Carbon Neutral Mobility

Lon Y Law 20055742

Michelle C Majalang 16058429

Sook Wai Lee 19014204

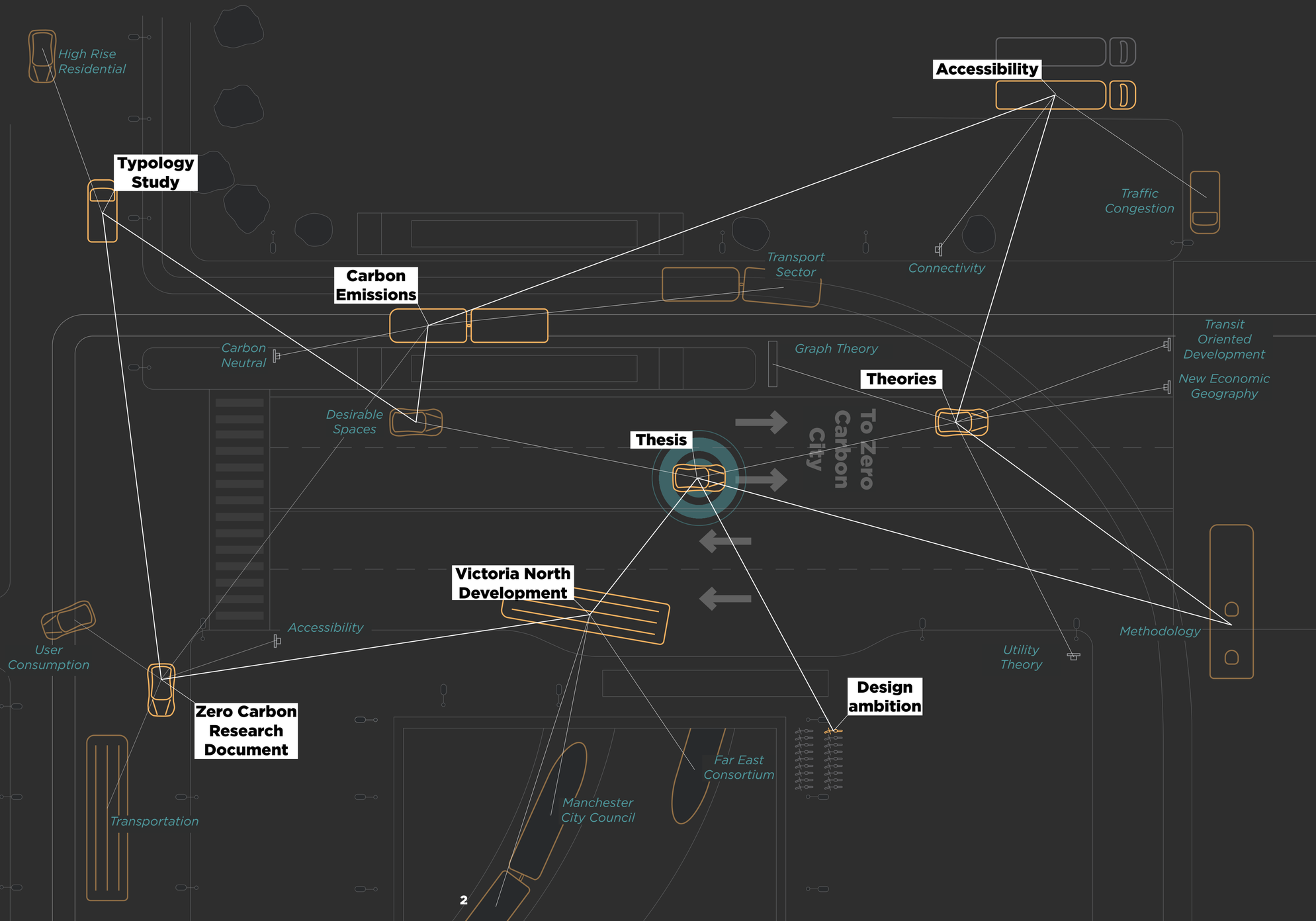
MSA M.ARCH | CPU[AI] Studio 3 Submission

INTRODUCTION

Manchester City Council is leading a redevelopment project in Victoria North aiming to provide 15,000 new residential units for 35,000 residents, while addressing commercial viability and infrastructure provisions.

At 27%, transportation is the largest GHG (greenhouse gas) emitting sector in the UK (Tiseo, 2021). In order to achieve Manchester's Zero Carbon goal by 2038, new solutions must be explored to provide great connectivity for the 35,000 new residents while decreasing transport to minimise GHG emissions.

The thesis examines ways to design a city with high levels of connectivity and accessibility while achieving a carbon neutral transportation system. In this portfolio, different factors, theoretical framework and detailed calculations were examined and used to develop an urban planning tool for testing different urban configurations and emission levels are covered. An extensive explanation of how this urban planning tool for Victoria North was built.



THESIS STATEMENT ///

How can the re-development of Victoria North be examined for accessibility and connectivity performance in order to test different strategies of achieving a Carbon Neutral Mobility network.

THESIS STATEMENT

How can the re-development of Victoria North be examined for accessibility and connectivity performance in order to test different strategies of achieving a carbon neutral mobility network.

Urban mobility and accessibility play a significant role in ambitions to achieve Zero Carbon cities. As a design problem, non-motorised accessibility needs to be maximised within Victoria North as the current pedestrian routes are eminently disjointed from different neighbourhoods, while the main route to the city centre is shared by vehicles and pedestrians.

Our design problem relates to generating and testing different strategic options for activity distribution in combination with the movement pattern, urban grain and related urban morphology. This includes important elements such as clustering or equidistance,density and form. This can be achieved through careful testing of different options for amenity and opportunity locations and the movement networks.

The different generated layouts and locations will then be studied in terms of accessibility by the residential population. On top of that, the project aims to test multiple options towards lowering emissions and energy use by adopting a preferred hierarchy of movement options such as walking, cycling, micro-mobility, public transport or mobility on call. The comparison will be to a future city in which current levels of private car use will be used as a point of assessment.

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01

ZERO CARBON GOALS & PROJECT BRIEF

Achieving Zero Carbon Goals for Manchester

“Our fragile planet is hanging by a thread. We are still knocking on the door of climate catastrophe. It is time to go into emergency mode — or our chance of reaching net-zero will itself be zero.”

(Guterres, 2021)

COP26 Protests

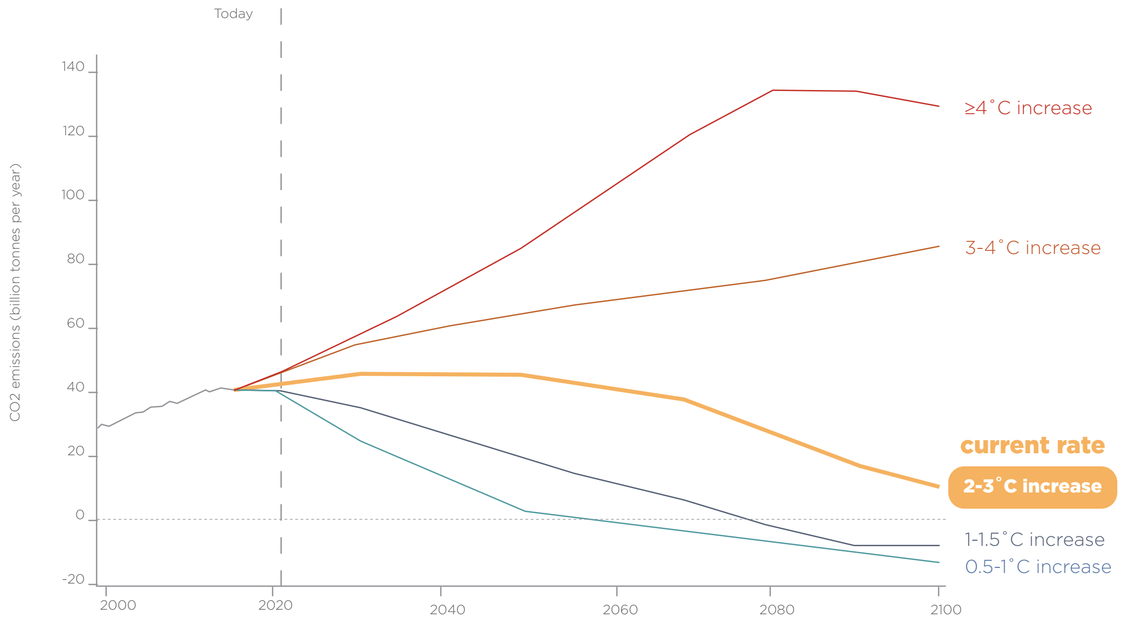
Image: (Milligan, 2021)

THE CLIMATE CRISIS

Why Does Zero-Carbon Matter?

The Paris Agreement in 2021 set the target of +1.5-2˚C increase in mean global temperature from pre-industrial period to reduce the effects of global warming. The recent COP26 set the target to +1.5˚C. (COP26, 2021) The graph below shows how many billion tonnes are needed to be cut to achieve the various sets of targets. The diagram on the right illustrates the effect the temperature change brings to the environment.(IPCC, 2021)

Emission Pathways and Predictions



To achieve the +1.5˚C targets, CO2 emissions have to be cut down as they directly impact the amount of heat trapped in the atmosphere. Despite the pledges by participating countries, the United Nations' Environmental Programme (UNEP) noted that current pledges only reduce forecast 2030 emissions by 7.5%, which will increase global temperature by 2.7˚C in 2100, above the 1.5˚C goal. (UNEP, 2021)

Even the new pledges made in COP26 are inefficient to reach the +1.5˚C goals. They would only reach 2.4˚C rise, and that is if the new targets are met. (Åberg, 2021) Evidently, a much larger and daring change is needed to achieve the 1.5°C targets.

"To achieve 2°C increase, a 30% emissions cut is needed. A further 55% cut is needed for 1.5°C"

(Chestney, 2021)

COP26 Targets

	today 1.1˚C increase	1.5˚C increase	2˚C increase	≥ 4˚C increase
Temperature	+1.2˚C on hottest days	**+1.9˚C** on hottest days	+2.6˚C on hottest days	+5.1˚C on hottest days
Drought	x2.1˚C drought frequency	**x2.4** drought frequency	x3.1˚C drought frequency	x5.1˚C drought frequency
Flood/ Precipitation	x1.3 flooding likelihood	**x1.5** flooding likelihood	x1.8 flooding likelihood	x2.8 flooding likelihood
Snow	-1% snow cover extent	**-5%** snow cover extent	-9% snow cover extent	-25% snow cover extent
Tropical Cyclones	--% proportion of intense cyclones	**+10%** proportion of intense cyclones	+13% proportion of intense cyclones	+30% proportion of intense cyclones

UNDERSTANDING ZERO CARBON

Sorting Out the Myriad of Terms

With the rise of awareness in the climate emergency, terms such as “Carbon Neutral”, “Net Zero emissions”, “Climate Neutral” under the guise of being “Zero-Carbon”. In this page we look into the actual meaning and differences between these terms. (Bernoville, 2021. Hodgson, 2021. CLEAR, 2020)

Terms to describe different climate practices:

Carbon Neutral

Any CO2 released into the atmosphere from a company’s activities is balanced by an equivalent amount being removed. (offsets) Offsets can be purchased as carbon credits from other countries.

Thesis statement

How can the re-development of Victoria North be examined through an accessibility and connectivity aspect to test different strategies towards achieving a Carbon Neutral mobility network.

Climate Neutral

Mitigate all Greenhouse Gases (not just carbon) to the point of zero while eliminating all other negative environmental impacts that an organisation may cause.

Net-Zero Carbon Emissions

Activity releases net-zero carbon emissions into the atmosphere. Done by reducing carbon emissions to the lowest possible before resorting to offsets.

Net-Zero Emissions

Balance the whole amount of greenhouse gases (GHG) released and the amount removed from the atmosphere.

Carbon Positive

Carbon Negative

Climate Positive

Activity goes beyond achieving net zero carbon emissions to create an environmental benefit by removing additional carbon dioxide from the atmosphere. Carbon positive is purely a marketing term with the same meaning.

Types of Greenhouse Gases (GHG):

CO2	PFC	N2O	HFC	CH4	SF6	NF3
Carbon Dioxide	Perfluorocarbons	Nitrous Oxide	Hydro fluorocarbons	Methane	Sulphur Hexafluoride	Nitrogen Trifluoride

(Department for Business, Energy & Industrial Strategy, 2021)

“By prioritizing sustainable urbanization within a broader development framework, many critical development challenges can be addressed in tandem.”

(Kacyira, n.d.)

Tuvalu’s Foreign Minister giving a COP26 speech in rising sea waters
(Tuvalu Foreign Ministry, 2021)

GLOBAL SUSTAINABILITY GOALS

Project Focus

The 17 UN Sustainable Development Goals (SDGs) are adopted by all UN member states. We studied the 17 SDGs and narrowed them down to 3 goals that are the most relevant to us and can help refine our aims and formulate our problem statement.

8) Decent Work and Economic Growth

Target: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

The foundation of a city is for it to have decent work opportunities and economic growth in order to sustain its dense population. In order to develop a 0-carbon city, we must not negate the fact that sustainable urbanization must not come at the expense of work and economic growth.

We aim to rejuvenate Victoria North and incorporate it into an extension of Manchester City Centre to provide opportunities for its residents.

9) Industry, Innovation and Infrastructure

Target: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

By improving connectivity and infrastructure throughout the site, this opens up opportunities for all areas of the site for development and businesses in order to rejuvenate disadvantaged areas like Victoria North.

11) Sustainable Cities and Communities

Target: Make cities and human settlements inclusive, safe, resilient and sustainable

Our cities will be measured by its embodied energy in its construction. Its improved accessibility and connectivity will also reduce the reliance on carbon-emitting transportation options in order to create a more sustainable city.

(United Nations, 2021)

MANCHESTER STRATEGIC REGENERATION FRAMEWORK

Improving Proposed Low Carbon Strategies

The Strategic Regeneration Framework (SRF) is a low carbon development planning framework for Victoria North by MCC & FEC. (Manchester Northern Gateway, 2019) Their current strategies are illustrated below. From these strategies 6 were identified as areas where designers/architects are able to contribute towards and among those 3 were chosen as the main focus area.

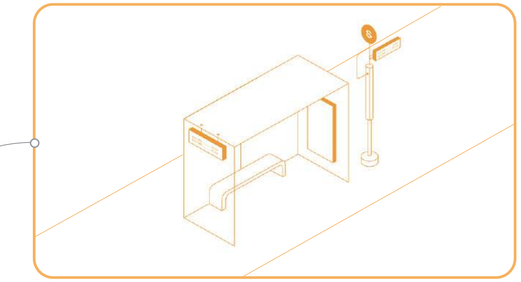
Current Low Carbon Strategies of SRF

- Energy Distribution
- Energy Generation
- Energy Use

- Project focus areas
- Possible Areas for Spatial Improvements

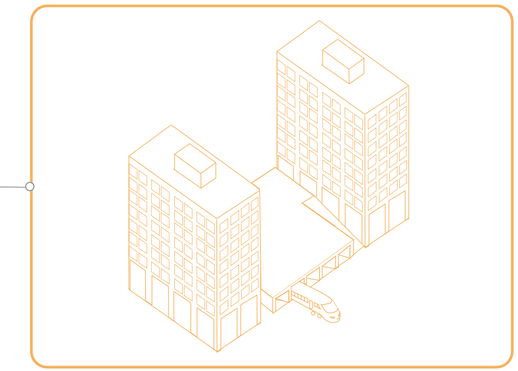
- District Heating
- Reinforcing Local Electricity Network
- Using Smart Grids
- Increasing Adoption of IoT and Block chains*
- Renewable Energy Generation
- **Improve Existing Infrastructure**
- Minimise Heating and Cooling Systems
- High Standards of Building Design
- **Promote Active Transport through Street Design**
- **Innovative Commercial Arrangements**
- Moving away from ICE Engine Vehicles*

Project Focus Areas



Using existing infrastructure like bus stops, Electric Vehicle chargers and improving upon it to promote zero-carbon transport methods

Promote active transport by designing streets prioritising them instead of the private car



Bring in innovative, mixed-use developments such as Transport Oriented Developments (TODs)

SUMMARY

Manchester City Council set a goal to achieve true zero carbon status by 2038 with MCC leading the way to the largest development in the UK - Victoria North. It raises the question,

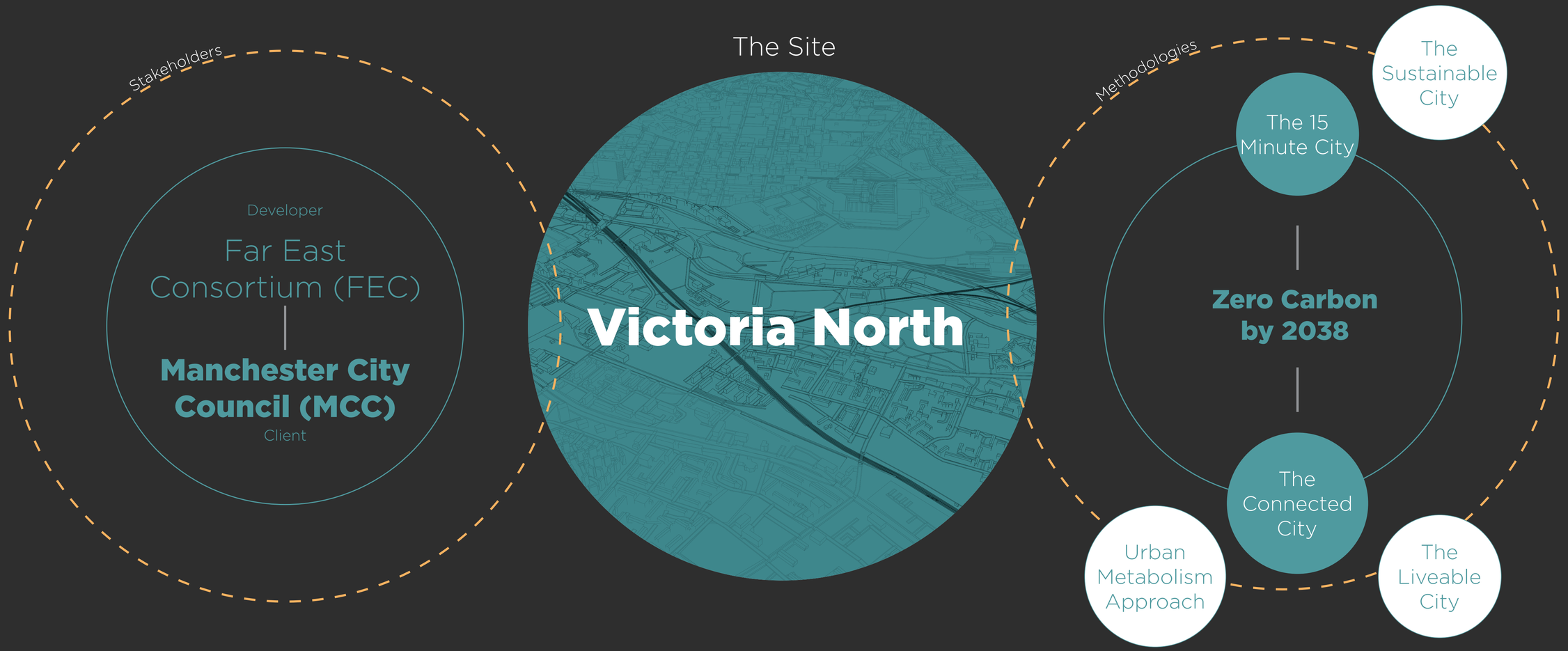
How to Design a Zero Carbon City?

Manchester Victoria Station
(Author, 2021)

PROJECT BRIEF

The Who, What & Why

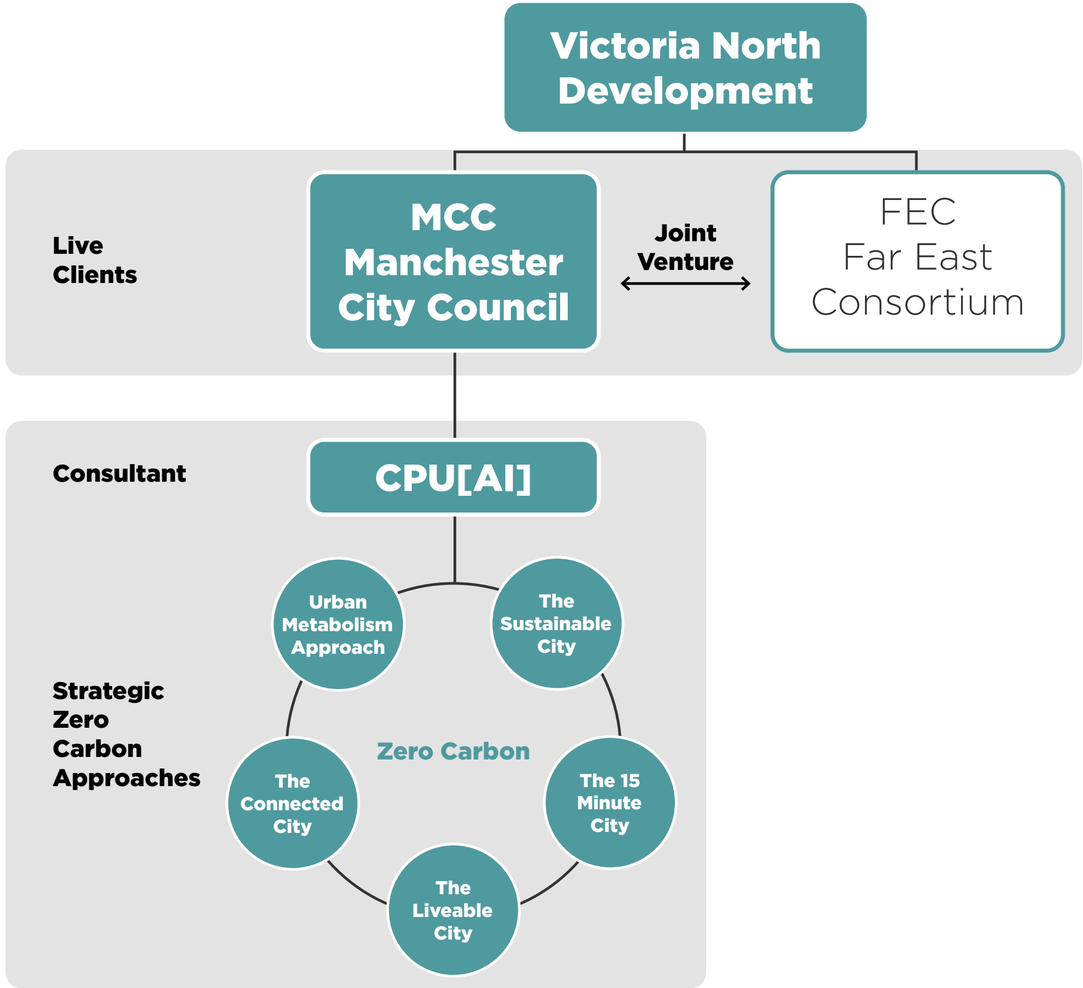
Victoria North is the largest redevelopment site in the UK currently in plan and together with Manchester City's 2038 zero carbon goal, created an opportunity to truly implement new technologies and planning methods that can achieve zero carbon. With MCC leading the way and FEC as the developer serving as a real-lift client, the project examines plausible zero carbon futures with in-depth understanding in urban planning, technological trends, embodied and running energy as well as detailed calculation models.



OUR ROLE

Outline of Project Relationships

The project is led by MCC (Manchester City Council) with FEC (Far East Consortium) as an external commercial partner, together they form the client of the project to employ different consultants to conduct feasibility studies. The atelier CPU[AI] of MSA (Manchester School of Architecture) (hereafter abbreviated as CPU) works with MCC to develop plausible futures for the goals that they are seeking, which also serve as live clients for student projects.



MANCHESTER CITY COUNCIL

MCC is the local authority of Victoria North and the leader of the redevelopment project. It produced the SRF to guide policies and development strategies.

Far East Consortium

FEC is a developer that is deeply involved in the site of Victoria North and works with MCC to redevelop the area. Their primary concerns lay in the commercial viability and infrastructural support.

CPU

CPU uses a complexity framework to develop new digital tools, computational thinking and urban theory addressing future cities. Zero carbon cities is focused in partnership with MCC to examine their identified areas of interest.

MISSION & VISION

Towards Sustainable Goals

The MCC brief set out a list of goals translated from the SRF (strategic regeneration framework) and the CPU aim listed out 5 strategic approaches as starting points. With the chosen strategic approaches the project set out to achieve the core objectives in the SRF.

MCC & FEC aims & goals

MANCHESTER CITY COUNCIL

Far East Consortium

SRF Core Objectives

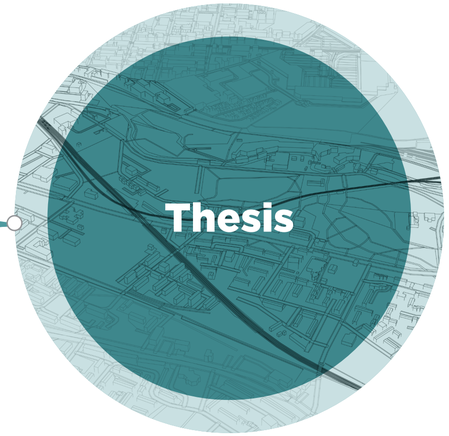
- A Unique and High-Quality Residential-led Regeneration Scheme
- A Varied Network of High Quality Green Streets and Public Open Spaces
- Manchester's Unique City River Park
- Build on the Best of What is There
- Improve Connectivity Across the Northern Gateway and Beyond
- Create New Gateways To and From the City Centre
- Promote Truly Sustainable Places
- Foster the Emergence of Local Retail and Service Hubs

MCC Brief

- Provide 15,000 residential units
- Adhere to Manchester City's zero carbon goals
- Consider the development to be an extension to the city and should function in similar density
- To ensure a wide range of typologies
- Family oriented development
- Long term sustainability goal
- Create a legacy from the development project

The Connected City

The 15 Minute City



The thesis utilises 2 of the 5 strategic approaches - The Connected City And The 15 Minute City to develop a solution for the MCC brief. These are believed to be the most relevant and are in line with the initial research that had been done when exploring the problem.

CPU Atelier Aim

To produce low carbon to zero carbon solutions for the Victoria North development site as a consultant for MCC and to disrupt the status quo and demonstrate pathways to more desirable future cities as designers.

Strategic zero carbon approaches:

1) The Sustainable City
2) The Connected City
3) The Livable City
4) The 15 Minute City
5) Urban Metabolism Approach

STATEMENT RATIONALE ///

Connectivity, which covers walkability, micro-mobility, public transport and private motorised transport is an essential consideration for socio-economic activities. However, this can contradict to lower energy and emission strategies. Transport contributes 27% to the UK's emission and 1/3 of a city's emissions. While the urban morphology of the city and renewable energy have a positive correlation, combining these with an optimal low carbon mobility design strategy proposes a challenge to be tested in our experimental design approach.

The thesis examines ways of design that can improve accessibility and connectivity while minimising all transport emissions, in efforts to create a carbon neutral transportation network.

Osborne Street bus station
(Author, 2021)

PROJECT FOCUS

Limiting Rising Temperature to +1.5˚C

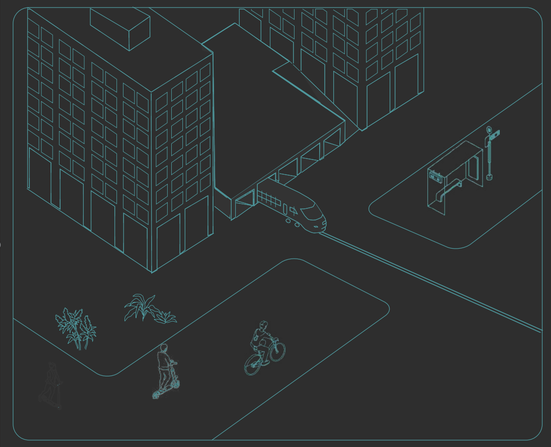
As observed in this chapter, the current emission pledges committed during COP26 are not anywhere close to sufficient to meet the +1.5˚C aims. More needs to be done in order to cut down emission levels in order to limit the rise in global temperature.

+2.4˚C
Current COP26 pledges insufficient

More Radical Change Needed

Analyse Current Low Carbon Aims

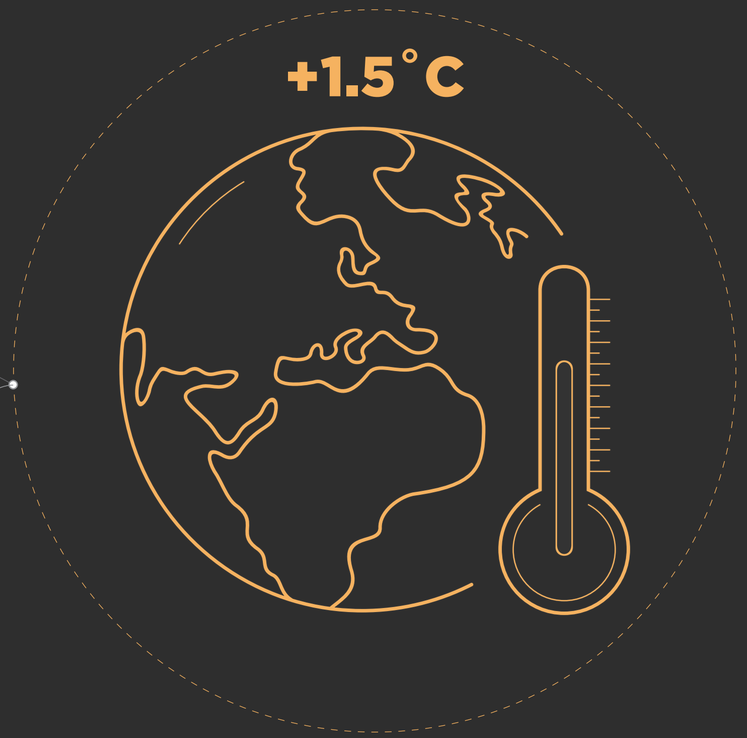
Target Identified Critical Points of Intervention



• Improve Existing Infrastructure
• Promote Active Transport
•Innovative Commercial Arrangements

Push Aims to Zero Carbon

Limit Rising Global Temperature



CHAPTER

02

ANALYSING SITE & THEORIES

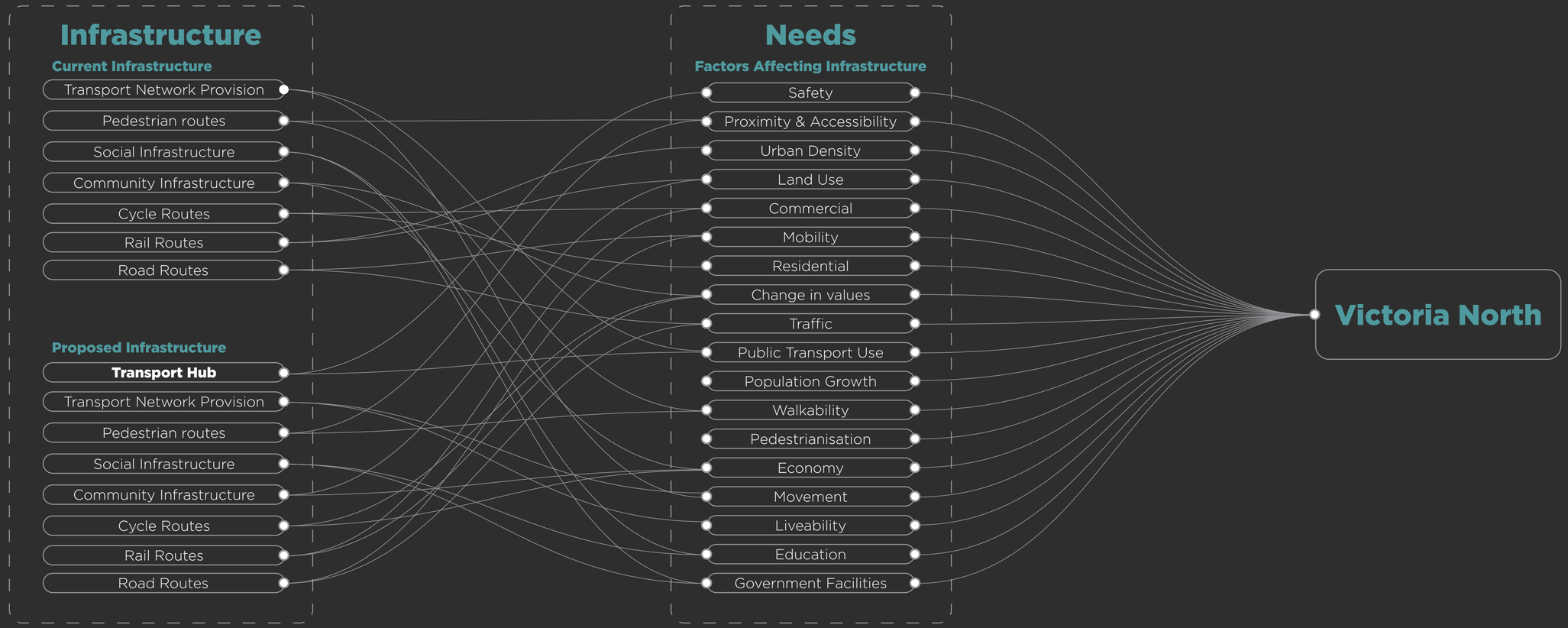
Understanding Issues regarding Victoria North & Carbon Emissions from Transport

VICTORIA NORTH

Improving Current Infrastructure

Victoria North is currently part of a regeneration project that aims to create 15,000 new homes and build strong connections with its neighbouring communities, namely New Islington and Ancoats. *The project will study key aspects in Victoria North to examine whether the current infrastructure will be able to serve the proposed development and what proposed infrastructure will be needed.*

Will the current **infrastructure** be able to **serve the proposed development** and what is **needed to make it sufficient?**

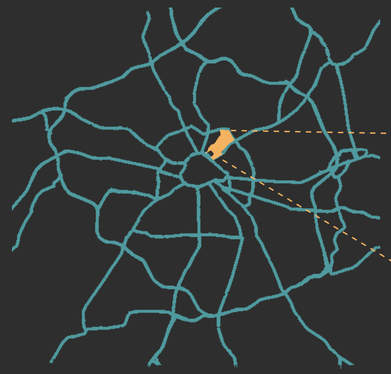


VICTORIA NORTH

Site Context

Victoria North is a neighbourhood to the north of Manchester City Centre with a population of about 50,000 people. 155 hectares of mostly brownfield or underutilised land a location The development area has been bordered by well-established communities such as New Islington and Ancoats. Victoria North, which is one-third the size of the city centre is referred to as the most significant possibility for residential-led growth by Manchester City Council.

Location: Manchester, UK



The Radial Road Network in Manchester

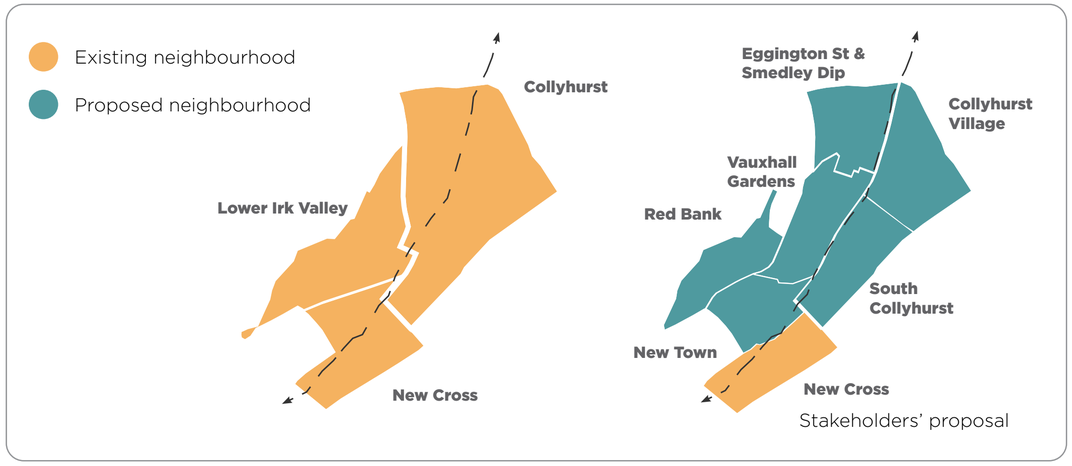
"It is hoped that **15,000 new homes** will be **created** through the development **over the next 15-20 years** which will be a significant contribution towards the Manchester Residential Growth Strategy."

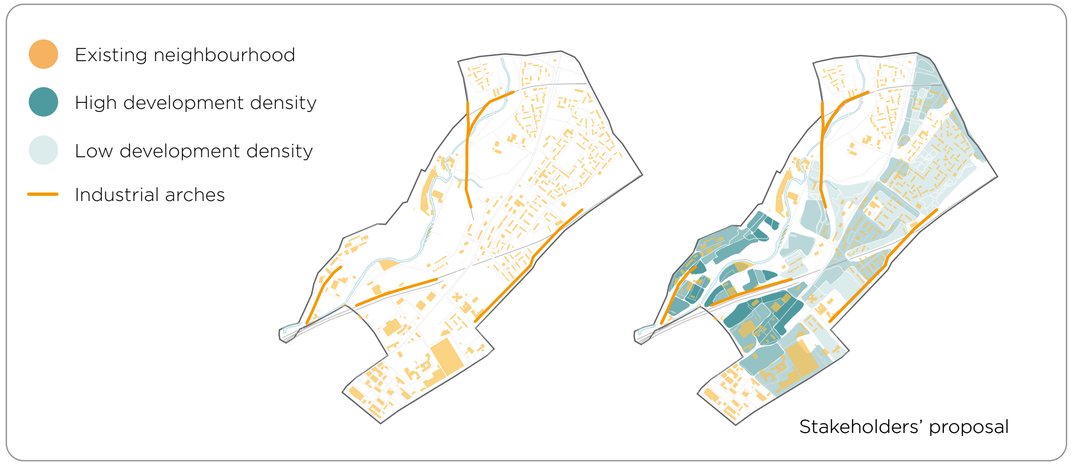
(SRF, 2020)

INCREASING DENSITY OF VICTORIA NORTH

Land Use & Neighbourhoods

15,000 new homes are expected to be built. There will be an increase in residential neighbourhoods, primary retail and service hubs. As the density increases, so do the amenities required which includes accessibility to transport links.





Land traits & Infrastructure
Development type
Gateway square
Neighbourhood square

Eggington St & Smedley Dip

Family-oriented, integrates **social and community infrastructure** with excellent wider **transport links,** increased permeability into Irk Valley.

Vauxhall Gardens

Residential-led to successfully integrate with existing residential context, serves as heart of Northern Gateway containing **primary retail, service and transport hubs.**

Collyhurst Village

Family oriented, **residential-led**, dynamic community heart supported by **social and community infrastructure.**

Red Bank

Residential-led, **unique topography** and **river setting** suits high density apartments, town houses and family-housing. Provides urban living punctuated with industrial heritage.

South Collyhurst

Residential-led, transition from higher density New Cross and New Town, mix of **social and community infrastructure** supports range of lifestyles.

New Town

Residential-led, range of housing types and tenures, key interface with N.O.M.A. estate and Northern Quarter, well connected **public transport** nodes

New Cross

Residential-led, **large grid-based plots**, marks transition from city centre to Northern Gateway, network of **small parks and green spaces.**

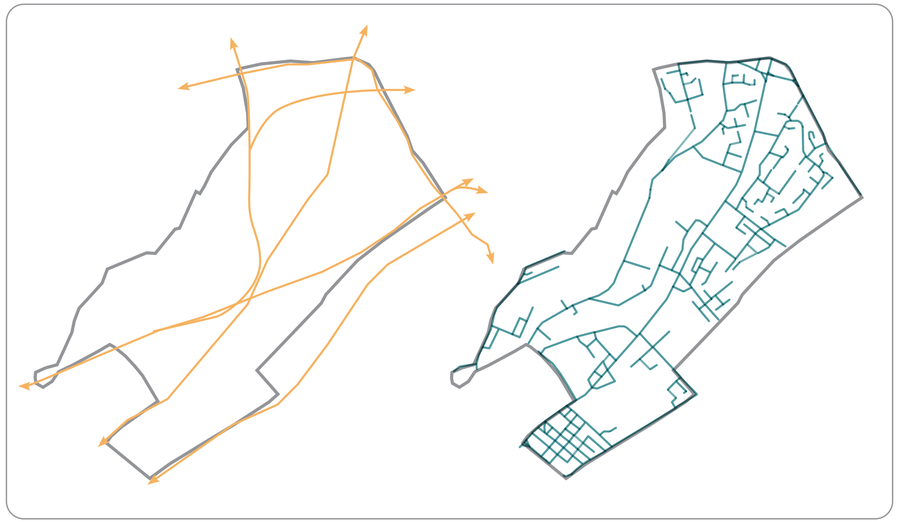
N

TRANSPORT NETWORK

Mobility Within the Site

It is important to study the connections between the proposed neighbourhoods to establish the connectivity and accessibility within the site. Besides the proposal of a new transport hub to improve mobility in and out of the site, new pedestrian routes are also introduced as the current pedestrian route network is quite disjointed.

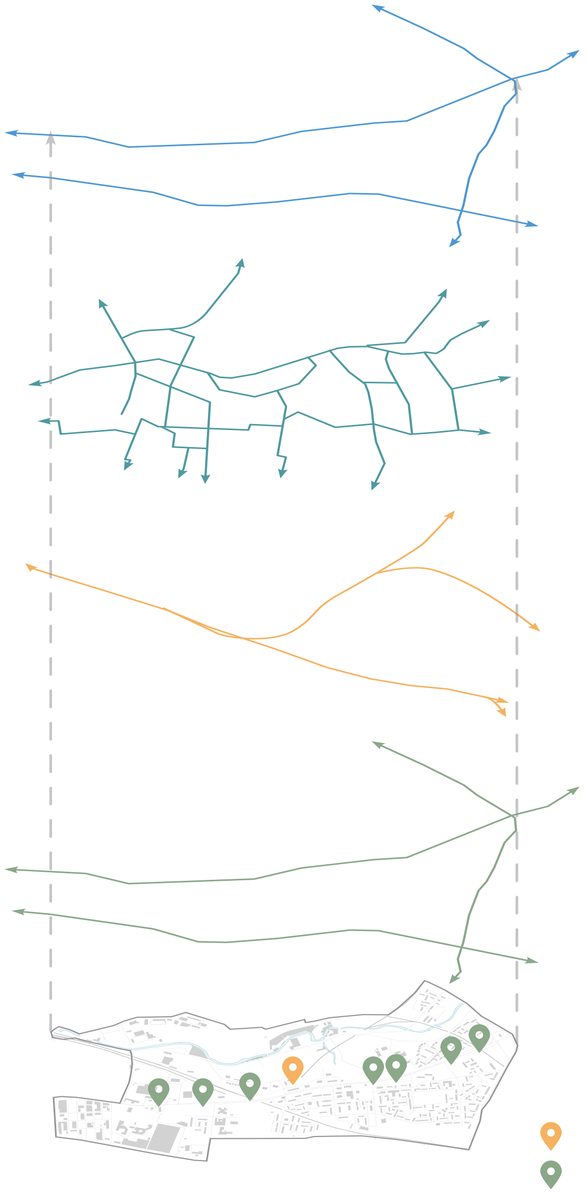
Current transport network in site



Proposed pedestrian routes by MCC & FEC

- Accessibility in and out of the site
- Accessibility within the site

The proposed network introduces a new Transport Hub to increase mobility in and out of the site and **improvements to internal pedestrian routes to improve mobility** within the seven new neighbourhoods.



The proposed Transport Hub will be set on vacant properties as a way to revitalise Victoria North and build stronger connections with the surrounding areas.

The Proposed Site of the Transport Hub, Hamerton Road, Manchester
(Author, 2021)

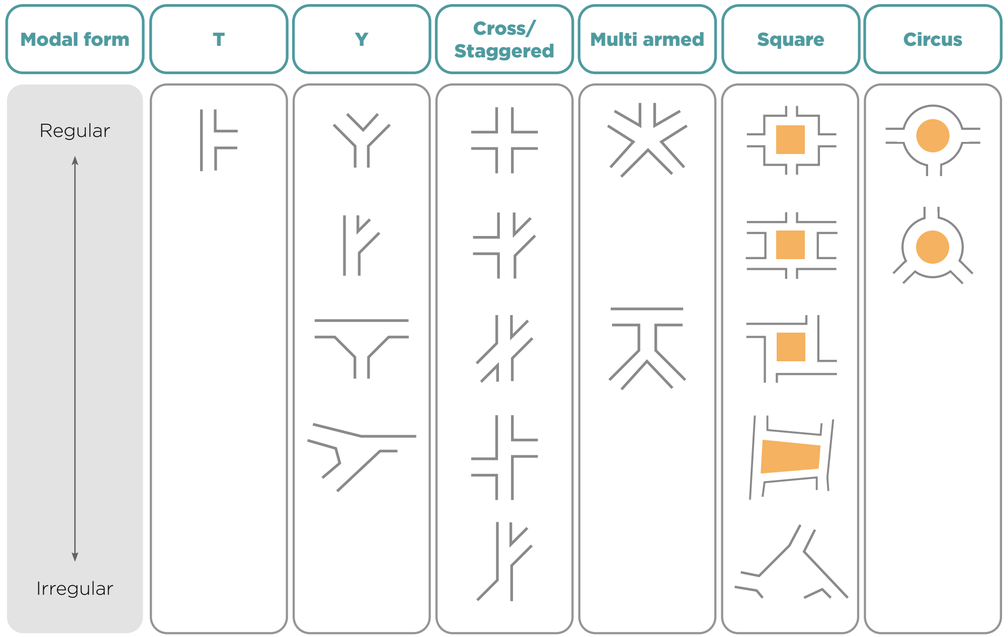
ANGULAR WALKING ROUTES

Accessibility & Way finding

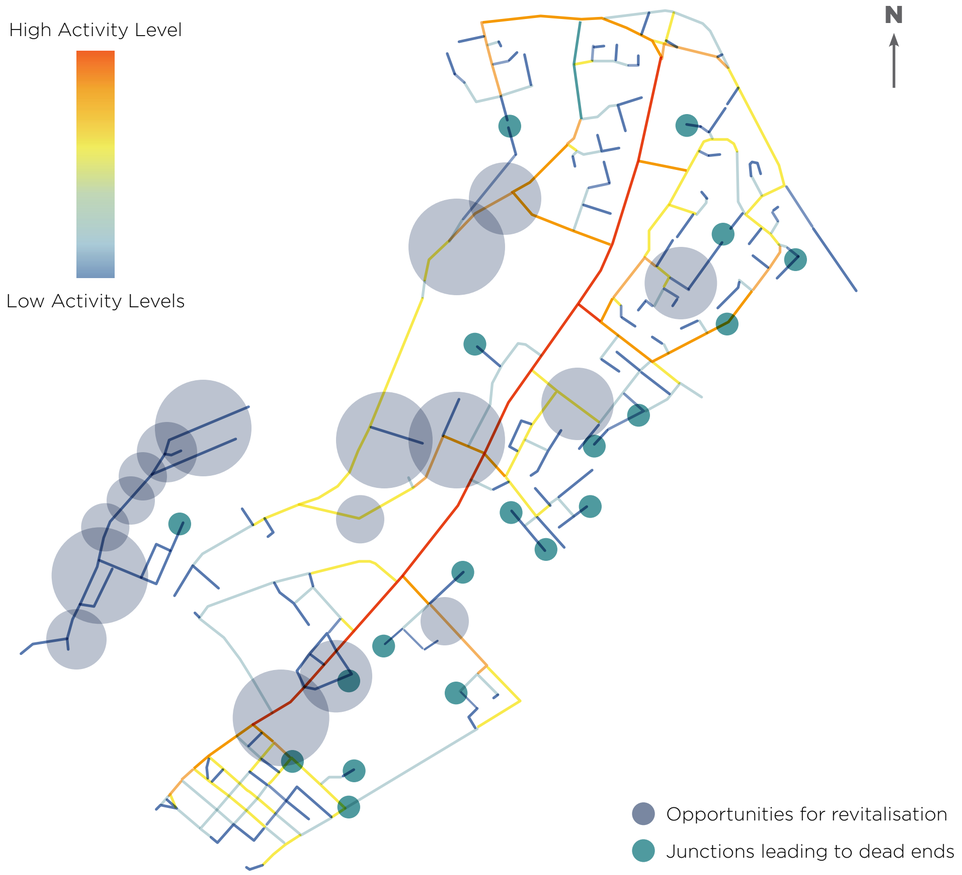
Junctions can be seen as opportunities. Based on Chartered Institution of Highways and Transportation (CIHT), junctions are the most natural way for people to find their way around. Across the site, most junctions are regular with T or Y forms. Typically, people would prefer to walk in straight lines to their destination, with minimum detours.

Pedestrians and vehicles share the same route to the city centre as **most of the residential routes are disjointed** and do not share a direct route to the city centre.

