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Integrating modelling-based and stakeholder-focused scenario approaches to close the planning gap and accelerate low-carbon transitions

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ABSTRACT

While many transition scenarios describe potential low-carbon systems, few link these system-level outcomes to the microlevel stakeholder decision-making needed to actualise them, resulting in a 'planning gap'. Closing this gap requires that insights from modelling-based transition scenarios on *what* must happen to achieve climate targets are linked to those on *how* to make it happen from stakeholder-focused transition scenarios. This link requires a different understanding of decision-making rationality from that of a representative agent with rational expectations, as employed in much climate-change modelling currently. Rationality conceived as 'frame-sensitive reasoning' can better account for heterogenous stakeholders' alternative preferences, the actions they take in pursuit of them, and the effect of these actions on low-carbon transitions. This paper augments the Intuitive Logics (IL) stakeholder-focused scenario approach to enable frame-sensitive reasoning and provide modelling-based transition scenarios with realistic innovation-diffusion assumptions. In so doing, the paper assists in closing the planning gap.

1. Introduction

The scale, breadth and urgency of the changes needed to address the climate emergency make how to accelerate low-carbon transitions a pressing concern (Roberts and Geels, 2019a, 2019b; Roberts et al., 2018). Yet, while many transition scenarios describe potential low-carbon systems, few connect these system-level outcomes to the microlevel stakeholder decision-making needed to actualise them (Geels et al., 2020; Hughes, 2013), leading to a 'planning gap' (Pavia and Muñoz Castañer, 2023). Closing this planning gap requires the active engagement of heterogenous stakeholders (Sundqvist-Andberg and Åkerman, 2022) and recognition of their diverse framings of transition issues (Geels et al., 2020; Hughes, 2013). Participatory approaches that recognise stakeholder heterogeneity may assist in identifying a wide diversity of drivers specific to a focal transition, which might otherwise be overlooked (March et al., 2012).

Yet, despite the importance of stakeholders' heterogeneity and diverse framings of focal transition issues, climate-change models have great difficulty recognising stakeholder heterogeneity because of their assumption of a representative agent with rational expectations (Mercure et al., 2016). Their employment of this assumption prevents climate-change models from recognising the heterogeneity of stakeholders involved in transition decision-making, the diversity of their framings of focal transition issues, or the reflexivity they enact in seeking to enable, block or alter transitions in accordance with their outcome preferences. This deficiency has contributed to the emergence of the planning gap that stymies faster transition (Mercure et al., 2016; Pavia and Muñoz Castañer, 2023).

Stakeholder-focused scenario approaches are specifically designed to engage heterogenous groups of stakeholders and to recognise their alternative framings, preferences, and decision-making (Cairns and Wright, 2018; Wright et al., 2013). As such, they have the potential to provide new insights into possible policy pathways for transition (Akgün et al., 2012). Using stakeholder-focused transition scenarios to inform modelling-based transition scenarios can therefore assist in closing the planning gap and accelerating transitions. This methodological paper describes how this can be done.

When stakeholder interests are in conflict, accelerating a transition can become a highly complex 'wicked problem' characterised by ambivalence, uncertainty, and value divergence (Head, 2008; Mahlalela et al., 2022; Morgan, 2020; Sauermann et al., 2020). This makes transitions 'inherently political' and subject to 'protracted processes of conflict and contestation' (Rosenbloom, 2017, p.46). These conflicts and contestations affect a transition's speed, extent, and direction (Meijer and Hekkert, 2007; Mercure et al., 2016). They may be resolved organically but this can take time (Leipprand and Flaschland, 2018),

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which is now short (Derbyshire and Morgan, 2022).

Transition conflicts and contestations are played out through discourses designed to frame a transition in ways favourable to a particular stakeholder group's outcome preference (Geels, 2014; Lowes et al., 2020). For example, official analysis has shown electrification to be the lowest-cost and most feasible transition pathway for domestic heating in the UK (Gibb et al., 2023; Lowes et al., 2020). Yet, manufacturers of the gas-boiler technology predominantly used for domestic heating have sought to delay government measures designed to accelerate electrification (Lowes et al., 2020). The Energy and Utilities Alliance–a lobby group representing gas-boiler manufacturers—has engaged in an intensive two-year campaign to frame adaptations to gas-boiler technology that enable use of 'green gases' (e.g., hydrogen) as a better solution than electrification. Essentially, incumbent regime stakeholders have established a 'discourse coalition' (Lowes et al., 2020) that has created a 'discourse of delay' (Lamb et al., 2020) that frames wholesale change as unnecessarily disruptive.[1]

The uncertainties arising from such transition conflicts and contestations challenge conventional notions of planning, governance, and decision-making rationality (Turnheim and Nykvist, 2019). Overcoming these uncertainties requires more realistic and open transition-management tools that avoid claims of certainty, predictability, and control (Geels et al., 2020; Turnheim and Nykvist, 2019). Specifically, it requires a focus on heterogenous stakeholders' alternative preferences, framings, and decision-making (Geels et al., 2020; Turnheim and Nykvist, 2019), which in turn requires a new understanding of decision-making rationality (Bermúdez, 2020).

However, at the same time, the effectiveness of collaborative and stakeholder-focused approaches for overcoming conflicts and contestations, and for planning and managing environmental and transition-related matters more broadly, has been quite widely questioned, including in this journal (see Ananda and Proctor, 2013). This paper does not suggest that participatory and stakeholder-focused scenario approaches are a panacea that will inevitably lead to agreement and resolve conflicts. On the contrary, it suggests that, while they can help identify mutually beneficial outcomes that lead to agreements that accelerate low-carbon transitions, they can also lead to no agreement, and in some cases, might even exacerbate any existing conflict between stakeholders with opposed interests.

