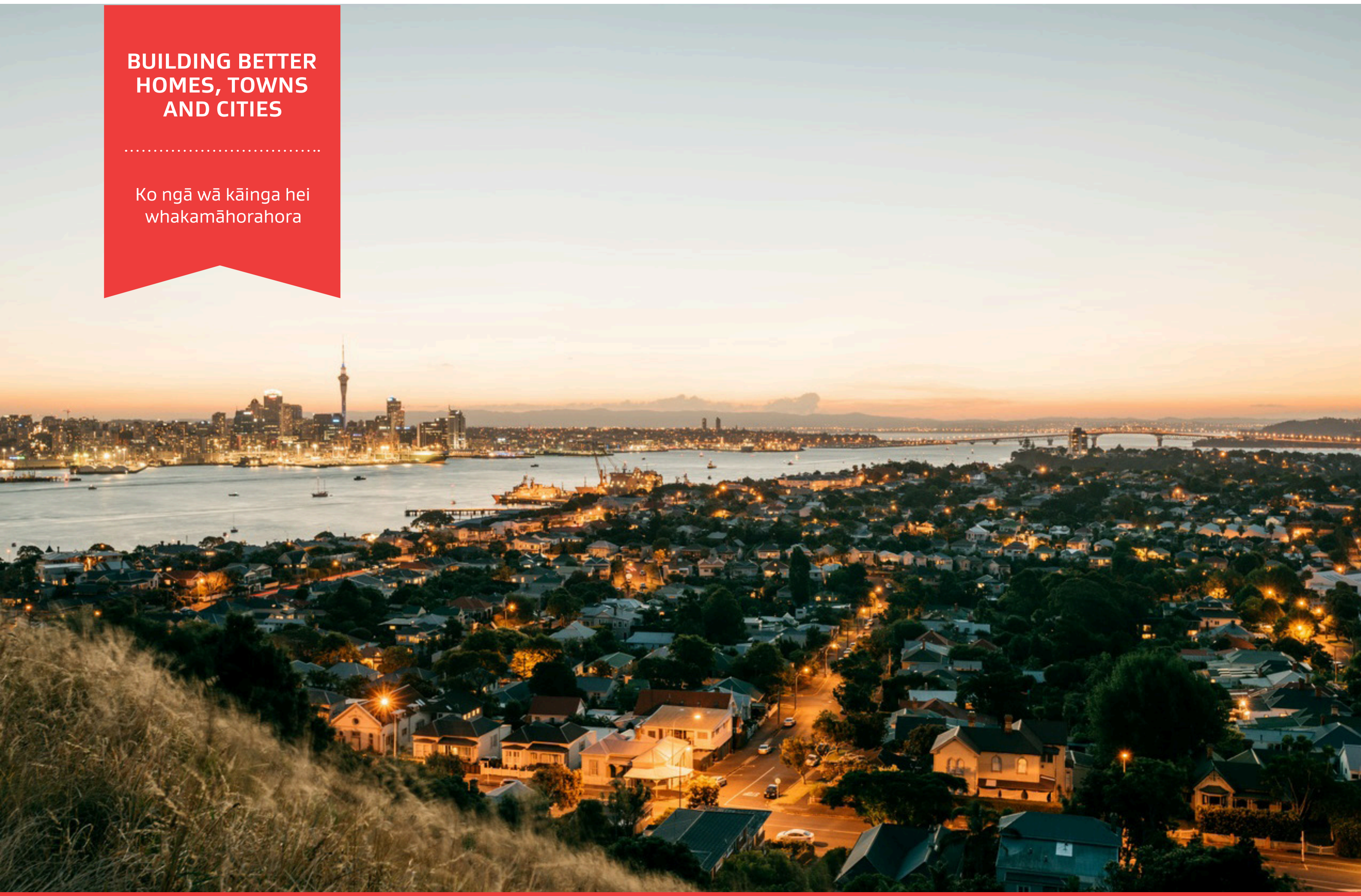
National SCIENCE Challenges

BUILDING BETTER HOMES, TOWNS AND CITIES

Ko ngā wā kāinga hei whakamāhorahora



Whanake Mai Te Ara Hiko

Think piece: Wellbeing-led, home-based energy infrastructures and low-emissions transport

Think piece / Mauri ora and Urban Transformation

Think pieces are designed to both prompt and present thought. This think piece enquires into disruptive technologies and approaches to energy policy and infrastructure. We review wellbeing-led frameworks and total value assessment tools for their potential to catalyse a more holistic and transformative energy analysis, strategy and action in an era of climate crisis. The home is central to our analysis here: we ask whether a city-wide, small-scale/nodal energy infrastructure could provide for both building and, transformatively, local low-emissions transport energy needs in a granulated, consumer-led manner.

Acknowledgements

This Te Puna Wai-Papa-Ora research was funded by the Building Better Homes, Towns and Cities National Science Challenge.

Warm thanks to Professor Jonathan Boston of Victoria University of Wellington for his perceptive and rigorous response while peer reviewing this think piece – this certainly enhanced the final paper.

Warm thanks also to Leonie Bule, PhD candidate, for her role as research assistant.

Front cover image: Auckland cityscape from Devonport, Auckland Council.

Recommended Citation

Yates, A.M., Nair, N., Renwick, J. (2019). *Whanake Mai Te Ara Hiko: Think piece – Wellbeing-led, home-based energy infrastructures and low emissions transport.* Tāmaki Makaurau/Auckland, NZ: National Science Challenge 11: Building Better Homes, Towns and Cities. http://buildingbetter.nz/resources/publications.html

About

Research | Mauri ora and Urban Wellbeing:
A Holistic Approach to Neighbourhood Transformation

For Māori, ora is wellbeing, health, life. Mauri has been described as an integrated life-force connecting for example rivers, rocks, trees, people, summatively te Ao (the world) as an indissoluble "network of interacting relationships" (Durie, 2001, p. x). Mauri ora is the vitality and wellbeing of this life as network or field. The climate of this research is the Anthropocene, an era of human-led harm to planetary wellbeing, a time of climate and biodiversity emergency. The city is our primary research site – cities both contribute to the production of the Anthropocene and are subject to its disruptions. Cities are sublimely complex socio-cultural assemblages of geologies, climates, economies, ecologies, technologies; they are 'wicked' problem fields where complex interdependencies mean that the positive resolution of one issue may effect a negative outcome elsewhere. This research employs transcultural, transdisciplinary and transversal – connecting across a range of urban conditions – methods as a means of engaging with urban complexity. Mauri ora, as integrative all-of-life wellbeing, becomes the connective analytic against which all research questions, processes and outcomes are indexed. We hypothesise that such an integrative all-of-life wellbeing framework can activate a more responsive and coordinated urban analysis, planning and action for wellbeing in the ecological crises of the Anthropocene.

