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Noel Keough & Geoff Ghitter

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ORIGINAL ARTICLE

Pathways to sustainable low-carbon transitions in an auto-dependent Canadian city

Noel Keough[1] · Geoff Ghitter[2]

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Abstract
Can growth-oriented resource-intensive cities be redesigned as non-consumptive sustainable places in a climate constrained world? This research tests that proposition through a design exploration of the transformation of a 500-ha inner city industrial district in Calgary, Canada, to a sustainable low-carbon city district. The research is formulated with respect to three theoretical axis—theories of urbanism, complexity and transitions; three spatial moments of the production process—production, reproduction and consumption and three temporal moments of the production process—manufacture, use, and post-use. The spatial and temporal moments leverage models of, industrial ecology and circular economy, sustainable cities and derivatives including smart, post-carbon and eco-cities. We employ a participatory design and backcasting methodology informed by theories of path dependence/creation. We establish a set of performance criteria, conduct three rounds of participatory design explorations and follow a strategy of scale-up of existing technology, engineering and design precedents. We identify a set of eight barriers and associated mitigation strategies. These include the stigma of living adjacent to, and the cost to rehabilitate, industrial lands; spatial and cultural auto-dependence; fragmentation of land ownership; infrastructure financing; regional connectivity and path dependence of the planning process. We propose that in order to achieve socially, ecologically and economically sustainable low-carbon cities attention needs to be addressed to culturally transformative alternatives to automobility, new forms of cooperative and localized economy, provision of non-market modes of land development and democratic and regulatory reform. To conclude we reformulate our conceptual framework within three nested domains—socio-technical, econo-political and cultural–cosmological.

Keywords Sustainability · Low-carbon · Design · Backcasting · Industrial ecology · Path dependence

Introduction

As global circumstances converge to threaten the environmental, social and economic stability of the anthroposphere it is becoming apparent that our continuing existence will require a transition away from the current unsustainable patterns of human settlement. Dating from Silent Spring (Carson 1962), 50 years of analysis has chronicled the alarming slide to the condition we now find ourselves in. Whether it is Sachs' (2009) warnings of the perils of inequality and injustice, or the revelations of unsustainable consumption of the world's resources by Rees (2010) and others or the most recent IPCC Report (2018) which makes clear the dangers of an increase of atmospheric carbon, the need for sustainability transitions at a global scale is undeniable. With up to 70% of global population residing in cities by 2050, the fate of humanity hinges on transforming urban life.

Cities around the world are taking up the challenge of the sustainability transition with a clear focus on the reduction or even elimination of carbon emissions (Fraker 2013). Of note are the scenarios generated by the Wuppertal Institute (2009) for transition in Munich; and innovations in Vancouver (Punter 2004); Hammarby-Sjöstad (Fränne 2007; Svane et al. 2011); Freiburg (Daseking et al. 2012; Forum Vauban 1999); Malmo (Rosberg no date); Curitiba (Macedo 2013);

Handled by Peter John Marcotullio, Hunter College, United States.

✉ Noel Keough
nkeough@ucalgary.ca

1 Faculty of Environmental Design, University of Calgary, 2500 University Dr. NW, Calgary, AB T2N-1N4, Canada

2 Institute for Sustainable Energy, Environment and Economy, University of Calgary, 2500 University Dr. NW, Calgary, AB T2N-1N4, Canada

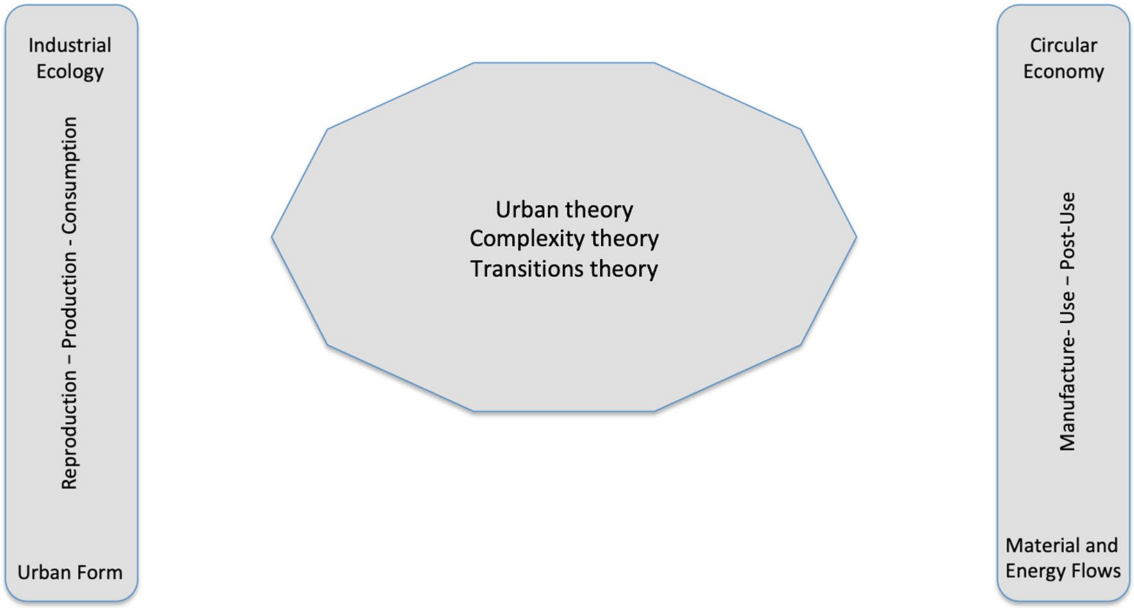


Fig. 1 Conceptual framework

Portland (City of Portland 2018); and Hannover (Rumming 2004).

It has been said that we make our places and then our places make us. If so, then the growth-oriented resource and energy-intensive modes of city life we have created can be re-imagined and redesigned to be non-consumptive sustainable places—an alternative way of life that Ehrenfeld (2009) calls flourishing. This research tests that proposition through a design exploration of the transformation of a 500-ha inner city industrial district.

We begin this paper by presenting a conceptual framework for thinking about city transitions. We describe a methodology that combines abductive design process with backcasting in the exploration of city district transitions. We describe the evolution and current state of urban planning in Calgary, Canada, with particular reference to the study site—the 500-ha Manchester industrial district. We construct a vision of the transformation of the district's built form as imagined for 2060. We present the findings of a participatory backcasting exercise that challenged a group of stakeholders to identify major barriers to the realization of the 2060 vision. We identify strategies (big moves) to address the identified barriers and finally, propose a reformulation of the initial conceptual framework.

