Social Science Approaches to Understanding the Implications of a Net Zero Transformation of Society

UKERC Working paper

Olivia Thompson, University of East Anglia
Mel Rohse, Anglia Ruskin University
Jake Barber, Office for Product Safety and Standards

March 2024

Introduction to UKERC

The UK Energy Research Centre (UKERC) carries out world-class, interdisciplinary research into sustainable future energy systems.

It is a focal point of UK energy research and a gateway between the UK and the international energy research communities.

Our whole systems research informs UK policy development and research strategy.

UKERC is funded by the UK Research and Innovation, Energy Programme.

About Energy SHINES

This paper is an output from Energy SHINES (Energy Social sciences and Humanities Insights for Non-Energy Sectors) – a project delivered through UKERC's Whole Systems Networking Fund.

Energy SHINES was set up to facilitate partnerships between women Early Career Researchers from energy social science and humanities backgrounds and organisations in key non-energy sectors undertaking work towards net zero.

Access all publications produced from the [project here](project%20here).

Contents

1. Executive summary

The net zero transformations of society that develop in response to the climate crisis will require new approaches to policy-making that consider the societal and cultural shifts that occur as people engage with a world adapting to climate change. Effective regulatory policy-making must approach policy-making as systemically and intrinsically linked to these wider changes occurring within society, such as new approaches to home building, novel relationships between people and products, and changes to the ways in which people interact with existing everyday products and things. This report aims to provide a toolkit of various social science theories, such as 'Reflexive Governance Theory', 'Actor Network Theory' and 'Ecologies of Participation' in order to navigate some of these issues. These theories may provide valuable social science insight for policy-makers in response to a society adapting to net zero transformations within a rapidly changing climate.

2. Introduction

Regulatory decision-making is becoming more difficult, with more complex, multi-faceted and interconnected issues to consider due to the urgent need to reduce carbon emissions. Current approaches to governance and their resulting structures must take into account the far-reaching implications of a net zero transformation of society, which start by understanding:

- How this transformation is taking place, and if institutional structures are ready to adapt to this transformation,
- the actors involved,
- the relationships that exist between these actors, issues and their associated risks.

The transition of society to net zero is inevitable, and governance and policy-making must adapt if it is to be effective. This report provides examples of social science theory that aim to provide new ways of thinking about regulatory challenges that may arise through a net zero transformation of society.

A net zero transformation of society includes any societal or cultural shifts that may occur as policy adapts to transition all sectors of the UK economy to net zero emissions. Understanding how people engage with the world around them due to these societal or cultural shifts around a net zero transformation is vital to ensure effective regulatory policy-making, since individual behaviours may shape how our homes are built, what products we bring into our homes, and how we may interact with the products already at hand. These theories also aim to explore how governments should adapt to the system-wide changes that may occur as the transition to a net zero carbon economy develops.

Since preindustrial times, the planet has warmed by 1.1°C, with disastrous consequences for the environment and climate-vulnerable communities around the world. As temperatures rise, the world will experience increased instances of natural disasters, such as flooding, wildfires and droughts in previously temperate areas. These will trigger political and social unrest through the displacement of millions. Food shortages, housing precarity and civil unrest on an international scale will become more common, with discussions around these consequences already reflected in political discourse concerned with the widespread disruption of society (Laybourn et al., 2023; IPCC, 2023).

Maintaining current levels of warming below a 1.5°C threshold is therefore vital, with governments around the world pledging to become carbon neutral. The UN has called for carbon neutrality by 2050, with current emissions halved by 2030, and over 70 countries have now committed to achieving net zero emissions targets, including the biggest polluters such as China, the European Union member states and the United States (UNEP, 2022; IPCC, 2023). In October 2021, the UK government introduced

its own Net Zero Strategy, which provides a pathway to the decarbonisation of the UK economy by 2050 (BEIS, 2021).

Although policies outlined in The Building for 2050 (UK Gov, 2021) strategy will enable the UK to meet these targets, this decarbonisation effort may still not be adequate in halting and reversing the effects of climate change (IPCC, 2023; Chatham House, 2023). Around the world, governments are committing to meeting net zero targets by implementing their own set of policy and targets. These countries include, among others: China by 2060, France by 2050, Australia by 2050, New Zealand by 2050 and Germany by 2045 (with a view to being carbon-negative by 2050) (SNBC, 2020; BGBI, 2019; Commonwealth of Australia, 2021; Ministry for the Environment, 2019 and LTS, 2021).