Types of junctions and intersections based on their modal form



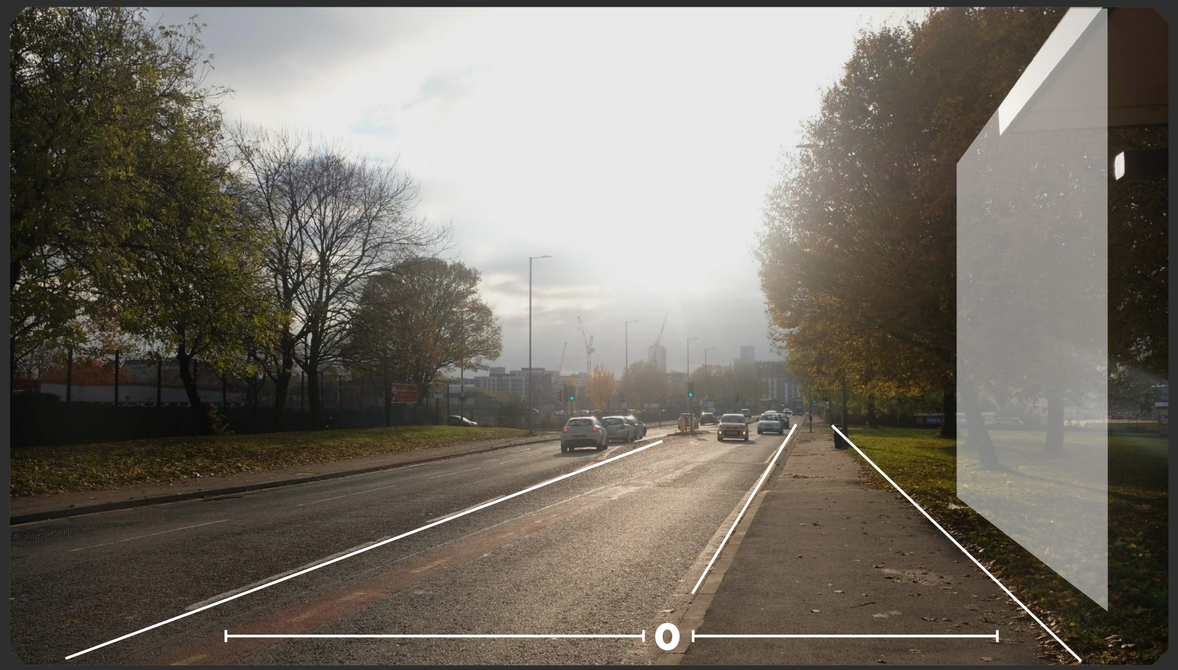
(Hillier et. al., 2012. CIHT, 2010)



(CPU, 2020)

THE ARTERIAL ROUTE

Walkability Comfort



While the arterial pedestrian route Rochdale Road city centre is direct to the city centre, **walkability comfort is reduced due to loud fast-moving traffic, a lack of separation between vehicles and pedestrians and no frontages to the street** on this busy vehicle route.

How can pedestrian routes be introduced within the site to **maximise user comfort** and **minimise travel time**?

Rochdale Road, Manchester
(Author ,2021)

NOISE LEVELS

Walkability Comfort

Different noise levels emanate from different transportation routes. Pedestrian routes are considerably much quieter with noise levels rising only during peak hours, while have freight trains and heavy good vehicles often pass through the main routes to delivery goods. The data on the number of vehicles passing through the site indicates the noise levels and will be used to calculate the emissions released by each vehicle type.

The **straightest pedestrian route** to the city centre is also, the **busiest and noisiest in site**.

While this provides a direct route to the city centre, it **reduces the walkability comfort**

https://www.nature.com/articles/jes201556

WALKABILITY IN VICTORIA NORTH

Safety & Accessibility

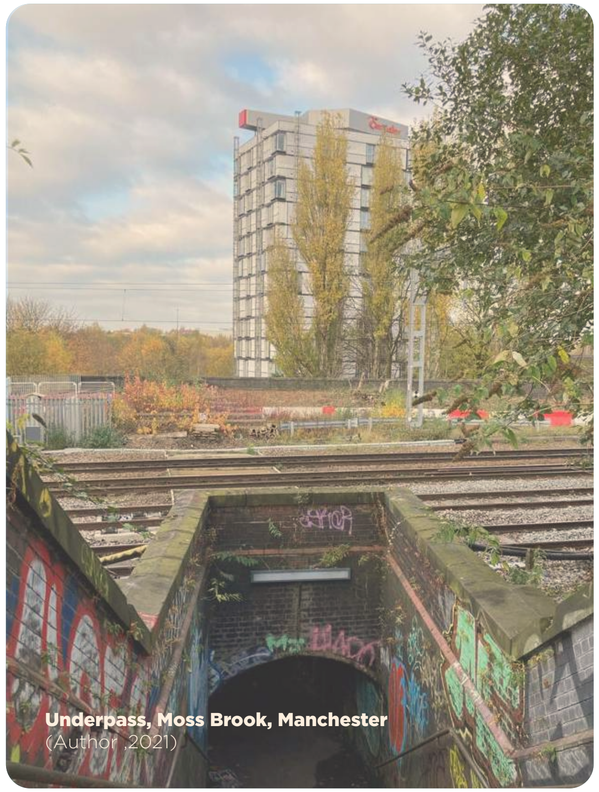
Many routes in the site are dead-end routes, dark and difficult to walk through. This not only reduces the safety and walkability of pedestrians in the site, it also creates a negative feedback loop that deters people from going to these locations.

Victor Street, Manchester
(Author ,2021)

Many unfriendly corners lead to dead-ends and reduces connectivity within the site

Peach Stone Henge, Manchester
(Author ,2021)

Some stairs in the provided green space lead to overgrown bushes



Underpass, Moss Brook, Manchester
(Author ,2021)

Many connections to important points of attractions are poorly lit, vandalised, have no visibility and feel unsafe.

Bridge to Manchester Fort
(Author ,2021)

Many connections to important points of attraction are maintained poorly

TRENDS IN PEOPLE'S NEEDS

What Do Communities Want?

After the COVID-19 pandemic hit, many people have changed their opinions on what they want or need from their living environments. Like how some people do not require to live near the city centre anymore due to the change in working habits, there are some fundamental changes in the way people interact with green spaces and the city.

Public Space

- Public spaces are set to become more flexible in terms of physical engagement.

- Natural elements creates buffer zones to highlight safe areas and to mark personal unapproachable spaces.

- Studio Precht has proposed a green space designed- "Parc de la Distance", the project introduces an outdoor space that encourages social distancing and short-term solitude.

Density

- To prevent inhibit future pandemics, different physical forms for density are needed to permit people to socialise and participate in street life

- The changing nature of urban space—and the potential revival of the more spacious suburbs—are opportunities for architects to rethink and redefine fundamentals of living.

Transport/ Mobility

- Many cities are planning for an alternative future, replacing traffic lanes with pedestrian paths.

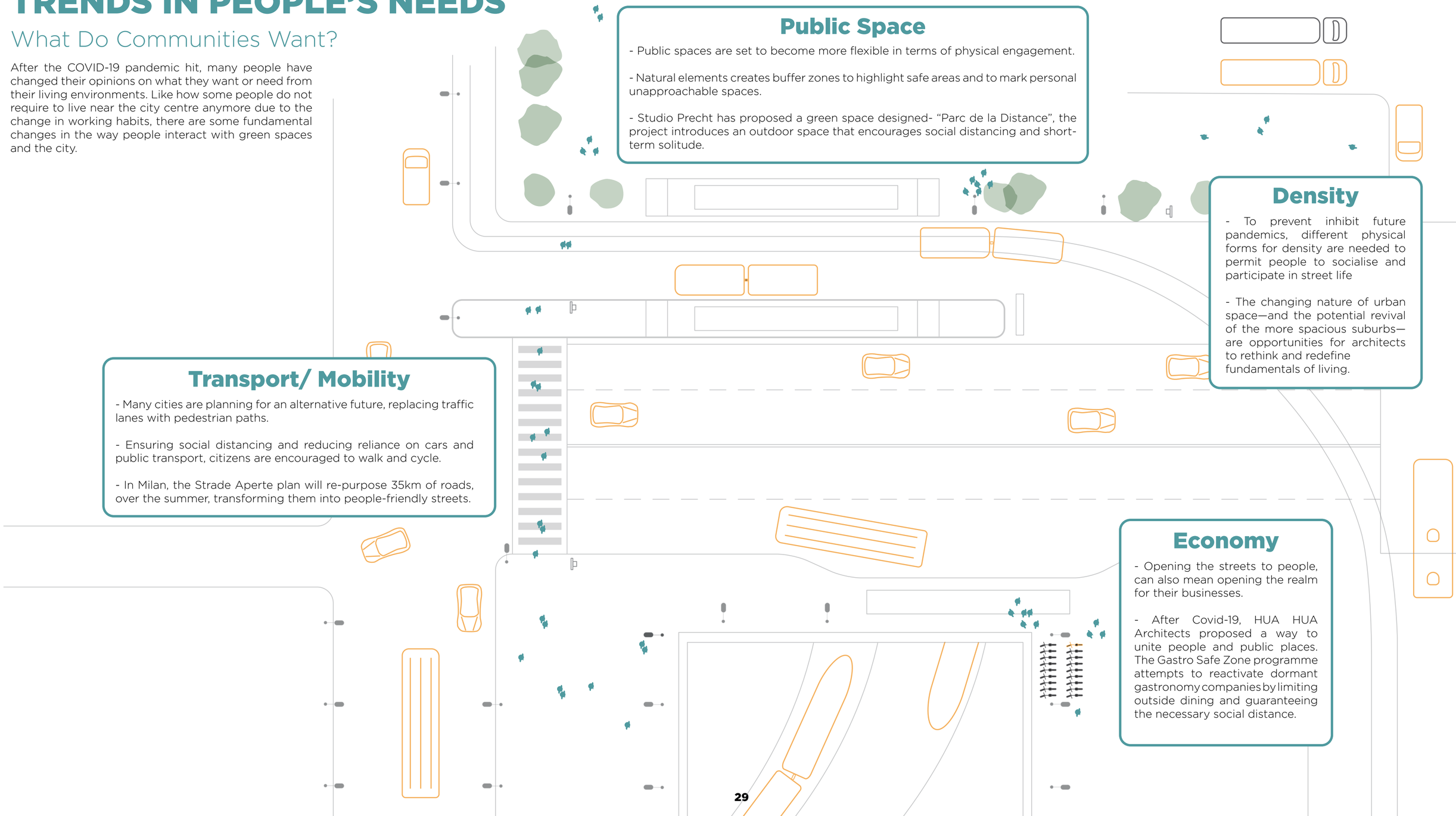
- Ensuring social distancing and reducing reliance on cars and public transport, citizens are encouraged to walk and cycle.

- In Milan, the Strade Aperte plan will re-purpose 35km of roads, over the summer, transforming them into people-friendly streets.

Economy

- Opening the streets to people, can also mean opening the realm for their businesses.

- After Covid-19, HUA HUA Architects proposed a way to unite people and public places. The Gastro Safe Zone programme attempts to reactivate dormant gastronomy companies by limiting outside dining and guaranteeing the necessary social distance.



Abandoned railway lines in Victoria North can be reused for vibrant activities and frontages which highlight safe inhabited areas that can be engaged with.

Bromley Street, Manchester
(Author ,2021)

GENERATING DIFFERENT URBAN LAYOUTS

How Different Layouts Affect Accessibility & User Activities

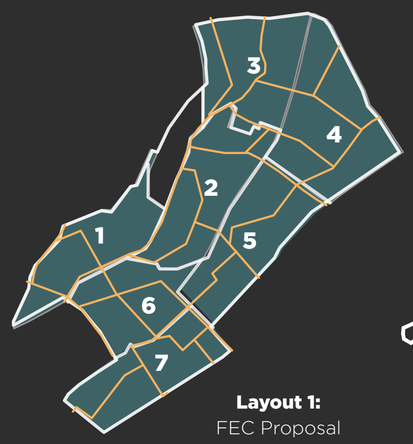
Three important aspects were identified to focus on through the study of the current infrastructure on site: *Transportation, Accessibility & User Activities* - how would different urban layouts improve accessibility within the site? These factors would be considered when creating the computational design tool.

Existing network

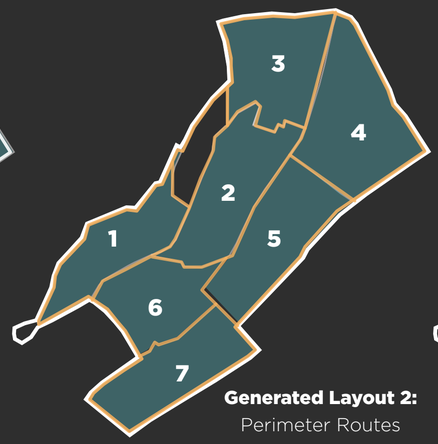
Considerations

- TRANSPORTATION
- ACCESSIBILITY
- USER ACTIVITIES

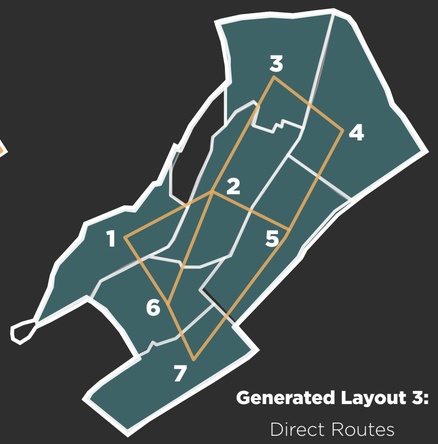
Potential generated urban layout



Layout 1:
FEC Proposal



Generated Layout 2:
Perimeter Routes



Generated Layout 3:
Direct Routes

Three important aspects have been identified to focus on throughout the study of the current infrastructure on site: **Transportation, Accessibility & User Activities**

With these three aspects in mind, how would **different layouts improve accessibility** within the site?

APPROACH TO ZERO CARBON

Transport, Accessibility & Social

After first engaging with MCC, the Atelier aimed to produce a research document that focuses on different aspects of a zero carbon city. The topic that was chosen was transportation, in line with the research that we were interested in conducting and developing into a thesis.

The document is divided into 12 chapters and each chapter went in detailed and lengthened analysis of the respective topic. For transportation, from executive level data to detailed per-vehicle emission with respective tax bands were collected and developed into a detailed model of emissions in Victoria North.

The chapters are as below,

1) Introduction
2) Carbon accounting & policies
3) Air pollution
4) Energy [System generation]
5) Social Transformation and Human behaviour
6) Urban Heat Island
7) Urban forest & greenspace
8) Accessibility
9) Transportation
10) Buildings
11) Urban water life
12) Smart cities

Produced by group
Examined in detail

//Important findings from these 3 chapters provide a critical insight into the demographics of people and their social and transportation needs.//

ZERO CARBON CITIES

A full version of the publication can be found online at the website below:

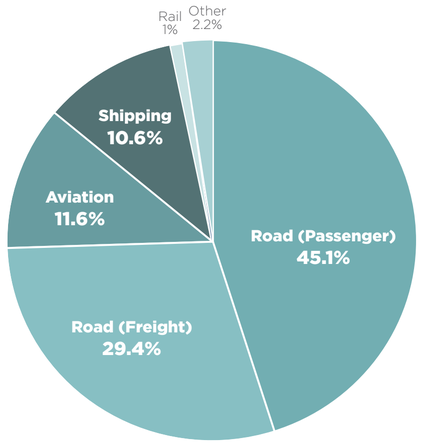
https://www.lonylaw.com/cpuai2021

TRANSPORTATION

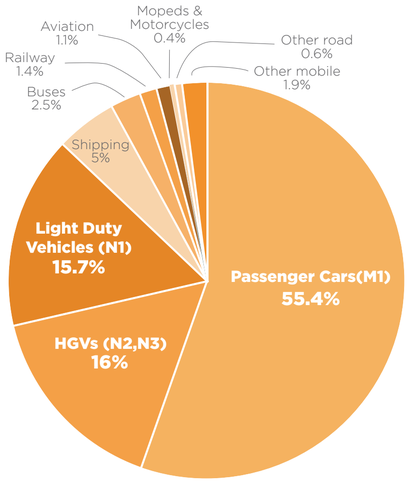
Highest Carbon Emission Contributor

Transportation, specifically passenger cars (M1) are a emitter of CO2 and greenhouse gas both in the UK and worldwide. (International Energy Agency, 2018) (Department for Business, Energy and Industrial Strategy, 2021) Despite heavier regulations and deeper awareness of the climate emergency, transport emissions have remained a significant contributor of CO2 emissions in the UK with no downward trajectory from 1990-2020. (Department for Business, Energy and Industrial Strategy, 2021)

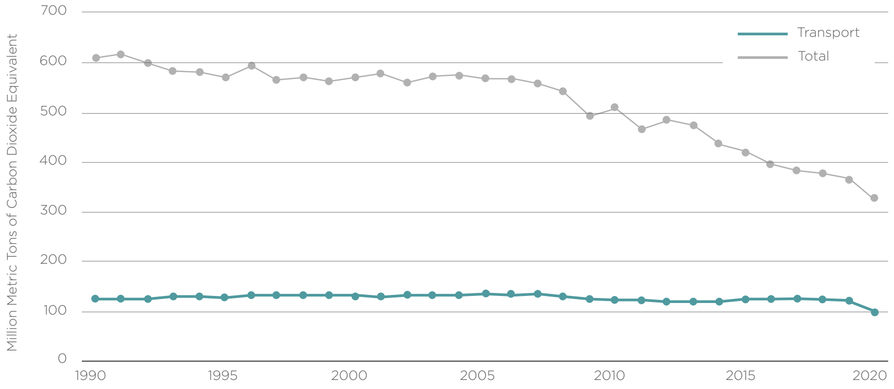
CO2 Emissions produced by Transportation Sector Worldwide (2018)



Transportation Emissions in the UK (2019)

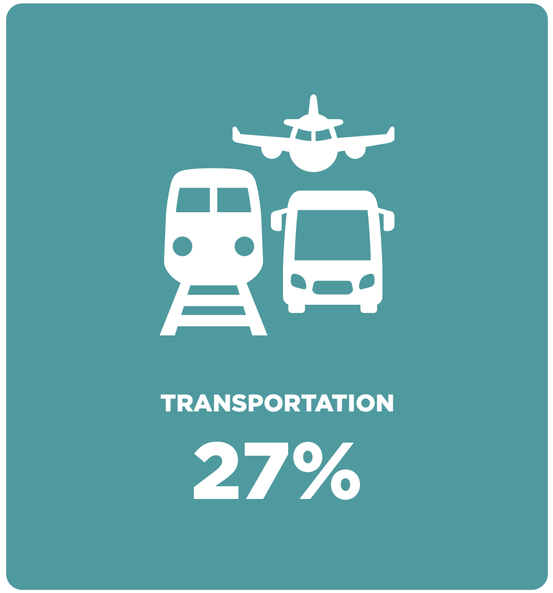


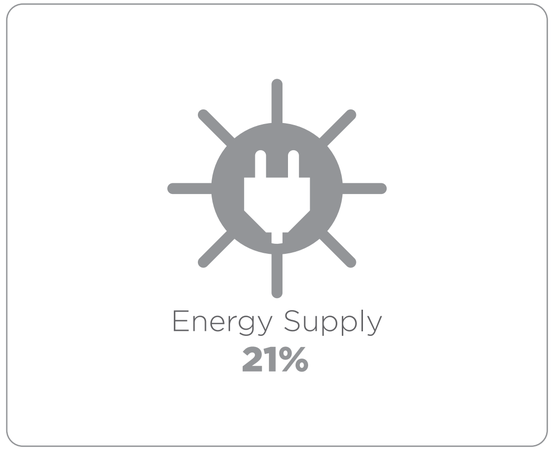
UK Greenhouse Gas Emissions

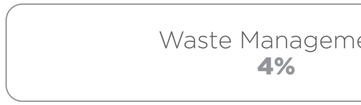


Transportation is a huge hurdle to UK's net zero goals. It is clear that heavier regulations involving emissions from vehicles have not been effective in cutting them down. Regulations are not the solution to cutting down emissions from the transportation sector, in the next pages we delve deeper into the issue to try to find an alternate solution.

Greenhouse Gas Emissions by Sector UK (2019)



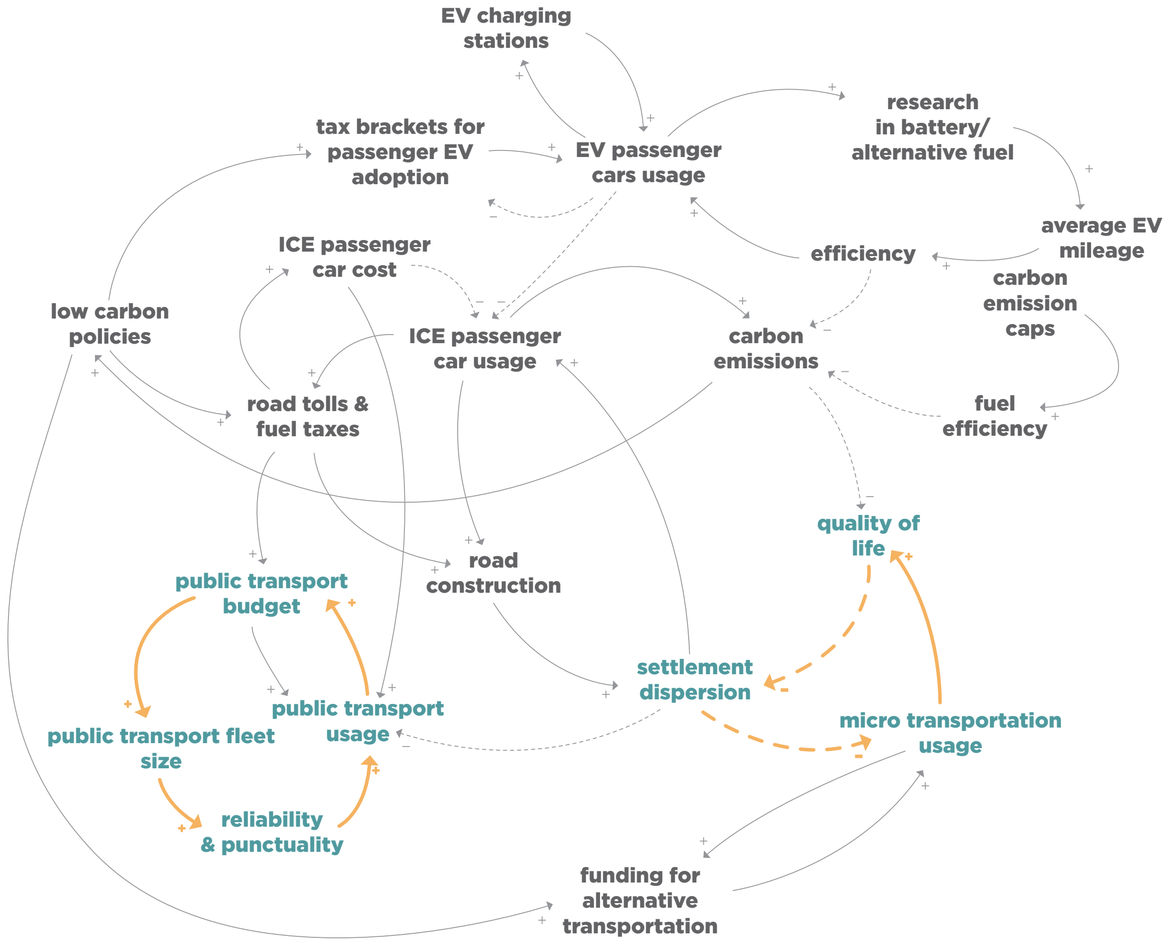




INFLUENCING FACTORS IN TRANSPORTATION

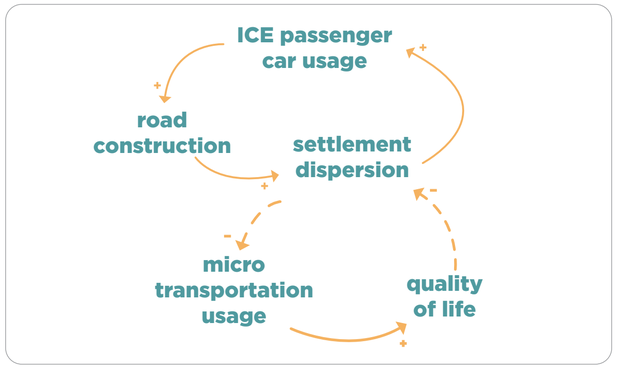
What Factors Result to Great Transport Infrastructure?

A Systems Dynamics Map is employed to lay out all links and feedback loops within the Transportation sector in order to aid our understanding and formulate our thesis statement. We then used it to identify the leverage points.

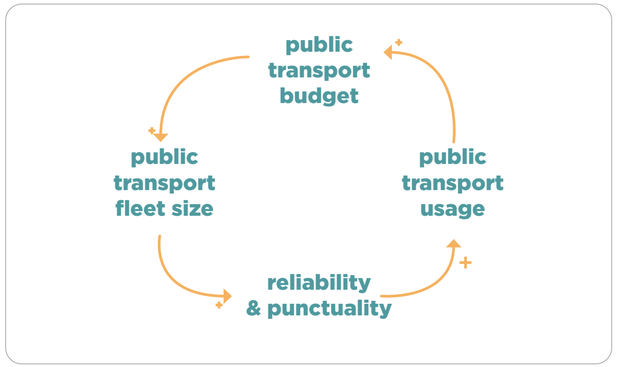


Main findings

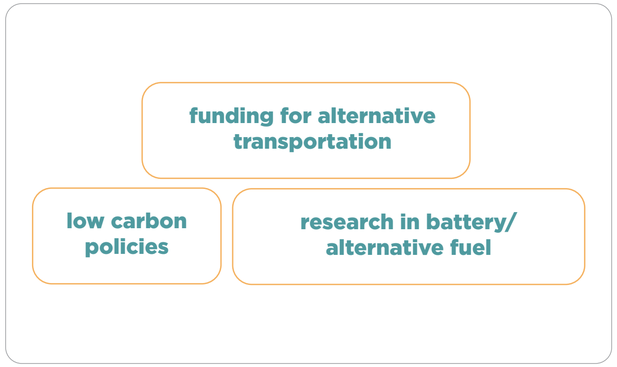
From the System Dynamics Map we have established 3 leverage points seen above. These findings highlight the importance of the infrastructure design and layout, apart from research, policies and funding.



The layout of the city is a fundamental component in driving the use of vehicle types



The main point to increase ridership is reliability & punctuality of a fleet



Research, policies, funding and grants are important component to kickstart the system

How do we design a zero carbon city that can encourages the use of active transport and discourages the use of private motorised vehicles?

Rochdale Road
(Author, 2021)

TYPES OF VEHICLE

Combustion, Hybrid & Electric

Diesel and Petrol vehicles have been the predominant fuel types found on the roads throughout the years. However, there has been a rise in alternative fuelled vehicles as well as hybrid vehicles on the road. The UK's central government is also looking into electrifying the vehicle fleet The different fuel types available on the market will be examined.

It is clear that diesel and petrol cars are falling out of favour with its falling sales. Although this is no doubt better for the environment and reaching the UK's net zero 2050 goals, the solution to cutting down carbon emissions from Transportation is not as straightforward as switching from the normal ICE engines to less emissive types, as embodied carbon also needs to be taken into consideration. With reference to the systems dynamics map shown previously, the problem is more complicated and would rarely be solved with just one solution.

Internal Combustion Engine vehicles

Diesel vehicles

Even though the appeal of diesel cars are diminishing, mostly due to the Dieselgate scandal, it is still a relevant player with 8.1% market share in sales and 16% of 2020's new registrations , and is a key contributor to GHG emissions. (Grundy, 2021) (SMMT, 2021)

Petrol vehicles

Petrol cars are the most abundant on current roads, consisting of 55% of all PC vehicles. Advancements in recent decades and tighter regulations significantly reduced emissions by more than 10%. (Department for Business, Energy and Industrial Strategy, 2021)

Compressed Natural Gas vehicles

Natural gas vehicles are not widespread in the UK in the private sector, but is popular in public transportation, which many bus fleet utilises the technology

Liquefied Petroleum Gas vehicles

LPG vehicles make up less than 1% of the vehicles in the UK, with continue shut down of refuelling stations from fuel companies, it signifies a principal change in moving away from natural gas. (RAC, 2021)

Hybrid Vehicles

Hybrid EV

Hybrid EVs have both a ICE and a electric motor, but the electric motor is only used to improve fuel economy. 2020 saw 12% growth in Hybrid EV registration in the UK . However, tighter regulations will eventually lead to the complete phase out of ICE vehicles, including hybrids. (SMMT, 2021)

Plug-in Hybrid EV

Same as a hybrid, an electric motor is present alongside an ICE in a plug-in hybrid EV but each can be individually used or used together. Plug-in hybrids improves a lot on fuel efficiency, thus having lower carbon emissions. Plug-in hybrid EV almost doubled in vehicle registration in 2020. (SMMT, 2021)

Extended Range EV

Extended Range EV provide the benefit of significantly lower emissions than ICE vehicles while having the range of ICE vehicles. In an EREV the electric motor would be utilised primarily until power is depleted, which then the ICE will carry on, having the best of all worlds.

Electric Vehicles / ZEV (Zero Emission Vehicles)

Battery EV

BEV is the fastest growing type of electric vehicles and is the most promising in replacing ICE vehicles with batteries that provide ranges on par with ICE vehicles.

Fuel cell EV

FCEV mostly refer to hydrogen cell EV. The difference between BEV and hydrogen cell EV is that while battery weight increase with vehicle range, hydrogen cell are almost the same weight regardless of vehicle range. With huge players like Toyota and governments investing in the technology, FCEV can replace EVs in the long run with drastically better range.

Glossary

ICE	Internal combustion engine
EV	Electric vehicle
GHG	Greenhouse gas
L-ion	Lithium ion

EXISTING VS. NOVEL SOLUTIONS

Novel Solutions to Reduce Emissions & Congestion

There are many current forms of transportation options, some emitting more carbon than others. However, not all are relevant to the Victoria North Development like trains, mostly due to scale. There are also emerging trends in apparently zero-carbon transportation options that are usually shared and short-distance. However, it is important to be critical of these trends and consider that it might be the best option for the Victoria North Development.

Existing Solutions

Passenger cars

Accounting for more than 50% of carbon emissions in the UK and being the most dominant, it will surely be present in the foreseeable future.

Minibuses

Minibuses have shown to be one of the best choices, balancing emissions and passenger amount. It is also more agile than large buses, which therefore is a great choice to include in a low carbon transportation system.

Buses & Coaches

Buses are one of the vehicle type that can hold the most people and driving up ridership would accelerate the transition to zero carbon.

Light goods vehicles

The versatility of light goods vehicles in carry either goods or passengers allow it to result in a lower emission amount than private cars, and as usual LGV can fit up to 5 people, it decreases the need of a second vehicle.

Trams

Trams are high capacity public transport sharing the same road with pedestrians, also creating a sense of belonging to citizens as the tram serves as a landmark itself.

Trains

Trains are the lowest carbon emitting public transport, with the highest capacity it connects people cross country with a dedicated rail, though not every useful in the site of Victoria North

Bicycles

Without any running carbon, it is one of the best way to travel, further infrastructural development to support bike lanes can drive down emissions significantly.

Novel Solutions

Dockless Vehicles

Dockless vehicles such as shared E-Scooters are usually focused on micromobility and last mile travels. As these E-Scooters are powered by electricity, assuming that the power grid is from clean energy, their journeys are carbon-free. However, there are other factors to consider, such as embodied energy as well as the vehicles needed to collect them overnight to charge them for their journeys the next day. (Temple, 2019)

Ride-Sharing Solutions

Ride-Sharing apps such as Uber and Lyft provide opportunity for people going the same route to share their ride in order to split costs as well as reduce the carbon emission per person as one trip can be made with a car instead. However, recent studies show that ride-sharing apps can potentially cause more cars to end up on the roads instead and increase congestion. (Donatelli, 2020)

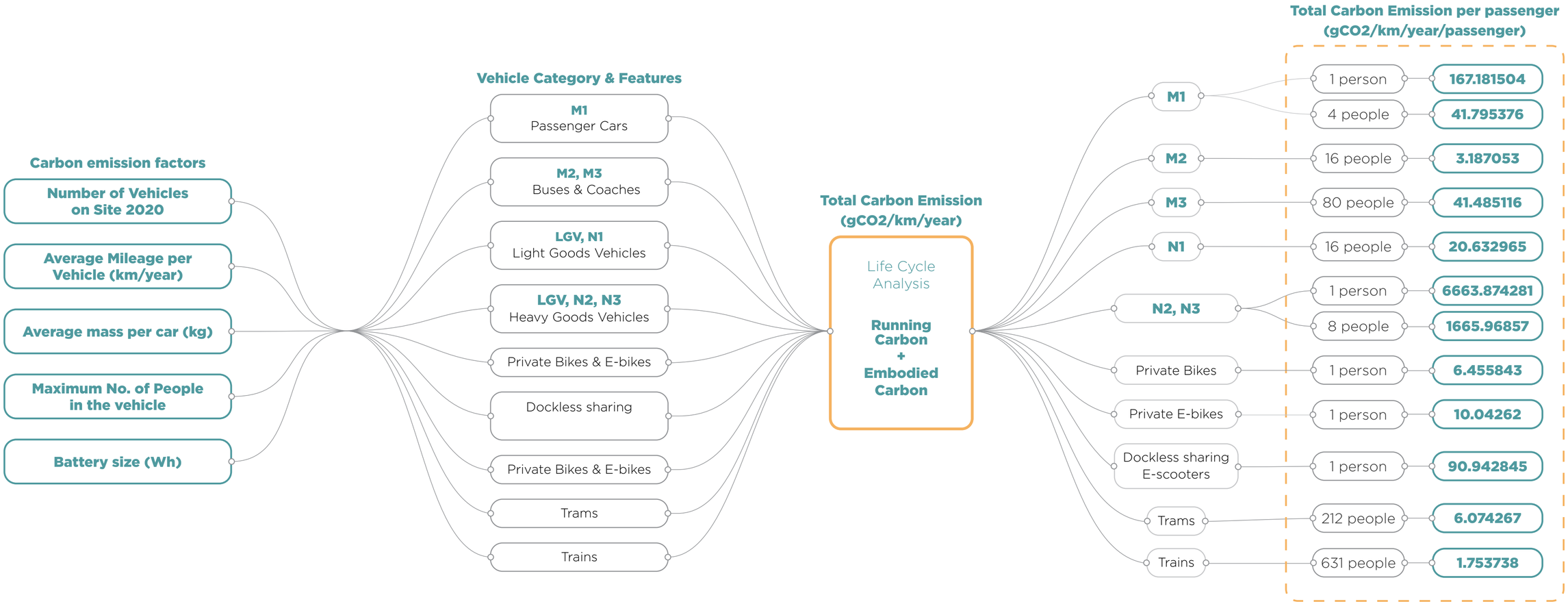
Connected Autonomous Vehicles (CAV)

CAV are vehicles that have the ability to self-drive and communicate with other vehicles./infrastructure on the road using technology. It is touted as a low carbon solution to transportation due to being apart of shared mobility movement, making EVs accessible to all. By being autonomous, it also cuts down on undesireable driving habits exhibited by humans that causes more carbon emissions. (Kopelias, 2019)

CALCULATING EMISSIONS IN VICTORIA NORTH

Carbon Emissions by Vehicle Categories

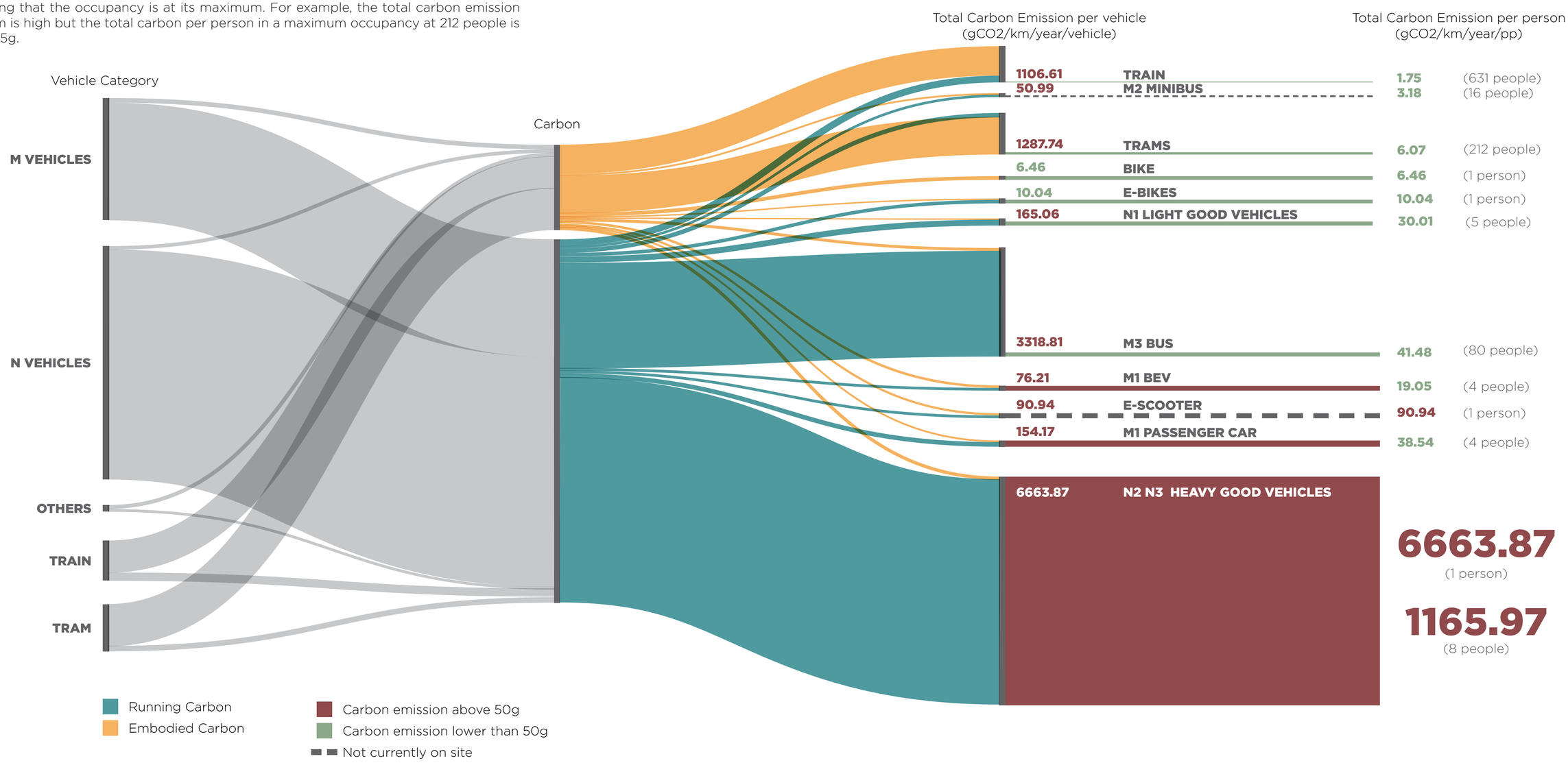
A calculator was formulated using Grasshopper, a visual programming language, to discover the amount of emissions released by each type of vehicles. By taking 5 factors that affect carbon emissions for vehicles, the results were then divided by the emissions into different UK vehicle categories via their Life Cycle Analysis calculations. The results were then differentiated through minimum and maximum capacity which are shown on the right.



EMISSIONS PER PERSON IN VICTORIA NORTH

Embodied & Running Carbon for Vehicles

The diagram below translates the amount of running carbon emission and embodied carbon in each type of vehicle on site. Although the total carbon emitted per mode of transport may be high, the total carbon emitted per person in said transport may be low, assuming that the occupancy is at its maximum. For example, the total carbon emission for tram is high but the total carbon per person in a maximum occupancy at 212 people is only 1.75g.



Victoria North is one of UK's biggest urban regeneration projects, which aims to serve the city's growing population. This is an opportunity to revive current amenities that have been poorly maintained.

Bothwell Road, Manchester
(Author ,2021)

THEORIES USED TO INFORM DESIGN PROPOSAL

Linking the Agglomeration of Neighbourhoods to Accessibility

Five main theories are analysed and used as base concepts to explain the relationships and problems in Victoria North. It also allows an in depth discovery on how carbon neutral mobility may be achieved through identifying key problems within the urban context.

THEORETICAL FRAMEWORK

NEW ECONOMIC GEOGRAPHY THEORY

Shows how large-scale agglomerations can emerge from the interaction of increasing returns and transportation costs

Formula:

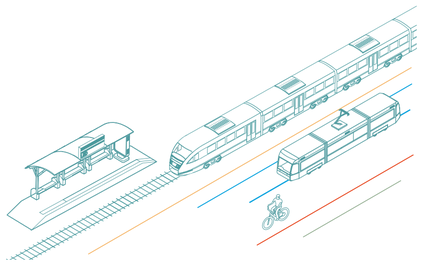
$$C_M = \left[\sum_{i=1}^{I} c_i^{\sigma - 1/\sigma} \right]^{\sigma/\sigma - 1}$$

A bi-regional model structure that considers:

- Utility
- Consumption
- Labour demand & supply
- Population
- Production cost
- Transportation cost

TRANSIT ORIENTED DEVELOPMENT

A theory that maximises the use of public transport and land use

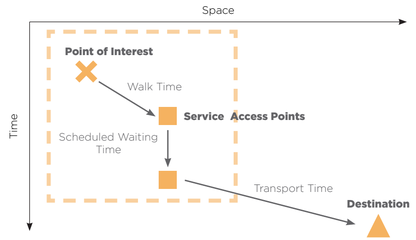


7 principles of TOD

- Quality Public Transit
- Active Transport
- Car Use Management
- Mixed-Use Neighbourhoods with Efficient Buildings,
- Good Public Spaces
- Collective Identity.

GREATER MANCHESTER ACCESSIBILITY LEVELS & PUBLIC TRANSPORT ACCESS

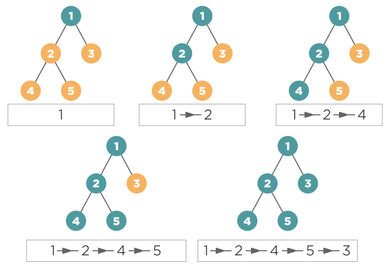
By "measuring accessibility", these theories relate to "point of interest" by examining and giving a location a connectivity score



To calculate its connectivity, the area in red is examined. The walk time and Scheduled Waiting Time is added together and parametrized to an Equivalent Doorstep Frequency, which all EDFs are then added to give the Access Level, which is the connectivity score.

GRAPH THEORY

Shows how objects connect through mathematical connections of vertices that acts as destinations and edges



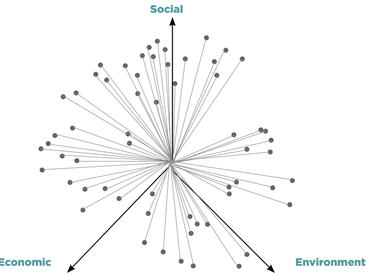
The diagram above is an example of Depth First Search Connections

Types of Connections

- Minimum Spanning Tree
- Maximum Flow Network
- Depth First Search
- Connectivity

UTILITY THEORY

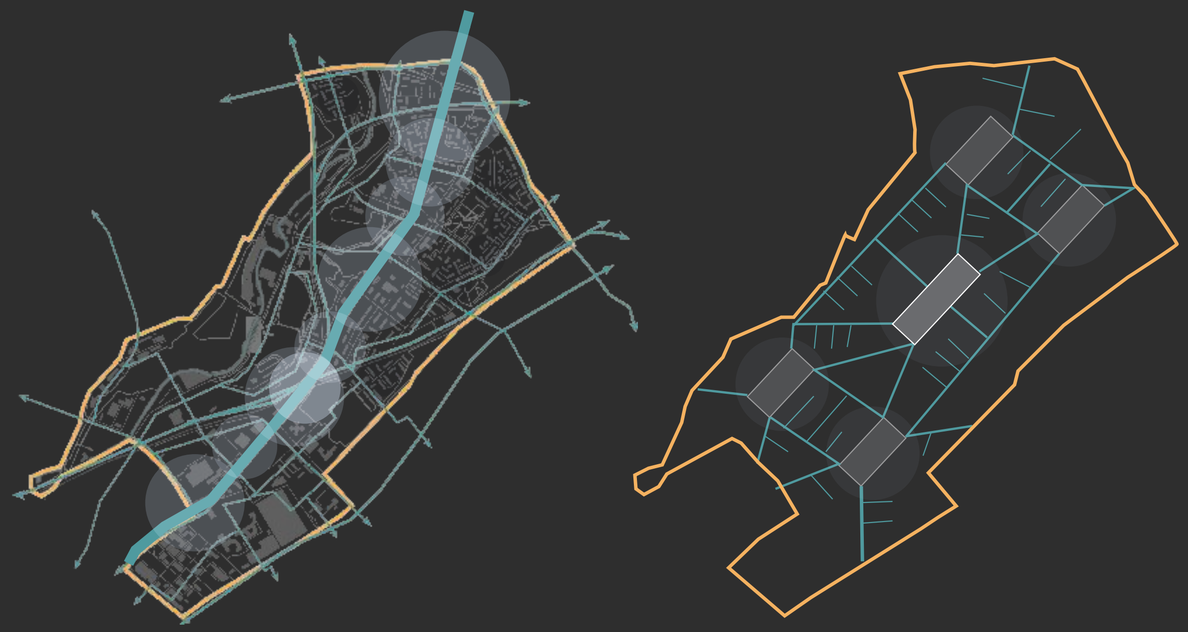
Explains the behaviour of individuals based on their choices depending on their preferences



The main strategy is to explore deeper into the graph repeatedly until all vertex are explored once.

REDUCING EMISSIONS THROUGH URBAN LAYOUTS

How Designing Urban Layouts Help Reduce Emissions



As observed, private cars (M1) are the largest emitter of carbon for Transportation. However the current layout of Victoria North is centered around travelling via the private car, with the Rochdale A664 Road being the main route towards the city centre as well as the M60 and it being the road within the site with the most recorded vehicles and carbon emission. (Department for Transport, 2021) The Rochdale Road, while providing straightforward access to the city centre, fragments Victoria North and makes transportation within the site a hassle due to the way the roads are laid out. Furthermore, the main walking routes within the site is also along Rochdale Road, making it a very unpleasant and unsafe walking experience.

At the moment, travelling to the city centre is necessary due to the lack of amenities within the site. However, by rethinking and replanning the network, amenities and spaces within Victoria North, prioritising and centering spaces around lower carbon transportation options instead of private cars, carbon emissions from transportation can be reduced within the site and create a better living environment for its occupants.

How can vehicular **carbon emissions be reduced through urban layout design** to create a better living environment for occupants in Victoria North?

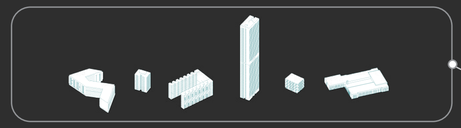
Rochdale Road
(Author, 2021)

COMPUTATIONAL TOOL STRUCTURE

Deciding Necessary Elements for the Tool

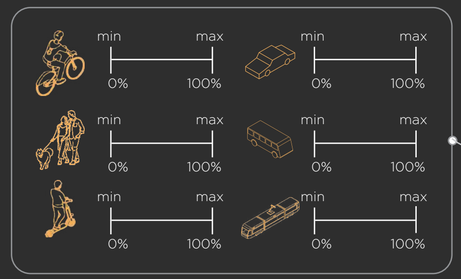
Computational approaches and simulations will be carried out. This will be the foundation to creating a design tool that can be used to generate city layouts that can inform the user of its predicted carbon emission and level of accessibility. The intent is for this tool to be able to carry out thorough analysis and comparisons of different generated layouts for any site in order to find an optimise layout that promotes active and public transportation to mitigate carbon emissions.

