Sustainable Built Environment National Research Centre AUSTRALIA

## For The Routledge Handbook of Urban Design Practice

# Net Zero Cities and Urban Design

**Peter Newman, Professor of Sustainability, Curtin University, Australia**

**SBEnrc P1.84 Net Zero Corridors – The Business Case and an Engagement Process**

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**The manuscript**

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**Project Leader:** Professor Peter Newman, Curtin University
p.newman@curtin.edu.au

Peter Newman is the Professor of Sustainability at Curtin University. Peter has written 23 books and over 400 papers on sustainable cities and decarbonization policy. He has worked to deliver his ideas in all levels of government having been an elected councillor, seconded to advise three Premiers and on the Board of Infrastructure Australia 2008-14. He is the Co-ordinating Lead Author for the UN's IPCC on Transport. In 2014, Peter was awarded an Order of Australia for his contributions to urban design and sustainable transport. In 2018/19 Peter was the WA Scientist of the Year.

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## Executive Summary

The net zero city agenda is gathering momentum but needs bottom-up processes that enable creative design solutions using 21st century technologies integrated using smart systems and sustainable design. The need to enable different solutions for each urban fabric is shown. The transition can begin by finding the best urban regeneration areas and directing a process called net zero corridors along main roads using 21st century mid-tier transit and urban regeneration around station precincts. The approach is outlined.

## Introduction

Climate change is seeping into all professional practice, especially cities and their design. This chapter will outline how such design intention is emerging and the challenges that urban design practitioners face in delivering the global and local outcomes that are increasingly being demanded by communities, politicians and business. Net zero design is now on the desks of practitioners across the world.

In the Climate Mitigation report (IPCC, 2022) there were chapters on Transport, Power and Buildings as before but there were also new chapters on Cities and on Demand all of which discuss in detail the importance of net zero cities. It is thus emerging as a major agenda for urban development (Zero Carbon Cities Action Planning Network, 2020; Seto et al 2021) but it is not clearly defined in professional practice.

Whatever net zero practice becomes it needs to be integrated into the historic role that cities have always played. It will continue the role of urbanism and urban design to enable the growth of civilized spaces and enhanced human activity through places that encourage interaction, productivity and equity (Hall, 1998; Kostoff, 1991; Glaeser, 2011) as well as net zero outcomes (Newman, 2020).

## Background – Why the old urban design needs updating.

Urban design has a long history but the biggest impact on our cities came from the Modernist movement of Le Corbusier from the 1930's that built new cities while emerging from the Great War and the Great Depression (Kostoff, 1991). Modernist design sought to find a way of cleaning up the old city and creating new forms using new materials and infrastructure based around cars and fossil fuels. This has shaped urban development until the sustainability and climate change movement began to question its fundamentals and suggest new approaches particularly ways of overcoming automobile dependence (Jacobs, 1961; Newman et al 2015).

The major problem is that modernist urban design saw the one Manual of design practice for all parts of the city in terms of urban form and transport. In response a theory of urban fabrics

suggests that there are three historic periods of urbanism based on the priorities of transport infrastructure (Newman, Kosonen and Kenworthy, 2019) which has created three different cities within each city. There is a very large difference in form, structure and metabolism of each part of the city with the most recent parts (the Automobile City) significantly higher in input resources and output wastes. Net zero design needs to respect each fabric and regenerate them differently.