Conceptual framework

So what is the malady for which low-carbon sustainability transition is the medicine? The hangover of the Newtonian machine metaphor of the world and its blithe application to the planning of cities is surely part of the diagnosis. Current systemic path dependencies are propped up by our hubristic belief in the power of the command and control directive in our dominant urban development models that persuade us to ignore all we have learned about ecologicalprocesses and limits (Rees 2010); the ideological commitment to 'economic-growth-as-well-being' and the Judeo-Christian affirmation of our utilitarian and instrumental relationship with the rest of nature. However, these ontological predispositions are being challenged by a more sophisticated understanding of basic human physical and psychological needs and renewed attention to the articulation of a normative moral and ethical code that addresses intergenerational, intra-generational and intra-species obligations in the face of irreversible climate change (Gardiner 2008) and the humbling realization of the existential threat posed by the power and sophistication of the technologies of intervention we have at our disposal.

There is far from universal agreement about the concept of sustainability so not only is inertia inherent in the struggle to alter the current unsustainable path, but the forging of a new path confronts active resistance of those still wedded to the hangover view of the world described above. With respect to the trajectory of change in cities, business as usual persists because of a tenaciously defended status quo and successive layers of customs, codes, incentives, legislation, by-laws, norms, standards, prohibitions and practices enacted through rigid corporate cultures that produce a tightly coupled self-replicating system (Burch 2010).

Our framework (Fig. 1) is an amalgamation of concepts embedded in urban theory and sustainable post-carbon cities; complexity theory; and transitions theory. The framework is augmented by consideration of three spatial moments of the production process—production, reproduction and consumption and three temporal moments of the production process—manufacture, use, and post-use.

Leading urban theorist David Harvey (2013) positions urbanization at the core of capitalist accumulation strategies or what Keough (2005) calls capitalist place-making. Citing the work of Bourdieu and Latour (Bender (2006) is drawn to questions of agency and practice—who does the work of change—in urban transitions. For Bender cities 'are a precipitate of history' (p: 2). Cities are both the 'thing' of our inquiry but at a deeper level they are process with a history, a trajectory, and porous boundaries 'marked by complex, conflicting, multi-scaled and dense processes, relations and interconnections' (p: 3) They are no less than 'the most complex human and material aggregation ever realized on this planet' (p: 4) He argues for more attention to processes of assemblage, disassembly, networks of persons and materials where the social is a 'provisional pattern of associations' and where change happens as a result of 'multi-causal' or 'conjunctural' explanations (p: 11).

These theories of the urban are consistent with the notion that cities are human-dominated manifestations of the more general phenomenon of complex adaptive systems. Complexity describes an ecological and evolutionary ontology where multiple, overlapping and hierarchical systems solidify, dissolve and re-form over time through endogenous and exogenous processes. Complex adaptive systems (CAS) (Holling 1994) are typically non-linear, open, emergent, creative and more fundamentally, predominantly indeterminate (Arthur et al. 1987; Funtowicz and Ravetz 1994; Inayatullah 1994; Kauffman 1995; Kay et al. 1999; Gunderson and Holling 2002; O'Sullivan 2004).

In our conceptual framework the phenomenon of path dependence is a core characteristic of CAS. The evolutionary nature of CAS suggests that path dependence is not a pathological condition but is a ubiquitous attribute of complex adaptive systems. In recent decades the concept of path dependence has become the lynchpin of an 'evolutionary turn' in the social sciences, especially in economics (Arthur et al. 1987), political science (Pierson 2000; Boas 2007), and, more recently, economic geography (Martin and Sunley 2007). Path dependence theory was originally conceived by economist Paul David to help shed light on the puzzling persistence of particular economic processes that do not converge, as neoclassical economic theory demands, to the most efficient outcomes (David 1985) and that, in fact, multiple equilibrium states were possible.

That new pathways emerge is uncontested; how they catalyse, what they look like, which ones endure and where they lead are not as simple to predict. One point of contention centres on the role of human agency (or lack of it) in so-called path-dependent systems. The notion of lock-in was criticized for being too deterministic and was interpreted to mean that once the initial conditions and inertia have established a systemic trajectory, the future prescribed by those initial conditions is indelible. Garud and Karnøe (2001) for example, reject an ontology in which 'the emergence of novelty is strictly a result of serendipity with no accounting for human agency' (p: 6). We would agree that there has to be room for human agency. But human agency can disturb a system, not necessarily direct it (Maturana and Varela 1998). Interventions are not random but neither are they prescribed. Critical conjunctures can result from historical accident, serendipity, intentional acts, or through unanticipated convergence of the accidental and the intentional.

Varela et al. (1993) provide an intriguing possibility with the notion of path making and natural drift wherein the evolutionary process is imagined as a kind of bricolage and tinkering that 'satisfices', i.e. finds a 'suboptimal solution that is satisfactory'[1] (p: 196). System and environment are co-implicated in their mutual specification. Varela's guiding metaphor is that 'a path exists only in walking' (p: 241).

The path dependence exhibited by complex evolutionary systems is a core concept in transitions theory. Transitions theory has inspired a burgeoning literature exploring how change actually happens. The most prominent proposition of the change process is the Multi-Level Perspective proposed by Geels (2010). The MLP describes three elements of transition—the niche innovation, the business as usual regime and the contextual landscape of larger and longer processes that inform and shape transitions. While CAS are inherently evolutionary, what is unique to sustainability transitions theory is its purposiveness (Geels 2010), the conscious attempt to influence the pace and direction of evolutionary change.

Transitions theory has been criticized as being too focused on sector specific technologies, Eurocentric realities and the nation state. Our research adapts the MLP identifying the low-carbon sustainable city district and its bundle of sector specific technologies (transport, energy, water, land use, consumption, etc.) and social processes as the niche; the political, economic, regulatory systems of the city as the regime; and global ecological change (predominantly climate change), the neo-liberal economy and a cultural discourse about the relationship between humans and the rest of nature as constituting the landscape.

From within the transitions literature Loorbach (2007) calls for transition experiments, 'iconic projects with a high level of risk that can make a potentially large innovative contribution to a transition process' (p: 176), and that broaden, deepen and scale up existing and planned initiatives and

[1] In fact Kenneth Arrow's impossibility theorem suggests that with respect to the interaction of multiple systems or agents, the holy grail of optimization is a chimera.

actions. Transition experiments establish a broad constituency of representatives from industry, politics, and society that accompany the ongoing planning and implementation process; develop a vision of a sustainable future; identify pathways towards these future states by means of backcasting and set up experiments for particularly interesting development options.

