

Applying Systemic Co-design Methods for Transport Transitions at City Scale

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Abstract

This positioning paper introduces the *Inspiring Futures for Zero Carbon Mobility (INFUZE)* project, which applies systemic co-design methods to support city-scale transport transitions. INFUZE addresses the UK's focus on car ownership and technology-led decarbonization and explores how citizens, providers and policymakers can co-create alternative mobility futures. The project is grounded in Meadows's leverage points and extended through the PEKEM framework (Philosophy, Emotions, Knowledge, Experience and Material agency). The collaborative research integrates participatory design, systems thinking and value-sensitive approaches, linking to understanding change, solution modeling, impacts and trials to generate new insights into physical and cultural change and developing a new 'participatory mobility science'.

Keywords: Co-design, decarbonization, participatory mobility science, sustainable mobility, systemic change.

Research Context

As the UK struggles to decarbonize its transport, the INFUZE project pioneers a citizen-led system co-design approach that aims to disrupt car ownership and reimagine how we get around our cities together. The UK drives 252.9 billion miles (Department of Transport 2025) and spends GBP 116 billion per year on owning, maintaining and insuring cars – more than is spent on food and clothing combined (National Audit Office 2024), highlighting its deep dependency on the system of *automobility* (Urry 2014, 25). Since 2015, domestic transport has become the most carbon-intensive with the sector only achieving a 1% reduction in 2022/2023 (Department of Transport 2024); accounting for 29% of all UK carbon emissions.

The UK government's net-zero pathway to 2050 prioritizes the transition to electric vehicles (EV) as the main strategy for decarbonizing transport (Department for Energy Security and Net-Zero 2025). Nevertheless, whole-systems analysis shows that the narrow focus on electrification and technological solutions is insufficient to meet these ambitious targets and will also require demand reductions and mode shift (Marsden 2023). Moreover, this narrow strategy overlooks the broader social, environmental and urban challenges it creates. Projections estimate an extra 10 million vehicles on the road from the uptake of Electric and Autonomous Vehicles (AV), leading to a 54% rise in road traffic by 2060 (Institute of Policy Research 2021). This increase in traffic intensifies the demand for land, reduces the liveability of our cities and continues the path of car dominance in our public realm.

The causal relationship between domestic transport and health, social, and economic inequalities is well documented. Traffic-related air pollution affects everyone; it has a disproportionately adverse

impact on vulnerable groups – such as children, the elderly with pre-existing conditions and ethnic minorities – particularly those living in areas where access to green space is limited (Buzzelli and Jerrett 2007, 197). In its pathway to net-zero by 2050, the UK government has prioritized the transition to electric vehicles (EV) as its preferred strategy for decarbonizing transport. However, technological adjustments to the existing system are counterproductive to driving meaningful social and environmental change. How will UK cities like Leeds accommodate an extra 100 000 cars on their roads and streets under such a policy direction and at what cost to people, place, and planet?

Leeds City Council (2025) has recognized that such a future is both unsustainable and undesirable. Its *Connecting Leeds Transport Strategy* sets out an ambitious vision to transform Leeds into a city where you don't need to own a car to get around. To achieve this vision, the strategy focuses on six 'big moves': decarbonizing transport; creating healthier streets, spaces and communities; transforming the city centre; enhancing public transport; delivering a mass transit system and adopting new smart technologies. A key commitment in delivering this transition is the active participation of citizens and businesses from across the city to deliver change and to capitalize on the opportunities that arise through engagement and collaboration in pursuit of a shared vision.

Despite these moves, there is a gap where collaborative and systemic design research can better act as a bridge between policy ambition and the realities of real-world mobility choices and behaviours.

Our Conceptual Framework: People in Systems

INFUZE is grounded by Meadows's (1999) concept of system leverage points which identifies places within a system where interventions and their effectiveness can produce change. Interest in deeper leverage points has grown among researchers and theorists, emphasizing the need for transformative approaches to address complex systemic challenges. The following articles provide important context for this discourse and form the foundation for our conceptual approach.

