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Calculative infrastructures of net zero urban governance: A transformative science-based agenda or reductive territorial project?

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Abstract

The current emphasis on data-driven urban climate governance, while not a new project, is nevertheless evolving as part of a new calculative politics shaped by a net zero agenda. This urban project is realised via the development of calculative infrastructures that deploy more robust measurement fields through which urban action can be made directly relevant to global climate targets. A key premise is that it is possible to project the global scientific concept of net zero onto the ground as a territorial target, which in turn relies on the technical work of balancing emissions. I argue that this often materialises as a reductive governance project based on the accountability of public actors to new carbon balance sheets, wholly detached from a more systemic transition politics. This critical commentary begins by introducing net zero as an urban agenda and explores how calculative infrastructures offer the means of making a consolidated international agenda actionable as an urban territorial governance project. I examine the urban carbon inventory protocol as the foundation to other calculative work and discuss three subsequent infrastructure projects: reporting frameworks and platforms, scenario planning tools and carbon budgets. This calculative project promises a long-term pathway to decarbonisation but is based on a narrow lens that misjudges the more systemic transformation that must take place. The commentary concludes by considering how (or if) net zero as a political framework could support a more radical transition politics.

Keywords

carbon accounting, climate governance, data-driven policy, net zero, urban environment

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摘要

虽然数据驱动的城市气候治理已不是一个新项目，但其已成为净零议程驱动的新计算政治的一部分，当前人们对其越来越重视。此城市项目通过开发部署更强大测量场的计算基础设施来实现， 其可以使城市行动与全球气候目标直接相关。一个关键前提是，有可能将净零排放这个全球科学概念作为领土目标转移落地，而这又依赖于平衡排放的技术工作。本文认为这通常会基于公共参与者对新的碳平衡表的责任，作为简化的治理项目来实现，与更系统的过渡政治完全脱节。本文首先介绍了作为城市议程的净零排放，并探讨了计算基础设施如何提供途径，使综合的国际议程可作为城市领土治理项目付诸实施。本文将城市盘点查协议作为其他计算工作的基础进行研究，并讨论三个后续基础设施项目：报告框架和平台、情景规划工具和碳预算。这个计算项目承诺了一条长期的脱碳路径，但是它基于狭隘的视角，会对必不可少的更系统性的转型形成错误认识。本文最后探讨了净零排放作为政治框架如何（或者是否能够）支持更激进的过渡政治。

关键词

碳核算、气候治理、数据驱动政策、净零、城市环境

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In addressing the capacity of cities to address climate change, the need for data – more data, more reliable data, more consistent data – has become a popular refrain. The maxim that measurement comes before management is now gospel. As I introduce below, an important pillar to this agenda in urban environments has been the development of international protocols for urban carbon accounting. A decentralisation of the international climate regime occurring in the lead-up to the Paris Agreement of 2015 has encouraged development of more coordinated methods of measuring carbon in urban environments. This has been key to the rescaling of global climate politics, where accountability in urban climate governance can be expressed more rigorously via carbon's calculability (Hughes et al., 2020). With the adoption of net zero as a logic focused on balancing emissions within urban territories, climate governance is being driven by a distinct calculative politics that is different from low carbon urban governance of the past.

This emphasis on urban climate governance as a politics of calculation may seem contradictory to scholars who have recently pointed towards other emerging urban climate agendas, particularly those that approach urban transition as a more systemic issue shaped by dispersed agents and sites and tied to a wider set of co-benefits associated with social justice and ecological health (Bulkeley, 2021). Yet at the same time that some of the most enduring ecomodernist assumptions around environmental governance are being seriously questioned, a deepening of a more reductive calculative politics is taking place which suggests that urban transition can only be the product of local actors remaining accountable to new carbon balance sheets.