In their study of leading global cities, Hodson and Marvin (2010) find that urban transition is driven by global forces of competition; energy and resource scarcity; and ecological challenges like climate change. In response cities are seeking less resource-intensive infrastructure and strategies for more localized resource provision. Hodson and Marvin also emphasize that 'the production of visions is an important participatory process used to engage, inspire and mobilize a wide variety of different social actors' but caution that it 'involves negotiation and struggle' (p: 481), and that a vision 'is a necessary but not sufficient condition of a purposive urban transition…' (p: 482) Van den Bergh et al. (2011) are more forthright in acknowledging that 'beyond incremental environmental innovations we need major, system-wide changes that are likely to involve breakthrough technologies and possibly fundamental changes in social aims, institutions, industrial structure and demand.' (p: 7). Likewise, Williams (2013) argues that low-carbon transitions in cities will require the mobilization, through the planning process of 'protected spaces' that are collaborative, systemic and market shaping.

In their examination of 18 large-scale post-carbon transition strategies Wiseman et al. (2013) find that 'The strategies typically did not go into great detail about how to address social equity or governance aspects of the transition' and that they lacked 'detailed game plans… for mobilizing the required level of political leadership and public support for rapid transitions.' (p: 91) Hodson and Marvin (2013) reinforce this concern in their study of five diverse low-carbon transition cities, pointing to the conflicting motivations of neo-liberal competition against social inclusion and ecological integrity in existing experiments in the UK.

From the North American experience, Bronstein (2009) and Leigh and Hoelzel (2012) introduce the concept of the 'blind side' of smart growth and new urbanism—the marginalization of places of production in cities. These authors bring attention to a lacuna that is prominent in some of the most iconic examples of sustainable or low-carbon city initiatives including Vancouver, Portland, Freiburg, Stockholm, Copenhagen and Helsinki. From the industrial ecology literature Kennedy et al. (2012) call for the discipline to apply its methods 'to push the interdisciplinary boundaries of industrial ecology even further, linking with other disciplines and recognizing that it is social actors (i.e., people) who shape urban systems' (p: 775). Inspired by the concept of industrial ecology the Manchester district design exploration attends to the 'blind side' and applies the concept of industrial ecology to processes of production, reproduction and consumption in ways similar to that proposed in the maturing model of the circular city (Prendeville et al. 2018; Vilella 2018; Milios 2018).

The study area in historical context

Calgary was founded in 1875 as a western hub along the trans-Canada railway. The land surrounding Calgary was ideal for dry-land farming and livestock grazing and swiftly a strong agricultural economy emerged. In 1894 Calgary incorporated as a city (population 10,000) and by 1912, owing to successive waves of European immigration beginning in the late 1890s, the population swelled to 55,000. Amid a land boom fuelled by immigration, the Manchester industrial district was commissioned in 1911 and envisioned as the city's primary heavy industrial area complete with a tramline servicing both the district and the adjacent workers neighbourhoods. But, as the pre-war boom turned to bust, the hoped-for development did not fully materialize.

The development trajectory of the city changed forever when, in 1947, Imperial Oil made a major oil discovery at Leduc, just south of Edmonton, the provincial capital. Calgary emerged as the financial and administrative centre of Canada's oil industry. At that time Calgary, like many North American cities, was already experiencing a rapid increase in economic activity to meet the pent-up demand for housing, consumer goods, automobiles and luxury items (Stamp 2004) of returning WWII veterans. The Leduc discovery stimulated billions of dollars more in energy-related investments with Calgary eventually becoming the fastest-growing, youngest, best educated, and highest income city in Canada.

The post-WWII pace of urban development reflected the optimism and wealth of that generation and the resulting suburban form manifested these values (Stamp 2004). For many years almost all growth occurred in greenfield suburban development on Calgary's fringes. Not surprisingly, Calgary's extensive tram system, including the Manchester line, was decommissioned in 1947 when the private automobile emerged as Calgarian's preferred transportation choice (Hatcher and Schwarzkopf 2013). During this period Manchester thrived.

But city planners faced a dilemma. Conditioned by decades of pre-war slow growth and low revenue and unconvinced that the new oil economy was permanent, decision-makers were reluctant to underwrite the exploding demand for urban services provoked by the oil rush. As an adaptive response, through a series of agreements beginning in 1955, the city retreated from its traditional role of developer and ceded that function to the private sector. (Foran 2009). Over time, zoning, permitting and approval processes were streamlined and the city bureaucracy was actively reengineered to conform to the suburban vision.

By the 1980s Calgary's development pattern began to alarm city managers. They realized a growing disconnection between land use and transit planning and the unsustainably high costs of future maintenance. In 1984 a legally mandated municipal development plan (MDP) was drafted, however the modest reforms it proposed were seen by the developers, and their allies on city council and in the administration, as threatening to the highly profitable status quo. In a Flyvbjergian-style (Flyvbjerg 1998) showdown the plan was rejected following intense lobbying by the development regime with a strong ally as mayor, himself a former developer. The planners who created the plan were summarily replaced while a new town plan, reverting to the "business as usual" suburban model, was adopted in 1986.

Stimulated by Local Agenda 21, the urban manifesto of the 1992 Earth Summit in Rio de Janeiro, new design approaches and participatory processes emerged in Calgary. The 1998 municipal development plan signalled the City of Calgary had engaged with the new agenda. In that same year the newly formed citizens organization inspired by the Earth Summit, Sustainable Calgary Society, published its first State of Our City Report. Yet, owing to its fossil-fuel-generated wealth, rapid growth and the maturation of the automobile era, and the entrenched trajectory of the development paradigm, the city remained among North America's most sprawling.

Galvanized by the failure of the 1998 MDP to achieve meaningful change, a new municipal-government-led initiative designed to engage citizens in participatory planning and sustainable transitions—imagineCalgary—began in 2003. Taking a cue from the Vancouver model (Punter 2004) stakeholders and citizens embarked on the most extensive public engagement process of its kind at that time engaging approximately 18,000 citizens in crafting a 100-year vision for the city. Guided by systems thinking and instilled with extensive public and expert contributions the vision it produced was unanimously adopted by Calgary city council. The imagineCalgary vision became the foundation for developing the legally binding 2009 Municipal Development Plan[2] and a complementary transportation plan (collectively known as PLAN IT). PLAN IT contemplates urban growth and development over a 60-year time horizon in which the population was forecasted to double to 2.4 million with half of the 1.2 million new inhabitants settling in greenfield developments and half in the existing city

