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Concept Paper

Net Zero Corridors: A Case Study Approach from Perth, Australia to Decarbonize Urban Power and Transport

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Abstract

The transition to net zero cities is a pivotal challenge in the face of climate change. This research introduces a novel methodology termed "Net Zero Corridors," which emphasizes a bottom-up approach to decarbonize urban power and transport systems. By focusing on urban corridors, this method integrates distributed power systems with urban transport, offering a localized solution to the broader challenge of urban decarbonization. Drawing from urban fabric theory and urban metabolism data, the study provides insights into the application of various renewable technologies in diverse urban settings, particularly in automobile-dominated cities like Perth, Australia. The net zero city agenda is gathering momentum but faces the issues of transition using either top-down large-scale technologies or bottom-up local-scale technologies that make the most out of the small-scale niches that have been created around renewables. This paper seeks to show how a bottom-up process can be used to start a more effective local scale approach using net zero corridors that can enable more net zero precincts with distributed power systems and at the same time integrate and decarbonize transport systems. Data on Perth are collected and processed to show the economic viability of such net zero projects though they are not yet linked to good transit systems. The net zero corridor concept is demonstrated and shows how to enable a series of net zero precincts that create large steps in removing fossil fuels. These corridor precincts can spread into surrounding suburbs through expanding the local microgrids and their local

governance embracing more and more of the city. The net zero corridor concept can be used to transition to net zero cities using bottom-up approaches that link the transformation of power systems and the transformation of transport systems.

Keywords
Net zero; corridors; precincts; distributed energy systems; urban fabric; urban metabolism; movement and place strategies; urban regeneration; transit activated corridors; and sustainable urban development

1. Background

Many cities are committing to the net zero journey [1, 2]. The World Economic Forum has a model for a Net Zero City which has many visionary parts. In such visions the final image shows a fully integrated, solar-based city with all its buildings, businesses and transport electrified and feeding off renewable energy presumably with a large scale renewably powered grid (see Figure 1). But is it best to focus primarily on large scale power and how would we begin such a net zero transition? This paper examines whether it may be better to begin with distributed power and do urban regeneration at the same time as fixing the power and transport together.

