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The condition of urban climate experimentation

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ABSTRACT

As the trend of urban climate experimentation continues, many accounts now seek to identify how it can be harnessed toward responses of sufficient scale and magnitude for the crises at hand. The imperative is to move beyond experimentation. Yet some authors now suggest that this may not be so straightforward for, they argue, we increasingly inhabit a condition of permanent experimentation. Taking its cue from this premise, this article explores where the condition of experimentation may have emerged from. I trace these roots to the limit points now encountered within ecologically modernist governance—the shifting dynamics of governing authority, the relation between knowledge and policy, how to address indeterminacy, and what progress or improvement looks like in the condition of a climate-changed socio-natural world. Viewed in this light, experimentation, I want to suggest, represents a significant and potentially paradigm-shifting break with established norms and practices concerning the nature of the climate problem. Fundamentally, this line of thought means that it may neither be possible nor even desirable to abandon experimentation and to return to more centralized, controlled, and certain responses for it is from within the difficulties of governing a climate-changing world through this paradigm that experimentation has arisen in the first place. The vital task is instead to understand the politics and possibilities of experimentation for progressive and just urban sustainability.

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Introduction

At face value, perhaps one of the most surprising things about the evolution of climate governance over the past three decades has been the growth of experimentation as a mode of response. If in the 1990s climate politics was primarily a matter of targets, timetables, (proposed) taxes and plans, by the 2010s commentators were noting the rise of climate experimentation and diverse perspectives from socio-technical transitions to environmental politics were marshaled to seek to explain this phenomenon (Bulkeley and Castán Broto 2013; Evans, Karvonen, and Raven 2016; Fuenfschilling, Frantzeskaki, and Coenen 2019; Hoffmann 2011; Turnheim, Kivimaa, and Berkhout 2018). Climate, and more broadly sustainability, experimentation has become prevalent across diverse urban contexts, generating new visions, networks, techniques, forms of learning, and experiences that in turn are creating capacities to change infrastructure systems, social practices, and established norms and ways of doing urbanism (Hodson, Evans, and Schliwa 2018; Sengers, Wieczorek, and Raven 2019; Torrens and von Wirth 2021; Voytenko et al. 2016). The notion of experimentation itself covers multiple forms of intervention, including, for example, living labs, testbeds, demonstration projects, and pilot schemes, as well as a diverse array of institutional novelties and socio-technical innovations that are described by their proponents as experimental. The conceptualization of experimentation is equally broad, though two distinct approaches can be identified. Within the transitions-studies tradition, experimentation is used to refer to spatially and temporally discrete innovations that are generated through specific niches that are protected from dominant regimes which shape, for instance, energy provision and through which testing and learning take place that can lead to the scaling up of innovations such that they displace (elements of) existing regimes. Work on the governance and politics of environmental issues points in a different direction, suggesting that experimentation is itself a mode of governing or disposition toward, in this case the city, serving to

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stage "encounters through which new possibilities for politics might emerge along with new political subjectivities" (Braun 2015, 242).

Whichever conceptual point of departure is chosen, while initial research may have focused on individual experiments as objects of study, urban experimentation is now more often considered as "an approach and associated set of practices that characterizes contemporary urban innovation and the profusion of place-based approaches like pilots, demonstrations, and living labs" (Evans et al. 2021, 172). Experimentation of this kind has been documented through large-n studies across diverse urban contexts internationally (Castán Broto and Bulkeley 2013; Dignum et al. 2020; Trencher et al. 2014), as well as through studies of particular urban contexts from Norway to China, Chile to Australia (Hofstad et al. 2022; McGuirk et al. 2015; Peng, Wei, and Bai 2019; Tironi 2020) that together demonstrate that experimentation is far from a localized or singular occurrence but now forms the basis of urban (sustainability) governance. In Amsterdam, for example, Savini and Bertolini (2019) document how the city authorities actively employ "experimentation as a trigger for sociotechnical and economic innovation" initiating over the past decade "several urban laboratories and test-beds in all kinds of sectors, from the circular reuse of materials to smart mobility services." Across China, and "global arenas where China is increasingly perceived as a leader in delivering low-carbon policies," a distinctive form of experimentation under hierarchy is emerging which involves conducting a "large number of local policy experiments through multi-level governance" which in turn are used to sift and select policy choices (Lo and Castán Broto 2019).

Such has been the growth of experimentation that some now "refer to ours as an experimental society" (Tironi 2020, 504; see also Gross 2016). The dominant interpretation of this phenomenon is that it challenges the "conventional model of the policy process … widely taken for granted by jurists, economists, and political scientists [that] holds that policy analysis, formulation, and embodiment in legislation precede implementation" while experimentation "means innovating through implementation first, and drafting universal laws and regulations later" (Lo and Castán Broto 2019, 2). A second interpretation, drawing on the conceptualization of experimentation as a disposition of governance, is now gaining traction. Rather than being a means to an end—experimentation as a means through which policy in its traditional form can be generated—experimentation may be a new end in itself, a mode through which governing takes place (Bulkeley and Castán Broto 2013). For Lösch and Schneider (2016, 262) the shifting nature of governing energy systems in Germany "engenders a *permanent experimentation* of all relations between the actors, organizations, techniques, knowledges, etc., which are included in an energy system based on the envisioned smart grid" (emphasis added). As Karvonen (2018) puts it, the outcome in the urban arena is that we may be witnessing the emergence of a "city of permanent experiments" where "experiments might not simply serve as one-off trials to provide evidence and justification for new low-carbon policies, regulations, and service provision through existing circuits of policymaking and regulation. Instead, these activities are emerging as a new mode of governance in themselves." Seen in these terms, experimentation now appears to be an enduring feature of environmental governance.