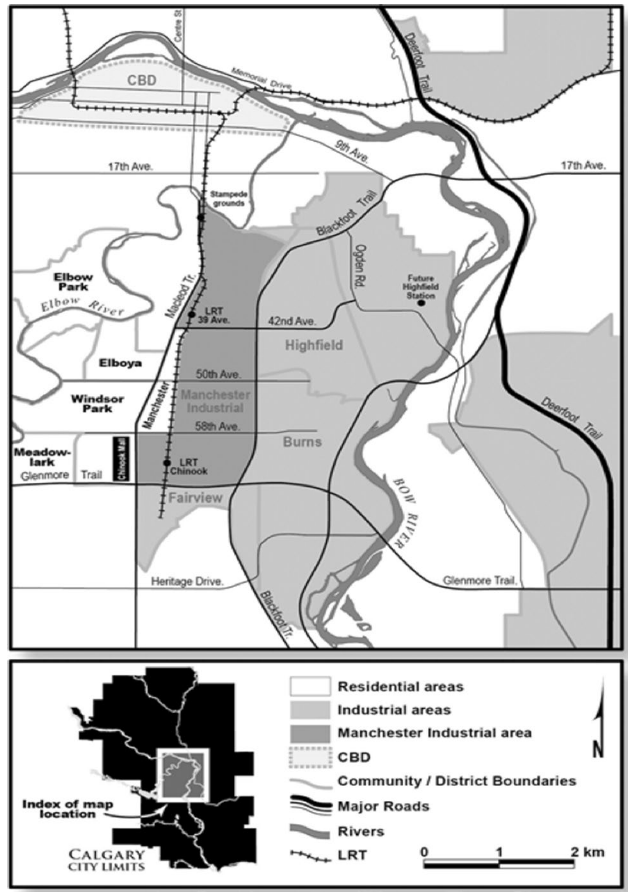


Fig. 2 Location of Manchester district

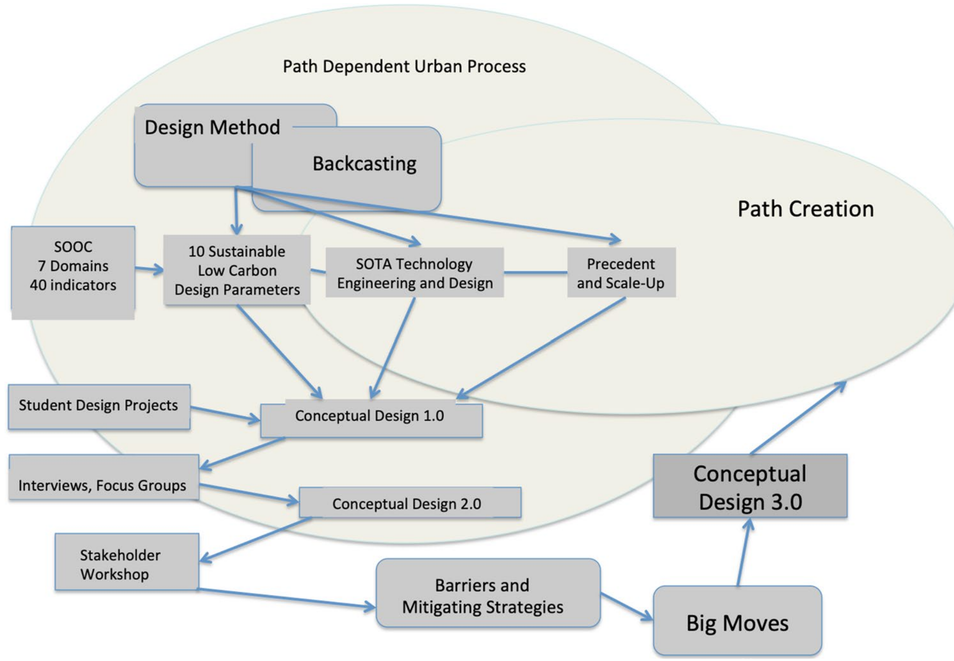
footprint.[3] In recognition of the historic slippage from vision to policy to action the Manchester project was undertaken as an academic and citizen action research attempting to set the agenda for sustainable low-carbon transition within the existing city footprint.

The 500-ha Manchester district (Fig. 2) is located only two kilometres from the central business district (CBD) in the southeast quadrant of the inner city and is traversed by thesouth leg of Calgary's light rail transit (LRT). In 2018 little heavy manufacturing now takes place in the district with land uses chiefly devoted to logistics (warehousing and distribution); commercial, industrial and wholesale retailing; specialty auto and truck servicing; home renovation supply and services; big-box consumer retail operations and a wide variety of small businesses and services. There is a small residential enclave on the western boundary of the district

[2] Provincial legislation mandates 10-year updates for every municipality's development plan.

[3] The 50/50 split between inner-city and greenfield development represents a last-minute 'compromise' forced by the suburban developers and their allies on council who threatened to scuttle the entire process if the division was not reduced from the 65/35 split originally recommended.

Fig. 3 Methodology



housing approximately 500 people. Manchester is characterized by low-density land uses having an average floor/area ratio (FAR) less than one on most blocks. Approximately seventy percent of the land surface is devoted to automobile infrastructure (roads and parking).

Materials and methods

Figure 3 depicts our research method. Accepting Garud and Karnoe's argument about agency and Varela et al.'s notion of satisficing, then the critical question is what methods can optimize the creation of stable and resilient pathways for sustainable transitions. For the Manchester project, we decided on a backcasting methodology (Robinson 1982; Robinson 2003). The concept, originally formulated as 'backward looking analysis' by energy analyst Amory Lovins (Lovins 1977), distinguished between likely energy futures and desirable energy futures. While the 'likely' and the 'desirable' occasionally coincide, more often they do not. Lovins' assumption was that after having identified strategic objectives in a particular future, it would be possible to work backwards to determine the policy measures needed to create a pathway toward that future. Lovins' original insight has been adapted for participatory process by Quist and Vergragt (2006) and Carlsson-Kanyama et al. (2008). Vergragt and Quist provide a definitive overview of backcasting for sustainability defining it as 'generating a desirable future, and then looking backwards from that future to the present in order to strategize and to plan how it could be achieved' (Vergragt and Quist 2011 p: 749). In this present study, we deploy Vergragt and Quist's 3rd class of backcasting—a normative scenario of what should happen.

Metrics for a sustainable low-carbon district

A first step in the design process was to establish a set of metrics, or design parameters representing a sustainable low-carbon future and to employ them as a heuristic tool to orient the design process. Our design parameters were derived from the State of Our City (SOOC) Community Sustainability Indicators Report (the work of the aforementioned Sustainable Calgary Society) reports on a set of 40 sustainability indicators for Calgary across seven domains (economy, community, wellness, education, resources use, natural environment and governance) (Sustainable Calgary Society 2011). These indicators were established through of participatory processes involving 2000 citizens over a 3-year period—1996–1999. These citizens were self-selected based on a broad invitation to citizens disseminated through municipal government, community organization and academic networks. Five SOOC Reports were published between 1998 and 2018. The analysis of the 40 indicators revealed two consistent challenges to sustainability transitions—resource overconsumption and socio-economic inequity.