Typology Library

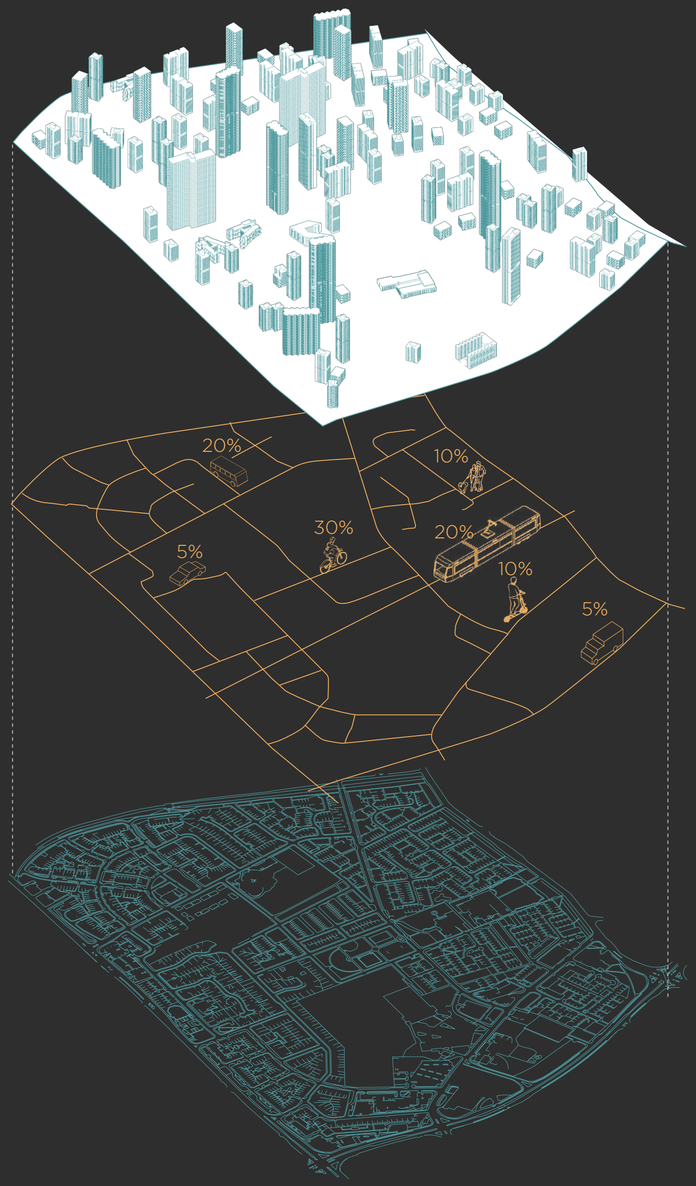


Population Density

Transport Mix



Urban Grid Size



Maximise Accessibility

Run Agent Simulation

Generate Urban Plan

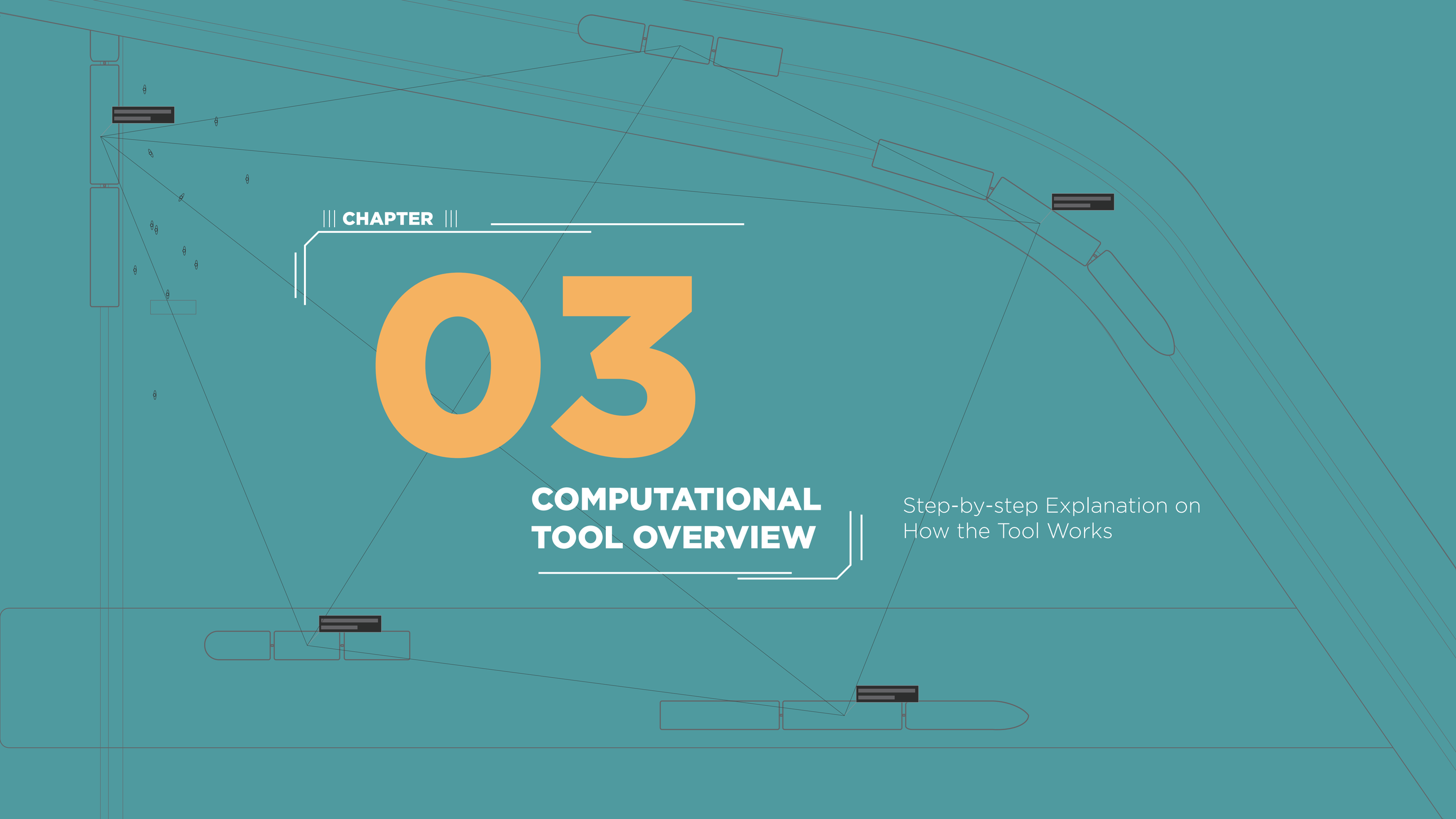
Accessibility Score

1000

Carbon Emissions

0032

gCO2/Year/Passenger



CHAPTER

03

COMPUTATIONAL TOOL OVERVIEW

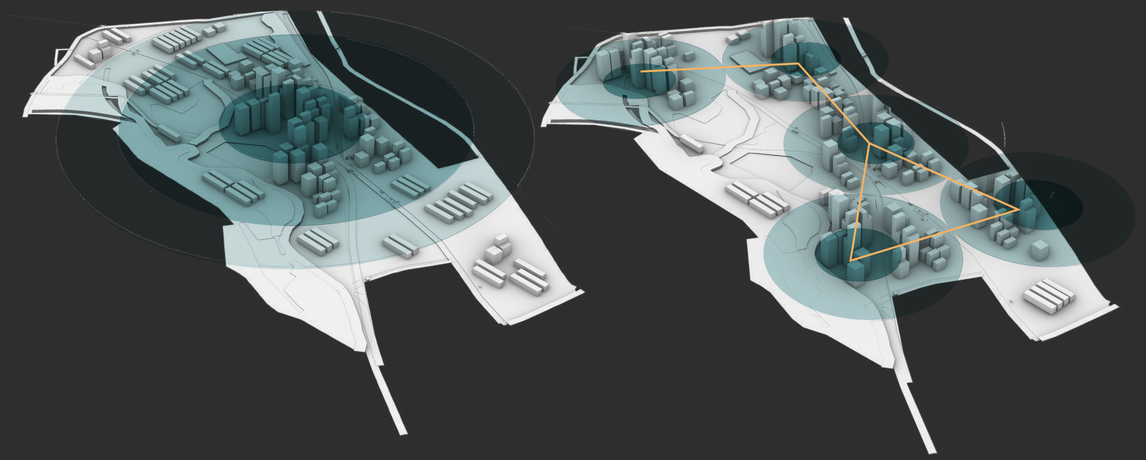
Step-by-step Explanation on
How the Tool Works

DESIGN TOOL AIMS

Generating & Analysing the Urban Generation

This chapter discusses the multi-layered strategic approach implemented in ST2 to address carbon emissions from motorised transport. By deciding the aims of the design tool, the appropriate approaches can be decided to achieve these aims.

GENERATION



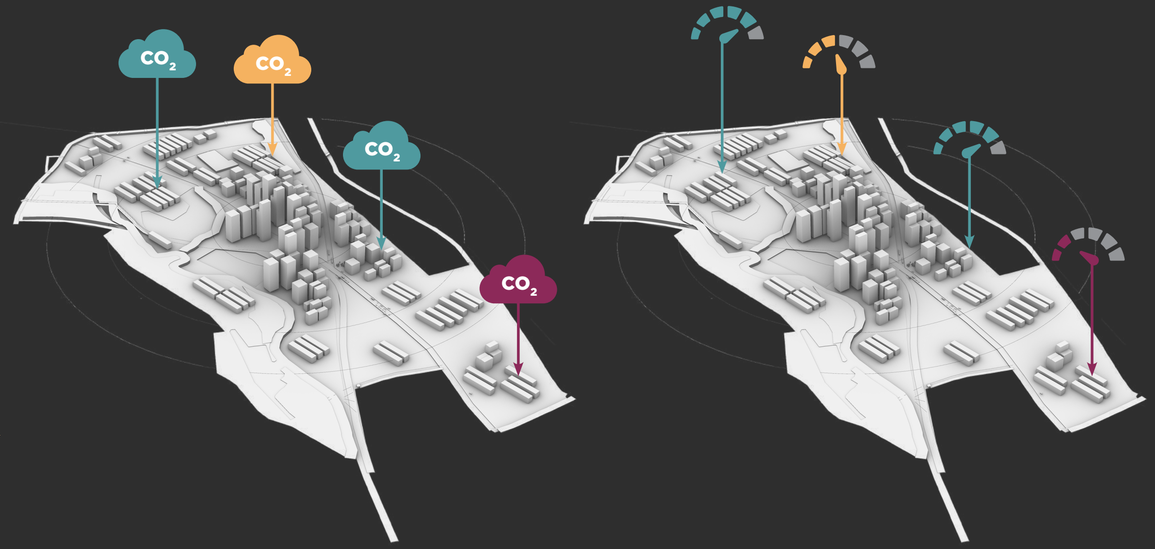
Generate High Accessibility Transport Zones

The aim in designing High Density Walkable Clusters based on the Transit Oriented Development concept is to reduce the reliance on private car use and increase the usage of public transports such as trams and buses.

Generate Accessible Neighbourhoods

Design highly walkable, cyclable, micromobility friendly neighbourhoods based on Pedestrian Oriented Development concept around secondary roads in relation to major developments that revolve around transport hubs.

ANALYSE



Analyse Carbon Emissions Levels

Analyse the use of various motorised transport modes for local access, on call services and private car uses. Households that do not have easy access to (appropriate mix of) amenities need to take public transport (i.e. buses or walkable amenities). Those with no direct public transport option will use private cars, and those with poor access to walkable facilities will use them.

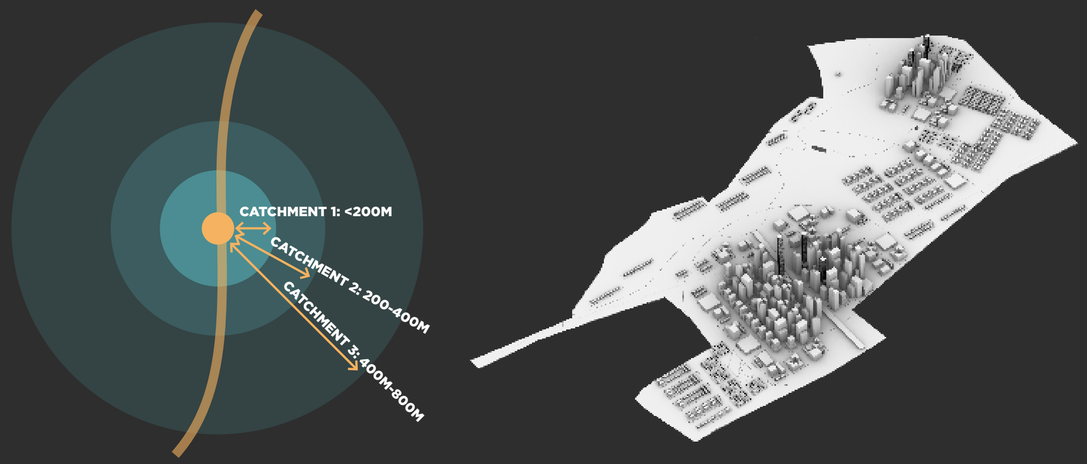
Analyse Accessibility Score

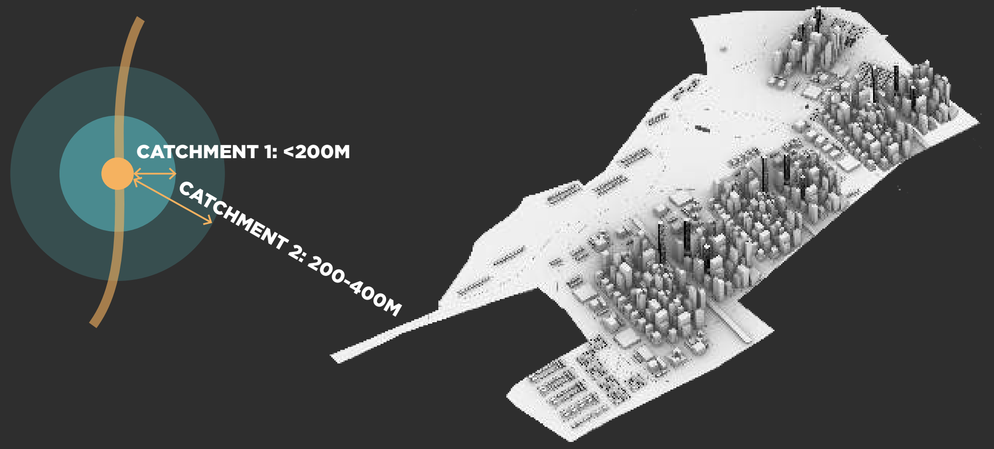
Emission score around movement & transport. A high accessibility score would mean the residents of Victoria North have easy access to amenities and public transport whereas a low accessibility score would mean the residents rely heavily on private motorised vehicles.

DIFFERENCES BETWEEN TWO URBAN STRATEGIES

Transit Oriented Development VS Pedestrian Oriented Development

Transit Oriented Development and Pedestrian Oriented Development are two neighbourhood strategies that are not too disimilair to each other. *While both neighbourhood strategies focus on accessibility to Transport Infrastructure, Pedestrian Oriented Development gives more emphasis Pedestrians.*





TRANSIT ORIENTED DEVELOPMENT (TOD)

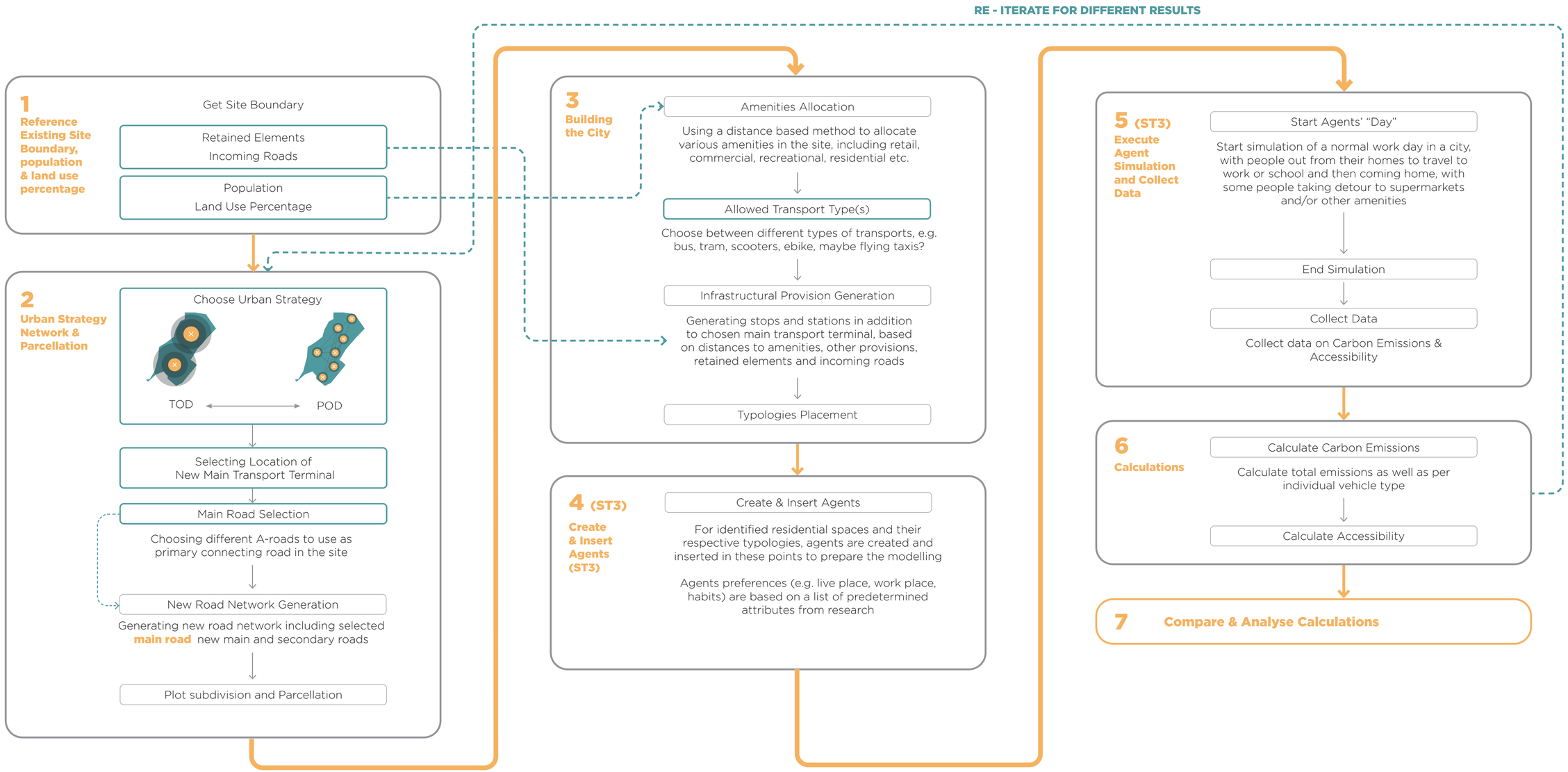
PEDESTRIAN ORIENTED DEVELOPMENT (POD)

	MAIN DIFFERENCES	
Lower frequency but higher density agglomerated at one point	Density & Frequency	Higher frequency but lower density, more “centres” scattered
Prioritise connectivity to public transport & Tram Dependant	Priority	Prioritise walkability & Bus Dependant
Moderate distance by walk, small distance by public transport	Distance to Amenities	Short Walking Distance
Promote walkability on street supported by public transport	Lowering Carbon Emission Strategies	Promote walkability primarily supported by active transport (bikes/ scooters)

PSEUDOCODE

Structure of the Computational Tool

The diagram below shows the pseudocode that outlines the process in scripting the computational design tool. Each step plays an important role in determining ways to design a city with high levels of connectivity and accessibility to discourage the use of private motorised vehicles.



DESIGN TOOL OVERVIEW

Stage 1 & 2

The expanded stages shows a more elaborated version of the work flow, with explanations, rationales and inputs from user explained. It also shows where does the work flow reiterate and from what stages and what inputs are required again.

STAGE 1 **Reference Existing Site Boundary & New Points of Interests**

Start

Reference Existing Site Boundary & New Points of Interest

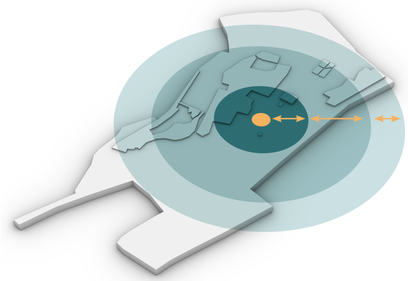
Get Site Boundary

Retained Elements
Incoming Roads & Transport
Point(s) of Interest

No. of Housing Units

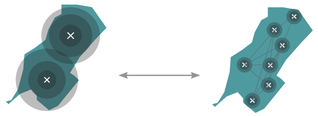
- Rivers
- Rail Lines
- Parks
- School
- Clinics
- Site Boundary

STAGE 2 **Urban Strategy Network & Parcellation**



Choose Urban Strategy

2 Urban Strategy Options



Transit Oriented Development

Pedestrian Oriented Development

The diagram above illustrates the Transit Oriented Development Option

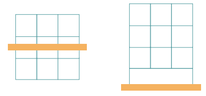
User Input of new Transit Node

Main Road Selection

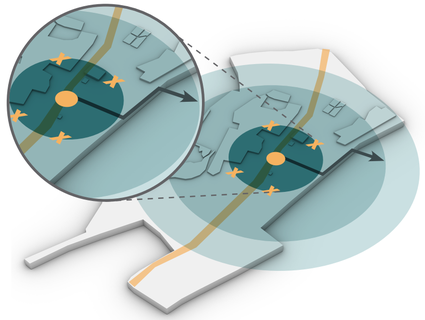
Choosing different A-roads to use as primary connecting road in the site. The diagram above shows the selection of Central as the main road.

User Selection between 5 choices

Network Parallel Intersect



Central Peripheral (Left/Right)



New Road Network Generation

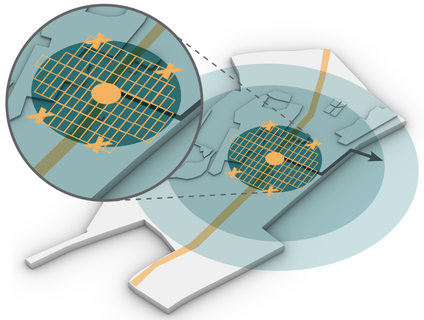
By locating existing roads that are incoming or located along the border, it allows the new roads to be created based on rules & logic listed below:

Single Roads

- Retain existing incoming & boundary roads as potential connection points
- Road connections cannot be between close proximity roads
- Road connections cannot cut through existing parks

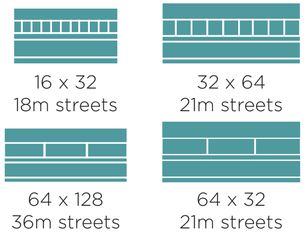
Multiple Roads

- Connections between main roads are prioritised over incoming roads
- Connections between main roads are prioritised + no cutting through parks
- Network placements will generate 3 road connections + all connections must be > 45 degrees



Plot subdivision and Parcellation

The plot sizes will be generated through circle packing and will differ depending on the location of the nodes within the neighbourhood catchments



16 x 32
18m streets

32 x 64
21m streets

64 x 128
36m streets

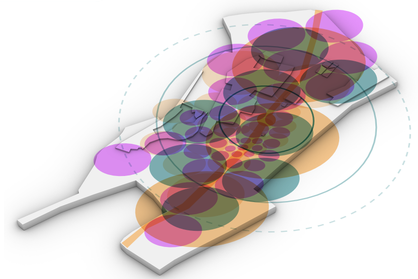
64 x 32
21m streets

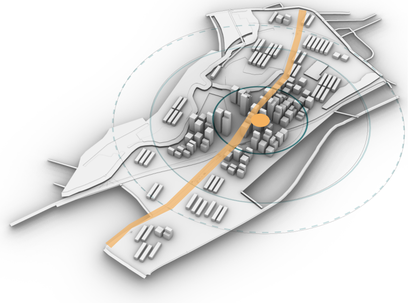
DESIGN TOOL OVERVIEW

Stage 3,4 & 5

The diagram below shows the evolution of city grids throughout different eras. These evolutions results in many benefits and criticisms, such as: financial cost, ecological features, rain water absorption, pollutant generation, social environment and security, pedestrian and bicycle movement, safety, reconstruction and development.

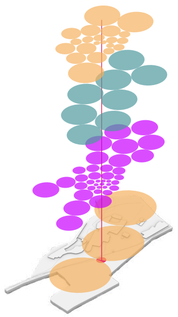
STAGE 3 Building the City



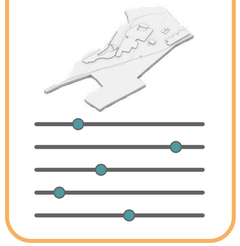


Land Use & Amenities Allocation

Different amenities have different demands, forming rules leading to their emergence at varying radii at different distances. The overlapping circles will form mixed-used typologies.



User Input Land Use Percentage



Infrastructural Provision Generation

Users would be able to choose different provision types to provide to observe the effect

User input allowed Transport Provision type

- Tram
- Minibus
- Bus
- Dockless
- e-Scooters
- Dockless e-Bike

Typologies Placement

Depending on its location on the different catchments of the neighbourhood, a typology will be assigned to each plot depending on set rules.

Types of Typologies:

- Low-rise Residential
- Mid-rise residential
- High Rise Residential
- Semi-detached House
- Terraced House
- Skyscrapers
- Low-rise Commercial
- Mid-rise Commercial
- High Rise Commercial
- Warehouse/Shed

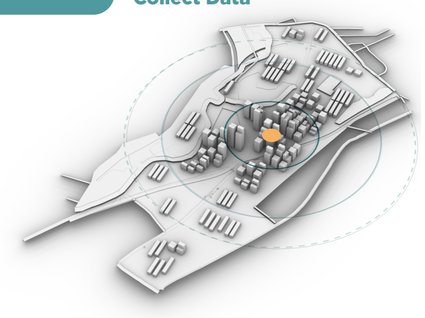
STAGE 4 Create & Insert Agents

Create & Insert Agents

For identified residential spaces and their respective typologies, agents are created and inserted in these points to prepare the modelling

Agents preferences (e.g. live place, work place, habits) are based on a list of predetermined attributes from research

STAGE 5 Execute Agent Simulation and Collect Data



Execute Agent Simulation and Collect Data

Start Agents' "Day"

Start simulation of a normal work day in a city, with people out from their homes to travel to work or school and then coming home, with some people taking detour to supermarkets and/or other amenities

↓

End Simulation

↓

Collect Data

Collect data on carbon emissions and connectivity

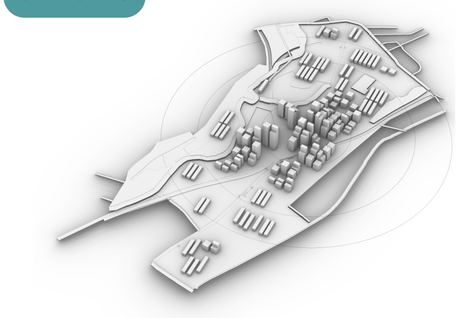
DESIGN TOOL OVERVIEW

Stage 6, Repeat Stage 2-6 & End

The diagram below shows the evolution of city grids throughout different eras. These evolutions results in many benefits and criticisms, such as: financial cost, ecological features, rain water absorption, pollutant generation, social environment and security, pedestrian and bicycle movement, safety, reconstruction and development.

RE-ITERATE STAGE 2-6 FOR DIFFERENT RESULTS

STAGE 6 Calculations



Calculations

- Calculate Carbon Emissions
- Calculate total emissions as well as per individual vehicle type
- Calculate Connectivity
- Compare and Analyse Emissions

STAGE 2

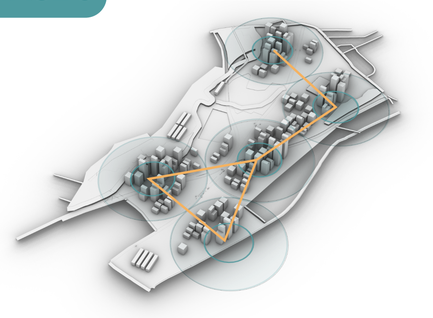
Urban Strategy Network & Parcellation

2 Urban Strategy Options

Transit Oriented Development | **Pedestrian Oriented Development**

- Selecting Location of Main Transport Terminal
- **User Input of new Transit Node**
- New Road Network Generation
- Plot subdivision and Parcellation

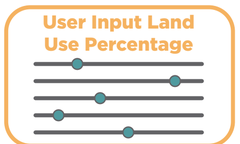
STAGE 3



Building the City

- Amenities Allocation

User Input Land Use Percentage



- **User input allowed Transport Provision type**
- Typologies Placement

STAGE 4,5,6

Create & Insert Agents, Execute Agent Simulation & Collect Data, Calculations

STAGE 4
- Create & Insert Agents

STAGE 5
- Start Agent's "Day"
- End Simulation
- Collect Data

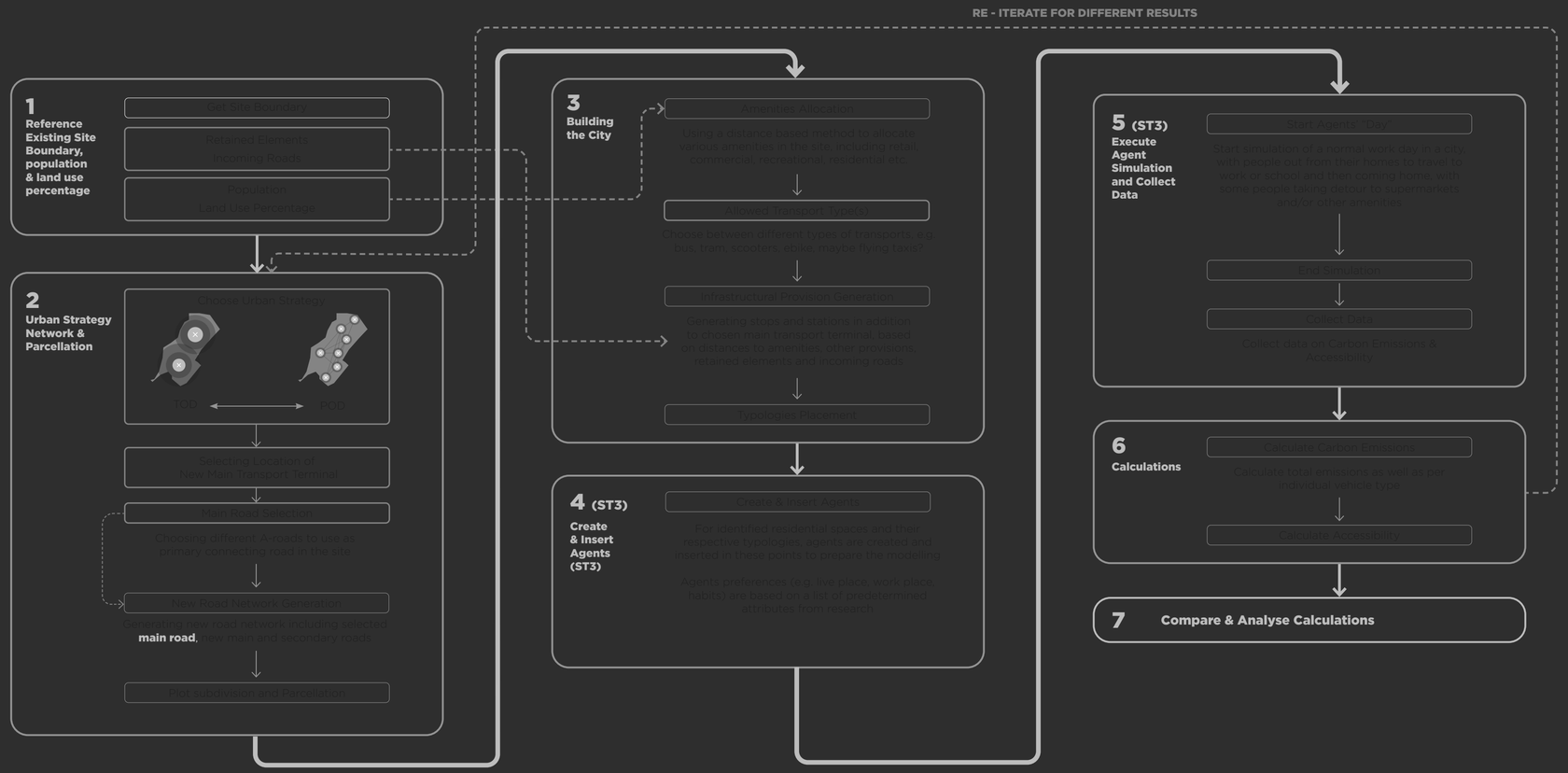
STAGE 6
- Calculate Carbon Emissions
- Calculate Connectivity

End

Iteration Comparison

STEP-BY-STEP EXPLANATION

Video of How the Tool Works

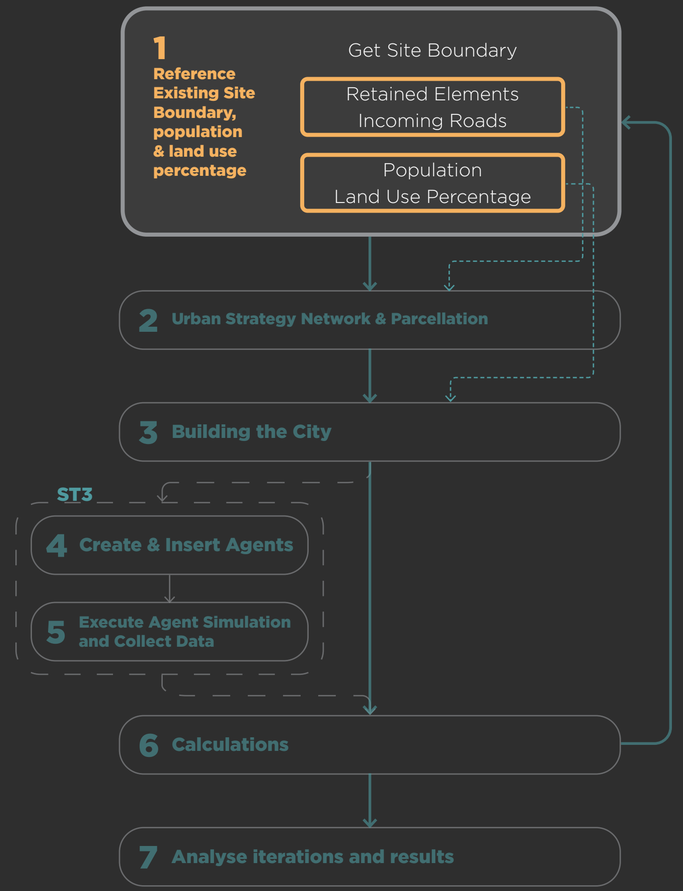


Click on the link below to watch the tool in action

https://www.youtube.com/watch?v=I6RCJ2ySIb8

STEP 1: REFERENCE EXISTING SITE BOUNDARY, POPULATION & LAND USE PERCENTAGE

Determining Exclusion Zones



TREATMENT OF SITE GEOMETRY

Determining Generation Zones

The diagram below shows how Victoria North is prepared before the generating the streets and further stages of the computational tool is implemented. Much of the road entrances and structure will be retained so its function will remain. The River Irk and much of the nearby green spaces will also be retained to support the proposal by MCC and FEC to support a social and community led neighbourhood.

All Static Elements

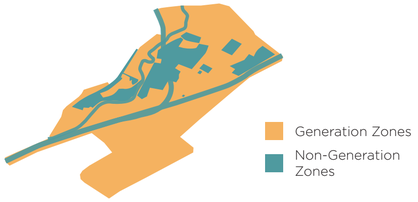
- River Irk
- Rail Lines
- Parks
- School
- Clinics
- Site Boundary
- Site Entrances
- Incoming Roads
- Population
- Land Use Percentage

Retained elements listed on the left, Incoming Roads, Population and Land Use Percentage are categorised as Static Elements. These will not be affected in the proposal as to remain its connectivity in and out of the city centre.

Treatment of Existing Green Spaces

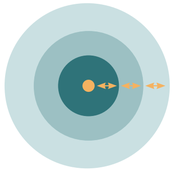
The green spaces will be retained as to upkeep the social infrastructure in the site. This will further be improved with a proposal of more green spaces in the generated neighbourhood later.

Generation and Non Generation Zones



By defining retained elements and incoming rioads, non generation zones and generation zones can be established. The proposed street generations will only be applied in the generation zones.

Starting Geometries for Design Tool



The map shows the generating zones, where you can choose the starting places for creating street layouts. These include the density zones, which serve as network generation boundaries depending on the strategy chosen. The primary highways divide the zones into'super-blocks,' which are subsequently subdivided by the block formation process.

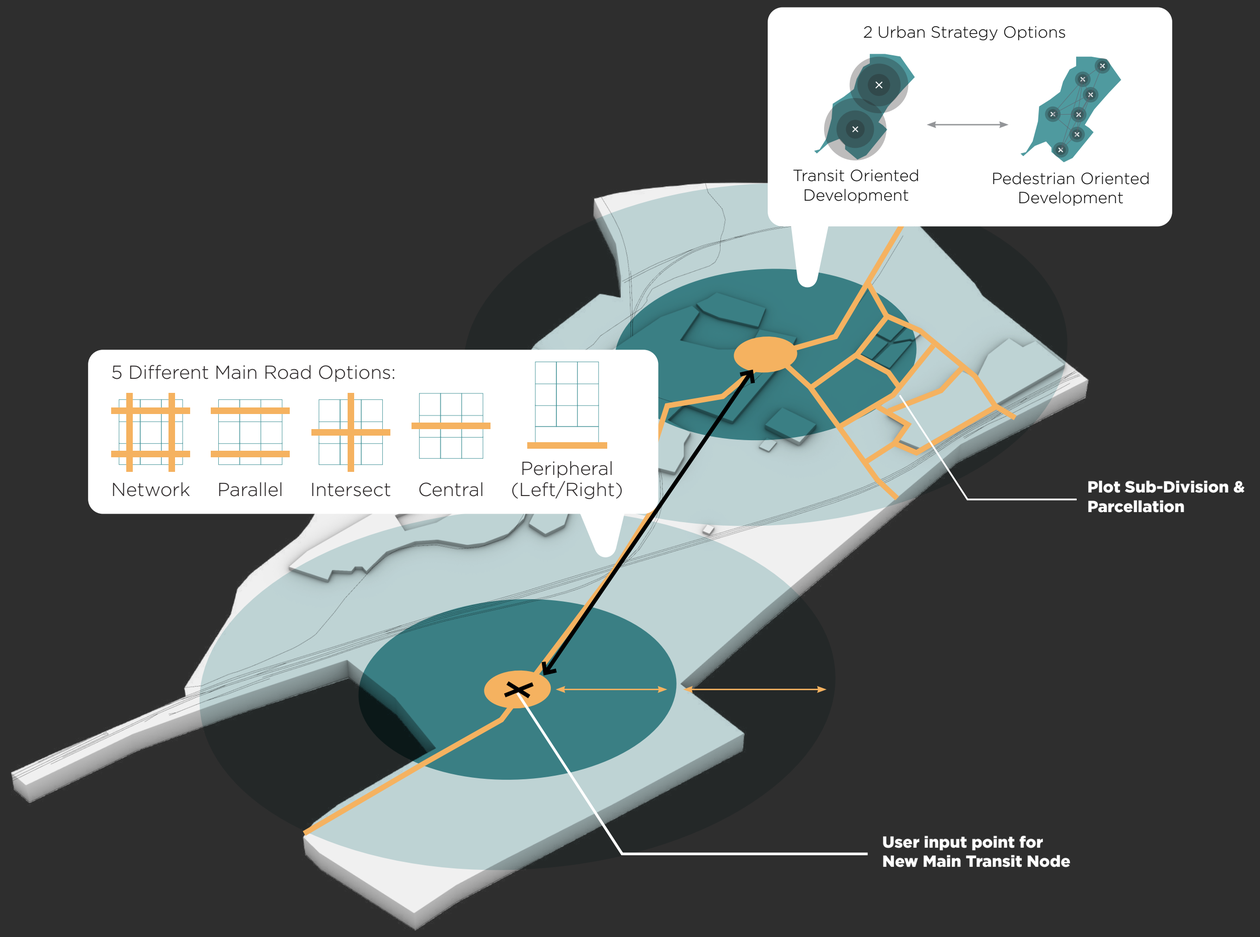
THESIS STATEMENT ///

How can the re-development of Victoria North be examined for accessibility and connectivity performance in order to test different strategies of achieving a carbon neutral mobility network.

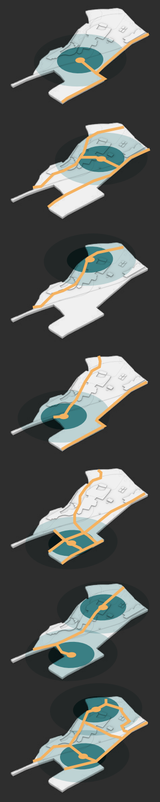
The Co-op Headquarters at NOMA
(Author, 2021)

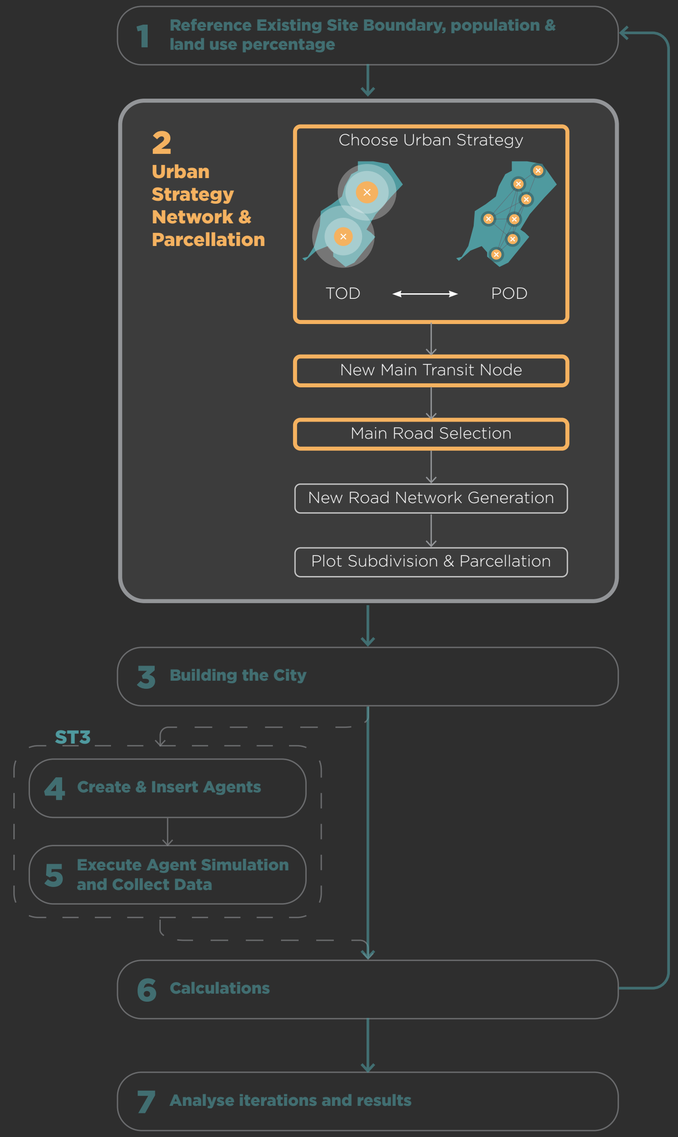
STEP 2: URBAN STRATEGY NETWORK & PARCELLATION

Placing Main Roads & Implementing Urban Strategies



Numerous possibilities based on user input point for transit node, urban strategy and main road choices





OVERCOMING COMPUTATIONAL CHALLENGES

Improving Plot Sizes & Increasing Successful Road Generations

This page outlines the obstacles when designing the computational design tool below. While the computational tool aims to generate urban layouts and analyse the carbon emission levels, Calculation for Accessibility may be affected due to the limitations listed below:

Inaccuracies

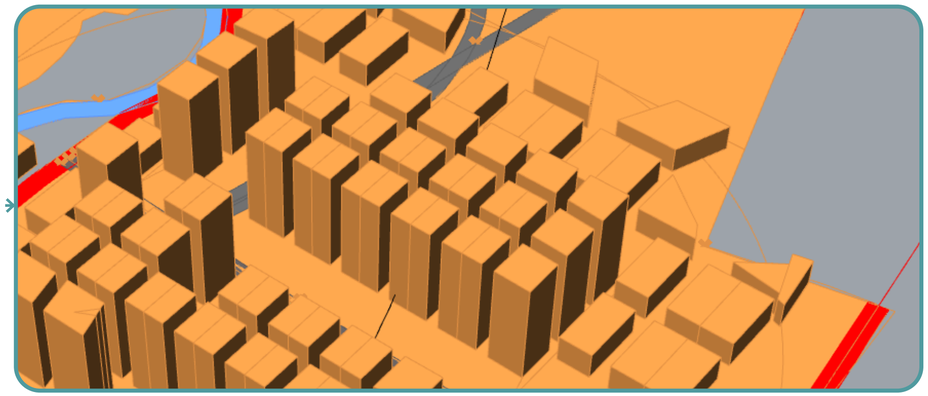
Plot Orientation

Plot orientation in the computational tool is set to be perpendicular to the road that connects the neighbourhood to main road. This means that the orientation of the plots are the same throughout the site, which does not reflect realistic plot orientations.

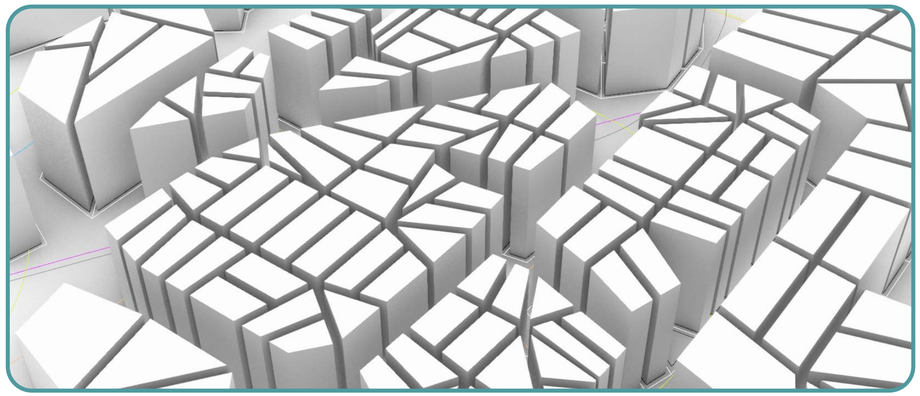
Number of Plots

The user input to generate the centre of the neighbourhood does not successfully connect the secondary road all areas of the site, even if it was within the boundaries of the Generation Zones.

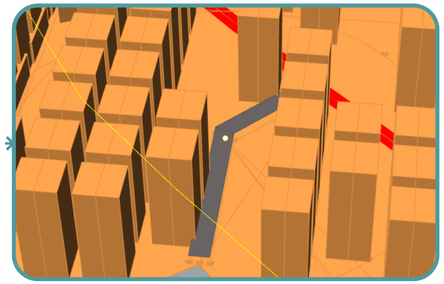
Computational Challenges



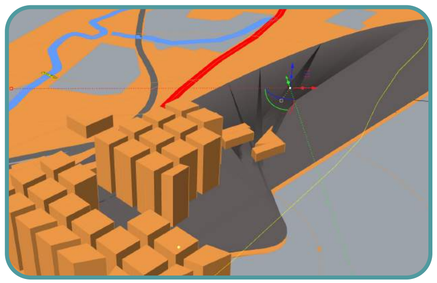
Improved Walkable Plot Sizes with Extrusions



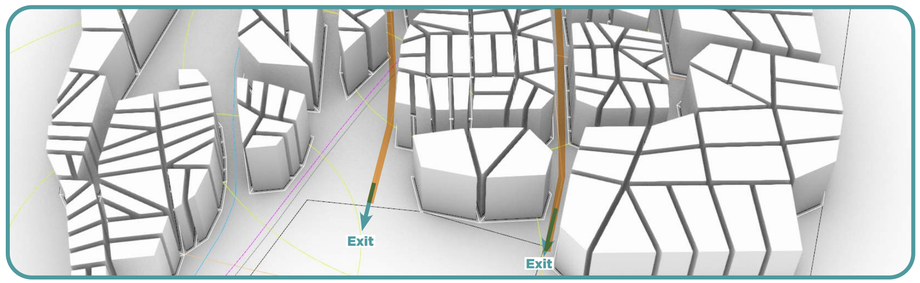
Successful Generated Connections from Main Roads to Site Exits



Unsuccessful Generated Connections from Main Roads to Site Exits



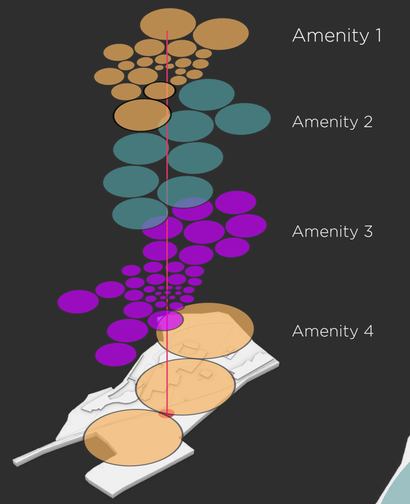
Successful Generated Connections from Main Roads to Site Exits



STEP 3: BUILDING THE CITY

Applying Circle Packing to Allocate Amenities

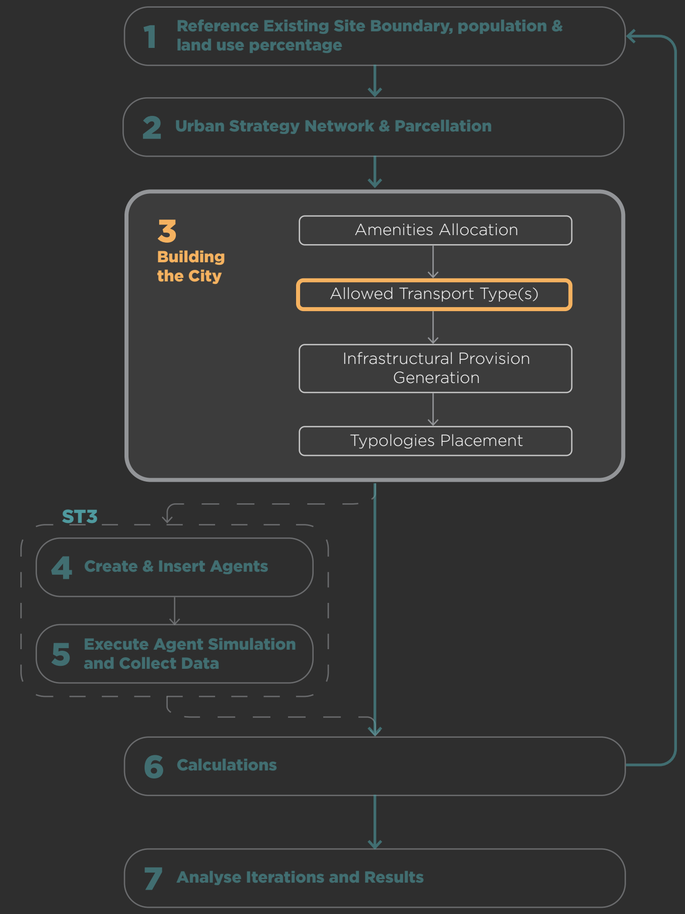
Amenities Allocation
Different amenity type have different demand, which lead to them emerging at different distances, simulating with rules that govern the generation of amenities allow the user to observe the effects



Types of Transport Provision to Select From:

- Tram
- Minibus
- Bus
- Dockless e-Scooters
- Dockless e-Bike
- Connected Automated Vehicles (CAV)

Users would be able to choose different provision types to provide to observe the effect

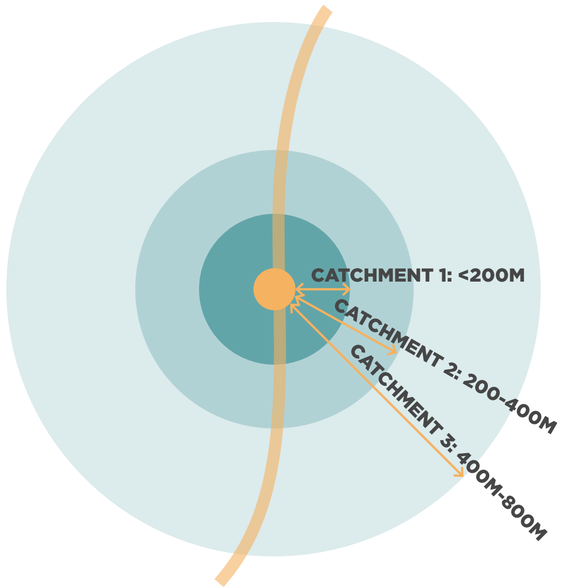


EMERGENCE OF AMENITIES

Proximity of Amenities Based on Demand and Agglomeration

Each amenity type signifies a different demand, which equals to different demand for them. For example, a restaurant might appear very often but a post office would be set up at much further distances. These rules are made for each type of amenity based on research of them.

