Part V

A Future Perspective

27

Visions, Scenarios and Pathways for Rapid Decarbonisation of Australian Cities by 2040

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Introduction

Over recent decades it has become clear that any successful move towards decarbonisation of the global economy (and any enduring shift towards low-carbon living) will require significant *transformation of existing cities* (Barber 2017; CRISP 2014; Eames et al. 2017;

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Frantzeskaki et al. 2017; Webb et al. 2017). A new focus on cities in global action on climate change reflects their *role*:

- in *economic* development (from production, innovation and services[1];
- as *engines* of greenhouse gas *emissions* (both from consumption and production)[2];
- as potent *agents of change* (an emerging political force), reflecting rapid urbanisation, where over 68% of global population is projected to live in cities by 2050 (UN DESA 2018);
- as shapers of *cultural allegiance* and *belonging* (with successful cities generating a potent sense of social identity);
- as generators of *creativity and innovation* (related to the density and diversity of social interaction).

Cities are also increasingly vulnerable to climate change impacts, both chronic (progressive shifts in weather patterns) and acute (extreme weather events).

Low-Carbon transformation will be hugely challenging for Australian, fossil-fuel-dependent, cities. The co-benefits of such action could be significant, creating opportunities to simultaneously improve

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the quality of life, social creativity and innovation, livelihoods and opportunities for all, as well as ecological diversity and vitality (Philip, Taylor & Thompson 2015).

The Visions and Pathways 2040 (VP2040) project is an exploration and investigation of possible and plausible pathways for the transformation for the southern capital cities of Australia, aiming for an 80% reduction of their 2013 greenhouse gas contributions by 2040.[3] The four-year project was designed as an interlinked research and engagement process to develop, analyse and communicate visions, scenarios and pathways for such transformation.[4] VP2040 involved three universities (University of Melbourne, University of NSW and Swinburne University of Technology) and a range of government and industry partners including the cities of Sydney, Melbourne, Adelaide and Perth. Its research objectives included:

- tracking international research and coordinating with related international projects;
- identifying emerging technological and social innovations that could disrupt current trajectories of development;
- developing and refining a set of visions and scenarios for low-carbon resilient cities;
- communicating and translating those scenarios to stimulate engagement of CRC partners and the general public; and
- back-casting from those future visions to develop potential pathways for their realisation.

Throughout the four years, the research team worked alongside a panel of around 250 experts—professionals from the built-environment, planning and design sectors, university researchers, representatives of all tiers of government, social entrepreneurs and relevant NGOs. Those experts volunteered their time. Panel members later acted as a sounding board for the research-led process of generating initial 'proto' scenarios, which attempted to codify divergent trajectories of transformation for the cities.[5]

A set of narratives of four scenarios and possible pathways were produced, again linking research with expert panel feedback. Finally, 'carbon modelling' was undertaken using the Australian Stocks and Flows Framework.

The VP2040 Project: Visualisation, Scenarios and the Wicked Challenge of Complex City-Transformation

As global action on climate change has progressed, researchers, governments and citizen groups have increasingly focused on the importance of *low-carbon transitions* for cities, adopting terminology from the growing field of analysis of disruptive shifts in the history of socio-technical change (Geels & Schot 2010; Twomey & Gaziulusoy 2014). The VP2040 project adopted the term *transformation* rather than *transition,* partly to reflect its etymology as 'changing shape', but also to emphasise the necessary scale of change (beyond incremental change) as well as the principal objective of the project: to *investigate the potential form of radically decarbonised urban futures*—the future to which we might transition.[6] Cities are complex adaptive systems; as they grow, specific technical, social, economic and cultural systems are entangled with their physical fabric, shaping their urban morphology (Ryan 2013; Twomey & Ryan 2013). 'Carbon dis-entanglement'[7] becomes a truly transformational challenge for a city; it requires a significant shift in its 'metabolism' (Bai 2016), a realignment of all its systems of provision, its established and interconnected infrastructures of life that make the city productive and habitable.

