia. As regulation is legally mandated, it is the purview of regional and national governments. There is little to no room for interpretation and affected stakeholders must adhere to regulatory expectations or face consequences for noncompliance. Furthermore, given the timescales required to introduce or amend laws, developing regulatory systems is by default a protracted process.

By contrast, stakeholder led standards are voluntary and collaboratively derived through a consensus process with expert input from academics, government officials, and industry representatives, as well as input from consumers. The QI offers several processes for developing standards, ranging from the full international process to fast-track, online authoring processes. Importantly, standards can be more reflexive and proportionate than regulations. In the quest to mitigate climate change, new technologies are urgently needed and should be implemented as fast as possible, making it desirable to avoid the rigid use of regulation for a problem as acute as climate change. Standards can provide an adaptive alternative to regulation that allows for regular recalibration as more evidence becomes available. They can thus evolve alongside the products, practices, and services they are intended to oversee.

Standards can also reduce the burden on governments and policymakers by helping to tailor governance initiatives to the properties of an innovative product or service, rather than aiming for a one-size-fits-all approach.

Heavy regulation is to be expected where the need for public safety overrides the drive for innovation, such as in the nuclear or transport sectors. However, even here a case can be made for regulatory adaptation.[7] In fast-moving sectors like quantum or AI – both of which factor prominently into the net zero equation – regulatory timescales are often at odds with the pace of innovation and in some cases, the tests and procedures required by a particular regulatory scheme may be irrelevant or even damaging to the technology at hand.[8] In other words, innovations might be limited by inappropriate or dated regulatory schemes which fail to recognize the very qualities that make them innovative. It is important for governments to understand when it is appropriate to orchestrate the governance process so that standards communities can contribute fully to devising the most appropriate and effective governance solutions.

[7] Regulatory Horizons Council – Report on Fusion Energy: https://bit.ly/484Y6pq
[8] Regulatory Horizons Council – Regulating Quantum Technology Applications: https://bit.ly/486I924

Flexibility

As mentioned, standards can be a more flexible alternative to fixed regulatory mechanisms and in the last ten to fifteen years, there has been a noticeable trend towards more agile, responsive standards. As a result, standards can follow several different models, some of which take less time to develop or rely on quicker methods of reaching consensus. The goal is for these standards to be iterative, informed by regular consultation with stakeholders to ensure they remain fit for purpose. If properly designed, standards can also be a way of informing or even preempting regulation. In the case of the former, standards can also provide a testing ground to pilot new regulations before they become rooted in law.

This agility can be capitalized on to fast-track solutions to key societal challenges like net zero. For example, the newly introduced ISO Net Zero Guidelines were developed through a formal international workshop process involving over 100 countries and over 1,200 people in record time – four months – illustrating the potential for standards to be developed rapidly without sacrificing rigour.

BSI has implemented fast-track processes for many years that are widely used by government and industry. The Publicly Available Specification (PAS) process is a truncated international or British Standard process that maintains a high level of consensus and public consultation and can be completed in six to twelve months. The BSI Flex process was launched before the pandemic and works in a similar style to software development with experts working online through an iterative process including piloting and a cycle time as fast as four weeks. Key to fast-track standards development is maintaining a well-defined and transparent governance process. The three core BSI standards governance processes are themselves set out in standards: BS 0, PAS 0, and Flex 0.

Securing consumer, industry, and investor trust

Even the most ingenious solutions to tackle climate change will fail in the absence of widespread buy-in among consumers, industry peers, investors, and governments.

Much has been made of the Scottish Government's admission that its 2030 interim emissions reduction target is no longer viable. This has undoubtedly led to frustration across some segments of the business community who may be skeptical that the investments they were encouraged – or in some cases, mandated – to make in their climate performance will pay off. This is where the QI can step in to help reaffirm sectoral commitments to climate action.

The QI transcends political short-termism and provides an enduring link to global markets and the wider economic picture that cannot be undone through changes in domestic policy. This ensures that innovation continues to be incentivized and rewarded.