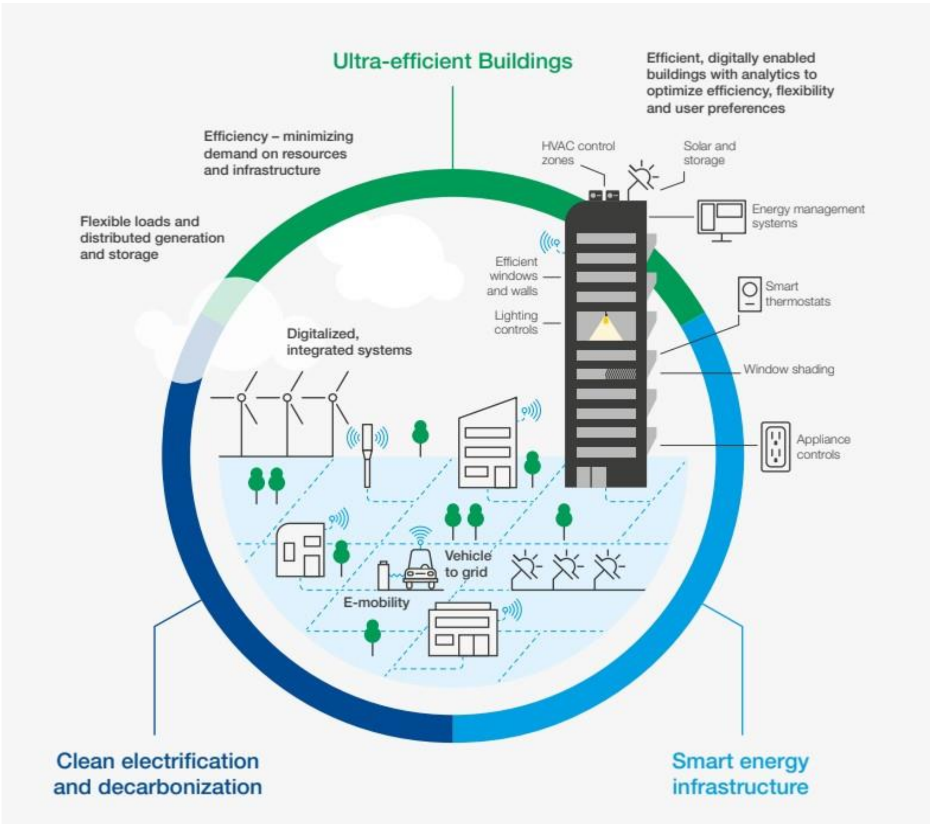

Figure 1 World Economic Forum Net Zero City model 2023.

This will be shown to enable a transition process that applies to each part of the city.

There are many reasons for suggesting a more bottom-up approach. The top-down large- scale approach focusses just on transforming the grid through big project solar and wind systems, and then electrifying everything– households, industry and transport. This is largely what most places with large grids like in Europe and North America have been doing, as well as the eastern states of Australia. However, this approach misses out on the fact that communities are already transforming their futures by choosing small scale renewables, and the new economy is being driven by the city through localized energy developments that increasingly are more cost effective than simply depending on large- scale grid-based approaches [3, 4]. The major difference is that transmission costs are significantly reduced or removed altogether as the power is used where it is being made. This can reduce up to 40% of transmission costs [5]. The approach suggested by Saul Griffith in The Big Switch is to combine both large scale and small-scale approaches [6]. Both scales require new smart systems to be used that can enable very different ways to integrate the decarbonization of power, transport and industry. The paper will not focus on the large scale such as in manufacturing or process industry but will show how a new approach is emerging that can integrate power and transport decarbonization in cities with perhaps industry becoming more of a rural and regional focus based on hydrogen [7, 8].

The main approach suggested in this paper follows the more localized approach that is part of the Distributed Energy Resources (DER) agenda. It will emphasize that all parts of the city can play a role in addressing the important climate agenda through different urban fabrics that have different transport character. In particular it will show how suburbs can be regenerated along net zero corridors. It will also outline how demonstrations of this are emerging using Perth, Australia, as the source of data.

The underlying question in this paper is: how can cities integrate their transitions to net zero in both power and transport?

2. Methods

The paper sets out some core concepts that are derived from the combined literature of planning theory and climate policy: the theory of urban fabrics, urban metabolism and how new technologies for net zero work within cities using the New Urbanism design approaches at local level. The foundation of this research lies in the urban fabric theory [9], which categorizes cities based on their structural and functional characteristics. By understanding the unique attributes of different urban fabrics, we can tailor renewable energy solutions to suit specific urban contexts. Additionally, the urban metabolism model [10] provides insights into the energy consumption patterns of cities, enabling a more targeted approach to energy transition.

2.1 Net Zero Across Cities and Regions

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 [3, 8]. 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 [11].

But the key issue for decarbonization is that these must be integrated using smart technology [5, 12]. The first key method therefore is how to focus decarbonization on different solutions for different parts of cities and their regions. This paper focuses on net zero corridors through suburbs, beginning with middle suburbs that are ready for urban regeneration, that can be focused on new technology solar-electric transit and e-microbility with decentralized micro-grids at station precincts that could then spread out across the city.

Table 1 shows how the urban metabolism of a city can vary across its various urban fabrics, especially focusing on the differences in resource inputs and waste outputs for walking city, transit city and automobile city urban fabrics.

Table 1 Input resources and output wastes associated with three urban fabrics in Perth, Australia. Source: Thomson and Newman [10].

