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The technosphere: a new concept for urban studies

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According to the United Nations University Institute for the Advanced Study of Sustainability, 'cities are responsible for 67% of the total global energy consumption and more than 70% of greenhouse gas emissions and these trends significantly intensify the severity of some of the two great challenges of our time; climate change and energy security'.[1] Moreover, if cities are driving anthropogenic climate change, the effects are felt everywhere on earth, from glaciers to atolls, from oceans to the troposphere. It is no longer simply society that has been, to cite Henri Lefebvre, 'completely urbanized'.[2] The entire planet and its atmosphere have been subordinated to the metabolic demands of extremely large human settlements.

If urban activity is largely 'responsible' for climate change, then climate change itself is often most palpably experienced within cities. Heat waves, for example, are amplified in urban areas by the aggregation of heat-absorbing materials (concrete, asphalt, slate, stone), the so-called 'urban heat island effect', while tall buildings create heat-trapping 'urban canyons'.[3] Shanghai's rising heat is produced mainly by the city itself: 'increasingly over time, Shanghai is producing its own weather'.[4] As Brian Stone has cogently argued, there are two distinct processes of climate change: a *global* greenhouse effect and *local* urban heat-island effects.[5]

We have, then, two giant, mutually reinforcing phenomena: cities and climate change. How do we conceptualize their relationship? The simplest, most straightforward way is to say that *cities are the agents causing climate change*. This statement, however, occludes as much as it reveals. The terms 'city' and 'agent' arguably cannot capture the full complexity and significance of this process. This essay uses the example of cities and climate change to rethink 'urban agency'. It argues that while large-scale, industrialized systems are causally related to climate change, the

[1] 'Sustainable urban futures', http://urban.ias.unu.edu/index.php/cities-and-climate-change/ (accessed 15 Jun. 2015).
[2] H. Lefebvre, *The Urban Revolution*, trans. Robert Bononno (Minneapolis, 2003), 1.
[3] B. Stone, Jr, *The City and the Coming Climate: Climate Change in the Places We Live* (Cambridge, 2012), 13, 75.
[4] *Ibid*., 90.
[5] *Ibid*., 85.

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blunt concept of agency is not the best or only way to conceptualize this relationship. Instead, a range of more nuanced terms (such as reactivity, biological agency and disposition) capture the set of activities and interconnections leading to large-scale environmental transformation. Moreover, the essay argues that cities have become so networked and dispersed that we might plausibly reconceptualize the urban as the *technosphere*, an entirely artificialized environment, a hyperobject within which most of the world's human beings increasingly live. The technosphere is the sum total of all the earth's physical infrastructure. The city, in contrast, refers to specific areas of the technosphere whose physical density, history and individuality produce and sustain unique, and attractive, cultural characteristics.

The argument, very simplified, runs something like this: cities are not agents, so they do not 'cause' climate change in any simple, linear fashion. Instead, a much bigger entity, the technosphere, is responsible for climate change. The technosphere is powered by fossil fuels, which sustain its transportation systems, housing, office complexes, food systems, water supply, heating, air-conditioning and electronic devices. The repeated use and collective interaction of these devices and systems has created a new ecological niche for human beings and a disposition towards high energy use, carbon emissions and other forms of pollution. This, and not some abstract idea of the city, is the driver of planetary climate change.

Splintering urban agency

Twentieth-century scholarship on cities often subjugated the material dimensions of cities to more abstract social, economic and cultural forces.[6] The physical, concrete dimensions of urban existence have regularly been viewed as secondary to more salient, abstract processes. This is evident in traditional urban sociology, which tended towards formalized, abstract urban models; Marxist approaches, whose purported materialism actually often reduced the city's physical form to an epiphenomenon of the deeper, more abstract forces of capital; and cultural history, in which the ultimate reality of urban experience became discursive, imaginary, symbolic or psychological.[7] As Robert Park put it, 'the city is a state of mind'.[8] Agency was rarely located in the physical city itself.