VP2040 focused on eight systems of provision: energy, water, food, transport, buildings and open-space, waste disposal, information, products and services. For every city those systems are developed in response to different resource contexts (regional eco-systems, arable land, seasonal weather, rainfall, rivers and so on), different spatial conditions, different economic histories and utilising different technologies. Systems of provision become deeply interconnected in different ways, around different physical morphologies. Because of that interconnection, transforming the city to achieve an 80% reduction in emissions cannot be approached through a reductive process taking each of the systems of provisions in turn; they are not independent variables. A living city is even more complex; its metabolism is not merely a function of its ecological-technological-physical systems, it reflects human agency. Architectural and urban history demonstrates how profoundly economic systems, cultures, rituals, practices, aspirations, lifestyles, power structures and so on, are intermingled with the physical form of our constructed world (Harvey 2012; Jacobs 1961; Mumford 1961; Sorkin 2011).

Transforming these intermingled *technical-physical-ecological-social-cultural systems* represents an archetypically wicked problem, where an effort to solve one aspect of the problem may reveal or create others. For this reason the approach taken in this project emphasised transdisciplinary research (Gaziulusoy et al. 2016), the co-design and testing of alternative system configurations, the visualisation of transformed system conditions and patterns of urban living and a multiple scenario approach. The scenario approach reflects what Sondeijker (2009) defined as the 'third generation' of scenario thinking, moving beyond the question of 'what will we do if something happens?' to 'what do we actually want the future to look like?' This idea of the scenario, as producing ideas of the future that we collectively want, has become important in participatory futures design (e.g. Quist & Vergragt 2000, 2006; Ryan 2013; Vergragt & Quist 2011).[8] The lead institution for VP2040, the Victorian Eco-Innovation Lab (VEIL) at the University of Melbourne has more than a decade of action-research projects that involve processes of co-envisaging future urban systems and modelling those changes to evaluate their potential for decreasing carbon emissions and increasing resilience.[9]

Methodology and Process

Figure 27.1 depicts the sequencing of research and engagement tasks throughout the project.[10] To focus the research and workshop processes, a simplified schema of a city was developed with a focus on elements involved in transformation (see Fig. 27.2). With this schema, VP2040

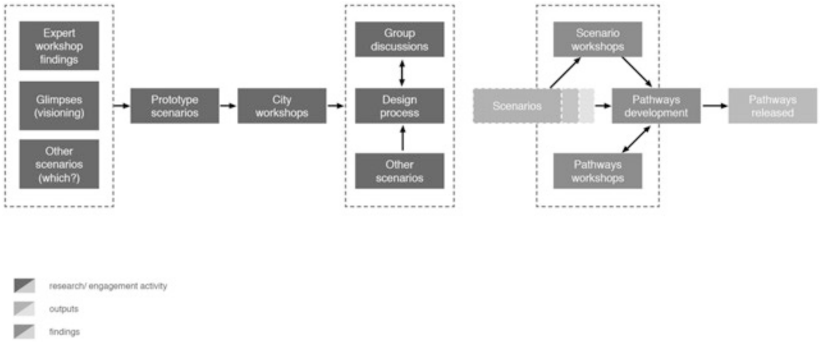

Fig. 27.1 The VP2040 process

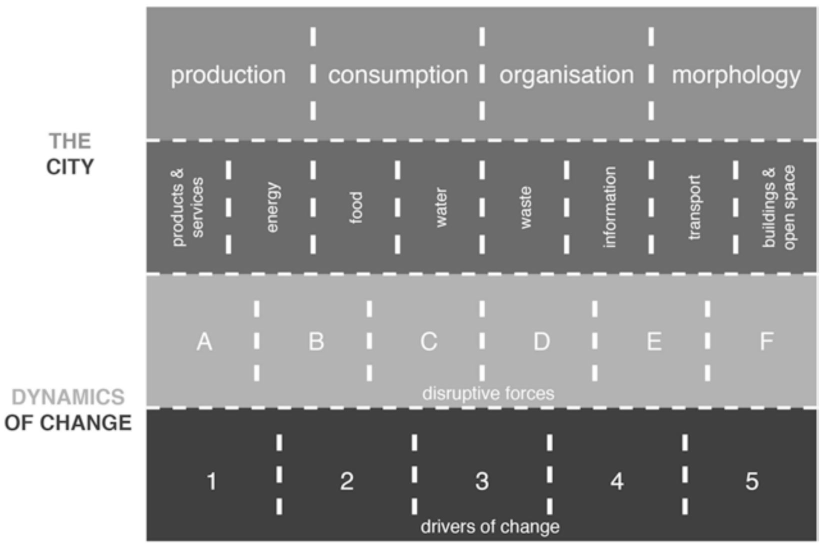

Fig. 27.2 A simplified schema for understanding the complexities of transformation for the city

research began with analysing the *dynamics of change*; both the 'drivers of change' as well as 'disruptive forces'. In this work, and the later scenario generation process, the researchers were able to draw on related projects in the UK and Europe.[11] Representatives from those overseas projects formed an international scientific committee for the project.[12]

The knowledge base for the 'dynamics of change' was regularly reviewed by the panel of experts (as part of their workshop process).[13] This data on the dynamics of change covered disruptive shifts in technology, socio-cultural dynamics (including values and behaviour), organisational developments (from governance to new business models) and external forces (essentially environmental and physical limits).