Meadows (2014) outlines fourteen principles for engaging with system redesign. These include: listening to the wisdom of the system, surfacing mental models, understanding systemic behaviours, prioritizing significance over measurability and adapting to emergent outcomes. Abson and Lang (2016, 30) extend Meadows's hierarchy by identifying four system characteristics: parameters, feedback, design and intent. Critically, they argue that policy interventions typically focus on shallow points and call for deeper engagement to address the underlying causes of unsustainability, through design and intent. Jones (2014) situates design research within this systems foundation, arguing that design methods must evolve to tackle the complexity of socio-technical systems. This approach integrates systems thinking with participatory and reflective design practice, providing a conceptual bridge between systemic leverage and design-led transformation. Here, the introduction of technology-based interventions – like EVs – to address the UK's decarbonization challenge clearly represent a shallow leverage point and therefore offer limited effectiveness in driving transformation change.

Bolton (2022, 2435) examines Meadows's hierarchy in further detail and how it is applied in sustainability governance, illustrating the constraints and influences within public decision-making. They demonstrate why policymakers often concentrate on shallow leverage points, while emphasizing the benefits of a *one-deeper* approach to drive meaningful change in response to sustainability challenges. Nerland et al. (2025, 700) stresses when transforming local governance, the importance of paying particular attention to who holds the power structures to understand its system malfunctions.

Here, they introduce the concept of 'space of leverage' in the system and propose two key recommendations that align with the collaborative design team's approach: establishing new means for collaboration that integrate system perspectives and a shared vision across all stakeholders.

In *Shades of Co-design* Blomkamp (2024) highlights the incongruence in how co-design is adopted and applied, while recognizing that it often means different things to different people and across disciplines, and scope and resources can vary significantly between projects. To help researchers reflect on these challenges, especially those engaging in participatory action research, Blomkamp poses three questions: how big is the co-design? (scale); how deep is your co-design? (level) and how wide is the co-design? (extent of design). To evaluate the depth of co-design, Blomkamp provides a matrix that cross-references components found within Arnstein's (1969, 217) ladder of participation against four forms of knowledge acquisition: lived experience, practice wisdom, research evidence and cultural knowledge. These questions and self-assessment tools are not only pertinent to design teams but even more so for trans-disciplinary research teams, where diverse experiences and assumptions related to co-design – may complicate the integration and development of a shared, coherent understanding of co-design and its consistent application.

While Blomkamp focuses on the processes and structures to enable meaningful co-design practice to flourish, Ives (2019, 208) invites us to shift our perspective inwards and to consider how such structures influence an individual's receptiveness to system change. Ives observes how "inner worlds" often shape our human experience through the systems and structures we design, experience and inhabit; physically, socially, culturally and mentally. He calls for greater recognition of the overlooked potential of embedding a deeper "inside-out" approach to sustainability and asks, "how could inner life be approached in sustainability science?" This question is equally relevant for transport policymakers and planners – to ensure future policies are purposely designed to be in tune with inner values and beliefs of citizens.

Reconnecting society with nature, he argues, requires leveraging five types of connection – the material, experiential, cognitive, emotional and philosophical – echoing Meadows’s deeper leverage points and forming a conceptual framework that INFUZE advances through design across policy, systems, services and products.

Connecting People, Values and Change

The conceptual framework being adopted by the INFUZE team builds on Ives’s thinking by establishing the conditions, methods and tools necessary, applied within a design methodology, to understand the system problems and co-create preferable futures. We build system knowledge by starting with deep leverage points: Philosophies, Emotions and Knowledge, and then moving to Experience Design and Material Agency (PEKEM). PEKEM serves as our conceptual framework, positioning human, cultural and emotional dimensions at the forefront of sustainable mobility futures and linking, at different levels, to our propensity to change as well as the societal readiness of transport systems. Understanding how citizens and communities engage with possible futures requires systematic and equal attention to the five interrelated dimensions of PEKEM – as these factors shape how people imagine, evaluate and act upon transformative possibilities.