There are many for whom this is cause for concern. For Davidson et al. (2019, 12) the question is one of the adequacy of experimentation for "the time left for urban testing and trialing may be rapidly coming to an end in the face of manifest shocks, especially climate change." From this perspective there is simply no time to be experimenting while the planet burns. For others, experimentation is a necessarily exploitative practice. Sovacool et al. (2019) identify experimentation alongside financialization and dispossession as an elite form of climate politics. Drawing on Paprocki (2018), they argue that experimentation has an insidious underside which "envisions low-carbon pathways, often deployed in more social, economic, or geographically peripheral areas, as an arena where technical elites can pilot new, novel, or risky technologies" often in the global South justifying them as means through which to generate new responses to climate change without transferring their benefits (Sovacool et al. 2019, 3). Such forms of inequality and injustice are, of course, not confined to the north-south politics of climate change, but also to be found across urban landscapes (Bulkeley 2021; Castán Broto 2020; Long and Rice 2019; Rodrigues, Vale, and Costa 2022; Tironi 2020). The prominence and potency of experimentation has primarily generated two responses across the academic community. For some, such concerns are sufficient to call for experimentation to be abandoned in favor of (previous) modes of policy and planning that are more stable and far-reaching in their effects (Castán Broto and Bulkeley 2018). For others, the imperative is to improve experimentation. Sengers, Turnheim, and Berkhout (2021, 1149–1150) suggest that there is an urgent need to challenge the widely held assumption that "the proliferation of empowering local initiatives will expand, diffuse or 'add up' to broader systemic change" and analyze instead "the processes

for these transformations" which are currently "under-theorised and explained." As they go on to argue, what is needed for experimentation to have truly significant impact is further work to specify its outputs and explain "the processes by which these … come to adopted 'beyond' individual experiments" spatially, temporally, and structurally (Sengers, Turnheim, and Berkhout 2021, 1150). Here experimentation is a necessary step toward "cumulatively more ordered and stable socio-technical or governance configurations" (Sengers, Turnheim, and Berkhout 2021, 1155) and the key question is where experimentation *is going* and how this can be enhanced in the face of complex and urgent sustainability challenges. In short, if experimentation is a necessary step toward the kinds of systemic change needed to tackle complex sustainability challenges, the focus of attention should be on whether and how it is generating such change and, if not, how experimentation can be improved and its outcomes scaled up.

In this article, I want instead to take this debate in a different direction. Rather than seeking to understand the value or importance of experimentation in terms of the outcomes it can/not generate, I suggest we need to consider its root causes. Understanding, as the workshop which originally gave rise to this article asked, whether we can experiment our way out of the climate crisis requires questioning where experimentation is *coming from*—why is it that experimentation has come to dominate, in this case, the landscape of urban environmental governance? While experimentation is often equated with the need to establish knowledge in areas of uncertainty, when it comes to urban environmental governance the prevalence of multiple forms of experimentation—from green infrastructure to eco-demonstration homes, food cooperatives to car-sharing clubs—whose possibilities are increasingly well-known points to other root causes. Drawing on fifteen years of empirical analyses of the nature and dynamics of urban experimentation here, following Wakefield (2021, 332), I want to explore how "in the search for new ways to secure the environmental, infrastructural, and social lifelines of liberal society amidst the crises the latter generates, governance is being recalibrated" through and by experimentation. In the first part of the article I turn back to ecological modernism, whose core tenets have formed the basis for climate governance over the past three decades and find that there are increasing signs that these tenets are beginning to fray, not least as their capacity to govern the unruly socio-materialities of the Anthropocene comes under pressure (Biermann 2021; Wakefield 2018, 2021). It is, I suggest, in this context that experimentation is taking root as both a response to and reinforcing mechanism through which an ecologically modernist response to the challenges of environmental governance is coming undone. The second part of the article seeks to explore what this means for how we understand the "politics through which experiments are defined, framed and constituted" (Savini and Bertolini 2019, 845). Experimentation, I want to argue, represents a significant and potentially paradigm-shifting break with established norms and practices concerning the nature of the climate problem which revolve around who is authorized to govern, the relation between knowledge and policy, the indeterminacy of climate futures, and what it means to improve the condition of society.

The shifting nature of the climate problem and the limits of ecological modernism

> *Mr President, the environmental challenge which confronts the whole world demands an equivalent response from the whole world. Every country will be affected and no one can opt out. We should work through this great organisation and its agencies to secure world-wide agreements on ways to cope with the effects of climate change, the thinning of the Ozone Layer, and the loss of precious species. We need a realistic programme of action and an equally realistic timetable. Each country has to contribute, and those countries who are industrialised must contribute more to help those who are not. The work ahead will be long and exacting. We should embark on it hopeful of success, not fearful of failure.*
> UK Prime Minister Margaret Thatcher, Speech to the United Nations General Assembly, November 1989

> *COP26 will not, cannot, be the end of the story on climate change. Even if this conference ends with binding global commitments for game-changing real world action, two weeks from now smokestacks will still belch in industrial heartlands, cows will still belch in their pastures … cars powered by petrol and diesel will still choke congested roads in the world's great cities and no one conference could ever change that. If summits alone solved climate change then we would not have needed 25 previous COP summits to get to where we are today. But while COP26 will not be the end of climate change it can and it must mark the beginning of the end. … We have the ideas, we have the technology, we have the bankers, we have the corporations and the NGOs … [to] make this the moment when we began irrefutably to turn the tide and to begin the fightback against climate change.*
> UK Prime Minister Johnson, Speech to the COP26 World Leaders Summit Opening Ceremony, November 2021