A similar process of research and expert feedback was used in the mapping of change in the city, modelled as the eight systems of provision, each considered in terms of their role in production, consumption, organisation and physical morphology ('the city' component of Fig. 27.2). In a series of workshops, members of the expert panel considered each of the systems of provision using the 'layered system mapping' methodology of VEIL (Ryan 2013; Ryan, Gaziulusoy, et al. 2016). They were asked to speculate on possible changes to production and consumption that could lead to lower carbon emissions. The output of this process became briefs for a series of *design charrettes*.[14] The charrettes visualised future glimpses and, later, early visualised scenarios; these can be considered as 'dialogic objects' (Manzini 2013; Ryan, Gaziulusoy, et al. 2016) through which the possibility and desirability of projected future states (and their potential contribution to decarbonisation) were debated in the expert workshops. When any dynamic appeared particularly critical or controversial, additional topic-focused expert round-tables were convened as a sounding board for the research team (Gaziulusoy & Ryan 2017; Gaziulusoy et al. 2016).[15]

Scenario Generation

The scenario generation processes used by the research team generated early 'proto' scenarios. In research conducted in 2014–2015, the project considered a range of possible, challenging, divergent and plausible futures. This work involved combining multiple elements[16] into a coherent description of plausible futures of sustainable and resilient Australian cities and drew on the early visualised futures glimpses as well as research on trends (see Ryan, Twomey et al. 2016). All this was informed by other sustainability-related scenarios work internationally.[17]

The proto-scenarios were refined in workshops with panel members in Adelaide, Perth and Sydney, extending to considerations of the impact of different scenarios on the urban morphologies of Australian cities (low and high density, residential and mixed use). The potential uptake of social and technological innovations in each scenario was considered according to the core scenario 'logic' (Ryan, Twomey et al. 2016, Appendix 1), with the research team drawing on the workshop discussions when refining the scenarios, in particular when considering major sectors like energy, transport, buildings, food, information, water and waste. Again, a design charrette developed scenario visualisations. Finally, an additional set of experts were interviewed in order to better understand aspects of the scenarios (Ryan, Twomey et al. 2016).

Scenario Pathways

As workshops and research progressed, the scenario refinement extended to deliberations on pathways—plausible and internally consistent narratives of how each scenario of a 2040 future could have unfolded from baseline conditions in 2013. A refined version of these pathway narratives was published in 2017 (Candy et al. 2017, p. 19).

Modelling of Future States

The final stage of the project concerned the measurement of the scenario changes through quantitative modelling. In low-carbon transitions work, emissions accounting is often used to determine baseline emissions and their distribution across goods and services to identify key intervention points for mitigation. To simulate emissions reductions between a baseline level in 2013 and four different end states in 2040, each scenario narrative and summary table was translated into a set of specific modelling assumptions ('settings') across six sectors (electricity/energy, transport, food, goods, water and waste) and 11 core variables (proportion of renewable energy generation, energy consumption, transport mode distribution, number of vehicles, need to travel, diet profile, consumption of processed foods, amount of food waste, consumption of goods, changes in urban water infrastructure).

Dynamic modelling methods are typically employed to simulate the effects of low-carbon initiatives implemented over time. The potential non-linearity and non-continuity of change can make quantitative modelling difficult, particularly in accommodating fundamental shifts in the structure and dynamics of systems. This challenge was faced in this project, as the first input–output modelling method used was limited to quantifying carbon emissions reductions from changes to demand and carbon intensities, governed by linear equations and with no interaction with other domains. This consumption-based environmentally extended multi-region input–output (MRIO) model was used initially—provided by the Integrated Carbon Metrics research programme within the CRC LCL (Teh et al. 2015). In addition to the indirect emissions calculated using MRIO analysis, the household direct emissions were also estimated on the basis of spending on energy derived from household survey data.