Te Puna Wai-Papa-Ora | Emergent Ecologies Lab

Te Puna Wai-Papa-Ora ('The Puna') is an urban wellbeing research and activation lab based at the Auckland University of Technology. Indigenous thinking for wellbeing is the tuāpapa, the ground, for the Puna's urban research and practices. We generate new urban research and communicate and activate this through publications, collaborations and art-science activations or design events. System change and Anthropocenic (of the Anthropocene) counter-practices are key areas of engagement and activism within our future-focused, urban ecologies and wellbeing enquiry.

Te Puna Wai-Papa-Ora | Emergent Ecologies Lab

Auckland University of Technology

Private Bag 92006

Auckland 1142

Contents

Ehara taku toa i te toa takitahi,

engari, he toa takitini

My strength is not as an individual,

But as a collective

1. Introduction

Recent discourse in climate governance, particularly the Intergovernmental Panel on Climate Change (IPCC) Special Report Global Warming of 1.5C° and the outcome of the United Nations Climate Change Conference of the Parties in Poland, has emphasised the need for a rapid decarbonising of energy infrastructures within the next decade (IPCC, 2018). Such a transition will require innovative and disruptive approaches to shift established economies and energy infrastructures. Cities, as high energy users and generators of planet-warming carbon emissions, bear responsibility for and vulnerability to climate chaos. Cities are also well placed to take a lead in strategizing for and implementing zero carbon transition given their sub-national scale and the potential of civic-public collaborations for change.

This think piece explores the house as a basic urban unit and site of energy usage and generation within this rapidly decarbonising energy landscape. We address energy strategy and policy here in relation to its generation, usage patterns, outputs, global atmospheric, urban and public health implications, all within a holistic wellbeing-led analysis/action framework. Wellbeing is an increasingly important concept and focus in policy development and governance nationally and internationally (Adler & Seligman, 2016; John Helliwell, Layard, & Sachs, 2012). Both Sweden and Italy are incorporating wellbeing indicators into economic policy and assessments as a means of achieving more holistic indexing and strategy (Government Offices of Sweden, 2017; Ministero dell'Economica e delle Finanze, 2017). New Zealand is leading in this area as wellbeing is reintroduced to the Local Government Act and into national budgeting processes within 2019's "wellbeing" Budget (Local Government (Community Well-being) Amendment Bill (*NZ Parliament*, 2019).

We employ here a particular, locally situated mauri ora wellbeing framework that considers the ora-wellbeing of mauri as connected life-force or life-field. Mason Durie describes mauri as an integrated life-force, an indissoluble "network of interacting relationships" – between for example people, rivers, rocks, trees, or within te Ao (the world) summatively (Durie, 2011, p. x). This is an expanded and connected concept of wellbeing, that extends past a reductive human focus to emphasise the collective life-vitality and wellbeing of te Ao. In other papers we have outlined how an urban-focused mauri ora wellbeing framework may enable an integrated, multi-dimensional city analysis. This mauri ora framework stresses total or holistic urban analysis processes that take account of intersecting relationships and effects and as such may activate the more responsive and coordinated urban analysis, planning and action necessitated by current ecological crises. In this energy-focused paper we explore how a more integrated and holistic method of energy analysis might enable transformative energy policy and practices.

This think piece is concerned with connections: between energy, urban, wellbeing and economic policy; between atmospheric, urban and human wellbeing. We outline here the global, national, urban and citizen-led renewable energy contexts and explore civic-public collaborations for decarbonising. Key elements of the global carbon-zero project include a transition to renewable energy, reforestation, changes in urban development and agricultural patterns and carbon capture technology (IPCC, 2018). In this paper we limit our focus to renewable energy. Because New Zealand's urban and industry infrastructures are fed by a relatively low-carbon grid, with some 80 percent of electricity generated renewably (Electricity Authority, 2018) we pay particular attention to a low-carbon transport energy transition strategy. Here we emphasise a home-focused energy approach that considers housing, local energy generation and storage, and electric vehicles as a circular zero carbon ecosystem. Further public health and pyschosocial wellbeing arising from energy security or sovereignty are key components of this energy discussion. We ask how might we shift the current system working with wellbeing-led analytic tools to effect transformation?

2. Carbon and Global Wellbeing

The IPCC's Special Report on Global Warming of 1.5°C (IPCC, 2018) emphasises the urgency of decarbonising global energy systems. The report establishes 1.5°C, rather than 2°C, as a more prudent limit for warming, and points out that any amount of further warming from the present may cause extreme damage to the life-systems (including biodiversity, climate, and ocean systems) that sustain our human civilisation. Remaining within a 1.5°C limit would mean materially reduced risk of extreme heat events, droughts, floods and associated mortalities and damage to infrastructures and economies (IPCC).

We are currently at around 1°C of warming, measured as a global average (WMO, 2018). Climate researchers have shown how recent extreme climate dysregulation, manifesting as extreme weather events – including the long-running drought in California, the 2003 European heat wave, and the 2010 Pakistan flood and Russian heatwave – are linked to human-caused increases in atmospheric carbon (Mann et al., 2017). Atmospheric carbon is now close to 415 parts per million (NOOA, 2019) driven largely by the burning of carbon-based fossil-fuels. In moving above 400 ppm we have now passed a significant carbon 'threshold': the last time the planet was at or above 400 ppm was some 3.6 million years ago in the Pliocene, a time prior to humans, when the arctic was ice-free, and the ocean was some 5-40 metres higher than it is today (Brigham-Grette et al., 2013). Copernicus, Europe's "Earth Observation Programme," confirms that 2017, 2016, 2015 are the warmest years on record. The last decade is likely to have been the hottest in over 11,000 years (Marsicek, Shuman, Bartlein, Shafer, & Brewer, 2018).