Over the thirty years since it rose to international political attention, the climate problem has changed. On one hand, concentrations of greenhouse gases in the atmosphere and the number of climate-related

disasters has risen. On the other hand, and intertwined with the shifting physical basis of climate change, how climate is problematized has changed, in turn pushing up against the limits of the ecologically modernist paradigm of environmental policy within which it was once contained. To recognize that the kind of problem that climate change is has shifted is not to deny the very real nature of the climate risk, but neither is it merely what is sometimes termed a social construction. This is because the work of problematization—or as Li (2007a, 265) terms it, "how problems come to be defined as problems in relation to particular schemes of thought, diagnoses of deficiency and promises of improvement"—shapes what is intelligible, what is deemed relevant and can be comprehended and contained, and the kinds of solutions that are regarded as both practical and (politically) feasible. In this sense, problems do not precede solutions, but rather "the identification of a problem is intimately linked to the availability of a solution. They co-emerge within a governmental assemblage in which certain sorts of diagnoses, prescriptions and techniques are available" (Li 2007b, 7). What the climate problem is, then, is not only a matter of atmospheric concentrations of greenhouse gases and the impacts of a changing climate system but also of how these dynamics are made legible and contained in relation to particular schemes of thought, what is deemed to be wrong. and how it might be improved, by and for whom, through solutions that are seen as effective and legitimate (Bulkeley 2016). This then serves to direct flows of knowledge, resources, power, and intervention through particular "intelligible fields" of the climate problem, in turn shifting how it comes to be understood and constituted as well as its material realities (Hajer 1995; Machin 2019). These dynamics of problematization and response are all the while entangled in the coupled physical, political, economic, and social dynamics through which greenhouse-gas emissions are produced and climate impacts encountered and ameliorated such that the climate problem is never settled but always shifting, ongoing, and multiple.

Against this fluid background, there has been—as the two quotes above suggest—a discernible shift in the way in which the climate problem and its solutions are circumscribed. Looking back at UK Prime Minister Thatcher's speech to the United Nations General Assembly as the world began to negotiate what would become the United Nations Framework Convention on Climate Change we can see that climate change was an issue of the global commons, of "end of pipe" emissions reductions which needed to be collectively addressed through agreed-upon targets and timetables with action forthcoming on the basis of sound scientific evidence and incentives that would "internalize" the externalities of rising greenhouse-gas emissions such that national governments would recognize their "common but differentiated" responsibilities for action. Fast-forward to UK Prime Minister Johnson's speech to the COP26 [26th Conference of the Parties] World Leaders Summit in Glasgow in November 2021 and climate change is no longer a question of science or a matter of the global commons but rather, as he paraphrased it, "coal, cars, cash and trees." Moreover, global institutions, the international negotiation process they support, and the agreements that may be reached have only partial purchase. The climate problem as articulated here is not one of a global commons as such, but of a wide array of geographically uneven and distributed socio-material systems (coal, cars, cash, trees) which have carbon at their root (Shaw 2011; Stripple and Bulkeley 2019) and whose resolution in relation to the climate change is more than (or even beyond) collective political agreements and international institutions but requires "technology … bankers … corporations and NGOs." This shift in the nature of the climate crisis is, of course, not of Prime Minister Johnson's own making, but rather his comments reflect a broader shift away from considering the climate problem essentially as an emissions-reduction problem (Shaw 2011)—where the framing of the issue in terms of the global commons focused attention on how to reduce releases at the end of pipe in order to protect this resource—to primarily a matter of *decarbonization*, that is of a systemic removal of carbon from the economy (and society) (Owens 2010; Stripple and Bulkeley 2019). While the framing of climate change as a collective challenge has remained, this has pivoted to a focus on achieving the decarbonization of everything from our electricity system to travel choices, the content of the weekly shop to industrial processes and devices such as carbon footprints, offsets, net zero targets, and so forth abound as the various means through which not only to make this field of intervention legible but also practically governable.

The changing nature of the climate problem has also, I want to suggest, been generated by and served to create a more fundamental shift in the paradigm of ecological modernism that has dominated environmental policy over the past three decades. This is in no small part because, as Weale (1992) argues, the emergence of ecological modernist approaches to environmental policy was not only coincident with but deeply bound to the recognition of a suite of environmental problems as matters of the global commons in the late 1980s. The central tenet of ecological modernization is that economic

growth is not only compatible with addressing environmental issues but fundamental to their resolution—while modernization has historically generated environmental challenges, in this view their solution lies in more rather than less modernization (Barry and Paterson 2003). As a paradigm for environmental policy, ecological modernization carries with it deeply held and often implicit assumptions which are bound up with modernist ideas concerning progress and liberty. Central, for example, has been the weight given to scientific assessment as a means of knowing and anticipating environmental harm (Hajer 1995). Departing from previous environmental management schemes which relied on nebulous concepts such as whether or not air quality was "good" or interventions "practicable," the growth of ecologically modernist environmental policy has been marked by a commitment to and belief in scientific knowledge as the means through which to diagnose environmental problems and their solutions. This has, of course, been especially evident in the case of climate change, where one of the first initiatives taken by governments globally was to establish the Intergovernmental Panel on Climate Change (IPCC) and its reporting mechanism. This has in turn lent the notion of climate change the kind of singularity and universality associated with scientific knowledge. Equally crucial has been a focus on technological and economic development for the resolution of environmental challenges, with particular efforts to price the externalities of environmental pollution into markets and on technological innovation and progress as means through which growth and environmental improvement can be made compatible. The institutions of the modern state—from specialized agencies to international organizations—were also cast as the primary actors through which environmental policy should be determined and delivered, albeit under neoliberalized conditions (Hatzisavvidou 2020). Beyond the core ideal that economic growth and environmental protection are intimately connected, the paradigm of ecological modernization relies then on distinct notions of the importance of expertise in diagnosing the parameters for action, of centralized authority to govern, of progress as a primarily technical or economic matter, and of uncertainty as being managed through increasing knowledge.