INPUT (Per Person Per Year)	**Automobile City**	**Transit City**	**Walking City**
Resources			
Fuel in Megajoules (MJ)	50,000	35,000	20,000
Power in Megajoules (MJ)	9240	9240	9240
Natural Gas in Megajoules (MJ)	4900	2940	2950
Total Energy in Gigajoules (GJ)	64.14	47.18	32.18
Water in Kilolitres (Kl)	70	42	35
Food in Kilograms (kg)	451	451	451
Land in Metres Squared (m^2)	547	214	133
Urban Footprint in Hectares (ha)	2.29	1.97	1.78
Basic Raw Materials (BRM) for New Building Types Per Person[6]			
BRM 1) Sand in Tonnes (T)	111	73	57
BRM 2) Limestone in Tonnes (T)	67	44	34
BRM 3) Clay in Tonnes (T)	44	29	23
BRM 4) Rock in Tonnes (T)	66	43	33
Total BRM in Tonnes (T)	288	189	147
OUTPUT (Per Person Per Year)	**Automobile City**	**Transit City**	**Walking City**
Waste			
Greenhouse Gas (Fuel, Power & Gas) in Tonnes (T)	8.01	5.89	4.03
Waste Heat in Gigajoules (GJ)	64.14	47.18	32.18
Sewage (incl. storm water) in Kilolitres (KL)	80	80	80
Construction & Demolition (C & D) Waste in Tonnes (T)	0.96	0.57	0.38
Household Waste in Tonnes (T)	0.63	0.56	0.49

The different approaches needed in different parts of the city can be illustrated in the following examples:

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 [13], as well as biophilic urbanism in the form of green roofs and green walls that will reduce the need for power through cooling the urban heat island effect as well as insulating buildings [14, 15].
2. Transit city corridors are better for solar PV and batteries and are ideal for transit, micro-

mobility, and active transport. As set out below on Net Zero Corridors these suburban areas are perhaps the best place to start the net zero transition.

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 [16]; 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 [11].
4. Rural villages and peri-urban areas are all part of the systems that need to be transformed and this is increasingly where industry is located. All of such areas will also need to form new localized centres in order to make the most of the benefits of power and transport with integrated solar-PV-batteries-electromobility. However, this is also where industry will be requiring large scale solar for its Hydrogen requirements to decarbonize its production.

Hydrogen has been seen as necessary for larger freight vehicles (trucks, trains and primary production vehicles) but increasingly these are not being seen as necessary due to cost and other issues to do with hydrogen distribution and storage [7]. Thus, the integration of solar, electric recharge and smart systems will increasingly be part of cities and settlements throughout regions and rural areas. Peri-urban area villages 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 electric bikes. Peri-urban areas will grow in their usefulness to the rest of the city for the following types of functions [17]:

- Local food production based on intensive permaculture that has short food miles and local types of food thus utilizing local sources of distributed power;
- Waste-recycling centres 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;
- Carbon sequestration in soils and trees for offsetting the city's excess greenhouse emissions; and
- The electric recharge systems for all electric vehicles and machinery can also be part of the local power system in terms of its ability to provide power services and balance.

Guidelines don't yet exist for each of these different urban areas so they will need to be developed to enable the transition to begin with their transport, power, water and waste systems as illustrated above. Each conurbation and each urban fabric will have different economic and social systems and require considerable creativity and community-based participation as such processes have demonstrated the economic multiplier and social benefits in every other period of economic and technological transition (4).

2.2 Net Zero Corridors

This paper suggests that a very opportune way to begin an integrated approach to the transition to a net zero city is by looking at those suburbs that need urban regeneration. This section therefore examines how the literature is suggesting the major steps needed in corridor urban regeneration and how this may include the net zero agenda.

The literature below suggests that urban regeneration is shifting to focus on main roads particularly old tram routes that once went through inner and middle suburbs that are now regenerating. These would be turned into boulevards through using the integration of new mid-tier transit systems and creating new walkable urban villages around station precincts. The question in this paper is whether net zero can be integrated into this process and indeed help to drive it. Can net zero corridors enable integration of the electric transport innovations with solar building innovations? If so, can the approach be a catalyst for how a net zero corridor of transport and buildings enables a transition that can spread across the city?

The genesis of an integrated net zero corridor is the concept of a Transit Activated Corridor (TAC) [18]. The TAC concept appears to work best through the provision of a new 21st century mid-tier transit system (BRT, LRT or Trackless Trams) as mid-tier transit has been known for decades to be able to facilitate urban regeneration in station precincts [19, 20].