At 1°C of warming we are already leaving the temperate climate of the last 10,000 years, the Holocene epoch, whose conditions enabled agriculture and a globalised urban civilisation. The Special Report emphasises that an increase to 2°C of warming brings more extreme risks than 1°C or even 1.5°C (IPCC). The declines in biodiversity that are already occurring under the sixth mass extinction event (Ceballos, Ehrlich, & Dirzo, 2017) would be greatly exacerbated by a 2°C increase leading to loss of vital crop-pollinator insects and reduced yield or loss of crop plants (IPCC). Ocean warming, de-oxygenation and acidification will also affect marine fisheries, with losses potentially doubled at 2°C over 1.5°C (IPCC). Speed of transition is key to remaining within this life-systems critical temperature limit with the report emphasising that by 2030 global carbon dioxide emissions would need to be cut by around 45 percent from 2010 levels, going to zero by 2050, instead of the 2075 timeline for 2°C (IPCC).

3. Aotearoa New Zealand's Carbon Context

New Zealand's Climate Change Response (Zero Carbon) Amendment Bill is moving through Parliament currently with a potential enactment towards the end of 2019 at which time New Zealand will have a legislated and well-signaled timeline for zero carbon action. The Bill is a step-change in climate change governance in New Zealand in that it proposes a pathway to a zero carbon emission environment by 2050 (NZ Parliament, 2019) aligning with the IPCC Special Report's timeline for a likely 1.5°C degree warming limit. Further, the proposed independent Climate Change Commission emplaces a governance body with a singular focus on zero-emissions pathways. The new Government's carbon zero planning includes an aim to transition New Zealand's electricity grid to 100 percent renewable energy by 2035, and the planting of one billion trees by 2028 (Ministry for the Environment, 2018). At the same time, groups are calling for much quicker transitions: the Centre for Alternative Technology has suggested a 2025 date is possible for Britain, using current technologies (CAT, 2019) and international climate lobby group Extinction Rebellion has called for the United Kingdom to be zero carbon by 2025 (CAT, 2019; Extinction Rebellion, 2019). One can argue a case for New Zealand to be more assertive in our zero carbon agenda given our high per capita emissions profile and the high percentage of renewables in our current electricity system.

What might a transition to a net zero greenhouse gas energy system mean for New Zealand? This is a fundamental change in economies and technologies. If we are to transition much of our transport to renewable energy sources this will require a veritable renewables revolution, as transportation technologies move out of the carbon culture of the last few centuries particularly. How viable is this proposition? A report by Vivid Economics, Net Zero in New Zealand, details a range of potential paths to reach to achieve this goal. Key findings are the importance of predictable and robust emissions pricing as a signal for private sector, the need for a coherent cross-party political platform, and the importance of a holistic policy programme that includes cultural as well as economic interests (Vivid, 2017). A Transition to Low-Carbon Economy report by the Royal Society of New Zealand is emphatic about the need to begin the transition process immediately (Sims et al., 2016). Both reports emphasise the need for more data and deeper analyses of potential transition pathways, with the Royal Society report also stressing the case for more science communication to the public in order to build consensus and energy for change. The New Zealand Productivity Commission's 2018 report emphasises the need for a swift transition in the transportation sector to electric vehicles and other low emissions vehicles, along with the establishment of a durable climate change policy framework, reformation of the New Zealand Emissions Trading Scheme, and a significant increase in resources for low-emissions innovation and technology (New Zealand Productivity Commission, 2018).

New Zealand's greenhouse gas (GHG) emissions in 2017 were 80.9 Mt CO2-eq which is a 2 percent increase from 2016 (Ministry of Business, Innovation and Employment NZ). 2016 gross emissions were 79.1 MT CO2-eq, 2.7 percent down on 2015 (MFE, 2019). Transport and agriculture are the largest contributors to the GHG emissions (49 percent from agriculture and 40 percent from energy). The figures for 2009 showed transport at 44 percent, electricity generation 19 percent, manufacturing industries 16 percent and the rest from transformation industries and other sectors (Ministry of Business, Innovation and Employment NZ).

New Zealand energy sector major consumers are transport and industries with 37 percent and 35 percent consumption of energy in 2016 (Transpower, 2018). Residential consumers account for 11 percent energy consumption (with 2 percent supplied by gas and coal). In the transport sector 100 percent is from oil, in industry some 40 percent of energy is supplied by gas and around 30 percent supplied by electricity (Transpower, 2015). Clearly a timely transformation of the transport energy provision is critical here, with industries that use fossil-fueled heating in their manufacturing also ripe for innovation.

New Zealand has natural resources which could currently enable it to generate almost 100 percent of its electricity from renewable resources. Already its hydropower and geothermal capacities place it as a leader in renewable electrical energy generation. The main challenge with hydropower, over and above community resistance to more dams, is the dry winter periods where generative capacity is reduced: currently fossil fuelled power plants enable the system to meet peak demands at these times. The key limit currently with these renewable technologies is the inherent flux in energy provision: investment in innovative storage technologies is the key to enable large-scale systematic energy banking. Current technologies include the pumping of water uphill to enable subsequent hydro-power generation, hydrogen gas as storage medium (electrolysed from water with intermittent renewable energy), molten salt energy storage (for solar power), large-scale battery banks (such as South Australia's Tesla-backed 100 megawatt battery), and small scale house and even electric car batteries. A further current limit occurs in the design of national energy systems which emphasise large-scale, centralised energy generation distributed to users via the national grid. Distributed solar power particularly has the potential to disrupt the current emphasis on centralised power generation. Having a national electrical energy model that supports both centralised and distributed energy generation would require a resilient national grid.

4. Low-Carbon Electricity and the Transportation Sector

A transformative expansion of New Zealand's current electricity system, 80 percent of which is renewable (Stats NZ, 2013) is a key way for this country to participate in the global campaign to reduce carbon emissions. Expanding this largely renewable energy ecosystem to include a significant proportion of transport energy would transform the national energy landscape and greatly reduce carbon emissions. Replacing fossil fuel used in transport and industries with renewable electricity would allow significant decarbonisation. Electricity generated from renewable sources is not only cleaner than fossil fuels but is also more efficient in energy conversion: in transport, electricity is approximately 80 percent efficient, compared with petrol at only approximately 20 percent efficiency.