For Hajer (1995, 32) ecological modernism did not require a radical departure from previous approaches, but rather represented greater integration and political attention to "some institutional principles that were already discussed in the early 1970s: efficiency, technological innovation, techno-scientific management, procedural integration and co-ordinated management" enabling inherent questions of contradictions between economic development and environmental protection to be put to one side (see also Christoff 1996). Yet as Hatzisavvidou (2020, 102) demonstrates in her account of the rise of the environmental state in the UK, the dominance of neoliberalism as a governing rationality through the 1980s bore a significant influence on ecological modernism given the need to secure "modalities of talking about the environment that not only would not contradict the norms of the neoliberal state, but they would actually reflect, reproduce, and reinforce them." In particular, forms of economic valuation, the mode and calculation of efficiency and a logic of competitiveness pervaded the way in which the UK sought to invent an "environmental state" that could carry forward an ecologically modernist response to both national and international environmental challenges (Hatzisavvidou 2020). So dominant has the notion of ecological modernization become in some corners of the world, notably the European Union and wider Organization for Economic Co-operation and Development, that it has become "reified as the only feasible strategy, a matter of 'common sense' and therefore one that is 'outside' or 'beyond' politics" (Machin 2019, 209). While some authors point to ecological modernization as one among several discursive positions or imaginaries of climate governance, even where there are differences in emphasis—say between a market-based reading of ecological modernism, techno-optimism, and disruptive innovation (Marquardt and Nasiritousi 2022)—at root they share the core tenets of ecological modernism when it comes to the role of markets, science, technology, and the state and what it means to know and manage environmental issues and to seek progress.

While accounts of the specific nature and influence of ecological modernism vary, there is then broad agreement that it has become the dominant paradigm of environmental policy over the past three decades and is now so embedded as to be taken for granted as common sense, rarely even surfacing to be questioned, while what are seen as more radical alternatives, usually framed in opposition to ecological modernism as narratives that challenge the logics of continued growth and consumption, remain confined to the margins. If the economic core of ecological modernism appears to remain unshakeable, there are however signs that this dominant paradigm of environmental policy is starting to fray.

In a recent and telling essay, Biermann (2021) argues that the key premise of environmental policy—that it is concern with a discrete arena of intervention that can be termed the environment—is

coming undone. Biermann (2021, 63) defines the "environmental policy paradigm" as "a traditionally widely shared belief (a) that a definable "environment" exists outside the human sphere that needs to be protected by humans and their political institutions; and (b) that "environmental" institutions and policies are the right way of dealing with such challenges, as entities distinct from economic, health, food or agricultural institutions" (Biermann 2021, 63). Under conditions of the Anthropocene, where distinctions between the natural and the human are ever more indistinct and where the root causes of environmental challenges lie beyond the boundaries of environmental policy in the structures and dynamics of multiple agricultural, industrial and social systems, environmental policy is both increasingly challenging to demarcate and irrelevant to the challenge of Earth-system transformation (Biermann 2021, 65–66). Further, the traditional positioning of the environment as a separate sphere "lends itself to a technocratic approach that focusses on reducing emissions or managing 'nature areas,' as opposed to a deeper critique of underlying societal conflicts and injustices" and fosters hubris in our ability to manage and control nature (Biermann 2021, 67). This technocratic, managerial approach not only leaves "the unprecedented normative question of how we want our planet to be" (Biermann 2021, 69) unaddressed but also risks marginalizing critical issues of human and non-human survival (Biermann 2021, 70). For Biermann, the response can be seen in two trends within (largely) academic circles—on one hand, he calls attention to the expansion of the grounds of environmental policy to encompass an ever-increasing spiral of issues from migration to poverty, diet to conflict, and, on the other hand, the growth of new concepts that seek to name and frame the present condition, from "Anthropocene geopolitics" to "earth system governance" and many in between (Biermann 2021, 72). Noting that these debates have "barely left a trace in daily politics," Biermann calls for scientific assessments, sectoral policies, and governance arrangements that are more integrated, adopting socio-ecological, Earth-system thinking to how we design and operate institutions to manage the planetary crisis while at the same time ensuring that the challenge of addressing socio-economic inequality and marginalization is at the root of any such response.

Yet while such a call for integrated science, sectoral policies that recognize their externalities, and more and better governance through institutions that are capable of managing "Earth systems" may address some of the limitations of the environmental policy paradigm as laid out (though see Wakefield 2021 for a critique), they rather curiously appear to further embed the key tenets of ecological modernism by and through which this paradigm has been structured over the past three decades. Here holding power—in this case, the specific form of power as authority to govern—provides both the legitimacy and means for control (Stirling 2014). Such an approach may be conceivable under conditions in which those who rule are relatively few and the nature of the problem to be governed is singular, evidenced, and where what constitutes "good" outcomes are both clearly defined and held in common. However, as Biermann's own analysis suggests, and many across the field of environmental governance have argued over the past decade, this is no longer (if it was ever) the case as in the face of the shifting nature of the climate problem and changing geopolitical conditions multilateral governance institutions have both come under strain and new actors and forms of governing have emerged (Bulkeley 2016; Hoffmann 2011; Jordan et al. 2018). If the climate problem is multiple, encompassing everything from what is available on supermarket shelves to the conditions for carbon capture and storage involving Indonesian rainforests through to the peatlands of Scotland and its whiskey industry, the possibilities of using "power over" others to govern for outcomes that are shared among all appear slim at best. Even areas which appear relatively simple in these terms—ban petrol cars, bring in a carbon tax—carry with them the complexities of justice and geographies, of how to calculate who or what should be exempt and the means through which they should be compensated, or where interventions will be needed to enable the (right kind of) transformations to take place so that, for example, those who live in high-rise apartments are not penalized by their lack of access to land upon which to charge the required electric vehicles. The supposed authority and capacity of command and control appears to very quickly run out of steam when faced with the intricacies of governing in practice and the challenge of doing so in an integrated way rapidly multiply so as to become pretty much unmanageable.

