CREATING RESILIENT CITIES

How a new generation of tools can assist local governments in achieving carbon their abatement goals

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INTRODUCTION

'Resilient Cities' is a relatively new term that is designed to go further than 'Sustainable Cities' by pushing the transformational aspects of the changes needed within cities to adapt to the long-term challenges facing the planet such as climate change and resources scarcities. Sustainability is still a powerful word in application to cities as it enables us to focus on holistic, synergistic solutions that integrate economic, social and environmental outcomes. Nevertheless, the ambitious goal agreed to in Copenhagen in 2009 of reducing global greenhouse gas emissions by 80% by 2050, will need more than just integrated solutions - it will require the fundamental transformation of cities.

This paper looks at the role local government's can play in helping to meet this challenge. A range of city types are outlined based on work done by Newman (et al 2009) that will help to create the resiliency needed within cities. However, it is argued that for cities and local governments to implement the required changes, new, 21st century tools are needed to help deliver the sustainability features and resilience that each aspect brings. Such tools should provide data on the carbon abatement opportunity and cost implications associated with the implementation of a range of policies and actions, along with the ability to track progress. Until now, few tools have been able to deliver these outcomes effectively (Beattie et al 2011). As a result, decisions have been limited to check lists, which have proliferated globally and dominate current decision-making.

This paper identifies and examines a new web-based tool that provides the above-mentioned capabilities and therefore, can offer the transformational support needed. The authors explore how the tool could be applied to each of the Resilient City types and argue that this new generation of tool will be fundamental in transforming cities to become low carbon, resilient cities of the future.

RESILIENT CITIES – THE COMPONENTS OF THE TASK

In the book by Newman, Beatley and Boyer (2009) 'Resilient Cities: Responding to Peak Oil and Climate Change', seven city types were identified and outlined. Each of these city types have characteristics that could lead to major reductions in carbon; each has a specific task to apply to a different part of city management that needs to make a contribution to reducing carbon and oil vulnerability. The city types are outlined below and will be given some focus before applying a new tool, C^{CAP} City, to see how it can help to give substance to local government policy-making in each area.

Characteristics of resilient cities

Globally, there are seven features of resilient cities that are emerging. These are described as seven archetypal cities:

- The renewable energy city
- The carbon-neutral city
- The distributed city
- The biophillic city
- The eco-efficient city
- The place-based city
- The sustainable transport city.

These city types are overlapping in their approaches and outcomes. The challenge for urban professionals is to apply all of these approaches together, to generate a transformational sense of purpose through a combination of new technology, city design and community-based innovation.

Resilient City Types

1. The renewable energy city

There are now a number of urban areas that are partly powered by renewable energy technologies, from the region to the building level. Renewable energy enables a city to reduce its ecological footprint, and if using biological fuels, can be part of a city's enhanced ecological functions.

Renewable energy production can and should occur within cities, integrated into their land use and built form, and comprising a significant and important element of the urban economy. Cities are not simply consumers of energy, but catalysts for more sustainable energy paths, and can increasingly become a part of the earth's solar cycle.

New model cities that are 100% renewable are needed (see Masdar City in the United Arab Emirates), but retrofitting existing cities is just as important. In Europe, Freiburg and Hannover have become demonstrations on how to bring renewable energy into city planning (City of Hannover, 1998; Scheurer and Newman, 2008).

Along with planning strategies and incentives (financial and density bonuses), renewable cities recognize the need to set minimum regulatory standards (see Barcelona solar ordinance). Transport can also be a major part of the renewable energy challenge. The more public transport moves to electric power, the more it can be part of a renewable city (see Calgary Transit's "Ride-the-Wind" program). Renewable power enables cities to create healthy and liveable environments while minimizing the use and impact of fossil fuels.

Every local government needs to have a goal of major increases in renewable energy but, by itself, this will not be enough to ensure resilient urban development that can meet the 80% less CO_2 goal by 2050. However local governments will need to assess policies for economically introducing renewables and to assess each new development in a city to show how its renewable energy components can be contributing to the city.