Yet, for exactly that reason (i.e., exactly because there is no guarantee that transition conflicts and contestations will be resolved or even just ameliorated by their use) the conflicts and contestations uncovered as part of a participatory and stakeholder-focused scenario approach, and the potential for them to slow, block or alter a focal transition (or, more optimistically, to accelerate it) need to be incorporated in system-level, modelling-based transition scenarios so that they better reflect reality. Only that way can the planning gap be closed. They cannot be incorporated currently because of the understanding of decision-making rationality on which climate-change modelling predominantly relies, which, as noted, is based on the assumption of a representative agent with rational expectations. Accordingly, this paper does four things:

1) It shows how the understanding of decision-making rationality currently employed in much climate-change modelling has caused a planning gap to emerge.
2) It describes how stakeholders employ (re)framing tactics to influence action preferences in ways favourable to their outcome preferences and how recognising the effect of this reflexivity on transitions requires a new understanding of rationality.
3) It outlines the alternative understanding of decision-making rationality that is frame-sensitive reasoning (Bermúdez, 2020) and describes its usefulness for understanding and managing transitions.
4) It augments the Intuitive Logics (IL) stakeholder-focused scenario approach to enable frame-sensitive reasoning and to provide modelling-based transition scenarios with more realistic innovation-diffusion assumptions, thus aiding closure of the planning gap.

In so doing, the paper responds to Köhler et al.'s (2019) call for transition researchers to create tools that may help to accelerate transitions (Gorissen et al., 2018; Nilsson and Nykvist, 2016; Sovacool, 2016). The next section describes how the understanding of rationality on which many modelling-based transition scenarios are based has caused a planning gap to emerge.

2. The rational expectations of a representative agent and the planning gap

Nearly all models of rational decision-making assume it is irrational for individuals to allow their action preferences (i.e., choices) to be influenced by how outcomes are framed (Bermúdez, 2020). That assumption is central to the Expected Utility Theory (EUT) used in much climate-change modelling, as manifest in the assumption of a representative agent who has rational expectations (Mercure et al., 2016). Under this understanding of rationality, an individual maximises their utility by considering the full panoply of available information, rank-ordering a transitive set of preferences, and continuously optimising on that same basis (Bermúdez, 2020).

Keynes (1978) long ago highlighted the problems with this understanding of rationality and the knowability of the future it implies (Morgan et al., 2023). It requires all the consequences from every possible course of action to be known in advance, to which are attached one number expressing their comparative advantage, and another number expressing the probability of their following from the course of action in question. This enables the decision-maker to multiply these numbers together, leading to a set of comparable options and outcomes, which are used to determine actions (Culham, 2023; Keynes, 1978). This eliminates uncertainty by investing in the future the same calculable status as the present (Keynes, 1978).

It is because of their basis on this understanding of rationality that modelling-based transition scenarios tend towards a 'technology push' view of transition (Mercure et al., 2016). This implies transition to be a mere matter of producing more sustainable and cost-effective innovations, which automatically diffuse because agents seek to optimise their utility rationally (Mercure et al., 2016). However, if incumbent regime stakeholders have an interest[2] in blocking this diffusion, a low-carbon innovation may fail to diffuse even if it performs better in terms of sustainability and cost effectiveness, both of which can anyway be highly uncertain when it comes to new, low-carbon technologies (Lowes et al., 2020; Wesseling et al., 2022).

This understanding of rationality has caused transitions research to focus on technological artefacts rather than on stakeholders' agency, framing, power, and politics (Mercure et al., 2016). The simplistic technology-push view of diffusion and the equally simplistic rational expectations understanding of decision-making rationality are deeply intertwined. If all stakeholders make choices as the latter implies, it is unnecessary to delve into microlevel stakeholder decision-making because the decisions stakeholders make will be uniform, frame-neutral, automatic, and highly predictable. This is even more so

[1] The UK's domestic-heating transition is far from unique in featuring such attempts by incumbent regime stakeholders to delay or even outright block transition. It also features in, for example and among other transitions, the transition of transport systems away from car dependence (Mattioli et al., 2020) and, as later discussed by reference to Rosenbloom et al. (2016), in the transition to renewable sources of electricity generation.

[2] This paper follows Lowes et al. (2020) in adopting Lowes et al.'s (2017) understanding of 'incumbent' and adopts Kern's (2011) understanding of an 'interests-based' perspective.

because this understanding of rationality is operationalised through the assumption of a 'representative agent'—i.e., a single stakeholder type with an average set of preferences (Kirman, 1992; Mercure et al., 2016). This assumption inhibits climate-change models' ability to take account of stakeholder heterogeneity.

In this way, the understanding of decision-making rationality employed in modelling-based transition scenarios has been pivotal to creating the planning gap between climate targets and action plans. Because they employ the assumption of a representative agent with rational expectations, modelling-based transition scenarios offer much useful guidance on *what* needs to be achieved to meet climate targets, but little guidance on *how* to achieve it. Stakeholder-focused scenario approaches, by contrast, focus specifically on the 'Who? Where? and Why? of heterogenous stakeholders' actions and decisions (Cairns and Wright, 2018). The next section illustrates the importance of accounting for heterogenous stakeholders' actions and behaviour in transition scenarios.

3. Who frames wins: The relationship between stakeholders' action and outcome preferences

Rosenbloom et al. (2016) identify several competing framings of the diffusion of solar photovoltaic (PV) electricity-generation technology in Canada. Incumbent regime stakeholders advanced a narrative framing that suggested inflated consumer prices were because electricity was being generated using PV. Conversely however, niche innovators framed conventional means for generating electricity as the cause. Competing narrative storylines thus framed the same information (high consumer prices) in different ways to suit the competing objectives of accelerating and resisting transition (Geels, 2014).

This matter is not one of 'a resistance to change due to imperfect information' (Fortes et al., 2015, p.175). Nor, similarly, is it a matter of stakeholders suffering from bounded rationality (Jones, 1999). Rather, it is a matter of the same information being framed in very different ways in accordance with stakeholders' outcome preferences, with the intention of influencing the action preferences of other stakeholders (e.g., regulators) to align with those outcome preferences.

Such contested narrative-based framings are a common feature of low-carbon transitions (Rosenbloom et al., 2016; Geels, 2010; Jørgensen, 2012). They feature in Lowes et al.'s (2020) description of the domestic-heating transition in the UK and in Leipprand and Flaschland (2018) description of the transition away from coal in Germany. Notably, in the latter case the conflicting discourses converged over time, suggesting it *is* possible to chip away at deeply entrenched and seemingly incommensurable framings, and thereby accelerate transitions (Leipprand and Flaschland's, 2018).