Public procurement is an important driver of behaviour and is a powerful lever for change. Through procurement, governments can act as consumers and their outgoings can be significant: as one example, the Scottish Government spends more than £16bn annually buying goods, services, and works while the total for the whole of the UK in 2023/24 was £407bn, a figure which is projected to increase by 10% by the end of this fiscal year. Given this huge volume of investment, it becomes particularly critical to ensure that appropriate standards are applied to the public procurement of goods and services, including

sustainability standards.[9] This can also contribute to building to economies of scale as government spending decisions can then stimulate further demand for innovative technologies.

Consumers are not immune to developing a jaded attitude towards climate action. For many, measures such as retrofitting their homes with climate-friendly technology at the behest of government campaigns can be overwhelming and expensive. Although some incentive programmes do exist, they arguably only scratch the surface of what is needed to motivate widespread behaviour change. Consumers are seeking and indeed deserve peace of mind that the investments they make in green solutions will pay off, both from a financial as well as an environmental perspective. By having the appropriate standards in place, consumers can be assured that new technologies are not only safe and effective, but that they will remain fit for purpose over a reasonable timeframe.

Elevating the consumer voice is becoming an increasingly central concern within the standards community. The UK is already regarded as an exemplar in involving consumers in the process of setting standards, and the NQI is further improving their representation. The challenges lie in differentiating QI from proprietary schemes (in the eyes of the consumer) and in making the more technical or esoteric aspects of the standards process accessible. It will be important to facilitate an effective feedback loop between consumers, regulators, and the NQI (potentially mediated by an ombudsman) to ensure the lived experience of the consumer can be used to further grow the evidence base and promote continuous improvement. There is also an opportunity to make consumers more aware of the NQI by encouraging them to require traders with whom they engage to demonstrate that they are actively supporting and contributing to the NQI. Involving consumers also brings a healthy 'reality check' to the process, helping to ensure that standards reflect how consumers really think, behave, and make decisions. As one example, building on this notion of standards as a public good, the BSI standard PAS 440 Guide on Responsible Innovation[10] includes guidance for innovators on responsible stakeholder engagement.

[9] Sustainable Procurement Tools: https://bit.ly/3Yk6sWW
[10] PAS 440 Responsible Innovation – Guide: https://bit.ly/3ZYtUKL

Identifying challenges to using NQI to support innovation

We have examined some of the ways in which QI can positively benefit climate action. However, this is not always happening in practice. What obstacles are there to using NQI to best effect in the research and innovation space?

Lack of awareness

Simply put, stakeholders may not even be aware that QI exists. For those that do, they may not fully understand how it applies to them and how to engage with the system confidently and strategically. Government and public agencies may be similarly unacquainted with all the nuances of the standards space, particularly those which are new or emerging. There is a need for competence-building within government with respect to standards and regulation to ensure that officials possess the knowledge and experience to engage in meaningful dialogue with sectors to regularly refresh regulatory schemes in line with changing industry expectations and norms.

Industry reticence

When developing or adapting standards, it can be difficult to achieve the necessary consensus, particularly in industries where a few vocal players exert a disproportionate influence on the direction of the sector. Indeed, there can be a strong reluctance among incumbents to accept new standards that threaten to disrupt their business models or whose return on investment is not immediate. Environmental and social standards can often fall into this category of delayed returns. It is important for QI to effectively manage competing voices and provide a neutral space to negotiate standards in the public interest. In some cases, with enough internal pressure to 'do the right thing', industries may eventually move towards self-regulation to normalize new standards of behaviour.

Applying systems thinking to standards

Developing a system of standards and assurance to govern a particular product, practice, or service can introduce a dilemma: is the optimum solution one that governs the technology itself, or one that covers the overall market framework where that technology is deployed? One increasingly pertinent example is the use of AI which is becoming more embedded across business operations and indeed daily life. It also generates massive energy demands that cannot be ignored. Conventional wisdom on the governance of innovations suggests that we should not have a single set of standards that covers AI from all stages of development through to the end user. Instead, we should target the key factors driving development of a product or service (such as computing and energy) and find ways to integrate them, based on a more accurate picture of the whole-life carbon cost. This would demonstrate how industries could share 'ownership' of standards to prevent any gaps in our carbon accounting.