The current demand for electricity is approximately 40 TWh per annum and is expected to double in 2050 if New Zealand economy and policies become focused on decarbonisation and the disruptive technologies like electric vehicles for sea and air transport become viable. Currently residential consumers consume around 32 percent of the total annual electricity (Stats NZ, 2013). The residential demand varies during the day and also with season. The peak demands are around 6 to 8 am, and in the evenings around 6 pm to 8 pm when people return from work and peaks during winter periods when heaters are turned on. The Te mauri Hiko Energy Futures white paper from Transpower discusses the distributed energy technologies (including solar, electric vehicles and battery technologies) now coming into use in the context of the decarbonisation of New Zealand's economy (Transpower, 2018). The paper emphasises the need for a transformed and resilient grid capable of connecting across a national and distributed local energy generation. A doubling of demand is projected by 2050 particularly if the New Zealand economy and policies become focused on decarbonisation and the disruptive technologies like electric vehicles for sea and air transport become viable. Solar and wind energy are now competitive not only for utility-scale projects but also in smaller scale deployments. The white paper projects that by 2050 under a base scenario for New Zealand's growth solar utility will contribute 6 percent of the energy supply while distributed solar energy on rooftops could contribute up to 8 percent of the electricity supply (approximately 16 TWh) (Transpower).

Important social and urban strategies for reducing carbon emissions include increased provisions for public transportation, design for multi-modal transport, and an emphasis on more dense urban fabric and walkable urban landscapes. Yet in terms of energy landscapes the most radical change in transportation will come from disruptive technologies like electric self-driving cars within a broader context of low or zero carbon transportation fuels. Electric vehicles are becoming popular in New Zealand. There was a total of 5,179 registered electric vehicles in November 2018, increased from 38 registered in 2013 (Ministry of Transport, 2018). It was estimated that by 2035 electric vehicles will make up approximately 40 percent of the total fleet, as the price for electric vehicles continue to reduce while the vehicles become durable with a longer lifetime. Tāmaki Makaurau/Auckland has the highest number of vehicles contributing to approximately 30 percent of the total NZ fleet (NZ Transport Agency, 2018).

It is clear that the systemic reduction of carbon emissions from transport will have a significant effect on New Zealand's carbon status. There is an indication that the population are becoming aware of the adverse impacts of climate change and are moving towards electric vehicles. Electric heavy duty vehicles are currently technically challenging to implement, however in the near future these will likely become viable for the market. Electric buses are already in usage and a proliferation of these in public transport will further accelerate the reduction of greenhouse gas emissions. At present the cost and limited availability of electric vehicles in New Zealand impedes market penetration, but does potentially create opportunities for social innovations such as electric vehicle car sharing.

As Transpower's Energy Futures paper suggests, the transition to electric vehicles will radically shift the metrics of electricity provision in New Zealand. Deployment, at an urban scale, of distributed solar rooftop panels with electric cars (and home energy storage) is one way to satisfy this increase in demand. Such a strategy emphasises a distributed energy system, yet one that can mesh with large-scale centralised energy infrastructures – if we design the system to enable it. Solar technology has improved rapidly in the past few years and continual improvements and deployments at scale may further radically reduce unit costs. Clearly, system-wide changes are also necessary: counter-transition practices like the high subsidies afforded to fossil fuel and the absence or unreliability of subsidies for renewables distort the potential for rapid transition to low and zero carbon energy systems. A recent paper in the World Development journal estimates some $5.3 trillion in subsidies in 2015 (Coady, Parry, Sears, & Shang, 2017). Creating an effective and timely carbon transition for New Zealand's largest city Tāmaki Makaurau Auckland is critical. In the following we discuss some key metrics and opportunities relating to Auckland's energy system.

5. Towards a Low Carbon Tāmaki Makaurau Auckland

Tāmaki Makaurau Auckland is a vibrant city with a population estimated to be around 1.66 million in 2017, around 34 percent of the country's total population. The population is increasing at a rate of 1.6 percent per annum (Auckland City Council, 2018). Auckland's long term spatial plan, The Auckland Plan 2050, and the The Low Carbon Strategic Action Plan are important governance tools that provide vision and strategies for low carbon transition (ref). The Low Carbon Strategic Action Plan aims for 40-50 percent of the vehicle fleet to be electric. Tools have already been created such as the Auckland transport android application which includes walking and cycling routes in their search engines for the user to have variety of choices of means of transportation. The city's carbon dioxide emissions amounted to some 10, 955 ktCO2e in 2013, out of which 69 percent came from the transport and non-transport energy sector (Auckland City Council, 2018).

As a high-energy consumer and contributor to greenhouse gas emissions the transport sector is key. The total number of passenger type vehicles registered in Auckland region in 2018 is around 22 percent of the total registered vehicles in New Zealand and around 99 percent of these Auckland passenger registered vehicles use diesel or petrol. Although the assumption of estimated fuel consumption depends on the mileage on the road and efficiencies of each vehicle, for the sake of expediency here, fuel consumption estimates will be based on proportionality. In 2017, the New Zealand transport sector consumed around 48 percent of total energy produced from petrol and diesel (Stats NZ, 2017). In Auckland, we estimate passenger vehicles consumed around 10 percent of total energy produced from diesel and petrol in that year.

In terms of the electricity sector, the Auckland region residential electricity demand is one of the highest in New Zealand. While the consumption of electricity per household during the summer and winter periods is lower than regions in the South such as Dunedin, the significant number of electricity household connections makes Auckland the highest residential electricity consumer as a region. For a typical household in Dunedin, winter demand increases above 2,500 kWh in winter (an estimated increase of around 1,000 kWh) compared to an increase of an estimated 2,000 kWh for a typical household in Auckland (an estimated increase of around 1,000 kWh) (Electricity Authority, 2018). There were 340,550 connections recorded in 2017, as compared to Wellington with 171,364 connections and Dunedin with 55,400 connections (Electricity Authority). It is clear that Auckland residential electricity consumers impact on the country's peak demand over the winter period. Any systemic shifts to the energy usage and generation patterns of this region will have a direct impact on the country's total greenhouse gas emissions and might also mitigate or improve on energy security over the winter periods.