In this vein, Roberts (2017) describes how narrative storylines have varying ability to achieve 'frame resonance', which can assist in accelerating transitions. Drawing on Verhees' (2012) concept of cultural legitimacy, and Snow and Benford's (1988) research on social movements' framing efforts, Roberts (2017) describes the four ingredients of frame resonance as:

— *Empirical fit*: a narrative framing may gain traction if it fits the emerging empirical evidence;
— *Experiential commensurability*: A narrative framing may gain traction if it chimes with the lived experience of its intended audience;
— *Macro-cultural resonance*: A narrative framing may gain traction if it corresponds with deeply held cultural values, identities, ideologies, or myths;
— *Actor credibility*: A narrative framing may gain traction if promoted by credible and trustworthy stakeholders.

People's negative interactions with incumbent regimes can be harnessed to create frame resonance (Roberts, 2017). For example, many people experience the persistent frustration of traffic jams. This may create the experiential resonance needed to garner support for transition to a less car-centric local transport system. However, a similar approach can be used to inhibit, delay, or outright block transitions. For example, Geels (2014) describes how incumbent regime stakeholders may employ three types of 'reframing' strategy to resist transition:

— A *diagnostic reframing* changes problem definitions and policy goals, thereby repositioning existing technologies as the solution rather than the problem;
— A *prognostic reframing* downgrades clearly better (i.e., more sustainable) technology to just one among a range of options, which includes cleaner versions of presently dominant technologies, as with the suggested use of 'green gas' for domestic heating in the UK (Lowes et al., 2020);
— A *motivational reframing* uses economic problems to argue for the weakening of transition policies.

However, according to the understanding of rationality on which modelling-based transition scenarios are based, how a decision is framed should not matter. The rational choice remains the same regardless of framing (Bermúdez, 2020). Yet, as Sher and MacKenzie (2006, 2008, 2011) show, framing *can* affect choice (Bermúdez, 2020). If framing did not affect choice, incumbent regime stakeholders would not deploy it to resist transition, as they are in the case of the domestic-heating transition in the UK (Lowes et al., 2020). Recognising this requires an alternative understanding of rationality, to which we now turn.

4. Rationality as frame-sensitive reasoning

Bermúdez (2009, 2020, 2022) contrasts rationality conceived as frame-sensitive reasoning with rationality as conceived in EUT by drawing on Tversky and Kahneman (1981, 1989), whose experiments are foundational to behavioural economics. In Tversky and Kahneman (1981), changes of preference resulting from changes to the way an outcome is framed are deemed to be a 'framing effect' and a violation of rationality. For example, if alternately framing a meat product as 25% lean or 75% fatty affects a person's choice, then that person is assumed to be subject to a framing effect and is deemed irrational. In Tversky and Kahneman (1989) this logic is made still more explicit in the comment that 'Alternative descriptions of a decision problem often give rise to different preferences, contrary to the principle of invariance that underlines the rational theory of choice' (Tversky and Kahneman, 1989, *abstract*). This logic of framing effects affecting individuals' preferences is widespread in climate-change related research, an example from this journal being that of Bujosa et al. (2018).

Yet, while their research recognises that people do *not* naturally make decisions in the way this conception of rationality implies, what seems to be of primary interest to Tversky and Kahneman is why people deviate from this approach as a normative benchmark for rational decision-making. They seem not to question the norm itself, despite explicitly recognising its descriptive inaccuracy. Tversky and Kahneman (1989) recognise that the rational theory of choice does not accurately represent how people make decisions, yet suggest it is nevertheless how they *should* make them. The implication is that researchers must choose between normative adequacy and descriptive accuracy, which are mutually exclusive.

Someone who allows their preferences to be influenced by framing is in danger of violating 'transitivity' by having 'cyclical preferences'—so titled because they lead to an infinite loop (Bermúdez, 2020, p.79). For example, someone with cyclical preferences may prefer A to B, B to C, and C to A, but that leads back to the preference for A over B restarting the cycle, and so on, ad infinitum. Yet, in many real decision contexts, it is quite natural to allow oneself to value things differently based on different framings leading to intransitivity. People play many roles in their lives, which foreground one outcome over another, leading to a change of preference depending on which is foregrounded. In this vein, Bermúdez (2020) questions whether humans really do suffer from the 'litany of irrationality' (Bermúdez, 2020, p.8) Tversky and Kahneman's research suggests. An alternative view is that sensitivity to framing is not only commensurable with rationality, it is integral to it and assists in ensuring a focal issue is considered from all angles (Bermúdez, 2020).

In alignment with Bermúdez (2020), this paper argues that evaluating a matter differently based on a different framing of it is essential to good decision-making. And this is especially so when it comes to low-carbon transitions because sustainability assessments rarely provide a sharp demarcation line between facts and values, meaning that epistemic and normative statements and questions cannot be easily separated (Grunwald, 2007; Jasanoff, 2004; Nowotny et al., 2001). Moreover, that so-called framing effects are a normal, natural, and desirable part of good decision-making is why the attempt to make model-based transition scenarios more 'scientific' by omitting 'subjective outcome value judgments' (Mercure et al., 2016, p.105)—i.e., alternative framings–will widen the planning gap rather than close it. Leaving subjective outcome value judgments in the form of alternative framings 'outside of the scientific framework' (Mercure et al., 2016, p.105) is what caused the planning gap in the first place. Rather than the solution, it is the problem. To provide realistic guidance, transition scenarios must take account of subjective outcome value judgments, their influence on action preferences (such as those of regulators), and in turn, the enabling, blocking, delaying, and altering effect of the resulting actions and decisions on transitions. This requires the alternative conceptualisation of rationality that is frame-sensitive reasoning (Bermúdez, 2020).

Frame-sensitive reasoning requires that subjects step back from how they frame a focal issue and reflect on the framing itself (Bermúdez, 2020). It allows consideration of powerful stakeholders' framings and their attempt to influence the framing of others to their advantage. It requires alertness to the misrepresentation of subjective and value-laden framings as factual (Bermúdez, 2020). In essence, frame-sensitive reasoning enables a shift from thinking *through* frames without awareness of them, to thinking *about* frames with full cognisance of their influence on one's own and others' perspectives (Bermúdez, 2020). But this shift is difficult because the illusion of frame-neutrality is very powerful.