URBAN STRATEGY: TOD
(TRANSIT ORIENTED DEVELOPMENT)

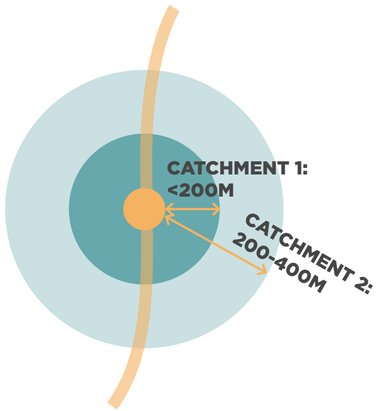


Transit Oriented development is justified to have 3 catchments, where the inner catchment is within walking distance to the transit node (i.e. transport terminal); the second catchment is 400m, which is the distance that people are willing to travel to a bus stop and 800m as the outer catchment is how far people are willing to travel for a tram station.

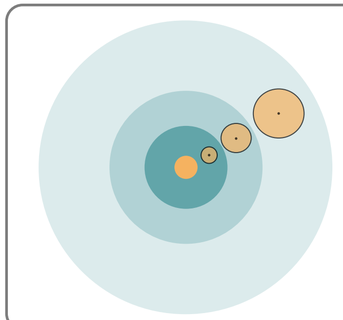
Distance willing to travel to use:

Bus Stops	**400m (5 minute walk)**
Tram Station	**800m (10 minute walk)**

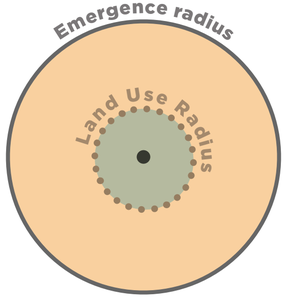
URBAN STRATEGY: POD
(PEDESTRIAN ORIENTED DEVELOPMENT)



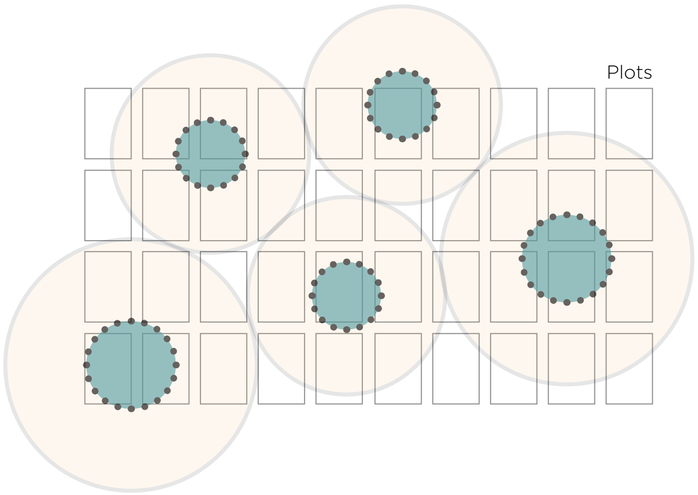
Pedestrian Oriented development compared to TOD is more compact and more pedestrian oriented. Comparing to time, a POD would be a 5-minute-city rather than a 15-minute city (TOD).



Each amenity has a different emergence radius based on their demand in different parts of the city, which results in changes or no changes in size of their circle in different catchments

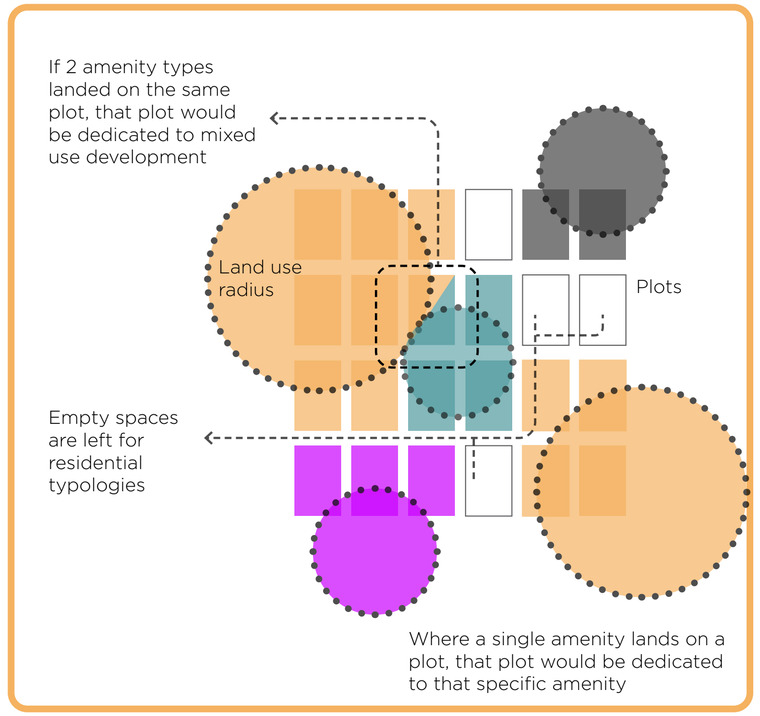


Every amenity each has both an emergence radius and a land use radius, while the emergence radius governs the distance between amenities, the land use circle governs the plots that an amenity will take



Amenities emerging on plots

A TYPICAL RESULT WILL LOOK LIKE THIS:



DISTANCE RULES OF AMENITIES EMERGENCE

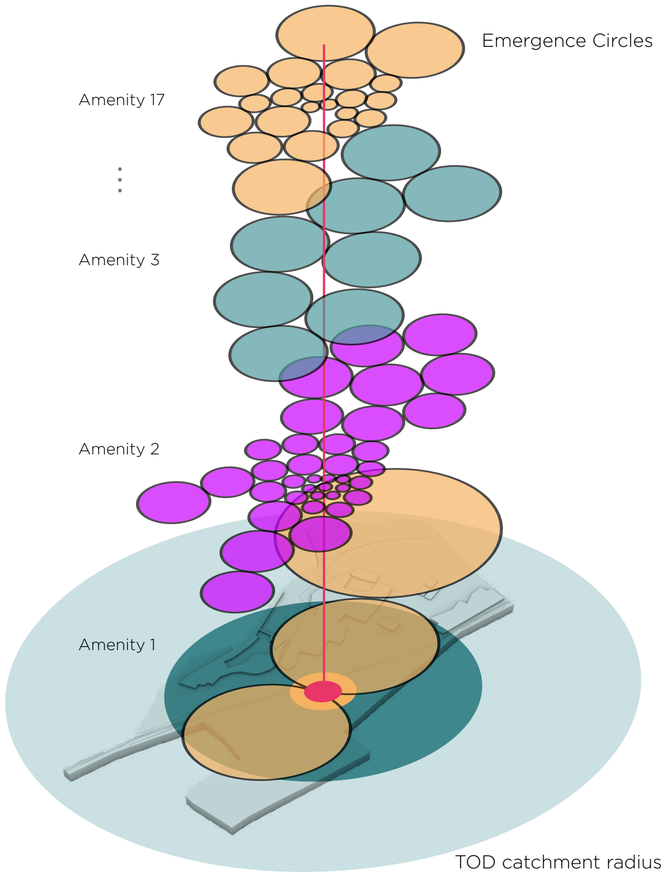
Distances for Different Types of Amenities Based on Research

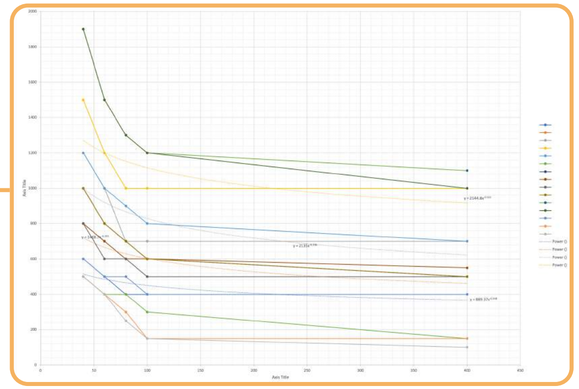
With detailed research distances are identified for each of the type of amenities, the diagram below show all the amenities identified to put into the site.

The emergence distances are from research that is based on different measurement of density in the unit of person per hectare acre (PPHA). An regression curve equation is obtained to implement these data into higher density areas in the site.

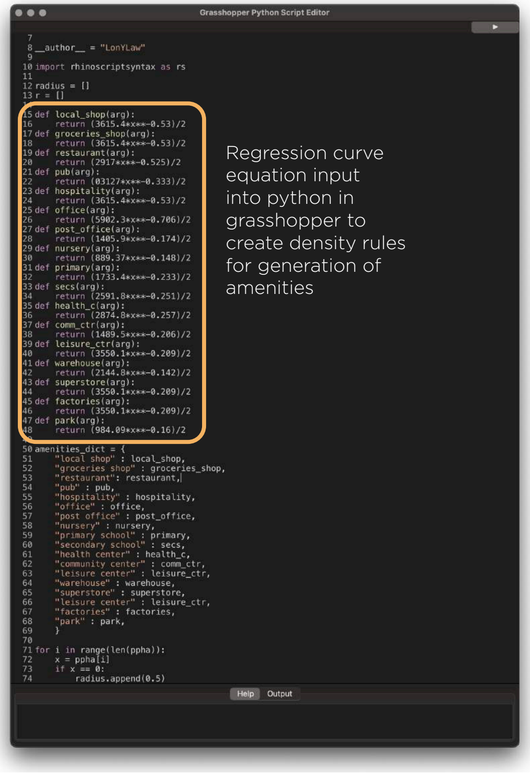
AMENITY TYPE	DISTANCES OF EMERGENCE		
	CATCHMENT 1	CATCHMENT 2	CATCHMENT 3
	EQUIVALENT PPHA: 100	EQUIVALENT PPHA: 80	EQUIVALENT PPHA: 60
COMMERCIAL			
LOCAL SHOP	300M	400M	400M
GROCERIES SHOP	300M	400M	400M
RESTAURANT	150M	300M	300M
PUB	500M	700M	800M
HOSPITALITY	300M	400M	400M
OFFICE	300M	400M	500M
SUPERSTORE	1200M	1300M	1500M
GOVERNMENTAL			
POST OFFICE	600M	600M	700M
INSTITUTIONAL			
NURSERY	400M	400M	500M
PRIMARY SCHOOL	500M	600M	700M
SECONDARY SCHOOL	700M	700M	1000M
HEALTH CENTRE	800M	900M	1000M
COMMUNITY			
LEISURE CENTRE	1200M	1300M	1500M
COMMUNITY CENTRE	500M	600M	600M
RESIDENTIAL			
INDUSTRIAL			
WAREHOUSE	600M	700M	800M
FACTORY	1500M	1900M	1900M
OPEN SPACE			
PARK	400M	500M	500M

HIGHER PPHA (PERSON PER HECTARE ACRE) ↑ = HIGHER DENSITY ↑ = LOWER EMERGENCE DISTANCE ↓ = MORE AMENITIES IN AN AREA





Plotting emergence distance against PPHA as hyperbola function to obtain regression curve equation

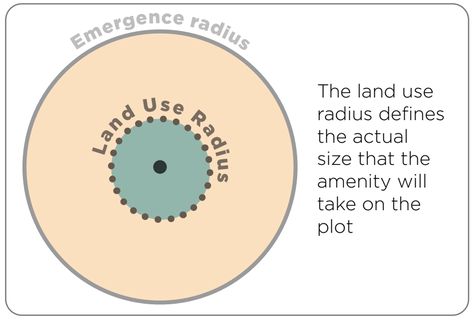


Regression curve equation input into python in grasshopper to create density rules for generation of amenities

LAND USE & AMENITY SIZE

Land Use Categories Percentage Affecting Amenity Size

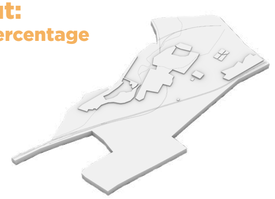
Land use percentage between different categories are defined by the user, which allow a high level view towards the goals that the user might have. Incorporating all amenity types possible in the site, there are 8 land use categories: Commercial, Governmental, Institutional, Community, Residential, Industrial, Country Park and Open space.



The land use radius defines the actual size that the amenity will take on the plot

User input:
Land Use Percentage

Total: 100%



Commercial

Governmental

Institutional

Community

Residential

Industrial

Country Park

Open space

Actual size of amenities are generated from:

User input:
Population

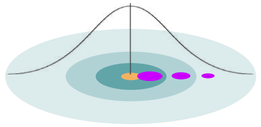
Population ÷ 6
(6 desirable land use type excluding industrial and open space)

Number of amenities circles to place on site

Number of circles X **Land use percentage**
To obtain amount of circles per amenity

Total catchment area ÷ Land use percentage ÷ Number of circles
To obtain base line size for each amenity circle in each type

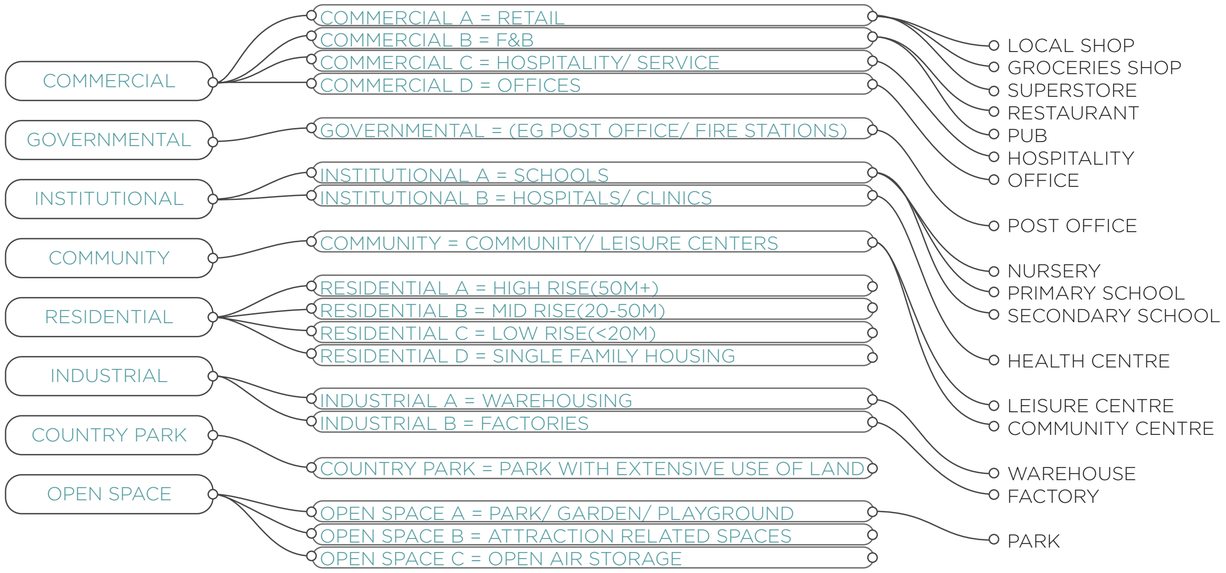
Redistribution of baseline size based on distance to centre
Unique rule for each amenity, some might becomes larger towards the centre and some becomes smaller



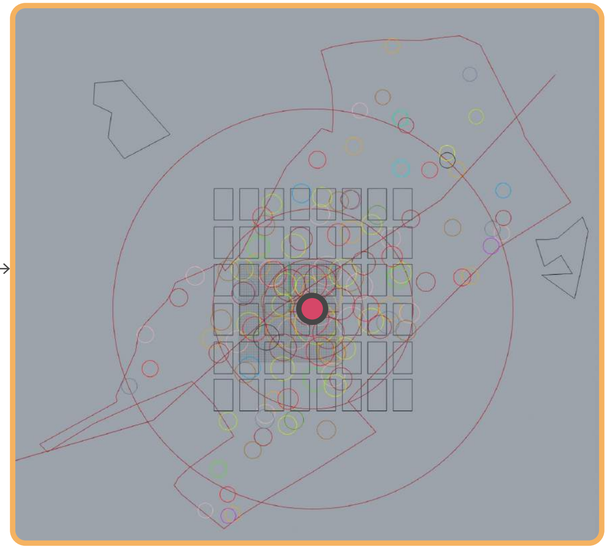
Get amenity on plot circle

User defined transit node point

The 8 land use categories extends into different sub type that encompass all the amenities that will be placed in the site



Initial testing



In progress generation on actual site and plots

A BUS STOP HERE... TRAM STOP THERE...

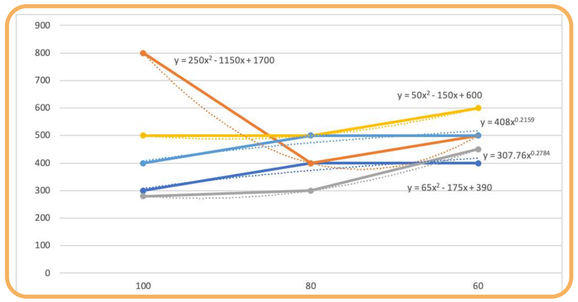
Infrastructural Provisions Generation

After the site is populated with amenities, the creates demand for accessing these amenities and a good public transport system is an important medium to increase the value of an amenity / plot as well as being able to lower carbon emissions through less people driving in private cars.

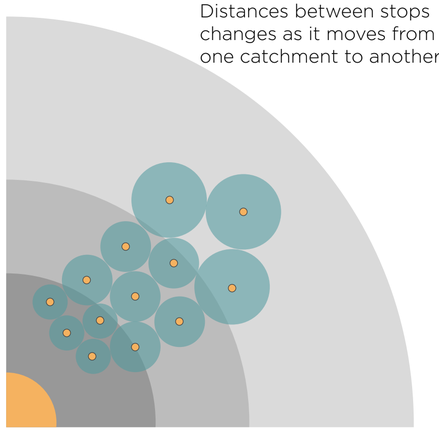
Based on the same principles as amenities circle packing, the distribution of transport stops also varies its distances, with less distance between each bus stops in the inner catchments and increasing distance as it goes outwards.

TRANSPORT TYPE	DISTANCES OF GENERATION		
	CATCHMENT 1	CATCHMENT 2	CATCHMENT 3
	EQUIVALENT PPHA: 100	EQUIVALENT PPHA: 80	EQUIVALENT PPHA: 60
BUS STOPS	300	400	400
TRAM STOPS	800	400	500
MINIBUS STOPS	280	300	450
DOCKED BICYCLE STATION	500	500	600
DOCKED SCOOTER STATION	400	500	500

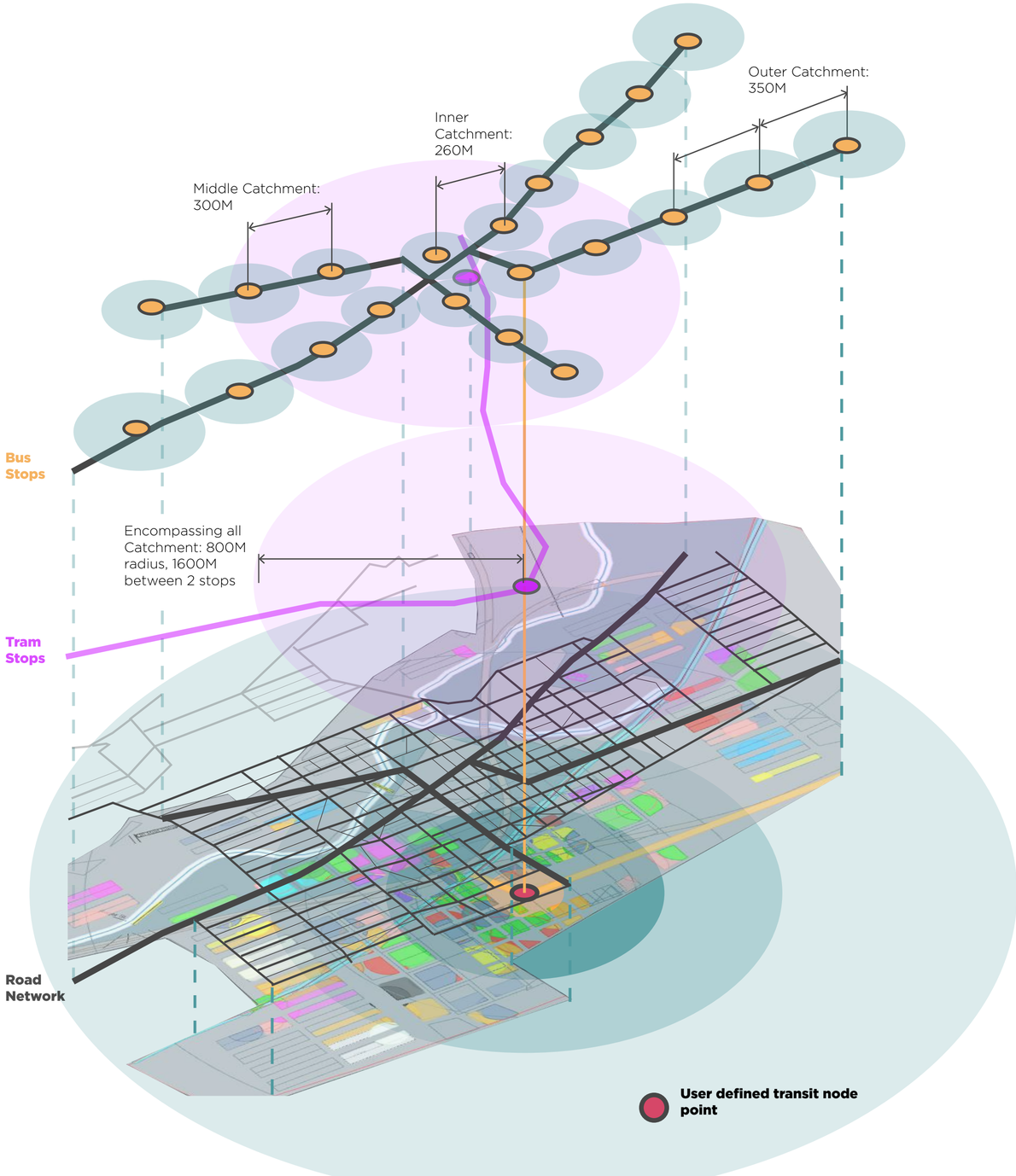
Same as plotting emergence distance against PPHA, the transport generation distances from research are plotted as hyperbola function to obtain regression curve equation



Distances between stops changes as it moves from one catchment to another



Transit Node Centre

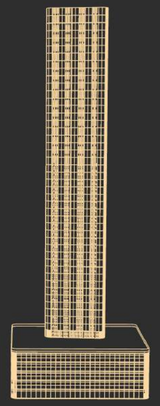


ATELIER TYPOLOGY LIBRARY

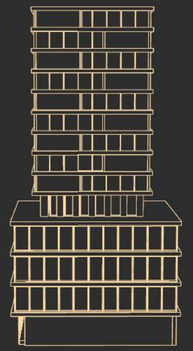
Introduction, Overview & Usage

In order to build a library of typologies of typical buildings found in a city to test different combinations in the site, the entire atelier divided all typologies and each student group would build a single type and they would feed into a larger repository for use in S2. In order to be able to adapt to different testing, the typological models were designed to be able to parametrically respond to different plots and site conditions based on different typologies.

This repository would then be used in each group's city generation in order to aid in their specific thesis questions with relation to building zero carbon cities

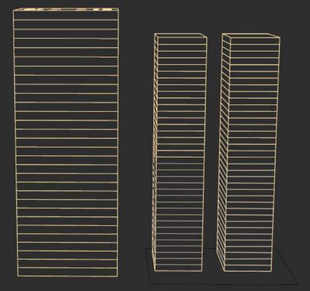


Skyscraper

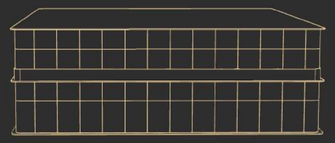


Mid Rise Commercial/
Residential

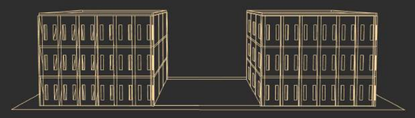
Our Group's



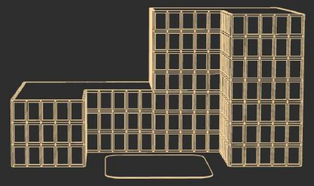
High Rise Commercial/
Residential



Low Rise

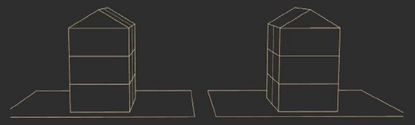


High Density, Low Rise

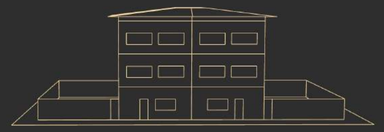


Perimeter Block

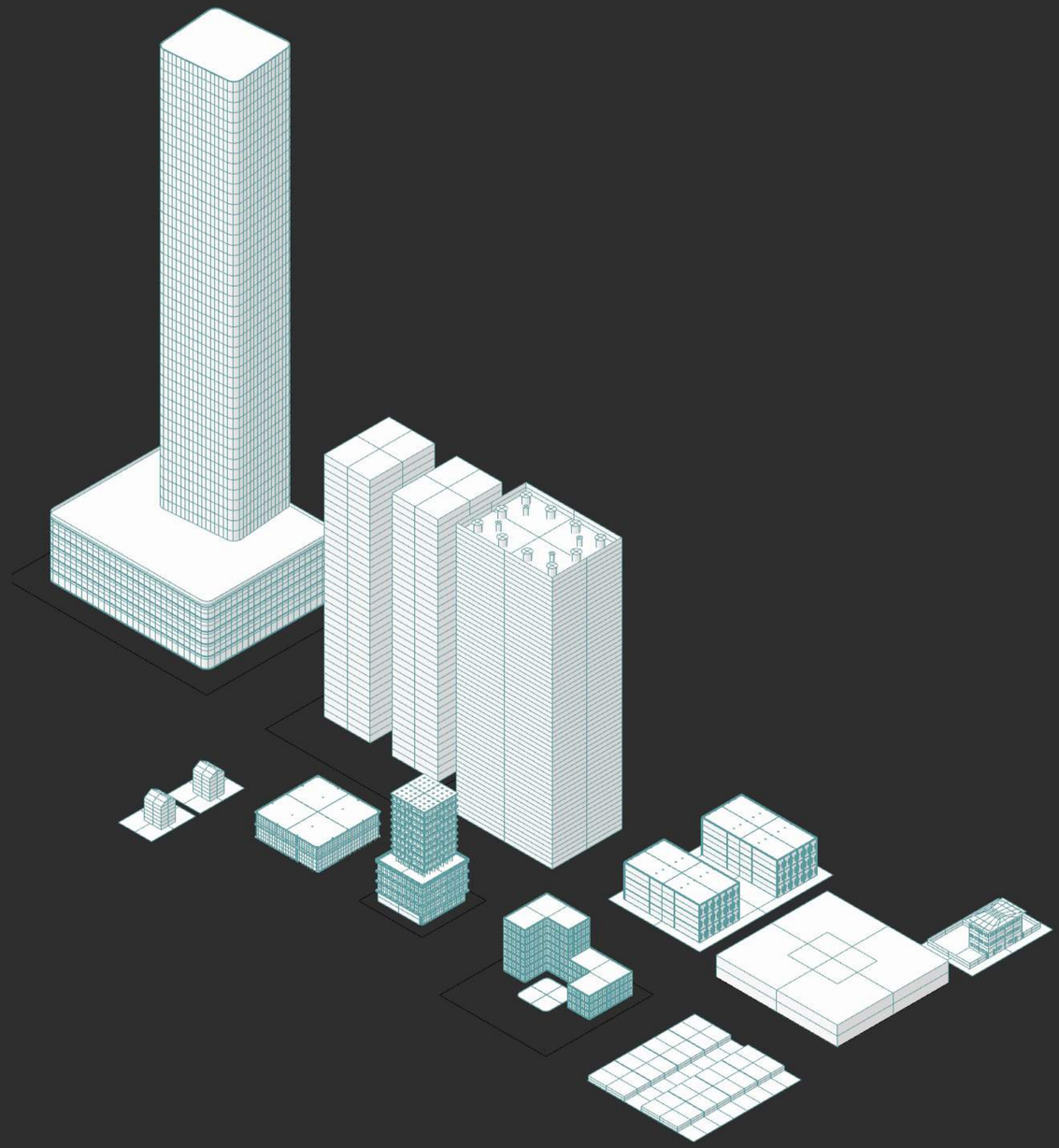
Warehouse



Detached Houses



Semi-Detached House

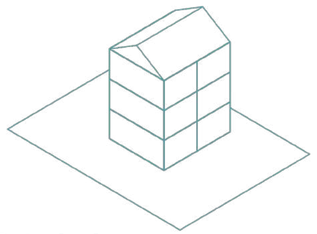


TYPOLOGY REPOSITORY

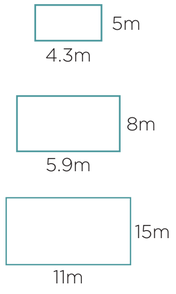
Depth & Width Threshold

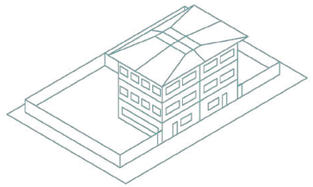
In this page, we have an overview on the different depth and width threshhold of all the typologies within the atelier repository.

This will help in determining which catchment and plot size is best suited for certain typology buildings.

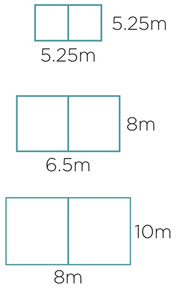


Detached Houses

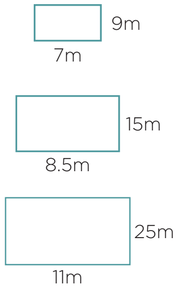


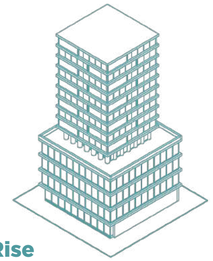


Semi- Detached Houses

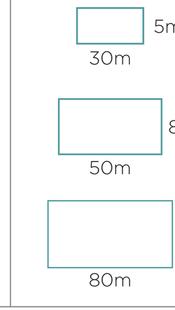


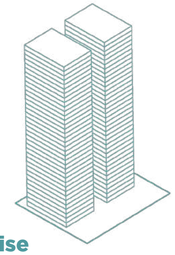
Low Rise Residential



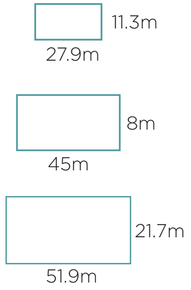


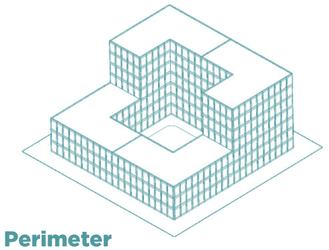
Mid Rise Residential



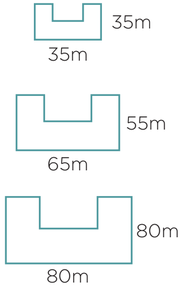


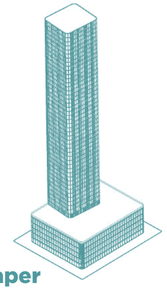
High Rise Residential



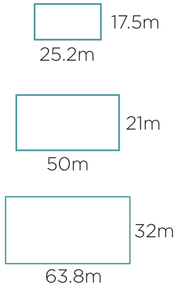


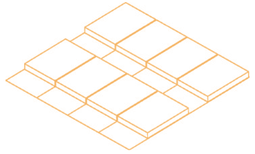
Perimeter Block



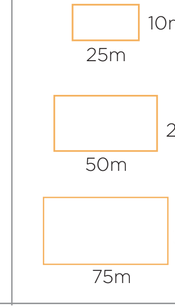


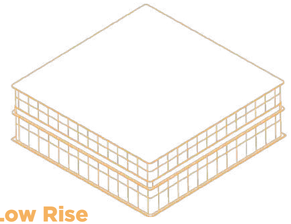
Skyscraper



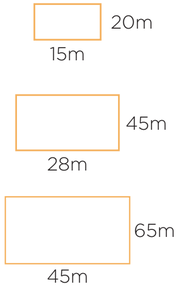


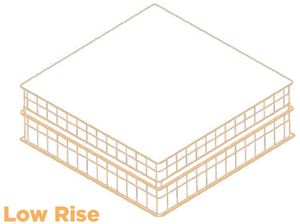
Warehouse



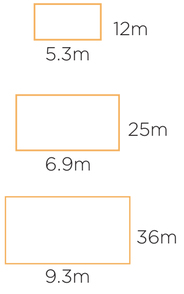


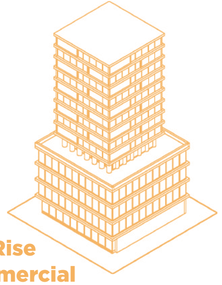
Low Rise Commercial



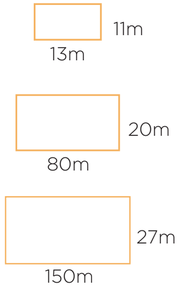


Low Rise Retail

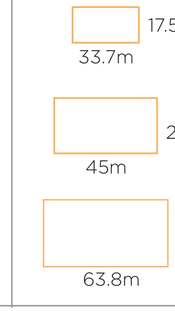




Mid Rise Commercial



High Rise Commercial

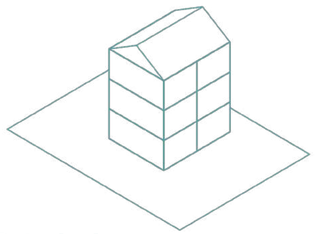


TYPOLOGY REPOSITORY

Height Threshold

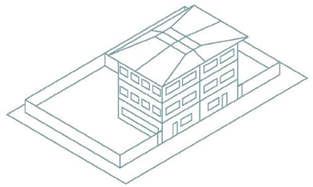
In this page, we have an overview on the height and number of storeys threshhold of all the typologies within the atelier repository.

This will help in determining which catchment and plot size is best suited for certain typology buildings.



Detached Houses

3.1m 1 Storey
7m 2 Storeys
15m 4 Storeys

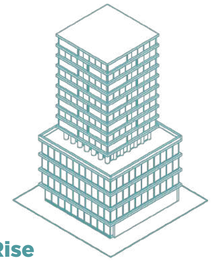


Semi- Detached Houses

7m 2 Storeys
10m 3 Storeys
13m 4 Storeys

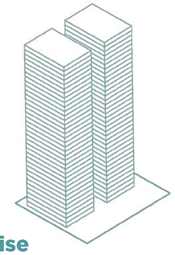
Low Rise Residential

8m 3 Storeys
11.5m 4 Storeys
15m 5 Storeys



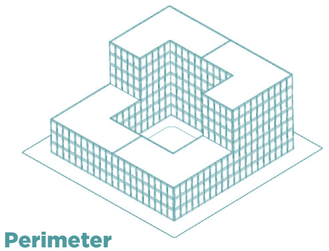
Mid Rise Residential

15m 5 Storeys
30m 10 Storeys
45m 14 Storeys



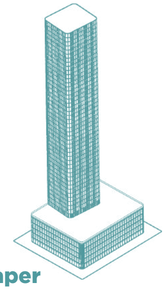
High Rise Residential

36.8m 15 Storeys
72.8m 26 Storeys
95m 40 Storeys



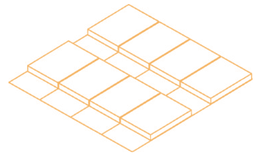
Perimeter Block

13m 5 Storeys
30m 10 Storeys
45m 15 Storeys



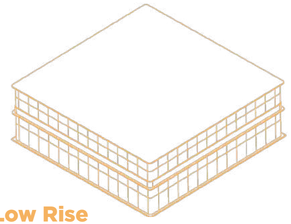
Skyscraper

150m 40 Storeys
163m 47 Storeys
201m 65 Storeys



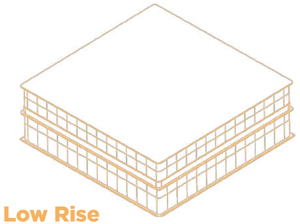
Warehouse

8m 1 Storey
10m 1 Storey
12m 1 Storey



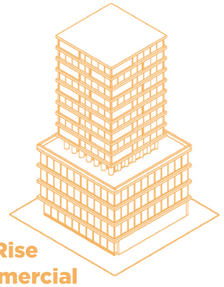
Low Rise Commercial

5m 1 Storeys
12m 2 Storeys
16m 4 Storeys



Low Rise Retail

3.1m 2 Storeys
7m 3 Storeys
15m 4 Storeys



Mid Rise Commercial

18m 5 Storeys
38m 10 Storeys
56m 14 Storeys

High Rise Commercial

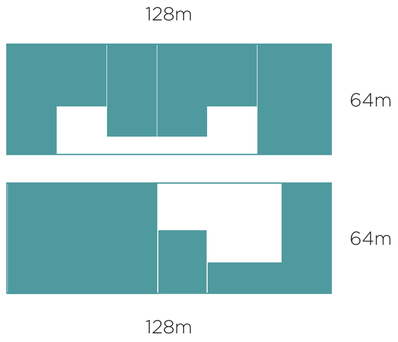
54.5m 15 Storeys
74.1m 26 Storeys
95m 40 Storeys

PLOT SUBDIVISION

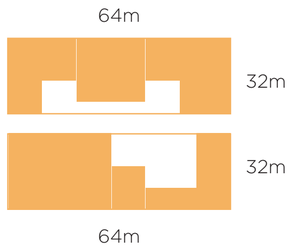
Plot Sizes in Different Catchments

In this page, we look at how the land plot sizes changes in the different catchment areas. Utilising information about the most walkable plot sizes, we will implement the different sizes in their respective catchments. With the smallest plots in the densest centre, and slowly radiates into larger plots as we move towards the outermost catchments.

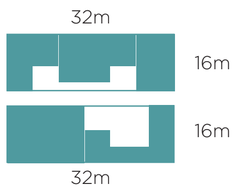
A plot is not indicative of a building block, and there can be multiple building blocks within a plot.



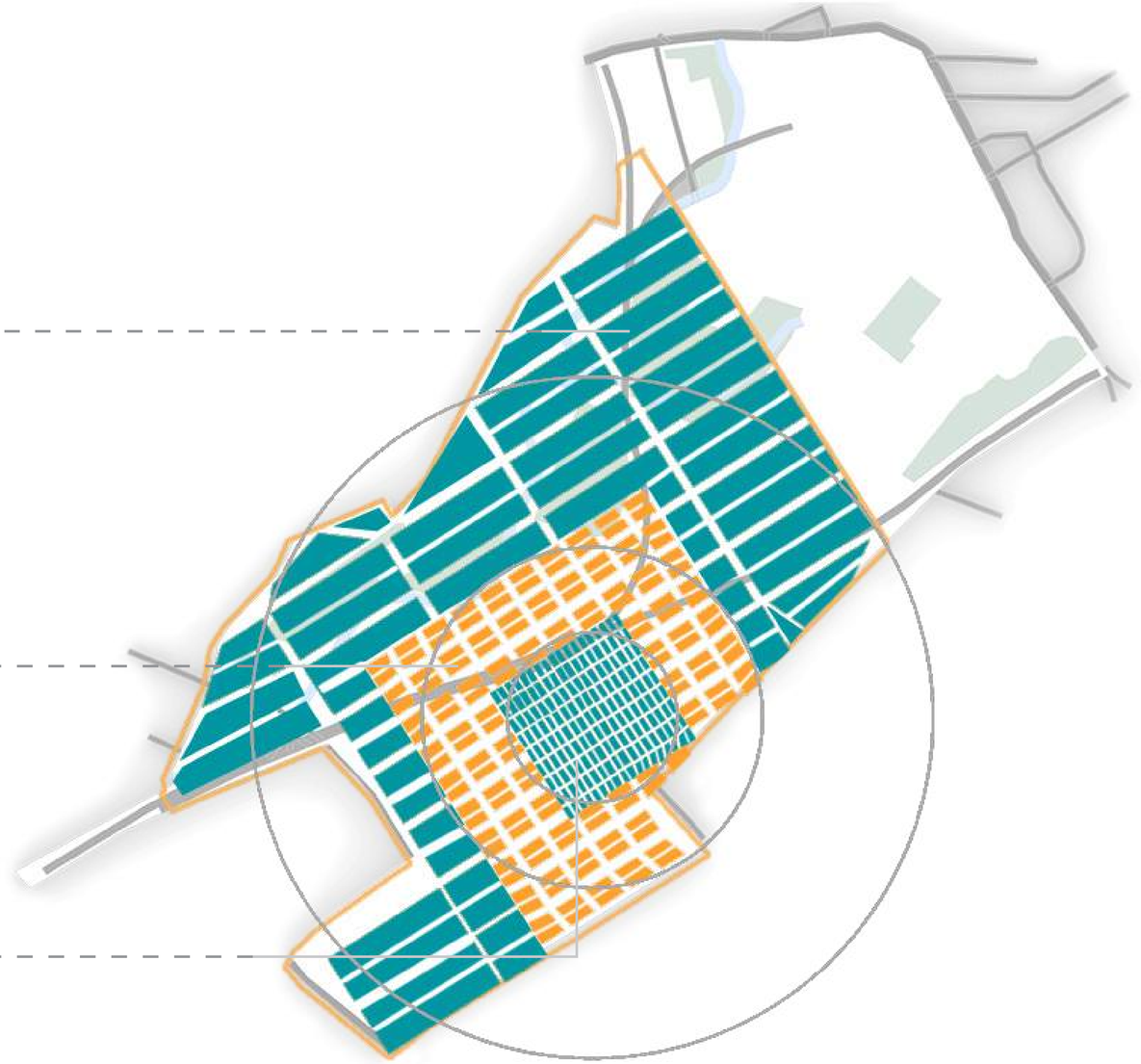
Outer Catchment



Medium Catchment



Inner Catchment



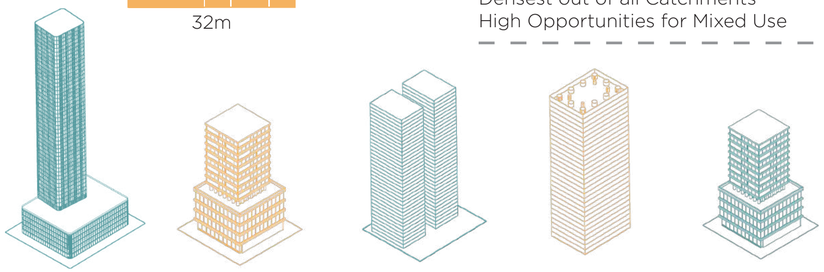
TYPOLOGY APPLICATION

Strategies for Incorporating Typology into City Generation

Not all typologies are created equally. Some are more suited for the different conditions inherent in the different catchment areas In this page we look at where certain typologies are prioritised to a plot in a specific catchment area.

Inner Catchment

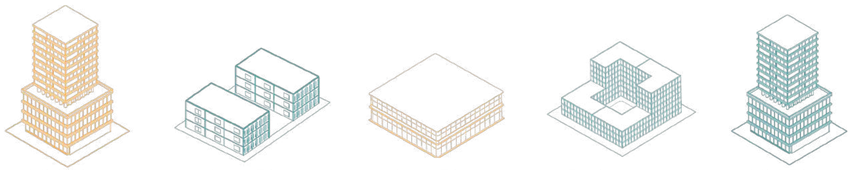
Smallest Plot Size
Densest out of all Catchments
High Opportunities for Mixed Use



Skyscraper + Mixed Use Podium
Mid Rise Commercial
High Rise Residential
High Rise Commercial
Mid Rise Residential

Medium Catchment

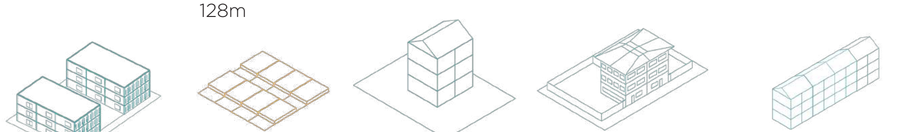
Medium Plot Size
Second Densest out of all Catchments
Some Opportunities for Mixed Use



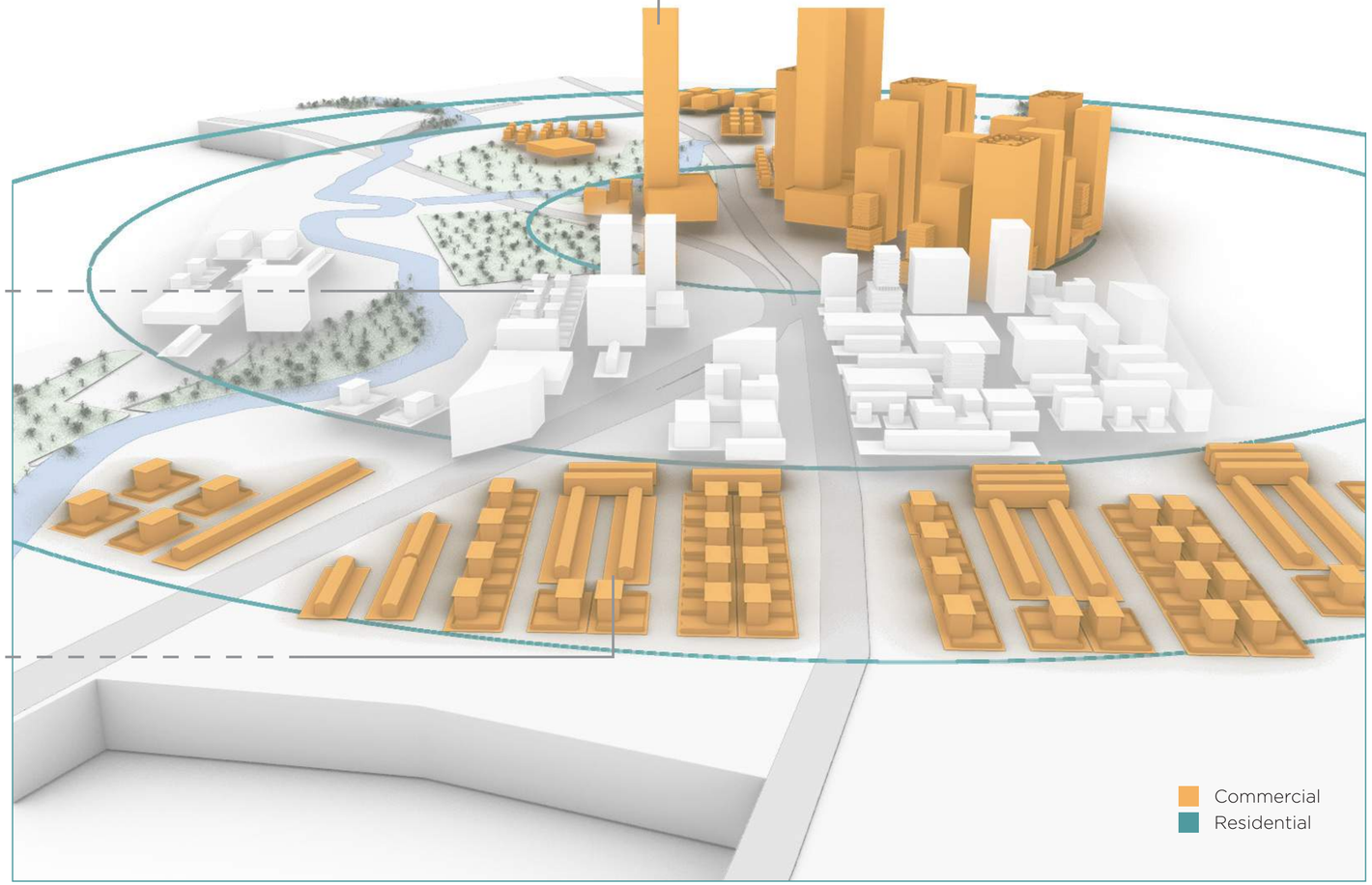
Mid Rise Commercial
Low Rise Residential
Low Rise Commercial/Retail
Perimeter Blocks
Mid Rise Residential

Outer Catchment

Largest Plot Size
Least Densest out of all Catchments
Limited Opportunities for Mixed Use



Low Rise Residential
Warehouses
Detached Houses
Semi Detached Houses
Terrace Houses



“When planning for sustainable travel it is essential to include perceptions... as people’s experiences of accessibility with different travel modes are likely to affect their modal choice”

(Lättman, 2020)

Angel Meadow Park
(Author, 2021)

TYPOLOGY RULES

Transit Oriented Development

Not all typologies are created equally. Some are more suited for the different conditions inherent in the different catchment areas In this page we look at where certain typologies are prioritised to a plot in a specific catchment area.