2. The carbon-neutral city

Many businesses, universities, local governments and households are now committed to minimizing their carbon footprint and even becoming carbon neutral. But can it become a feature of whole neighborhoods and even complete cities? There are those who suggest it is essential if the world is to move to 'post-carbon cities' (Lerch, 2007).

Several initiatives focus on helping cities to reach these goals, including ICLEI-Local Governments for Sustainability's Cities for Climate Change, Architecture 2030, the Clinton Foundation's C-40 Climate Change Initiative and UN-HABITAT's Cities for Climate Change Initiative (CCCI).

The United Kingdom government has decided that all urban development will be carbon neutral by 2016, and phasing in began in 2009. The Beddington Zero Energy Development initiative is the first carbon-neutral community in the United Kingdom. It has extended the concept to include building materials and, as it is a social housing development, it has shown how to integrate the carbon neutral agenda with other broader sustainability goals, making it a more resilient demonstration.

Cities using carbon neutral as their planning strategy include Malmö and Växjö in Sweden, Newcastle (UK), Adelaide, Sydney and Fremantle in Australia. Vancouver's Winter Olympic Village was built as a model North American demonstration in carbon neutral urban development. The link to the green agenda of a city is very direct with respect to the carbon neutral approach of bioregional tree planting schemes. By committing to be carbon neutral, cities can focus their offsets into bioregional tree planting, as part of the biodiversity agenda as well as to address climate change.

Although there are many good tree-planting programs (see Australia's Green Fleet and Gondwana Links), none are committed yet to a comprehensive city-wide carbon-neutral approach that can link tree planting to a broader biodiversity cause. If this is done, cities can raise urban and regional reforestation to a new level and contribute to reducing the impact of climate change, simultaneously addressing local and regional green agenda issues.

The carbon-neutral city will receive a big boost when a global compact on carbon trading can be achieved, as this will enable the voluntary carbon trading market to become mainstream.

Each local government should be able to assess how it can achieve a carbon neutral standard in its own activities including local carbon abatement/offsetting options as well as the ability to assess any urban development within their jurisdiction that claims to be carbon neutral.

3. The distributed city

The development of distributed power, water and waste systems aims to achieve a shift from large centralized systems to small-scale and neighbourhood-based systems in cities. The distributed use of power and water can enable a city to reduce its ecological footprint, because power and water can be more efficiently provided using the benefits of electronic control systems and community-oriented utility governance. While this also applies to localised waste management, waste is discussed as a function of the eco-efficient city.

The distributed water system approach is often called ‘water sensitive urban design’. It includes using the complete water cycle, i.e., using rain and local water sources like groundwater to feed into the system and then to recycle ‘grey’ water locally and ‘black’ water regionally, thus ensuring that there are significant reductions in water used and pumping requirements - hence reductions in energy and CO_2 (Benedict and McMahon, 2006).

A number of large cities including New York, London and Sydney are moving to distributed energy generation through co-generation and tri-generation from natural gas as well as local solar and wind. This distributed generation offers a number of benefits, including energy savings, given the ability to provide power without long distribution lines, better control of power production to meet demand, lower vulnerability and greater resilience in the face of natural and human-made disaster (including terrorist attacks). Clever integration of this small-scale infrastructure into a grid can be achieved with new technology control systems (i.e. smart grids) that balance the whole system in its demand and supply from a range of sources as they rise and fall and link it to storage, especially vehicle batteries through vehicle-to-grid, or ‘V2G’, technology (Went, James and Newman, 2008). A number of such small-scale energy systems are being developed to make cities more resilient in the future (Sawin and Hughes, 2007).

Distributed infrastructure needs compact, mixed-use urban development and new governance to go with new urban design. Examples of new locally owned and operated utilities are now appearing (see Woking, UK and The City of Sydney).

Each local government requires a tool to enable it to assess the cost and carbon implications of any infrastructure, especially in urban developments that are planning to use the new green infrastructure of small scale, localised systems.