The limitations of the MRIO method for modelling low-carbon interventions, particularly due to the complex nature of cities and the systemic challenges implied by decarbonisation, became apparent. It was decided to change the modelling of the pathways utilising the Australian Stocks and Flows Framework (ASFF). The ASFF is a scenario modelling platform for integrated analysis of the physical economy of Australia (Turner et al. 2011). It is a process-based simulation model of all sectors of the Australian economy, tracking the dynamics of major capital and resource pools, and the flows associated with these stocks such as productive output, resource inputs, changes in capital and carbon emissions. Emissions calculated within the ASFF at a state or national level were attributed to cities based on methods developed for a previous project by VEIL (Turner et al. 2017). For VP2040, city consumption factors were calculated based on data from household expenditure surveys, similar to the MRIO method. The ASFF method proved more transparent, providing the ability to examine detailed mechanisms to reduce emissions in alternative scenarios, and to determine flow-on effects such as material implications or economic impacts.[18]

With the modelling from ASFF, there was the potential to iteratively refine each scenario (adjusting the settings) to ensure they deliver the projected 80% reductions by 2040. Per capita reductions in greenhouse gas emissions (CO2e) for each unrefined 2040 scenario (based on the 2013 emissions profile for Sydney) ranged from 66 to 70%. That modelling showed that achieving the additional 10–15% reductions would require substantial adjustment of many settings.

Due to resource constraints, iterative refinement of all four scenarios (see below) was not able to be attempted; instead the four futures were combined into two 'Action Pathways', that made it possible to address some questions of plausibility and desirability of the four scenarios. Most importantly they simplified the process of adjusting settings to approach the 80% carbon mitigation target.

Results

With its scenario approach, the most important contribution of VP2040 has been to demonstrate, for its city partners, that radical urban decarbonisation is possible, but that a performance target does not define the conditions of its realisation. This is particularly relevant as it runs counter to the often prevailing idea that the realisation of low-carbon futures is essentially a technical challenge, with the outcome more-or-less technically determined. VP2040's set of four scenarios describe urban/city futures that differ significantly in the way that energy, food, transport and built-form are provided for citizens; they also differ in the way that information is utilised and in the way that the city is governed. Most critically, the four futures differ significantly in *the nature of their social, cultural, political and economic life*. These four scenarios are schematically mapped in Fig. 27.3.

The Four Scenarios

The scenarios mapped in a two-axis space is shown in Fig. 27.4.

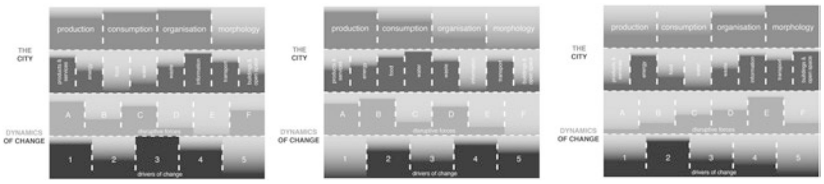

Fig. 27.3 A schematic representation of different scenario choices for the simplified city schemata (different combinations of the dynamics of change lead to different effects on the systems of provision and their production, consumption, organisation and morphological structure)