QI's reach is limited. After all, climate change is among the most complex problems humanity has ever faced and QI cannot be singlehandedly responsible for solving it. However, by embracing systems thinking, QI could be the pressure point that frees up innovative options across a broad range of codependent subsystems. As the AI case illustrates, sectors, sub-sectors, and products do not exist in silos and are instead deeply interconnected. If a new product is rolled out

in accordance with the latest standards, we must ensure that industry is ready to receive it and that its introduction will not lead to any unintended consequences as far as we can tell. This is particularly important if standards are to be developed on increasingly abbreviated timescales. Although systems thinking can be a challenge, it is important for the standards community to face it head on. It would also help to remedy the fragmentation that is often observed across Scotland's policy environment, providing another example where standards may be more suitable than legislation in governing innovation.

Case studies

The paper now presents a series of case studies across different sectors and contexts, demonstrating where the QI is successfully promoting innovation and climate action. These case studies have been authored by Fellows of the RSE, members of the Young Academy of Scotland, and other expert contributors who took part in the working group that informed the preparation of this report.

Case study

Built Environment

The transition towards a decarbonized built environment is an area of rich debate relating to how best to approach the retrofitting of existing buildings.

Whilst there is no one-size-fits-all approach to the challenge, given the rich tapestry of building archetypes, regional variations, and supply chain capability, there is an inherent inefficiency in the way the industry has traditionally engaged in the retrofitting process.

Standards such as **PAS 2038, PAS 2035, and PAS 2030** have become key frameworks for improving the way in which we standardize approaches to improving the energy efficiency of UK buildings. These standards provide guidance on the holistic retrofit process, from initial assessments to installation and monitoring of energy efficient measures like insulation, heating systems, and ventilation.

By offering a structured approach to retrofitting, compliance with PAS 2035 ensures interventions made to existing buildings result in tangible reductions in energy use and carbon emissions while improving indoor environmental quality. PAS 2030 ensures that energy efficiency measures installed in buildings are completed to a high-quality standard and PAS 2038 sets out similar standards for non-domestic buildings.

The development of PAS 2030 brought together key actors across the construction, energy, and retrofit installers sectors to create a common framework for high quality retrofit interventions. By linking compliance with the standard to government backed grant schemes, adoption of the standard has been positive and public trust in the industry has improved. PAS 2035 has given rise to two new occupations, Retrofit Co-ordinator and Retrofit Assessor, bringing enhanced professionalism to specialist roles involved in the retrofit process. In both cases, organizations like TrustMark are now better equipped to provide quality assurance of retrofit interventions and are reducing the risk of sub-standard retrofit interventions experienced through previous government grant schemes.

Critics of the retrofit PAS standards point to added complexity, cost, and barriers to adoption. PAS 2030 requires the demonstration of certified competence which has been positioned as a barrier to small and micro businesses engaging in work underpinned by the standard. Whilst the market will undoubtedly evolve to address these issues, it highlights the critical need to ensure that the introduction of new standards is underpinned, at the earliest stages, by a skills and training infrastructure that is equipped to support adoption.

Case study

Regulatory equivalence

Both quantum and engineering biology sectors are sources of disruptively innovative products and services that could contribute to the delivery of net zero in a scalable and more timely manner.

However, the governance systems that are likely to be applied to these developments are often ill-adapted to their innovative properties. In extreme cases, this mismatch can cause innovations to be stalled completely and never reach market, a waste of the public and commercial investments already committed to them. For example, EU standards testing regimes for some quantum-enabled medical devices would require subjecting quantum products to high radiation fields which would destroy the sensitivity of the device. Likewise, where living products of engineering biology are likely to be used in an open environment (diagnostic bio-devices for detecting down to nano-scale levels of chemicals across numerous applications, such as microorganisms for soil remediation), they are subject in many countries to rigorous and demanding regulatory regimes.

Standards and guidance can mitigate some of these requirements and greatly speed up development. An example from the USA would be applying the category ‘generally recognized as safe’ to a wide range of microorganisms that can then be developed more rapidly and flexibly than others.

The concept of ‘regulatory equivalence’ has evolved in the financial services sector as a mechanism by which one jurisdiction can recognize relevant standards in another jurisdiction as equivalent to their own. Applying similar criteria to enable smarter, more rapid adaptation of the quality infrastructure could make a useful contribution to the complex challenge of meeting governments’ - including Scotland’s - net zero ambitions.