4. The biophillic city

Biophillic cities are using natural processes as part of infrastructure: green roofs, green walls and integrated open space management together with creative use of urban areas for food production (Beatley, 2010). One of the core reasons for cities moving down the Biophillic path is to air condition their city through the photosynthetic cooling effects of plants and water in the urban landscape as well as using less heat absorbing materials.

One of the most important potential biofuel sources of the future is blue-green algae that can be grown intensively on roof tops. Blue-green algae photosynthesize, so all that they require is sunlight, water and nutrients. The output from blue-green algae is ten times greater than most other biomass sources, so it can be continuously cropped and fed into a process for producing biofuels or small-scale electricity. Most importantly, city buildings can all use their roofs to tap solar energy for local purposes without the distribution or transport losses so apparent in most cities today. This can become a solar ordinance set by town planners as part of local government policy. Chicago and Toronto are requiring green roofs in commercial development and Singapore is moving to be Asia’s first Biophillic City (Newman, 2010).

Progress in moving away from fossil fuels also requires serious localizing and local sourcing of food and building materials (Halweil,and Nierenberg, 2007). This, in turn, provides new opportunities to build more biophillic economies. The value of emphasizing the local is many-fold with the primary benefit of dramatic reductions in the energy consumed in mass producing and delivering products and food (see BedZed example). A biophillic approach can produce local fibre which will mean an added reduction in fibre miles as well as potential to help re-grow local bioregions.

The new agenda of the biophillic city will be confronting every local government as it seeks to cool its city through landscaping of land and buildings. The carbon implications in such policy needs to be assessed and local governments need to be able to access such a tool.

5. The eco-efficient city

In an effort to improve eco-efficiency, cities and regions are moving from linear to circular or closed-loop systems, where substantial amounts of their energy and material needs are provided from waste streams. Eco-efficient cities reduce their ecological footprint by reducing wastes and resource requirements, especially in industry and industrial parks.

The eco-efficiency agenda has been taken up by the United Nations and the World Business Council on Sustainable Development, with a high target for industrialized countries of a 10-fold reduction in consumption of resources by 2040, along with rapid transfers of knowledge and technology to developing countries. While this eco-efficiency agenda is a huge challenge, it is important to remember that throughout the industrial revolution of the past 200 years, human productivity has increased by 20,000%. The next wave of innovation has a lot of potential to create the kind of eco-efficiency gains that are required (Hawkens et al., 1999; Hargrove and Smith, 2006).

The urban eco-efficiency agenda includes the ‘cradle to cradle’ concept for the design of all new products and includes new systems like industrial ecology, where industries share resources and wastes like an ecosystem (McDonaugh and Braungart, 2002). Good examples exist in Kalundborg, Germany; and Kwinana, Australia (Newman and Jennings, 2008).

One extremely powerful example of how this eco-efficiency view can manifest in a new approach to urban design and building can be seen in the dense urban neighbourhood of Hammarby Sjöstad, Stockholm, which is connected to central Stockholm by a high-frequency light-rail system. Here, from the beginning of the planning of this new district, an effort was made to think holistically, to understand the inputs, outputs and resources that would be required and that would result. For instance, about 1,000 flats in Hammarby Sjöstad are equipped with stoves that use biogas extracted from wastewater generated in the community. Biogas also provides fuel for buses that serve the area. Organic waste from the community is returned to the neighborhood in the form of district heating and cooling. Industries in the area are similarly integrated in their resource and waste management (Newman, Beatley and Boyer, 2009).

Eco-efficiency does not have to involve just new technology; it can also be introduced into cities through intensive use of human resources, as in Cairo’s famous Zabaleen recycling system (UN Habitat, 2008). There are many other examples of how cities across the third world have integrated waste management into local industries, buildings and food production (Hardoy et al., 2001).

Local governments need a tool that can assess the eco-efficiency of developments including the way that wastes are integrated into the overall carbon reduction goal of the city.

6. The place-based city

The more place-oriented and locally self sufficient a city’s economy is, the more it will reduce its ecological footprint and the more it will ensure that its valuable ecological features are enhanced. Place-based city concepts will increasingly be the people-oriented motivation for the infrastructure decisions that are made in each of the other city types.