The following ten design parameters chosen for the Manchester design exploration were derived from the resource use and economic domains of the SOOC Report: a fair share ecological footprint; 100% renewable energy; 70% reduction in Oil and Gas Reliance Index (a combination of oil and gas contribution to city employment, GDP and exports); 80%

reduction in CO2 emissions; 80% of water harvested within the district boundaries; zero waste to landfill; automobile-optional living; optimization of local material sourcing and goods and service provision; a ratio of 10 between the top 20 and bottom 20 percent of income earners and levels of inequality (Gini co-efficient) at or below those of Scandinavia.

Conceptual design process

Designer Jon Kolko has described design as 'a way of organizing complexity' through abductive thinking and sensemaking (Kolko 2010 p. 15). He defines sensemaking as 'a motivated, continuous effort to understand connections (which can be among people, places and events) in order to anticipate their trajectories and act effectively' (p 16). Contrary to deductive and inductive reasoning, the abductive process is not about finding the 'truth', or even the 'right' answer, but a 'good' answer (reminiscent of Varela's notion of satisficing). A design is manifest when a designer steps beyond the threshold of what Stuart Kaufmann (1995) calls 'the adjacent possible', where an infinite variety of hypotheses exist, and commits to a solution. Kolko uses Roger Martin's definition of abduction as the 'logic of what might be' or the argument to the best explanation' (p: 20). Abductive reasoning generates insight and creative problem-solving. As Kolko explains, design synthesis has its own form of rigour that involves issue framing, prioritizing, judging, recognizing semantic connections and concept mapping.

Our design process was framed by the aforementioned design parameters and three key strategies: deployment of state-of-the-art technology, engineering and design (TED); precedent and scale-up; and expert and stakeholder consultation. Typically, solutions to critical challenges like climate change (e.g. ecological modernization) defer to heroic technological solutions and imagine the emergence of disruptive and transformative technologies to save the day. Imagining new technological fixes is often a reason for inaction in the present. Our strategy is to assume a realistic transition path to be one wherein at full build-out the Manchester district deploys state-of-the-art existing technology, engineering and design—no magic fixes, simply a rigourous deployment of proven TEDs.

A standard design tool is precedent research (van den Toorn and Guney 2011). Following from the decision to deploy proven TEDs, precedents demonstrate examples of where a particular TED has been used successfully. Precedents used in conceptual design of the Manchester vision, have to date been deployed at a much smaller scale. For this reason, scale-up of precedents is another element of our methodology. For example, neighbourhood and community design precedents for this study include Vauban, Freiburg; Hammarby-Sjostad, Stockholm; Western Harbour, Malmo; and Olympic Village, Vancouver. All are in the range of 30–40 ha—less than ten percent of the size of the Manchester district.

The initial design concept 1.0 for Manchester emerged out of a series of course-based (housing, infrastructure, sustainable design, participation in planning) design projects at the University of Calgary, School of Architecture, Planning and Landscape from 2009 to 2012. Design concept 1.0 was refined and adjusted between June 2012 to May 2013 as the authors presented the initial concept in a series of one to 2 h interviews, public presentations and focus groups with a diverse group of approximately 50 stakeholders including City of Calgary units (land use planning; environmental services; transportation); land owners and developers, university researchers, Calgary Economic Development, Chamber of Commerce, ENMAX (the city-owned energy utility) and community organizations. This process yielded design concept 2.0.

Backcasting, barriers and strategies

In May 2013 a day-long workshop brought seventy stakeholders from the same sectors as noted above (a microcosm of those who actually build the city) together to identify the major barriers to achieving design concept 2.0) and strategies to surmount the barriers. The workshop was subdivided into 7 working groups: housing, water and waste, transportation, land use, energy, industrial diversification and governance. Each working group identified specific barriers to the realization of the vision, strategies for overcoming the barriers, precedents that illustrated the strategy and major milestones along the imagined path of transition. Figure 4 is an example of the worksheets used for working group reporting. During the second half of the workshop each group was given the opportunity to present their preliminary findings to the other groups and then return to their own working group to refine their strategies. Using a modified grounded theory (Strauss and Corbin 1997) approach to analyse workshop results, the study team identified eight key barriers and associated strategies and precedents. This workshop analysis informed thegeneration of Design Concept 3.0.

Results: stakeholder workshop

Almost universally stakeholders were enthusiastic about the vision for a future Manchester, but were cautious to sceptical about the capacity to achieve it. Several key barriers and associated mitigation strategies were identified.

Stigma of industrial land

As an industrial district Manchester carries a significant stigma as a dirty, noisy and undesirable place. Modern planning emerged as a response to the health and safety

Fig. 4 Design workshop working group worksheet: barriers

Worksheet 1A. Describe The Barrier

Describe the Barrier:					Rank
How big an obstacle is this barrier?	1	2	3	4	5
In which sector does this barrier appear?	Government – Municipal/Provincial/Federal Private Sector Civil Society Other				
In what time frame must this barrier be dealt with?	Immediate 2 years	Short 5 years	Medium 10 years	Long-Term	

NOTES/Questions to Answer/Research to Conduct:

concerns of unregulated urban development where polluting and toxic factories operated alongside residential areas, and inadequate water and sewer systems promoted disease. The response was to implement rigid land use segregation of residential, commercial and industrial activity. To realize all of the benefits of mixed-use development, the Manchester vision requires that new industrial activity will be clean, quiet, safe and compatible with retail and service activity and most critically, residential land uses.

Costs of rehabilitation

The historical legacy of noxious industrial activity presents a more particular challenge of brownfield development—the risk and liability, cost of development and technical challenges of clean-up associated with contaminated sites. The question of who bears the risk—taxpayers, residents and tenants, landowners—becomes contentious. Navigation of multi-jurisdictional regulatory hurdles and the financial and technical limitations of reclamation technology pose significant challenges.

Auto-dependence

Transportation's dependence on fossil fuels is perhaps the most intractable energy sustainability transition challenge. To achieve the modal split required to make the Manchester vision viable, auto-dependence will have to be addressed. In an auto-dependent city like Calgary, people will have difficulty imagining life without a private vehicle or that most travel within the city can be accomplished via modes other than the automobile. Whether the psychological and technical barriers can be overcome by the social, ecological and financial benefits remains to be seen.