Case study

Wind energy

BSI's work in wind turbine technology standards has set a global benchmark for product quality and circular economy principles.

With the UK having the second largest installed capacity of offshore wind turbines worldwide, wind energy now powers over 7.5 million homes. In a notable achievement, wind power surpassed gas as the UK's primary electricity source in the first quarter of 2023.

BSI oversees the British national technical committee, PEL/88, which is aligned with the IEC technical committee on Wind Energy Generation Systems. PEL/88 has played a crucial role in shaping international, European, and national standards to support the growing wind energy sector. With over 98 technical experts contributing to international standards development, six of whom hold leadership roles, UK expertise has driven standards in areas such as preventive waste principles in wind turbine design and floating lidars.

The development, uptake, and adherence to technical standards is critical for the continued growth of the wind energy industry and the UK's net zero targets. These standards provide essential benchmarks and consensus on best practices, ensuring safety, reliability, and efficiency within the sector.

BSI's national technical committee includes a wide range of stakeholders, from government and regulatory bodies including Department for Energy Security and Net Zero and the Crown Estate to independent companies like BP, Ramboll, and Wood. Academic institutions, standards development organizations such as Det Norske Veritas (DNV, formerly DNV GL), and not-for-profits like the Carbon Trust also contribute to this collaborative effort, ensuring that wind energy standards continue to evolve and support the industry's rapid growth.

Tim Camp, Director of Turbine Engineering at OWC, describes the UK effort as:

"
...key to the development of many of the technical standards now used day-to-day by the international offshore and onshore wind industries, many of which have become European good practices.

Case study

Water

In the UK, water companies manage water and wastewater services for over 28 million homes and businesses.

The energy associated with delivering this level of service translates into almost one third of all industrial process and waste management greenhouse gas (GHG) emissions in the UK. Gross operational GHG has been reduced by about 45% over the last decade, largely by using renewable sources of energy. Further shifts to electrifying the fleets of passenger vehicles and commercial vehicles exploiting alternative fuels will contribute to the continued decarbonization of the sector.

However, transport only accounts for around 6% of the GHG emissions in this sector. A further 2.4MtCO2/ yr has yet to be removed to achieve the net zero target, of which around 10% can be attributed to Scotland. For Scottish Water, these are typically attributed to drinking water treatment and pumping (23%), wastewater treatment and pumping (41%), and sludge treatment and pumping (30%).

The remaining 7% emissions are associated with transport and administration, emphasizing the scale of the challenge. At the same time, managing water across a diverse natural and economic landscape, from remote island communities to industrial heartlands at a time of rapid climatic change, only exacerbates the challenge. The need for standardization is critical to support effective decision making. Standards are required for everything from the measurement of GHG emissions to establish the baseline against which we are to deliver net zero, through to the use of innovative, low-carbon building materials in largescale infrastructure projects, through to standards in the implementation of nature-based solutions to effectively manage water at the landscape scale, offsetting residual emissions whilst delivering multiple benefits in biodiversity and human health and wellbeing.

Case study

Hydrogen

The Hydrogen Skills and Standards for Heat Programme was initiated to explore hydrogen as a potential decarbonization pathway for both domestic and non-domestic sectors.

This includes small commercial buildings and light-industrial settings where gas is currently used in manufacturing processes. As part of this pre-normative work, the development of three fast track PAS Standards (PAS 4441, PAS 4442, and PAS 4443) by BSI was closely aligned with evidence gathered by the Department for Energy Security and Net Zero (DESNZ) and the concurrent development of IGEM's H series of standards. While The Institution of Gas Engineers and Manager's (IGEM) focus was on consolidating knowledge for gas installers and users, BSI's PAS standards concentrated on component and piece-part requirements.

PAS 4441, PAS 4442, and PAS 4443 provide agreed sets of principles, requirements, and guidance for manufacturers, engineers, and installers, focusing on functionality, safety, installation, operation, and servicing of ancillary devices, pipework, materials, meters, and appliances for hydrogen use. These standards offer essential guidance to notified bodies, helping to establish safe, high-quality, and environmentally conscious deployments of hydrogen in both commercial and residential settings.