The changes required to achieve this in practice are large, and require a systemic change in policy to ensure that these targets are met, which will inevitably involve a net zero transformation of society. This systemic change must be informed by diverse and multidisciplinary contributions from the natural sciences, economists, statisticians, social scientists and policy-makers (Davies and Oreszczyn, 2012). As a result of this transformation, new products, or ways of manufacturing existing products, may emerge.

Societal values and perceptions around sustainability and lifestyle may also evolve, and a change in the way that energy needs are met is likely to occur. Further to this, the roles citizens play in bringing about change and their engagement with climate issues will need to grow to ensure that a net zero transformation of society may occur. This engagement may range from grassroots activism to the more everyday practices of public engagement with climate change through the consumption choices people make. As public engagement unavoidably influences the consumer products brought into the home and the construction materials homes are made from, it is vital to understand how this public engagement is formed and how it evolves. Understanding and tracking this engagement is thus essential for policy-makers concerned with regulating product safety (UKERC, 2020).

As society adapts to large-scale changes taking place within our communities and homes in response to the transition to a net zero UK economy, the governance and regulation of construction materials and consumer products will become more complex. The planning and execution of supporting research, along with the associated decision-making processes, will likewise require a more systemic approach, which can be enhanced by social science theory and methodology.

Social science theory can help to make sense of some of the systemic changes that are likely to occur within society due to the net zero transition. These theories offer new perspectives and additional tools to understanding how people drive these changes and how these changes will, in turn, affect people. The social science theories detailed below aim to provide alternative insight into informing regulatory decision-making while also challenging assumptions by reframing the issues at hand.

Social science provides theoretical alternatives to the interpretation of scientific data and research by offering new approaches to identifying areas for future research. It also provides alternative answers to existing problems that are more complex than previously imagined. This results in more effective regulation, which captures the effects of people's behaviour and the relationships which exist between people, objects and communities.

A supporting brief to this OPSS report, "The implications of a net zero transformation for product safety within the home" (Thompson, Rohse and Barber; 2023), highlights areas for future research within OPSS. This report aims to reframe the implications of a net zero transformation for product safety and standards through a social science lens to uncover areas of interest that may otherwise be overlooked.

This brief examines:

- The concept of reflexive governance, which offers an alternative to conventional decision-making structures and processes.
- The systemic nature of objects and society through Actor Network Theory.
- The participatory potential and interconnectedness of everyday objects, people, and issues.

3. Reflexive governance

A reflexive approach to regulation calls for research and decision-making processes to be both inward-looking (through reflexive processes of internal evaluation) and future-oriented (through democratic and flexible engagement with ordinary people).

Reflexive governance emerged following the first drive towards sustainable development policies in the early twenty-first century. This theoretical approach to regulation developed as a response to previous policies that had not been significantly effective in providing positive and lasting changes to environmental degradation, atmospheric pollution, resource depletion and destruction of eco-systems (Fiendt and Weiland, 2018)

A reflexive governance approach allows space, not only for the natural sciences, but also for the social sciences. It includes an approach to policy and regulation that involves people, as well as governments, in the process of decision-making. Another key to this approach is that there is an ongoing process of governance looking inward through a process of self-examination to ensure that decision-making is effective and fair. (Gottschick, 2018).

Reflexive governance is also mindful of the relationship between science and society and the dynamics of co-production when engaging in policy and decision-making (Stirling, 2006). This means that it accounts for society and science as constantly developing together, each responding to the demands of the other, and takes into account the importance of this relationship in decision-making.

Co-production is the core theme of the academic field of Science and Technology Studies (STS), a large and in-depth field of study dedicated to understanding the complexities of society and science as constantly evolving together (Jasanoff, 2004).

Being mindful of the relationship between society, science and technological progress means taking into account the consequences of scientific advancements and technological progress on society and, likewise, considering the impact of societal evolution on science. This is an essential component for a reflexive governance approach to regulatory decision-making.