Inability to think in generational time horizons

Stakeholders perceived that the articulation of a long-term vision would blunt the immediate task of kick-starting the transition of Manchester—the need to take action now. There was a sentiment that "we can't predict what will happen over a longer period of time… what do we do right now and in the next 5 years!" While there are certainly rational arguments to support the focus on the shorter term coupled with the adoption of adaptive management strategies, the discourse around this issue portrayed a dissonance between a strong consensus about the real and potentially catastrophic consequences of global climate change, and the rather conventional framing within the strategies and scenarios discourse, of what development in Manchester might look like. Given that the core economic engine of Calgary's economy is the climate-sceptical fossil fuel industry this resistance to thinking long term, to an era when fossil fuels no longer dominate the city's economy, is a difficult leap for many.

Inertia in the planning process

The inertia and fragmentation associated with planning and regulatory processes that control land use and development emerged as a critical consideration in workshop discussions. Planning regimes evolve slowly over time. Even as what constitutes good urban design converges to the desire for walkable, mixed-use communities entrenched planning codes formulated to separate uses often prevail. Planning system inertia dictates that at least in the short run—the time frame for election cycles or land development processes—the established way of doing things is generally less time consuming and less costly. In response to the risk associated with innovation, planning regulations may become even more onerous forcing developers to set the investment decision bar higher. The issue is compounded by the historically closed alliance of city government as a facilitator of private sector-led development finance and planning (Foran 2009).

Fragmentation of land ownership

Unlike most successful large brownfield site conversions where there is a single landowner (often public) land ownership in Manchester is highly fragmented. The fragmentation makes it difficult to assemble land, to arrive at common ground with respect to the vision for the district or to initiate, sustain or achieve a long-term integrated vision.

Financing transition

The scale of the Manchester district makes it a formidable challenge even for a conventional redevelopment regime. The barrier is more formidable when we consider that the case for Manchester rests largely on social and environmental return on investment and the ability to tolerate conventional return on investment over a very long time horizon. To manage the risk associated with the financing of the water, energy and transportation infrastructure will require innovative professionals, collaboration among many institutional actors, and assemblage of multiple funding sources. In a political culture dominated by neo-liberalism, where government is usually an enabler and the private sector the active agent in urban development, where municipal revenue generation is limited to property taxation, large-scale public investment for a master-planned, high-risk innovative vision of Manchester, will be challenging.

Urban and regional scale connectivity

The Manchester vision proposes a radical departure from the existing urban fabric with consequences for the connectivity of major infrastructures (energy, water, and transportation) and material flows (of industrial activity) with existing city and regional infrastructures. We imagine Manchester as a district scale niche development, but it most certainly will have to evolve in close relationship with the existing urban and regional fabric. Here governance is key. The Calgary Regional Planning Authority was abolished in 1995 and replaced by the voluntary Calgary Regional Partnership that in turn was disbanded and replaced anew by a legally mandated Calgary Metropolitan Regional Board in 2018.

Results: Manchester district conceptual design 3.0

The conceptual design envisions that in 2060 the Manchester district will house approximately 80–100,000 people. Housing types will range from single-family detached to 20 + story high-rise condominiums. Mid- and high-rise buildings will be predominantly mixed with retail and commercial activity, and where appropriate, light industrial. Affordability is a critical metric for the future Manchester. In Canada, with one of the most private sector oriented housing regimes in the world, the private sector has been unable to deliver affordability and processes of gentrification expand and intensify.

In Manchester, affordable housing will be achieved through a variety of non-market innovations including municipally owned and operated social housing; cooperative housing; and co-housing. Long-term affordability will be protected through the establishment of a Manchester Community Land Trust. Buildings will be required to achieve the highest water, material and energy efficiency building standards (LEED Platinum, Living Building, Passivhaus, or Net Zero). The district will have an abundant supply and diversity of entry-level and mid-level housing choices to ensure the community life cycle is accommodated. A large supply of rental housing will make up a significant proportion of the districts housing stock.

The residential, commercial/retail and industrial/manufacturing land use mix will vary across the district, sub-district neighbourhoods and precincts, block-by-block and even building-by-building (e.g. design, fabrication, retail and residential could locate in the same building). As depicted in Fig. 5, heavier industrial activity will occur predominantly on the central east district of Manchester. Moving in a radial fashion east, north and south the percentage of retail and residential activity will increase with residential dominant along the LRT line. Mixed-use compatibility criteria will guide industrial enterprise recruitment.

The Manchester energy strategy includes conservation, efficiency and renewables. It begins with a determination of energy demand (electricity, heat, light and motive power) and its internal provision via insolation, wind, biomass and industrial waste and waste heat from industrial processes supplemented with wind and solar energy from the southernAlberta region, and the potential to access hydro-electricity supplied through a western Canada grid. The backbone of the physical energy generation and distribution infrastructure will be a combination of distributed and district energy and combined heat and power facilities. The majority of buildings will achieve a net-zero or equivalent standard generating their own energy requirements.