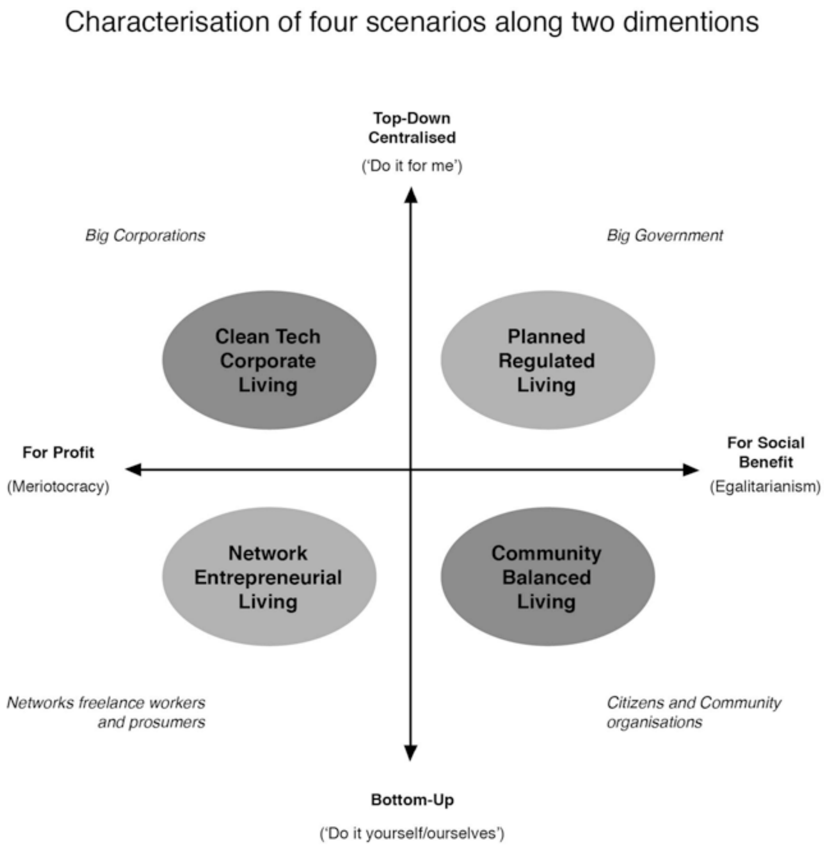

Fig. 27.4 The scenarios mapped against two axes—profit to social benefit and top–down to bottom–up

Clean-Tech, Corporate Living

This is a city of clean and efficient production, a model for the application of circular economy principles and clean-tech innovation. International agreements have redirected market competition towards innovation for triple bottom line success. Large, for-profit companies with the resources to invest in innovation are the primary actors in the economy. Significant decarbonisation has been achieved through a focus on changing production systems and product design and the adoption of low-carbon clean technologies, rather than limiting consumption. The private sector owns and manages most of the city infrastructure from energy supply to transport and building technologies, to food and water. Services and public space (even green spaces) are privately owned, deriving revenue from fees for access as well as public funding for ecosystem services delivered. Competing corporate services is a feature of life for citizens. Information technology has created a city that is smart and efficient; corporate investment in the 'internet of things' is significant with the sale of privately held data now an important contribution to corporate profits and overall GDP. Robots and automation have reduced labour costs in many areas of production and service provision, generating significant unemployment, increasing social inequality. A significant proportion of the population has very low income and (consequently) low consumption.

Planned Regulatory Living

This is a city of planned order where a democratic consensus has concluded that the challenges posed by a carbon and resource-constrained world are best addressed through public planning, public investment in green infrastructures and tighter regulations that limit behaviour and practices to an acceptable environmental norm. Rational and technocratic approaches guide all areas of development and the use of public assets and capital. Private sector activity is limited and regulated; taxation levels are high. There is great public trust that the balance between corporate profits and public needs is best managed by government.

Environmental and social ethics is accepted as a guide all decision making, for maximum societal benefits. Greenhouse emissions reduction has been achieved through: reduced per capita energy and material consumption; changes in social behaviour; public investment in renewable energy supplies, grid-connected storage, production of biofuels and hydrogen and improvement of building stock. Planning has delivered a 'twenty minute city', with comprehensive and integrated public transport systems, including bicycling, walking, driverless electric taxis and small community shuttles. Business premises are more dispersed; teleworking accounts for almost half of working hours. New behaviours and limitations on consumption align with up-to-date monitoring of environmental conditions. City information systems are ubiquitous and publicly owned; they provide feedback on consumption levels, for individuals and for communities.

Networked Entrepreneurial Living

This is a city where large corporations and government are less influential but where the economy has developed around nimble, self-organised entrepreneurial activity, particularly for the sharing and exploitation of excess capacities of various assets. It is a future characterised by a dynamically changing economy, experimentation and innovation and the development of networked platforms that are open source and open data. Many workers are freelancers. There has been a rapid growth in agile microbusinesses that produce innovative technologies, products and services to exploit renewable energy and to increase resource and material efficiencies. All new businesses are supported by informal, digitally connected networks. Individuals have also taken up such technologies to become 'prosumers' and actively engage with businesses in the design of products. In this new market context the value of information is rising rapidly compared to materials. Many material products are now manufactured within a distributed system involving open source design studios and an extensive network of local 3D printing fabrication workshops. While non-profit social entrepreneurialism is strong, small business is primarily profit oriented.