Frame-sensitive reasoning's relevance to transitions is brought sharply into focus when one considers that an incumbent socio-technical regime 'specifies ideas about cause and effect, defines legitimate means-end-relationships, influences what is conceivable and orders interactions of all sorts' (Heiberg et al., 2022, p.8). An incumbent regime is therefore a dominant framing. Yet this framing is not inevitable. There are many possible framings of a socio-technical system and its future rather than a singular 'objective' one. Frame-sensitive reasoning can assist in recognising this. The next section outlines the Intuitive Logics scenario approach and that which follows it augments it to enable frame-sensitive reasoning.

5. The Intuitive Logics scenario approach

In its modern format, IL is a matrix-based, stakeholder-focused scenario approach of exactly the type recommended as a complement to modelling-based scenarios by the Intergovernmental Panel on Climate Change (Nakićenović et al., 2000). Cairns and Wright's (2018) popular version of IL follows the eight-stage procedure summarised in Table 1.

In stage 1, the focal issue and scenario timescale are identified. In stage 2 a list of 'driving forces' expected to impact on the focal issue over the timescale are identified. In stage 3, individual driving forces regarded as causally related are 'clustered' (i.e., grouped together) and made into an 'influence diagram' depicting the cause-and-effect relationships between them, leading to a specific 'resolved outcome'. Fig. 1 provides an example adapted from Derbyshire et al. (2023) of an influence diagram in which the outcome is the diffusion of electric vehicles. Through negotiation several of these clusters that have been made into influence diagrams are selected to be 'higher-level factors' because they are perceived by the scenario team to have the broadest and most critical bearing on the focal issue (Cairns and Wright, 2018; Derbyshire et al., 2023).

Table 1
Summary of the stages of the Intuitive Logics scenario planning approach.[a]

Stage	Description
1 Setting the scenario agenda	Defining the issue of concern and process; setting the scenario timescale.
2 Determining the driving forces	Eliciting a multiplicity of wide-ranging forces.
3 Clustering the driving forces	Clustering causally related driving forces, testing and naming the clusters.
4 Defining the cluster outcomes	Defining two extreme, but plausible and hence possible, outcomes for each of the clusters over the scenario timescale.
5 Impact/uncertainty matrix	Ranking each of the clusters to determine the critical uncertainties; i.e., the clusters that have both the most impact on the issue of concern and the highest degree of uncertainty as to their resolution as outcomes.
6 Framing the scenarios	Selecting two initial critical uncertainties to create a scenario matrix, framing the scenarios by defining the extreme outcomes of the uncertainties.
7 Scoping the scenarios	Building a broad set of descriptors for each of the four scenarios.
8 Developing the scenarios	Developing scenario storylines, including key events, their chronological structures, and the 'who and why' of what happens.

[a] Adapted from Derbyshire (2023, p.483).

In stage 4, two values are assigned to each of these higher-level factors' resolved outcomes, representing the two most extreme yet still plausible values that can be associated with them—one having a positive valence and the other a negative (Cairns and Wright, 2018). Fig. 2 illustrates the assignment of two extreme values to the outcome of the higher-level factor in influence-diagram form illustrated in Fig. 1. These values may be numerically specific or qualitative / categorical. In the case of a low-carbon transition, these extreme values could represent the full diffusion of a low-carbon innovation or its complete rejection by the market. Alternatively, they could represent different degrees of partial diffusion, such as in terms of a specific number of electric vehicles sold, as in Fig. 2.

In stage 5, the higher-level factors are ranked based on the uncertainty of their resolved outcomes and their resolved outcomes' impact on the focal issue (Cairns and Wright, 2018), as illustrated in Fig. 3.

In stage 6, the two ranked highest in terms of uncertainty / impact in stage 5 are labelled Factor A and Factor B and provide the axes for the 2 × 2 matrix that will ultimately frame the scenario writing, each quadrant of which represents one of the four combinations of outcome values assigned in stage 4 (A1/B1, A1/B2, A2/B1 and A2/B2), as illustrated in Fig. 4. In stage 7, drawing on discussions occurring throughout the exercise and encompassing all driving forces, descriptors are added to each quadrant of this scenario matrix to aid scenario writing (Derbyshire et al., 2023). In stage 8, four narrative scenarios are then written using these descriptors.

6. Augmenting Intuitive Logics to enable frame-sensitive reasoning and close the planning gap

This final section augments the IL stakeholder-focused scenario approach described above to enable frame-sensitive reasoning and inform the innovation-diffusion assumptions employed in modelling-based transition scenarios. We earlier noted that stakeholders form 'discourse coalitions' to create narratives that promote choices aligned with their outcome preferences (Lowes et al., 2020). To uncover these framings, Lowes et al.'s (2020) questions for identifying discourse coalitions should be considered in stage 1 of IL:

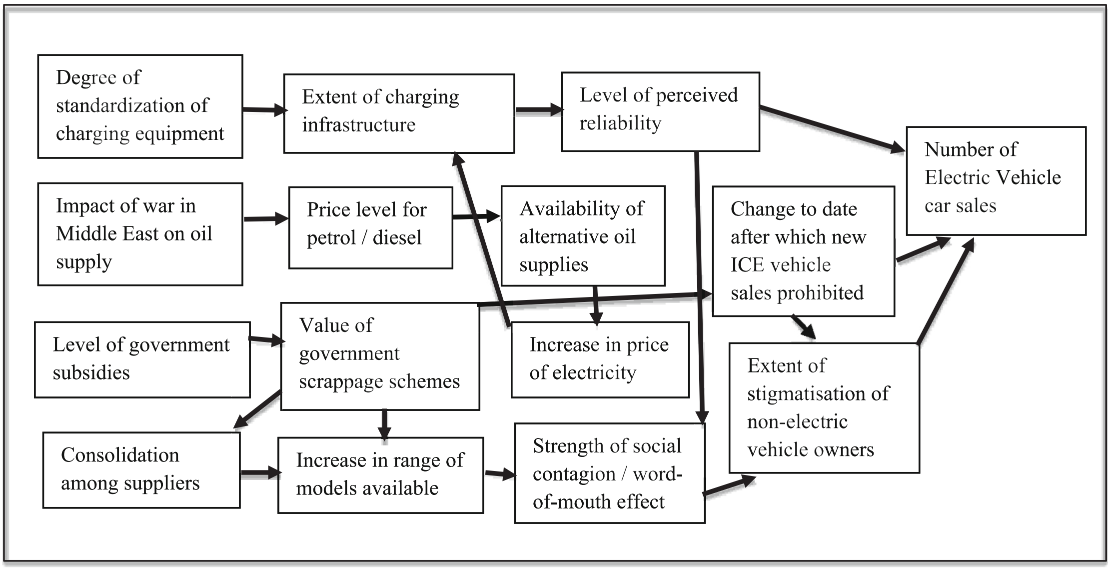

Fig. 1. An example of an influence diagram as might be created in stage 3 of Intuitive Logics scenario planning and in which the outcome is the diffusion of electric vehicles.
Adapted from Derbyshire et al. (2023, p.641).