- **Philosophy, values and beliefs:** these represent our openness to change and include individual and group values, principles and worldviews. They capture our deeply held commitments and can shape and inform how we respond to future missions and challenges such as health, sustainability and equity.
- **Emotions and feelings about the future:** these point to our willingness to act and describe our emotional responses to potential changes, ranging from optimism and hope to fear and resistance. They influence our acceptance of new experiences and readiness for action, often informed by our social norms and our physical and media environments.

- **Knowledge, opportunities and risks:** these highlight our decision-making clarity and show our awareness and understanding of choices, benefits and risks associated with different decisions and futures. They help us clarify choices, reduce uncertainty, and share preconceptions and can even change our opinions if communicated well.
- **Experience including our lived and practical realities:** these show our ability to imagine meaningful futures and can describe our personal or household routines, constraints and past experiences. They shape our perceptions and our current behaviour but can also be used to help us imagine more practical, inclusive and delightful futures if grounded on new knowledge and inspired by deep connections to our philosophy and values.
- **Material change, agency and resources:** this reflects our capacity to make change in our lives and affects our ability to act, which can be determined by our resources, tools and wider support systems. Without real agency even willing people cannot change. Change is not just physical and technological but also cultural, political, legal and economic.

Together with “triple-loop learning (Tosey, Visser, and Saunders 2002, 293) and value-sensitive design” (Friedman 1996, 17) we advance our collaborative work beyond shallow interventions and consultations to consider our openness to change, willingness to act, decision-making clarity, ability to imagine meaningful futures, and our capacity to make change at urban, neighbourhood and household level.

Introducing the INFUZE Project

INFUZE is a transdisciplinary project to encourage people in Leeds to design and try alternatives to private vehicle ownership. Supported by a £8 million Engineering and Physical Sciences Research Council (EPSRC) programme grant, INFUZE is a five-year research project led by the University of Leeds with the Royal College of Art (RCA) and Lancaster University. The team is supported by thirty-one partners including public bodies such as Leeds City Council, West Yorkshire Combined Authority, the Department of Transport, third-sector charities and private consultants and service providers.

Rather than asking, “can you live without a car?” The central question guiding the INFUZE team is: “what would a world where people did not need to own their own cars look like?”

The primary aim of INFUZE is to shape a new “participatory mobility science” to spark systemic changes in mobility through co-design. As noted above, a strategy of electrifying the vehicle fleet neither meets carbon goals nor does it enable a wider transition in society to more positive travel futures. The research project aims to address these gaps to explore whether genuinely distinct pathways can be built with people, providers and politicians. To fulfil the vision established above we set out seven key research objectives which include three collaborative design challenges:

1. Co-design with communities and stakeholders a set of vision-led approaches to building mobility systems that provide a positive alternative to car ownership.
2. Develop new tools and conceptual models to understand the propensity to shift mobility ownership to mobility access taking account of new mobility service characteristics.
3. Change how mobility transitions are researched, developing a new approach to participatory mobility science for change.

INFUZE is being delivered through a programme of four interconnected and interdependent work packages (WP): Co-design; Understanding change potential; Building design solutions and Trial delivery, evaluation and governing change (see Image 1). Structured around an inclusive and participatory design process, a cycle of ‘listen, vision, build, and change’ is repeated through the five years of the programme grant.

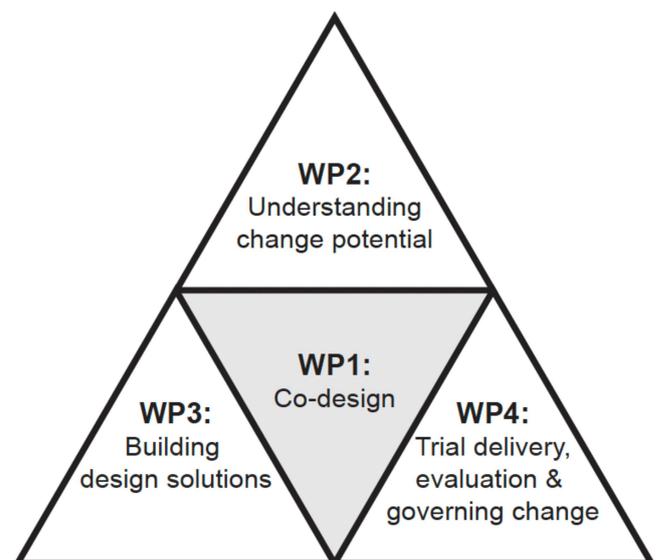


Image 1: INFUZE work packages.