	Local Shops	Grocery Shops	Restaurant	Pub	Hospitality	Office	Health Centre	Warehouse
Local Shops	Mid-rise	Mid-rise	Mid-rise	Mid-rise	High-rise	High-rise	Mid-rise	Perimeter Block
	Low-rise	Low-rise	Low-rise	Low-rise	Low-rise	Low-rise	Mid-rise	Perimeter Block
	Low-rise	Low-rise	Low-rise	Low-rise	Low-rise	Low-rise	Perimeter Block	Perimeter Block
Grocery Shops	Mid-rise	Perimeter Block	Perimeter Block	Mid-rise	Mid-rise	High-rise	Mid-rise	Perimeter Block
	Low-rise	Perimeter Block	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Perimeter Block
	Low-rise	Perimeter Block	Perimeter Block	Low-rise	Low-rise	Warehouse/ Car Park	Perimeter Block	Warehouse/ Car Park
Restaurant	Mid-rise	Perimeter Block	Mid-rise	Mid-rise	Mid-rise	High-rise	Mid-rise	Perimeter Block
	Low-rise	Mid-rise	Low-rise	Mid-rise	Mid-rise	Low-rise	Mid-rise	Perimeter Block
	Low-rise	Perimeter Block	Low-rise	Low-rise	Low-rise	Perimeter Block	Perimeter Block	Perimeter Block
Pub	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	High-rise	Mid-rise	Perimeter Block
	Low-rise	Mid-rise	Mid-rise	Mid-rise	Low-rise	Mid-rise	Low-rise	Perimeter Block
	Low-rise	Low-rise	Low-rise	Low-rise	Warehouse/ Car Park	Low-Rise	Low-Rise	Low-Rise
Hospitality	High-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Perimeter Block
	Low-rise	Mid-rise	Mid-rise	Low-rise	Mid-rise	Mid-rise	Mid-rise	Perimeter Block
	Low-rise	Low-rise	Low-rise	Warehouse/ Car Park	Low-rise	Low-Rise	Perimeter Block	Low-Rise
Office	High-rise	High-rise	High-rise	High-rise	Mid-rise	Warehouse/ Car Park	Mid-rise	Warehouse/ Car Park
	Low-rise	Mid-rise	Low-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Warehouse/ Car Park
	Low-rise	Warehouse/ Car Park	Perimeter Block	Low-rise	Low-rise	Low-rise	Perimeter Block	Warehouse/ Car Park
Health Centre	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	High-rise	Perimeter Block
	Mid-rise	Mid-rise	Mid-rise	Low-rise	Mid-rise	Mid-rise	Mid-rise	Perimeter Block
	Perimeter Block	Perimeter Block	Perimeter Block	Low-rise	Perimeter Block	Perimeter Block	Perimeter Block	Perimeter Block
Warehouse	Perimeter Block	Perimeter Block	Perimeter Block	Perimeter Block	Perimeter Block	Warehouse/ Car Park	Perimeter Block	Warehouse/ Car Park
	Perimeter Block	Perimeter Block	Perimeter Block	Perimeter Block	Perimeter Block	Warehouse/ Car Park	Perimeter Block	Warehouse/ Car Park
	Perimeter Block	Warehouse/ Car Park	Perimeter Block	Low-Rise	Low-Rise	Warehouse/ Car Park	Perimeter Block	Warehouse/ Car Park

TYPOLOGY RULES

Pedestrian Oriented Development

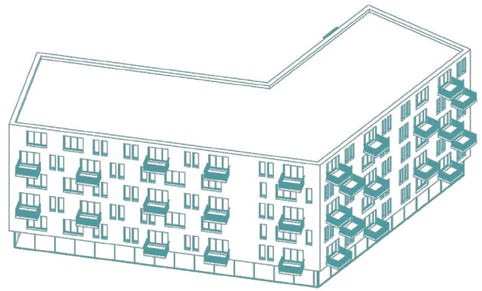
Not all typologies are created equally. Some are more suited for the different conditions inherent in the different catchment areas In this page we look at where certain typologies are prioritised to a plot in a specific catchment area.

	Local Shops	Grocery Shops	Restaurant	Pub	Hospitality	Office	Health Centre	Warehouse
Local Shops	Mid-rise	Mid-rise	Mid-rise	Mid-rise	High-rise	High-rise	Mid-rise	Perimeter Block
	Low-rise	Low-rise	Low-rise	Low-rise	Low-rise	Low-rise	Mid-rise	Perimeter Block
Grocery Shops	Mid-rise	Perimeter Block	Perimeter Block	Mid-rise	Mid-rise	High-rise	Mid-rise	Perimeter Block
	Low-rise	Perimeter Block	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Perimeter Block
Restaurant	Mid-rise	Perimeter Block	Mid-rise	Mid-rise	Mid-rise	High-rise	Mid-rise	Perimeter Block
	Low-rise	Mid-rise	Low-rise	Mid-rise	Mid-rise	Low-rise	Mid-rise	Perimeter Block
Pub	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	High-rise	Mid-rise	Perimeter Block
	Low-rise	Mid-rise	Mid-rise	Mid-rise	Low-rise	Mid-rise	Low-rise	Perimeter Block
Hospitality	High-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Perimeter Block
	Low-rise	Mid-rise	Mid-rise	Low-rise	Mid-rise	Mid-rise	Mid-rise	Perimeter Block
Office	High-rise	High-rise	High-rise	High-rise	Mid-rise	Warehouse/ Car Park	Mid-rise	Warehouse/ Car Park
	Low-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Warehouse/ Car Park
Health Centre	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	High-rise	Perimeter Block
	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	Mid-rise	High-rise	Perimeter Block
Warehouse	Perimeter Block	Perimeter Block	Perimeter Block	Perimeter Block	Perimeter Block	Warehouse/ Car Park	Perimeter Block	Warehouse/ Car Park
	Perimeter Block	Perimeter Block	Perimeter Block	Perimeter Block	Perimeter Block	Warehouse/ Car Park	Perimeter Block	Warehouse/ Car Park

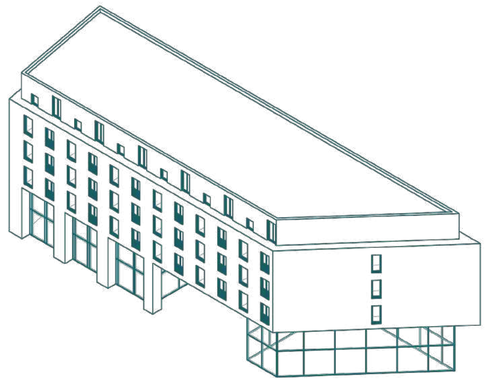
ADDITIONAL RESIDENTIAL TYPOLOGY

Additional Typologies Designed for Variety & Fitting into Irregular Plots

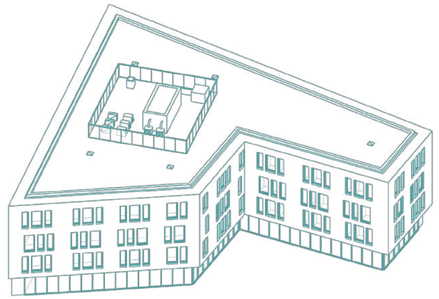
Additional typologies were designed to fit irregular plots and variety. These are essential in identifying the Residential sector with recognisable elements such as balconies, smaller windows compared to the commercial sector and bigger frontages at the lower floors.



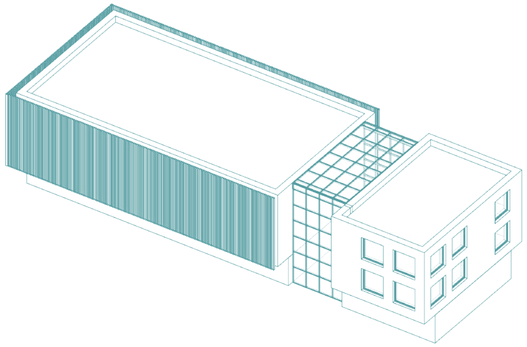
Low-Rise Residential



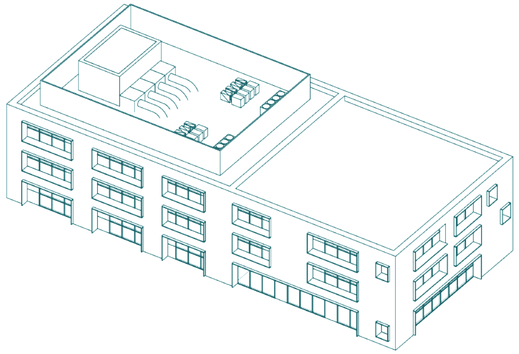
Hybrid Typology



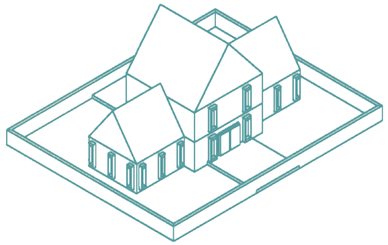
Low-Rise Residential



Academic Building



Academic Building



Academic Building

Commercial
Residential

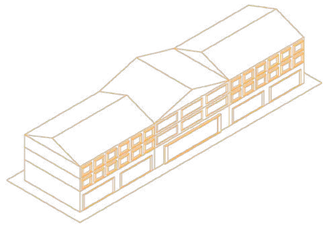
ADDITIONAL COMMERCIAL TYPOLOGY

Additional Typologies Designed for Variety & Fitting into Irregular Plots

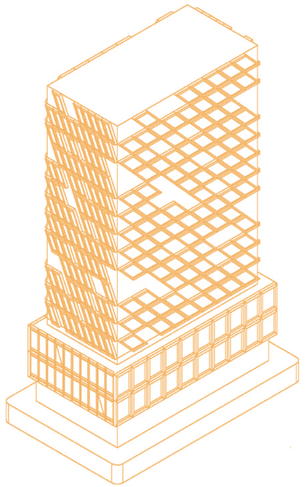
Additional typologies were designed to fit irregular plots and variety. These are essential in identifying the Commercial sector with recognisable elements such as large frontages and windows that welcomes pedestrians.

Urban typologies are a symbol of development intensity, scale & grain, land use & movement network characteristics.

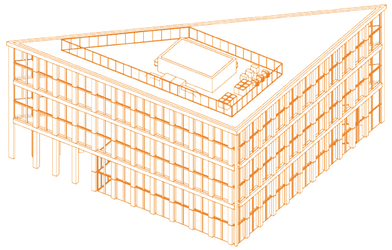
(gov.uk, 2018)



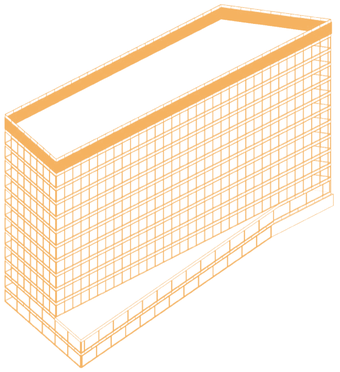
Low-Rise Commercial



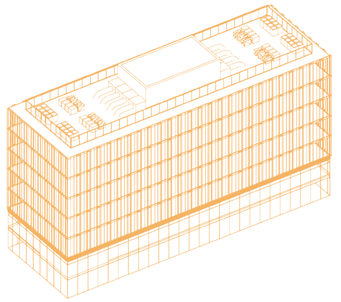
Skyscraper



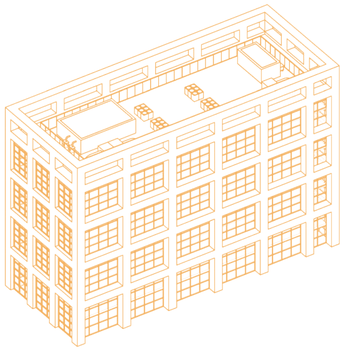
Mid-Rise Commercial



Mid-Rise Commercial

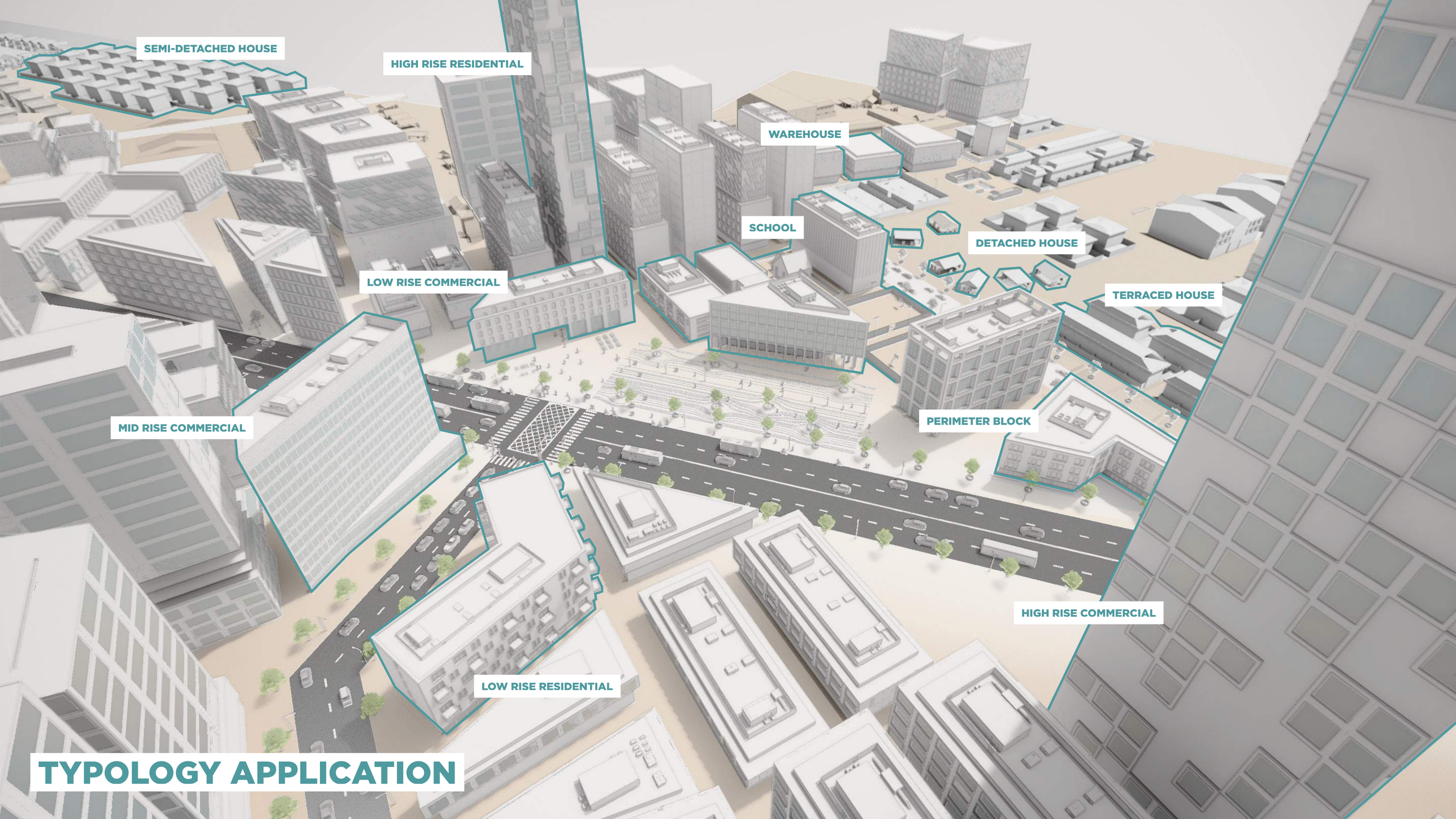


Mid-Rise Commercial



Mid-Rise Commercial

Commercial
Residential



TYPOLOGY APPLICATION

STEP 4 & 5: RUNNING SIMULATIONS

Agent Based Modelling & Simulation Compared to Area Based Evaluation

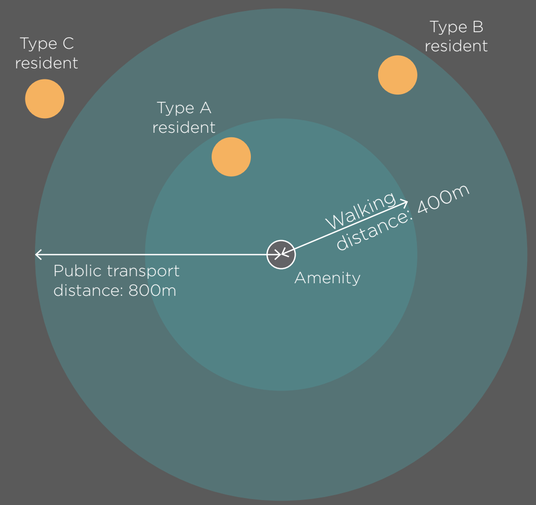
This page outlines the difference in analysing the carbon emission levels and accessibility score in ST2 and ST3. While ST2 will rely heavily on calculations, ST3 will implement Agent Based Modelling to visualise these calculations.

ST2 METHOD:
AREA BASED EVALUATION ON ACCESSIBILITY

This method is a simplified method that only view the site on a plane view. Taking a radius of walking distance, the method categorise people into 3 types:

A) residents that are able to walk to amenities
B) residents that need to take public transport to amenities
C) residents that can only drive to amenities

The diagram below shows the definition of the 3 types. **Although this disregard all site elements (e.g. buildings, streets, turning in angle, difficulty to traverse), it is a good way in judging a location's accessibility on a high level scale during testing phase. ST3 will see this method replaced by a more elaborate method of using agent based modelling.**

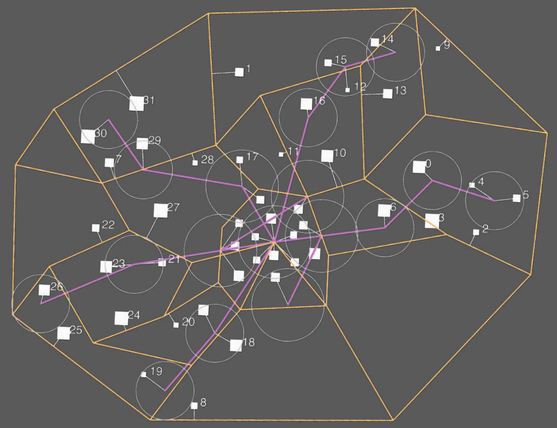


ST3 METHOD:
AGENT BASED MODELLING

ABM (Agent based modelling) is a simulation that can give more granular control to the user, moving from a analysing a building to individual agents. Each agent can be identified with a different preference that will make them behave in a different way.

This method although takes more time to prepare, it provides a clearer picture and more generate a more accurate model in measuring the accessibility, which also allows the hardest factor to be considered - time.

ST2 testing on transit and road networks towards agent behaviours had been done to gain more experience. ST3 will see the replacement of the area based evaluation with ABM.



Test transit network
Test road networks
Agent homes and workplaces

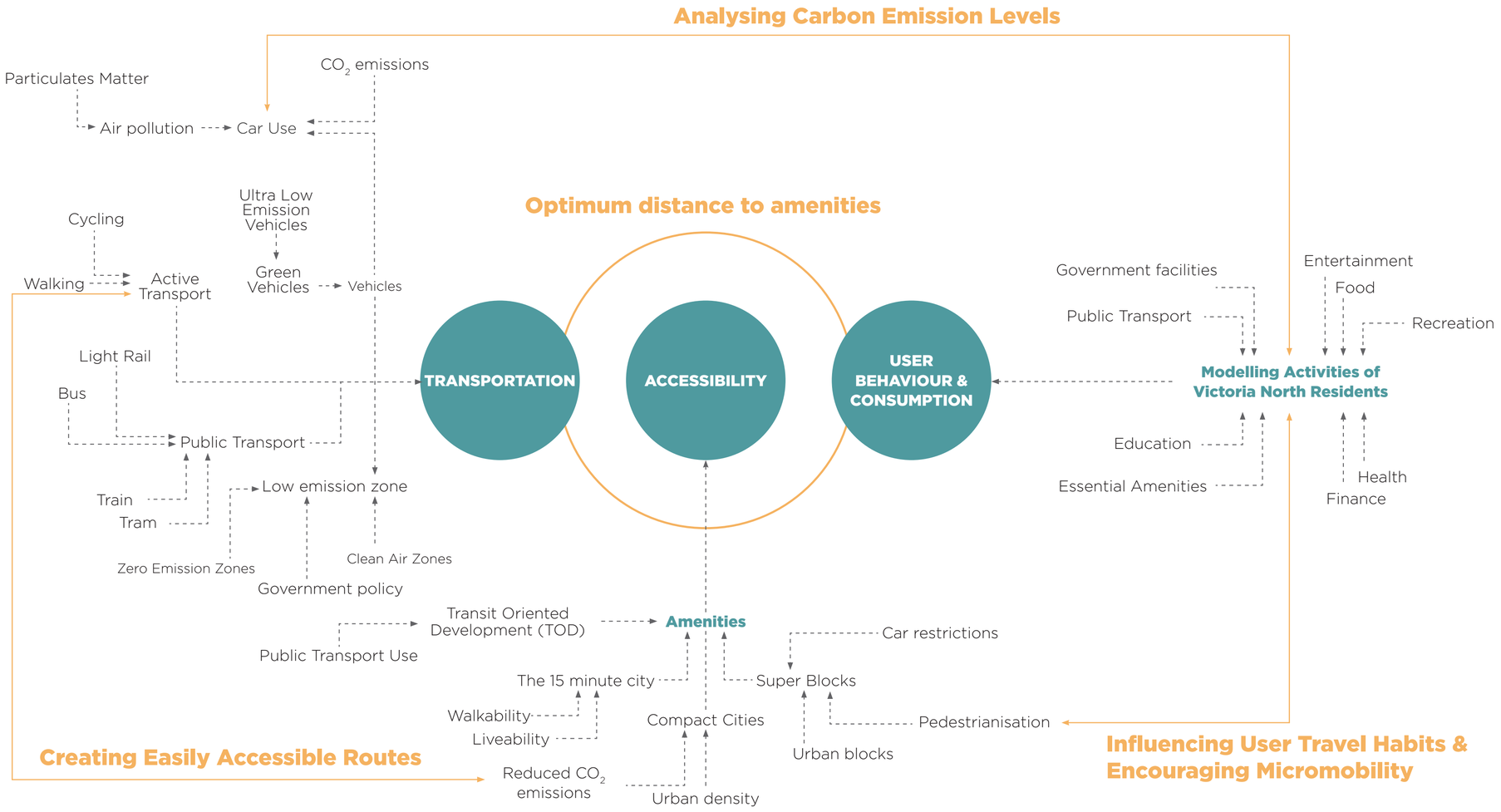
ST3

1 Reference Existing Site Boundary, population & land use percentage
2 Urban Strategy Network & Parcellation
3 Building the City
4 Create & Insert Agents
5 Execute Agent Simulation and Collect Data
6 Calculations
7 Analyse iterations and results

AGENT BASED MODELLING FRAMEWORK

Simulating Relationships between Transportation, Accessibility & User Consumption

Studying the relationships between Transportation, Accessibility and User Behaviour and Consumption allows for the identification of important links and issues that should be tackled when trying to design a climate neutral mobility network. These links make up the important aspects of designing the optimum urban layout.

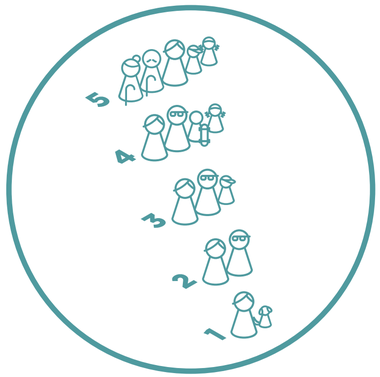


CATEGORISING 35,000 AGENTS

Assigning Family Size, Individual Types & Homes

35,000 agents have been categorised in terms of family size and 3 different categories which are elderly, Adults & Children. Each agent is then assigned attributes such as Transport Preference, Home Location & Workplace Location.

Categorizing Agents



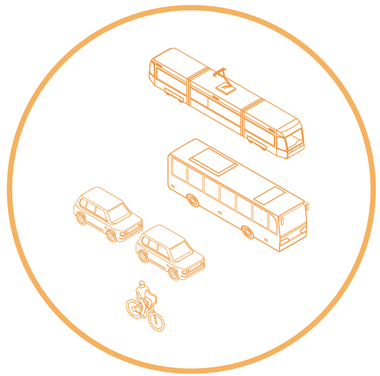
Family Size

A typical family size ranges from 1 person to 5 individuals. The average family size is 2.4. The family sizes for each generation are varied.

Individual Category

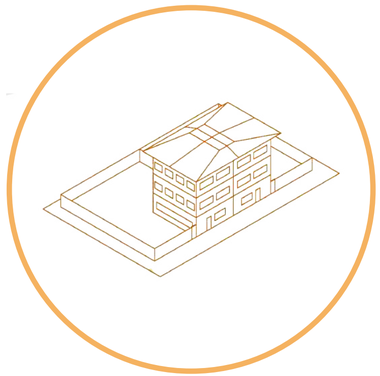
There are three categories, which are Elderly, Adult and Children. The numbers in which the 35,000 residents are assigned to each category varies for each generation.

Assigning Agent Attributes



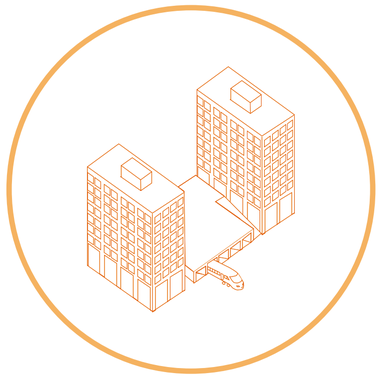
Transport Preference

The transport preference for each agent varies. For example, adults and the elderly are more likely to prefer driving private cars compared to children. Children will be assigned transport preference like bus or walk for when they go to school.



Home Location

Each agent is assigned a home location at the beginning of the simulation to start their journey before going to work.



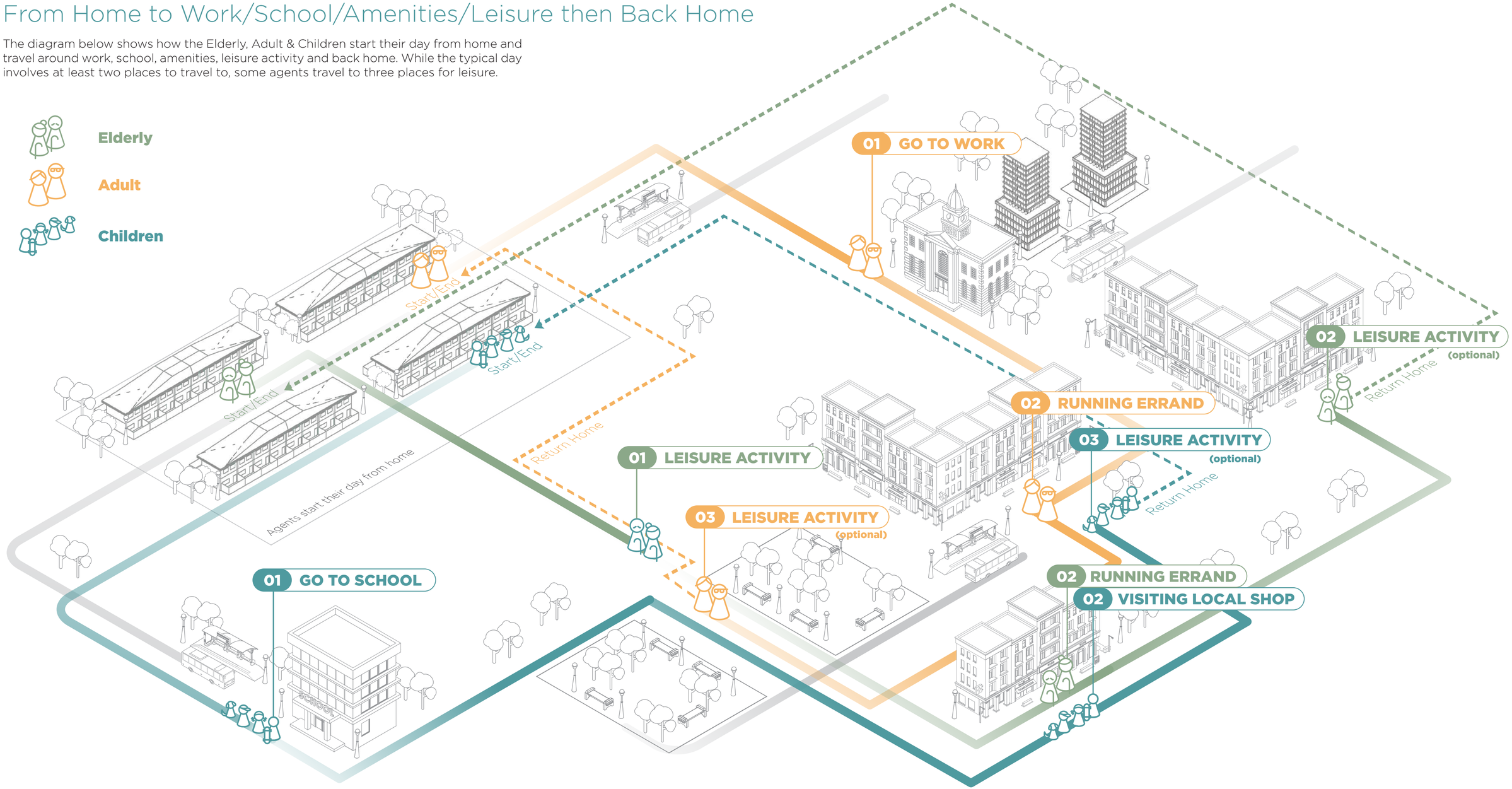
Workplace Location

The agents are assigned a workplace location as an aim to travel to from their home location.

AN AGENT'S SCHEDULE

From Home to Work/School/Amenities/Leisure then Back Home

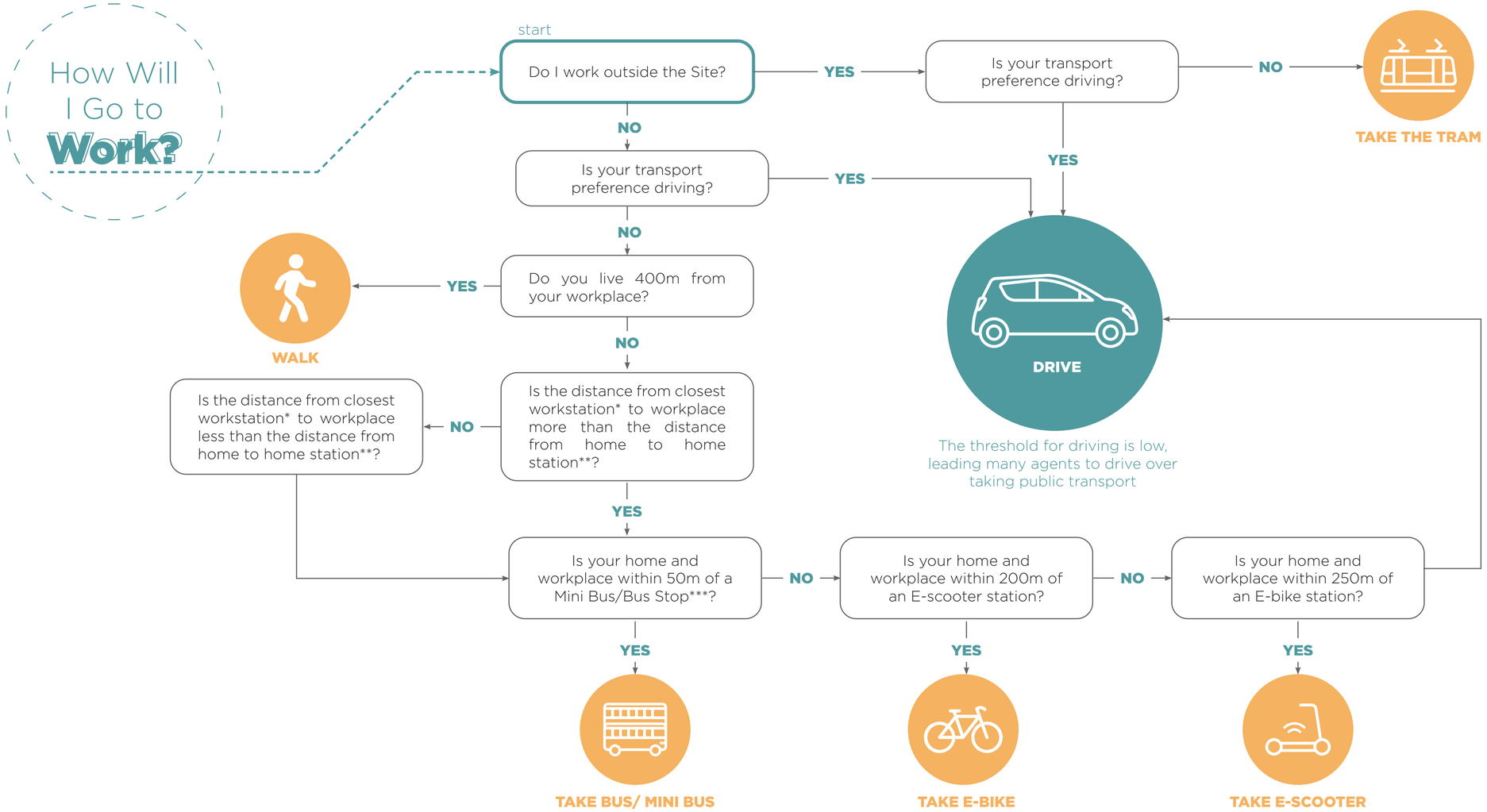
The diagram below shows how the Elderly, Adult & Children start their day from home and travel around work, school, amenities, leisure activity and back home. While the typical day involves at least two places to travel to, some agents travel to three places for leisure.



WHAT TRANSPORT DO I TAKE TO WORK?

Deciding Mode of Transport

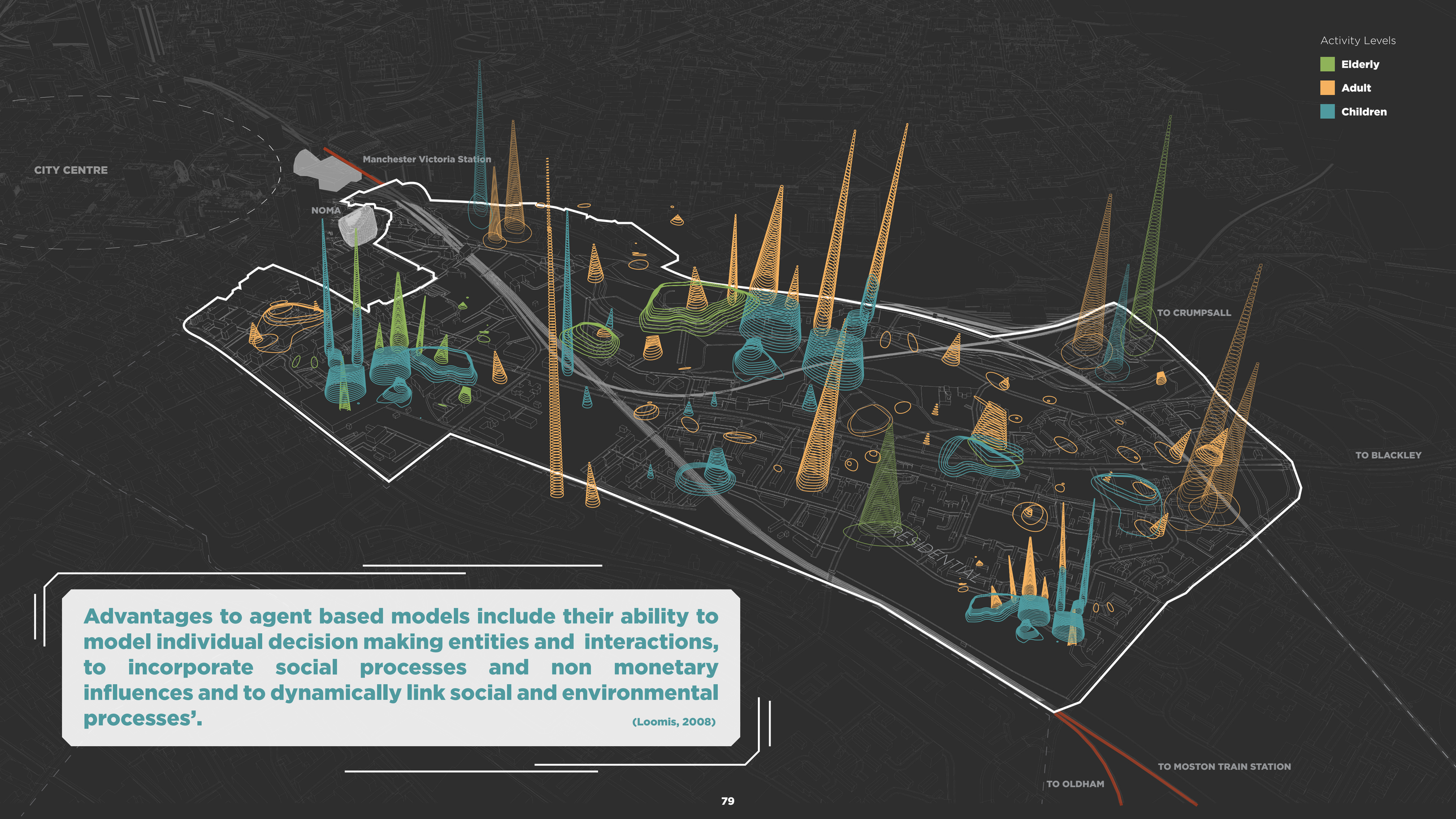
The diagram below shows a deciding work flow for agents to decide their mode of transport as they start their day. This method can also be used after work as they decide how to get to their next stop, and how to travel home.



*Workstation in diagram is defined as transport stops closest to workplace

**Home station in diagram is defined as transport stops closest to home

*** This is assuming that the mini bus/ bus routes stops from house to work pace



Advantages to agent based models include their ability to model individual decision making entities and interactions, to incorporate social processes and non monetary influences and to dynamically link social and environmental processes'.

(Loomis, 2008)

STEP 6: CALCULATIONS CARBON EMISSION LEVELS & ACCESS TO TRANSPORT & AMENITIES

Calculating the Performance Criteria

Site Generation No. 62

Site Generation No. 17

Site Generation No. 23
Amenity Number: 107
Accessibility:
(Population access to amenities types)

3 Amenities type: 51% = 7650 people
2 Amenities type: 30% = 4500 people
1 Amenities type: 9% = 1350 people
0 Amenities type: 10% = 1500 people

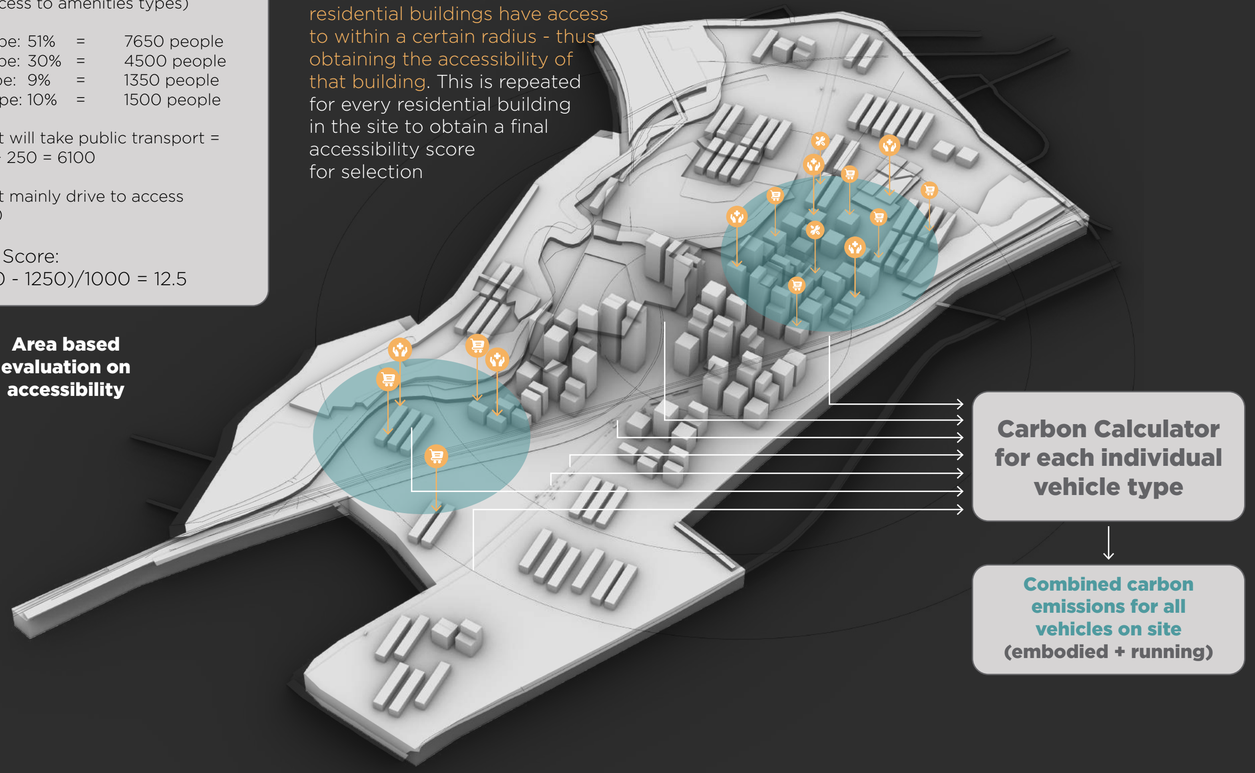
Population that will take public transport =
4500 + 1350 + 250 = 6100

Population that mainly drive to access amenities: 1250

Accessibility Score:
(7650 + 6100 - 1250)/1000 = 12.5

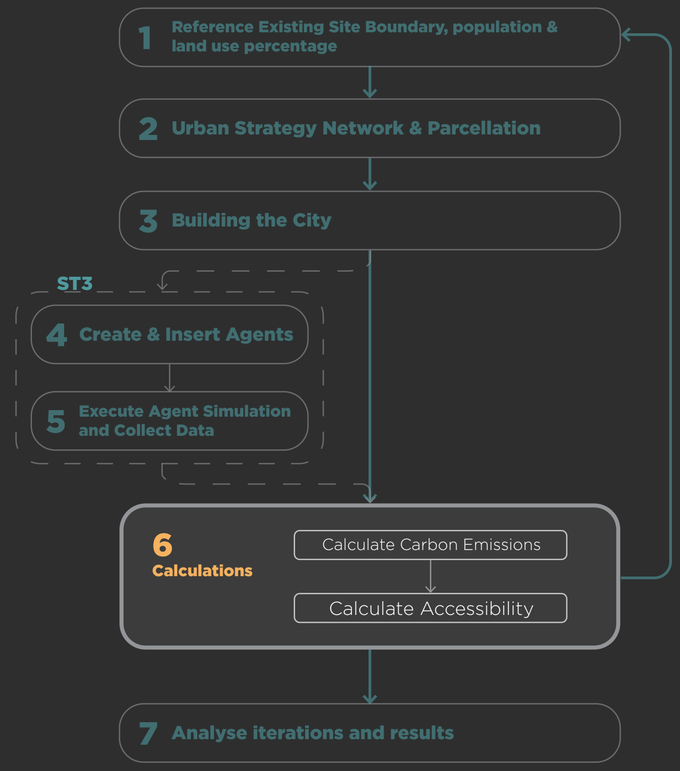
Multiple amount of generations are ran, with each generation resulting in a "nutrition label" like sheet, listing out the amount of amenities that each residential buildings have access to within a certain radius - thus obtaining the accessibility of that building. This is repeated for every residential building in the site to obtain a final accessibility score for selection

Area based evaluation on accessibility



Carbon Calculator for each individual vehicle type

Combined carbon emissions for all vehicles on site (embodied + running)



IDENTIFYING THE PERFORMANCE CRITERIA

Achieving Brief Goals, High Levels of energy & Low Carbon Emissions

The performance Criteria aims to meet Manchester City Council & Far East Consortium's goals for Victoria North Redevelopment. The Accessibility to Transport Stops & Amenities, Carbon Emissions & Energy of the 72 results will be calculated.

Brief Goals

Site Data

Family Size
Agent Type
No. of Adults
No. of Kids
No. of Elderly
Total no. of People
No. of People Working Outside Site

Total Homes
(All Generated Homes meet the minimum requirement of housing 35,000 residents)

Accessibility

Transport Travel Data

Accessibility to Amenities
Accessibility to Transport

People Who Drive (%)
People Who Walk (%)
People Who Take Public Transport (%)
People Who use Active Transport (%)

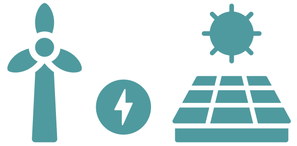
Carbon Emissions

Transport Travel Data

% of people driving Total CO^2 (Tram)
Total CO^2 (Bus)
Total CO^2 (Minibus)
Total CO^2 (E-Bike)
Total CO^2 (E-Scooter)
Total CO^2 (Car)

Total CO^2 (Site)

Total Car CO^2 (if everyone drives)
Total CO^2 (Petrol)
Total CO^2 (BEV)



Energy

Initiative Required to Achieve Carbon Neutral

Wind Turbine Required (m^2)
No. of Offshore Wind Farms

Solar Panels (m^2)
Roof Area (%)
Solar Panels Installation (£million)

GWh

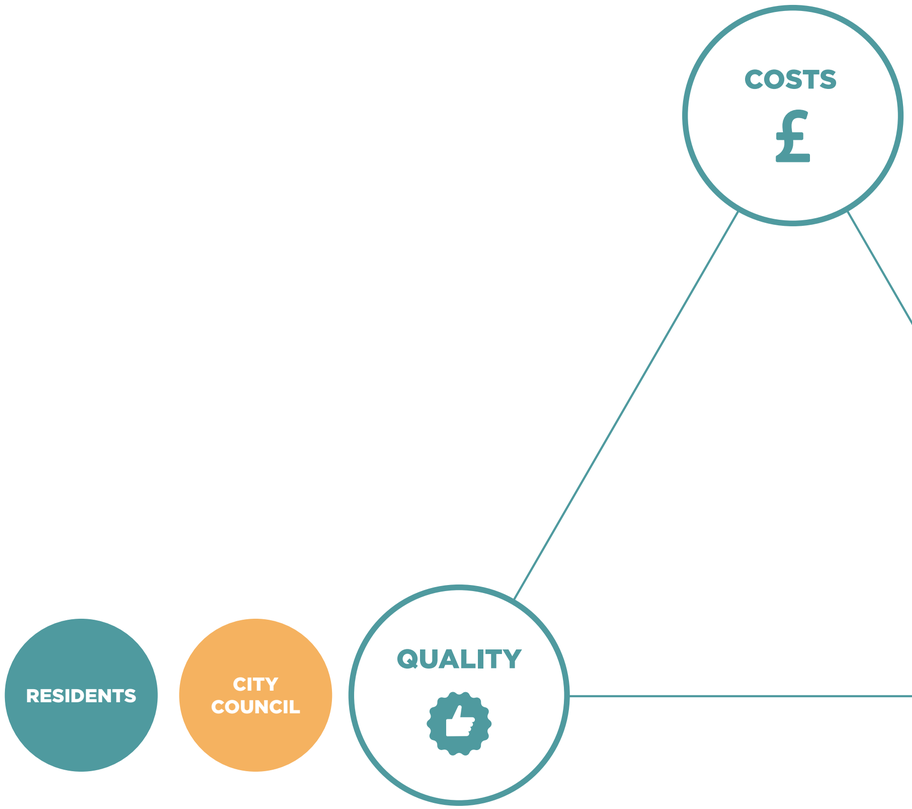
CONFLICTS IN PERFORMANCE CRITERIA

How Residents, the Council & Developers have Different Interests

All 72 results does not have the best results in terms of emissions, accessibility and energy levels. All of them are affected by influencing factors such as Cost, Quality & Time. When planning for the Victoria North Redevelopment, stakeholders such as Residents, City Council & Consultants will take these factors into account.

STAKEHOLDERS IN VICTORIA NORTH DEVELOPMENT

- RESIDENTS
- CITY COUNCIL
- DEVELOPER/ CONSULTANTS



DEVELOPER/ CONSULTANTS

CITY COUNCIL

Both Developers/ Consultants & the City Council would like to minimise the costs spent as much as possible when redeveloping Victoria North and achieving Zero Carbon Manchester

RESIDENTS

CITY COUNCIL

Residents of Victoria North would want high quality of living in terms of infrastructure, amenities and residential standards in Victoria North.

The City Council must fulfil their responsibility in meeting the needs of the community and consider their interests.

RESIDENTS

CITY COUNCIL

Residents of Victoria North would want high quality infrastructure, amenities and residential standards to be delivered as soon as possible.