Table 1: Core values of reflexive governance

Reflexivity	Flexibility	Interactivity
Looking inwardly at decision-making processes to ensure these are as effective, fair and wide-reaching as possible. Ensuring that the decision-making process is democratic.	Adapting and responding to regulatory issues and trends as they arise (not assuming to predict the future in relation to social change).	Being aware of and engaging with external trends, issues, changes and values as they arise. Actively seeking input from a wide range of stakeholders in matters of regulatory importance.

Conventional approaches to regulatory policy-making are often rigid, and employ a predefined and hierarchical set of methods. What is needed instead are approaches that are reflexive, flexible and interactive, therefore enabling people to play a more active and influential part in the decision-making processes which affect their lives.

Failing to think holistically about the implications of social change and the wider relationships that exist between science, society and governance may lead to decision-making processes that fail to ask the right questions, and therefore risk missing key elements essential to ensuring comprehensive and effective policy (Leonard and Lidskog, 2021). In the case of reflexive governance, which aims to respond to the changing needs of society within the net zero transition, this means being attentive to the complex global, national and local implications of climate change and the evolving regulatory needs of society.

A reflexive approach to regulatory policy-making for product safety allows the regulator to be more responsive to:

- the increasingly complex implications of a warming world (which may not progress linearly),
- changes in government policy around net zero targets (which themselves may shift in response to non-linear change),
- the changing relationships between products, people and safety (which will be subject to innovation and change),
- the diversification and increase in complexity of products,
- the growing ethical considerations these entail, and
- a shift in social values as net zero becomes a growing and collective concern among citizens.

Gottshick (2018) proposes an analytical process of assessment for determining whether or not governance follows a reflexive governance approach. For institutions tasked with regulatory governance, developing a framework which responds to

specific areas of policy-making of the institution could help ensure that the core values of reflexive governance are adhered to.

This concept provides a gateway to future research and topics to explore, such as Actor-Network Theory and material participation, below, or an increased awareness of the multi-level perspective (MLP) and conflict-oriented understanding (COU) employed by Gottshick in building the above analytical framework.

3.1 Recommendation for bodies tasked with regulatory decision-making

The net zero transformation of society will inevitably lead to more complex, multi-faceted and interconnected issues surrounding product safety. Policy-making will become more complex as new challenges emerge, and existing institutions and processes may no longer meet the growing regulatory needs of a society transitioning to meet net zero emissions targets.

A reflexive governance approach to policy-making is introspective, democratic, flexible and interactive, and strives to adapt to these increasing demands. Policy-makers may look to ensure that internal structures support the criteria of meeting a reflexive governance approach by developing a framework that ensures that its regulatory decision-making processes are inward-looking (through reflexive processes of internal evaluation) and future-oriented (through democratic and flexible engagement with ordinary people).

Decision-making processes that respond to these criteria ensure that policy is well-equipped to address existing and future challenges that a net zero transformation of society may incur, and that this policy is able to respond quickly and effectively to the emerging needs of society. A reflexive governance approach exists within environmental governance, for example, and ensures that policy-making in this field responds to both human and non-human needs within a wider socio-ecological system (Dryzek and Pickering, 2016).

4. Actor network theory

Actor-Network Theory (ANT) is a complex theoretical and methodological approach to the study of society where everything in society and nature exists in constantly shifting networks of relationships. This theory questions the divide between what is human and what is non-human (for example, humans, objects, animals, technologies and matter), and focuses on the relationships between these actors and the ways in which they influence one another (Latour, 1996; Callon, 2001).

ANT places equal importance on the participation of human and non-human actors, such as the built environment, products, materials and connected technologies, and provides a new way of thinking about the relationships between products and people in society. These relationships may not have been a distinct and explicit focus of research for policy-makers in previous regulatory policy-making decisions, but must be taken into account as society transitions to adapt to the demands of a net zero economy.

Like the reflexive governance approach, ANT provides an alternative to the conventional understanding of science, and in turn governance, that has tended to exclude the social. The foundational literature of ANT is complicated and has been extensively debated. However, the key message of the importance of the relationships between things (human and non-human actors) is a vital consideration for the effective regulation of product safety. The section below examines some of this literature, and aims to provide a gateway for further discussion and research.