| **INPUT (Per Person Per Year)** | **Automobile City** | **Transit City** | **Walking City** |
|---|---|---|---|
| **Resources** | | | |
| Fuel in Megajoules (MJ)[1] | 50000 | 35000 | 20000 |
| Power in Megajoules (MJ) [2] | 4620 | 4620 | 4620 |
| Gas in Megajoules (MJ) [2] | 2450 | 2450 | 2450 |
| Total Energy in Gigajoules (GJ)[2] | 57.07 | 57.07 | 57.07 |
| Water in Kilolitres (Kl)[2] | 70 | 70 | 70 |
| Food in Kilograms (kg)[3] | 451 | 451 | 451 |
| Land in Metres Squared ($m^2$)[4] | 547 | 547 | 547 |
| Urban Footprint in Hectares (ha)[5] | 2.22 | 2.22 | 2.22 |
| **Basic Raw Materials (BRM) for New Building Types Per Person[6]** | | | |
| BRM 1) Sand in Tonnes (T) | 56 | 22 | 5.7 |
| BRM 2) Limestone in Tonnes (T) | 34 | 13.2 | 3.4 |
| BRM 3) Clay in Tonnes (T) | 22 | 8.7 | 2.3 |
| BRM 4) Rock in Tonnes (T) | 33 | 13 | 3.3 |
| Total BRM in Tonnes (T) | 145 | 57 | 15 |

| **OUTPUT (Per Person Per Year)** | **Automobile City** | **Transit City** | **Walking City** |
|---|---|---|---|
| **Waste** | | | |
| Greenhouse Gas (Fuel, Power & Gas) in Tonnes (T)[1] | 7.13 | 4.98 | 2.95 |
| Waste Heat in Gigajoules (GJ)[2] | 57.07 | 39.90 | 23.65 |
| Sewage (incl. storm water) in Kilolitres (KL)[3] | 80 | 80 | 80 |
| Construction & Demolition (C&D) Waste in Tonnes (T)[4] | 0.29 | 0.22 | 0.18 |
| Household Waste in Tonnes (T)[5] | 0.63 | 0.56 | 0.49 |

***Table 1.*** *Input Resources and Waste output variations between urban form types Source: Thomson and Newman, 2015*

## Net Zero Design – the challenges

The need for net zero cities came out of the Paris Agreement where all nations committed to address the climate agenda by achieving net zero greenhouse gas emissions by 2050 in order to keep global warming below $2^0$C preferably below $1.5^0$C. This was focussed to a more immediate goal of 45% by 2030 in the Glasgow Compact in late 2021. Cities were urged to take up this agenda as they were seen as a major way to help with the transition and indeed 2023 will see a special IPCC Report on Cities and Climate Change. The need to relate to the local aspects of all SDG's and the need for adaptation was also firmly on the agenda from the IPCC $1.5^0$C report in 2018 through to the Adaptation Report in 2022, always showing the importance of combining adaptation and mitigation.

### ➢ Adaptation

The context of climate-based design is that the world's climate is going to continue to receive more energy through the greenhouse effect and we are already close to the limits on many aspects of weather including flooding, fires and extreme heat waves.

Climate resilient urban design means avoiding development on climate sensitive sites, adaptation of materials and green infrastructure for cooling cities, especially biophilic design, and managing water better. These are necessary first steps in net zero design as many adaptation design tools are also part of the mitigation design tools. These tools need to be applied differently for different parts of cities as explained below on mitigation. Flooding is usually a coastal and river flood-plain issue and forest fires are generally a peri-urban and rural area issue; in many cases this means retreat from such high-risk places and redevelopment with eco-villages using net zero design (Norman, Newman and Steffen, 2020). Manuals for how to do this are increasingly available and training is being conducted as part of professional development as well as academic credentials (ICLEI, 2018).

### ➢ Mitigation

The main focus of net zero is on what urban design practitioners can begin to deliver in their projects that are increasingly focussed on mitigation design tools. The dramatic period we are now living in is that cities are able to be reshaped by a highly commercial and attractive new combination of technologies for decarbonising the world: solar, batteries and electric vehicles. These are now more efficient and more able to achieve the multiple goals of net zero along with the broader goals of historic urbanism. We can now build cities better than the previous era based on fossil fuels (Newman, 2020). Hence the new urban economy that is emerging post-covid is accelerating faster than many could have seen in the past decade, even the IPCC in the $1.5^0$C report and it is being driven by cities.

The future is now rapidly emerging around very cheap solar, batteries and electric vehicles of all types including e-micromobility, e-transit and e-cars. At the same time net zero buildings have

been developed using new materials, solar design and new appliances such as induction cookers and heat pumps for an all-electric building that is then linked into renewable power, often in net zero precincts where solar can be shared (Newton et al 2021).