Auckland's 'solar potential' is significant. Indeed, a recent study found that house-based generation capacity is sufficient to both power the house and an electric vehicle with potential to also supply urban daytime electrical loading peaks (Byrd, Ho, Sharp, & Kumar-Nair, 2013). In a home-based radically local energy strategy the transport and electricity sector become co-located within the suburban home, with the home-owner generating energy sufficient to meet domestic demands – of house and transport – with the additional potential to scaffold the local urban system at times of peak demand.

6. Disruptive Energy Policy, Tools, Tactics and Technologies

While security of national electricity provision is a key aspect of energy policy development, the issue of individual and whanau energy security or sovereignty is also central in a wellbeing context. Some quarter of New Zealand households experience energy insufficiency or fuel poverty (Statistics NZ; Howden-Chapman,): Brenda Boardman defines fuel poverty as occurring when more than 10 percent of household income is spent on all household fuels to achieve a warm home (Boardman, 1991). Household-level energy insecurity has an income gradient, affecting lower socio-economic groups disproportionately. Insufficient access to energy should be understood as a public health issue given diverse and potentially severe effects on wellbeing (Lawson & Williams, 2012) which include increased vulnerability to respiratory illness but also to social exclusion as cold homes deter visitors. A paper on child and youth fuel poverty describes the wide-ranging effects of this kind of deprivation: negative outcomes include "reduced calorific intake in winter (Bhattacharya, DeLeire, Haider, & Currie, 2003) increased risk of under-nutrition, being overweight, or acute hospitalisation (Frank et al., 2006); poorer health and development outcomes for children under three years (Cook et al., 2008); and the risk of mental health problems and increased antisocial behaviour among adolescents (Liddell & Morris, 2010) (O'Sullivan, Barnard, Viggers, & Howden-Chapman), 2016). Further, transport poverty can also lead to social exclusion (Rose, 2009) and limit access to a range of urban provisions. Any wellbeing-led, home-based enquiry into low-emissions energy and transport must also attend to how to reduce barriers to accessible transport, whether in the form of public transport, electric car-sharing, low-emissions autonomous vehicles, or individually owned low-emissions vehicles.

It is worth returning to our particular indigenous and integrated model of wellbeing at this juncture, in order to map the purported relationship between a disruptive energy strategy, wellbeing-led policy, and improved wellbeing outcomes. The mauri ora wellbeing model we are exploring in this research exemplifies an extended and more-than-human wellbeing construct (Yates, 2019; Yates, 2018; Yates, 2010). Ora, is life, health, wellbeing. Mauri is that interpenetrating life force which is "immanent in all things, knitting and bonding them together" as a life-field (Royal, 2003 p.47). Mauri ora is the vitality, the wellbeing of this life-field. The concept of mauri is analogous, though not exactly equivalent, to an ecosystem as an enmeshed matrix of environmental and biotic entities. One might therefore describe mauri ora as a form of "ecological wellbeing", though this would rely upon an expanded understanding of the environment where rivers, skies, mountains for example have agency and importance as ancestral entities in and of themselves (Randerson & Yates, 2016; Yates, 2010; Yates, 2008). Mauri ora as an integrative all-of-life wellbeing construct enables a wellbeing framework that is culturally-geographically situated and educes the kind of holistic thinking we suggest is necessary in the Anthropocene.

So how might a mauri ora wellbeing-led transformation be different from a simple decarbonisation strategy that addresses equity issues with integrity? Outcomes may not be greatly different in the aggregate – but in Aotearoa New Zealand there is a case, and indeed a legal infrastructure in the vehicle of Te Tiriti o Waitangi, for working with locally specific constructs. Further – a concept such as mauri ora offers the potential to catch a glimpse into another world through a wellbeing construct that is not human-centric and framed on economic models but rather on a relational and more-than-human model where life is understood as an interconnected field. We assert that this wellbeing construct offers genuine difference and value in the era of the Anthropocene as globalised ecological crisis – at such a time it is fitting and indeed necessary we argue to look to radically different cultural models as disruptive exemplars.

Working with a mauri ora integrated wellbeing model means understanding that mauri connects across all. It requires the comprehension of a different cultural construct in the mode for example of attention to the wellbeing of a river, or of the sky: atmospheric wellbeing is not a concept that yet registers within the majoritarian Euro-American thought of the Anthropocene. Such a model foregrounds how the wellbeing of a human being is affected by the wellbeing of a bird population, a river, a forest, the sky – that we live in relation to the planet always in a way that requires an ethical attention to mauri, to life-vitality, in all of our actions. More instrumentally perhaps, a holistic all-of-life wellbeing model registers across public health, energy, transport, and ecological policy, for example, in a way that discloses how these urban policy matters interrelate, and how policy can leverage across these to gain the widespread benefit that is urgently needed in this era of climate and ecological crisis.

In a mauri ora wellbeing integrative context we can see how a transition from a high to low-carbon energy system holds the potential to benefit not only atmospheric wellbeing, as energy decarbonises and greenhouse gas emissions and particulate levels decrease, but also urban, public health and psycho-social wellbeing. These are complex interdependencies that cut across urban conditions, that link the global with the local, the ecological with the individual. Determining and accounting for these cross-cutting effects, costs and benefits has been a challenge for energy policy analysts, sustainable development planners and governmental balance sheets. Cost-benefit analysis (CBA) is a tool that supports decision-makers by quantifying benefits (improvements in human wellbeing) and costs (reductions in human wellbeing). These are wellbeing analysis tools that also enable decision, policy-making and delivery, as they support infrastructural investment determinations. A report by international infrastructure firm ARUP on total value analysis, a particular form of CBA, describes how current practices generate a "value gap": investments are unable to represent an optimal total value as normative appraisal models in the public sector don't capture a wider value case outside of the monetary (ARUP, n.d). A recent OECD report on CBA notes that while there has been a sizeable increase in the use of such analysis and in its application in policy development, one might have expected even more significant usage given its utility as an analysis tool (OECD, 2018). Challenges to the analysis process include the inherent difficulty of forecasting complex or emergent situations and the question of how to monetise items or conditions that sit outside of normative economic frameworks. There are some significant recent developments in the area of cost benefit analyses however: these include advances in monetising climate costs afforded by the new field of climate economics; the use of valuation approaches in ecosystem analysis; and the way that the increased use of subjective human wellbeing valuation approaches have leveraged the monetisation of environmental impacts, supporting wellbeing related policy and investment.