WP1 Co-design

WP1 brings together the research expertise of the RCA's Intelligent Mobility Design Centre (IMDC) and Lancaster University's Centre for Social Futures (CSF). The CSF was founded in 2015 by John Urry and Linda Woodhead. Its current research activities are situated within the themes of digital and material, culture and creativity, mental health and well-being and environmental and social futures. Past research enquiries and conferences within the Environmental and Social Future have explored themes such as *Everyday Futures*, *Mobile Utopias* and *DecarboN8*. The projects *Cumbria 2038* and *Bridging the Gap* tested alternative approaches to deploying reflective design in planning. One of the key learnings was that the current separation between expert visioning and community visioning was evident, highlighting the need for greater integration in co-design processes.

The IMDC was established in 2016 with foundational support from Hyundai-Kia to create a transdisciplinary centre exploring, experimenting, prototyping and evaluating new mobility and automotive transitions via the synthesis of design and research. It integrates design and technology with insights into people and the social, environmental and economic context to enable a 360-view on the design of future mobility. The IMDC is organized into three distinct yet complementary studios enabling a multifaceted perspective on mobility design: The Automotive Transitions Studio, The Humanizing Technology Studio and The People & Places Studio (P&PS).

Over the past decade, the IMDC has undertaken a wide range of collaborative research projects spanning investigative themes such as *Driverless Futures*, *Streets for Diversity* and *Our Future Towns*. *Our Future Towns* project – led by the RCA in collaboration with the Transport Planning Society, Chartered Institution of Highway Engineers and local councils – served as a foundational initiative for the IMDC's People and Places Studio. Through engagement with

three rural communities, the project developed a set of participatory design tools and methods to help citizens listen, learn, imagine and lead change around mobility, spatial and town futures. Its findings demonstrate the value of co-creating shared visions rooted in local values, emotional insights and lived experience – highlighting how meaningful change can emerge from community participation not just from predictive systems, infrastructure or policy (Phillips 2021). The learnings from *Our Future Towns* directly informed INFUZE's systemic co-design approach and acted as a small-scale testbed for the human-centred methods now being applied at city scale.

The co-design work package serves as the project's spine, enabling networked connectivity across all work packages through a continuous process of integrating, synthesizing and sharing insights. The team seeks to address the uncertainties of generating mobility system transformations by developing a new 'participatory mobility science' – a collaborative design approach that seeks to embed citizens and stakeholders in the process of integrating creativity and equity into the scientific models of transport planning. The co-design work is structured around an annual cycle of co-produced design research, implementation and reflection, and includes a series of Creative Assemblies, Visioning and the development of a Toolkit.

In the first year, the authors aimed to position citizens as equal partners – co-creators of future mobility systems – grounding the process in their shared values and knowledge, rather than in journey maps or new technologies, to explore how they want to move, feel, and live in the future. In response to the initial call to action, they established a creative assembly to explore citizens' individual and communal philosophies, values, knowledge, experiences and agency for change (see Image 2).