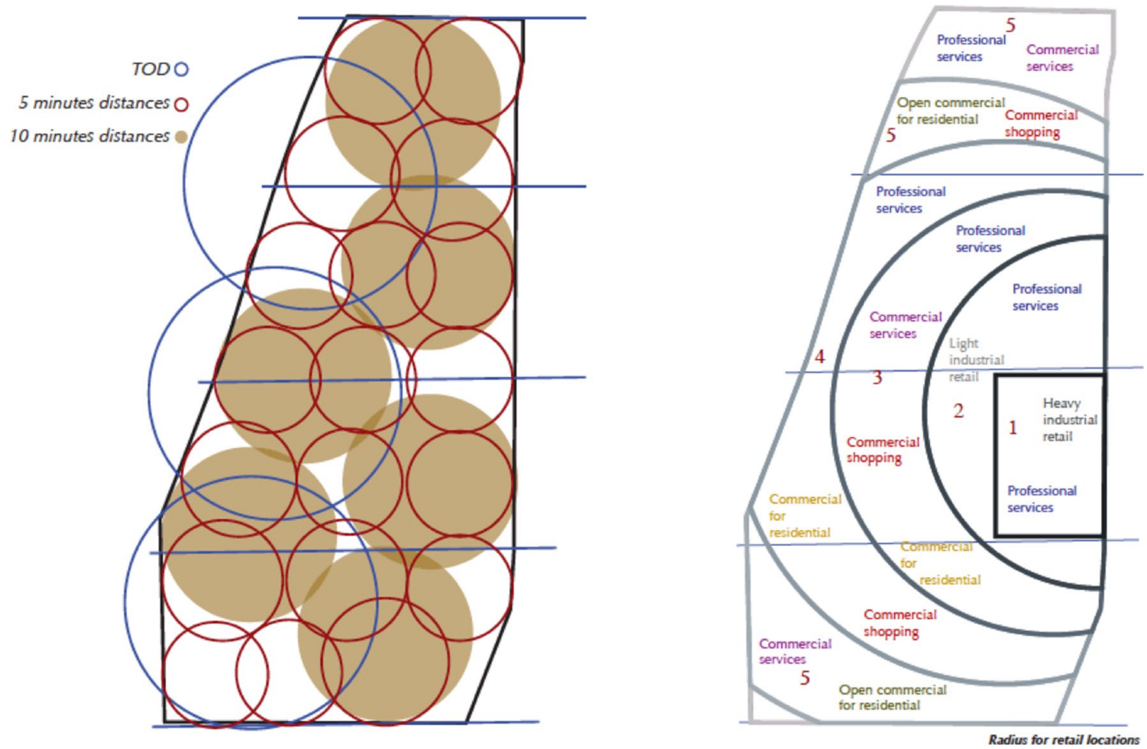


Fig. 5 Spatial strategy for residential, commercial and industrial

Fig. 6 Active modes-oriented transportation network

The backbone of the transit system will be a wind-powered streetcar network.[4] The district will continue to be served by the LRT with a third station to be built at the mid-point between the two existing stations. Streetcar lines will host predominantly retail/commercial activity with a residential and light industrial mix. The rail-based transport systems; a community-operated, electricity-powered car-share programme; bike and green space networks; and

[4] Calgary's Light Rail Transit is currently powered by wind electric energy.

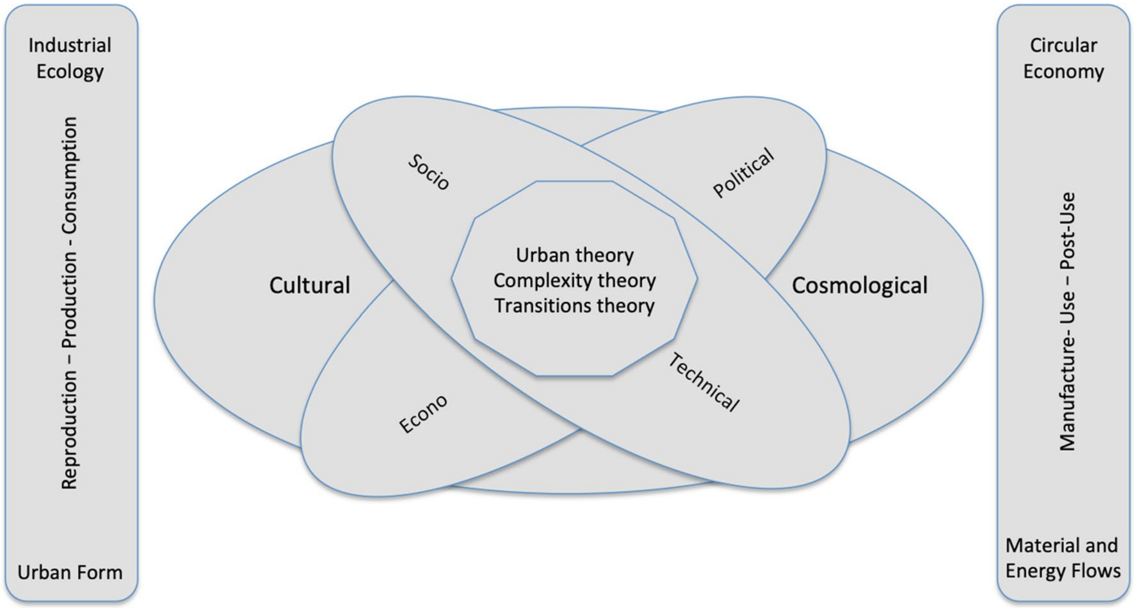


Fig. 7 Revised conceptual framework

the provision of high-quality pedestrian environments will quarter the modal share of the automobile. Some residential neighbourhoods will be car-free (Fig. 6).

Manchester's water demand will be met through the deployment of aggressive rainwater capture and recycling. The triple mix of residential, commercial and industrial land uses will facilitate optimization of grey water for non-potable purposes. The water strategy will also employ low-impact development to reduce runoff and hard infrastructure requirements (Fig. 7).

Organized around an industrial ecology concept, Manchester will achieve zero waste to landfill by diversion of solid waste to industrial processes (energy production and materials) or to reuse and recycling. Organic waste will be eliminated through a comprehensive composting programme. Heat energy, nutrients and water will be captured from the liquid waste stream and reused and recycled. Urban agriculture will employ a combination of rooftop hydroponic and aquaponic production, community gardens and vertical agriculture to optimize food grown locally.

Industrial activity will be managed through a public or cooperatively operated district logistics and management facility. Its role will be to create the industrial ecology, identify and exploit synergies between existing enterprises and recruit new enterprises and anchor tenants to the district that add value to and fill available niches with a focus on sustainable, clean-tech and localizing[5] industrial activity. Over time the district's ecology will be built around the anchor tenants. The facility will manage water and energy provision and material flow logistics between enterprises in to and out of the district. Internal large-truck traffic will be aggressively restricted. The edge-of-district terminal will receive and dispatch material via truck and rail. Material movement within the district will be via a materials movement system utilizing the streetcar grid, conveyors, elevators, electric powered small trucks, lightweight airport-like materials handling and two- or four-wheeled human powered vehicles.

The district will be supported by a research, development, teaching and learning centre—a joint venture between the municipality, industry, and Calgary's post-secondary research institutions. The centre will be mandated to support research and development pertaining to the particular needs of the Manchester District—e.g. green buildings, renewable energy technology and industrial ecologies. The centre will facilitate the integration of post-secondary teaching and learning and serve as a site for industrial tourism—interpreting and showcasing the green industries, technologies and urban designs integrated into this working urban socio-industrial landscape.

[5] Localizing refers to an anticipated trend toward the return of manufacturing to North America as seen in the on-shoring phenomenon and to the trend toward more goods for local consumption being produced locally as argued by economist Jeff Rubin in 'Why Your World is About To Get a Whole Lot Smaller".

Discussion

The stakeholder workshop yielded design concept 3.0, and the identification of eight barriers and associated strategies to address the barriers. In this discussion we focus on four 'big moves' we propose will be necessary to achieve the Manchester vision. The 'big moves' address the culture of the private automobile, land ownership, a cooperative and localized economy and democratic and regulatory reform.

Arguably one of the most important yet entrenched elements of a high-carbon city is the private automobile. The rise to dominance of the automobile, has spun a web of practices produced via what Seiler (2008) calls "automobility". Seiler argues that very early in its life, the automobile has been imbued with deep cultural meaning—modernity, freedom, individualism—that is more important even than the utility (or not) of the automobile. Automobility has evolved as a capitalist market oriented solution with public transportation as an inferior supplement. We propose to transform transportation as a public utility in the sustainable low-carbon city where there is no private automobile ownership. The automobile is deployed where it is the best option but precedence is given to human powered modes, and public transit. Walkable neighbourhoods, bicycling infrastructure, electric streetcars, LRT, commuter rail and carshare systems would all be part of the transportation utility matrix by design.