The key principle of a Transit Activated Corridor is set out in Figure 2 with a major transport corridor having a mid-tier transit line given priority instead of simply high capacity for individual cars. Mid-tier transit patronage can enable up to 6 lanes of traffic equivalent. Such accessibility benefit, from focused use that depends on more human activity rather than just car activity, always increases land values and enables urban regeneration [21]. Thus, if an integrated strategy can be created between transit providers and urban developers, it is possible to create urban regeneration that uses renewable power for the buildings and the transport. As each station is built, a precinct is built around it with urban regeneration that prioritizes feeders and distributors such as micro-mobility as well as walking. All can be net zero through a microgrid.

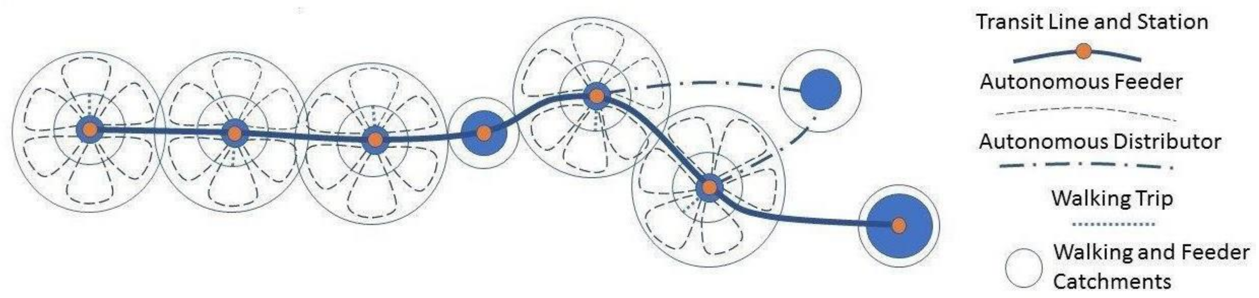

Figure 2 Transit Activated Corridor. Source: [22].

The issue in this paper is how such TAC's could become a net zero corridor and spread across the whole city with the resulting urban regeneration creating a net zero city. They would need to be integrated net zero systems that provide both net zero buildings and net zero transport and would need to spread into each form of urban fabric. Figure 3 shows how the result could be a multi-nodal city joined together by corridors of electric transport all feeding off the solar systems built into the urban fabric.