While agreeing with much of Biermann's forensic analysis of the crisis in the current paradigm of environmental policy, here I want to take the diagnosis of both its effects and potential implications in a different direction. Rather than being only a matter of the veracity of the "environment" as a policy domain, I want to suggest that the signs of tension identified in this and other accounts of contemporary environmental governance point to more fundamental fracture points in the paradigm of ecological modernism. The multivalent nature of the problem, the dispersed and fragmented authority to govern,

the essentially contested character of what constitutes a good climate-changed future and the indeterminacy of knowing what it will mean to undo carbon from our economies or to be sufficiently resilient suggests that governing climate change cannot proceed on the basis of past assumptions concerning the role of knowledge, where authority lies, what the climate problem entails, and what it will mean to have delivered progress. This stems from the difference that Easterling (2014, 81–85), following the philosopher Gilbert Ryan, articulates between *knowing that* and *knowing how*. There is no single reasoned response to the question of what, by and for whom, and with which consequences we should govern climate change. Instead any approach must necessarily be dispositional, unfolding in relation to the latent and emerging potential, agency, and capacities encountered such that power is to be found in "the prospect of shaping a series of activities and relationships over time" (Easterling 2014, 85). Rather than "barely leaving a trace in daily politics," I want to suggest that the tensions within the environmental policy paradigm that Biermann's analysis reveals are at the heart of the rise of experimentation as a dispositional form of governing, in this case, climate change in the city. Experimentation here is not an alternative to ecological modernization, but rather emerges from within it as a means through which the shifting grounds of the Anthropocene and the tensions it provokes in relation to a future that can be managed and controlled toward particular ends and a pervading indeterminacy about what a "good" future might be. Examining experimentation in this light can, I suggest, generate new insights as to how and with what implications we may be moving to a situation of permanent experimentation.

Experimentation forever?

> *[T]he experimental … [is] articulated as an imperative—"become experimental!"—and only with vague hints of how this might be accomplished. Becoming experimental is therefore the sought-after mode of practice which produces and re-produces the apparatus and its effects, it is the goal and the means to reach it.*
> Lösch and Schneider (2016, 277)

> *[W]e propose theorising the "new" as an event taking place in the temporal drop of the "now." The new … is not the beginning or the result of a process of innovation and does not emerge via a comparison of the present with the past and the future. The new is, rather, a moving, changing and relational quality of the present, induced by various means and practices. The new is not simply a break with the past and a vision for the future but an event induced in the "now" which should be understood as a present articulation of what has been and what could be.*
> Hutter and Farías (2017, 2)

The tenets of ecological modernization that have anchored much of what we know as environmental governance have, as the previous section explored, come under increasing tension over the past decade as what, how, whom, and to which ends we should govern the manifest crises of the environment become ever more complex and entangled. Far from being merely coincident, I suggest that the rise of experimentation as a mode of governing, an apparatus as Lösch and Schneider (2016) put it, is both an outcome of these growing tensions and serves to reproduce them. Experimentation is not a beginning or break from the past, but as Hutter and Farías (2017) argue, is a moment or event that is actively, relationally produced in the "drop of the now" and hence inextricably linked to the same dynamics that are currently animating concerns for the nature and prospects of environmental governance. Experimentation, it is often argued, is rising to prominence for largely instrumental reasons: because it offers both the promise of novel solutions to complex problems and because it allows for a process of trial and error that can generate the learning needed to address uncertain and often wicked problems. In this section, I contend that the root causes of experimentation are far deeper. Foregrounding four key tensions within the current ecological modernist paradigm of environmental—the shifting dynamics of governing authority, the relation between knowledge and policy, how to address indeterminacy, and what progress or improvement looks like in the condition of a climate-changed socio-natural world—suggests that the fracturing of ecological modernist environmental governance and experimentation are connected with significant and consequent implications for governing the climate-changed city.

Making experimentation between knowledge and agency

Despite the different conceptual perspectives that they bring to bear, most commentators agree that when it comes to climate change and sustainability experimentation is a more-than-technical matter such that it involves fundamental shifts in how, by, and for whom governing is undertaken. Within the literature on innovation niches, significant weight is given to the need for novel processes of design and involvement—particularly those which entail one or more form of co-production between experts, practitioners, and citizens—as well as to the importance of the generation of new actor coalitions in the successful working and extension of sustainable innovations. Likewise, work on the role of

experimentation as a new mode of environmental governance points to the significance of new kinds of multilevel, private, public and hybrid networks, partnerships, and arrangements in both establishing and relaying experimentation (Hofstad et al. 2022; Smeds and Acuto 2018). In each case, the association of experimentation with a more distributed, or (as some see it) fragmented, authority to govern, capacity to intervene, and knowledge with which to do so is acknowledged. While for some experimentation is either a last resort or temporary intervention in the absence of sufficiently coherent or sustained capacities to govern, others view it as a vital means through which forms of authority and power to govern climate change which are necessarily diverse, distributed, and often contested can be held in alignment (McGuirk and Dowling 2021).