Social formation, capitalism and the imaginary are not, obviously, irrelevant to the study of cities: they most definitely are, and they remain

[6] C. Otter, 'Locating matter: the place of materiality in urban history', in T. Bennett and P. Joyce (eds.), *Material Powers: Cultural Studies, History, and the Material Turn* (London, 2010).
[7] R. Park, 'The city: suggestions for the investigation of human behavior in the urban environment' [1916], in R. Sennett (ed.), *Classic Essays on the Culture of Cities* (New York, 1969); D. Harvey, *The Urbanization of Capital: Studies in the History and Theory of Capitalist Urbanization* (Baltimore, 1985); C. Schorske, *Fin-de-Siècle Vienna: Politics and Culture* (New York, 1981).
[8] Cited in J. Donald, *Imagining the Modern City* (Minneapolis, 1999).

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so. The city in many ways *is* a state of mind. Cultural analyses are, however, less well equipped to think about cities and climate. The activities linking cities and climate change occur outside of human discourses and imaginations. Climate change, along with economic crisis, has called the traditional tools of social and cultural theory into question, and generated a revivified materialism across the humanities.[9] This is evident in philosophy, literature and history.[10] While sociological and cultural approaches to cities made humans, capital or culture primary agents, these approaches refocused on material things, and particularly their capacity to do things: to act, to be agents. If one entity affects another, it has agency, irrespective of whether it possesses a brain, consciousness or intentions. 'Material agency' has become particularly associated with the work of Latour.[11] This is not a reintroduction of anything cryptic, noumenal, spiritual or essential, since agency is generally a co-production of two or more entities. Agency is distributed: it concentrates in knots and disperses across networks, and occurs within a 'collective'.

The idea that agency is co-produced by humans and non-humans in networks has become one of the most significant, even hegemonic, ideas in recent social theory. The concept of 'material agency', however, is not above critique. The term 'material' itself is problematic. Rather like 'matter', the term implies something undifferentiated, general and abstract: Tim Ingold has suggested that 'materials' is a more empirically satisfying term, referring to the incredible variety of different materials and their capacities.[12] 'Matter' does not cause climate change: oil- and coal-powered machines and devices do. Much nuance is lost by making wildly different entities analytically or even ontologically equivalent. If everything material has a basically equivalent capacity for agency, the term surely loses much of its critical thrust.

When coal burned in a steam engine, it oxidized, producing heat, carbon dioxide, hydrocarbons, small particles, sulphur dioxide, nitrogen oxide and traces of other substances. Is this best characterized as *material agency*? Or is it simply *reactivity*? By adopting the term 'agency' we flirt with anthropomorphization which, ironically, disrespects a resolutely non-human, inorganic process. Reactivity, in contrast, refers to the chemical interaction of two substances brought into contact, either accidentally or deliberately. The steam engine is a particular reaction captured and directed by humans to produce a very particular effect: the generation of energy. The successful capture, control and directing of physical and

[9] For a particularly bracing, caustic argument, see V. Chibber, *Postcolonial Theory and the Specter of Capital* (London, 2013).
[10] D. Coole and S. Frost (eds.), *New Materialisms: Ontology, Agency, and Politics* (Durham, NC, 2010); B. Brown (ed.), *Things* (Chicago, 2004); J. Brooke, *Climate Change and the Course of Global History: A Rough Journey* (Cambridge, 2014).
[11] B. Latour, *Reassembling the Social: An Introduction to Actor-Network Theory* (Oxford, 2005).
[12] T. Ingold, 'Materials against materiality', *Archaeological Dialogues*, 14 (2007), 1–16.