Complementing the Hy4Heat Standards, **PAS 4444 and PAS 4445** clarify the interaction between the Gas Appliances Regulation and hydrogen-fitted appliances for heavier manufacturing and commercial purposes, with PAS 4445 expected to be published in 2025.

The development of the PAS 444X suite was supported by a broad range of stakeholders, including consumer groups such as the Consumer and Public Interest Network (CPIN, hosted by BSI), standards development organizations including DNV and IGEM, and key regulatory agencies such as Health and Safety Executive, Ofgem, and DESNZ. Utility companies, private organizations like National Grid and Bosch, and NQI partners including UKAS and NPL also played crucial roles. This broad engagement exemplifies the integrated quality infrastructure approach adopted in the development of PAS 444X to mitigate risks associated with new technologies and to accelerate the innovation needed to achieve net zero by 2050.

Case studies

Consumer rights

Achieving clean power and net zero by the target dates will not be possible without wholesale adoption of new technologies and systems by the end users - domestic and non-domestic consumers. Confidence in standards is key to achieving consumer engagement.

Most obviously, this is to do with the safety, quality, and efficiency of products as well as the competence and trustworthiness of suppliers and installers.

Statutory and voluntary regulators, however, are increasingly focusing on regulation and standards which are principles- and outcomes-based, built on a requirement to 'treat customers fairly'. Consumer trust is further boosted when they know they have easy access to out-of-court redress.

Two separate case studies are included to illustrate the above points.

Case study 1: The Office of the Gas and Electricity Markets (Ofgem)

In 2013, Ofgem added a standard condition requiring suppliers to treat domestic customers fairly. That condition was later moved to the front of the Standard Conditions and now also encompasses the treatment of non-domestic customers: 'Condition 0. Treating Domestic Customers Fairly' and 'Condition 0A. Treating Non-Domestic Customers Fairly'.

The Ofgem Guidance Notes explain that these broad principles are enforceable and 'relate to how suppliers behave, provide information, and carry out customer service processes.

In the case of domestic consumers, the Standards also relate to how suppliers seek to identify each consumer in a vulnerable situation and respond to their needs'.

Case study 2: The Financial Conduct Authority (FCA)

Following a consultation process, the FCA confirmed that it would introduce a new Consumer Duty, setting out the standard of care that firms should give to customers in retail financial markets. The Consumer Duty was implemented in two stages, the first on 31 July 2023 and the second on 31 July 2024.

The FCA describes the Duty as comprising three components:

- A Consumer Principle which reflects the overall standard of behaviour that firms should follow
- Cross-cutting rules which further develop expectations for behaviour and help firms understand the four outcomes
- Four outcomes: a suite of rules and guidance setting out more detailed expectations for firm conduct in four areas that represent key elements of the firm-consumer relationship: the governance of products and services, price and value, consumer understanding, and consumer support.

The Consumer Duty is underpinned by the concept of reasonableness. What is expected of firms under the Duty will be interpreted through the lens of what is reasonable given the circumstances.