This critical commentary examines this new calculative politics as one that frames accountability as a territorialised commitment to balancing carbon emissions. I argue that this is a significant break from low carbon urban measurement of the past. Urban systems, activities and infrastructures are appropriated differently into a calculative lens that bases its rigour and legitimacy on scientific objectivity. Making urban climate politics a calculative project not only requires that representations of our urban environments are presented in consistent carbon

terms but also requires new spaces, tools and frameworks to comparatively evaluate urban places, futures and actions *on* said terms. These are the practical ways through which a calculative politics is made actionable as an international agenda. I explore these spaces, tools and frameworks as 'calculative infrastructures' below.

Recognising how net zero broadly may be characterised by a more heterogenous politics extending past the limited calculative project discussed here, I return to the concept at the end of the article and explore what a more transformative agenda might suggest. Can net zero as a political framework be used to galvanise more systemic and just transformations of urban environments that support global goals, or do the technical requisites of such an agenda limit its potential? Before then, in what follows, I first introduce how net zero operates as an urban calculative agenda, then discuss the role of comparable and consistent measurement protocols and explore some of the key calculative infrastructures through which climate governance comes to be performed as a net zero territorial project.

From low carbon to net zero: Calculative politics in an evolving science-policy context

In the 2000s, amongst many well-resourced municipalities of the Global North, carbon inventories were popularised as a new territorial governance technology that measured carbon and enabled stricter forms of state environmental regulation via quantitative target setting compared to earlier eras of sustainability planning (While et al., 2010). The use of carbon inventories amongst local governments was pivotal to territorialising carbon in ways that made climate a new political resource for local actors (Rice, 2010; Rutland and Aylett, 2008). This helped to shape a contemporary form of climate urbanism that relies more explicitly on the measurement and surveillance of carbon as part of the means of justifying local policy (Long and Rice, 2019).

Carbon as a type of 'direct count' (Merry, 2016) allows for the public to engage quite differently with climate change compared to other agendas like sustainability or biodiversity. Complex indicators devised to measure the progress of the Sustainable Development Goals (SDGs) remain poorly understood by the public; carbon, in contrast, appears to be a more naturally measurable entity, and climate change certainly benefits as a public issue from its association with the simple, quantifiable discourse of carbon. This easily overlooks, however, that the carbon accounting protocols used to create politically and economically relevant counts of carbon that are used to shape policy and gain public support are not the same as physical (or scientific) accounting protocols of carbon (Ascui and Lovell, 2011). Still, because they maintain their philosophical basis in the physical, scientific study of carbon, these other forms of carbon accounting often stake their claims to authority in bringing climate change science into policy.

Political forms of carbon accounting have always had as their basis the territorialisation of carbon, transforming a global and deterritorial climate into a governable entity via calculative practices that turn 'stocks and flows of carbon into objects of governance' (Lövbrand and Stripple, 2011: 187). Net zero as a collective international agenda has helped intensify a political environment in which territorial claims to carbon have become even more critical. While the low carbon urban agenda introduced territorial targets that became manageable through accounting work, the net zero agenda extends this premise in ways that further complicate the distinction of carbon accounting as a science. Most significantly,

this evolving territorial accounting project places the focus on the *balancing* of emissions with offsets (or negative emissions) within a given territorial boundary (Allen et al., 2022). At the urban level, the role of offsets in achieving net zero targets has been much more widely discussed in just the past few years, as has the need for standard rules to help codify what constitutes a 'verifiable' offset which ensures that future claims to local net zero remain rigorous.

A city that established its own net zero (usually by 2050) target is often referred to having adopted a Science-Based Target (SBT). This concept of an SBT is established from the premise that (1) science is capable of providing politics with consensus-based targets that align with desired and forecastable future outcomes and (2) global atmospheric targets that represent such future outcomes can be extracted as a scientific concept and applied faithfully onto territorial grounds. Whether net zero by 2050, first of all, should be considered a scientific concept in its current usage is increasingly debated, particularly as the underlying science has evolved since its initial popularisation (Parris et al., 2023). But the second premise – the territorial application of the concept – underscores the consequential shift of net zero from a scientific to more conventional accounting framework: where imaginary yet durable boundaries of the urban territory become a fresh container to measure emissions in and emissions out with the authority of science supporting its claims.