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chemical reactivity has been integral to all military technologies and systems of energy generation.[13]

Reactivity and agency are two types of action, roughly corresponding to the distinction between the chemical and the biological worlds, a clear distinction with an unavoidably fuzzy boundary. Biological entities, despite extraordinary variation, have their own distinct material forms and capacities (a specific chemical composition, metabolism, DNA, a capacity for self-organization and reproduction). Over the course of evolutionary history, biological agents from microorganisms to humans have had tremendous, and active, effects on Earth: transforming the atmosphere, building niches, slowly generating the biosphere. Human beings are biological entities which think, plan and act: they possess true agency, as do (arguably) many animals and even insects. Human beings have probably harnessed and channelled more reactions than any other biological agent. Some large non-biological entities, however, have massive effects irrespective of human activity: hurricanes, earthquakes and volcanoes for example. Rather than call this agency, a better term is *force*. Force is sometimes used to describe human actions, but it is also non-volitional effect of large, powerful and non-living entities. It suggests something big, crude and brutal, which operates outside the direct control of humans, even if complex links increasingly exist between humans and hurricanes and even tectonic plate activity.

Within any given urban space, an almost unimaginable amount of action is constantly taking place. Microbes, insects, animals and humans perform the multifarious actions of living beings, from eating and breathing to actively planning. Air perflates, suffuses and wafts. Concrete supports but slowly crumbles: steel and brick endure relatively longer. Wood rots, coal burns, water flows. During the twentieth century, innumerable new and synthetic materials entered urban life, from rare metals to plastics. This made the urban environment more materially diverse and increased the variety of physical interactions and reactions within it. Today's everyday artefacts like cars and computers are far more materially complex than those of a century ago. Simply put, cities are arguably more reactive places than they used to be.

Keller Easterling has recently suggested that the concept of *disposition* can capture the way in which physical entities interact to produce collective action. Disposition is the 'unfolding relationship between potentials', existing 'not in the moving parts, but in the relationship between the components'.[14] The arrangement matters as much as the individual entities being arranged. Moreover, when such arrangements are replicated and recursive, individual chemical reactions and biological activities begin to have large effects. Easterling calls such recursion

[13] A. Pickering, *The Mangle of Practice: Time, Agency and Science* (Chicago, 1995).
[14] K. Easterling, *Extrastatecraft: The Power of Infrastructure Space* (London, 2014), 72.

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the *multiplier*, which translates individual into large-scale action.[15] One road, house or car disposes things in particular ways, but the effects remain small scale. Millions of roads, houses and cars, however, produce large-scale material and metabolic effects: 'more powerful than a single object form in these landscapes, multipliers piggyback on repetitive components'.[16] Disposition and multipliers explain how small effects, actions and reactions provide a collective orientation which can change something as massive as climate. Disposition and multipliers give material systems what Thomas Hughes called *momentum*.[17]

These various concepts – reactivity, force, biological agency, disposition, multiplication, momentum – are provisional tools through which we can start to break apart the concept of agency. But this is not enough. We also need to reappraise the category 'city' itself.

The technosphere

The idea of material agency has been productively extended into the realm of urban studies, particularly through analyses of infrastructure. Urban scholars have explored the interlaced material systems undergirding cities, and explored what infrastructures do.[18] Infrastructures 'produce space' in a Lefebvrian fashion: they 'dramatically, but highly unevenly, "warp" and refashion the spaces and times of all aspects of interaction – social, economic, cultural, physical, ecological'.[19] They make connections and establish divisions. Infrastructures also are the conduits through which critical resources flow into and out of the city: goods, people, water, electricity, money, information. In such studies, material things play a much greater and more active role than in older sociological or cultural analyses of cities. Analysis turns to flows of water, the circulation of electrons, the removal of waste, to metabolism, non-linearity and feedback.[20]

For Graham and Marvin, the primary event in the recent history of urban infastructure is the recent 'splintering' or 'unbundling' associated with neoliberalism and the collapse of the 'social city' of equalized infrastructural provision.[21] Without denying the significance of this