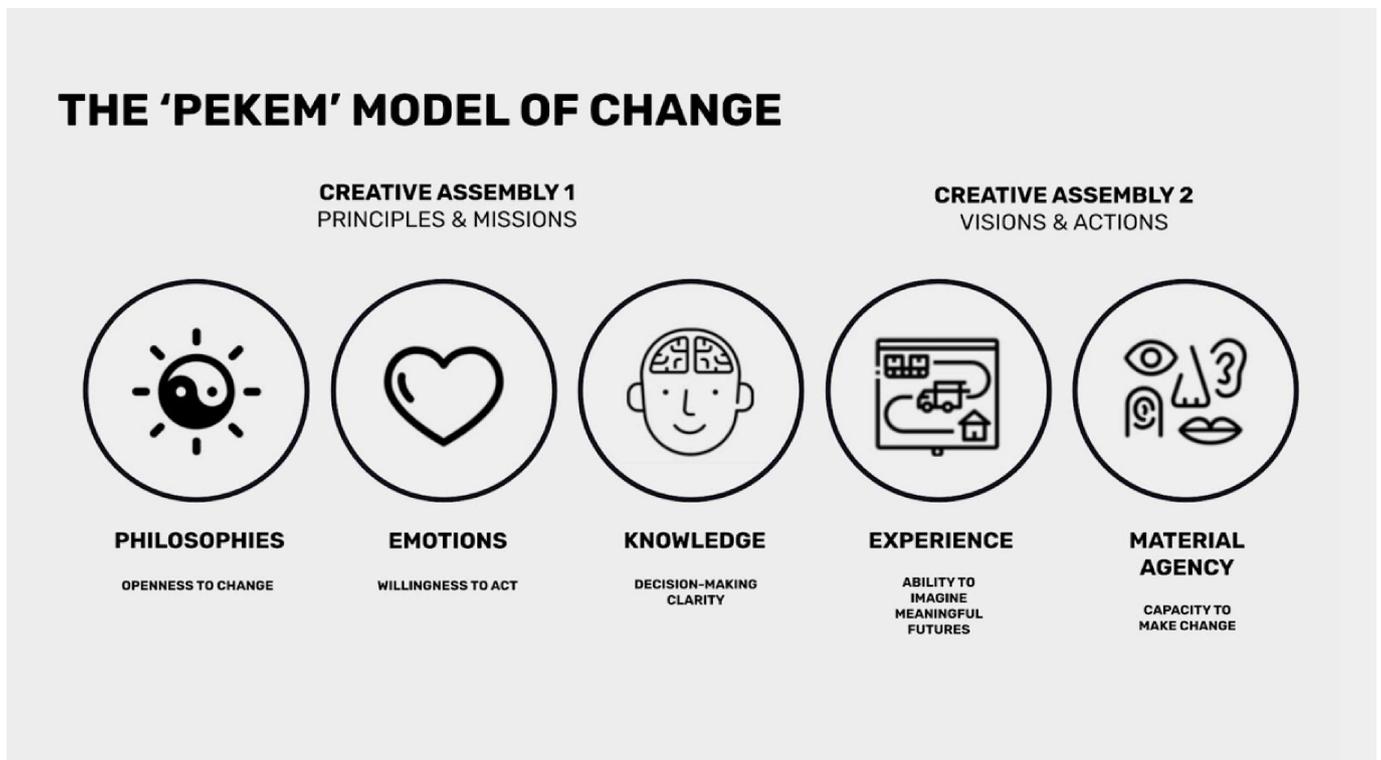


Image 2: The conceptual framework.

The authors brought together a consistent group of 25 citizens from across the city for two connected Creative Assembly events hosted at Leeds City Museum. To support a process of active listening and mutual learning, they developed a formative philosophies, values and emotions card set (see Image 3). Together, the Assembly shared their hopes and concerns and identified the risks, opportunities and missions for the future of their city. This activity included the exploration of the risks, opportunities and missions people share when interrogating desirable (utopian) and undesirable (dystopian) futures.