It is not only the new discourse on the use of offsets and negative emissions that signals a shift in the politics of calculation. Rather, the premise of a scientific balancing of carbon within territorial space – which currently animates net zero governance and legitimises its science-based principles – is only made politically influential with the belief that the calculative tools at our disposal contain the technical rigour and objective lens necessary to measure and manage said territorially circumscribed balances. Accountability towards the carbon balance is prompted through a politics of the *net*, which exemplifies the calculative agenda of this new policy context more than the seemingly more quantitative concept of *zero* (Hale et al., 2022). The *net* concept foregrounds more explicitly the technical work of transition governance and the precise management of carbon as the means of performing accountability. The *net* offers a new framework of costs (carbon emissions) and revenues (reductions, offsets and negative emissions) that inspire treatment of climate change similar to the more familiar financial balance sheets of local governments. Technical rigour, comprehensive quantification and continuous verification are each critical to the net zero territorial project.

The carbon inventory: A foundation for calculative work

Here, I use the term 'calculative infrastructures' to make sense of collective projects that help centre urban climate governance around an evolving politics of calculation. This emphasises, first, that attention must be focused not only within the urban territory but also amongst and across territories. Calculation entails making distinctions between things: by detaching them from their contexts so that they can be compared, added, ordered or evaluated (Callon and Muniesa, 2005). Alongside calculation, the concept of infrastructure describes the role of new accounting, reporting, planning and monitoring frameworks assembled in transnational circles, which operate to reorder fields of knowledge and resources according to new informational and material practices (Bowker, 1996; Star and Ruhleder, 1996). While Tichenor et al. (2022) recently proposed the concept of 'epistemic infrastructure' to explore how counting becomes a

terrain around which global governance goals, like the SDGs, are made legible as part of a broader epistemological agenda, the concept of calculative infrastructures used here is an intentionally narrower concept. It reflects an intention to survey and discuss more instrumental tools and frameworks, which are one key part of enabling the translation of complex urban systems and relations into a quantifiable and comparable discourse of carbon.

This territorial calculative politics inevitably begins with the local carbon inventory. With its popularisation in the 2000s, the urban carbon inventory was initially an opportunity for local governments to leverage earlier sustainability strategies like public transit or compact development under a climate agenda. Under a net zero politics, it has become harder to make many such strategies directly relevant as they must become more fundamentally associated with the quantitative outcomes of net zero (Seto et al., 2021). Stricter adherence to how climate actions reflect on the carbon inventory is thus a key characteristic of net zero urban governance. More than just a political resource to advocate for climate action, the carbon inventory becomes a shared ledger that urban actors become accountable to and evaluated by, hence concerns that such a focus on data in judging public accountability can 'incentivize city governments to prioritize narrowed metrics and external interests, inhibiting the broader transformation required to realize climate change goals' (Hughes et al., 2020: 1085).

Recent projects to create a standardised protocol of carbon accounting have been crucial to establishing the legitimacy of local actors as governors of climate (Gordon, 2020), where the quantitative outcomes produced through standardised protocols are infused with scientific authority that supposedly shapes the collective development of said protocols. Networks like the C40, established in 2005, helped provide the early groundwork for this standardisation agenda. Emphasising the more active role that local actors and institutions should take in international climate politics, the C40 early on sought to reframe data collection beyond just a local policy resource towards a 'foundational credo of what might in practice be a new global paradigm of data-driven policy making' (Acuto and Ghojeh, 2019: 710). Under its third Chair, Michael Bloomberg (2010–2012), the C40 was instrumental to helping establish a new international emissions inventory protocol standard, the Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC), which was co-developed by C40, ICLEI – Local Governments for Sustainability and the World Resources Institute (WRI). The GPC has quickly become the most popular protocol used by global cities (Chen et al., 2019). Its importance is not necessarily in its substantive contributions, however, as the method built significantly on existing urban and corporate inventory protocols (Wilmsen and Gesing, 2016). More important is the GPC's efforts to reorganise a field of transnational climate governance around more easily comparable fields of measurement.