In the Aotearoa New Zealand context a further significant development is in the governance landscape in which public infrastructure cost-benefit analyses take place. As noted New Zealand is leading in wellbeing-led governance and investment processes, exemplified by the 2019 "wellbeing" Budget and the reintroduction of wellbeing to the Local Government Act (NZ Parliament, 2019). This change in emphasis is disruptive in and of itself as it shifts the signals for policy and investment. What might this change look like in the the local government landscape? Auckland Council's property group Panuku has recently begun to employ a total value analysis (TVA) tool to enable a more integrative analysis and signal for investment. Managing some $3 billion worth of land and building infrastructure Panuku's reach is wide: they are mandated to deliver urban renewal and to render both strategic (environmental, social, cultural and/or economic wellbeing) and commercial outcomes. Further, they are required to be consistently transparent and accountable in the decision/delivery process. In their Onehunga and Manukau regeneration plan (Panuku Onehunga, n.d.) they describe how the total value analysis approach enables them to index and monetise non-commercial environmental, social, cultural and/or economic aspects of their strategic mandate in a way that subverts normative siloed analysis (Panuku Manukau, n.d). This TVA tool enables an analysis of overall positive effect in the real socio-ecological fabric of the city. Further, and transformatively, it makes a holistically determined economic case for action: as such it may be a powerful tool for wellbeing-led transformation.

Another Auckland-based example of a disruptive tactic is found in the place-based partnerships of local iwi Ngāti Whātua Ōrakei and energy company Vector. The Kupe Street case study exemplifies an innovative iwi-industry partnership: here potentially disruptive technologies are tested out in place. Ngāti Whātua Ōrakei's 30-home development Kāinga Tuatahi is a case study neighbourhood where each house is fitted with innovatory technologies in the form of solar rooftop generation and home battery (Vector, 2017). Wellbeing outcomes have been diverse. The community has benefitted from reduction of electricity bills enabling increased energy agency and sovereignty. More expansively, the community has noted a sense of ownership and kaitiakitanga (stewardship) over their energy system (Vector). One can argue that this increased awareness of energy provenance and guardianship of the energy resource is a vital social awareness tool with which to target climate change, and sustainable wellbeing more broadly.

The Kupe Street case study is instructive in regards to how a house-based energy eco-system (solar panels, home battery, and potentially an electric vehicle – owned or shared) may perhaps shift societal attitudes towards energy usage, from a consumer-driven model to a producer/guardian-led model that instantiates sustainable practices. It is also an example of a successful change-making tactic, using a place-based small scale intervention as a means of testing out potentials, opportunities and barriers in a manageable fashion. Panuku's use of a total value approach, within for example its South Auckland Manukau regeneration planning, illustrates how a local government organisation can balance economic and other critical wellbeings to achieve larger strategic urban wellbeing goals. One can argue that this kind of holistic approach has its highest value when utilised in conditions of extreme need – such as in respect to the current climate emergency, but also in relation to critical socio-economic deprivation. The value case for a home-based low-emissions energy infrastructure changes radically if a total value analysis is used in such an instance: this can account for the wider benefits of reduced carbon and greenhouse gas pollution in terms of climate and human health, as well as civic-private benefits of improved access to energy, or enhanced social or economic wellbeing through improved access to transport.

A wellbeing-led urban energy framework creates a strong case for a housing-based energy infrastructure: such a small-scale, radically local urban energy system could begin to address some of the most difficult wellbeing issues around energy and transport poverty while at the same time taking local strategic action to limit climate change. Further, as we have seen Council enterprises such as Panuku already use innovative total value analysis tools to design and assess the delivery of services. Might such a holistic analysis tool create the value-case for transformative civic-private partnerships in home-based low-carbon energy infrastructures? Might those in rental properties receive a basic allowance of energy as a roofing rental fee? Such power could be used to heat the home, or if signed up to a low emissions car-share scheme, could charge a car. Home-owners could rent their roof and solar access in a manner akin to a farmer renting out a cropping field; or install solar panels, perhaps through a neighbourhood or urban energy cooperative that assists with the process and affords reduced costs as a function of scale. Power could be returned to a resilient grid designed for both centralised and distributed power models, or banked in home or car batteries. In such a model home owners and home renters might attain a degree of energy, transport and economic sovereignty: as energy farmers they would have the potential to supplement their own family economies via constantly renewing energy within a collaborative civic-private, urban-suburban energy framework developed as a radical socio-ecological response to the current climate crisis.

7. Conclusion: Home-based energy systems and low-emissions transport

Given the rapid timeline for decarbonisation, just over 10 years now for the 45 percent target and then another 20 years to get to net zero carbon emissions, we outline here analysis frameworks and tools that may leverage system change and speed of transition. We have many of the technological tools needed to decarbonise (Sims et al., 2016). Yet there is a complex socio-cultural-economic inertial resistance to change. This think piece asks whether wellbeing-led frameworks and value analysis tools might enable a more rapid carbon transition as amassed benefits leverage the "business case" for a viable Earth. Such a framework would consider global atmospheric wellbeing and local ecological system wellbeing together with urban, public health and individual human psycho-social wellbeing. In such a wellbeing-led decision framework total value can be recognised and attributed in contrast to the normative financial models where each siloed condition is considered separately with little regard to the complex interactions between multiple elements of the system. Similarly an emphasis on place-based interventions and connectivity of actors – local government and industries, neighbourhoods, or individuals for example – could give effect to the interest many groups and communities have in taking action against climate change. This is a system-based approach, a means of analysis that addresses planetary, urban and individual wellbeing holistically, conceiving of these as an integrated eco-social system whose mauri (life-vitality) must be maintained.