The City Council are pressured to meet the residents' interests by delivering as soon as possible but may not be able to.

BENEFITS IN THE LONG & SHORT TERM

How Cost, Time & Quality Differ from Long vs. Short Term Solutions

While some stakeholders may choose cheap, quick solutions to save money, it may work out more expensive in the long run. Low Carbon Infrastructure is expensive, but works out better for the environment in order to achieve Zero Carbon Manchester.

ACHIEVING ZERO CARBON MANCHESTER

SHORT TERM SOLUTIONS

RESIDENTS

Quality of Victoria North Development may be compromised if delivered with cheap, quick solutions. While residents may benefit from immediate solutions, it may prove impractical in the long run.

£ Initial cost is low

CITY COUNCIL

Quality of services provided by the Council vary. High Quality Social Services can be provided short term but not major responsibilities such as Infrastructure and Residential.

£ While councils may get funds, Manchester City Council's goal to achieve Zero Carbon

DEVELOPER/ CONSULTANTS

The developers have a higher interest in finishing their tasks as quick as possible in order to minimise variable costs, period costs and non-controllable costs.

LONG TERM SOLUTIONS

RESIDENTS

Residents will be able to benefit from long term solutions that has gone through extensive planning.

£ Cost continues to stay low if quality development is provided. Cost increases when quick, cheap solutions are implemented

CITY COUNCIL

Detailed Infrastructure and Resdiential Planning may take up time and high cost, but in the long run it will prove to be more cost-effective, and the goal to achieve Zero Carbon is more realistic.

DEVELOPER/ CONSULTANTS

The main advantage for developers and consultants to deliver quality services is to improve company image and be able to have returning customers or new customers in the future.

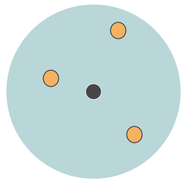
CALCULATING ACCESSIBILITY

Using the Area Based Evaluation Method

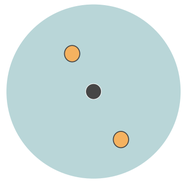
Using the area based method to calculate accessibility provides a fast and reliable way to estimate accessibility in the site during testing phase. The method draws a circle around each residential housing typology generated on the site and count the numbers of amenities in that radius.

Using the land use categories as a basis, 3 most essential ones are taken as the judging factor - commercial, community and open space (i.e. parks and gardens). The residential housing would be assessed in terms of these land use category of amenities. Results can be divided into 4 types, having access to all 3 amenities type within walking distance (on average 100m), having only 2, only 1 and none within walking distance. This is repeated for transit stop distance (300m) to see within this radius how many amenities are accessible through taking transit.

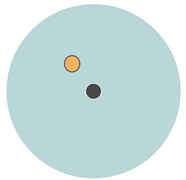
Within Walking Distance: 100m



Type 1:
Residents with access to 3 amenities within walking distance, allowing them to carry out their “typical day” without motorised vehicles



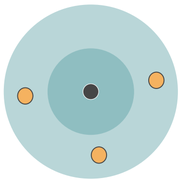
Type 2:
Residents with access to only 2 amenities within walking distance, requiring them to either compromise or access the remaining type with transport



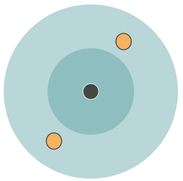
Type 3:
Residents with access only to 1 amenity within walking distance, requiring most of their day to be completed with public transport

Type 4:
Residents with no access to any amenity only within walking distance, requiring any access to amenities to be completed with public transport

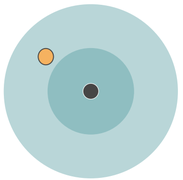
Within Transit Distance: 300m



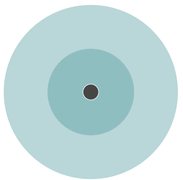
Type 1:
Residents with access to 3 amenities within public transport reachable distance, requiring them to use public transport on a daily basis



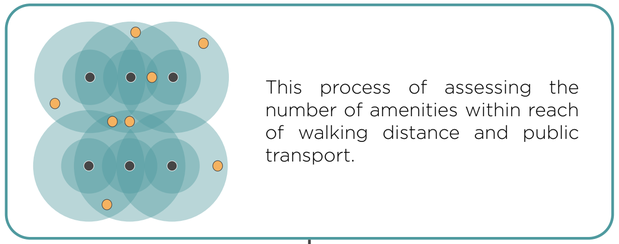
Type 2:
Residents with access to only 2 amenities within public transport reachable distance, increasing the chance of using private cars



Type 3:
Residents with access to 1 amenity only within public transport reachable distance, causing most to drive instead



Type 4:
Residents with no access to any amenity within public transport reachable distance, resulting them to drive anywhere

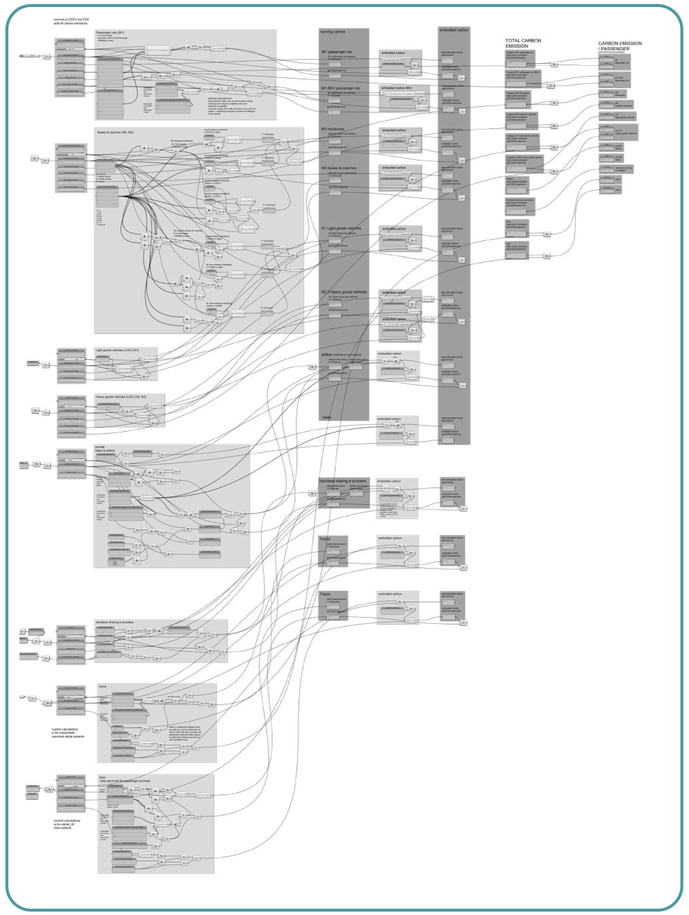


To Calculate Carbon Emissions

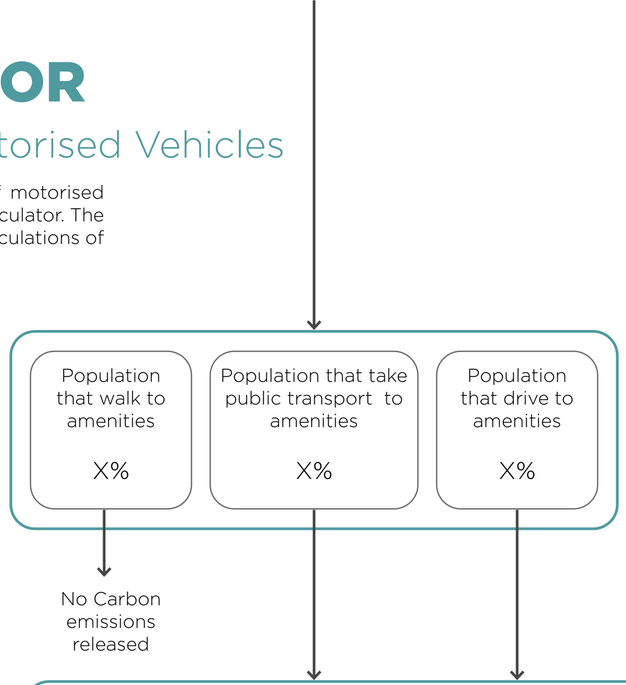
THE CARBON CALCULATOR

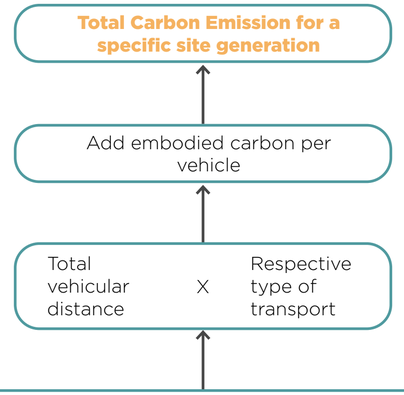
Calculating Carbon Emissions from Motorised Vehicles

The carbon calculator was developed during ST1, allowing various types of motorised vehicles from private cars to buses to trucks and lorries to be input into the calculator. The methodology can be seen in chapter 1 ST1 Recap. This page focuses on the calculations of emissions, including embodied and running carbon.



Grasshopper definition to create carbon calculator





For each residential building:

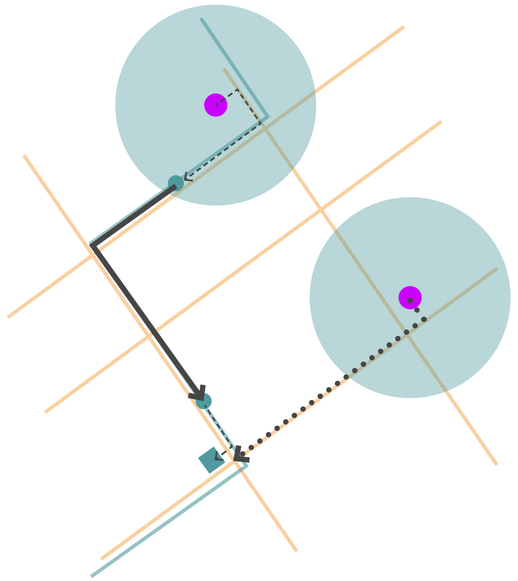
Population that take public transport to amenities

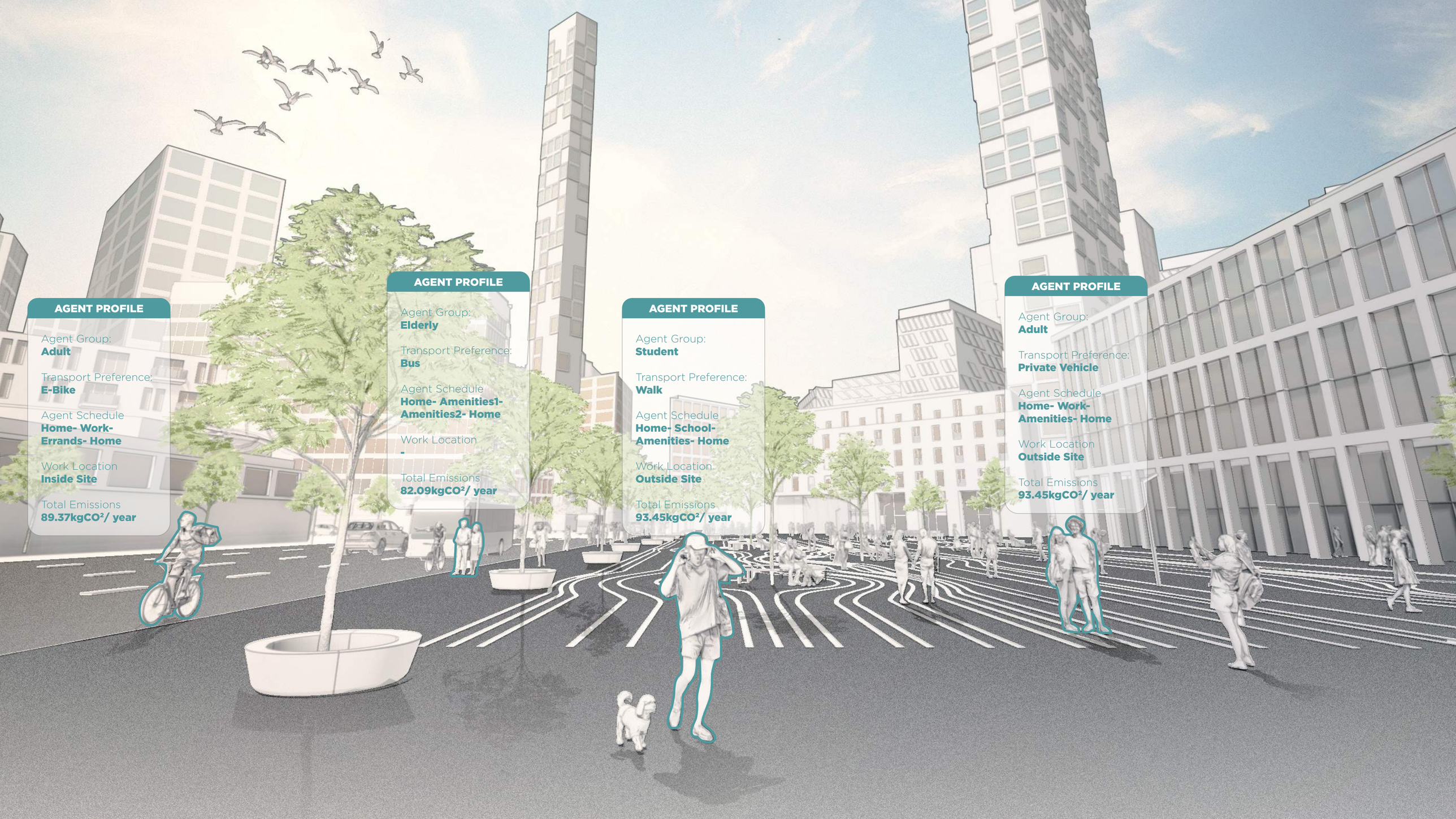
For trips of public transport only the distances that was travelled on the public transport is calculated, which means calculating the distance between stops on a network. This is repeated for every residential building accessing an amenity through public transport, then multiplied by the amount of residents in that building.

Population that drive to amenities

For people who drive, the distances are taken from the the residential building to the amenities on the road networks. If there are multiple residents in the building, this calculation of distance is repeated for each resident.

- Residential building
- Transport stop
- Amenity
- Transport Route
- Road network
- Waking distances
- Public transport distances
- Private vehicle distances





AGENT PROFILE

Agent Group:
Adult

Transport Preference:
E-Bike

Agent Schedule
Home- Work- Errands- Home

Work Location
Inside Site

Total Emissions
89.37kgCO²/ year

AGENT PROFILE

Agent Group:
Elderly

Transport Preference:
Bus

Agent Schedule
Home- Amenities1- Amenities2- Home

Work Location
-

Total Emissions
82.09kgCO²/ year

AGENT PROFILE

Agent Group:
Student

Transport Preference:
Walk

Agent Schedule
Home- School- Amenities- Home

Work Location
Outside Site

Total Emissions
93.45kgCO²/ year

AGENT PROFILE

Agent Group:
Adult

Transport Preference:
Private Vehicle

Agent Schedule
Home- Work- Amenities- Home

Work Location
Outside Site

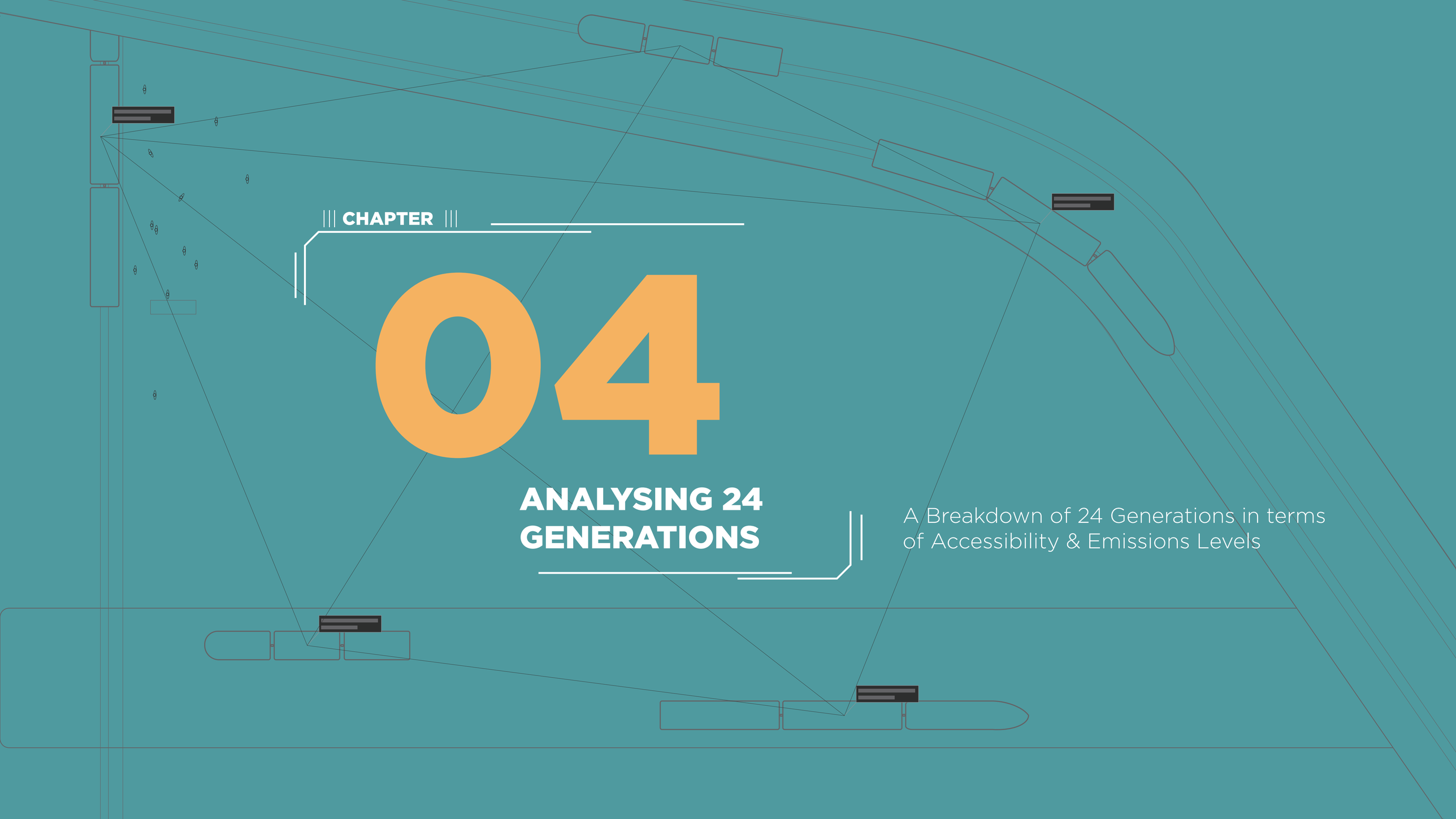
Total Emissions
93.45kgCO²/ year

CHAPTER

04

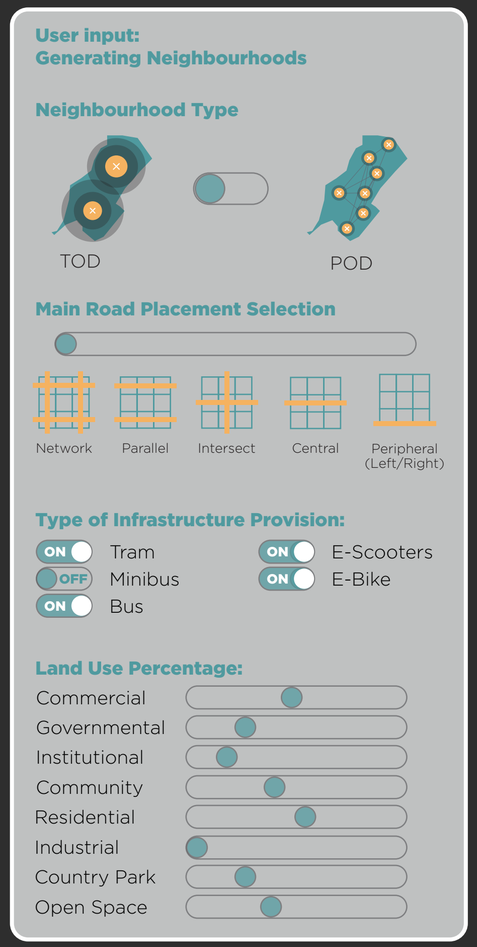
ANALYSING 24 GENERATIONS

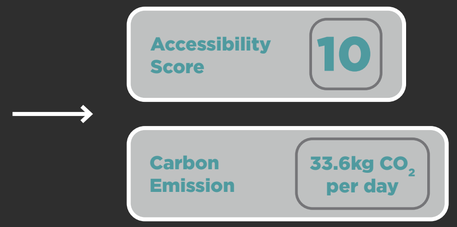
A Breakdown of 24 Generations in terms of Accessibility & Emissions Levels



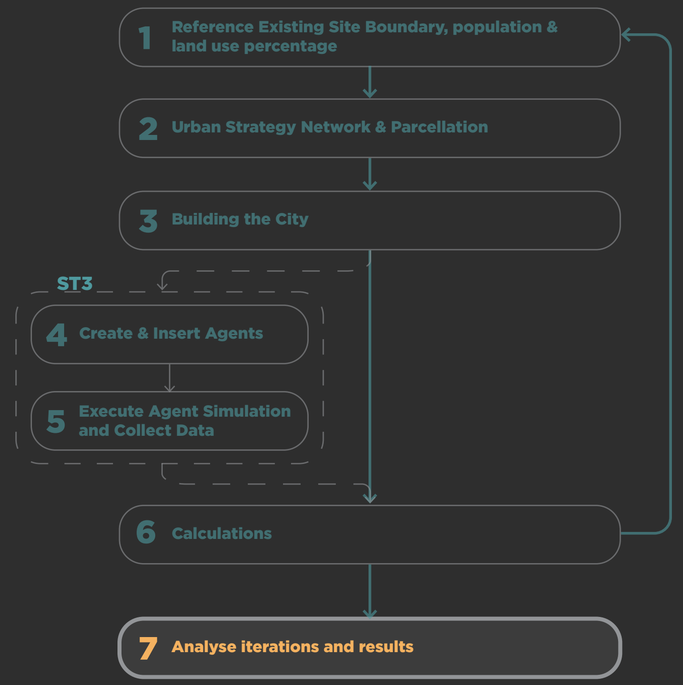
STEP 7: ANALYSIS OF ITERATIONS & RESULTS

Analysing 24 Generated Outputs, 72 Different Results





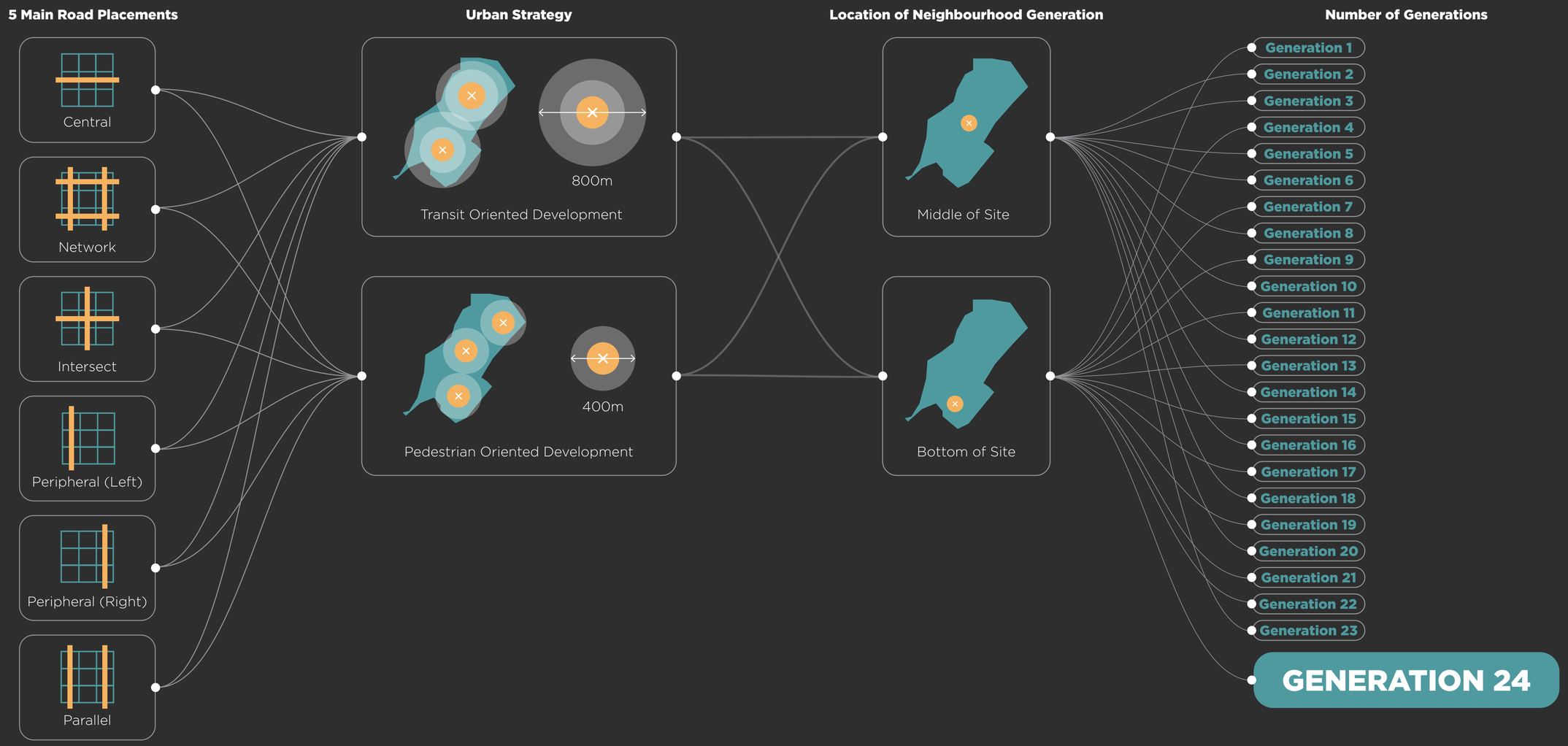
The results are affected by three control panels on the left, which includes all the different input that a user need to decide, the generated results are then compared side by side and analysed to select a better one. This allows the user to observe the advantages and disadvantages of each of the generation and can decide the way forward. This completes the function of the tool.



BREAKDOWN OF 24 GENERATIONS

Testing All Possible Iterations

In order to test out all possible iterations, all road placements will be tested with the two urban strategies and both location of neighbourhood generations. Altogether there would be a total of 24 generations.



CENTRAL ROAD GENERATIONS

How Neighbourhood Strategies Affect Transport Network & Plots

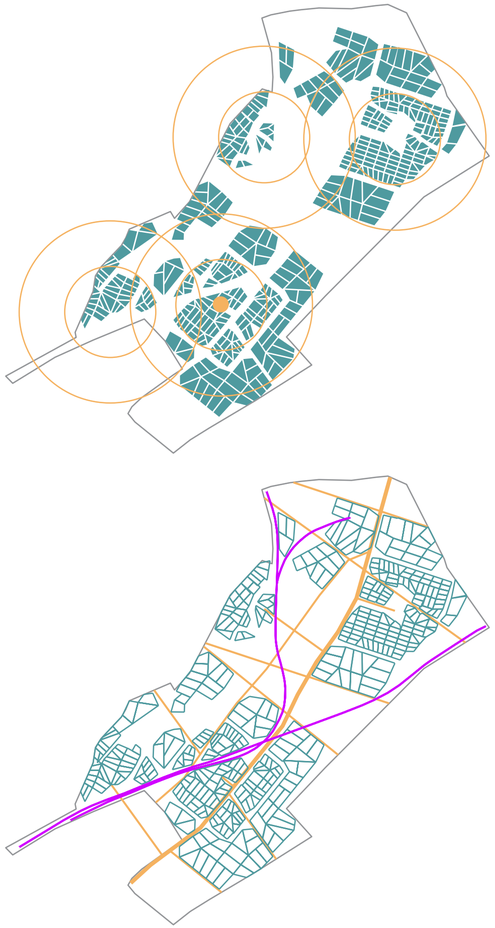
The generated urban city shows the difference between the plot generations in Pedestrian & Transit Oriented Development. There are more generated secondary roads in Pedestrian Oriented Development than Transit Oriented Development. However, Transit Oriented Development covers a larger site area.

GENERATED PLOTS

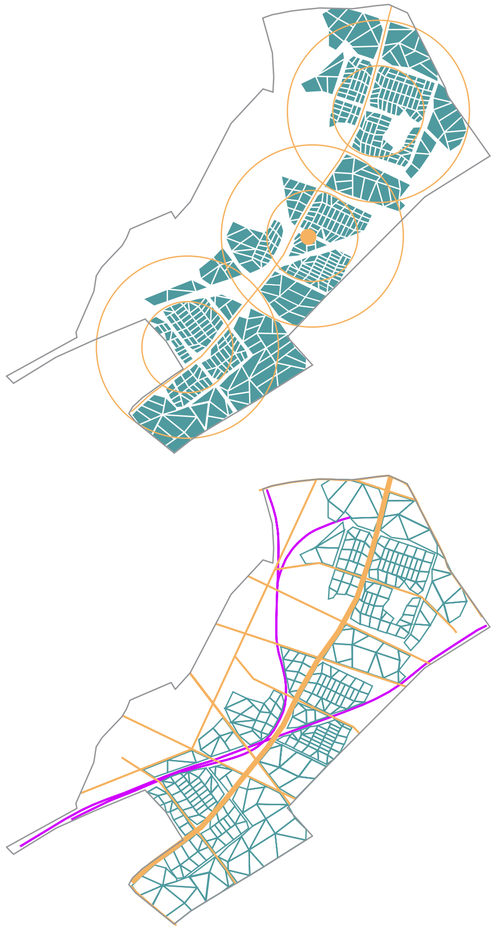
NETWORK ANALYSIS

- Pedestrian Route
- Vehicular Route
- Rail Line

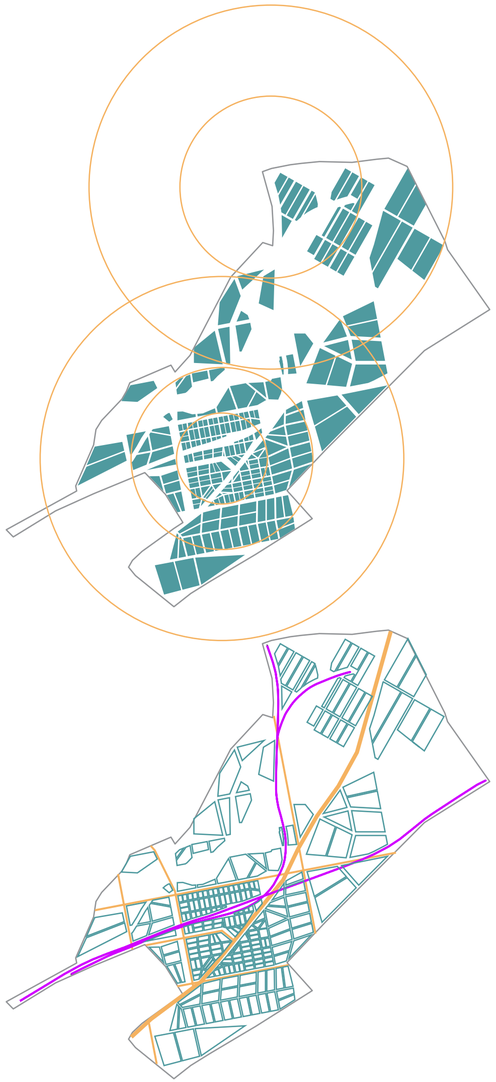
PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 1



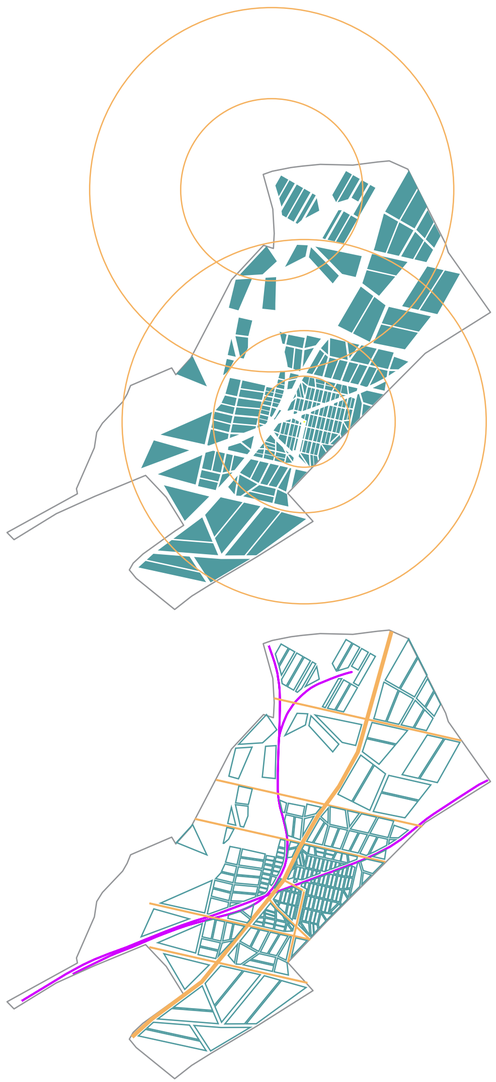
PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 2



TRANSIT ORIENTED DEVELOPMENT LOCATION 1



TRANSIT ORIENTED DEVELOPMENT LOCATION 2



INTERSECT ROAD GENERATIONS

How Neighbourhood Strategies Affect Transport Network & Plots

The generated urban city shows the difference between the plot generations in Pedestrian & Transit Oriented Development. Both strategies cover most of the site area while Transit Oriented Development have larger plots. Both strategies both 2-4 generated secondary roads.

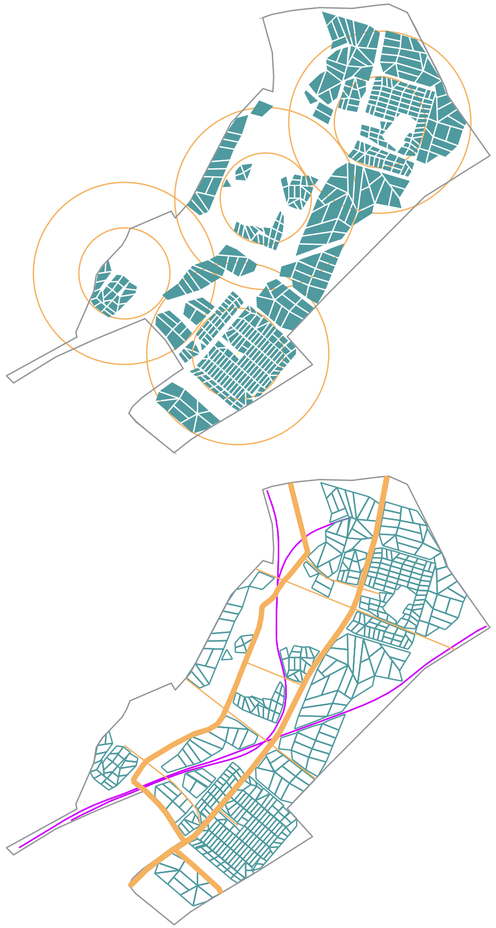
GENERATED PLOTS

NETWORK ANALYSIS

- Pedestrian Route
- Vehicular Route
- Rail Line

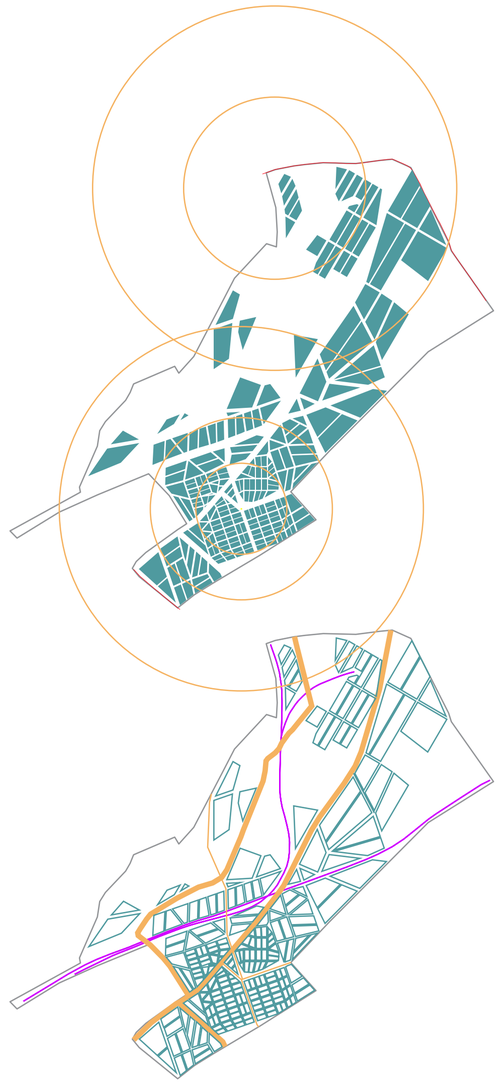
PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 1

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 2



TRANSIT ORIENTED DEVELOPMENT LOCATION 1

TRANSIT ORIENTED DEVELOPMENT LOCATION 2



PARALLEL ROAD GENERATIONS

How Neighbourhood Strategies Affect Transport Network & Plots

The generated urban city shows the difference between the plot generations in Pedestrian & Transit Oriented Development. Transit Oriented Development covers a larger site area and have more generated secondary roads compared to Pedestrian Oriented Development.

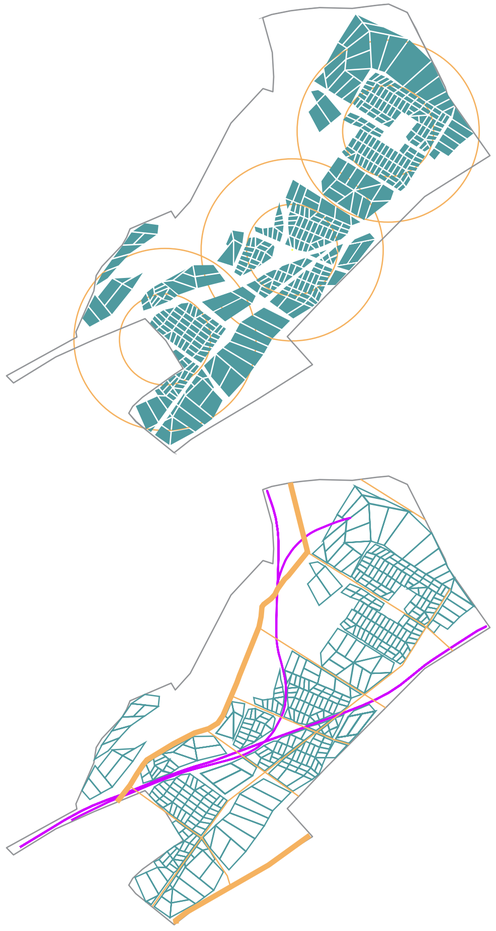
GENERATED PLOTS

NETWORK ANALYSIS

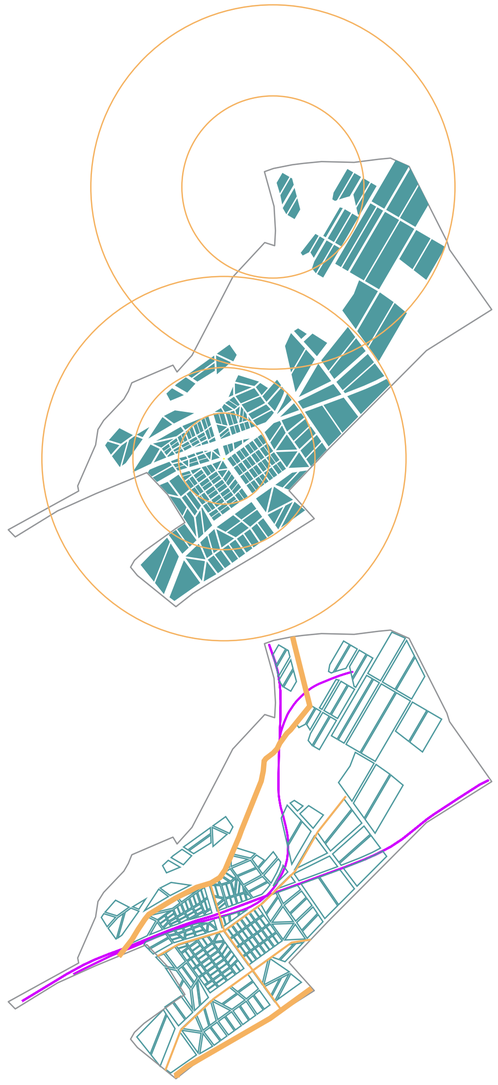
- Pedestrian Route
- Vehicular Route
- Rail Line

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 1

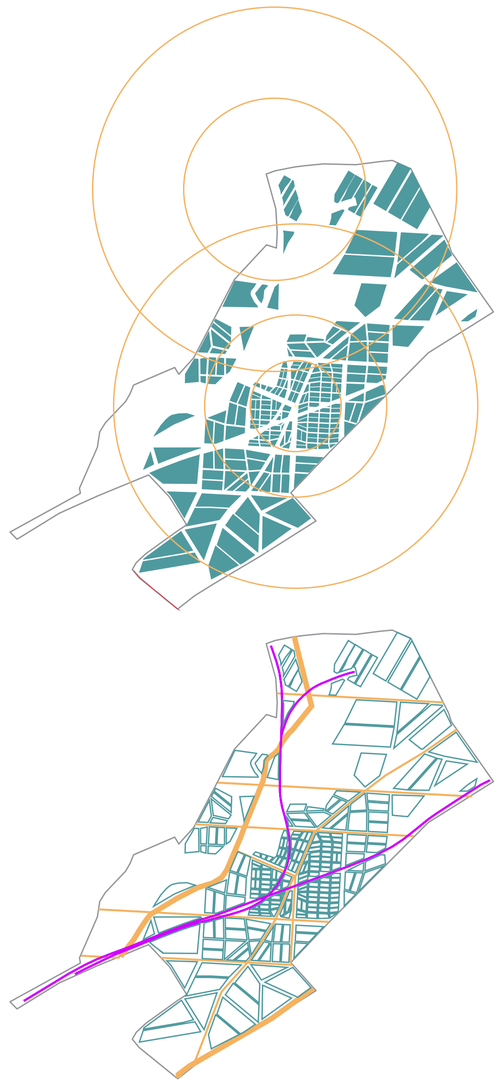
PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 2



TRANSIT ORIENTED DEVELOPMENT LOCATION 1



TRANSIT ORIENTED DEVELOPMENT LOCATION 2



NETWORK ROAD GENERATIONS

How Neighbourhood Strategies Affect Transport Network & Plots

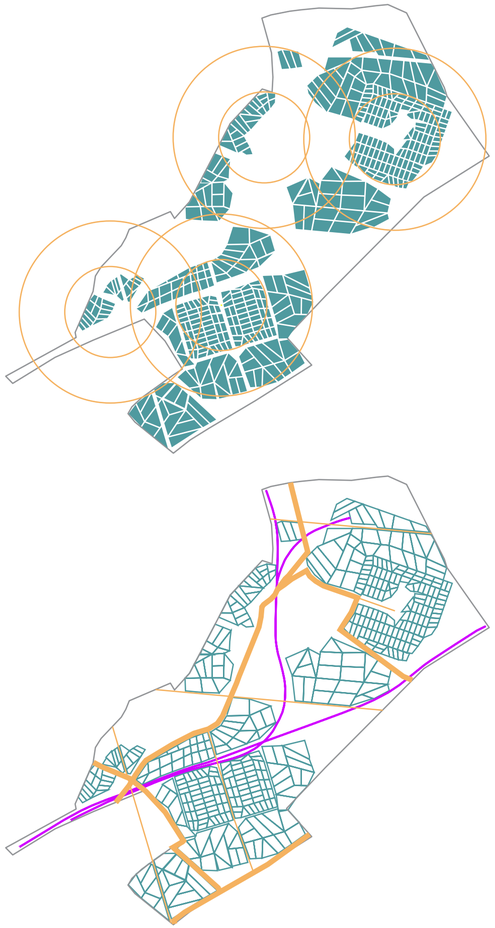
The generated urban city shows the difference between the plot generations in Pedestrian & Transit Oriented Development. There are more generated secondary roads in Pedestrian Oriented Development than Transit Oriented Development. However, Transit Oriented Development covers a larger site area.

GENERATED PLOTS

NETWORK ANALYSIS

- Pedestrian Route
- Vehicular Route
- Rail Line

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 1



PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 2

TRANSIT ORIENTED DEVELOPMENT LOCATION 1

TRANSIT ORIENTED DEVELOPMENT LOCATION 2

PERIPHERAL (LEFT) ROAD GENERATIONS

How Neighbourhood Strategies Affect Transport Network & Plots

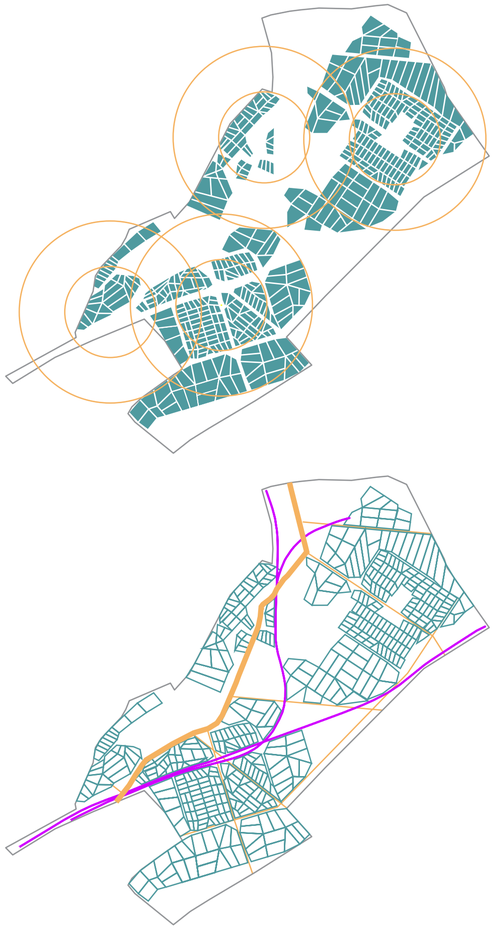
The generated urban city shows the difference between the plot generations in Pedestrian & Transit Oriented Development. There are more generated secondary roads in Pedestrian Oriented Development than Transit Oriented Development. However, Transit Oriented Development covers a larger site area.