The 'network' in ANT could be imagined as a spider's web, with weaker strands coming together to make a strong whole. Each actor is treated as a node within the same system, and it is the strands between nodes in the overall system, or web, that are important to consider. Latour explains this as a "netting, lacing, weaving [and] twisting together of ties that are weak by themselves", and not in a more conventional way of thinking about rigid technical or social networks (such as a car engine or a computer as an example of a conventional technical network, or as a family hierarchy as an example of a conventional social network) (Latour, 1987).

The components within these networks are diverse and give each other meaning through their relationships with each other. It is through this framing of things and people as systemically interconnected and equally important, both acting and influencing the other, that gives relevance to considering the social in the regulation of the safety of products.

The diagram below (figure 1) aims to illustrate these relationships between actors. It shows that all the seemingly individual actors of the net zero transformation of society are connected and exist within a systemic whole. Although a highly simplified visual, the diagram helps to visualise how seemingly unconnected actors within the network may exert influence upon others. Examining these relationships more closely may reveal complex, multi-faceted and interconnected issues and allow policy-makers to mitigate against previously unknown risks.

Figure 1: An Actor Network based approach to the Net Zero Transformation of Society
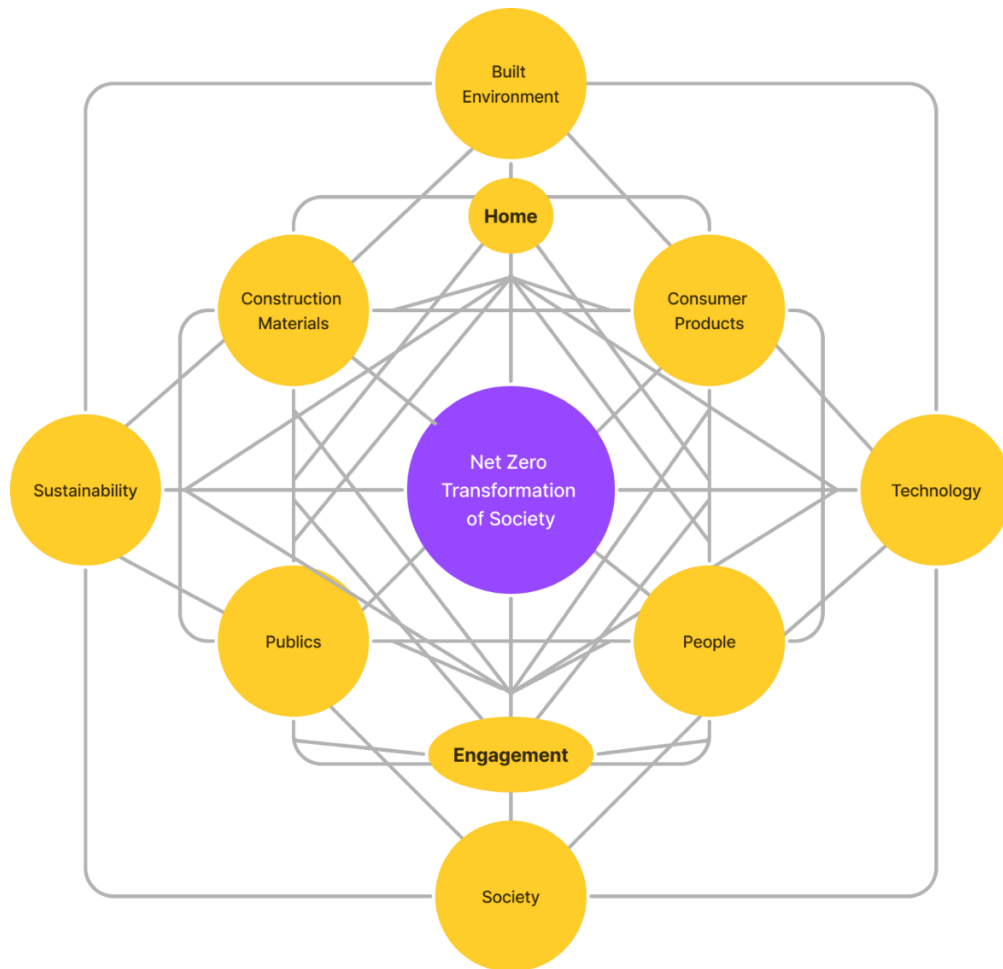
Callon (1986) highlights the relationships in these networks as being significant, as opposed to the individual actors, places or instances of knowledge alone. For regulatory decision-making, it is these relationships that may shift the most drastically through a net zero transformation of society. The connections that exist between these actors and their associated risks will be key to understanding how to regulate individual products or materials effectively.