Ten years before, the WRI had co-led the development of the most popular corporate inventory standard, the Greenhouse Gas Protocol (GHGP) (WRI and WBCSD, 2001). The GPC combines methods from past urban inventory protocols and adopts IPCC accounting principles where applicable, but is also obviously based on the GHGP corporate protocol in its translation of the corporate Scopes Framework to the urban territory. This includes a Scope 1 account (pure territorial accounting) and Scopes 2 and 3, which more closely resemble a community-wide infrastructure-based carbon footprinting method (CIF) intended to account for carbon emissions direct from and embodied in all key urban provisioning

systems (energy, mobility, buildings, water, waste/sewage managements and green infrastructure) supporting daily life within the urban territory (Chen et al., 2019; Ramaswami et al., 2021). The GPC represents a relatively sophisticated method focusing on comprehensive analysis more so than targeted data collection for direct policy relevance (which was often characteristic of urban accounting protocols of the past). This also makes it a more complex, resource-intensive process. Collecting the requisite data can be particularly challenging. Downscaled national data or the application of standardised IPCC emissions factors is acceptable where more precise bottom-up data is impractical, yet there remains obvious pressure to procure higher-quality data and create comprehensive GPC-based emissions analysis within a policy environment in which high-quality data is promoted as the precursor to effective governance.

Recognising the limited representation of sector-based emissions inventories, the C40 has begun encouraging its members to compile consumption-based inventories in parallel (C40 Cities, 2018). Because these consumption inventories mostly rely on downscaled national monetary data, they are often regarded as less directly useful in a policy sense without the precision to monitor quantitative impacts of particular interventions (Heinonen et al., 2020). Still, it is generally acknowledged that no single inventory method can be said to be more useful or explanatory, and that different approaches instead provide important information to unique policy problems (Balouktsi, 2020; Chen et al., 2019; Ramaswami et al., 2021). Nevertheless, given its dominance today, the sector-based method adopted in the GPC is becoming the foundation from which all other calculative work is performed. This world of measurement is becoming the basis of global, comparative knowledge on urban climate action. A new landscape of winners and losers is being fixed around policies that produce positive quantitative outcomes through the territorial Scopes framework but speak little to the massive developmental challenges of embodied carbon in urban infrastructure, food systems or household consumption, for example. Notably, discussing trade-offs between different inventory methods is possible because these each refer to the common principle of carbon units, which is useful when analysing the effects of a single framework like the GPC structuring a broader governance field; yet it is must harder to understand what cannot be captured by carbon metrics in the first place.

As a territorial balance sheet whose claims to legitimacy rest on the application of scientific expertise through standardised and internationally shared methods of accounting, the inventory becomes a more pervasive terrain around which accountability to territorial climate goals is performed. Through the development of consistent international carbon accounting methods, a new field of measurement enables a more systemic reorganisation of urban governance centred around a net zero calculative politics.

Emergent net zero calculative infrastructures

With an inventory standard codifying the relevant principles and boundaries of urban measurement, a host of supporting calculative infrastructures have become instrumental to making a net zero calculative politics *actionable* as an international agenda. This has partially taken place through a more formal convergence of international urban institutions. The establishment of the Compact of Mayors in 2014 (led by Bloomberg following his time as C40 Chair), and the later merger with the European Covenant of Mayors in 2016 to form the

Global Covenant of Mayors (GCoM), is exemplary. Today, the GCoM has over 12,500 government members and is a platform for other networks and institutions to coordinate action. Making the compilation of a GPC inventory a compliance requirement for GCoM members has been essential to rapidly popularising the protocol internationally. Discussed below, the unification of existing CDP and ICLEI reporting platforms into a consolidated reporting space that feeds data out to other urban organisations, investors and campaigns similarly signals consolidation as a key element of this measurement project.