Realization of Manchester vision will require the assembly of a critical mass of public lands. Manchester is currently characterized by very fragmented and predominantly privately owned land. In most of the precedents we have examined land was typically publicly owned—often the land was decommissioned industrial lands. Currently approximately 10–15% of Manchester is publicly owned. Step one of this strategy is to retain public lands. Second is to begin assembly through purchase, or to establish a land bank (Lewis and Turnbull 2011). A land bank is a mechanism whereby as quid pro quo of city investment in public infrastructure (e.g. an Light Rail Transit station) the city acquires a portion of the bump in private land value in the vicinity of the station either through private sector contributions to the cost of the infrastructure or via direct transfer of a portion of the lands to public ownership. In this manner a critical mass of publicly owned land can be assembled and can be used to shape the path of a sustainable low-carbon transition.

Implicit in Harvey's (2013) critique of capitalist accumulation through urban development is the imperative to wrest control of city-building from the capitalist growth model. The Manchester vision will require all levels of government to incentivize a cooperative economy. As Lewis and Conaty (2012) and Restakis (2011) both argue a cooperative (or social or solidarity) economy puts the economy under more local and democratic controls and makes it more likely that the logic of the growth imperative can be undermined. An important tool in this effort is to leverage the land bank of public lands for affordable non-market housing. There are various existing models to achieve this end. Canada has a long history of successful cooperative housing with over 50,000 Canadians living in cooperative housing (Cooperative Housing Federation of Canada 2018). Co-housing is another important ownership and community-building housing option that has been borrowed from Denmark but is flourishing in western Canada (Canadian Co-Housing Network 2018). Community-land trust is a very promising model that has recently been piloted in Vancouver (Patten 2015) and has a long and successful history in the US most notably in Burlington, Vermont. Most ambitiously the Mondragon Cooperative in the Basque region of Spain and the Letchworth model in the UK offer examples of communities where production, reproduction and consumption activities are organized on a large scale under an integrated cooperative model (Conaty and Large 2013). A key element of the cooperativization strategy is to reform investment and tax regimes that currently restrict investment options in cooperatives and favour investment in private markets (McQuaig and Brookes 2011). Another key element in this cooperativization strategy is to leverage worker capital,particularly the hundreds of billions of dollars of public sector pension funds now invested in private markets fueling unsustainable corporate economic activity. A final key opportunity to cooperativize the economy is the emerging new industrial and innovation strategies at both provincial and federal levels of government. These strategies need to include explicit incentive and support for cooperative industrial development.

As Jeff Rubin (2010) has argued in *Why Your World is About to get a Whole Lot Smaller*, a post-carbon world is one that is re-localized. Our proposal for Manchester is to build a district that is designed to serve that re-localized world. This begins with a strategy of harvesting resources locally (particularly energy and water), sourcing other materials locally and servicing and manufacturing locally for goods and services that in the fossil fuel age of growth were globalized (TD Economics 2012).

The transition of Manchester district as imagined is a monumental task. It is made all the more difficult in a dysfunctional polity, whose manifestation is in part the identification of planning regime inertia as a barrier to the Manchester vision. In short, in Calgary and Alberta the processes by which we make decisions that determine the success or failure of sustainable low-carbon transitions, is broken. Taft (2017) has demonstrated the issue specifically at the provincial and Federal levels in Canada with his investigation of

Oil's Deep State. Geels (2014) identifies the role of power and the need for regime resistance in transitions. Hodson and Marvin (2013) argue that a democratic deficit is a barrier specifically to low-carbon transitions in five case study cities in the UK. To be successful this transition process must engage with civil society allies championing democratic renewal. Meadowcroft (2011) also calls for an engagement with the politics of transitions. In the Sustainable Calgary, 2018 State of Our City Report (Sustainable Calgary 2018) two goals stand out as key to this effort—campaign and political party finance reform and proportional representation. Money in politics and a skewed electoral system ensure that elected representatives are in fact not representative of the people they serve and decisions are made that do not represent the will of the people.

Conclusions

We propose a revised conceptual framework to guide the prospects for a sustainable post-carbon city district that situates the initial framework within three nested domains that can be mapped onto and provide useful alternative conception of the MLP—a socio-technical domain (niche), an econo-political domain (regime) and a cultural–cosmological domain (landscape).

We argue that strategies are required to re-orient human activity in each of the nested domains if we are to achieve sustainable post-carbon cities. The socio-technical domain addresses the most proximate problem we face—climate change—with technological and organizational responses. The econo-political domain calls for alternative economic forms that transcend the capitalist economic growth paradigm. We point to the burgeoning literature on no growth and degrowth (Kallis 2018) as important ingredients to resolve the unlimited-growth-on-a-finite-planet paradox and the notion of a sharing or cooperative or solidarity economy as a way forward. The cultural–cosmological domain is concerned with an even more deeply embedded pathway—the Eurocentric utilitarian relationship to an inert and objectified nature. This demands a re-orientation of the human nature relationship—our understanding of our place in nature and the cosmos.

The design exercise remained predominantly within the socio-technical domain. There was wide agreement among workshop participants as to its logic and normative value of the urban form of the future Manchester district. We would argue that the integrated consideration of both the spatial moments and the temporal moments of production are imminently sensible within the socio-technical domain and are readily imaginable by most stakeholders. The most problematic barriers were found to reside in the econo-political and cultural–cosmological domains. These include issues of infrastructure financing, land assembly and an alternative economic model, all of which present a challenge to the entrenched capitalist economic model. The hegemony of automobility is a complex problem (in design parlance a wicked problem) that we argue represents a material manifestation of tensions in the cultural–cosmological domain. Scientists at NASA (Unger et al. 2009) have demonstrated that the automobile is the most critical single contributor to climate change. As such it is uniquely implicated in the question of who we are, how dependent we are on technology in defining individual and cultural meaning and the question as to whether human communities can live in ecological balance with the rest of nature.

This particular transitions experiment engaged those who have professional and political responsibilities for building our cities. The outcomes of the design and backcasting exercise provide valuable insight into the challenges of sustainable low-carbon futures as perceived by these city-builders in a city that matured in the age of the automobile. Within the socio-technical domain these findings should be of practical value in moving the city-building process toward sustainability. Ultimately though, these findings do suggest that creating a durable path for a sustainable, low-carbon transition is certainly a technological and economic challenge but is predominantly a social, cultural and political one.

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