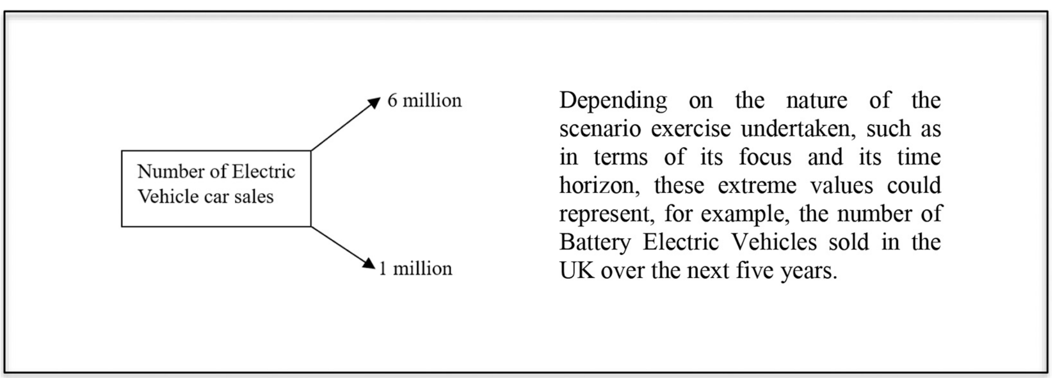

Fig. 2. Assigning two extreme values in stage 4 of Intuitive Logics scenario planning.

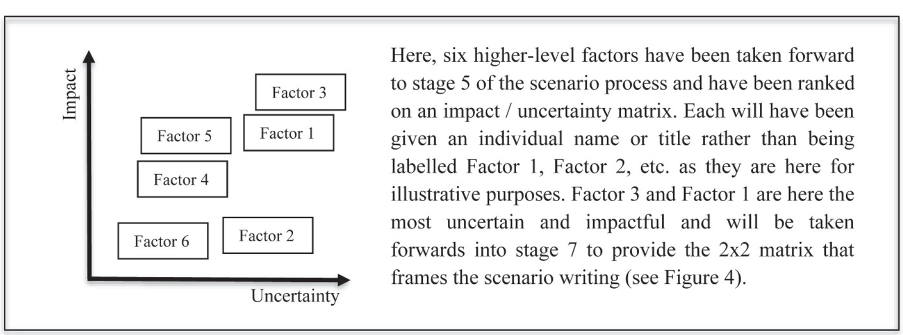

Fig. 3. Ranking higher-level factors based on uncertainty and impact.

1) Can a coalition be identified?
2) What practices are being used to promote the storyline it employs?
3) How does the identified storyline compare to official analysis?
4) What are its policy and transition implications?

It is also useful to consider the specific type of (re)framing discourse in play (Geels, 2014) through a further question:

5) Can the discourse be identified as pursuing a specific reframing type or strategy?
(e.g., prognostic reframing).

Augmenting with a further question can uncover the extent to which a reframing discourse has 'frame resonance' (Roberts, 2017):

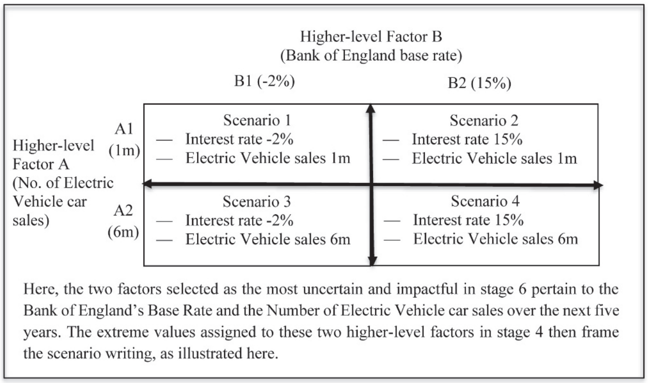

Fig. 4. Illustration of a 2 × 2 matrix.
Adapted from Derbyshire et al. (2023, p.641).

6) What type(s), if any, of frame resonance does the discourse have? (e.g., empirical fit).

By augmenting stage 1 of IL in this way stakeholder groups' framings, alliances, and discourse coalitions can be uncovered and made explicit, enabling consideration of their factual or value-laden basis.

IL focuses on creating narratives that describe how the specific actions and decisions of stakeholders lead to the scenario outcome. IL is specifically designed to emphasise the 'Who? Where? and Why? of each scenario (Cairns and Wright, 2018). In this way, it very directly links system-level outcomes to the microlevel stakeholder decision-making needed to actualise them. However, it can be further enhanced for this purpose by augmenting it with the Critical Scenario Method (CSM), resulting in an explicit link between modelling-based and stakeholder-focused transition scenarios.

The CSM augmentation is a process for considering the reflexive strategies that might be enacted by stakeholders to block, enable, or alter the unfolding of a scenario created through IL (Cairns et al., 2016; Wright and Cairns, 2011). The stages of the CSM process are summarised in Table 2 and begin with the creation of four scenarios through the basic IL scenario approach. Each scenario will have varying implications for the extent to which stakeholder groups' objectives are achieved. If a powerful stakeholder group considers that the unfolding of a scenario would obstruct their ability to realise their objectives, they are likely to act reflexively to block or delay its unfolding. This reflexive behaviour by one stakeholder group will have a knock-on effect on other stakeholder groups in terms of their ability to realise their own objectives, leading to cascades of response and counter response.