As den Uyl and Munaretto (2020, 5) explain the context of the Dutch Fenlands, "deteriorating water quality, increasing decomposition of peat soil, soil subsidence and risk of worsening of these problems due to climate change had been mounting pressure on the leading authority (water board)" to find solutions. For two water boards in this study, the goal of securing political acceptance led to the choice of "a relatively safe option which was experimenting with small adjustments to the water-table. Their rationale was that the experiments would produce enough evidence to settle controversies over land-uses and water-table levels and would allow to achieve their goal of a renewed water-table decree" (den Uyl and Munaretto (2020, 5). In contrast to more radical forms of experimentation, which applied a more top-down, center-led approach, after a decade and more it has in this case been these incremental forms of experimentation that sought politically expedient outcomes which have had the most impact. In this way, experimentation has not just become a means of governing for existing actors, but has also changed the nature of governing itself. In their analysis of the governing of smart electricity grids in Germany, Lösch and Schneider (2016, 275) similarly find that experimentation is not confined to specific interventions or moments, but rather experimentation as an apparatus of government involves "whole sociotechnical arrangements in the simultaneous creation and testing of knowledge, positions of actors and power constellations" such that "the steering of the transition and its experiments, itself are becoming experimental" shedding light on how "modes and institutions of governance and regulation … sedimentations or representations of a certain power constellation" are themselves being transformed through experimentation.

Central to this reconstitution of power and agency is a recalibration of the relation between knowledge and action. While ecological modernist environmental governance has long relied on a belief in "evidence-based-policy," the working of experimentation serves to unravel this distinction such that the boundary between evidence and action is no longer clear cut and indeed may be reversed. Ostensibly, of course, the logic of testing, trialing, prototyping, and the like that animate the framing of experimentation seem to place the gathering of evidence as first and foremost to policymaking—experimentation provides a means of "learning by doing" such that the most effective, efficient, or suitable policies can be selected (Evans et al. 2021; Tironi 2020; den Uyl and Munaretto 2020). Certainly, the centralized governance structure of the Chinese state appears to offer one model—"experimentation under hierarchy"—through which such an approach can be executed (Lo and Castán Broto 2019). Beyond this (exceptional) case however there is much more limited evidence that the learning undertaken by doing experiments directly translates to the wider uptake or implementation of successful examples. Indeed, commentators frequently suggest that little is known about the mechanisms through which the "scaling" of experimentation—either "up" to different levels of governance or "out" to a wider range of contexts—takes place (Peng, Wei, and Bai 2019; Smeds and Acuto 2018). Others suggest that what is needed to understand the ways in which experimentation takes hold is a focus on the ways in which they become embedded "as materialized and durable features of new configurations in settings outside the original experimental milieu" (Sengers, Turnheim, and Berkhout 2021, 1155; see also Castán Broto and Bulkeley 2018; Tozer et al. 2022). Rather than cleaving a neat divide between learning and (then) doing, this suggests that doing and knowing are reciprocally generated and transformed through experimentation such that action, intervention, and policy can precede knowing, learning, and evidence.

For example, in their study of a suite of smart grid projects in cities across Europe, Evans et al. (2021, 175–176) found that "when learning and inter-city exchange took place, it was based on personal experience and contacts. Individuals learn by taking part in projects and then try to implement their know-how in subsequent projects and persuade others" such that the most significant learning that emerged from experimentation was "how to undertake experimentation." Rather than learning *from* experimentation, these interventions served as a means through which practitioners and policymakers learned the art of experimentation itself and

the ways in which to enroll, persuade, and enable the practice of government. In Santiago, Chile, Tironi (2020, 515) found that not only did intervention precede learning, but also that the potential to learn from the situations generated around these interventions was actively contained as the "unanticipated, recalcitrant events" which they generated were left out of official narrative. Official results, reports, and presentations "never alluded to the conflicts that the deployment of the various urban tactics caused" such that the "frictions that emerged from the experiment were not considered worthy of being addressed, and were instead seen as noise that had to be eliminated" (Tironi 2020, 515). Rather than taking for granted the framing of experimentation as a response to sustainability crises that serves as a means through which the best course of action can be identified, we need instead to critically examine the "politics through which experiments are defined, framed and constituted" (Savini and Bertolini 2019, 845). Experimentation is not merely a response to a problem, but like other governmental apparatus serves to both bound the problem itself such that it becomes legible and legitimize particular forms of action and intervention (McGuirk and Dowling 2021). Trials, labs, prototypes, and so forth become legitimate because they provide the basis on which to test the boundaries not only of what the solutions to climate and sustainability challenges might be, but also the nature and political salience of the problem itself. As Wakefield (2021, 332) argues "efforts to maintain order amidst the increasing omnipresence of catastrophic risks have led to a search for new technologies of government" that are capable of coping with the messy, situated, and more-than-human entanglements of the Anthropocene. The doing-with-learning that characterizes experimentation, I suggest, emerges as a response to the impossibility of knowing the inherent indeterminacy of climate change through ecologically modernist means.

Navigating indeterminacy and the "good" future city

One of the features that marks out experimentation is its use in relation to what are usually termed complex or "wicked" problems. As Sharp and Raven (2021, 195) put it "planning tools such as scenarios, land use controls, regulatory standards, and design overlays are very useful but less effective in situations of high complexity, deep uncertainty, and ambiguity about the future, as they rely on assumptions and conditions to be reliably known and predictable" while in such contexts "different approaches that are more explorative, adaptive, learning-based, and evolutionary in nature" are seen to be needed. Experimentation, it is often argued, can provide a means through which to generate the data, evidence, and experience needed to reduce uncertainty and complexity. However, the kinds of situation to which experimentation becomes the response are not simply uncertain or complex in the sense that with more knowledge, more practice, or more effort they can be resolved. Rather they are indeterminate, that is they are "situations that are open 'in the sense that its constituents do not 'hang' together'" (Dewey 1938, 105; quoted in Hutter and Farías 2017, 2) and are characterized as being "disturbed, obscure, troubled, ambiguous, confused and full of conflicting tendencies" (Hutter and Farías 2017, 2). In such situations, Dewey argues, protagonists deploy "inquiry" in order to render indeterminate situations "whole" and capable of intervention. Viewed from the perspective of the indeterminacy of governing climate change, experimentation can be seen as a form of "inquiry" intended both to reveal the situation at hand and to bring it to order, to form a problem around and through which actors can be enrolled and solutions found (Bulkeley 2016; Hutter and Farías 2017). At the same time, Hutter and Farías (2017) argue that indeterminacy does not simply arise but is actively sought and produced. Using Stark's (2009) notion of dissonance, they suggest that in "situations in which multiple and contradicting valuation modalities are available; situations in which the protagonists do not know what they are looking for but they know they could recognize it if they found it" dissonance drives actors to seek out such situations and to use them in their favor (Hutter and Farías 2017, 4). Similarly, Castán Broto (2015) argues that it is from the contradictions inherent in climate governance that desires for change both in terms of utopian thinking and concrete action emerge. Experimentation as a socio-materially situated expression of the "new" is then intimately bound with the generation of indeterminacy. The "new designates the occurrence of difference and a transformation of the real … specific occurrences, intrusions, breaches and shocks which invite actors to think, to establish connections, to attribute meaning and to assess value. Hence, the new defines the constitution of indeterminate situations" (Hutter and Farías 2017, 2). That experimentation is both a response to and serves to drive indeterminacy is revealing in terms of both how it contributes to the ongoing undoing of ecological modernism while at the same time generating a state of "permanent experimentation."