Local economic development has many advantages in the context of sustainable development, including the ability of people to travel less as their work becomes local. Finding ways to help facilitate local enterprises becomes a major achievement for cities in moving towards a reduced ecological footprint. What the pioneers of local job creation initiatives have found, time and time again, is that place really matters. When people belong and have an identity in their town or city, they want to put down their roots and create local enterprise.

Local economic development is a first priority for most cities. As part of this, many cities are placing increasing emphasis on local place identity, as social capital has been found to be one of the best ways to predict wealth in a community (Putnam, 1993). Thus, when communities relate strongly to the local environment, the city’s heritage and its unique culture, they develop a strong social capital of networks and trust that forms the basis of a robust urban economy.

This approach to economic development, which emphasizes place-based social capital, has many supporters, but very few relate this to the sustainability agenda in cities. For example, energy expenditures

— by municipalities, companies and individuals — represent a significant economic drain, because they often leave the community and region. Producing power from solar, wind or biomass in the locality or region is very much an economic development strategy that can generate local jobs and economic revenue from land (farmland) that might otherwise be economically marginal, in the process recirculating money, with an important economic multiplier effect. Energy efficiency can also be an economic development strategy. For example, research on renewable energy and the creation of related products have developed into a strong part of the economy in Freiburg, Germany. Worldwide, there is increasing dialogue around the importance of ESCO's (Energy Service Companies), which are not necessarily energy utilities but can provide numerous energy related services such as demand side management.

Sense of place in a city requires paying attention to people and community development in the process of change — a major part of the urban planning agenda for many decades. This localized approach will be critical to creating a resilient city. It creates the necessary innovations as people dialogue through options to reduce their ecological footprint, which in turn creates social capital that is the basis for on-going community life and economic development (Beatley and Manning, 1997; Beatley, 2005). City dwellers in many countries increasingly want to know where their food is grown, where their wine comes from, where the materials that make up their furniture come from. In addition to a slow movement for local foods, a slow fibre and slow materials movement for local fabric and building purposes can also help create a sense of place and make greater resilience.

Local governments need to be able to assess the carbon reduction potential of different ways of bringing local jobs into the community.

7. The sustainable transport city

Transport is the most fundamental infrastructure for a city, because it creates the primary form of the city (Newman and Kenworthy, 1999). Cities, neighbourhoods and regions are increasingly being designed to use energy sparingly by offering walkable, transit-oriented options, more recently supplemented by vehicles powered by renewable energy. Cities with more sustainable transport systems have been able to increase their resilience by reducing their use of fossil fuels, as well as through reduced urban sprawl and reduced dependence on car-based infrastructure.

The agenda for large sprawling cities now is to become a Polycentric City where real cities in the suburbs are rapidly developed as local centres of jobs, services and the focus for bringing distributed infrastructure. This will significantly reduce car use and help cities face peak oil and the need to decarbonise – the first signs of which are now appearing in all US and Australian cities as car use per capita declines and transit grows dramatically (Newman and Scheurer, 2010).

Sustainable transport strategies will need to incorporate: (i) quality transit down each main corridor that is faster than traffic; (ii) dense Transit Oriented Developments (TOD) built around each station; (iii) pedestrian and bicycle strategies for each centre and TOD, with cycle links across the city; (iv) plug-in infrastructure for electric vehicles as they emerge; (v) cycling and pedestrian infrastructure as part of all street planning; and (vi) a green wall growth boundary around the city preventing further urban encroachment (Newman, Beatley and Boyer, 2009).

21ST CENTURY DECISION MAKING TOOLS FOR RESILIENT CITIES

Each of the above policy options need to be fed into a tool that can enable local governments to rapidly assess the cost and carbon implications of various design and investment options. Until recently, however, such tools were hard to come by. There has long been a wealth of information available regarding various climate change mitigation and adaptation actions and policies, however, there has been little systematic way of analysing and comparing those options in order to determine which are the most beneficial and appropriate for each council.