GENERATED PLOTS

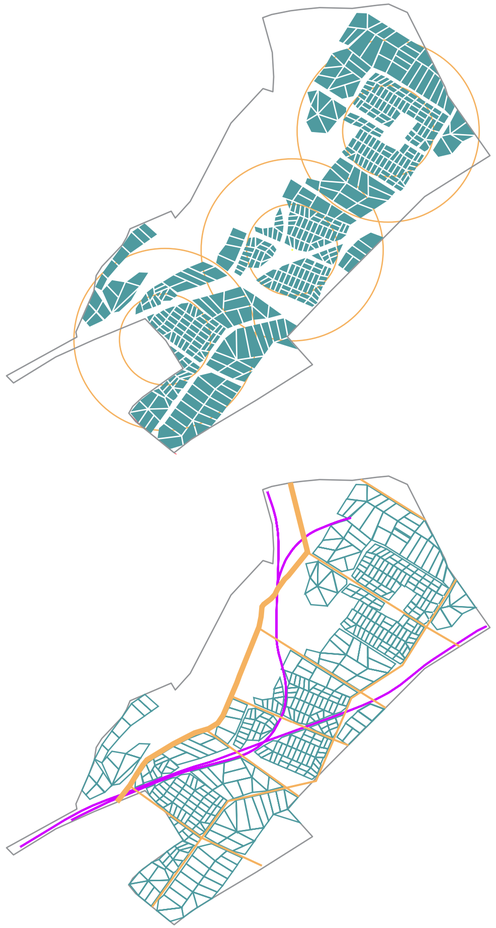
NETWORK ANALYSIS

- Pedestrian Route
- Vehicular Route
- Rail Line

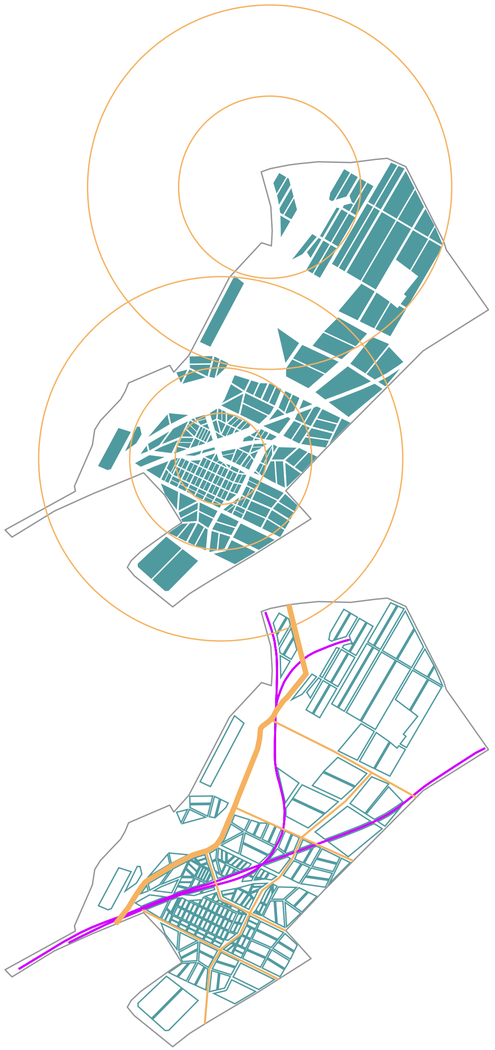
PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 1



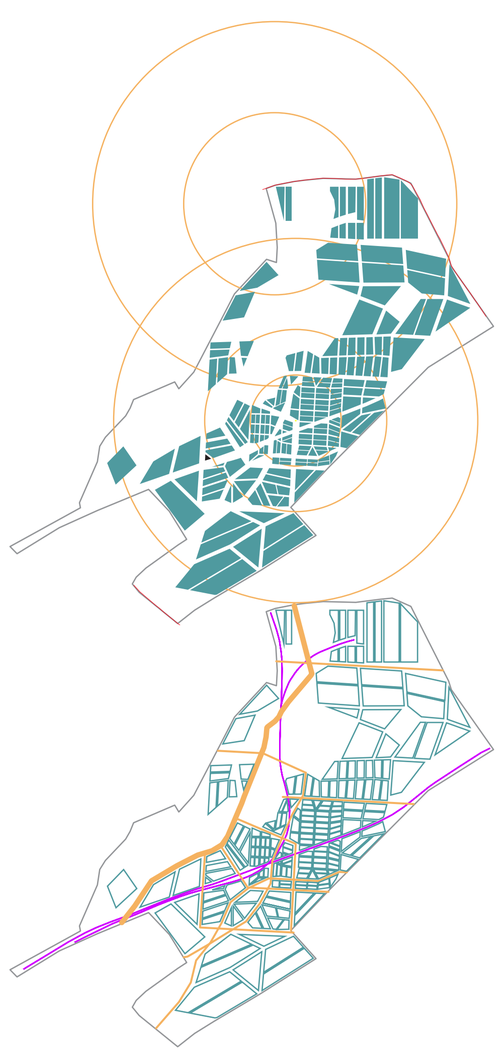
PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 2



TRANSIT ORIENTED DEVELOPMENT LOCATION 1



TRANSIT ORIENTED DEVELOPMENT LOCATION 2



PERIPHERAL (RIGHT) ROAD GENERATIONS

How Neighbourhood Strategies Affect Transport Network & Plots

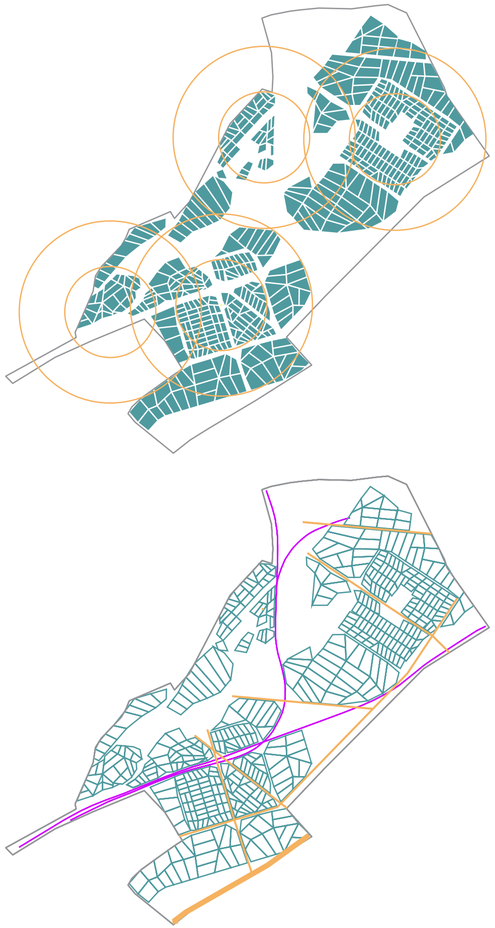
The generated urban city shows the difference between the plot generations in Pedestrian & Transit Oriented Development. Both strategies cover most of the site area while Transit Oriented Development have larger plots. Both strategies both 2-4 generated secondary roads.

GENERATED PLOTS

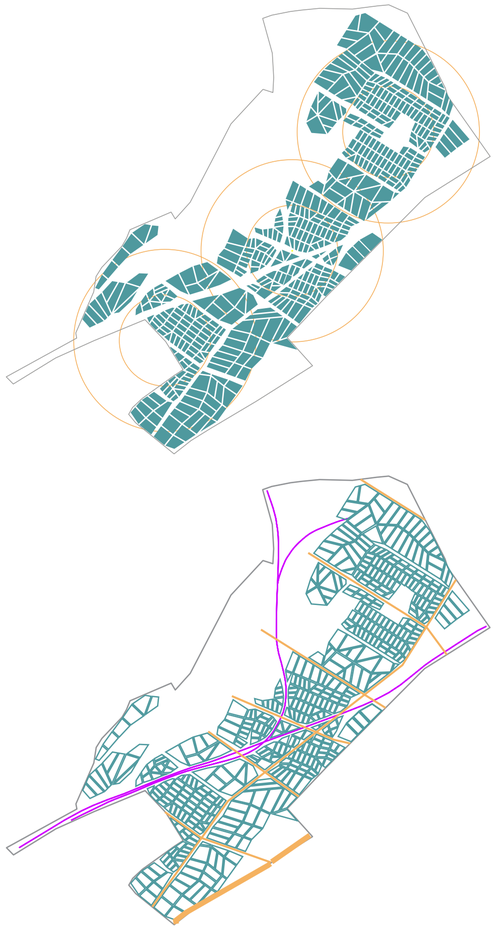
NETWORK ANALYSIS

- Pedestrian Route
- Vehicular Route
- Rail Line

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 1

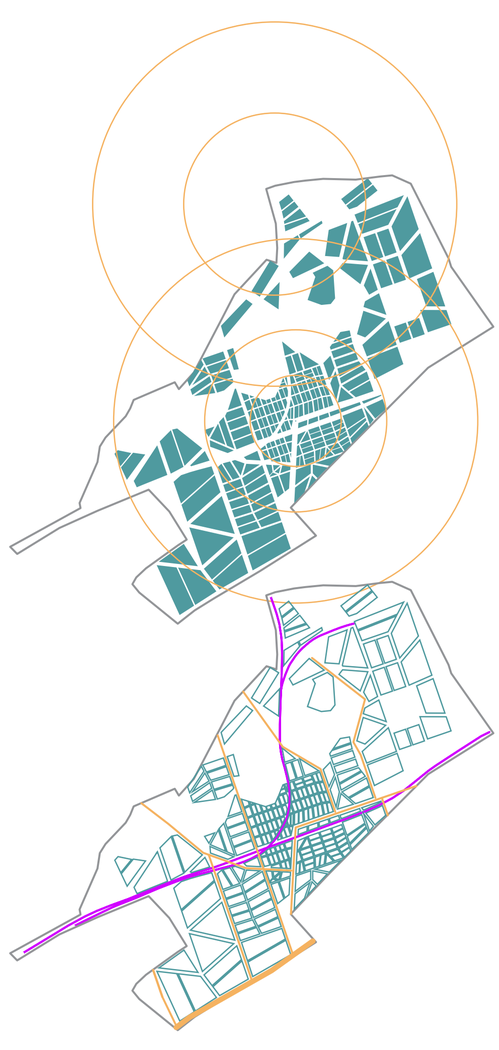


PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 2



TRANSIT ORIENTED DEVELOPMENT LOCATION 1

TRANSIT ORIENTED DEVELOPMENT LOCATION 2




Total Homes **15860**
Accessibility to Amenities **47.58**
People who take Public Transport **52%**
Total CO^2 (Car) **1768.81**
Total CO^2 (E-Bike) **3.1510454**
Total CO^2 (Bus) **57.952387**
People who take Active Transport **1.07%**
Total CO^2 (E-Scooter) **19.551063**
Total CO^2 (BEV) **1226.45**
Accessibility to Transport **2.44**
People Working Outside Site **4740**
Total Car CO^2 (if everyone drives) **10842.74**
Total CO^2 (Petrol) **4034.68**
People who Walk **13%**
People who Drive **31%**
Offsetting Carbon
Wind Turbine Required (m^2) **1210.27**
No. of Offshore Wind Farms **1**
Solar Panels (m^2) **39221.81**
Roof Area (%) **16.77**
Solar Panels Installation (£million) **7.84**
Results based on Central Road Generation, Pedestrian Oriented Development Location 2

CENTRAL ROAD GENERATIONS

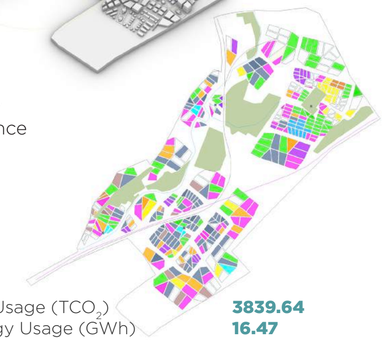
How Neighbourhood Strategies Affect Urban Density, Accessibility & Emission Levels

The generated urban city shows the affect of neighbourhood strategies on the plots and how they relate to network routes. The data on accessibility, emissions & ways to offset produced carbon are listed below.

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 1

3D Urban Generation

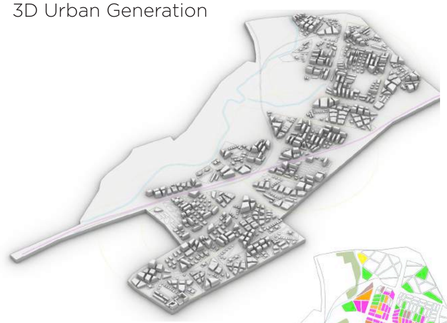
Amenity Emergence Result



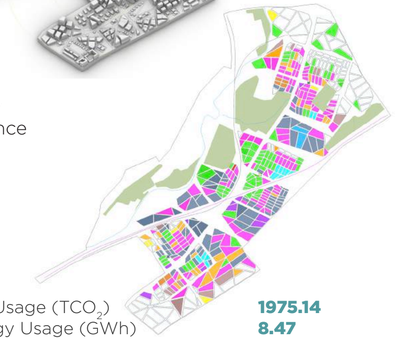
Total CO_2 Usage (TCO_2)	**3839.64**
Total Energy Usage (GWh)	**16.47**
Accessibility to Amenities	**34.83**
Accessibility to Transport	**2.69**
Average Vehicle Distance (m)	**716.95**
Total Homes	**19292**
People Working Outside Site	**8620**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(78.40)(57.95) (4.71)(1.19)(15.22) (3681.78)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(42%)(13%)(44%) (1%)**
Total Emission (TCO_2) (if everyone drives)	**7839**
Wind Turbine Required (nos)	**2353**
Solar Panels (m^2)	**76246.44**
Roof Area (%)	**28.81**
Solar Panels Installation (M£)	**16.78 7.84**

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 2

3D Urban Generation



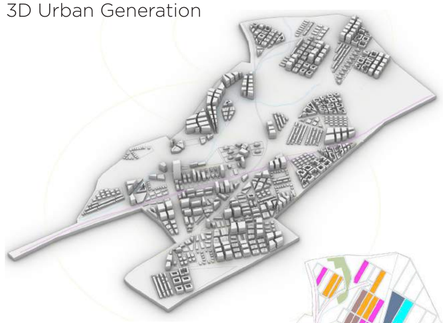
Amenity Emergence Result



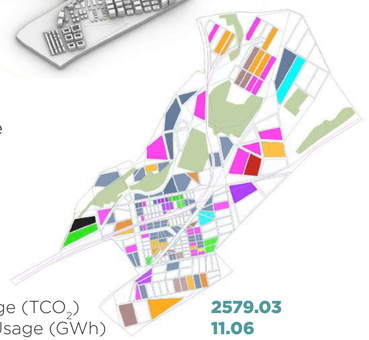
Total CO_2 Usage (TCO_2)	**1975.14**
Total Energy Usage (GWh)	**8.47**
Accessibility to Amenities	**47.58**
Accessibility to Transport	**2.44**
Average Vehicle Distance (m)	**616.81**
Total Homes	**15860**
People Working Outside Site	**4740**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(38.62)(91.07) (41.98)(2.49) (31.37)(1768.81)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(31%)(15%) (52%)(2%)**
Total Emission (TCO_2) (if everyone drives)	**5720.77**
Wind Turbine Required (nos)	**1211**
Solar Panels (m^2)	**39221.81**
Roof Area (%)	**16.77**
Solar Panels Installation (M£)	**784**

TRANSIT ORIENTED DEVELOPMENT LOCATION 1

3D Urban Generation



Amenity Emergence Result



Total CO_2 Usage (TCO_2)	**2579.03**
Total Energy Usage (GWh)	**11.06**
Accessibility to Amenities	**35.82**
Accessibility to Transport	**1.93**
Average Vehicle Distance (m)	**465.86**
Total Homes	**16%**
People Working Outside Site	**13524**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(18.31)(463.42) (11.46)(1.53) (30.75)(2053.06)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(25%)(18%) (56%) (1%)**
Total Emission (TCO_2) (if everyone drives)	**5302.46**
Wind Turbine Required (nos)	**1581**
Solar Panels (m^2)	**51213.64**
Roof Area (%)	**13.19**
Solar Panels Installation (M£)	**10.24**

TRANSIT ORIENTED DEVELOPMENT LOCATION 2

3D Urban Generation

Amenity Emergence Result

Total CO_2 Usage (TCO_2)	**2945.12**
Total Energy Usage (GWh)	**12.6**
Accessibility to Amenities	**27.62**
Accessibility to Transport	**1.71**
Average Vehicle Distance (m)	**714.88**
Total Homes	**14609**
People Working Outside Site	**6340**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(15.62)(53.31) (9.14)(0.29) (20.26)(2846.4)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(32%)(48%)(18%) (0.88%)**
Total Emission (TCO_2) (if everyone drives)	**7125.95**
Wind Turbine Required (nos)	**1805**
Solar Panels (m^2)	**58483.16**
Roof Area (%)	**18.96**
Solar Panels Installation (M£)	**11.7**

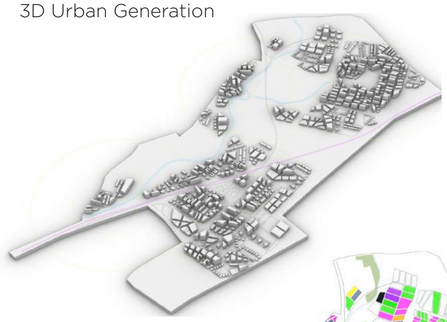
INTERSECT ROAD GENERATIONS

How Neighbourhood Strategies Affect Urban Density, Accessibility & Emission Levels

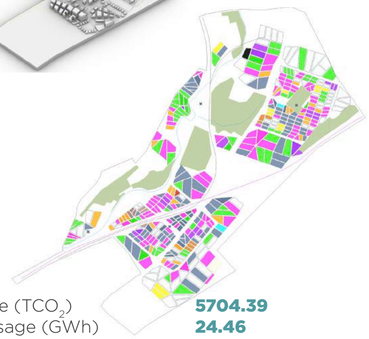
The generated urban city shows the affect of neighbourhood strategies on the plots and how they relate to network routes. The data on accessibility, emissions & ways to offset produced carbon are listed below.

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 1

3D Urban Generation



Amenity
Emergence
Result

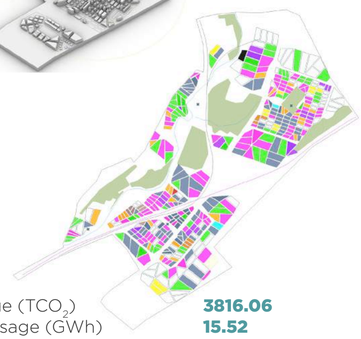


Total CO_2 Usage (TCO_2)	**5704.39**
Total Energy Usage (GWh)	**24.46**
Accessibility to Amenities	**35.82**
Accessibility to Transport	**23.17**
Average Vehicle Distance (m)	**1405.12**
Total Homes	**19292**
People Working Outside Site	**5126**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(34.46)(216.09) (18.15)(0)(43.69) (5391.99)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(61.59)(15.56) (22.21)(0.64)**
Total Emission (TCO_2) (if everyone drives)	**10790**
Wind Turbine Required (nos)	**3496**
Solar Panels (m^2)	**113276.13**
Roof Area (%)	**51.32**
Solar Panels Installation (M£)	**22.66**

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 2

3D Urban Generation

Amenity
Emergence
Result



Total CO_2 Usage (TCO_2)	**3816.06**
Total Energy Usage (GWh)	**15.52**
Accessibility to Amenities	**38.47**
Accessibility to Transport	**2.63**
Average Vehicle Distance (m)	**1413.28**
Total Homes	**17546**
People Working Outside Site	**4218**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(35.52)(185.58) (15.62)(11)(50.14) (3315.66)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(35.15)(42.80) (19.59)(2.00)**
Total Emission (TCO_2) (if everyone drives)	**10542**
Wind Turbine Required (nos)	**2217**
Solar Panels (m^2)	**71846.48**
Roof Area (%)	**25.31**
Solar Panels Installation (M£)	**14.37**

TRANSIT ORIENTED DEVELOPMENT LOCATION 1

3D Urban Generation

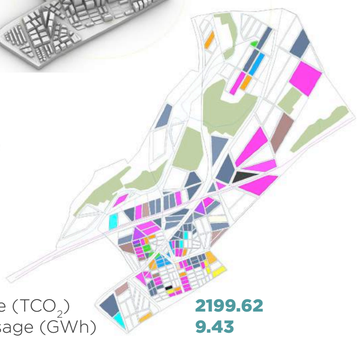
Amenity
Emergence
Result

Total CO_2 Usage (TCO_2)	**2714.20**
Total Energy Usage (GWh)	**11.64**
Accessibility to Amenities	**33.17**
Accessibility to Transport	**1.95**
Average Vehicle Distance (m)	**718.01**
Total Homes	**12910**
People Working Outside Site	**6389**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(18.89)(54.94) (15.51)(0.97) (22.29)(2601.29)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(27.27)(51.43) (20.38)(0.93)**
Total Emission (TCO_2) (if everyone drives)	**7141.55**
Wind Turbine Required (nos)	**1664**
Solar Panels (m^2)	**54897.79**
Roof Area (%)	**14.79**
Solar Panels Installation (M£)	**10.78**

TRANSIT ORIENTED DEVELOPMENT LOCATION 2

3D Urban Generation

Amenity
Emergence
Result



Total CO_2 Usage (TCO_2)	**2199.62**
Total Energy Usage (GWh)	**9.43**
Accessibility to Amenities	**29.42**
Accessibility to Transport	**1.80**
Average Vehicle Distance (m)	**367.82**
Total Homes	**14526**
People Working Outside Site	**5726**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(16.51)(79.74) (31.72)(0)(5.52) (2066.13)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(24.44)(18.30) (57.35)(0.18)**
Total Emission (TCO_2) (if everyone drives)	**4776.25**
Wind Turbine Required (nos)	**1348**
Solar Panels (m^2)	**43679.47**
Roof Area (%)	**14.47**
Solar Panels Installation (M£)	**8.74**

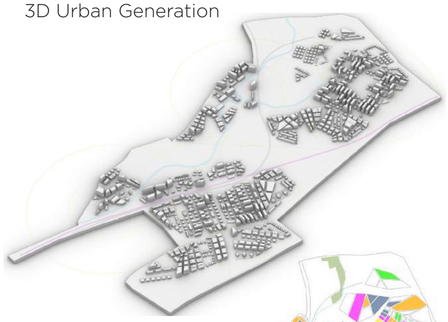
PARALLEL ROAD GENERATIONS

How Neighbourhood Strategies Affect Urban Density, Accessibility & Emission Levels

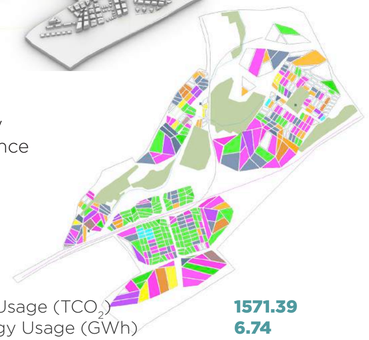
The generated urban city shows the affect of neighbourhood strategies on the plots and how they relate to network routes. The data on accessibility, emissions & ways to offset produced carbon are listed below.

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 1

3D Urban Generation



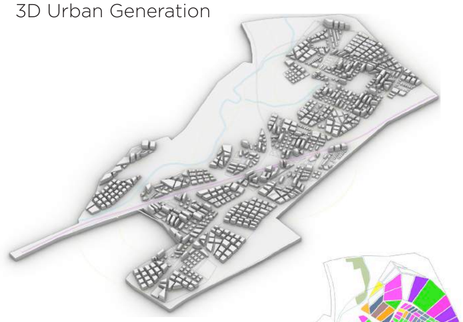
Amenity Emergence Result



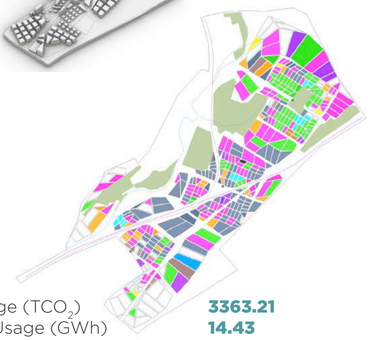
Total CO_2 Usage (TCO_2)	**1571.39**
Total Energy Usage (GWh)	**6.74**
Accessibility to Amenities	**39.82**
Accessibility to Transport	**2.50**
Average Vehicle Distance (m)	**635.17**
Total Homes	**19208**
People Working Outside Site (%)	**3723**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(37.27)(51.84) (6.40)(1.60) (8.37)(1465.39)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(29.31)(47.51) (22.04)(1.13)**
Total Emission (TCO_2) (if everyone drives)	**5465.82**
Wind Turbine Required (nos)	**962**
Solar Panels (m^2)	**31204.2**
Roof Area (%)	**12.51**
Solar Panels Installation (M£)	**6.21**

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 2

3D Urban Generation



Amenity Emergence Result



Total CO_2 Usage (TCO_2)	**3363.21**
Total Energy Usage (GWh)	**14.43**
Accessibility to Amenities	**43.19**
Accessibility to Transport	**2.48**
Average Vehicle Distance (m)	**1271.38**
Total Homes	**15490**
People Working Outside Site	**4756**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(32.46)(161.78) (15.20)(2.13) (70.27)(3080.69)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(33.77)(44.66) (20.06)(1.51)**
Total Emission (TCO_2) (if everyone drives)	**9878.98**
Wind Turbine Required (nos)	**2061**
Solar Panels (m^2)	**66785.70**
Roof Area (%)	**22.96**
Solar Panels Installation (M£)	**13.38**

TRANSIT ORIENTED DEVELOPMENT LOCATION 1

3D Urban Generation

Amenity Emergence Result

Total CO_2 Usage (TCO_2)	**2065.39**
Total Energy Usage (GWh)	**8.86**
Accessibility to Amenities	**35.47**
Accessibility to Transport	**1.96**
Average Vehicle Distance (m)	**539.79**
Total Homes	**14420**
People Working Outside Site	**5021**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(12.63)(106.552) (52.77)(1.85) (7.44)(1883.59)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(20.89)(19.12) (59.44)(0.56)**
Total Emission (TCO_2) (if everyone drives)	**5570.71**
Wind Turbine Required (nos)	**1266**
Solar Panels (m^2)	**41014.87**
Roof Area (%)	**12.52**
Solar Panels Installation (M£)	**8.20**

TRANSIT ORIENTED DEVELOPMENT LOCATION 2

3D Urban Generation

Amenity Emergence Result

Total CO_2 Usage (TCO_2)	**2424.28**
Total Energy Usage (GWh)	**10.40**
Accessibility to Amenities	**28.18**
Accessibility to Transport	**2.03**
Average Vehicle Distance (m)	**942.50**
Total Homes	**15401**
People Working Outside Site	**4664**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(13.23)(104.80) (19.23)(0)(6.86) (2280.15)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(24.76)(54.37) (20.74)(0.14)**
Total Emission (TCO_2) (if everyone drives)	**7945.68**
Wind Turbine Required (nos)	**1486**
Solar Panels (m^2)	**48140.63**
Roof Area (%)	**15.1**
Solar Panels Installation (M£)	**9.63**

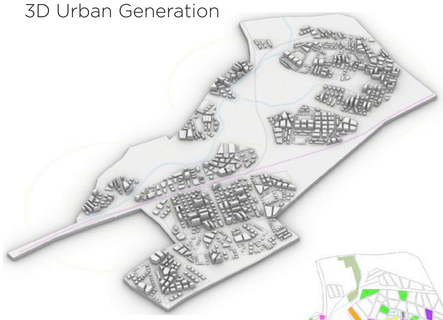
NETWORK ROAD GENERATIONS

How Neighbourhood Strategies Affect Urban Density, Accessibility & Emission Levels

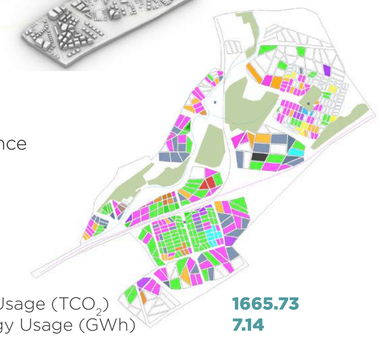
The generated urban city shows the affect of neighbourhood strategies on the plots and how they relate to network routes. The data on accessibility, emissions & ways to offset produced carbon are listed below.

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 1

3D Urban Generation



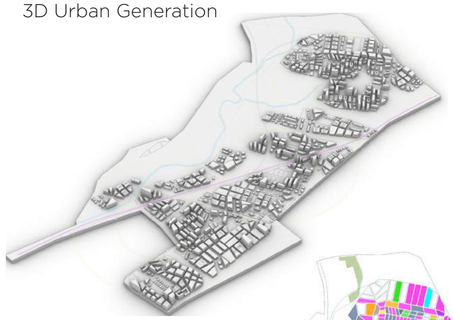
Amenity Emergence Result



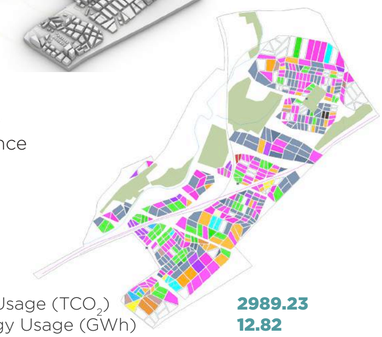
Total CO_2 Usage (TCO_2)	**1665.73**
Total Energy Usage (GWh)	**7.14**
Accessibility to Amenities	**35.52**
Accessibility to Transport	**3.21**
Average Vehicle Distance (m)	**389.37**
Total Homes	**17957**
People Working Outside Site (%)	**4691**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(36.20)(66.02) (3.58)(0.97) (18.86)(1540.94)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(33.45)(44.54) (20.90)(1.10)**
Total Emission (TCO_2) (if everyone drives)	**4320.76**
Wind Turbine Required (nos)	**1021**
Solar Panels (m^2)	**33077.64**
Roof Area (%)	**15.10**
Solar Panels Installation (M£)	**6.62**

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 2

3D Urban Generation



Amenity Emergence Result



Total CO_2 Usage (TCO_2)	**2989.23**
Total Energy Usage (GWh)	**12.82**
Accessibility to Amenities	**40.78**
Accessibility to Transport	**3.53**
Average Vehicle Distance (m)	**984.75**
Total Homes	**15020**
People Working Outside Site	**3886**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(20.33)(115.58) (8.36)(5.09) (75.57)(2762.67)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(37.17)(43.98) (16.01)(2.84)**
Total Emission (TCO_2) (if everyone drives)	**7889.67**
Wind Turbine Required (nos)	**1832**
Solar Panels (m^2)	**59359.27**
Roof Area (%)	**21.53**
Solar Panels Installation (M£)	**11.87**

TRANSIT ORIENTED DEVELOPMENT LOCATION 1

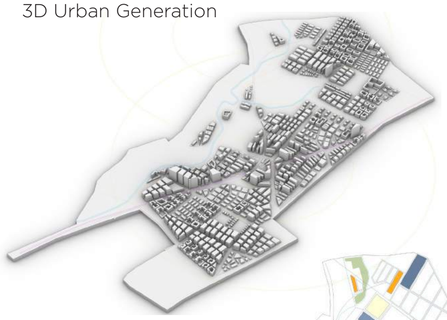
3D Urban Generation

Amenity Emergence Result

Total CO_2 Usage (TCO_2)	**2714.20**
Total Energy Usage (GWh)	**11.64**
Accessibility to Amenities	**33.17**
Accessibility to Transport	**1.95**
Average Vehicle Distance (m)	**718.01**
Total Homes	**12910**
People Working Outside Site	**6389**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(18.88)(54.94) (15.51)(0.97) (22.29)(2601.29)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(27.27)(51.43) (20.38)(0.93)**
Total Emission (TCO_2) (if everyone drives)	**7141.55**
Wind Turbine Required (nos)	**1664**
Solar Panels (m^2)	**53897.78**
Roof Area (%)	**14.79**
Solar Panels Installation (M£)	**10.78**

TRANSIT ORIENTED DEVELOPMENT LOCATION 2

3D Urban Generation



Amenity Emergence Result

Total CO_2 Usage (TCO_2)	**2199.62**
Total Energy Usage (GWh)	**9.43**
Accessibility to Amenities	**29.42**
Accessibility to Transport	**1.80**
Average Vehicle Distance (m)	**367.85**
Total Homes	**14526**
People Working Outside Site	**5726**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(16.51)(79.74) (31.72)(0)(5.52) (2066.13)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(24.44)(28.03) (57.35)(0.17)**
Total Emission (TCO_2) (if everyone drives)	**(4776.25)**
Wind Turbine Required (nos)	**1348**
Solar Panels (m^2)	**43679.47**
Roof Area (%)	**14.47**
Solar Panels Installation (M£)	**8.74**

PERIPHERAL (LEFT) ROAD GENERATIONS

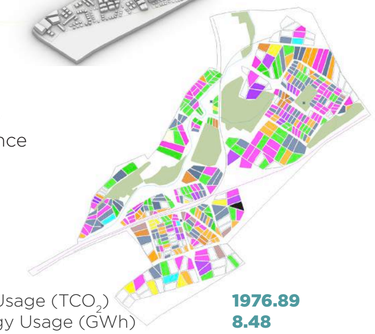
How Neighbourhood Strategies Affect Urban Density, Accessibility & Emission Levels

The generated urban city shows the affect of neighbourhood strategies on the plots and how they relate to network routes. The data on accessibility, emissions & ways to offset produced carbon are listed below.

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 1

3D Urban Generation

Amenity Emergence Result

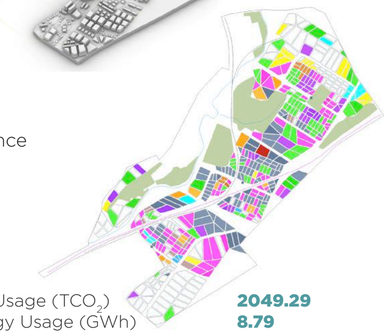


Total CO_2 Usage (TCO_2)	**1976.89**
Total Energy Usage (GWh)	**8.48**
Accessibility to Amenities	**45.89**
Accessibility to Transport	**2.79**
Average Vehicle Distance (m)	**477.41**
Total Homes	**18278**
People Working Outside Site (%)	**4313**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(24.12)(67)(5.68) (0.71)(13.75) (1865.40)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(34.68)(45.46) (1901)(0.84)**
Total Emission (TCO_2) (if everyone drives)	**4819.92**
Wind Turbine Required (nos)	**1212**
Solar Panels (m^2)	**39256.57**
Roof Area (%)	**13.27**
Solar Panels Installation (M£)	**7.85**

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 2

3D Urban Generation

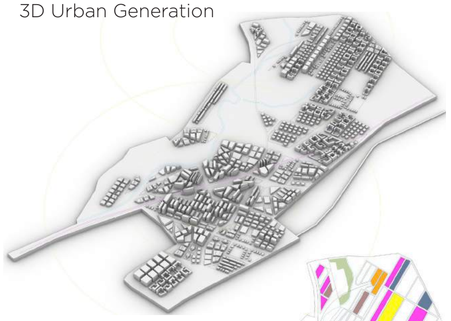
Amenity Emergence Result



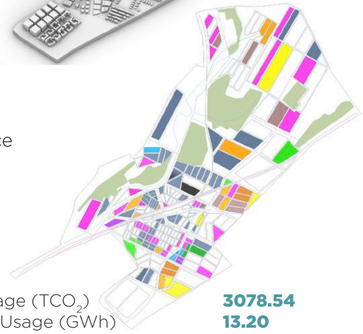
Total CO_2 Usage (TCO_2)	**2049.29**
Total Energy Usage (GWh)	**8.79**
Accessibility to Amenities	**32.28**
Accessibility to Transport	**2.78**
Average Vehicle Distance (m)	**555.13**
Total Homes	**15711**
People Working Outside Site	**4970**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(38.86)(51.65) (3.93)(0.97) (2.83)(1951.22)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(37.27)(41.14) (20.50)(1.10)**
Total Emission (TCO_2) (if everyone drives)	**5428.78**
Wind Turbine Required (nos)	**1256**
Solar Panels (m^2)	**40694.31**
Roof Area (%)	**15.59**
Solar Panels Installation (M£)	**8.14**

TRANSIT ORIENTED DEVELOPMENT LOCATION 1

3D Urban Generation



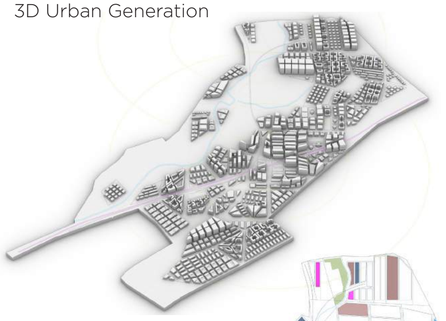
Amenity Emergence Result



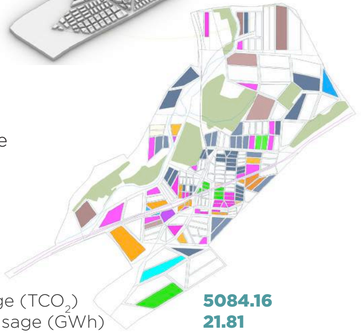
Total CO_2 Usage (TCO_2)	**3078.54**
Total Energy Usage (GWh)	**13.20**
Accessibility to Amenities	**31.56**
Accessibility to Transport	**2.03**
Average Vehicle Distance (m)	**406.33**
Total Homes	**16030**
People Working Outside Site (%)	**13276**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(91.41)(36.83) (5.77)(0.76) (10.31)(2933.21)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(29.71)(38.39) (31.08)(0.82)**
Total Emission (TCO_2) (if everyone drives)	**7438.83**
Wind Turbine Required (nos)	**1887**
Solar Panels (m^2)	**61132.82**
Roof Area (%)	**20.43**
Solar Panels Installation (M£)	**12.23**

TRANSIT ORIENTED DEVELOPMENT LOCATION 2

3D Urban Generation



Amenity Emergence Result



Total CO_2 Usage (TCO_2)	**5084.16**
Total Energy Usage (GWh)	**21.81**
Accessibility to Amenities	**27.33**
Accessibility to Transport	**1.97**
Average Vehicle Distance (m)	**496.28**
Total Homes	**13756**
People Working Outside Site	**13539**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(31.72)(38.84) (33.09)(0.66) (17.90)(4691.74)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(45.60)(11.95) (41.66)(0.78)**
Total Emission (TCO_2) (if everyone drives)	**8552.78**
Wind Turbine Required (nos)	**3116**
Solar Panels (m^2)	**100959.87**
Roof Area (%)	**30.14**
Solar Panels Installation (M£)	**20.19**

PERIPHERAL (RIGHT) ROAD GENERATIONS

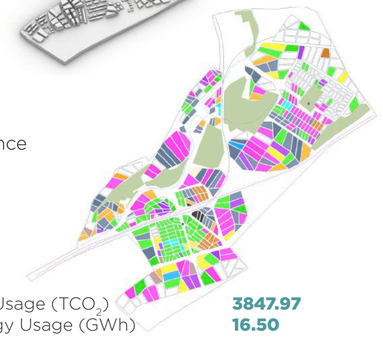
How Neighbourhood Strategies Affect Urban Density, Accessibility & Emission Levels

The generated urban city shows the affect of neighbourhood strategies on the plots and how they relate to network routes. The data on accessibility, emissions & ways to offset produced carbon are listed below.

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 1

3D Urban Generation

Amenity Emergence Result

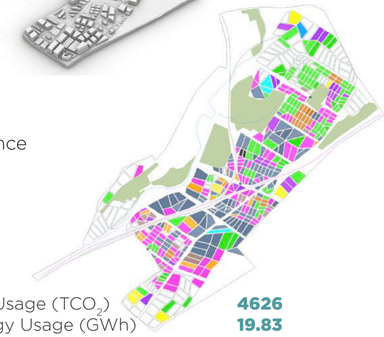


Total CO_2 Usage (TCO_2)	**3847.97**
Total Energy Usage (GWh)	**16.50**
Accessibility to Amenities	**38.40**
Accessibility to Transport	**3.13**
Average Vehicle Distance (m)	**334.11**
Total Homes	**18410**
People Working Outside Site (%)	**8995**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(34.12)(54.30) (3.45)(0.69) (11.46)(3744.74)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(67.66)(12.66) (18.85)(0.83)**
Total Emission (TCO_2) (if everyone drives)	**5796.99**
Wind Turbine Required (nos)	**2358**
Solar Panels (m^2)	**76411.85**
Roof Area (%)	**21.61**
Solar Panels Installation (M£)	**15.28**

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 2

3D Urban Generation

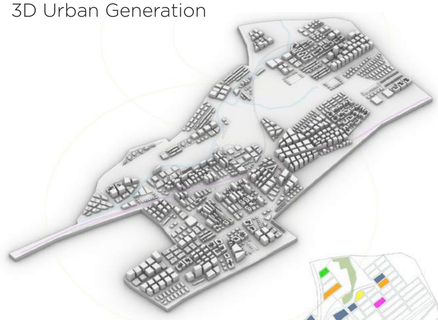
Amenity Emergence Result



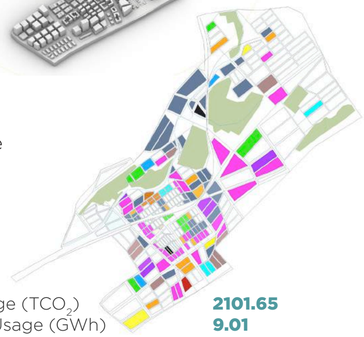
Total CO_2 Usage (TCO_2)	**4626**
Total Energy Usage (GWh)	**19.83**
Accessibility to Amenities	**47.02**
Accessibility to Transport	**3.27**
Average Vehicle Distance (m)	**1217.19**
Total Homes	**15420**
People Working Outside Site (%)	**8729**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(37.83)(149.60) (9.64)(2.77) (33.52)(4389.75)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(42.48)(37.46) (18.98)(1.09)**
Total Emission (TCO_2) (if everyone drives)	**10646.52**
Wind Turbine Required (nos)	**2834**
Solar Panels (m^2)	**91822.13**
Roof Area (%)	**33**
Solar Panels Installation (M£)	**18.36**

TRANSIT ORIENTED DEVELOPMENT LOCATION 1

3D Urban Generation



Amenity Emergence Result

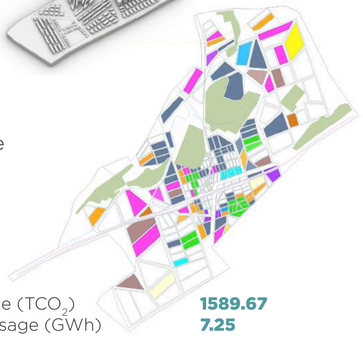


Total CO_2 Usage (TCO_2)	**2101.65**
Total Energy Usage (GWh)	**9.01**
Accessibility to Amenities	**28.72**
Accessibility to Transport	**2.480**
Average Vehicle Distance (m)	**502.78**
Total Homes	**14085**
People Working Outside Site	**4701**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(11.71)(27.98) (6.64)(0.14)(0.51) (2054.61)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(29.45)(50.98) (19.24)(0.32)**
Total Emission (TCO_2) (if everyone drives)	**5242.63**
Wind Turbine Required (nos)	**1288**
Solar Panels (m^2)	**41733.92**
Roof Area (%)	**11.47**
Solar Panels Installation (M£)	**8.35**

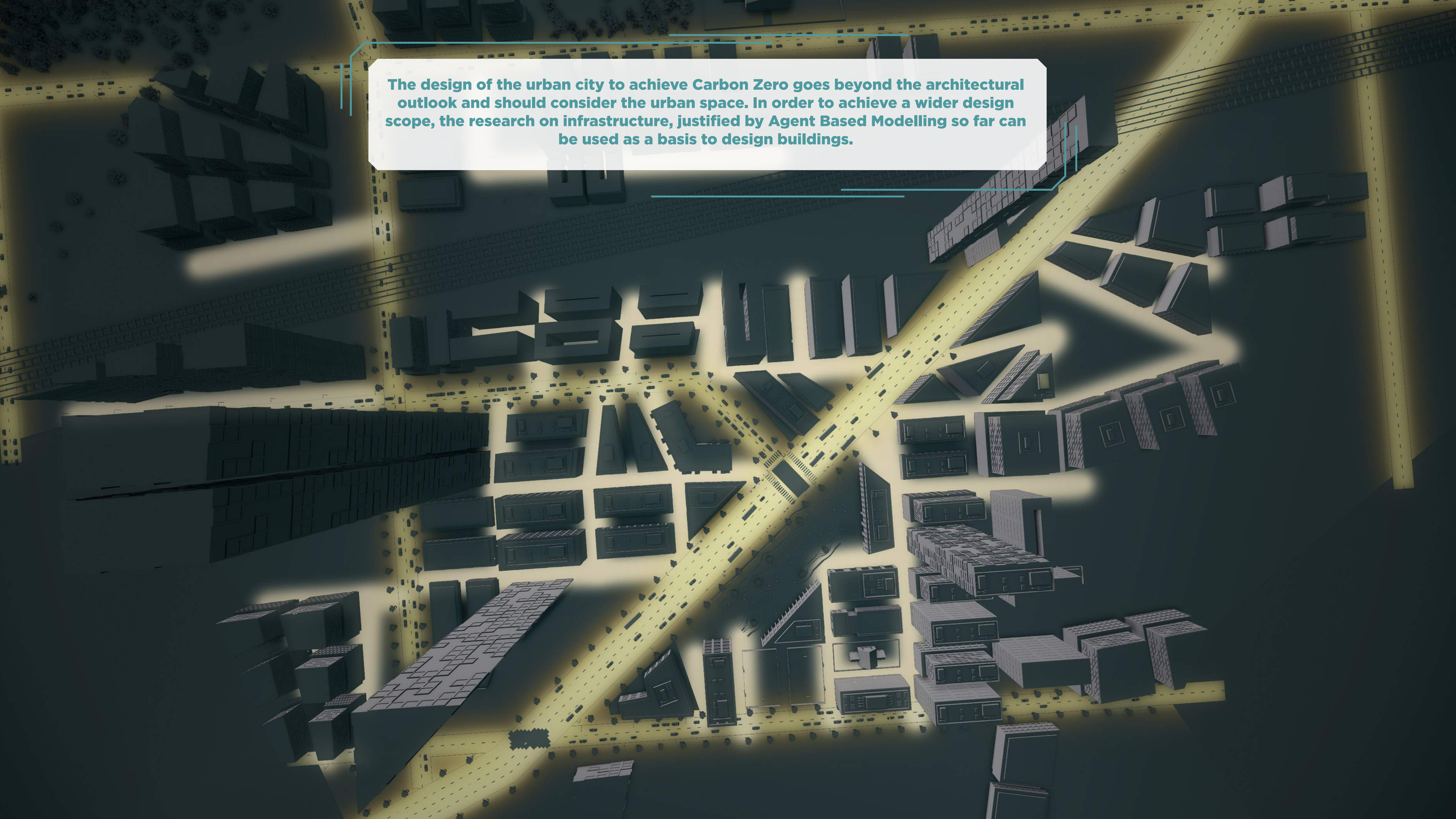
TRANSIT ORIENTED DEVELOPMENT LOCATION 2

3D Urban Generation

Amenity Emergence Result



Total CO_2 Usage (TCO_2)	**1589.67**
Total Energy Usage (GWh)	**7.25**
Accessibility to Amenities	**32.32**
Accessibility to Transport	**1.99**
Average Vehicle Distance (m)	**415.17**
Total Homes	**13842**
People Working Outside Site	**4561**
Total CO_2 (TCO_2) (Tram) (Bus) (Minibus) (E-Bike) (E-Scooter) (Car)	**(16.52)(75.79) (11.75)(0)(2.69) (1582.91)**
People Who Drive (%) Walk(%) Public Trans.(%) Active Trans.(%)	**(19.55)(57.72) (22.61)(0.11)**
Total Emission (TCO_2) (if everyone drives)	**4589.29**
Wind Turbine Required (nos)	**1036**
Solar Panels (m^2)	**33552.95**
Roof Area (%)	**10.98**
Solar Panels Installation (M£)	**6.71**



The design of the urban city to achieve Carbon Zero goes beyond the architectural outlook and should consider the urban space. In order to achieve a wider design scope, the research on infrastructure, justified by Agent Based Modelling so far can be used as a basis to design buildings.

OVERALL ANALYSIS

Comparing All Categories Against All 24 Results

The urban density plays an important role in reducing motorised vehicles. Each urban strategy has a different theory and approach and thus generate different results with different grid layout, plot sizes and urban grain. This page compares the urban layout from the 2 best performing results

POD Average Carbon Emission:
3227.15TCO_2

POD Average Carbon Energy Usage:
12.98GWh

POD Amenities Accessibility Score:
40.44

POD Transport Accessibility Score:
7.04

Average Vehicle Distance:
845m

TOD Average Carbon Emission:
3075.73TCO_2

TOD Average Carbon Energy Usage:
14.05GWh

TOD Amenities Accessibility Score:
30.74

TOD Transport Accessibility Score:
5.27

TOD Transport Accessibility Score:
643m

Number of wind turbines to offset carbon Emissions:
1855

Area of Solar Panel needed to offset Carbon Emissions:
60112.24m^2

In percentage of total roof space in the site
22.46%

Number of wind turbines to offset carbon Emissions:
2008

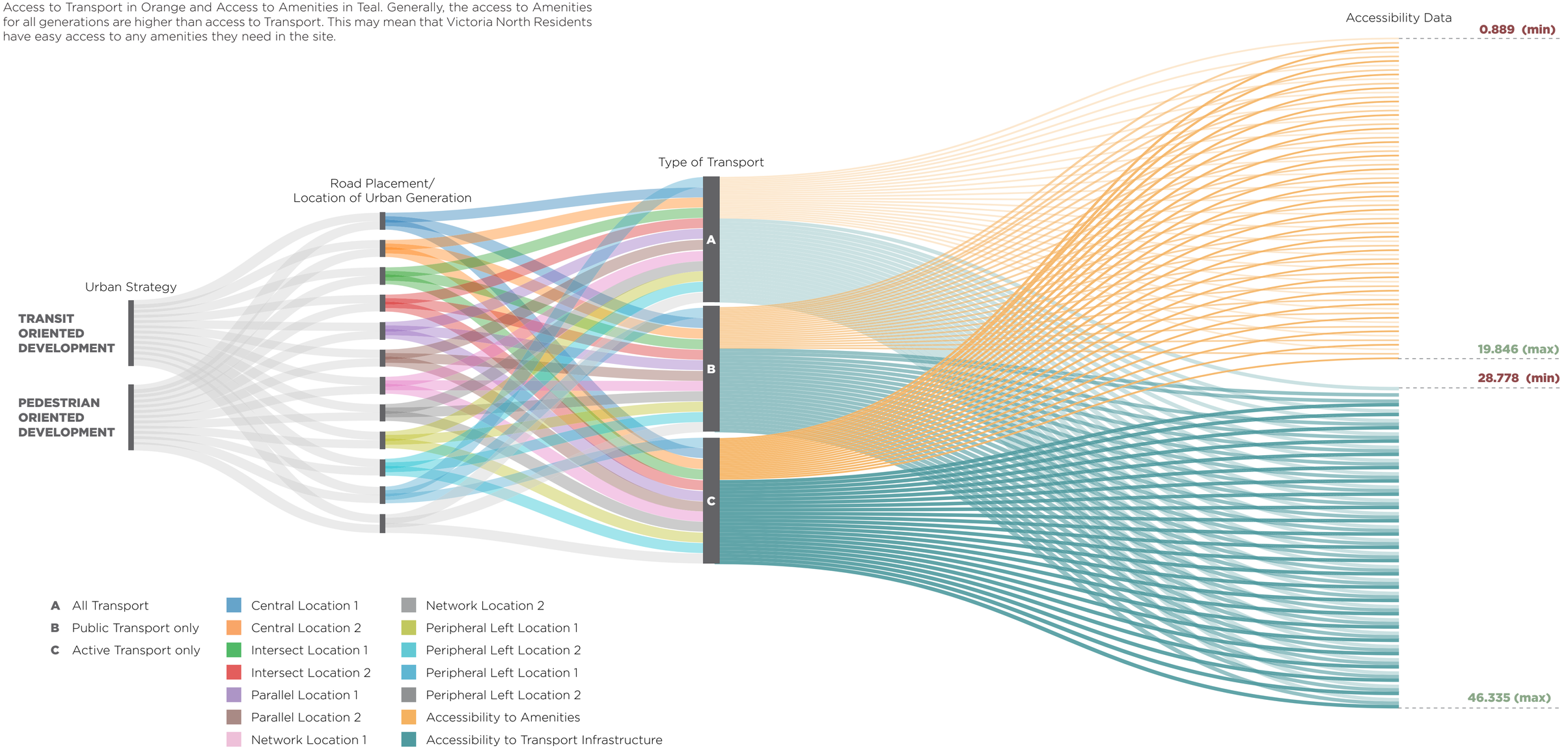
Area of Solar Panel needed to offset Carbon Emissions:
65048.5m^2

In percentage of total roof space in the site
20.41%

ACCESS TO TRANSPORT & AMENITIES ANALYSIS

Access to Amenities are Higher than to Transport for 24 Generations

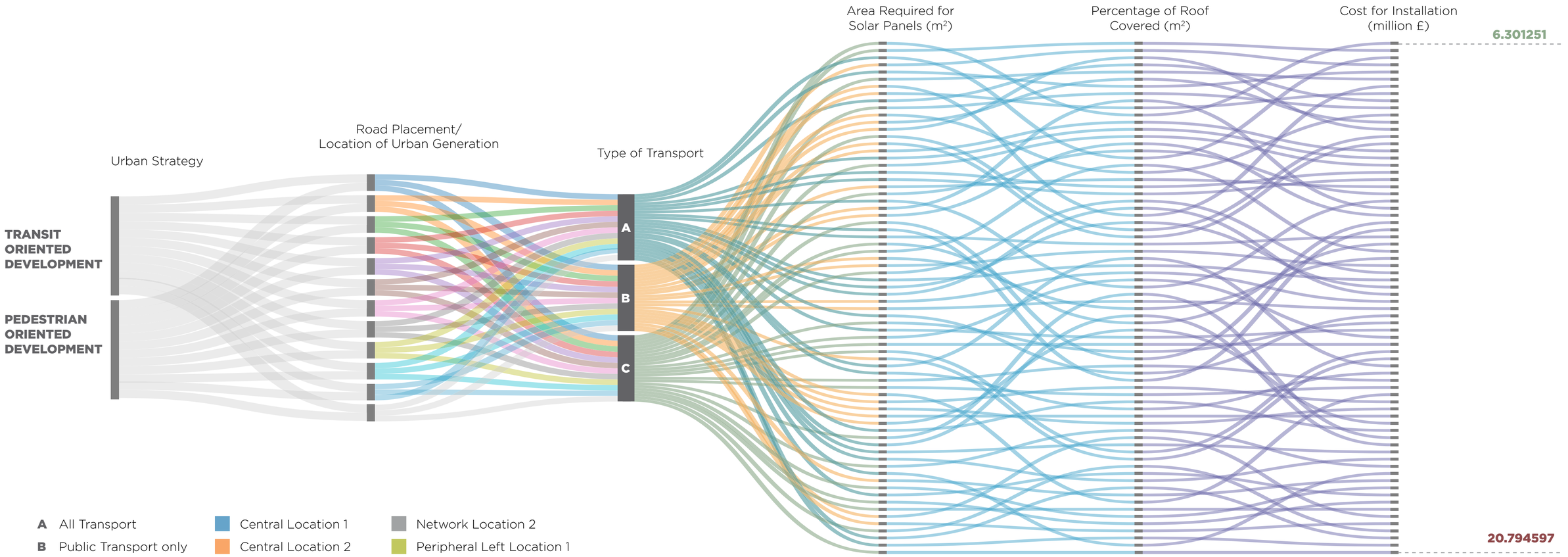
All the data from the 24 generations are translated to a Sankey diagram. This diagram visualises Access to Transport in Orange and Access to Amenities in Teal. Generally, the access to Amenities for all generations are higher than access to Transport. This may mean that Victoria North Residents have easy access to any amenities they need in the site.