The CSM uncovers this potential cascade of reflexive responses and counter responses by considering each stakeholders' power and ability to achieve their objectives and interests under the conditions described by a scenario, which it does using a 'means–ends analysis' (Gregory and Keeney, 1994; Keeney and von Winterfeldt, 2010). As Cairns et al. (2016) note, power is one of the most contested concepts in the social sciences and so the CSM draws on Flyvbjerg's (Flyvbjerg, 2001,Flyvbjerg, 2003) understanding of it, which in turn draws broadly on that of Nietzsche, Foucault, and others. Essentially, the CSM is a process for interrogating the scenarios created through IL based on Flyvbjerg's (Flyvbjerg, 2001,Flyvbjerg, 2003) value-rational question framework for phronetic social inquiry (Flyvbjerg, 2003, p.364), which comprises the questions (Cairns et al., 2016):

— Where are we going?
— Is this development desirable?
— What, if anything, should we do about it?
— Who gains and who loses, and by which mechanisms of power?

Cairns et al. (2016) set out a formal method for answering these questions that is based on Multi-attribute Decision Analysis (MADA–see Wright et al., 2019) and provide a detailed example of its implementation. Due to space limitations, we do not reproduce the example in its entirety here, instead highlighting some important aspects of it relating to the measurement of objectives and power, which show that these concepts can be rendered consistent and comparable despite their somewhat subjective nature. Readers are directed to Cairns et al. (2016) for the full exposition.

By applying concepts from MADA, such as value scales and swing weights, an assessment can be made of the extent to which a given stakeholder's objectives would be achieved under a given scenario, while accounting for the trade-offs they would be prepared to make between objectives (Cairns et al., 2016).[3] To ensure the extent to which a given objective would be achieved is accurately measured, and to ensure comparability of its achievement against other objectives, it is necessary to employ a 'global scale' (Monat, 2009), which has extreme end points of 'zero achievement' (scoring 0) and 'complete achievement' (scoring 10). There are several ways to identify these achievement extremes (Monat, 2009), but the types of objectives likely to be present in relation to low-carbon transitions provide for easily identified and natural extremes. For example, the UK government currently has a target for six-hundred thousand heat pumps to be fitted as a replacement for gas boilers in UK homes annually but is widely considered to be greatly falling short in the achievement of this target as only fifty-five thousand were fitted in 2022 (Beament, 2024). Where an IL scenario exercise focused on the diffusion of heat pumps has included the UK government as a stakeholder, and the CSM augmentation is then used to consider the achievement of its objectives under the different scenarios, a value of zero representing zero achievement might be assigned to the annual fitting of fifty thousand heat pumps, and a value of ten for complete achievement might be assigned to the annual fitting of six-hundred thousand heat pumps–or, since the UK government's objective must ultimately be to transition as many households as quickly as possible, the complete-achievement extreme might be seven-hundred thousand fittings annually, meaning they exceed their annual target. The intermediate levels of achievement associated with specific scenarios would then be assigned values on this scale, which is bounded by these two

Table 2
Summary of the critical scenario method.[a]

Stage	Description
1	Formulate scenarios.
2	Identify stakeholder groupings and the objectives each wants to achieve.
3	Obtain a weighted score to determine the extent to which each stakeholder group's objectives are achieved within each scenario. Plot the results.
4	For each stakeholder who has a significant shortfall in the achievement of their objectives under a given scenario, identify strategies available to them (if any) for remedying the situation.
5	For each strategy obtain a new weighted score to determine the extent to which the stakeholder's objectives would be achieved if the strategy was implemented.
6	For each strategy rate the relative power of the stakeholder to implement the strategy under the given scenario.
7	For each scenario, plot the weighted scores of the strategies against the power rating, and determine the strategy that each stakeholder would be likely to select.
8	Identify the consequences of these actions for all stakeholders in each scenario.
9	Apply sensitivity analysis to the assessed scores, weights, and power ratings.

[a] Adapted from Cairns et al. (2016, p.1054).

[3] As Zu Ermgassen et al. (2022) note, the thorniest issues have great potential for direct trade-offs, not least because of what we earlier referred to as their 'wicked' nature. This is particularly true when it comes to climate matters because of the trade-off between meeting fundamental human needs and remaining within the planet's safe operating space (zu Ermgassen et al., 2022; Fanning and O'Neil, 2019).

extremes, as illustrated in Fig. 5.

Swing weights are then assigned to objectives to ensure the comparability of the stakeholder's perception of how important a swing from zero achievement to complete achievement on one objective is compared to another. Continuing with the example of the UK government as a stakeholder, its representatives might consider that a swing from zero achievement to complete achievement in relation to its heat-pump diffusion targets is more important than another objective related to lowering household domestic-heating costs, meaning its swing weight for the former objective would be greater than for an objective associated with the latter.

As noted, Cairns et al. (2016) provide a simple example of the implementation of CSM in the case of three stakeholders operating in the ship-disposal industry. The scenarios are created in stage 1 through the IL scenario process already outlined. Stage 2 identifies the three stakeholders and their objectives. In stage 3, stakeholders' extreme achievement values and swing weights are used to understand the extent to which their objectives are achieved under the different scenarios, leading to a 'weighted score' for each stakeholder for each scenario (Cairns et al., 2016). From these weighted scores it is clear which stakeholders would be best served by a scenario and which would have a shortfall in the achievement of their objectives under it. Stage 4 then identifies the strategies that are open to them, which they might enact to remedy the shortfall. For example, as we have earlier noted by reference to Lowes et al. (2020), the objectives of gas-boiler manufacturers in the UK (which is for gas-boilers to remain the dominant domestic-heating technology) were ill served by a scenario in which heat pumps were positioned by the UK government as the technology needed for low-carbon transition of domestic heating. They have therefore acted to remedy the situation by creating a framing narrative to the effect that gas-boiler technology that runs on 'green gases' such as hydrogen is a better solution.