New tools need to acknowledge that each Local Government Area (LGA) varies in location (and hence climate), population, physical boundary, amount of resources (financial and natural), existing infrastructure, political setting etc (Laukkonen et al 2009, Genske date, Droege 2006), and therefore, no set group of measures will be applicable to every council. Moreover, the climate change impacts (i.e. river flooding, droughts, sea level rise etc) facing local councils will vary considerably presenting different challenges and requiring different priorities. These differences mean each local council, city and region will need to respond in different ways and that the assortment of policies and carbon mitigation efforts are likely to vary considerably. This ultimately affects the degree to which each city can implement the various 'resilient city' characteristics.

For a tool to be effective, these differences between LGA's need to be taken into consideration, and based on these differences, policy options, technologies and actions need to be compared and prioritised accordingly. New 21st century planning and decision-making tools will therefore need to be interactive and ideally web-based. They need to measure and compare the financial implications of the options, the amount of carbon abatement possible as well as having the ability to track and evaluate the implemented measures over time. C^{CAP} City is a new tool that appears to fulfill these requirements. The tool is discussed below.

C^{CAP} CITY

C^{CAP} City is a new web-enabled carbon analysis tool that allows governments and planning authorities to address the above-mentioned considerations. It allows context specific data to be entered into the tool and using evidence-based data, provides the necessary guidance to assist local governments in making the most suitable decisions based on the information available.

Using a GIS interface, C^{CAP} City allows local governments to spatially and temporally understand the emissions profile of their local government area (LGA), which includes their community's emissions, not simply Council activities, which have traditionally been the primary focus. By integrating local data on aspects such as land-use, transport, waste, floor space and metered energy, as well as financial information, a detailed carbon analysis is provided to councils on a range of policies and/or projects. The tool also enables Councils to have the ability to model and track the impact of implementing a variety of carbon abatement options over a given time period. The tool also calculates the expected financial implications of each policy selected in the tool. This allows local governments to choose the most appropriate, applicable and financially viable set of abatement options for their LGA as well as providing a design tool in assessing project development options.

While many tools and organizations are currently able to assist with the initial steps outlined (i.e. ICLEI and a range of private consultants), the process of selecting appropriate measures based on evidence and how to implement these remains a challenge for local governments. Research and practice shows a noticeable lack of information and tools to support the decision-making process by which the appropriate set of actions are chosen to meet the reduction goal. Carlisle and Bush (2009) refer to this as "the Planning Gap". Gore (2009) acknowledges that "cities and towns could benefit by developing computerized statistics on each of the major challenges they face and integrate them and display them visually for groups that include department heads and other stakeholders in a shared effort to discover what really works and what does not. The task confronting policy makers in the historic effort to solve the climate crisis will require the innovative use of every new tool available" (Our Choice, Al Gore 2009)

C^{CAP} City is one of the first tools designed to fill this gap by allowing local councils to explore the various carbon abatement options available using an evidence-based modeling tool. The user can instantaneously see what impact each abatement option will have on reaching the target. Verified consumption data from the LGA is entered into the tool annually in order to track actual progress against the projected scenario. This allows the implemented policies and actions to be evaluated in terms of their success, and where success is deficient, to explore reasons why. This knowledge can then be shared amongst councils.

Results are displayed spatially and graphically, which provide a variety of important information including the potential CO2-e that could be abated between the base year and the target year from each of the proposed policies, the marginal abatement cost of the policies over the time period (i.e. $/t CO2-e), and the tracking of progress.

Current Policy Options within the Tool

While a myriad of policy options and actions currently exist to reduce emissions at the local government level, C^{CAP} City focuses on those policies that urban managers can influence and control. The three areas targeted in this tool include energy, waste and transport and include:

- Energy efficiency, including as lighting and appliances
- Fuel switching, including as gas hot water and tri-generation
- Renewable energy, including solar PV, solar thermal and wind
- Waste strategies, including waste separation and waste to energy policies
- Land use and transport strategies, including changing land use, density and growth strategies, public transport availability and frequency, parking controls, car share and electric vehicles.