But the key issue for urban design professionals, and indeed urban professionals of all kinds, is that these must be *integrated* using smart technology systems to provide all the urban and industry systems that are necessary for good urbanism. The key urban design skill for practitioners is the integration of the three core technologies for decarbonization with different parts of the city. One simple example that illustrates this immediately is that EV's in the form of automobiles can still ruin urban centres where place-based walkability is critical; but perhaps net zero corridors through suburbs can be focussed on new technology solar-electric transit and e-microbility with decentralised micro-grids that could help create significant place-based opportunities as well as decarbonising the city.

## Next stages in Net Zero design practice – manuals on each urban fabric showing options for how to enable the transition for the whole city to be net zero.

Climate mitigation needs to be focused on how the new technologies of solar, batteries and electric vehicles of all kinds can be integrated with net zero buildings into the form and function of cities using smart city systems. These will need to create decarbonised design in buildings and infrastructure, especially transport. So the most important net zero design tools are: solar design, electric transit activated corridor design, and local e-mobility and walkability design. Other key net zero practices that are emerging as critical tools in enabling net zero cities are water sensitive urban design, circular economy design, biophilic and permaculture design, and as always integrated design practices. All these design practices need to be applied differently for each kind of urban fabric: central city walking fabric, corridor-based transit urban fabric, outer area car-dependent urban fabric, and to the more rural peri-urban and rural village fabrics (see Table 2).

| Net-Zero Urban Spatial Planning Tools | Central City Walking | Inner City Transit | Outer Suburb Automobile | Peri Urban and Rural Bioregional | Remote Settlement |
|---|---|---|---|---|---|
| Solar design | Strong transport carbon reductions but harder to do solar on buildings. Solar design for energy efficiency essential. | Easier to do solar on buildings and harder on transport carbon reductions. Solar design for efficiency essential. | Easy to do solar on buildings and much harder on transport carbon reductions. Solar design for efficiency essential. | Easier to do solar on buildings and harder on transport carbon reductions. Solar design for efficiency essential. | Easier to do solar on buildings and harder on transport carbon reductions. Solar design for efficiency essential. |
| Electric transit activated corridor design | Electric metro trains buses and Trackless Trams need to service city center with very few electric cars. | Electric metro trains buses and Trackless Trams need to service stations on corridors with some electric cars feeding in. | Electric metro trains buses and Trackless Trams can be built to service corridors but mostly electric cars. | Electric buses and Trackless Trams have some potential but mostly electric cars. | Electric cars, trucks and motorbikes only. |
| Local shared E-micro-mobility and walkability design | Last mile support for transit focussed on central function of walkability | Essential support for transit stations along with walkability | Necessary to build into any new and old station precincts but must mostly try to reduce impact of electric cars. | Electric bikes can work for local trips but mostly cars need to be accommodated. | Very little role other than in local movement. |

| | | | | | |
|---|---|---|---|---|---|
| Water sensitive urban design | Water efficiency easily created in dense buildings but recycling more difficult where space is constrained | Water efficiency easily created in medium density buildings and some recycling where space less constrained | All aspects of water sensitive urban design possible once space is set aside. | Recycling of waste water and stormwater can be fully integrated | Recycling of waste water and stormwater can be fully integrated |
| Circular economy urban design | Low carbon materials for buildings and infrastructure possible; all forms of waste can be recycled once collected | Low carbon materials for buildings and infrastructure possible; all forms of waste can be recycled once collected | Low carbon materials for buildings and infrastructure possible; all forms of waste can be recycled once collected | Low carbon materials for buildings and infrastructure possible; not all forms of waste can be recycled unless done locally | Low carbon materials for buildings and infrastructure possible; not all forms of waste can be recycled unless done locally |
| Biophilic and Permaculture Design | Biophilic buildings with green walls and roofs and small pocket parks | Emphasis on biophilic buildings, small pocket parks and green corridors | Emphasis on larger landscape-oriented development | Landscapes for carbon offsets, permaculture design the most appropriate for villages | Landscapes for carbon offsets, permaculture design the most appropriate for villages. |
| Integrated design processes | Essential for achieving net-zero | Essential for achieving net-zero | Essential for achieving net-zero | Essential for achieving net-zero | Essential for achieving net-zero |