ANT shows that it is impossible to understand the full extent of the effect of a consumer product (for example, on the safety of the wider built environment and people) without first considering the relationship that exists between the product and the human actor interacting, either directly or indirectly, with the product and the wider environment in which the product exists.

As Actor-Network Theory shows that everything in society and nature exists in constantly changing networks, and that nothing exists outside these relationships, for regulatory policy-making on product safety and standards, it is essential to consider the end-user, as well as the wider environmental, socio-economic and contextual influences that may impact upon the product and its safe use as an ever-evolving relationship.

4.1 Recommendation for bodies tasked with regulatory decision-making

Products and people are connected through their interactions, and both are equally essential to consider in regulatory policy-making, since the actions of people affect the safety of the product.

Actor-Network Theory provides a new way of thinking about the relationship between people and products, and there exists a wide and in-depth body of academic literature to explore. Key thinkers around this theory include Bruno Latour, Michel Callon, John Law and Madeleine Akrich. ANT is a highly influential approach to understanding humans and their interactions with objects, and continues to influence research in healthcare (Cresswell et al., 2010); international relations (Braun et al., 2019); sustainable tourism (Nguyen et al., 2019); and social science climate research (Maier, 2023) to name a but few diverse cases. This theory can help policy makers to think about the unique and dynamic relationships that exist between people and objects, and how examining these relationships may uncover new areas of risk in the regulation of consumer products and construction material safety. Applications of ANT within policy-making can be found in approaches to affecting institutional and organisational change, such as through the development and deployment of project management information systems in the public sector (Pollack et al., 2013), or through the implementation of policy aiming to reduce social inequalities in healthcare, for example (Potvin and Clavier, 2013).

5. Ecologies of participation and material participation

5.1 Ecologies of participation

Ecologies of participation is inspired by Actor-Network Theory and other STS theories. Where ANT focuses on the relationship between actors, ecologies of participation focuses on the engagement and participation of these diverse networks of actors in science and technology, especially in areas relating to participation in energy, climate change or net zero (Chilvers and Kearnes, 2015; Chilvers, Pallett and Hargreaves, 2015; Chilvers and Longhurst, 2018).

Ecologies of participation originates from the field of Science and Technology Studies (STS), an important field of study dedicated to understanding the complexities of society and science as being co-produced (constantly evolving together). Ecologies of participation focuses on how individuals and groups participate in areas of science and technology by emphasising the importance of the social, cultural, political and institutional contexts in which science and technology are developed and used, and

the ways in which different actors interact with each other in these contexts. These *contexts* are called constitutional stabilities (Chilvers et al., 2018).

Like Actor-Network Theory, the concept of ecologies of participation refers to the complex and diverse network of relationships that exist between actors such as scientists, engineers, policymakers, activists, and members of the public who are involved in the development and implementation of new technologies. This includes how these actors communicate with each other, share knowledge and expertise, and negotiate conflicting interests and values.

Ecologies of participation also recognises the value of contributions from the various aforementioned actors in science, including those who may not have formal scientific or technical training, such as citizen science groups or the lay public. This includes community members, patients, and other stakeholders who may have unique insights and experiences that can inform scientific research and technological development.

These ecologies of participation are reflexive (introspective and democratic; see *reflexivity,* Section I: Reflexive Governance) and responsible in their development around issues of political or societal concern, such as the net zero transition. A crucial element of this ecological perspective of participation is that it is necessary to consider all systemic occurrences of participation through their connections with other collective participatory practices, socio-technological agents, spaces, cultures, and issues of participation, through and within which, they are established (Chilvers and Kearnes, 2015; 52).