The examples of calculative infrastructures that I explore below are each in some ways products of this consolidation project, reshaping urban environments through a privileged calculative lens that powerful international interests have become invested in (both figuratively and literally). I focus on three projects specifically: new reporting frameworks and platforms; scenario planning tools; and carbon budgets. Although iterations of these projects may have existed before, a net zero calculative politics gives these tools and frameworks new importance.

Reporting frameworks and platforms

Recognising that national commitments remain wholly inadequate to reach a global goal of net zero by 2050, it is expected that substate and non-state actors can play an important role in closing the ambition gap (Hale, 2016). These actors are brought into the facilitative orchestrative model of international climate governance through commitments to continually report in consistent and commensurable terms (Hickmann, 2021). Creating shared reporting platforms helps to enable the practice of global benchmarking as a model to evaluate commitments and progress by offering the technical and evaluative spaces in which new quantitative insights can be made (Kuzemko, 2015). Such insights are, importantly, based on knowledge produced via comparison: such as between inventories submitted by the same city over different reporting years, or between cities over the same reporting year. Such insights often help to determine the directions in which global investment will flow. At its foundation, benchmarking is a comparative evaluation technique, using technologies like audits, indicators, baselines and targets to 'systematically assess the performance of actors, populations, or institutions on the basis of standardised measurements, metrics, and rankings' (Broome and Quirk, 2015: 820). Benchmarking thus enacts its governance power through infrastructural systems that establish an evaluative field of 'constructed objectivity' (Broome and Quirk, 2015: 821).

Although data may already be compiled in standardised formats according to the GPC, additional frameworks to make reporting itself consistent and comparable are needed. The GCoM's (2018) Common Reporting Framework (CRF) is used by many local governments, codifying methods of GHG emissions reporting in addition to reporting standards for risk and vulnerability assessments as well as climate action plans. For emissions reporting, the CRF overviews acceptable target types, target years and levels of reporting ambition, amongst other key benchmarking terms. It also stipulates relevant activity data, gases and emissions factors, and it solicits descriptive explanations of reported data. Alongside these reporting frameworks like the CRF, reporting platforms like the CDP-ICLEI TRACK ensure data can be easily accessed and analysed using basic software and with rudimentary skills in data analysis. Reported data feeds directly to the CDP's public disclosure site, which is used as the basis for CDP's own analytics and reports measuring the 'completeness' of disclosure and local government ambition (van Staden

and Appleby, 2019). Data uploaded to CDP-ICLEI TRACK is also automatically shared with GCoM to award its own Compliance Badges and feeds directly to other programmes like UNFCCC's Race to Zero Campaign, the Science Based Targets Network review process and the World Wide Fund for Nature's (WWF) One Planet City Challenge (CDP et al., 2023).

Reporting platforms appear to depoliticise city actions by overlooking many non-quantifiable aspects of transition, yet they are paradoxically also deeply political in that they 'favor some approaches over others, creating winners and losers, and shifting the resources and energy of global climate governance into particular channels' (van der Ven et al., 2017: 2). As is the case with many systems of global benchmarking, these practices can reinforce many existing inequities at the global level, serving to unintentionally slow global climate progress. They are only able to capture certain aspects of policy and action, whereas others (like the democratic aspects of local politics or the 'in-between' activities to realise quantitative goals) are not easily represented (Robinson and Gore, 2015; Sager, 2011). Although the CRF stipulates the addition of qualitative information to make shared data more useful and contextual, it is often these aspects of reporting requirements that are least developed and in many cases left missing in publicly reported data (Baltar de Souza Leão et al., 2020; Kongboon et al., 2022). This is particularly true for governments in the Global South or amongst smaller local governments in the Global North, which often face significant challenges with the requisite data collection. Because data challenges can be a barrier to participation in global campaigns, many cities do not have the opportunity to enter the field of comparison and evaluation to begin with. As Creutzig et al. (2016: 2) highlight, it is often the richest cities most dedicated to climate change that can compile the best data, which has broader implications for global knowledge as it results in a 'huge bias in the data representation of cities'. Often the implication is that the reported success of leading cities can be attributed to the ambition of local actors, rather than the underlying structural conditions which typically create disparities in capacity and performance (Broome and Quirk, 2015).