The tool allows the user to implement varying degrees of each policy. Drop down menu's allow the user to choose, for example, which percentage of residential dwellings should have Solar PV, what kind of street lighting could be used, or what type of, and how many parking controls could be realistically implemented within each precinct of the LGA. Varying the mix of policies affects the amount of carbon able to be abated as well the cost of the abatement options. Furthermore, when a major development opportunity confronts the city, it will have the ability to assess the carbon and cost implications involved and examine what would happen if variations to density, jobs, infrastructure, building ratings and transport options were altered.

These policy and project assessments can give Councils considerable assistance to measure their ability to respond to targets set by their own or other levels of government. In addition, as a live web-tool, C^{CAP} City tracks electricity and gas consumption, waste generation and travel patterns over time to ensure the implementation of strategies is achieving the expected outcomes.

The extent to which the tool can be valuable in helping meet the goals of the Resilient City as set out above will now be discussed.

APPLICATION OF C^{CAP} CITY TO RESILIENT CITIES

The various policies outlined above can be applied to the seven resilient city characteristics and help begin to facilitate the transformation of LGA's. As previously mentioned, the seven city types overlap in their approaches to resiliency meaning the outcomes from implementing one policy measure may have numerous benefits and be applicable in more than one city type. Below is a breakdown of how C^{CAP} City could assist in modelling the various city types.

1. Renewable Energy City

The tool can assist in evaluating the extent to which various renewable energy resources can be tapped in the council area and what costs would be involved. It can do this for particular developments and also what could happen if for example a whole area of warehousing or large shopping complex was covered in PV. Generally it has shown for the Australian context that PV will have limited ability to reduce carbon as there just isn't enough roof area. What is needed also is a balance between base load and intermittent power supply. The conclusion from the model has been that cost effective renewables is going to have to be a combination of PV, small scale wind, geothermal and localised, small scale trigeneration based on gas. This gas can be sourced from renewable biomass supplies such as solid waste, sewage, animal waste, agricultural waste etc in the local bioregion.

The tool's application was recently demonstrated in a public forum with Waverley Council to identify the most strategic pathways for emission reductions across their community. The key to implementing effective carbon reduction strategies is looking beyond the capacity of the technology at hand and considering how it will perform under the unique conditions that will exist in situ.

Given that Waverly council has the greatest population density of any local government area in Australia, solar power was never going to be the dominant emission reduction technology. C^{CAP} City was able to demonstrate that even if solar panels were installed on every residential building within the city limits, it would only achieve approximately 90 tonnes per year of carbon savings by 2020. By comparison, 9,000 tonnes per year of carbon could be avoided by 2020 by installing tri-generation within the Bondi Junction precinct, making this a far more desirable option. In another lower density local government area solar PV might well be the more optimal strategy. This highlights the need for carbon reduction policy to be place-sensitive.

2. Carbon Neutral City

The tool can estimate the various combinations of policies that will increase energy efficiency, add renewables and then how much more offsetting would be needed to meet the goal of carbon neutral. It can do this for particular projects as well as for the council seeking what would be needed for the whole area to reach such a target. The City of Sydney and the City of Fremantle have both reached carbon neutral status by purchasing green power. This is a legitimate and helpful way forward though both councils have now recognised that there is probably more they can do if they used the extra money they give to utilities for their greenpower and put it to use providing their own low and zero carbon locally. The savings in distribution losses are obvious and hence they are moving from a carbon neutral approach based on the big scale utilities approach to their own small-scale utilities – the distributed city model.

3. Distributed City

The tool is well set up to evaluate the many options in projects or across different council districts, of different distributed energy and waste systems. It can provide carbon implications in a way that shows the synergies between these different technologies. With the cost function it can enable an array of options to be assessed and weighed up as realistic policy options. For example in Western Australia the tool has been used on assessing the design options for a redevelopment project called the Cockburn Coast. The combination of building standards, density, mix, green infrastructure and public transport enabled the project to provide a development with 55% less carbon, 75% less water, 36% less car use, 23% less embodied carbon in the materials, and 17% more affordable housing, all for just $5600 extra per dwelling. This remarkable outcome shows the strength of the design tool in enabling all the features of a distributed city to be integrated and assessed as a total system, compared to a normal housing subdivision.