In stage 5 a new weighted score is estimated for each stakeholder to represent the extent to which its objectives would be achieved following the implementation of the remedying strategies identified in stage 4. In stage 6, for each remedying strategy, the relative power of the relevant stakeholder group to implement it is considered. This is where the CSM process could become somewhat subjective because assessments of stakeholders' power and ability to implement a remedying strategy could vary significantly. However, again, at least arguably, the problem of who has power to enact scenario blocking, enabling, or altering strategies might be more obvious in relation to low-carbon transitions than in other domains. As we have noted, the gas-boiler lobby has successfully slowed the diffusion of heat pumps in the UK (Lowes et al., 2020). Lowes et al. (2020), in their discussion of the domestic-heating transition in the UK, fully recognise how thorny the issue of power is, but suggest taking an interests-based approach to its assessment, which is essentially what the CSM is. In their analysis, Lowes et al. (2020) simply state power to be the ability of an actor to affect the transition to sustainable heating. Clearly, at least currently, it appears that the gas-boiler stakeholder group has the power to affect this transition in their favour, and heat-pump stakeholders much less so, hence the slow take-up of heat pumps despite the UK government greatly increasing the subsidy for fitting one (Beament, 2024; Lowes et al., 2020). In this case at least then, who has power seems obvious. In other jurisdictions such as the European Union, one might assess power using, for example, the market and stakeholder analysis created as part of the ReUseHeat Horizon Europe project (Tractebel Engineering, 2019).

The form that the assigned power rating takes in stage 6 is a probability on a scale from 0 (zero probability) to 10 (certainty) that a given stakeholder could and would implement a considered strategy in response to a given scenario. In stage 7, the weighted scores of each strategy are plotted against the power rating to determine which strategy each stakeholder group would be likely to pursue. In stage 8 the consequences of this pursued strategy are considered across the board for all stakeholders and the achievement of their objectives. Finally, stage 9 again recognises that the scores, weights, and power ratings are likely to be subjective to a degree and so applies sensitivity analysis to understand how sensitive the results are to changes to these values (Cairns et al., 2016). In this way, rather than assuming away the effect of framing, power, politics, and stakeholders' strategic reflexivity, the CSM seeks to tackle it head on and assess its implications. It enables consideration of complex, inter-stakeholder relationships, and the impact of strategic decision-making by one stakeholder group in support of, or opposition to, the objectives of other stakeholder groups (Cairns et al., 2016).

Taken together, these two augmentations to IL—that leading to the identification of discourse coalitions, the discourses they are propagating and their frame resonance on the one hand, and CSM on the other—enable an analysis of potential low-carbon transitions that uncovers stakeholders' frame-sensitive reasoning. Moreover, these augmentations can together inform the innovation-diffusion assumptions in climate-change models, thereby directly linking microlevel stakeholder decision-making and system-level outcomes and closing the planning gap. Transitions can involve small initial changes that have knock-on effects, leading to further changes, and so on, which may lead to a sudden avalanche of change (i.e., a tipping point) that greatly accelerates the transition. In this vein, Berkers and Geels (2011) refer to 'innovation cascades', which act to reconfigure system components and their relations comprehensively. Because of these characteristics, the

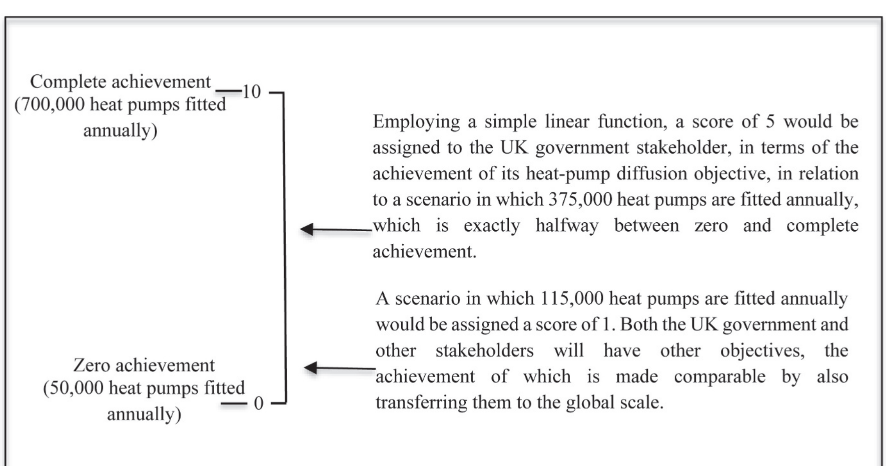

Fig. 5. Locating a stakeholder's objectives on a comparable 'global scale': The UK government's objective in relation to heat pumps.

diffusion of low-carbon innovations often follows an S-shaped pattern, as it does for most other types of new product.

In the widely applied Bass (1969) diffusion model, the specific shape of a new product's S-shaped diffusion curve is determined by the three parameters *p*, *q* and *m*, which respectively represent the probability of adoption of the new product at time *t*, the strength of the word-of-mouth or 'social contagion' effect that influences its adoption, and the potential full market size. As Bass et al. (1994) note, the estimate of $p + q$ usually lies between 0.3 and 0.7 with a mode of around 0.4–a generalisation that applies to all product types.

Framing and framing discourses can be expected to influence the social contagion effect. Considering the framings, discourses, discourse coalitions and frame resonance at play in relation to a specific transition can assist in estimating the 'social contagion' effect, providing values for *p* and *q*. The market potential *m* for most low-carbon innovations is straightforward to estimate. For example, in the case of the UK domestic-heating transition, it is the number of households who have a gas-boiler heating system, which is presently the vast majority.

After their initial estimation through the above means, the diffusion parameters can be further adjusted to reflect the blocking, enabling, and altering strategies that might be adopted by powerful stakeholders, as considered through the CSM augmentation. In this way, the planning gap can be closed through an integrated scenario approach in which modelling-based transition scenarios' innovation-diffusion assumptions are directly linked to realistic microlevel stakeholder decision-making through the outlined augmented IL scenario approach.

There is a question regarding at what scale of analysis the augmentations to IL outlined in this section might be applied. The most suitable scale for implementation is the system level, such as when considering the transition of the domestic-heating system in the UK. The planning gap exists at this level too, with there be many ambitious targets for transition and, as described in Broad et al. (2020), much modelling that illustrates the benefits of achieving these targets in terms of reduced carbon emissions. Yet, analysis of the specific decisions and actions that need to be taken by lower-level stakeholders to achieve these targets, and analysis of these stakeholders' reflexive strategies for blocking, enabling, or altering this transition in accordance with their interests and objectives, is much less prevalent.