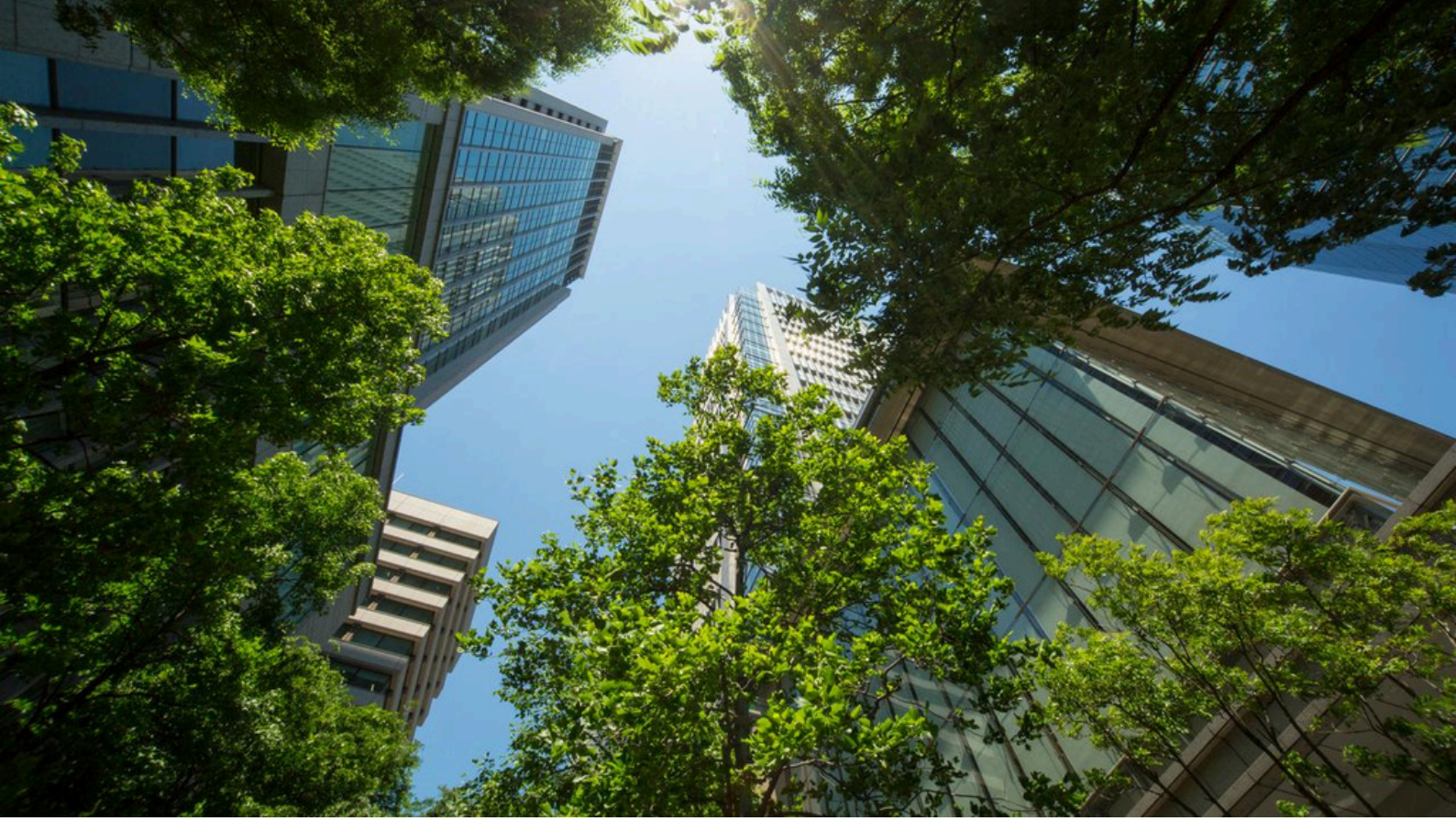
Consumer rights (continued)

Significantly, the FCA states that one of the ways it will monitor key outcomes is through monitoring Financial Ombudsman Services' final decisions on complaints.* Consumer Ombudsman schemes created or required by statute have a duty to: "...make reasoned decisions in accordance with what is fair and reasonable in all the circumstances having regard to principles of law, good practice, equitable conduct. and good administration."**

There are examples of voluntary sectoral regulatory regimes that are principles based and have 'treating customers fairly' as their overarching principle. Detailed standards are built on the principles and guidance issued. As the schemes are voluntary, principles, standards, and guidance are agreed through a process of research, review, and consultation within the sector – often including consumer viewpoints. Typically, these schemes will also offer redress through, for example, an ombudsman.

In the drive to achieve net zero, standards supporting QI must include the principle of treating customers fairly, including recognition of the role of ombudsman schemes in helping build trust with domestic and SME consumers while providing monitoring and assurance to regulators and governments.

* The Financial Ombudsman and the Energy Ombudsman can receive complaints from domestic customers and from SMEs with fewer than 50 employees, an annual turnover of less than £6.5m and a balance sheet total of less than £5m.
** The Energy Ombudsman Terms of Reference 9.9(b)



Recommendations for future action and improvement

This report has demonstrated the often-unsung role that QI plays in accelerating innovation. To continue to do this, it needs to remain open to continuing adaptation to keep ahead of evolving disruptive innovations. Making QI a more visible component of the innovation ecosystem, including its role in enhancing business performance, will be a necessary part of the process. For standards (in all their forms) to be of maximum value for industry in the context of the net zero transition and the ever-faster pace of technological innovation, it is vital that academics and industry experts engage, along with policy makers and regulators, in the standards-making processes of the NQI to bring maximum benefit to the economy and the nation.