Science and technology studies have, of course, long recognized the liminal position that

experimentation occupies between the new and the routine, and the tension between remaining open to indeterminacy and yet sufficiently stable so as to enable intervention. Building on the work of Rheinberger, Kullman (2013) argues that experimentation requires the destabilizing of existing knowledge, routines, and orders—it should be "sufficiently open to generate unprecedented events"—yet at the same time it must "be sufficiently closed to prevent a breakdown of its reproductive coherence" such that it can in fact proceed. In short, experimentation "has to be kept at the borderline of its breakdown" (Kullman 2013). Each and every form of experimentation then finds itself in the borderlands of control and contingency, of needing sufficient closure to be enacted and a necessary openness to the indeterminate such that they are "flexible enough to allow for reconfiguration so as to sustain their transformative potential but also controlled enough to hold together" (Kullman 2013, 885; see also Bulkeley et al. 2019). As a result, Hutter and Farías (2017, 6) suggest that experimental spaces such as "the laboratory and the studio become spaces for the cultivation of indeterminacy, equipped and dedicated to practitioners' engagements with the indeterminate." Their analysis resonates with the work of Tironi (2020, 505) in Chile who argues that experimentation, or prototyping in this case, is an avowedly political process that seeks both to demonstrate and justify the possible while also serving as a "mechanism of explicitation that can make visible the unexpected friction" where such friction is interpreted, following Tsing (2011) that are "as uncomfortable, unequal, and unstable moments that can 'make worlds' and generate inventive forms of interaction" (Tironi 2020, 505).

Experimentation is then a means through which indeterminacy is simultaneously suspended and sustained. Rather than seeking to overcome complexity, uncertainty. and ambiguity, experimentation then becomes a technique by which to govern with and live through conditions which are unable to be resolved through ecological modernist forms of planning and controlled intervention. If conventionally governance is seen as a means through which the world is ordered that in reality it is often experienced as a process of "muddling through" points to the importance of "navigating disorder and engaging with the confusion that emerges from having multiple points of view about what is possible or desirable" which it inevitably requires (Castán Broto 2020, 249). Examining the work of resilience thinking and practice, Wakefield (2021, 336) finds a discernible shift from "single 'command and control' solution to nature's incursions—massive sea gates around coastal cities, for example … [to] a mixture of diverse, modular, and interlaced systems-based designs working at multiple sites and scales to reconnect urban fragments." Within these emerging approaches, "emphasis is placed on the need to abandon views of human-natural urban systems as linear and built within a stable world" and instead on the need to embrace nonlinearity, complexity, and unpredictability and the "new normal of disequilibrium and chronic disturbance" (Wakefield 2021, 337). Experimentation provides a means through which to navigate the indeterminate conditions of the Anthropocene, yet this does not mean an abandonment of governmental intentions to manage and improve the conditions of liberal life (Wakefield 2021). While rejecting "modern urban planning's hubristic dreams of mastery, this approach forwards its own hubristic dream of mastery, once more envisioning the planned management of whole cities—albeit this time as a volatile social-ecological-technical system managed via situated, self-organizing, systems-based techniques—and calling for infrastructural experimentation toward this end" (Wakefield 2021, 340). In their analysis of the emergence of the smart grid in Germany, Lösch and Schneider (2016, 278) find similarly that the shift to a mode of governing which supports the "ongoing production and testing of sociotechnical arrangements that have to enable flexibility, risk taking, learning and self-regulation instead of controllability through predictability … paradoxically, need their contrary: the imagination of controllability, predictability, risk-avoiding and so on, in order to cause the ongoing demands for getting experimental."

In this sense, the political project of experimentation remains tied to notions of the mastery of socionatures toward some notion of a better future not only because this remains a strongly liberal project, but also because the vestige of control is required to engender experimentation itself. Yet at the same time what constitutes an improved or "good" future remains both ambiguous and contested (Edwards and Bulkeley 2018). If ecological modernism clearly articulated economic growth and technological progress as the means through which progress can be achieved, the changing nature of the climate problem unsettles the notion of improvement toward, in this case, the "good" climate city. The dissonance of urban climate governance arises then not only from the indeterminacy of what *can* be done, what will be effective under complex and uncertain conditions, but also from what *should* be done, by and for whom. When there are clear scientific imperatives to reduce total greenhouse-gas emissions it may seem trivial or even downright skeptical to say that what "good" climate action involves is ambiguous.