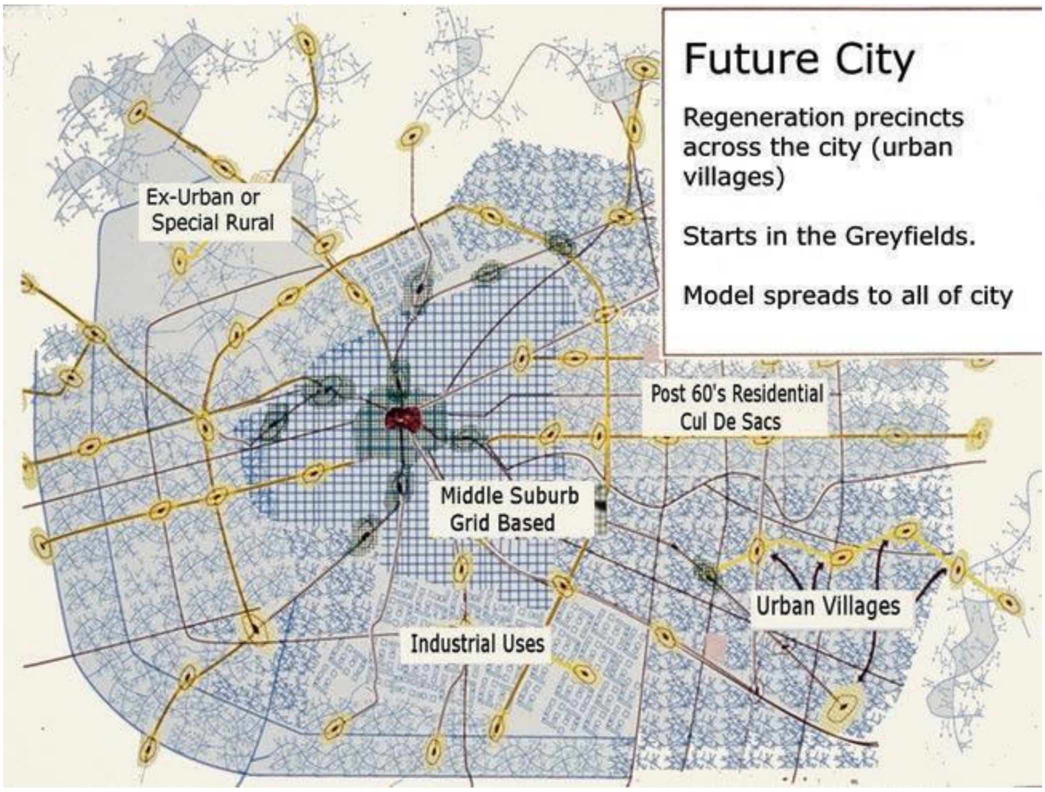

Figure 3 Future City based on Transit Activated Corridors and Net Zero Precincts across the city. Source: [21]

A core part of designing net zero corridors would be how to integrate a fast corridor transit system (using battery-electric vehicles) with a slow set of net zero precincts (solar-electric based) which are dense and walking-oriented to enable intense urban activity. This mixture of fast transit corridors and slow walkable station precincts would be fundamental to a net zero corridor. It would mean more of a focus on accessibility, sustainability and equity combined. 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. The value of this for improving transit and walkability can be evaluated using the SNAMUTS Model [23].

The urban planning literature helps resolve this issue. There is 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: [24]. These guidelines seek to shift the focus to people, accessibility and place over simple mobility based on increasing the speed and capacity of main roads for cars and trucks. The need to improve the balance between mobility and place has therefore become the next significant agenda in transport and urban policy. Net zero corridors could become the net zero design tool associated with Mobility and Place. It may then enable a transition to Net Zero Cities.

3. Results

3.1 Emerging Net Zero Precinct Case Studies

Net zero design is emerging and 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 and TAC's, 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 as shown in Figure 3.

Scheurer et al [25] have set out how 21st century boulevards are beginning to be created using 21st century mid-tier transit. These are mostly in Europe but are increasingly on the agenda in the more automobile dependent cities of the US, Canada, New Zealand and Australia [26]. There are proposals for how Trackless Trams could be used to enable low-income cities to leapfrog into the new net zero economy using this 21st century transit technology and solar-based station precincts [27, 28].

The integrated approach outlined in this paper can be seen emerging in several local projects in Perth, Australia, that are demonstrating net zero precincts. The results are provided here.

3.1.1 Case Study: White Gum Valley (WGV)

The WGV project is an infill residential development in White Gum Valley a middle suburb of Perth, Western Australia. Built on a former school site, it has over 100 housing units at medium-density levels of approximately 45 dwellings per hectare. WGV features a range of building types, including two-, three-, and four-storey apartment clusters and attached and detached homes. They all rely on leading energy strategies including climate-based design, a high energy rating, solar power of 3.5 kW or more, strata-owned solar panels and batteries on apartments using peer-to-peer energy sharing, shared electric vehicle for use by the community, and public open space created by regenerating an old stormwater sump into a neighborhood park [11, 29].

Solar photovoltaics and battery storage are incorporated into the development and create net zero carbon power through an innovative 'citizen utility' with peer-to-peer trading based on blockchain that enables the local strata title committee to also manage their power, PV, batteries, and EV recharge through software that is designed for their needs [30, 31]. The multiple sustainable development features such as water sensitive design, energy efficiency, social housing, heritage retention, landscape, and community involvement, were designed to be included in the net zero strategy and have been assessed under the SDG framework; the intensive community engagement processes used the One Planet Living accreditation process to generate local community support and from all the agencies involved [32].

The significance of innovation at WGV is that it demonstrated that a net-zero carbon urban revitalization project can:

- Be commercially viable (it sold very rapidly),
- Contribute to the Paris Agreement target that seeks to achieve deep decarbonization while also delivering the United Nations SDGs, and
- Build an integrated development using new green distributed technology and support a clear international demonstration of how to share solar energy through blockchain.