4. Biophillic City

The reductions in energy required to heat and cool buildings provided by biophillic designs can be factored in to how the carbon impacts are assessed in the same way that different levels of insulation are assessed. These will vary from region to region and need to be contextualised in the tool based on climate data. For example, the tool could be used to assess the value of street tree planting on local temperatures and hence air conditioning load. Thus green roofs and green walls introduced can be modelled based on assumptions about their temperature impacts and as well how much more water they would consume.

5. Eco-efficient City

The way that particular industries can contribute to the overall city's ability to reduce its carbon footprint can be estimated by assessing various infrastructure options. For example, embedded energy can be tested both at a building level as well as precinct or city scale. In the City of Sydney an assessment has been made of how a distributed energy system could reduce the carbon and costs for a whole series of precincts across the local government area including ones where major energy-consuming industries could be switched to the alternatives. Industry data can be fed into the model just as housing data are included.

6. Place-based City

The best way of assessing this policy is through varying the level of local jobs in an area and how the jobs-residents balance minimises transport carbon and costs. The kinds of policies that can enable these results to be achieved will need to be factored in based on local context and opportunities. The carbon and cost options of creating mixed use developments were assessed by the tool in a number of projects including the Cockburn Coast outlined above and Eastlakes in Canberra. The governance arrangements to manage this process still need to be dealt with separately but at least the potential carbon savings can be assessed.

7. Sustainable Transport City

The various transport policy options outlined above, can all be assessed by the tool. These include: degrees of polycentricity, transit options, density and mix options, pedestrian and cycle options, EV options, changes in fuels and vehicles, options for either containing growth through redevelopment or allowing fringe growth. For example the tool is being used in several local councils across Australia including Canning and Stirling in Perth, Waverley and Sydney to help optimise their integration of transport and land use.

INTERNATIONAL APPLICABILITY

Developed in Sydney, Australia by Kinesis, C^{CAP} City is currently being used by local governments in Sydney and Western Australia. It is linked to a similar project-oriented tool, C^{CAP} Precinct, that enables a similar assessment to be made of new infill or greenfield urban developments that are being designed and planned. C^{CAP} Precinct is currently used by local and state governments and developers across Sydney, Perth, Brisbane, Canberra and Melbourne.

Kinesis have endeavored where possible, to utilize each council's own data including planning, transport, land-use and environmental performance data in all of their planning tools. Additional data has been sourced from a variety of Government and non-government organizations, including energy and water utilities and transport and planning agencies.

While the first applications were based in Sydney, Australia, the fact that the tool has since been adapted for use in various climate and energy zones such as Perth and Regional areas of Western Australia such as

Geraldton, show that useful data could be found without too much adaption of the model. Trialling the tool in very different cities will enable a much greater appreciation of its strength, range and applicability.

The demonstrated adaptability of the tool between various regions suggests that this tool, given the availability of adequate data, could be applied anywhere in the world.

CONCLUSION

The seven resilient city types outlined in this paper require 21st century tools to be able to deliver the required features and the resilience that each aspect brings. C^{CA}P City is one such tool that can provide data on the carbon abatement opportunity and cost implications associated with the implementation of a range of policies and actions along with the ability to track progress. This guidance and decision-making capability together with the capacity to evaluate progress is critical for local governments to be able to move forward with the implementation of policies and required measures, and consequently fills an important gap that currently exists in local government planning. Without these new and innovative, evidence-based tools, decisions are limited to check lists, which have proliferated globally and dominate current decision-making. Whilst indicating a desire for local governments to do better at reducing carbon, they will never cope with the complexity and interactions between different factors that need to be optimized if real reductions in carbon are to be found. The C^{CAP} City tool is an example of the kind of 21st century web-based tool that can enable complexity to be modeled and real design options provided that can enable cost effective carbon reduction. Resilient cities begin to look feasible with the aid of such a tool.

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