Reporting platforms are spaces that globalise the urban territory, expanding accountability over the territorial emissions balance to a much wider audience. Outside of leadership cities which often use such spaces to reinforce their hegemony in urban climate politics, participation in reporting rituals and collaboration with related international campaigns is often motivated by the belief that this will open doors to opportunities and resources, such as financial investment or technical support. Where these benefits may be realised, they also come at the cost of narrowing goals to that which can be represented through carbon.

Scenario planning tools

Scenario analysis is a means of applying stricter calculative logics to the planning process. While national energy planning has long used scenario tools, city-wide energy scenario models are newer to local governments (Asarpota and Nadin, 2020). Historically, scenario modelling was offered as an alternative to strategic forms of planning as a way to confront deep uncertainty in energy systems futures, including both expected (data relevance or relevant parameters) and unexpected (changing political actors, unstable international and national policy contexts, unanticipated climate change impacts or technology breakthroughs) forms of uncertainty (Yazdanie and Orehounig, 2021). Increasingly, scenario planning is offered more objectively as the means for cities to create 'evidence-based'

policy. This has been championed by the C40 in particular, which argues that cities should use scenario tools as a way 'to develop mitigation strategies in an evidence-based way, identifying the things that need to change in the city to achieve science-based climate targets' (C40 Cities, n.d.).

This use of scenarios in urban climate governance typically relies on two future projections: the baseline emissions forecast (*what if no climate action is taken?*) and the net zero policy forecast (*what if successful action to realise our net zero goals is taken?*). For each proposed policy, investment or intervention that helps reach the net zero goal, the total carbon impact (*avoided emissions*) is the measurable difference between the baseline and net zero scenario for the sector in question.

The base year inventory provides the necessary foundation to project forward each of these distinct futures. The basic principles used in compiling an inventory, then, define the system and territorial boundaries that become relevant in a policy setting: in other words, how one accounts for emissions in the present determines how one can imagine pathways of action leading to net zero (and alternative) futures. In the context of city climate action, climate action plans are treated as a 'package of strategies' (C40 website) that (1) will establish a logical progression from the current base year inventory (an annual emissions surplus) to net zero future (an annual emissions balance) and (2) are verifiable in their effects on urban environments via quantitative comparisons between the future baseline scenario and the policy scenario.

Yazdanie and Orehounig (2021) find over 100 scenario tools available to modelling experts, planners and policymakers that represent a broad range of technical complexity, but the vast majority are currently beyond the technical capacity of most local governments. More advanced tools being developed by private companies in recent years focus on the relationship of energy use, emissions, urban form and spatial relations to project future emissions, integrating emissions models with land use and transportation modelling. Simpler tools like ICLEI's ClearPath and the World Bank's CURB tool offer more basic functions to project the emissions impact of policy actions. However, as a recent CDP (2022: 4–5) report acknowledged, even these tools often require more data than may be available to many cities.