The ecologies of participation approach also draws upon other systemic approaches to participation such as systems of practice (an approach to environmental social science that studies people's everyday actions without assuming that people make decisions rationally and as individuals). These systemic approaches provide alternative views to understanding the forms of participation that may occur in areas of science and technology and may provide insightful areas of further research for policy makers.

5.2   Material participation

Material participation explores the participatory role of objects and moves away from the notion that only people can affect change. A key author investigating material participation is Nortje Marres who argues that objects and technology, through people's everyday actions, enable a material form of participation. For Marres, participation revolves around societal issues, such as climate change or the need to transition to a low carbon economy, for example, and gives importance and agency to objects (Marres, 2007; Marres, 2015: 5).

Like Actor Network Theory (ANT), although Marres considers objects to have the ability to participate in science and technology issues, she states that it is people that give intention to objects' participation.

Marres (2015) provides the example of the "augmented teapot" whereby a teapot constantly polls the national power grid to assess the carbon intensity of the act of tea making, lighting up green to signify low energy consumption throughout the grid or red

to indicate periods of high energy consumption thus providing the individual with the power to make an informed decision regarding the carbon intensity of their cup of tea and whether or not to put the kettle on. In this case, the teapot is the material object foregrounding the everyday material action of tea-making which is framed as action upon the environment through the interaction with the object and given meaning through the intent of the interaction (Marres, 2015: 65-67).

This reframing of objects and devices as able to participate in issues by affecting behavioural change (in humans) or the functional change (of other objects) and influence cultural and political change allows us to rethink the definition of the product and allows for a new regulatory perspective on the use, intent and wider network of products both within the home and the wider built environment. This theory may be particularly relevant in understanding the risks associated with smart products or other decision-making products influenced by artificial intelligence (AI).

This approach also allows a regulator of product safety to understand the effects and impacts a product may have on human practices and behaviours. In this way, understanding the risks that may occur due to the usage of a product is therefore crucial and means that it may be possible to pre-emptively mitigate against these risks as early as the product design stage.

Approaching this perspective of material participation through a systemic lens accounts for the interlinkages between objects, people and issues which helps to understand the built environment, home and individual products as connected and part of a systemic whole. This reframing shows the necessity to consider all multiple, relational and diverse systemic occurrences of participation, through their interdependencies, not only of the object and human interaction, but also with other collective participatory practices, socio-technological agents, spaces, cultures, and issues of participation, through and within which, they are established (Chilvers and Kearnes, 2015; 52).

5.3 Recommendation for bodies tasked with regulatory decision-making

Material Participation shows that objects can affect people's behaviours through material participation. As objects can affect people's behaviour and the function of other objects, they may also increase or decrease the risk associated with their use (or the use of other products) through their design.

Using this theory as a gateway for further research, policy makers could consider how risk can be pre-emptively mitigated through product design therefore reducing the possible negative impacts and risks of the finished product.

6. Conclusion

It is inevitable that widespread changes to society will occur as the UK transitions to a low-carbon economy and it is vital that governmental institutions are ready to adapt to these changes. The theories presented above provide gateways to new ways of thinking about challenges to the regulation of consumer product and construction material safety and ways to think about how ready existing institutions are to adapt to new challenges.

Each of these social science theories offers a new way of thinking about the relationship between science, society and governance, and the relationship between people and objects and each places importance on the systems, or networks, within which people, objects and issues exist and influence each other.

These theories are all rooted in complex, robust and established bodies of academic literature and have been extensively studied and contested over decades. This report does not suggest that policy makers must delve extensively into this complicated and in-depth literature, however, it may consider some key conclusions in future policy design:

Table 2: Key conclusions of the three theories

Reflexive Governance	Actor Network Theory	Material Participation
Governmental institutions must be reflexive, flexible and interactive in their decision-making processes.	All actors (human and non-human) exist within diverse networks and the relationships between actors are important to understand.	Objects can change the behaviours of people and the functionality of other objects. Understanding material participation is vital when designing policy to regulate the safety of smart products.

For policy-makers, considering these alternative social science theories allows for a shift in perspective when planning future research and helps to ensure that questions, that may not otherwise be previously considered, are addressed. This reframing is vitally important for regulators going forward as the UK shifts towards a net zero transformation of society of which the implications are still largely unknown.