The evidence that a mid-tier transit activated corridor supports mobility and urban regeneration is well proven in the transport literature [21]. The WGV net zero development with energy sharing and other net zero precincts are emerging in the sustainability/climate literature to demonstrate that it is possible to integrate shared power and net zero development [32]. The WGV project does not have a quality transit system associated with its operations, so it is not fully demonstrating a Net Zero Corridor. It does however show that it is possible to make net zero precincts into practical station precincts that sell well. The extra value of living in a walkable environment next to a quality transit service can still happen and as the whole area develops a mid-tier transit system can be introduced.

3.1.2 Case Study: East Village

Byrne at al, [32] have analyzed another adjacent precinct that has all the WGV net zero qualities but takes them a few steps further. The East Village project includes solar design and energy efficient devices with no gas services and substantial rooftop solar. The net zero energy development can provide at least 100% renewable energy in each home but home owners can go further and create a carbon positive house that exports more renewable energy than it consumes by putting more solar panels on their roof. The project is managed through a shared battery and a blockchain based management system that also enables them to manage an electric vehicle charging scheme. The full net zero design qualities have been modelled and are set out in Figure 4. The data show it to be very cost-effective [32].

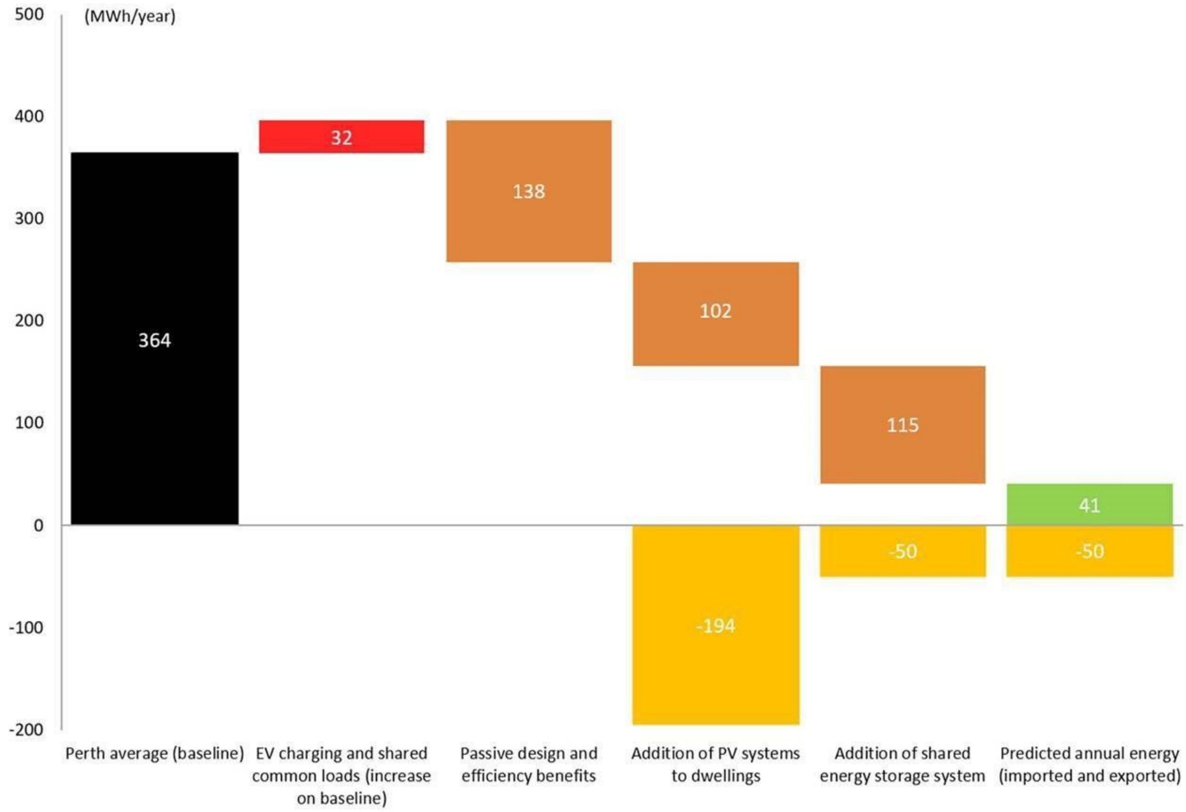

Figure 4 Net zero precinct of East Village, showing expected energy profile of 80-120% reductions in energy. Source Byrne et al [32].