Community Balanced Living

This is a city of low consumption that promotes a socially and environmentally meaningful life, including shared wellbeing, high liveability and (face-to-face) socialising. There is still a market economy, however, there is a thriving and diverse set of alternative forms of enterprises that are not profit-oriented, including cooperatives, B-corps and other types of social enterprise. A high proportion of the population works only part-time in the mainstream economy, with time freed for other pursuits that range from creative activity to cooperative work contributing to building community resources. Communities generally have much greater responsibilities for the creation, improvement and maintenance of commons spaces or essential resources, including food production, renewable energy generation, rainwater collection, storage and distribution, the maintenance of built infrastructure, urban forestation, education and training, aged care and so on. Recycling and repair of goods is an important service for small businesses and cooperatives. A high proportion of new building and building refurbishment depends on the contribution of cooperative, community labour. Decarbonisation has resulted from lower consumption and reuse of materials.

Pathways, Action Scenarios and Modelling

The initial pathways for each of the above scenarios, depicting plausible and consistent narratives for the trajectories from 2013 to the four 2040 states, were developed for the 2016 project report (Ryan, Twomey et al. 2016) and later refined with a more detailed critique of their plausibility and desirability in the final phase of VP2040 (Candy et al. 2017). Two combined 'Action Scenarios' were developed that allowed some of the artificially exaggerated dimensions of the four scenarios to be relaxed. The exaggeration of trajectories of change had been necessary to define critical decision points as the paths unfolded.[19] The development of the two combined Action Pathways allowed for more coherent and multifaceted activities and responses to drive climate mitigation; they were also more amenable to modelling and refinement (Candy et al. 2017, pp. 56–69).

The Two Action Pathways

Commons Transition

The City is a network of 'commons' where local communities organise themselves to manage key resources and systems of provision in collaboration with business and government. It is distinguished by peer-to-peer collaboration and community ownership; it is 'post-growth', 'post-smart', 'post-hierarchy' and 'post-pollution'. The will of the 'people' has been clearly and loudly expressed in actions to reduce greenhouse gas emissions by over 80%, creating common value for everyone, rather than private value for a few. People consume less material goods, work for themselves and their communities, and use much less energy. Infrastructure is managed through cooperatives, public utility trusts and public buy-backs of formerly privatised assets. Renewable energy infrastructure is distributed across networks spanning households, neighbourhoods, cities and beyond, and the benefits flow back into the communities that own and run them (Candy et al. 2017, pp. 56–61).

Green Growth

This is a city of clean and efficient production following circular economy principles and clean-tech innovation. Large corporations, with the resources to manage infrastructure and rapidly scale innovations, are the driving force of the economy. The private sector owns and manages most of the city infrastructure, from energy supply to transport and building technologies to water. The 80% reduction in greenhouse emissions has been achieved through decarbonisation of the electricity system, the substitution of electricity for other forms of energy, high energy efficient products and a relative increase in the service sector. A strong regulatory framework ensures carbon and resource costs are passed through the market. Competition in smart city technologies saw early proliferation of systems but these have given way to a few market monopolies. Some local governments have public–private partnerships with those monopolies accessing and using citizens' data for public policy. Robots and automation have reduced labour costs in many areas of production and service provision. There is a large shift towards casualised labour, decreased job security and increased disparity in income (Candy et al. 2017, pp. 62–67).

Based on new quantified 'settings' (Candy et al. 2017, pp. 68–69), both low-carbon pathways show a sharp reduction in emissions after 2020 compared to BAU. The total emissions for the Green Growth (GG) pathway drop lower than for CT initially, but then converge again after 2030. Both low-carbon pathways effectively achieve an 80% reduction in emissions compared to 2013 levels by 2040. The reduction is sustained after 2040 even with rising urban populations. However, zero-net carbon is not achieved until just before 2100. The differences in the two low-carbon trajectories are a result of the dynamics of emissions generated over time from various sources.[20] The final report of the project (Candy et al. 2017) shows the distribution of greenhouse emissions reductions by category, from the output of ASFF modelling. The results for both pathways require carbon sequestration to achieve the 80% target.