That the outlined approach could contribute insights leading to coordinated action involving multiple stakeholders, which in turn accelerates the transition of focal technology systems, is plausible. The domestic-heating transition in the UK has featured in several places throughout this paper as a running example. Sovacool and Martiskainen (2020) review 461 case studies and provide detailed analysis of past domestic-heating transitions in China, Denmark, Finland, and the United Kingdom. Sovacool and Martiskainen (2020) show that between 1960 and 1977 the UK coordinated a nationalised Gas Council and Areas Boards with industry groups, appliance manufacturers, installers, and marketing campaigns to transition half of homes to gas central heating. Hanmer and Abram (2017) provide a detailed analysis of this past UK transition, highlighting the important role played in it by 'translation hubs', which are coordinating bodies that communicate technical information and bring stakeholders together. Rapid transitions involving coordinated action between multiple stakeholders have therefore been achieved previously and so can be again. However, because climate change is accelerating (Derbyshire and Morgan, 2022), there is now a need to achieve transitions even more rapidly than in the past, which requires specialised tools (Köhler et al., 2019), such as those designed to enable frame-sensitive reasoning outlined in this section.

7. Conclusion

A planning gap is hindering the acceleration of low-carbon transitions needed for climate change to remain within non-catastrophic bounds. This planning gap has come about because, while there is no shortage of modelling-based transition scenarios that offer glimpses at potential low-carbon systems, there are relatively few that link these potential system-level outcomes to the microlevel stakeholder decision-making needed to bring them into being. This planning gap is caused by the understanding of decision-making rationality that is employed in many climate-change models, which prevents this link between system-level outcomes and microlevel stakeholder decision-making from being made.

Many models used to create transition scenarios employ Expected Utility Theory and therefore assume there to be a single representative agent (e.g., stakeholder) who has rational expectations and an average set of preferences. If decisions are made in the way this theorising implies, then it is both impossible and unnecessary to account for micro-level stakeholder decision-making because the decisions stakeholders make will be uniform, frame-neutral, automatic, and highly predictable. By employing such decision-making assumptions, it becomes impossible to take account of heterogenous stakeholders' alternative preferences, objectives, and interests, or the actions and strategies they might enact in pursuit of them. Under this understanding of rational decision-making, allowing one's outcome preferences to determine one's choices and action preferences is deemed irrational. Yet, many examples of exactly that exist in case studies on low-carbon transitions, in which stakeholders are shown to frame decisions in alignment with their interests and outcome preferences through narratives designed to influence other stakeholders, especially those that are powerful, such as regulators and governments.

Behavioural economics cannot help to close the planning gap. By employing the same understanding of decision-making rationality on which Expected Utility Theory is based as the benchmark by which so-called framing effects and biases are identified, behavioural economics simply reinforces its misguided normativity, while at the same time recognising its descriptive inaccuracy. In contrast, this simplistic understanding of decision-making rationality is neither descriptively accurate nor normatively adequate. It is neither how people make decisions, nor is it how we want them to make decisions if we want to combat climate change. In a similar vein, attempting to make transition scenarios more 'scientific' by omitting subjective outcome value judgments—i.e., alternative framings–will not assist in closing the planning gap as some have suggested. Instead, it will widen it. Attempting to leave subjective outcome value judgments in the form of alternative framings outside of the scientific framework (by assuming them away through use of Expected Utility Theory) is what has caused the planning gap in the first place. Rather than the inclusion of subjective and frame-sensitive value judgments making modelling-based transition scenarios somehow less objective or scientific, it is their absence that does that.

New scenario approaches that can bridge the gap between the system-level *what* and the microlevel *how* of low-carbon transitions are what is needed to close the planning gap. In addressing this issue, this paper has set out two augmentations to the popular Intuitive Logics scenario approach that are based on the alternative understanding of rationality that is frame-sensitive reasoning. The first augmentation uncovers the discourses being employed by groups of stakeholders to frame a focal transition decision in a way favourable to their outcome preferences. The second uncovers the strategic responses that might be enacted by them in response to the unfolding of a scenario that is deleterious to the achievement of these outcome preferences. The frame-sensitive reasoning enabled by these augmentations can be used to inform the innovation diffusion assumptions that are an input to modelling-based transition scenarios. In this way, this paper has set out a method for integrating modelling-based and stakeholder-focused transition scenarios, closing the planning gap, and accelerating low-carbon transitions.

Yet, in concluding this paper it is worth reflecting on and emphasising that, beyond the acceleration of any one focal low-carbon transition, the need for reframing is a matter of broader and more fundamental significance to climate-change mitigation—one that goes to the heart of ecological economics, its purpose, and what motivated its creation as a challenge to mainstream economics in the first place. Indeed, given the sluggish progress in addressing climate change, the feet dragging of incumbent-regime stakeholders with the most to lose from addressing it, and the largely inadequate actions of the governments they lobby in order to maintain their dominant positions, it is no exaggeration to say that whether climate change is kept within non-catastrophic bounds now depends on a radical, widespread, and urgent reframing of the present situation.

To truly address climate change within the small window of opportunity now left open to us, what is needed is a fundamental reframing of the economy and its relationship to the environment, as well as an associated reframing of the scale and urgency of what needs to be achieved to realise climate targets, and the need for government action on a commensurable scale that this implies. This amounts to a more fundamental and general reframing of the economy's purpose and the purpose of studying it—one that shifts the framing away from markets, price mechanisms, and individual preferences, and towards community decision-making for the collective good, investment on a scale commensurable with that of the problem, and support for strong government intervention to direct rather than merely encourage markets to transition.

This broader reframing, which is essentially ecological economics' very raison d'être, can be assisted by new decision-making tools based on alternative understandings of rationality, such as that set out in this paper. Yet, it cannot rely on them alone. It requires concerted action from all parts of society to challenge the discourses designed to inhibit or alter transitions in favour of powerful incumbents, whose interests and objectives require transition to be slowed, watered down or outright blocked. It requires that powerful stakeholders are not only held accountable for their past actions but still more so for their present inaction. And it requires new discourses to be created in the form of narrative scenarios that emphasise the possibility for, and desirability of, a radical breaking from the past rather than its continuation.

CRediT authorship contribution statement

James Derbyshire: Writing – review & editing, Writing – original draft, Project administration, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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