Yet it is precisely these ambiguities that contribute to experimentation as it serves as a means to explore both what can yield objectively appraised improvements toward multiple ends but also more intuitively what it is that is held to be precious about both that which might be at risk from climate change (action) and proposed new orders (Hutter and Farías 2017). For Wakefield (2021), experimentation is orientated less toward avowed forms of progress and improvement but offers a means through which to explore how we can live within what Tsing (2016) terms the "capitalist ruins" of the Anthropocene. In the absence of certainty about the means or ends of governing climate change, actors have turned to more open-ended, provisional approaches to governing which shift from a deterministic approach to *what* should be governed to ask *how, by and for whom, and to which ends* governing should be undertaken. The situated and messy nature of governing climate change means that the lessons of learning-by-doing, navigating fragmented authority, forming the indeterminacy of specific climate situations, and struggling over what it will mean to ensure progress are neither easily transferred or simply overcome (Castán Broto 2020). As a form of inquiry, experimentation both serves to seek to bring order and stability to situations such that intervention is possible while at the same time the purposive suspension of existing rules and frames invites, and indeed requires, actors "to improvise new sets of rules, to come up with makeshift value criteria and to adapt both rules and values to the very unfolding of the situation" (Hutter and Farías 2017, 7), in turn generating forms of newness that serve to create further indeterminacy and an ongoing process of experimentation.

Conclusion

Whether experimentation is either a viable or legitimate response to the climate crisis has become a core concern of urban sustainability research. In this article, I have suggested that understanding the role and potential of experimentation requires not only that we look beyond experimentation to see what its efforts might produce, but also that we examine what has given rise to this current wave of experimentation. As the socio-materialities of the climate problem have shifted from being a matter of the global atmospheric commons and how national level emissions can be controlled and reduced to those of how everything from supermarkets to supply chains and festivals to farms can be decarbonized and made more resilient, the ecological modernist tenets through which governing has been conducted have begun to fray. Governing the environment can no longer be (only) about the environment (Biermann 2021). And nor, it seems, can it proceed in a modernist frame in which knowledge precedes action, the authority to govern is clearly demarcated, the parameters of the problem are at worst uncertain, and there is consensus on the progress that economic and technological solutions can provide. Experimentation emerges from and serves to further the reconfiguration and recalibration of environmental governance under conditions of fragmented authority, the imperative of acting without full or certain knowledge, the indeterminacy of climate-governance situations, and the contestation over what a "good" climate-changed city might entail.

Of course, not every instance of experimentation serves as a response to all four of these interwoven dynamics. Some for example will retain a belief in the progressive nature of techno-economic thinking and interventions while at the same time grappling with the indeterminacy of the climate problem. Others might continue to press for knowledge to precede action while at the same time seeking to navigate the fragmentation of authority to govern. Yet looking beyond individual experiments to the phenomenon of contemporary urban climate-change experimentation as a whole, as this article has sought to do, the contours of a mode of governing by and through experimentation appears to be taking hold which breaks in fundamental ways with the paradigm of ecological modernism that has held sway in environmental governance for more than three decades. Fundamentally, this suggests that it may neither be possible nor even desirable to abandon experimentation and to return to more centralized, controlled, and certain responses for it suggests that it is from within the difficulties of governing a climate-changing world through this paradigm that experimentation has arisen in the first place. This argument also raises some significant challenges in terms of how experimentation might be improved. For Sengers, Turnheim, and Berkhout (2021, 1155) the improvement of experimentation is to be found beyond its original boundaries—spatially, temporally, or structurally—through processes of embedding in which they become "materialized and durable features of new configurations" through a "reciprocal process of new knowledge and capabilities coming to affect the world even as they are themselves transformed." Others suggest that the potential of experimentation is immanent to the socio-material relations within which it is generated, such that it is the capacity to create openings within existing configurations and to catalyze new kinds of social and material relations that generate their potential (Bernstein and Hoffmann 2019; Castán Broto and Bulkeley 2018; Jensen et al. 2015;

Patterson et al. 2021; Tozer et al. 2022). Whichever specific line of argument is taken, this emerging body of research suggests that it is by working through and with the immanent power of experimentation and indeterminate qualities of the climate-governance situation that the capacities of experimentation are likely to be enhanced.

Yet improving experimentation is not likely to lead to any specific finality. As Hutter and Farías (2017) convincingly demonstrate, "inquiry" here in the form of experimentation does not lead as straightforwardly to the determination of an open situation as Dewey once argued. Rather, the process of configuring the new—objects, ideas, interventions—itself creates indeterminacy which can be both incidental and strategically generated. In this way experimentation, more or less deliberately, in turn creates new situations within which existing rules and norms are suspended and new ways of relating to the social and material world are required, generating forms of dissonance that drive actors toward experimentation in order to establish stable situations in which intervention is then possible and so on. The condition of permanent experimentation may then be one that we need to get used to living with and governing through. Such dynamics are, like all other forms of power, still wrought with strategic intention and far from politically benign. As Lösch and Schneider (2016) suggest, the emergence of experimentation does not imply a more democratic or better form of politics, rather it offers the prospect of "strongly changed constellations of knowledge and power which govern the processes of transformation." Such constellations are cohered through "processes and devices" that can act as what McGuirk and Dowling (2021, 766) term "compositional forces" for governing through experimentation—including in their case intermediating, co-producing, financializing and legibilizing. However, such capacities to govern are "an inventive composition … [emerging] as elements present themselves and are taken up as forms of government and drawn together" through the very process of experimentation (McGuirk and Dowling 2021, 774). The resulting alignments are necessarily "emergent, inherently provisional, and embedded in both strategic intent and power relations." In a city of permanent experimentation, it matters more than ever who gets to experiment and how. Rather than seeking to abandon or move beyond experimentation, the crucial challenge now is to examine which kinds of socio-material orders are being produced and excluded through experimentation, by and for whom, and with which consequences as we continue to experiment our way through and with the climate crisis.

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