A switch from forest clearing to significant forest replanting leads initially to substantial carbon sequestration in the agri-forest sector for both pathways. The amount of sequestration required in the Commons Transitions (CT) pathway is less than for the GG pathway because overall emissions in other sectors are lower due to reduced consumption and reduced exports of emissions-intensive products. Sequestration is a short-term mechanism, as the net effect in a given area will rise to a peak and then decline due to the physical profile of carbon sequestration as trees mature. If no additional land is available, there is a physical limit to the total carbon abatement potential from revegetation. This suggests that reforestation can only provide a temporary reduction in emissions to buy time for long-term low-carbon structural changes in the energy sector and broader economy.

For both low-carbon pathways it is clear that the greatest reductions can be achieved by focusing on activities that typically occur outside city boundaries but support urban lifestyles and consumption patterns. This extends beyond sequestration and involves the embodied energy/carbon in the multitude of products and services that are imported into cities and represent the largest percentage of a city's carbon footprint (see Teh et al., this volume).

Notes

1. For example, Melbourne and Sydney each generate around 75% of their state's economic output [17].
2. The per capita emissions for Sydney and Melbourne have been calculated at 24.7 and 29.1 tCO2 eq, respectively, which are 7–27% higher than the national per capita emissions and around triple global per capita emissions (Candy et al. 2017).
3. That target was set from a review of city and national emissions reduction programmes at the time this research project was initiated (2014) (Candy et al. 2017, pp. 7–13).
4. Although it was formally out of scope for this work, it was accepted that scenarios and pathways for decarbonisation had, at the same time, to increase the resilience of the cities to cope with anticipated climate impacts.
5. They were providing critical feedback as to the internal logic of scenarios as they were developed.
6. Hölscher, Wittmayer and Loorbach (2018) discuss the differences in terminology between 'transition' and 'transformation', principally used to differentiate system foci.
7. To use the term adopted by the OECD as the climate challenge. See for example OECD (2018).
8. The emphasis on 'designing' a future reflects a literature on design and wicked problems where the involvement of a diversity of stakeholders is a way of addressing problems that cannot be solved by the application of standard methods but are amenable to creative speculation.
9. That work sits within an international network of 'designing the future' projects. In these projects, visions of possible futures are seen as a way of opening up alternative discourses on the nature, culture and dynamics of city development and planning, to break from existing institutionalised discourses that underpin regimes of planning and urban design (Hajer 1995; Hajer & Dassen 2014; Ryan 2013). The process of generating visualisations of changed urban conditions—and the visualisations themselves—can be considered as a feedback loop within

the multi-level transitions theory model, highlighting tensions at the socio-technical landscape level, portraying alternative (future) regimes in operation and defining potential new areas for innovation at the niche level.

10. Along with the academic researchers, three Ph.D. students worked in each of the three universities. Although the time lines for their research was not a good match for the project's program, they were involved in much of the early research team meetings and visioning workshops. At best this meant that the directions of the project had some influence on the specific thesis topic for each student. Their results however were not incorporated into the VP2040 final outcomes.
11. See note 17 below.
12. See Ryan et al. (2015) report, page 2.
13. The researchers also used 'polling' of the audience at a number of CRC related conferences and symposia, using 'tag cloud' software to stimulate some public debate in those meetings.
14. See, for example, the visualisations from Sydney and Melbourne: VP2040 2015 report 2015, pp 13–29, and http://www.visionsandpathways.com/research/visions/.
15. For example, workshops explored current theory and practice of 'the sharing economy', new business and financial models, and new models of governance (Gaziulusoy & Ryan 2016).
16. Elements such as: whether changes in production are dominant, or changes in consumption patterns (e.g. for energy); rate of technology development; centralised versus decentralised systems; access and use of data across urban systems of provision; high or low GDP growth; degree of social equality; carbon emissions priced or not.
17. Projects such as the Global Scenarios Group (gsg.org), EPSRC Urban Futures project (http://imagination.lancs.ac.uk/activities/Urban_Futures), RETROFIT 2050 UK (Dixon 2011; Eames et al. 2017), SPREAD (http://www.sustainable-lifestyles.eu) and the EPSRC Realising Transition Pathways (http://www.realisingtransitionpathways.org.uk).
18. For a detailed description of this process see Candy et al. (2017), pp. 21–26.
19. For the city partners in the project there was great interest in capturing those decision points so they could monitor 'signals' as an input to current and future debates about their own future pathways.

20. Consumption-based greenhouse gas emissions attributable to cities include both those emitted directly within the city (scope I), from production of electricity used in the city (scope II) and from production of goods and services consumed in the city (scope III).

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