[15] *Ibid*., 73–5.
[16] *Ibid*., 74.
[17] T. Hughes, 'The evolution of large technological systems', in W.E. Bijker, T.P. Hughes and T. Pinch (eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA, 1987), 76.
[18] C. McFarlane and J. Rutherford, 'Political infrastructures: governing and experiencing the fabric of the city', *International Journal of Urban and Regional Research*, 32 (2008), 363–74.
[19] S. Graham and S. Marvin, *Splintering Urbanism: Networked Infrastructures, Technological Mobilities and the Urban Condition* (London, 2001), 11.
[20] E. Swygedouw, 'Metabolic urbanization: the making of cyborg cities', in N. Heynen, M. Kaika and E. Swyngedouw (eds.), *In the Nature of Cities: Urban Political Ecology and the Politics of Urban Metabolism* (New York, 2006).
[21] Graham and Marvin, *Splintering Urbanism*.

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phenomenon, a more *longue durée* approach reveals another, earlier and more thermodynamic unbundling, beginning around 1800. For the majority of their existence, cities have relied upon renewable energy with low power densities. This limited their size and tied them to large, predominantly circumjacent hinterlands. Wood-powered cities require 50 to 100 times their area in woodland.[22] Their populations occasionally reached one million (Rome, Chang'an, Baghdad) but, seemingly, could grow no further.

The tapping of the 'subterranean forest' of coal deposits was a fateful event in the physical history of urban space.[23] It enabled tightly packed cities to extend their metabolisms over much longer distances by importing raw materials, water and food from multiple, disconnected locations.[24] These carbon ecologies generated various environmental issues (soot, smoke, acid rain), and catapulted elites out of cities into a new urban space, suburbia, where they could reconnect with the bucolic. In 1857, Thomas Bullock's *Illustrated Guide to Manchester* wrote of the city's suburbs: 'here resort our merchants, those who can bear the expense of residence beyond the region of smoke. These suburbs of Manchester resemble so many Edens, and you wonder such loveliness can exist so near the brown masses of chimney and streets in the city.'[25] Coal produced the reactions, and steam engines and domestic fireplaces acted as multipliers: when interwoven with factories, railways, illumination systems, tracts of industrial housing and steamships, urban space was squeezed, stretched and folded into conurbations and agglomerations. The disposition towards fossil fuel was created and cemented. The internal combustion engine then became the key reactor-multiplier, with roads and freeways warping space into novel shapes (edge nodes, rural fringes).[26] Instead of discrete nodes linked by paths and waterways, cities dissolved into and along their railways, roads, water mains, gaspipes, electricity and fibreoptic cables.

Cities lost their edges and walls, and combined with technological systems to produce a meshwork which sprawls around, beneath and above the earth, from the satellites beaming electromagnetic waves to our smartphones and televisions to the fibreoptic cables on ocean floorbeds. Infrastructure became 'the urban structure itself – the very parameters of global urbanism'.[27] Locating the city became increasingly difficult from the early twentieth century. Is the city outside of, within or continuous with

[22] V. Smil, *Energy in World History* (Boulder, 1994), 7.
[23] R.P. Sieferle, *The Subterranean Forest: Energy Systems and the Industrial Revolution* (Cambridge, 2001).
[24] S. Barles, 'Urban metabolism of Paris and its region', *Journal of Industrial Ecology*, 13 (2009), 898–913.
[25] Cited in R. Fishman, *Bourgeois Utopias: The Rise and Fall of Suburbia* (New York, 1987), 75–6.
[26] For a taxonomy of US suburban types, see D. Hayden, *Building Suburbia: Green Fields and Urban Growth* (New York, 2003).
[27] Easterling, *Extrastatecraft*, 12.