At the city scale, much of Tāmaki is well suited for rooftop solar. Materialising change at the smallest scale in a system – house by house, rooftop by rooftop – could be an effective small-scale transformation tactic. As noted wellbeing-led cost-benefit analysis, such as the total value analysis tool employed by Panuku, is a potential enabler for this kind of change particularly if it is utilised within a wellbeing-led governance framework such as proposed in the amended Local Government Bill. Here we see the utility of a wellbeing governance framework and wellbeing-led analysis tools in the context of the climate crisis of the Anthropocene.

A city-wide, small-scale/nodal energy infrastructure could provide for both building and transformatively, local low-emissions transport energy needs in a granulated, consumer-led manner. Our enquiry here focuses on the home as a low-emission energy infrastructure but equally we could apply these analytics to neighbourhood-level energy schemes, low-emission car-sharing programmes or other transformative energy programmes that may enable us to meet the very tight timelines outlined in the IPCC's Special Report (IPCC). We suggest that this integrative wellbeing-led energy policy approach is timely as it meshes with wellbeing-led governance approaches currently being tested by the New Zealand Government and with the rapid trajectory of globalised climate crisis. This think piece has enquired into disruptive technologies and approaches to energy policy and infrastructure – in further research we hope to test out the transformative capacity of wellbeing-led analysis/action tools through place-based neighbourhood-level collaborative partnerships.

Māku te rā e tō ana;
kei a koe te urunga ake o te rā

let mine be the setting sun;
yours is the dawning of a new day

References

Adler, A., & Seligman, M. (2016). Using wellbeing for public policy: Theory, measurement, and recommendations. *International Journal of Wellbeing, 6. 1-35. 10.5502/ijw.v6i1.429.*(1), 1-35. https://doi.org/10.5502/ijw.v6i1.429.

ARUP. (n.d). *Making the Total Value Case for Investment In Infrastructure and the Built Environment*: ARUP. Retrieved from https://www.arup.com/perspectives/publications/research/section/making-the-total-value-case-for-investment-in-infrastructure-and-the-built-environment

Auckland City Council. *Auckland Plan 2050.* (2018). Retrieved from https://www.aucklandcouncil.govt.nz/environment/state-of-auckland-research-report-cards/Pages/greenhouse-gas-emissions-report-card-auckland-reporting-area-2016.aspx

Bhattacharya, J., DeLeire, T., Haider, S., & Currie, J. (2003). Heat or Eat? Cold-Weather Shocks and Nutrition in Poor American Families. *American Journal of Public Health, 93*(7).

Boardman, B. (1991). *Fuel poverty: from cold homes to affordable warmth*. London; New York: Belhaven Press.

Brigham-Grette, J., Melles, M., Minyuk, P., Andreev, A., Tarasov, P., DeConto, R., . . . Herzschuh, U. (2013). Pliocene Warmth, Polar Amplification, and Stepped Pleistocene Cooling Recorded in NE Arctic Russia. *Science, 340*(6139), 1421-1427. https://doi.org/10.1126/science.1233137

Byrd, H., Ho, A., Sharp, B., & Kumar-Nair, N. (2013). Measuring the solar potential of a city and its implications for energy policy. *Energy Policy*, 944-952. https://doi.org/doi:101016/jenpol201306042

CAT. (2019). *"Can we reach zero carbon by 2025?"* Retrieved from https://www.cat.org.uk/can-we-reach-zero-carbon-by-2025/

Ceballos, G., Ehrlich, P. R., & Dirzo, R. (2017). Biological Annihilation via the Ongoing Sixth Mass Extinction Signalled by Vertebrate Population Losses and Declines. *PNAS (Proceedings of the National Academyof Sciences of the United States of America), 114*(30), E 6089-E6096.

Coady, D., Parry, I., Sears, L., & Shang, B. (2017). How Large Are Global Fossil Fuel Subsidies? *World Development, 91*(March 2017), 11-27.

Cook, J. T., Frank, D. A., Casey, P. H., Rose-Jacobs, R., Black, M. M., Chilton, M., . . . Cutts, D. B. (2008). A Brief Indicator of Household Energy Security: Associations With Food Security, Child Health, and Child Development in US Infants and Toddlers. *Pediatrics, 122*, e867-e875.

Durie, M. (2001). *Mauri Ora – the Dynamics of Mental Health*. Auckland, N.Z.: Oxford University Press.

Electricity Authority. Electricity in New Zealand. (2018). Retrieved from https://www.ea.govt.nz/about-us/media-and-publications/electricity-nz/

Extinction Rebellion; Our Demands. (2019). Retrieved from https://rebellion.earth/the-truth/demands/

Frank, D. A., Neault, N. B., Skalicky, A., Cook, J. T., Wilson, J. D., Levenson, S., . . . Berkowitz, C. (2006). Heat or Eat: The Low Income Home Energy Assistance Program and Nutritional and Health Risks Among Children Less Than 3 Years of Age. *Pediatrics, 118*, e1293-e1302.

Government Offices of Sweden. New measures of wellbeing. (2017). Retrieved from https://www.government.se/articles/2017/08/new-measures-of-wellbeing/

IPCC. (2018). *Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. Retrieved from https://www.ipcc.ch/sr15/

Helliwell, J., Layard, R., & Sachs, J. (2012). *World happiness report* https://doi.org/10.14288/1.0053622

Lawson, R., & Williams, J. (2012). *The nature of fuel poverty in New Zealand*. presented at the meeting of the Annual Conference of the Australia and New Zealand Academy of Marketing, Adelaide, Australia.

Liddell, C., & Morris, C. (2010). Fuel poverty and human health: A review of recent evidence. *Energy Policy, 38*(6), 2987-2997.

Mann, M. E., Rahmstorf, S., Kornhuber, K., Steinman, B. A., Miller, S. K., & Coumou, D. (2017). Influence of Anthropogenic Climate Change on Planetary Wave Resonance and Extreme Weather Events. *Scientific Reports, 7*(Article No. 45242). https://doi.org/10.1038/srep45242

Marsicek, J., Shuman, B. N., Bartlein, P., Shafer, S. L., & Brewer, S. (2018). Reconciling divergent trends and millennial variations in Holocene temperatures. *Nature, 554*, 92-96. https://doi.org/10.1038/nature25464.