Having taken account of the ways in which QI is already working for the innovation system, we now consider what might be improved to allow its benefits to be realized to their full potential.

Improving visibility of QI and signposting to resources

QI is often seen as something abstract that operates behind the scenes but whose practical applications may not always be appreciated. Businesses and public bodies may not understand how to harness QI to improve their performance and bottom line, particularly smaller organizations. Start-ups and SMEs could benefit from accessing road maps or guidance documents (whether generic or industry-specific) that explain how to leverage QI for the purposes of innovation and growth. In cases where such resources exist, these should be better promoted or made more accessible. BSI, through its association with Innovate UK, is already taking steps to address this (e.g. through the

Innovate UK Business Growth toolkit [11]).

In addition to resources, businesses and consumers would benefit from having access to case studies or archetypes that exemplify best practice standards in different contexts (for example, in the domestic heating sector).

Capacity building

This also raises a more fundamental point about capacity-building. As QI looks to raise its profile, it should also consider how it can support the development of associated training opportunities, perhaps in partnership with universities, research institutions, and standards bodies like the BSI. Such training would ideally cover not only the mechanics of QI (including their intersection with international schemes), but it would also explain how to engage constructively with the standardization process itself. This is a particular priority in sectors where much of the required sectoral transformation is likely to be led by SMEs, such as in the built environment. Without the necessary upskilling, SMEs may well find the prospect of collaborating in the development of standards to be daunting and out with their expertise and capabilities.

With respect to scaling up, funding from bodies such as UKRI is increasingly conditional on adherence to standards covering aspects such as data protection and procurement. However, SMEs often lack the capital to fulfil these expectations. There could be benefit in making dedicated financing available (e.g. through the enterprise agencies) to enable SMEs to understand and meet these standards' thresholds. This would allow SMEs to tap into these funding streams as well as improving their resilience by consolidating best practice across multiple facets of their operations.