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the infrastructures? If the latter, where does the city actually begin and end? Since cities cannot function without their infrastructures, what point is served by analytically separating them? One recent study concluded that 'urban and rural are no longer useful boundaries to make with regard to planetary stewardship'.[28]

Numerous terms have been proposed to describe these emergent urban morphologies: sprawl, *Zwischenstadt* or, more generally, anthroposphere or mechanosphere.[29] Such terms have merit, but from the perspective of urban studies, a concept which explicitly captures the infrastructuralization of space is necessary. One potential concept is the *technosphere*, proposed by Peter Haff and described by him thus:

> The set of large-scale networked technologies that underlie and make possible rapid extraction from the Earth of large quantities of free energy and subsequent power generation, long-distance, nearly instantaneous communication, rapid long-distance energy and mass transport, the existence and operation of modern governmental and other bureaucracies, high-intensity industrial and manufacturing operations including regional, continental and global distribution of food and other goods, and a myriad additional 'artificial' or 'non-natural' processes without which modern civilization and its present 7×10^9 human constituents could not exist.[30]

The technosphere covers the planet, albeit unevenly. It is densest in the global north, but its characteristic qualities make themselves felt, in one form or another, everywhere. It has geological and climatic effects: it is responsible, for example, for moving more solid materials over greater distances and at faster speeds than any natural processes except sediment transportation in rivers.[31]

The technosphere allows humans progressively to abandon a largely outdoor existence, and to retreat into increasingly sealed, climate-controlled spaces. Air-conditioning, for example, has transformed American housing, energy use and demography. Reactions involving refrigerants, condensers, compressors and evaporators, when multiplied, have created a climatically appealing sunbelt towards which white populations from the north gravitated, which catalysed a disposition to more conservative politics: conservative states began using more energy and releasing more carbon dioxide than liberal ones.[32] When

[28] S. Seitzinger *et al*., 'Planetary stewardship in an urbanizing world: beyond city limits', *Ambio*, 41 (2012), 790.

[29] T. Sievert, *Cities without Cities: An Interpretation of the Zwischenstadt* (London, 2003); P. Baccini and P. Brunner, *Metabolism of the Anthroposphere: Analysis, Evaluation, Design*, 2nd edn (Cambridge, MA, 2012); G. Deleuze and F. Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, trans. B. Massumi (Minneapolis, 1987).

[30] P.K. Haff, 'Technology as a geological phenomenon: implications for human well-being', *Geological Society of London Special Publications*, 395 (2014), 301–2.

[31] *Ibid*., 302.

[32] S. Cox, *Losing our Cool: Uncomfortable Truths about our Air-Conditioned World (and Finding New Ways to Get through the Summer)* (New York, 2010), 75–6.

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air conditioning was added to cars, it multiplied energy use: around 5 per cent of the fuel burned annually by American cars powers air conditioning.[33] Today, Americans use as much electricity for air conditioning as Africans consume for everything.[34] Air conditioning has facilitated a 'great enfolding' of humans. One recent study found that Americans spent only 7.6 per cent of their time outdoors.[35]

The technosphere is a new phase in the history of human niche-construction. It is ruthlessly cleansed, with sanitized surfaces, vacuum cleaners, disinfectants and antibacterial soaps. Along with the herd immunity granted by vaccination and a high-calorie diet, this has allowed human populations in the developed or technospheric world to grow bigger, taller and longer-lived, yet simultaneously subject to extended morbidity and a cascade of mismatch diseases (often related to our increasingly sedentary existence).[36] Microbes and insects are largely (if imperfectly) expelled from human settlements, while congregating, thriving and evolving in infrastructural niches. Pets and plants, meanwhile, are welcomed, while livestock inhabits its own increasingly hellish, mechanized zootechnosphere.[37]

Unlike the city, the technosphere is hard to visualize, imagine or map. Its scale and morphology are daunting. It is what Timothy Morton has called a 'hyperobject'.[38] A hyperobject is an entity so vast that it defies full phenomenological apprehension or cognitive comprehension. Yet we are enmeshed in it. This essay was written in and is sustained by the technosphere: it will probably never be read outside it. A hyperobject's temporal dimension is equally hard to grasp: watching the technosphere develop is not like watching the construction of an individual road or mall. The endless multiplication of infrastructural elements eventually generates something on an altogether new scale. Hence, the distinction between the technosphere and the city is vital. Particular cities are cognitively graspable precisely because they are 'states of mind' with specific histories, cultures, cuisines, rituals, architecture and designs. But these glittering, singular hubs are now engulfed by the murky, massive technosphere.