7. Acknowledgments

8. References

Ar6 synthesis report: Climate change 2023 (2023) IPCC. Available at: https://www.ipcc.ch/report/sixth-assessment-report-cycle/.

Department for Energy Security and Net Zero (2022) Net zero strategy: Build back greener, GOV.UK. Available at: https://www.gov.uk/government/publications/net zero-strategy

Braun, B., Schindler, S. and Wille, T. (2018) 'Rethinking agency in international relations: Performativity, performances and actor-networks', Journal of International Relations and Development, 22(4), pp. 787–807. doi:10.1057/s41268-018-0147-z.

Brass, I. and Sowell, J.H. (2020) 'Adaptive governance for the internet of things: Coping with emerging security risks', Regulation & Governance, 15(4), pp. 1092–1110. doi:10.1111/rego.12343.

Callon, M. (1986) 'The sociology of an actor-network: The case of the electric vehicle', Mapping the Dynamics of Science and Technology, pp. 19–34. doi:10.1007/978-1-349-07408-2_2.

Callon, M. (2001) 'Actor network theory', International Encyclopedia of the Social & Behavioral Sciences, pp. 62–66. doi:10.1016/b0-08-043076-7/03168-5.

Cresswell, K.M., Worth, A. and Sheikh, A. (2010) 'Actor-network theory and its role in understanding the implementation of information technology developments in Healthcare', BMC Medical Informatics and Decision Making, 10(1). doi:10.1186/1472-6947-10-67.

Chilvers, J. & Hargreaves, T. (2020) 'Societal engagement with energy and climate change beyond the citizens' assembly', In Review of Energy Policy: December 2020. London: UKERC.

Chilvers, J. and Kearnes, M. (2016) Remaking participation: Science, environment and emergent publics. London ; New York: Routledge, Taylor et Francis Group.

Chilvers, J. and Longhurst, N. (2016) 'Participation in transition(s): Reconceiving public engagements in energy transitions as co-produced, emergent and diverse', Journal of Environmental Policy & Planning, 18(5), pp. 585–607. doi:10.1080/1523908x.2015.1110483.

Chilvers, J., Pallett, H. and Hargreaves, T. (2018) 'Ecologies of participation in socio-technical change: The case of energy system transitions', Energy Research & Social Science, 42, pp. 199–210. doi:10.1016/j.erss.2018.03.020.

Davies, M. and Oreszczyn, T. (2012) 'The unintended consequences of decarbonising the built environment: A UK case study', Energy and Buildings, 46, pp. 80–85. doi:10.1016/j.enbuild.2011.10.043.

Dryzek, J. S., & Pickering, J. (2016). Deliberation as a catalyst for reflexive environmental governance. *Ecological Economics*, 131, 353-360.

Feindt, P.H. and Weiland, S. (2018) 'Reflexive governance: Exploring the concept and assessing its critical potential for sustainable development. introduction to the special issue', Journal of Environmental Policy & Planning, 20(6), pp. 661–674. doi:10.1080/1523908x.2018.1532562.

Gottschick, M. (2018) 'Reflexive capacity in local networks for sustainable development: integrating conflict and understanding into a multi-level perspective Transition Framework', Journal of Environmental Policy & Planning, 20(6), 704–719. doi.org/10.1080/1523908X.2013.842890.

Jasanoff, S. (2004) States of knowledge: The co-production of Science and Social Order. London: Routledge.

Latour, B. (1987) 'Science in action: how to follow scientists and engineers through society', Harvard University Press.

Latour, B. (1996) 'On actor-network theory: a few clarifications', Soziale Welt, 47, pp. 369–381. 10.22394/0869-5377-2017-1-173-197

Laybourn, L., Throp, H., & Sherman, S. (2023) '1.5° C–dead or alive? The risks to transformational change from reaching and breaching the Paris Agreement goal'.

Leonard, L., & Lidskog, R. (2021) 'Conditions and Constrains for Reflexive Governance of Industrial Risks: The Case of the South Durban Industrial Basin, South Africa', Sustainability 2021, 13, 5679. Urban Renewal, Governance and Sustainable Development, 45.

Maier, F. (2023) 'Social science climate research through the lens of actor-network theory: A proposition for organization studies'.