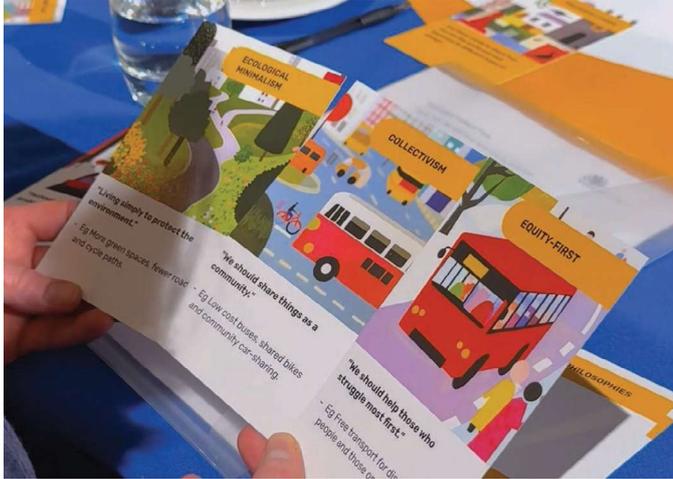


Image 3: Examples of philosophy cards.

Why this Work Matters

Situated in transport policy and design, this novel approach is the first of its kind to apply the systemic use of deep, medium and shallow leverage points in a real-world context using a design methodology. This claim is supported by a scoping review, which identified extensive theoretical discourse but, critically, found no demonstrable examples of its application in policy or design context beyond the RCA and INFUZE. Furthermore, examples of citizen participation where power and influence are afforded within transport planning and public policymaking remain rare (Pappers, Keseru, and Macharis 2020, 13).

Visioning has engaged participants and stakeholders in the design research process through two steps: imagining and changing. This creative process builds on the places and journeys that matter to people, as well as their values, skills, loves, fears, frustrations, and beliefs about the future. Groups worked together to develop a series of speculative visions based on the assembly's guiding principles and emotional design needs. This ongoing process is contributing to the co-creation of citizen-led visions and principles for changes to Leeds's mobility system.

A key output will be a new 'participatory mobility science toolkit' to transform the approach to transition planning. The Toolkit is evolving as a live, iterative resource across the whole project as the authors learn about how to co-design new mobility futures. Its finalized form will contain a portfolio of online resources, videos, visuals, guidance on making data and modeling accessible, and engaging citizens in trial design and delivery for change. The engagement activities throughout the project will also help promote wider adoption through active advocacy, increasing in intensity as the Toolkit matures.

The shared mental model developed by the Assembly is now being disseminated across the INFUZE research team and its partners, providing a set of principles and missions that will anchor the next phase of work – a phase in which the team will engage more deeply with the Assembly, in community settings and involve citizens who wish to rehearse the future through proto-practice experiments.

Although in its first year, as the research, learning and toolkit evolve, its delivery will serve as a dynamic case study for transport policymakers, planners, service providers and designers to re-evaluate how systemic co-design methods can be applied to support transport transitions at city scale.

Author's note: The original text has been submitted to ChatGPT for the sole purpose of grammar, language and clarity review.