While most governmental actors and members of the public are made familiar with a city's chosen net zero climate action plan (the policy scenario), decisions shaping the baseline scenario forecast are often left unclear despite being highly consequential to the calculative insights driving action. Often called the business-as-usual (BAU) scenario in published climate action plans, the baseline scenario is a no-action-taken future, and thus a measurable reference origin extending forward in time. Uncertainty characterises the baseline future as much as the net zero policy future. The concept of what counts as *usual business* is itself also a deeply subjective construct, making strong assumptions about how the energy system and current policies work (Ellenbeck and Lilliestam, 2019). Planning for the long term through scenarios involves wide-ranging assumptions that are social and political, as much as technological, and are all but impossible to predict. However, the stable baseline is needed to associate actions with future emission reductions: it is from this baseline that the quantitative impact of actions can be calculated. Some BAU scenarios are devised by forecasting only the basics: population and economic development, projected to the target year. Others incorporate a broader spectrum of inputs related to sectoral trends, urban planning or grid intensity, amongst others. Choosing and defining appropriate parameters means internalising assumptions about social, technological, ecological and

spatial relations in the present, which are used to define the future (Enserink et al., 2013). Balouktsi (2020: 247) argues that using multiple baseline scenarios would likely be a more appropriate and effective way to guide planning, engaging with not only the multiple ways of interpreting the present but also the contingency of the future, to understand how our choices in transition governance must inevitably respond to unpredictable events. Yet this would complicate the basic principles of producing evidence based on quantitative carbon differences between the baseline and the policy scenario.

In a net zero planning context – in which climate action planning is increasingly associated with the strategic allocations of emissions across both space and time – emissions forecasting must offer a level of certainty that can only be produced from these apparently more stable and predictable futures. As these scenario tools are developed and shared between cities and through networks and international organisations, the assumptions that go into how the future is imagined through such tools are inevitably internalised in the everyday practices of local actors. Where collective adoption of such tools is for the purpose of developing evidence-based policy – as opposed to exploring different futures and engaging the unpredictability of energy transitions – it enacts significant normative influence over what sorts of policy actions constitute accountable decision making.

Carbon budgets

Carbon budgets have been made relevant as a framework under the explicit assumption that there is a finite quantity of emissions left to be released into the atmosphere before overshooting a maximum global temperature rise. The net zero territorial framework is thus instrumental to making the carbon budget a locally relevant tool because it creates the necessary conditions of finitude for the budget concept to function. Popularised as part of the developing SBT discourse, the C40 was the first to establish a method for local governments to calculate a carbon budget that drew directly from IPCC's Fifth Assessment Report (AR5, 2014) by apportioning the global 1.5°C carbon budget using a city's portion of the global population (which is then adjusted for GDP and relative emissions contribution to capture differences in capacity and responsibility, respectively) (C40 and Arup, 2016). Ultimately this method gives cities a total amount of carbon left to be emitted within a particular territory before a 1.5°C global temperature scenario is surpassed locally. Each year, the total budget decreases by an amount equal to the annual inventory.

Outside of the C40, there has been scepticism on the relevance of the carbon budget as a meaningful tool. For example, the WWF used insights from the Special Report on Global Warming of 1.5°C (SR1.5, 2018) to explicitly reject the local carbon budget model in devising its method of establishing SBTs, instead focusing on the concept of decarbonisation pathways (WWF, 2019). This was meant to reflect a shift in scientific approach between AR5 and SR1.5 in which it became clearer that 'inherent uncertainty makes it challenging to attribute a specific budget (or a specific emissions pathway) to a particular temperature outcome' (IEA, 2018: 114). The C40 nonetheless continues to promote carbon budgets as a more accountable expression of an SBT, which enables yearly, quantitative benchmarks to evaluate whether a city remains 'Paris compliant' and to determine which actions have led to quantifiable successes or failures (Watts, 2022).

Building on the C40 carbon budget framework, the City of Oslo has since helped to pioneer another use of the carbon budget based on its direct adoption in the municipal financial budget process, which they call a 'climate budget' (City of Oslo, 2021).

Whereas the net zero framework treats urban climate governance analogously to the treatment of a financial budget that must be balanced with emissions and offsets, this type of climate budget *literally* brings carbon as a secondary constraint into the existing financial budget process. This mode of integrating carbon relies on, first, establishing scarcity – inventing the budget as a finite entity – followed by the disaggregation of the budget into its constituent carbon parts that can then be balanced, exchanged and traded off with not only carbon but also monetary units. Beginning in September 2021, the C40 began a pilot project to explore the use of such a climate budget in 10 of its member cities and to make practice recommendations (C40 Cities, 2021).