MFE. (2019). *Ministry for the Environment, New Zealand's Greenhouse Gas Inventory*. Retrieved from https://www.mfe.govt.nz/climate-change/state-of-our-atmosphere-and-climate/new-zealands-greenhouse-gas-inventory

Ministero dell'Economica e delle Finanze. Italy's 2017 economic and financial document for the first time includes BES indicators (BES – Benessere Equo e Sostenibile = Equitable and Sustainable Well-being). (2017). Retrieved from http://www.mef.gov.it/en/inevidenza/article_0276.html

Ministry of Business, Innovation and Employment NZ. *Developing our Energy Potential*. Retrieved from https://www.mbie.govt.nz/assets/55f3c6780c/nz-energy-strategy-lr.pdf

Ministry for the Environment 2018. Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment. (2018).

Ministry of Transport. Monthly electric and hybrid vehicle table. (2018). Retrieved from https://transport.govt.nz/mot-resources/vehicle-fleet-statistics/monthly-electric-and-hybrid-light-vehicle-registrations-2/

New Zealand Parliament, Climate Change Response (Zero Carbon) Amendment Bill. (2019). Retrieved from https://www.parliament.nz/en/pb/bills-and-laws/bills-proposed-laws/document/BILL_87861/climate-change-response-zero-carbon-amendment-bill

New Zealand Parliament; Local Government (Community Well-being) Amendment Bill. (2019). Retrieved from https://www.parliament.nz/en/pb/bills-and-laws/bills-proposed-laws/document/BILL_77941/local-government-community-well-being-amendment-bill

New Zealand Productivity Commission. (2018). Low-emissions economy: Final report. Retrieved from https://www.productivity.govt.nz/low-emissions

NOOA. (2019). *Earth System Research Laboratory, Trends in Atmospheric Carbon Dioxide*. Retrieved from https://www.esrl.noaa.gov/gmd/ccgg/trends/

NZTransport Agency. Motor Vehicle registration. (2018). Retrieved from https://opendata-nzta.opendata.arcgis.com/datasets/motor-vehicle-register

O'Sullivan, K., Barnard, L. T., Viggers, H., & Howden-Chapman, P. (2016). Child and youth fuel poverty: assessing the known and unknown. *People Place and Policy Online, 10*, 77-87. https://doi.org/10.3351/ppp.0010.0001.0006.

OECD. (2018). *Cost-Benefit Analysis and the Environment; Further Developments and Policy Use*. Paris: OECD. https://doi.org/https://doi.org/10.1787/9789264085169-en.

Panuku *Onehunga*. (n.d.). Retrieved from https://www.panuku.co.nz/downloads/assets/4839/1/onehunga high level project plan (part two).pdf

Panuku Manukau. (n.d.). Retrieved from https://www.panuku.co.nz/downloads/assets/5305/1/manukau%20framework%20plan%20(part%20three).pdf

Randerson, J., & Yates, A. (2016). Negotiating the Ontological Gap: Place, performance and media art practices in Aotearoa/New Zealand. In J. Adamson & S. Monani (Eds.), *Ecocriticism and Indigenous-Studies: Conversations from Earth to Cosmos* London and New York: Routledge.

Rose, E., Witten, K., & McCreanor, T. (2009) Transport related social exclusion in New Zealand: Evidence and challenges, *Kōtuitui: New Zealand Journal of Social Sciences Online*, 4:3, 191-203. https://doi: 10.1080/1177083X.2009.9522454

Royal, T.C (Ed.). (2003). The Woven Universe: Selected Writings of Rev. Māori Marsden. Wellington: MKTA-Living Universe Ltd.

Sims, R., Barton, B., Paul Bennett, Nigel Isaacs, Kerr, S., Leaver, J., . . . Stephenson, J. (2016). Transition to a low-carbon economy for New Zealand. Wellington, New Zealand: Royal Society of New Zealand.

Stats NZ, Census Quick Stats. (2013). Retrieved from http://archive.stats.govt.nz/Census/2013-census/profile-and-summary-reports/quickstats-about-a-place.aspx?request_value=13170&tabname

Stats NZ. New Zealand energy use: 2017. (2017). Retrieved from https://www.stats.govt.nz/assets/Uploads/New-Zealand-energy-use/New-Zealand-energy-use-2017/Download-data/energy-use-survey-industrial-trade-sector-2017-tables.xlsx

Transpower. *Te Mauri Hiko, Energy Futures, White Pages 2018*. (2018). Retrieved from https://www.transpower.co.nz/sites/default/files/publications/resources/TP Energy Futures – Te Mauri Hiko 11 June%2718.pdf

Vector. (2017). *Powering a real sense of community*. Retrieved from https://www.vector.co.nz/articles/powering-a-real-sense-of-community

Vivid, E. (2017). *Net Zero in New Zealand: Scenarios to Achieve Domestic Emissions*

Neutrality in the Second Half of the Century: Summary Report: Report prepared for GLOBE-NZ, March 2017.

World Meteorological Organization Statement on the State of the Global Climate 2017. (2018). Retrieved from https://library.wmo.int/opac/doc_num.php?explnum_id=4453

Yates, A. (2008). On Nature, Culture and Sustainable Design In C. A. Brebbia (Ed.), *Design and Nature IV: Comparing Design in Nature with Science and Engineering* (pp. 191-200). Southampton, UK: WIT Press.

Yates, A. (2010). Micro-urbanism: Regenerative Buildings and the Architectural Landscape of the Pā. In K. Stuart & M. Thompson-Fawcett (Eds.), *Tāone Tupu Ora: Indigenous Knowledge and Sustainable Urban Development* (pp. 23-27). Wellington, NZ: Steele Roberts.

Yates, A. (2018). Mauri-ora: Architecture, indigeneity and immanence ethics. In A. Jasper (Ed.), *Architecture and Anthropology*. London: Routledge.

Yates, A. (2019). *Whanake Mai Te Mauri Ora: Think piece – An Expanded Wellbeing Framework and Urban Science Data Tool For Integrated Wellbeing Governance.* Tāmaki Makaurau/Auckland, NZ: National Science Challenge 11: Building Better Homes, Towns and Cities.