References

- Abson, David J., Joern Fischer, Julia Leventon, Jens Newig, Thomas Schomerus, Ulli Vilsmaier, et al. "Leverage Points for Sustainability Transformation." *Ambio* 46 (2016): 30–39. <https://doi.org/10.1007/s13280-016-0800-y>.
- Arnstein, Sherry R. "A Ladder of Citizen Participation." *Journal of the American Institute of Planners* 35, no. 4 (1969): 216–224. <https://doi.org/10.1080/01944366908977225>.
- Blomkamp, Emma. "Shades of Co-design." *We Know How*, July 3, 2025. <https://www.newknow.how/resources/shades-of-codesign>.
- Bolton, Mitzi. "A System Leverage Points Approach to Governance for Sustainable Development." *Sustainability Science* 17, no. 6 (2022): 2427–2457. <https://link.springer.com/article/10.1007/s11625-022-01188-x>.
- Buzzelli, Michael, and Michael Jerret. "Geographies of Susceptibility and Exposure in the City: Environmental Inequity of Traffic-Related Air Pollution in Toronto." *Canadian Journal of Regional Science/Revue Canadienne des Sciences Régionales* XXX, no. 2 (2007): 195–210. <https://idjs.ca/images/rcsr/archives/V30N2-BUZZELLI.pdf>.
- Department for Energy Security and Net-Zero. "Final UK Greenhouse Gas Emissions Statistics: 1990 to 2023." March 27, 2025. <https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-statistics-1990-to-2023>.
- Department of Transport. "Greenhouse Gas Emissions from Transport in 2022." December 12, 2024. <https://www.gov.uk/government/statistics/transport-and-environment-statistics-2024/greenhouse-gas-emissions-from-transport-in-2022>.
- Department of Transport. "Provisional Road Traffic Estimates, Great Britain: October 2023 to September 2024." April 26, 2025. <https://www.gov.uk/government/statistics/provisional-road-traffic-estimates-great-britain-october-2023-to-september-2024>.
- Friedman, Batya. "Value-Sensitive Design." *Interactions* 3, no. 6 (1996): 16–23. <https://dl.acm.org/doi/10.1145/242485.242493>.
- Institute of Policy Research. "Shifting to Electric Vehicles Is Not Enough: Public Transport, Walking, and Cycling Needs a Greater Role in the UK's Future." June 23, 2021. <https://www.ippr.org/media-office/shifting-to-electric-vehicles-isn-t-enough-public-transport-walking-and-cycling-need-greater-role-in-uk-s-future-says-ippr#:~:text=Press%20Story,space%20used%20for%20car%20parking>.
- Ives, Christopher D., Rebecca Freeth, and Joern Fischer. "Inside-out Sustainability: The Neglect of Inner Worlds." *Ambio* 49, no. 1 (2019): 208–217. <https://doi.org/10.1007/s13280-019-01187-w>.
- Jones, Peter. "Design Research Methods for Systemic Design: Perspectives from Design Education and Practice." *Proceedings of the 58th Annual Meeting of the ISSS - United States* 1, no. 1 (2015). <https://journals.issss.org/index.php/proceedings58th/article/view/2353>.
- Leeds City Council. "Connecting Leeds Transport Strategy." April 30, 2025. <https://www.leeds.gov.uk/parking-roads-and-travel/connecting-leeds-and-transforming-travel/transport-policy>.
- Marsden, Greg. "Reverse Gear: The Reality and Implications of National Transport Emission Reduction Policies." Centre for Research into Energy Demand Solutions. Oxford, UK, 2023.
- Meadows, Donella H. *Leverage Points: Places to Intervene in a System*. Hartland, VT: The Sustainability Institute, 1999.
- Meadows, Donella H. "Dancing with Systems – The Donella Meadows Project." The Academy for System Change, January 20, 2014. <https://donellameadows.org/archives/dancing-with-systems/>.
- National Audit Office. "An Overview of the Department for Transport for the New Parliament 2023-24." November 12, 2024. <https://www.nao.org.uk/wp-content/uploads/2024/11/department-for-transport-overview-2023-24.pdf>.
- Nerland, Rita, Gisle Solbu, Kristin Hansen, and Heidi Rapp Nilsen. "Transforming Local Governance: Using System Leverage Points to Conceptualize Sustainability Transformations." *Sustainability Science* 20 (2025): 691–706. <https://doi.org/10.1007/s11625-024-01618-y>.
- Pappers, Jesse, Imre Keseru, and Cathy Macharis. "Co-creation or Public Participation 2.0? An Assessment of Co-Creation in Transport and Mobility Research." In *Towards User-Centric Transport in Europe 2*, edited by Beate Müller and Gereon Meyer. Cham: Springer, 2020.
- Phillips, Dan. "Our Future Town: Changing Hearts and Minds Policy Research." Royal College of Art, 2021.
- Tosey, Paul, Mark Visser, and Mark Saunders. "The Origins and Conceptualizations of 'Triple-Loop' Learning: A Critical Review." *Management Learning* 33, no. 3 (2002): 291–307. https://www.researchgate.net/publication/258171998_The_origins_and_conceptualizations_of_'triple-loop'_learning_A_critical_review.
- Urry, John. "The System of Automobility." *Theory, Culture & Society* 21, no. 4–5 (2004): 25–39. <https://doi.org/10.1177/0263276404046059>.