***Table 2.*** *Summarizing Urban Fabrics and their Net Zero Urban Design Practice Potential*

The urban fabrics in Table 2 are summarized below to show how urban design practice can enable net-zero outcomes.

1. Central city walking cities are less able to install solar PV (with some increasing possibilities of building integrated solar) but are ideal for walkable active transport and e-micromobility (Matan and Newman, 2016), as well as biophilic urbanism in the form of green roofs and green walls (Beatley, 2017; Soderlund, 2019).
2. Transit city corridors are better for solar PV and batteries and are ideal for transit, micro- mobility, and active transport, with some potential circular economy and biophilics with permaculture possibilities (perhaps in community spaces) – see below on Net Zero Corridors.
3. The middle and outer suburbs of the automobile era are very good for solar PV, as demonstrated in Australian cities where most of the poorer outer suburbs installed PV first (Newton and Newman, 2013); they are also good for circular economy processing and permaculture, which need more space, but these areas are likely to require EV cars and buses due to their car dependence along with some new transit activated corridors helping overcome automobile dependence (Newton et al, 2021).
4. Rural villages and peri-urban areas will need to form new localized centers in order to make the most of the benefits of power and transport with integrated solar-PV-batteries-electromobility and with some agricultural vehicles electrified. Peri-urban areas are likely to be able to have some rail access but are more likely to need EV car-share or cooperative bus services to link them to it and hence to the city. Local transport can use such vehicles and also electric bikes. Peri-urban areas will grow in their usefulness to the rest of the city for the following types of functions (Holmgren, 2018):

    - Local food production based on intensive permaculture that has short food miles and local types of food;
    - Waste-recycling centers and other new circular economy industries that cannot fit into the more built-up part of the city, for example, the recycling of treated wastewater to recharge groundwater systems;
    - Utility-scale solar and windfarms and in future hydrogen-based industry; and
    - Carbon sequestration in soils and trees for offsetting the city's excess greenhouse emissions.

Guidelines for how to enable these urban fabrics need to begin with their transport, power, water and waste systems but will all have different economic and social systems that need to be facilitated through community-based participation in the transition to a net zero city. Integrated design processes can proceed when this kind of engagement is enabled as most urban fabrics have their common-sense place-based solutions which are understood by those who live or work in that place (Caldera et al, 2021).

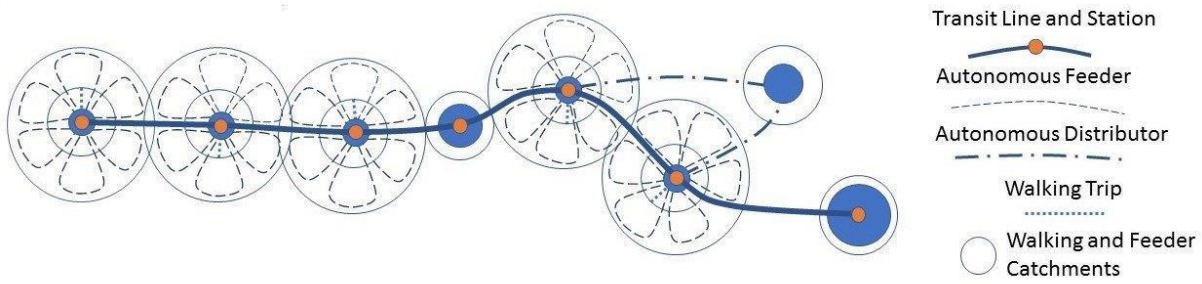
Manuals for net zero design are emerging as the basis of 21st century professional practice in all aspects of urban development and must include urban design as a fundamental factor.
Practice in urban design needs some guidance on how to begin in a city wanting to transition towards net zero and one approach is outlined next.