Perhaps we can leave the city and cross the threshold of the rural. But the rural, too, is largely a state of mind. In 1935, the botanist and grassland scientist George Stapledon, ruminating on the urbanization of

[33] *Ibid*., 82.
[34] *Ibid*., 32.
[35] N. Klepeis *et al*., 'The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants', *Journal of Exposure Analysis and Environmental Epidemiology*, 11 (2001), 239.
[36] R. Floud, R. Fogel, B. Harris and S. Chul Hong, *The Changing Body: Health, Nutrition, and Human Development in the Western World since 1700* (Cambridge, 2011); D. Lieberman, *The Story of the Human Body* (New York, 2013), esp. 209–92.
[37] T. Pachirat, *Every Twelve Seconds: Industrialized Slaughter and the Politics of Sight* (New Haven, 2011).
[38] T. Morton, *Hyperobjects: Philosophy and Ecology after the End of the World* (Minneapolis, 2013).

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Britain, declared that he wanted to see a rise in 'rural-mindedness'.[39] But he also wanted 'to equip the countryside with modern facilities and amenities . . . water supply, electric current, telephone facilities and roads'.[40] Through the multiplication of such materials and technologies, the technosphere expanded its reach while resurrecting 'the rural' as an idea. We are 'stuck' in and to the technosphere.[41] It disposes us to certain forms of behaviour which are very difficult to reject, which mobilize the countless chemical reactions which, cumulatively, are changing our climate.

The technosphere, finally, has generated numerous emergent political issues. Maintaining infrastructure is enormously expensive: in some parts of the United States, the condition of roads, water mains and electricity networks is causing serious anxiety.[42] To become homeless is largely to be banished from the technosphere or to experience it more episodically: megaslums proliferate around the technosphere's edges, a para-technosphere in which parasitic energy extraction is frequently criminalized. War is increasingly waged at technospheric level. Wars are driven by, and often for, oil. Terrorist attacks often target or utilize infrastructure, while military strategy involves the direct attack on power stations, sewage works or dams.[43] When the west fights, it brings its technosphere with it. At one point during the recent Iraq and Afghanistan wars, 85 per cent of all US diesel fuel was being used to cool soldiers and equipment.[44]

Conclusion

To comprehend the relationship between human activity, the built environment and climate change, we need to rethink two concepts at the heart of urban studies: agency and the city. 'Agency' is a problematic term in two ways: it is humanistic, and individualizing. The extraordinarily wide range of actions performed by living and non-living beings, at multiple scales from tiny chemical reactions up to the activities of vast infrastructures and planetary phenomena like climate, require an equally wide range of terms, some of which have been discussed in this essay. These terms have merely been sketched and the list is entirely provisional and far from exhaustive. The concept of the city, on the other hand, should not be replaced but complemented. For much of human history, perhaps, it made sense to speak of the urban and the rural, or the city and the country, as quite distinct entities. This is no longer the case. The advent of fossil

[39] R.G. Stapledon, *The Land: Now and To-Morrow* (London, 1935), 5.
[40] *Ibid*., 30.
[41] Morton, *Hyperobjects*, 27–37.
[42] America's crumbling infrastructure', *Economist*, 28 Jun. 2014.
[43] S. Graham, 'Urban metabolism as target: contemporary war as forced demodernization', in Heynen, Kaika and Swyngedouw (eds.), *In the Nature of Cities*.
[44] D. Zaborenko, 'U.S. army works to cut its carbon "bootprint"', *Reuters*, 27 Jul. 2008.

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fuels began a generalized dispersion, distension and agglomeration of urban space. This process ultimately produced the technosphere, a giant envirotechnical formation in which humans are born, live and die. The technosphere is where we live today. Its existence demands our urgent attention.

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