The design initiatives and strategies also include significant mains water savings by adopting water-sensitive features in the homes and within the private and public gardens. The project is seen as an important step in the application of available technologies and design features to meet net zero objectives, highlighting the benefits of an embedded living laboratory research approach.

The two case study precinct projects above show how a net zero housing project can be built with potentially strong benefits in a real estate market. However, the concept for a net zero corridor as a combined mid-tier transit and mixed-use station-precinct regeneration project has not yet been demonstrated as part of these projects.

3.2 Planning for Net Zero Corridors

A project in Australia has begun to analyze the process of creating net zero corridors. It has been studied in several cities that have begun the journey to deliver mid-tier transit and associated urban regeneration precincts all within a net zero framework (SBEnrc website for project 1.84 https://sbenrc.com.au/research-programs/1-84/). This paper will show some of the results for Perth. The metropolitan region of Perth in Western Australia has been built largely in the period of the automobile city since the 1960's and now has a population of more than 2.5 million. The metropolitan area's two walking cities of the 19^{th} century - Fremantle and Central Perth- are largely intact and the old suburbs along train and tram lines are also demonstrating their transit-oriented urban fabrics. These inner metropolitan suburbs have largely regenerated in the past few decades [33], yet the main streets that pass through them that were once corridors of enterprise and hubs of social activity, remain degraded and undervalued traffic thoroughfares. The next phase of urban regeneration is now focused on these inner and middle suburban corridors. Local governments are seeking to circumvent development that involves single lot infill as this results in highly sub-optimal outcomes with the loss of mature trees and without the density for new services. The new model being sought is called Greening the Greyfields [11, 34] and it is based on how net zero corridors could be created along main roads using the ideas outlined above to help create precinct-based net zero developments. Hence, Figure 3 (above) suggests that the net zero transition starts in the 'greyfields'.

3.3 Benefits and Costs of Net Zero Corridors Based on TAC's

Figure 5 shows a design image for one of these precincts and a trackless tram stop along a main road. Local governments are designing such developments around their Trackless Tram station precincts (and others across Australia have done similar analysis, see https://sbenrc.com.au/research-programs/1-74/).

Figure 5 An image created to demonstrate a net zero precinct along a Transit Activated Corridor using a modern trackless tram. Source: City of Liverpool, in Greater Sydney, Australia.

Each of the proposed corridors has been analyzed using the SNAMUTS Model to show how much urban regeneration can be created in precincts along the corridor. SNAMUTS is a model that enables the benefits of the whole transit system to be assessed due to both the better transit service and the more intensive, focused urban development along the corridor [23].

Table 2 sets out the results for how much it would cost and the benefits in terms of land value and jobs created to enable such net zero urban development.

Table 2 Benefits and costs of a trackless tram-based urban regeneration project along a net zero corridor in Perth. Source: Mouritz, Newman, and Verschuer [35].

	Public Investment	**Private Investment**	**Land Investment and Jobs Created**
	Vehicles, Recharge and Depot facilities ($4.33 m/km)[1] Roadworks ($19.2 m/km)[2]	Station precincts with 200 m of road around it ($6 m each precinct)[3]	Land development, (estimated value of land; with 9/37 jobs per $1 m)[4]
Stage 1. Cannington to Scarborough 30 kms	Stage 1: Vehicles $130 m Stage 1: Roadworks $576 m	30 station precincts $180 m	$19.8 b with 178,000 jobs directly and 732,600 jobs indirectly over 10 years, 10% per year. So 17,800 direct and 73,260 indirect.
Stage 2. Whole of Perth Metro 112 kms	Stage 1: Vehicles $485 m Stage 2: Roadworks $2.150 b	112 station precincts $672 m	Not researched in detail but likely to be three times above.