## Net Zero Corridors

This section sets out a concept for how to begin the net zero transition along main roads where urban regeneration is needed (Newton et al, 2021). It suggests how a city can begin delivering a net zero strategy by developing a series of net zero Transit Oriented Developments (TOD's) along a main road through the provision of a new electric mid-tier transit system (BRT, LRT or Trackless Trams) that facilitate net zero urban regeneration in station precincts. The result has been called a Transit Activated Corridor (TAC) (Newman et al, 2019) and these can spread across a whole city as the integrated net zero systems spread into each form of urban fabric. The result is a multi-nodal city joined together by corridors of electric transport all feeding off the solar systems built into the urban fabric.

The key principle is in Figure 1 with a major transport corridor having a mid-tier transit line given priority and at each station a net zero precinct is built with urban regeneration that prioritises feeders and distributors such as e-micro-mobility as well as walking.

Figure 1 Transit Activated Corridor. Source Glazebrook and Newman, 2018




A core part of designing TACs would be a set of detailed design options for how a transit service could travel at speed down a clearway where possible, and then slow down when it enters a

station precinct where the design and place focus would be to facilitate walkability and pedestrian activity. This would send the signal that dense urban development would be favoured as it would have a high-quality transit system linking it to the rest of the city and would have a highly attractive urban design quality for enabling people-based activities in and around the stations. This could be called a '70:20 strategy' as the aim would be to bring the road-based transit down the corridor at speed (70 kph max) and then slow down to prioritise walking (20 kph max).

This is a very different approach than on railways and on traditional main roads which mostly separate out urban development from the mobility goals along the different modal routes. Thus, roads chosen for this category would shift their priority for providing mobility services for 'through traffic', to a focus on how they could enable quality transit and urban design along the corridor. This delivers value to both developers and the community requiring mobility along the corridor. It would mean more of a focus on accessibility, sustainability and equity. Compared with car only lanes such routes could carry the equivalent of 6 lanes of traffic easing congestion issues while increasing activity along the corridor through transit and urbanism.

This urban design works in parallel with a global and local initiative called 'Movement and Place' that came out of Transport for London as a way of re-thinking main roads. This has involved the development of various movement and place policies and strategies (see for example: Guidelines for Sustainable Urban Mobility Plans, in Eltis, 2019), which seek to shift the focus to people, accessibility and place over simple mobility based on increasing the speed and capacity of main roads. The need to improve the balance between mobility and place has therefore become the next significant agenda in transport and urban policy especially in net zero corridors as the design tools associated with this approach can enable a transition to net zero cities (Newman et al, 2018).

There are four steps involved:

*The first urban design tool is to declare a high-quality transit system down a corridor and zone it in strategic and statutory plans as primarily for transit and dense urbanism.* A series of such plans are being developed around the world since Transport for London declared their policy called 'Street Families' (Transport for London, 2021) which sets out the streets that give priority to transit and where density will be given special encouragement. The movement and place framework enables the 'place' prioritisation of streets to create walkable, liveable centres. Such routes could be specified as potential Transit Activated Corridors with associated zoning along the corridor.

*A second step in designing a TAC would be to choose the station precincts where an area could become a 21st century net zero development.* The precinct area could be 'greenlined' as suggested by Newton et al (2021) so that a process could begin with the owners of buildings in the area. This process should involve full community engagement to enable partnerships to be formed

with the residents, businesses, developers as well as design professionals. A design charette can be a major exercise in resolving all the relevant agendas. This can ensure that multiple benefits are found as value increases in the land will be assured and higher quality development can be achieved (Sharma and Newman, 2020).

*A third step is an agency or cross-agency group that can provide the integrated design skills to deliver the TAC and its net zero precincts.* This would include affordable housing and how new net zero technology can be designed into all the buildings and local transport. Key technologies to be integrated include a microgrid based on roof-top solar that enables both sharing of the net zero power and recharge services for all the electric vehicles, micro mobility, shuttle buses, cars and the mid-tier transit. This integration step will be different for different urban fabrics.