Oslo's budget concept is meant to turn contested investments for climate mitigation into a more authoritative and less politicised debate. This suggests that it is primarily a lack of relevant data that is currently limiting local climate investments and fragmenting action across sectors. Once quantitative metrics demonstrate how cities 'measure up' against their annual reduction goals determined by their annual budget of emissions, necessary investments and collaborative goals will become much clearer. Despite Oslo's seeming success at reducing emissions using the budget tools, it is important to separate the emission reductions that occur *because* of quantification from others that might otherwise exist but are simply made visible by it. It is also important to see what is not made legible by the framework. Where accountability comes to be constructed around the budget, other important urban dimensions of global transitions are easily devalued.

Beyond the calculative net zero urban agenda

Inevitably, all calculative worlds are partial. Engaging the epistemic problems of carbon calculation seriously prompts reflection on whether resources should be placed into improving calculative practices that make net zero actionable, or if an alternative lens to represent, shape and realise climate action might be more effective. I conclude this critical commentary, then, by reflecting on whether urban net zero as a framework could support a different type of political project, beyond the calculative lens implemented through infrastructural projects above.

Many scholars continue to argue that net zero could offer a legible frame of collective action to promote more ambitious action based in a longer-term material politics (Fankhauser et al., 2022; Seto et al., 2021; Tozer, 2019). Even where the nature of global net zero by 2050 as a scientific concept is challenged, its importance as an international political framework to galvanise more ambitious, collective action is still frequently underscored (Parris et al., 2023). However, strict accountability to the territorial carbon balance sheet can also encourage the opposite: material abstraction, where action becomes more explicitly orientated towards achieving emission reductions in the carbon ledger. Perhaps more pessimistically, it can be used selectively to obscure longer-term transition objectives that are shaped by important social dimensions and that imply more urgency in measuring up short-term measurable outcomes.

As Rogelj et al. (2021) suggest, net zero targets established by governments and corporations are often left vague as quantitative goals, obscuring important ethical judgements like which gases in which spaces should be made relevant or how fairness and responsibility should be more fundamentally tied to target-setting practices. From a global scientific perspective, balancing emissions to achieve climate stability in the long term may be unavoidable, and clarity on how to define net zero as a collective global project remains an important task for those

working at the science–policy interface (Rogelj et al., 2021). Some fossil-based carbon emissions may continue to be a necessary (if temporary) burden of a post-fossil society, meaning a society in which our shared economy is no longer fundamentally based on fossil fuel production but which still might incorporate residual and targeted carbon-based fuels where they contribute to just social processes and institutions. But the balancing work that this ultimately necessitates still can never become the political *focus* of a just social transition, and certainly not one that is managed as a local territorial project.

Amongst public officials and experts, calculative infrastructures become the means of making net zero manageable as such a territorial project. Collective buy-in to calculative infrastructures amongst international networks and organisations, local governments and private investors exemplifies where these hegemonic discourses over net zero as an urban calculative politics might lead: to material and social abstractions that jeopardise long-term transformations. Making global decarbonisation a reality requires political frameworks that can support action at all levels without a demand for quantifiable carbon evidence to become the bottom line. While carbon data has become the basic material of public accountability in local climate action, what currently counts as 'evidence' is not strictly scientific fact but deploys selective accounting protocols to procure a partial representation of how urban systems relate to global climate. Data will certainly maintain an important role in knowledge production and communication, but it cannot be the political focus of transformation. Meeting the complexity of the current crisis thus requires us to go beyond our obsession with the *net*, to find ways of building on the absoluteness of transformation that the *zero* suggests. If that is not possible, then we must find a new common framework that can support a more radical transition politics.

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