Marres, N. (2007) 'The issues deserve more credit: Pragmatist contributions to the study of public involvement in controversy', Social Studies of Science, 37(5), 759–780. https://doi.org/10.1177/0306312706077367

Marres, N. (2015) Material participation: Technology, the environment and everyday publics. Basingstoke: Palgrave Macmillan.

Nguyen, T. Q. T., Young, T., Johnson, P., & Wearing, S. (2019) 'Conceptualising networks in sustainable tourism development', Tourism Management Perspectives, 32, 100575.

Pollack, J., Costello, K., & Sankaran, S. (2013). Applying Actor–Network Theory as a sensemaking framework for complex organisational change programs. *International Journal of Project Management,* 31(8), 1118-1128.

Potvin, L., & Clavier, C. (2013). Actor-Network Theory: The governance of intersectoral initiatives. *Health promotion and the policy process*, 82-103.

Stirling, A. (2004) 'PRECAUTION, FORESIGHT AND SUSTAINABILITY reflection and reflexivity in the governance of science and technology', Sustainability and Reflexive Governance.

UNEP. (2022) 'Emissions Gap Report', https://www.unep.org/resources/emissions-gap-report-2022

9. Appendix 1

The framework presented by Gottshick (2018), based on the Multi-Level Perspective (MLP) and a Conflict-Oriented Understanding (COU) allow stakeholders to assess whether a policy adopts a reflexive governance approach.

Framework Part I, Based on MLP

Q1: Is long-term transition addressed as a 'radical' change from one system (state) to another system (state)? This question includes at least three concepts. First, a 'long-term' perspective on reality, in this case 20–50 or more years, and second, a 'radical transition'. Other authors have already pointed out that the assessment of a 'radical' change compared with 'incremental' change is difficult (Genus & Coles, 2008, p. 1440) and might only be possible ex post. Third, the question includes the idea of one stable system situation in the beginning and at the end of a transition process.

Q2: Is reality conceptualized in levels of influenceability or stability with attention to dynamics betweens these levels?

All change processes will search for influenceable aspects and leave unfeasible aspects aside. But do they systematically recognize this with some sort of a structuration theory in mind? And—the second layer of this question—do they pay attention to the interrelationships and dynamics between these levels of influenceability?

Q3: Are the developments and dynamics of change on the relevant socio-technical dimension (like policy, administration, science, or technology) seen with regard to its path dependency restrictions?
Once again, the inertia of habits and cycles of investments are commonly known. However, to develop a strategy for change, path dependencies of ongoing processes could be analysed and considered explicitly.

Q4: Are the interrelationship and development of relevant social dimensions understood as a co-evolutionary process?
This stresses the importance of interdependence between dimensions which are usually ignored. This might discover new insights on path dependencies or options for innovations.

Q5: Are technological innovations considered as nuclei for social change?
Innovations in technology and in society seem to be strongly linked. At least historically, technological innovations play a core role in MLP (and in TM).

Q6: Are conflicts structured for better understanding and for the possibility to work constructively with them?
A basic assumption of COU is that conflicts are the nucleus of (or a barrier to) innovation to sustainable development. Therefore, actors might be systematically supported to reflect on their different kinds of conflicts.

Q7: Is 'to understand' used in a sophisticated way?
Implicitly, the term 'to understand' is often used as a synonym for 'to relate to' or 'to agree to'. The COU approach suggests to use degrees of understanding like: (a) to note the diversity, (b) to admit it, and (c) to include this diversity as a starting point for an integrated and reflexive interpretation of the values, situation, and options.

Q8: Are options for action clarified and their preconditions and implications analysed for all relevant stakeholder groups?
If all stakeholder groups have their options for action systematically analysed and documented, then bargaining and cooperation are eased.

Q9: Are new and theoretically possible actor-coalitions analysed and integrated with options for action to something like 'systemic alternatives'? Is the need and benefit of these systemic alternatives clarified and promoted?
To overcome restrictions of innovative and unfamiliar thinking, coalitions should be developed creatively. These new coalitions cannot simply be presented but have to be promoted in a politically sensible way.

Q10: Are suggestions for feasible processes and arenas developed systematically?
New processes and arenas have to be gently developed. The first step is to generate practical ideas based on a systematic and creative analysis.