*The fourth step in achieving the transition would be to enable the microgrid to spread so that the improved net zero systems can be shared further into surrounding suburbs*. This would enable solar and battery storage to be shared as well as electric vehicle recharging services to be shared. The governance of the precinct for such shared services can therefore spread across the city, like tentacles, enabling the net zero transition.

Fundamental design tools developed for TOD's can be used to make station precincts dense and mixed use in order to make them into 'inclusive, safe, resilient and sustainable' places. Such tools include walkable urban design, solar design, water sensitive design, biophilic design, affordable housing design and integrated design as set out in Table 2. This will need statutory requirements to include such best practice outcomes but will need an overlay of net zero technologies and how they can be shared.

## Conclusions

Net zero design is emerging but still needs demonstration projects in all parts of the city with different solutions for each urban fabric. It can start with net zero corridors that are enabled by new technology mid-tier transit using traditional approaches to TODs, adding the net zero components into station precincts with smart shared systems that enable new net zero precincts to begin to spread into the whole city.

## Summary

1. The concept of Net Zero Cities is emerging as a major agenda for urban development and although many cities are committing to the agenda it is not clearly defined in professional practice.
2. Whatever net zero practice becomes it must be part of the continuing role of urbanism and urban design to enable the growth of civilized spaces and enhanced human activity through places that encourage interaction, productivity and equity.

3. Climate resilience through avoiding development on climate sensitive sites, adaptation of materials and green infrastructure for cooling cities and managing water better, are a necessary first step in net zero design.
4. Climate mitigation needs to be focused on how the new technologies of solar, batteries and electric vehicles of all kinds can be integrated into the form and function of cities using smart city systems to create decarbonised design in buildings and infrastructure, especially transport. Other key net zero practices are water sensitive urban design, circular economy design, biophilic and permaculture design, and integrated planning practices.
5. These systems need to be applied differently within each kind of urban fabric from central city walking fabric, corridor-based transit city fabric, outer area car-dependent urban fabric, and to the more rural peri-urban and rural village fabrics.
6. Guidelines for how to enable these urban fabrics need to begin with their transport, power, water and waste systems but will all have different economic and social systems that need to be facilitated through community-based participation in the transition to a net zero city.
7. Manuals for net zero design are emerging as the basis of 21st century professional practice in all aspects of urban development and can begin by creating net zero corridors that are activated by electric mid-tier transit and have a series of net zero station precincts along the corridors.

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## Glossary of Terms

**Net Zero Cities** – Net zero is defined in the Paris Agreement as "achieving a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century". Net zero cities need to show how this can be applied to their metropolitan region. Seto et al (2021) show the complexities of this. An IPCC process to help resolve this will begin in 2022.

**Transit Activated Corridors** – Transit Oriented Development is a well known planning term for individual station precincts around railway lines. Transit Activated Corridors is where TODs are created in a corridor along a main road using mid-tier transit to increase value for developers to create station precincts like TODs. By doing TAC's along main roads a whole section of a city can become net zero nd thus spread into surrounding suburbs through shared microgrids.

**Mid-Tier Transit** – this is transit that is not a bus and not a train but is midway in terms of speed and capacity. The three main mid-tier transit systems are Bus Rapid Transit, Light Rail (trams) and Trackless Trams.

**Trackless Trams** – Trackless Trams have been defined by Newman et al using Chinese technology that involves 6 innovations from High Speed Rail thus creating a light rail-like system that can compete favourably with BRT and LRT. Other terms are being used such as Advanced Rapid Transit and Trackless Rapid Transit.

**Movement and Place Strategies –** Movement and Place Strategies came out of Transport for London as a way of re-thinking main roads. This has been adopted by many transport agencies across the world, including all Australian states. The MPS seek to shift the focus to people, accessibility and place over simple mobility based on increasing the speed and capacity of main roads.