Making standards more agile and adaptive

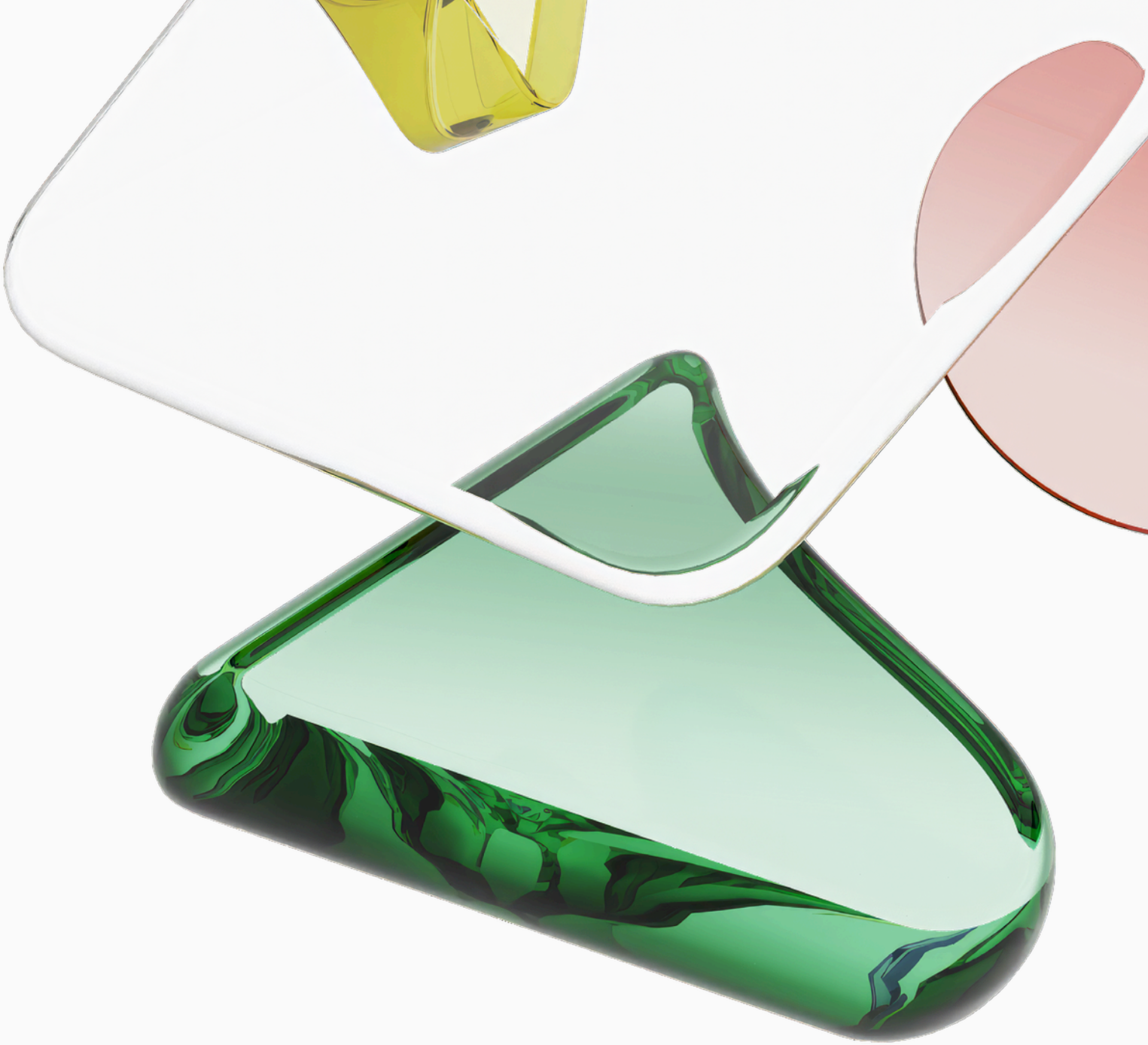
As this report has demonstrated, QI can act as a powerful tool to galvanize international progress towards net zero. However, the system needs to become even more forward-looking and adaptable than it is today. In some circumstances, we will continue to need standards that concentrate on detailed specifications (for example, in achieving interoperability). In other cases, standards may start to focus increasingly on principles, such as the previously referenced ISO Net Zero Guidelines. Society cannot conceive of all the solutions that will ultimately be deployed in meeting the climate change challenge and so QI must be able to deal with unanticipated opportunities or hazards. Indeed, standards should be as much a proactive as a reactive tool, one that complements its reputation for effective monitoring and evaluation with greater openness to dynamic experimentation. In this way, standards can form part of a feedback loop that both transmits and collects information, implementing proportionate expectations while also pointing to areas for improvement and helping to suggest a future direction of travel for the sector being considered.

As with regulation, prescriptive, technical standards can serve a valuable purpose, most often in the field of consumer products where safety is paramount and predicated on absolute clarity. Similarly, standards that are too broad run the risk of being inefficient if they are too superficial to accommodate the properties of the technologies they are meant to encompass. New or emerging practices and services can benefit from using a framework of process or outcome-driven standards which focus on performance requirements rather than prescriptive technical specifications. A performance-based QI framework will provide

[11] Innovate UK Business Growth: https://bit.ly/3ZXtp3z

flexibility as innovation progresses towards market-readiness and we learn more about its properties. A framework approach would ensure basic aspirations for quality and safety are met without imposing limitations on other aspects of a technology's design. By focusing on what we want a product or service to achieve as well as how it is designed, we can create the optimum conditions for innovative solutions to be developed and scaled in the market. This is important for disparate sectors, including the built environment and engineering biology, which feature some prescriptive standards that inhibit would-be industry disruptors.

Where new standards are developed, or existing ones adapted, to deal with the properties of innovative technologies, they will need to have a solid grounding in regular engagement with sectoral innovators and policy makers, citizens, and consumers. This engagement should take place at both national and regional levels. In the case of Scotland, it could include BSI being involved in promoting a greater understanding of the QI's role in net zero-related decision making, alongside an understanding of where Scottish governance systems and institutions lead to different opportunities for, and constraints on, innovation relevant to net zero objectives.



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