[1] See Core Report for details of vehicle costs and extra costs of fitting out recharge elements at stations and in Depots. https://sbenrc.com.au/research-programs/1-74/

[2] See Core Report for estimate of roadworks for TransitWay

[3] Based on 100m either side of station precinct with estimated roadworks costs of $19.2 m per km (see Core Report for details of this)

[4] Jobs estimated at 9 direct and 37 indirect per $ m invested by Ball and Wood [36] and same as those used by Property Council, UDIA and Master Builders in Perth. Land value before Trackless Tram improved value has been used to estimate investment.

The project focused on the Stage 1 Cannington to Scarborough Net Zero Corridor, but the costs were seen to be very manageable and the benefits in terms of jobs were very attractive. Hence, public discussions indicated the need for this to spread to other main roads with similar goals. The standard benefits from time savings and safety are not included nor are the net zero benefits due to climate change. The core difference between normal transport infrastructure assessment and this kind of mid-tier transit is the fundamental land value improvement that can enable urban regeneration to be facilitated. Such benefit is critical for any city facing a future where net zero must also be part of a broader set of benefits that make sense economically. It becomes very attractive for cities like Perth to establish such a net zero strategy that enables land value increases and hence is associated with strong urbanism and job creation as part of the net zero transition.

The benefit of a mid-tier (Trackless Tram or other) system along a corridor like this is that it will increase urban land value by 20% for residential and 50% for commercial properties [37]. This can be shown to increase land values along the corridor from around $19.8 b to around $33.4 b. This increase of $13.6 b enables the city to gain development where it is critically needed and with the inclusion of affordable and social housing this will see the city progress equitably and with a balanced workforce enabled to live within the area. The costs of development have been estimated based on the value of land in the station precincts before their value increased.

3.4 Steps to Create Net Zero Corridors

These separate projects are all new in terms of literature on urban developments as net zero urbanism is still developing. With these kinds of results, it would appear to be a potentially positive way to proceed in creating a net zero city. The benefit in creating the precincts as part of a net zero corridor strategy, is that these places will be enabled to create the local services that will form the basis of local distributed energy management such as community batteries and recharge services. That can then enable the microgrids that support such centres to spread out into surrounding suburbs and link the services that form the basis of a net zero city.

These extra benefits and costs associated with a TAC can then be added to those estimated above. The spreading of the microgrid into surrounding suburbs, using geographic proximity and virtual proximity through Virtual Power Plants, can then be illustrated and are on the agenda for the next stage of this research.

There are also policy and implementation results that can be concluded from this work and which help to set out the transition process. The following four steps illustrate the potential net zero city transition process that appears to be possible from the results shown above.

Step 1. 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' [38] 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' prioritization of streets to create walkable, liveable centres. Such routes could be specified as potential Transit Activated Corridors with associated zoning along the corridor.

Step 2. 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 [11] 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 [39].

Step 3. Nominate an agency or cross-agency group that can provide the integrated design skills to deliver the net zero corridor 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 as outlined above.

Step 4. 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.

4. Conclusions

The Net Zero Corridors methodology offers a viable solution for cities aiming to transition to a net zero status. By focusing on localized solutions and integrating power and public transport systems (especially mid-tier transit), cities can achieve sustainability goals more efficiently. This research underscores the importance of understanding the unique characteristics of urban fabrics and tailoring solutions accordingly.

The notion of a net zero corridor, as outlined, can provide a transition strategy to begin the goal of being a net zero city based on processes that utilize distributed energy resources unlocked by urban regeneration enabled by high quality mid-tier transit. The integration of a net zero quality transit service, like trackless trams, and a series of net zero station precincts that are ready for urban regeneration, can create a net zero corridor. As shown in the Perth case studies for WGV and East Village, the precinct around a station can be designed and built in a fully net zero way but there are no projects that show a full corridor of net zero precincts along a new technology transit route.

The next stage has been planned and assessed for benefits and costs. This net zero corridor project will be put together based on the four steps shown in this paper. Once a corridor and its precincts are net zero the microgrids that manage each precinct can expand out into the surrounding suburbs enabling a whole city to emerge in stages as net zero.

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Author Contributions

PN was responsible for the structure of the paper and supervising the research over the past decade. MV was a researcher on the project and helped clarify and apply many of the concepts.

Competing Interests

The authors have declared that no competing interests exist.

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