INSTALLING SOLAR PANELS TO OFFSET CARBON

How Much Would it Cost to Offset Carbon in Victoria North?

All the data from the 24 generations are translated to a Sankey diagram. This diagram visualises the total area required for installing solar panels and the installation costs. The cheapest cost is 6 million and the highest is 20 million to offset the carbon in Victoria North.



A All Transport
B Public Transport only
C Active Transport only

- Central Location 1
- Central Location 2
- Intersect Location 1
- Intersect Location 2
- Parallel Location 1
- Parallel Location 2
- Network Location 1
- Network Location 2
- Peripheral Left Location 1
- Peripheral Left Location 2
- Peripheral Left Location 1
- Peripheral Left Location 2
- Accessibility to Amenities
- Accessibility to Transport Infrastructure

SUMMARISING 24 GENERATED RESULTS

Comparing overall data between between Pedestrian & Transit Oriented Development

The data between all Pedestrian Oriented Development & Transit Oriented Development are compared in terms of carbon emissions, energy, Accessibility to Amenities & Transportation, Average distance travelled, Residents who work outside site and walk, residents who uses public transport & active transport. The number of wind turbines and solar panels needed to offset carbon for TOD is higher than POD.

	Total CO^2	Total Energy (GWh)	Accessibility to Amenities	Accessibility to Transportation	Average distance travelled	Residents Who Work Outside Site	Residents Who Drive (%)	Residents Who Walk (%)	Residents Who Uses Public Transport (%)	Residents Who Uses Active Transport (%)
Transit Oriented Development	3275.73	14.05	30.74	5.27	643.55	7229	35.87	34.07	24.26	5.8
Pedestrian Oriented Development	3027.15	12.98	40.44	7.04	845.01	5570	37.7	28.93	25.99	7.3

OFFSETTING CARBON

	Wind Turbine Required (m2)	Solar Panels (m2)	Roof Area (%)	Solar Panels Installation (£million)
Transit Oriented Development	2007.210831	65048.49914	20	13.00969992
Pedestrian Oriented Development	1854.892125	60112.24478	22	12.02244897

These results are extremely useful for planning consultants and Manchester City Council as they discover ways in which they can offset Carbon and take a step closer in achieving Zero Carbon Manchester, while considering costs & renewable energy.

MAIN FINDINGS FROM ANALYSIS

Pedestrian Oriented Development generates less emission (-8%).
Pedestrian Oriented Development is more accessible in general (both transit and amenities ~pod+32.5%).
Pedestrian Oriented Development results in less people working outside the site.
Pedestrian Oriented Development also have more people using public transport in general (+11%) and more people using active transport (+27%).

However,
Transit Oriented Development results in a better network, showing more people not using cars in general.
Transit Oriented Development also has a higher percentage of people walking*
Transit Oriented Development has lower average vehicle distance travelled**

*While this disproves the hypothesis that there would be a higher percentage of people walking in Pedestrian Oriented Development, this result could be affected by the the location of each agent's workplace (which is randomly assigned)

**While this disproves the hypothesis that there would be a higher average distance travelled with vehicles in Transit Oriented Development, this result could be affected by the the location of each agent's workplace (which is randomly assigned)

CHAPTER

05

ANALYSIS OF 2 OPTIMUM GENERATIONS

Generation Parallel, Location 1, Transit Oriented & Pedestrian Oriented Development

THE BEST PERFORMANCE

Comparing Parallel Road with Transit & Pedestrian Oriented Development

These two results portray the best performance in terms of Urban Density, Accessibility & Carbon Emissions. These elements will be analysed.

URBAN DENSITY

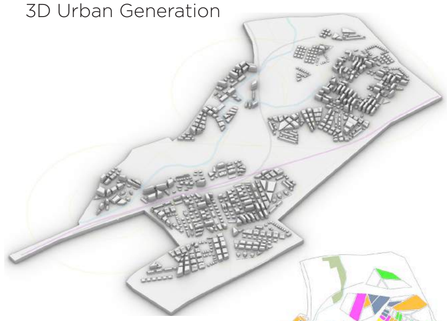
ACCESSIBILITY

CARBON EMISSIONS

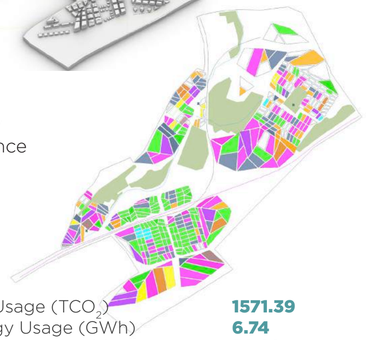
Comparison

PEDESTRIAN ORIENTED DEVELOPMENT LOCATION 1

3D Urban Generation



Amenity Emergence Result



Total CO_2 Usage (TCO_2)	**1571.39**
Total Energy Usage (GWh)	**6.74**
Accessibility to Amenities	**39.82**
Accessibility to Transport	**2.50**
Average Vehicle Distance (m)	**635.17**
Total Homes	**19208**
People Working Outside Site (%)	**3723**
Total CO_2 (TCO_2) (Tram) (Bus)	**(37.27)(51.84)**
(Minibus) (E-Bike) (E-Scooter) (Car)	**(6.40)(1.60)**
	(8.37)(1465.39)
People Who Drive (%) Walk(%)	**(29.31)(47.51)**
Public Trans.(%) Active Trans.(%)	**(22.04)(1.13)**
Total Emission (TCO_2) (if everyone drives)	**5465.82**
Wind Turbine Required (nos)	**962**
Solar Panels (m^2)	**31204.2**
Roof Area (%)	**12.51**
Solar Panels Installation (M£)	**6.21**

TRANSIT ORIENTED DEVELOPMENT LOCATION 1

3D Urban Generation

Amenity Emergence Result

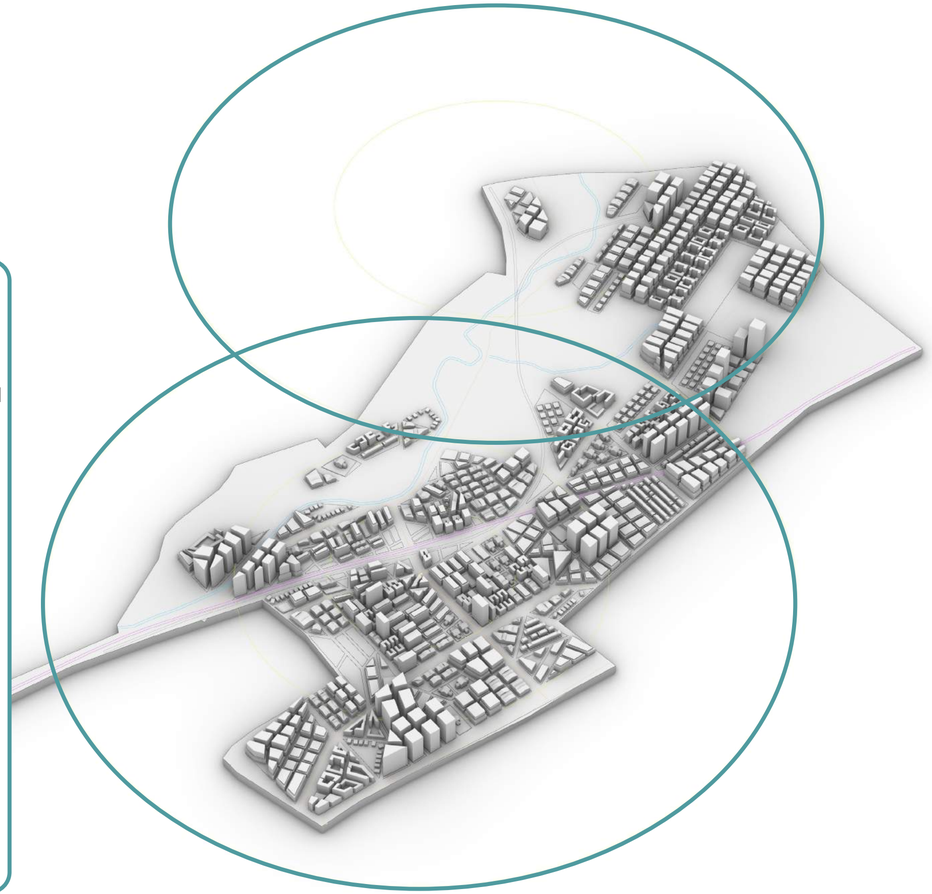
Total CO_2 Usage (TCO_2)	**2065.39**
Total Energy Usage (GWh)	**8.86**
Accessibility to Amenities	**35.47**
Accessibility to Transport	**1.96**
Average Vehicle Distance (m)	**539.79**
Total Homes	**14420**
People Working Outside Site	**5021**
Total CO_2 (TCO_2) (Tram) (Bus)	**(12.63)(106.552)**
(Minibus) (E-Bike) (E-Scooter) (Car)	**(52.77)(1.85)**
	(7.44)(1883.59)
People Who Drive (%) Walk(%)	**(20.89)(19.12)**
Public Trans.(%) Active Trans.(%)	**(59.44)(0.56)**
Total Emission (TCO_2) (if everyone drives)	**5570.71**
Wind Turbine Required (nos)	**1266**
Solar Panels (m^2)	**41014.87**
Roof Area (%)	**12.52**
Solar Panels Installation (M£)	**8.20**

ANALYSING THE URBAN GENERATIONS

Comparing the Urban Density between TOD & POD

The urban density plays an important role in reducing motorised vehicles. Each urban strategy has a different theory and approach and thus generate different results with different grid layout, plot sizes and urban grain. This page compares the urban layout from the 2 best performing results

POD		TOD
Pedestrian oriented	Urban design strategy	Transport oriented
Intra-neighbourhood connection	City focus	Inter-neighbourhood connection
4	Number of neighbourhoods	2
Medium to high	Mixed Use-ness	Very high
Bus	Main means of connectivity	Tram
Promote walkability & use of active transport	Strategic design goals	Promote use of public transport one or more transit hubs



Pedestrian Oriented Development: Parallel Road option Generation 1 (Seed 612)

The choice of using pedestrian oriented development produced a tighter urban layout that focuses on inner neighbourhood over inter neighbourhood movement. This strategy also creates an overall lower density city as there are more neighbourhoods that are able to fit into the site, which created more land that is in the highest importance spatially, or more “city centres”. However this also means that the connectivity between 2 neighbourhoods might be worse than transport oriented development.

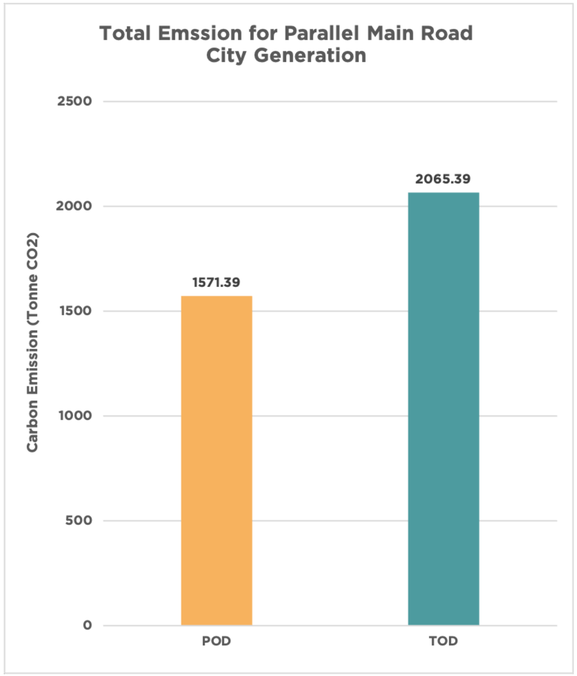
Transport Oriented Development: Parallel Road option Generation 1 (Seed 438)

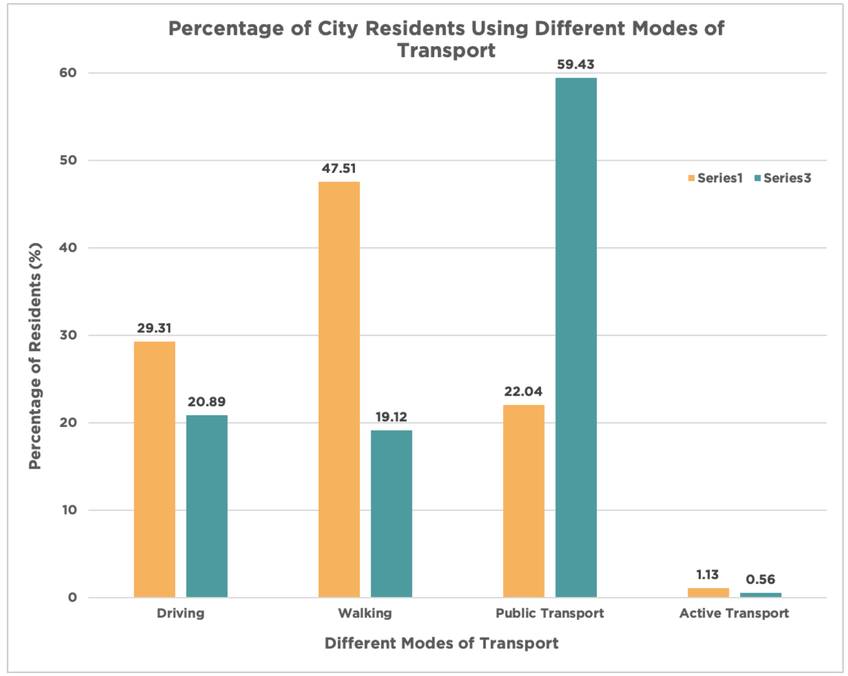
Transport oriented development connect residents mainly through tram, leading to a larger reach and therefore a bigger influence to surrounding areas thus less individual neighbourhood, similar to how current cities are built. Due to one small area acting as the city center for a large area, the agglomeration of amenities, offices and residential buildings is more severe, which creates a very high dense area with a lot of mixed use buildings.

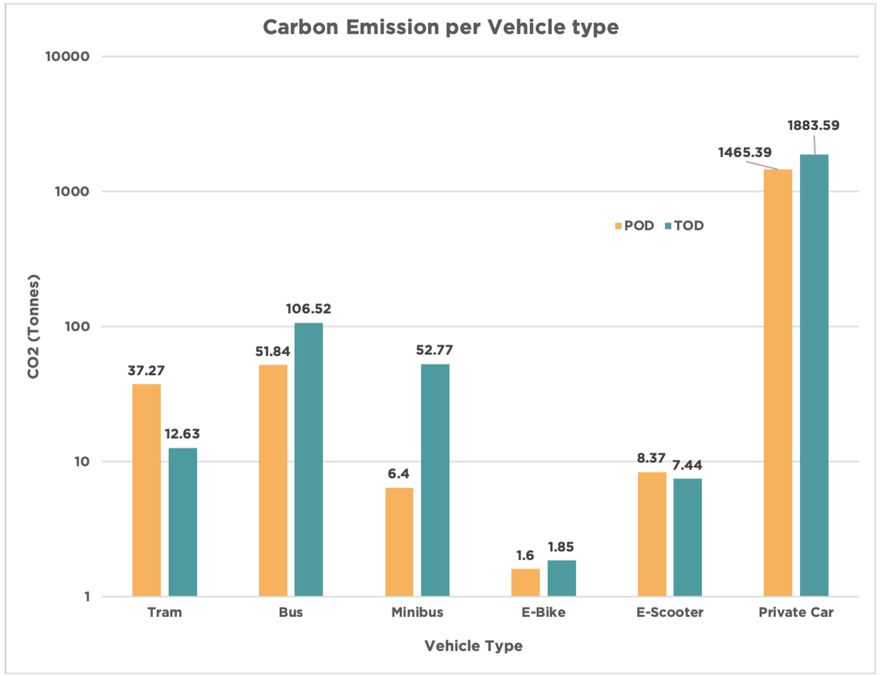
ANALYSING EMISSION LEVELS

Comparing the Emission Levels between TOD & POD

The generated urban city shows the affect of neighbourhood strategies on the plots and how they relate to network routes. It is important to understand that not one aspect of these urban generations are more important than the other but go hand in hand in affecting the urban density.







Comparing to overall average:

POD Average Carbon Emission (TCO_2):

3275.73

TOD Average Carbon Emission (TCO_2):

3027.15

The difference in carbon emissions for pedestrian oriented and transport oriented is not very big, standing at 494 Tonnes of CO_2. However this is still larger than the overall average difference of 249.5, nearly 2 times. However, both emissions are lower than their respective averages.

Overall, the lower carbon emission for pedestrian oriented development is due to a large amount of people walking to their destinations, which holds true as well when comparing to the overall picture. Although driving is still at a higher percentage than transport oriented, nearly half of the population walking compensated for it. Transit oriented also saw similar people decided to walk when compared to driving and almost 60% of the population takes a public transport. While being a mere 1.13%, pedestrian oriented development still managed to encourage more people to use active transport, which is its main goal.

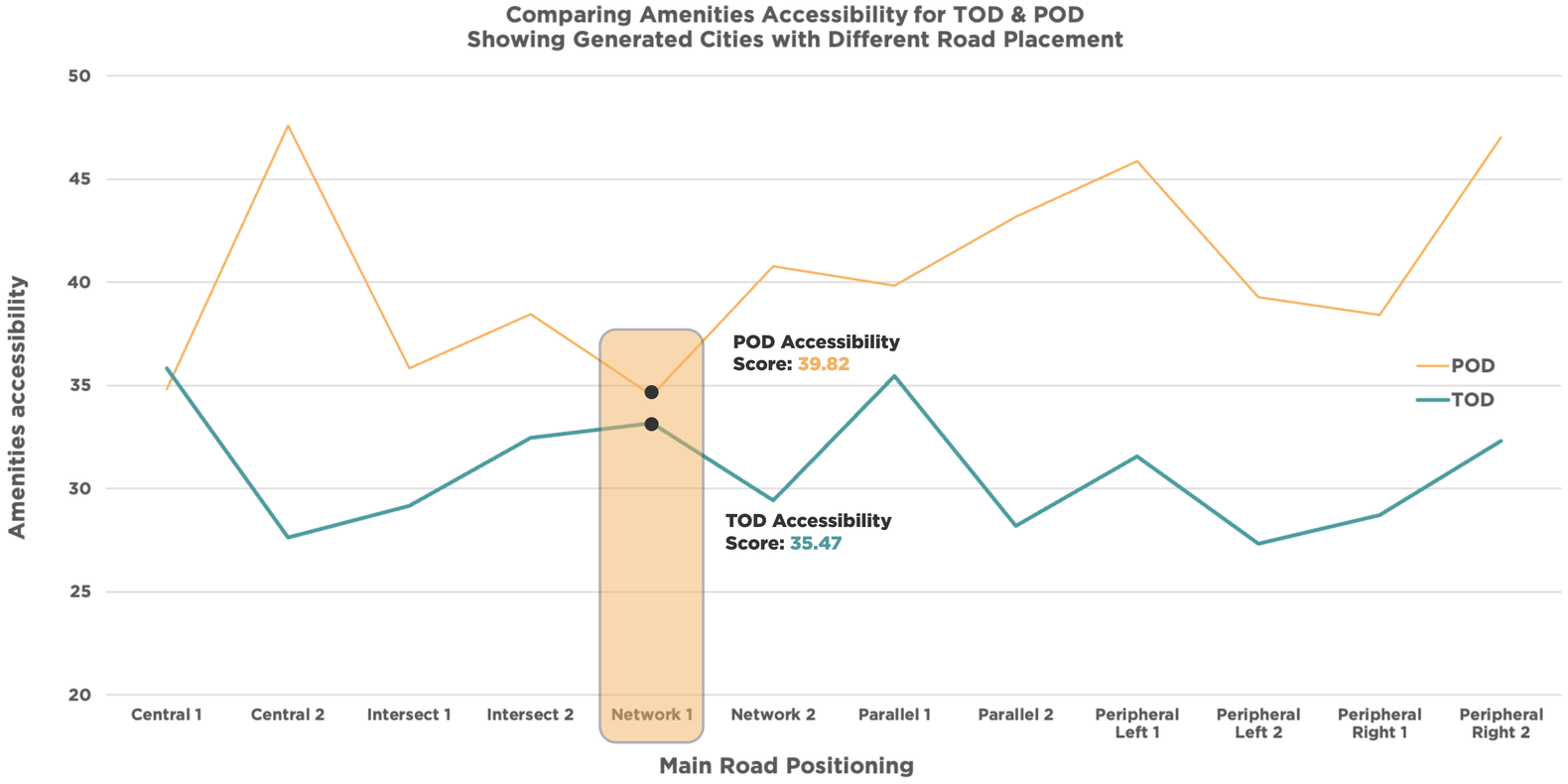
In order to show all the data in the graph, it was distorted into a logarithmic scale, but looking at the numbers will show a staggering 10 times higher emissions for private vehicles compared to the rest of the types of public transport.

Although a lot of people used public transport in TOD, the emissions is still lower combined compare to private vehicles. POD saw a more evenly distributed usage indicated by the carbon emissions and TOD saw a large usage in public transport compared to active transport.

ANALYSING AMENITIES ACCESSIBILITY

Comparing the Accessibility between TOD & POD

Accessibility is measured for 2 categories, accessibility to amenities and accessibility to transport. They are calculated through the number of amenities and transport stops in the vicinity of a residential building and its respective distance to it.



Accessibility in both categories will naturally be higher for pedestrian oriented development due to the compactness of neighbourhood spread out over a large site, however due to large area assigned as green and parks, the amenities accessibility is actually lowered.

As for transit oriented development, large residential plot size at the outer catchments brings amenities accessibility down as agglomeration draws most of the amenities inwards.

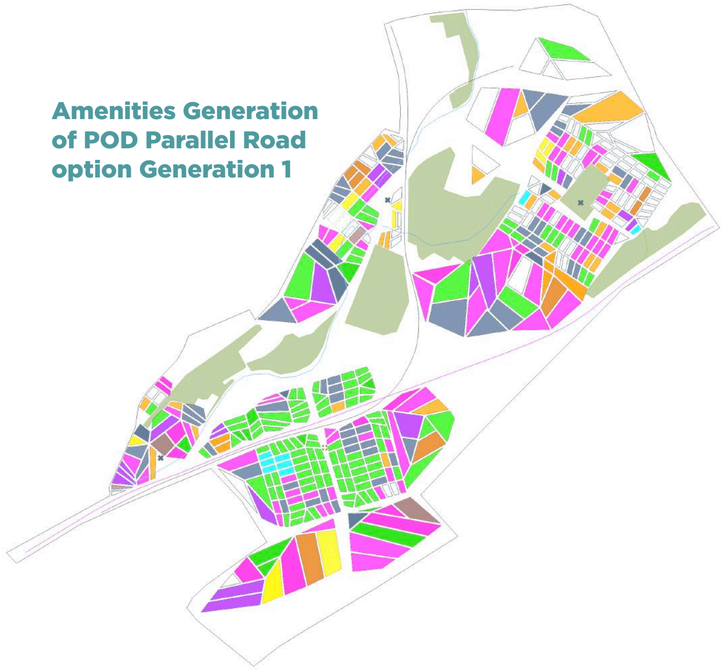
Another factor that leads to the close score might be due to the location of the main transit hub and the road selection. These factors greatly affect how the network is drawn and thus affect the plots and amenities distribution.

Comparing to overall average:

TOD Average Accessibility Score:
30.74

POD Average Accessibility Score:
40.44

Amenities Generation of POD Parallel Road option Generation 1



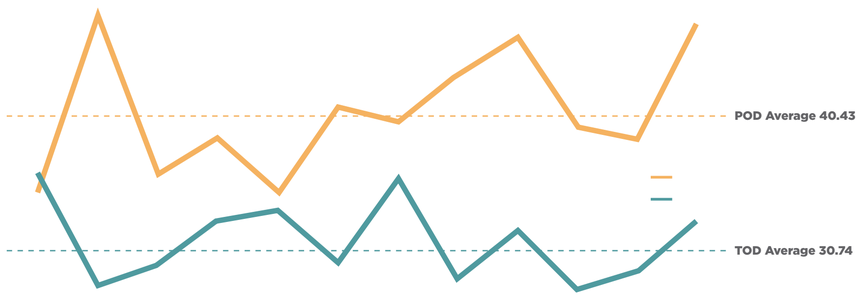
Amenities Generation of TOD Parallel Road option Generation 1

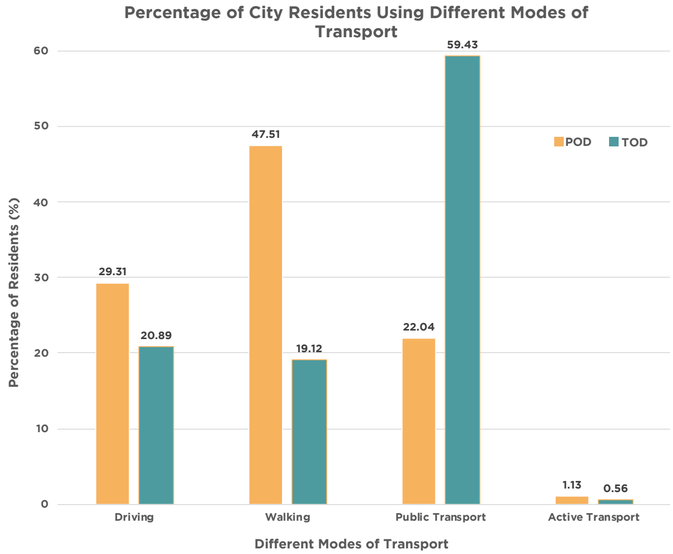
ANALYSING TRANSPORTATION ACCESSIBILITY

Comparing the Accessibility of Transport between TOD & POD

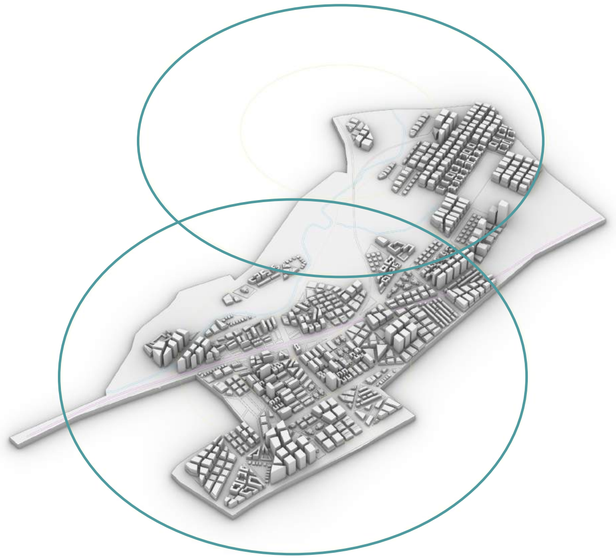
Accessibility is measured for 2 categories, accessibility to amenities and accessibility to transport. They are calculated through the number of amenities and transport stops in the vicinity of a residential building and its respective distance to it.

Transportation accessibility





Pedestrian Oriented Development:
Parallel Road option Generation 1 (Seed 612)



Transport Oriented Development:
Parallel Road option Generation 1 (Seed 438)

The pedestrian oriented development(POD) outperforms the transit oriented development(TOD) in transportation accessibility score.

This is due to the fact that PODs are inherently smaller neighbourhoods with smaller catchment circles (400 at the largest), compared to the TOD (800). This results in more bus stops being assigned due to the smaller occurrence circle sizes in a smaller catchment size.

Although this leads to better intra-neighbourhood connectivity, but at the expense of inter-neighbourhood connectivity, which the TOD strategy would fare better at. Thus, it is important for planners to prioritise the type of connectivity required in order to reap the rewards of the correct urban strategy.

POD Average Transportation Accessibility Score:
40.43

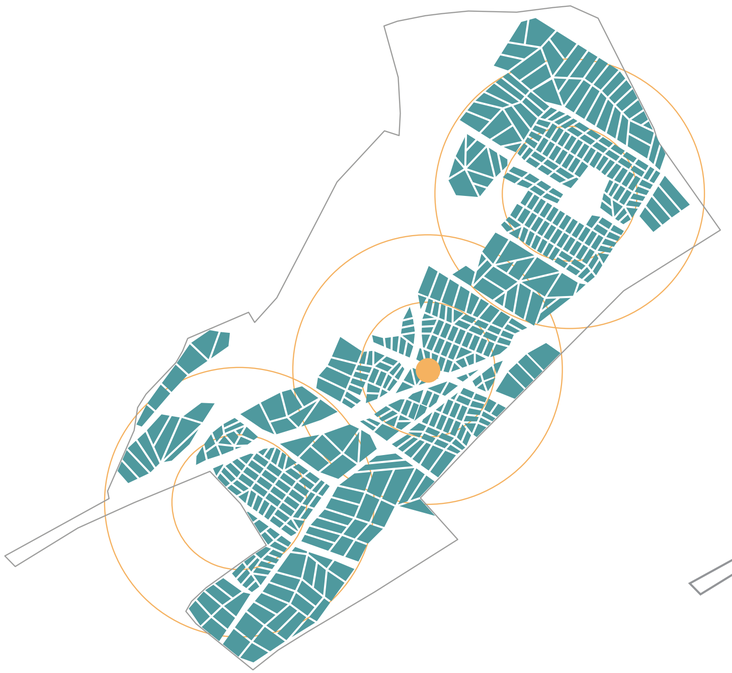
TOD Average Transportation Accessibility Score:
30.74

HAVE MEDIEVAL CITIES GOT IT RIGHT?

Comparing the Generated Urban Plots to Medieval Cities in terms of Accessibility

Pedestrian Oriented Development Generations prove to have higher accessibility levels compared to Transit Oriented Development. It is compared to Medieval City Plans ad the generated plot and layouts are similar in form and sprawl.

Pedestrian Oriented Development has a lower carbon emission levels, proving a better strategy in order to get closer in achieving Zero Carbon Manchester. The Generated are Urban Plots are similar to medieval cities.



PEDESTRIAN ORIENTED DEVELOPMENT
LOCATION 2

PEDESTRIAN ORIENTED DEVELOPMENT
LOCATION 2

(ArchDaily, 2020)

BUILDING AN URBAN PLANNING TOOL

How will the Data Help Manchester City Council?

In ST3, the possibility of interaction with the design with parametric inputs will be explored. Users will be able to interact with multiple visual interactions and analyse the statistical readouts of the 24 generations to compare against ambitions and allow for discussion between council & planning consultants.

Urban Strategy Selection

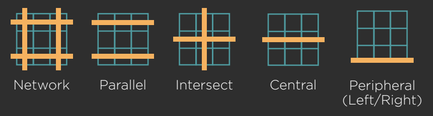
Allows user to select between two neighbourhood strategies: Transport Oriented Development or Pedestrian Oriented Development

New Main Transit Node Placement

A user input point would signify a new transit node that can be inserted within the Generated Zone.

Main Road Selection

5 different options:

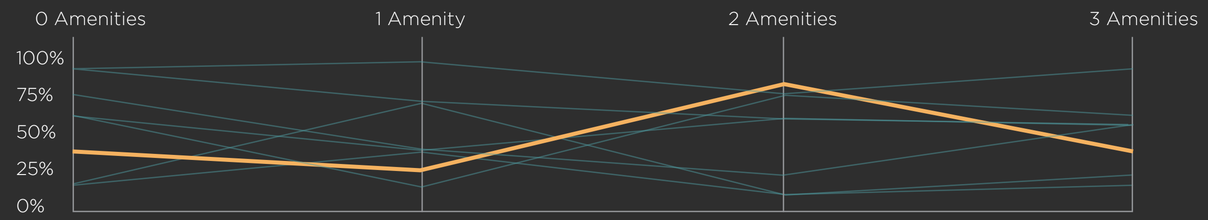


Allowed Transport Type(s)

Testing different provisions of transport type, e.g. trams, buses etc allows the user to view the changes on site based on the availability of a type of motorised transport

Carbon Emission Levels: (gCO2/km/year/pp)

Private Vehicles	38.54
Tram	6.07
Minibus	3.18
Bus	41.48
E-Scooters	90.94
E-Bike	10.04



▼ Proposed Development

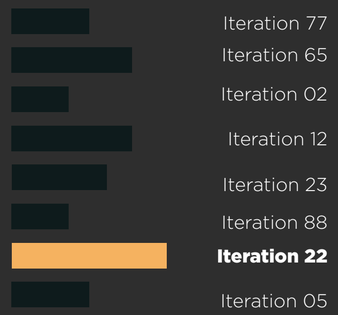
Type of Infrastructure Provision:

- ON Tram
- OFF Minibus
- ON Bus
- OFF E-Scooters
- OFF E-Bike

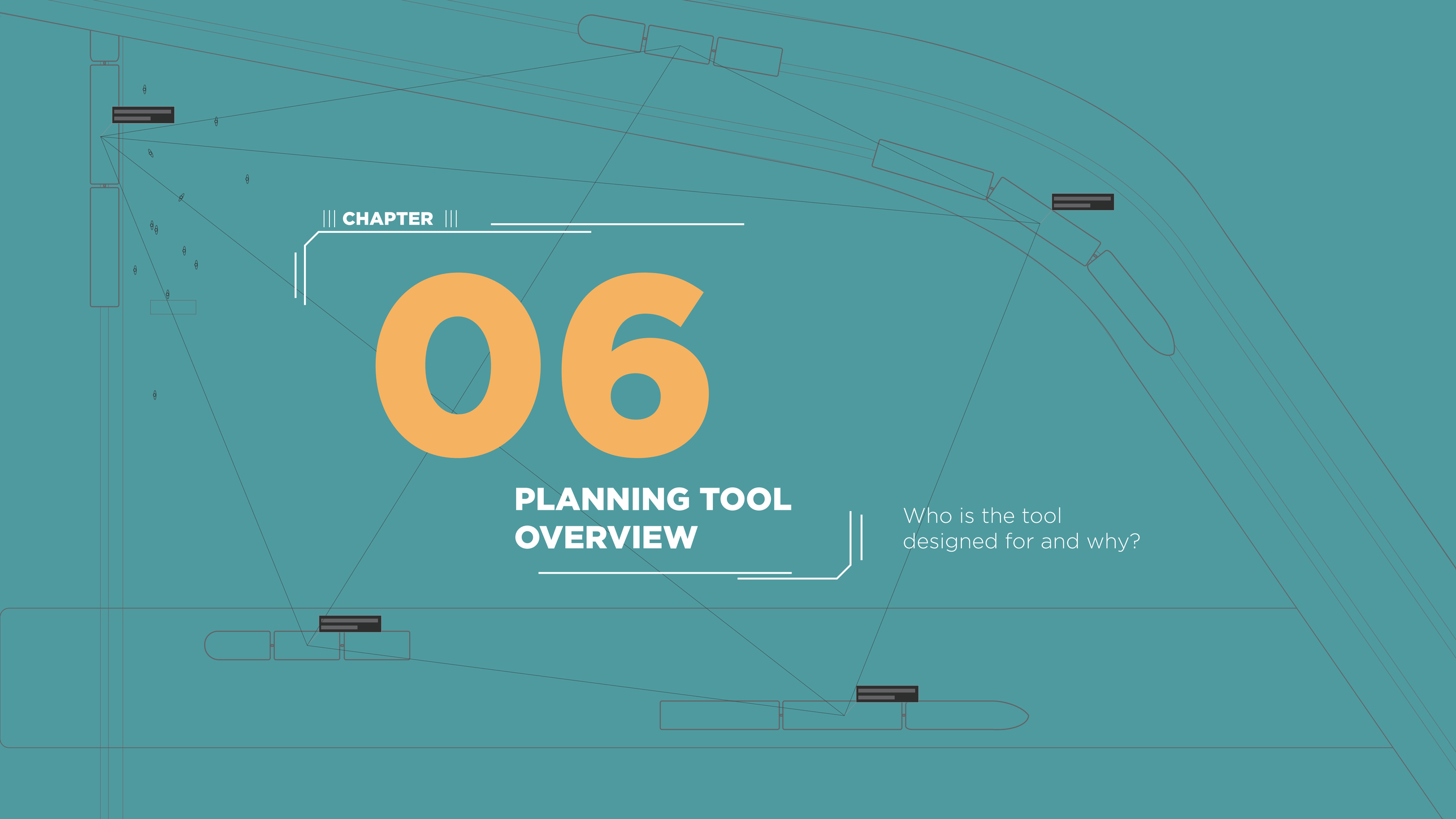
Accessibility Score

5.5

Carbon Emissions



▼ Transit Oriented Development ▼ Central Road ▼ Blank Model View



CHAPTER

06

PLANNING TOOL OVERVIEW

Who is the tool designed for and why?

CARBON NEUTRAL MOBILITY

Helping Local Councils Achieve Lower Carbon Transportation Networks

BEGIN

What is
Carbon Neutral Mobility?

A Computational Tool that allows user control parameters such as neighbourhood Strategies, where the neighbourhood begins, the type of transport available to the residents and the land use percentage

NEXT

Who is the tool designed for and Why?

A Computational Tool that helps councils design a better masterplan for the optimum city with high accessibility and low carbon emissions.

Zero Carbon Manchester is Manchester City Council framework to make Manchester a healthy, green, socially just city where everyone can thrive.

NEXT

CHAPTER

07

PLANNING TOOL WORK FLOW

A Detailed Breakdown of the Urban Planning Tool

Inbox (476 messages)

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Sort by Date

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Carbon Neutral Mobility

Carbon Neutral Mobility

At 27%, transportation is the largest GHG (greenhouse gas) emitting sector in the UK. In order to achieve Manchester s zero carbon goal by 2038, this must be minimised. Yet our lifestyles demands a more accessible and connected, bringing us to our destinations in the minimum time required.

If you are in charge of the redevelopment of Manchester North, what design decisions would you make to create a highly connected city with good accessibility while minimising carbon emissions from our transportation system?

START DESIGNING

ABOUT THE THESIS

ABOUT THE TEAM

QUIT TO DESKTOP

Copy paste the link below to watch the planning tool in action

https://www.youtube.com/watch?v=Qy7Vw4fb7Lo

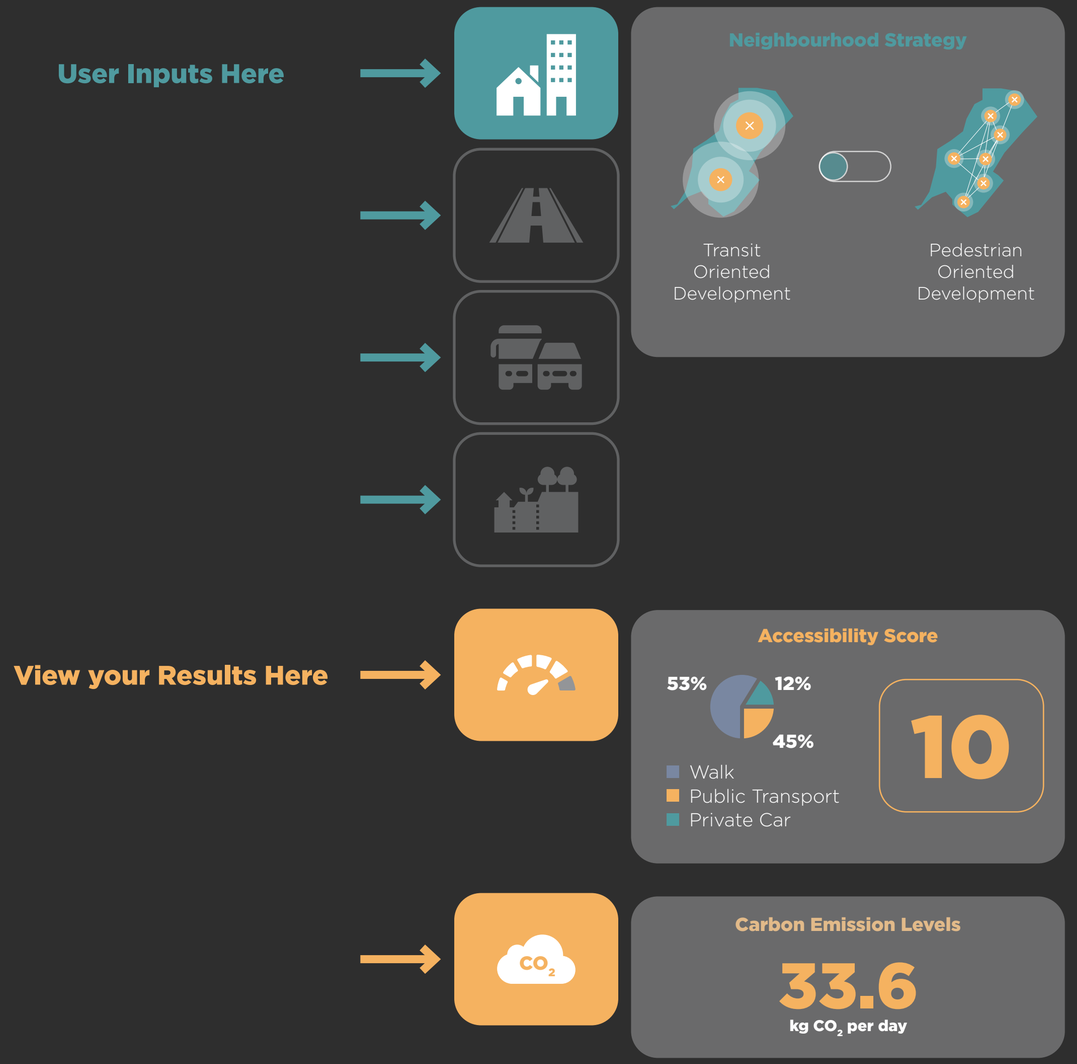
How does the tool work?

The user will be able to design the city by controlling variables such as Urban Strategy, Main Road Positioning and Type of Transport Provision.

The user will be able to observe how these changes affect the accessibility score and the carbon emission levels.

Don’t worry! These will be explained step by step.

START DESIGNING



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START DESIGNING

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ABOUT THE TEAM

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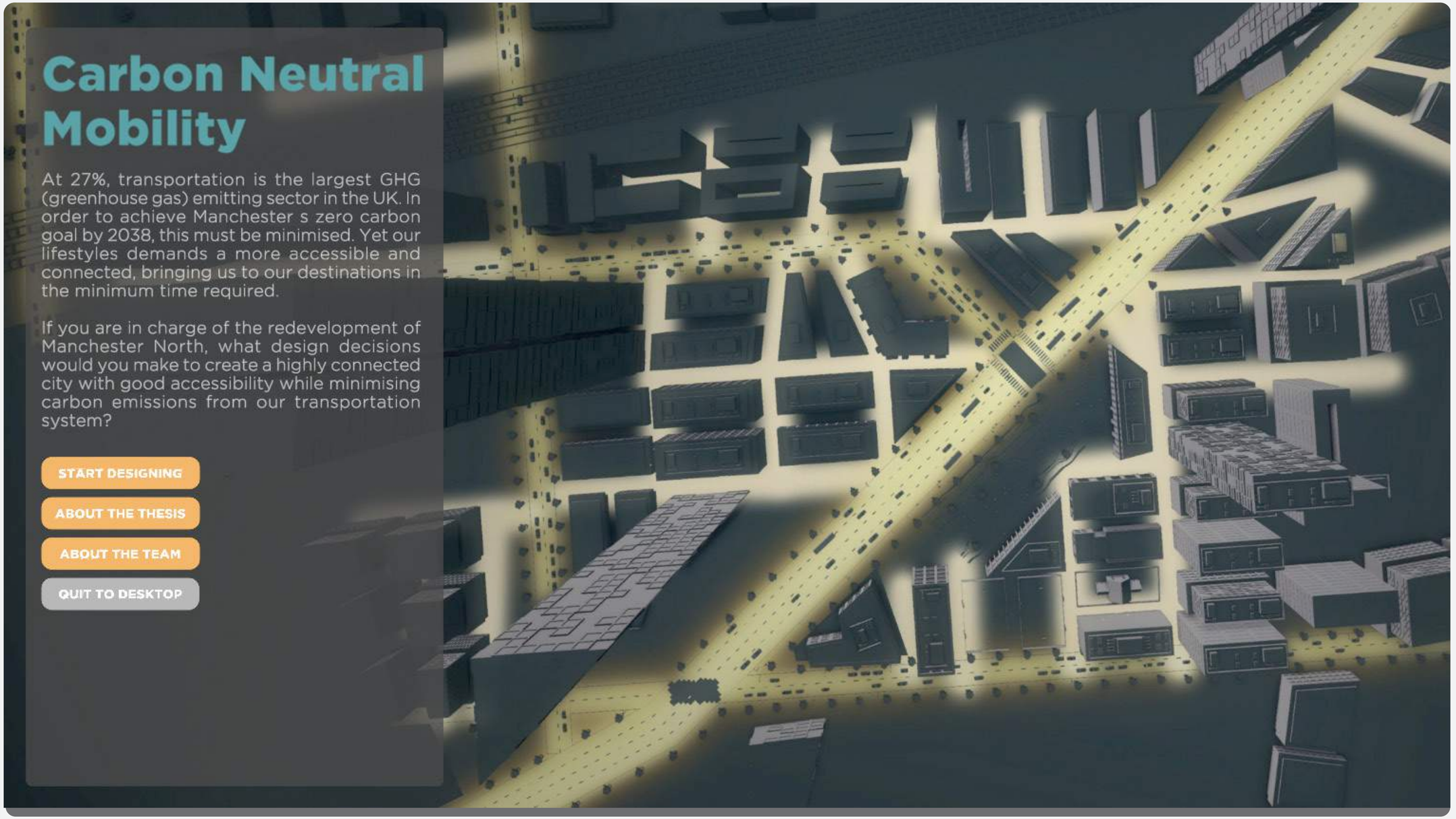


The user will be able to control **4 different variables** which will influence the design. These will be explained further.

1

Urban Strategy

Allows user to select between two neighbourhood strategies: Transport Oriented Development or Pedestrian Oriented Development

2

Transit Node Location

A user input point would signify a new transit node that can be inserted within the Generated Zone to locate where the main area of the city develops..

3

Main Road Selection

5 different options:

4

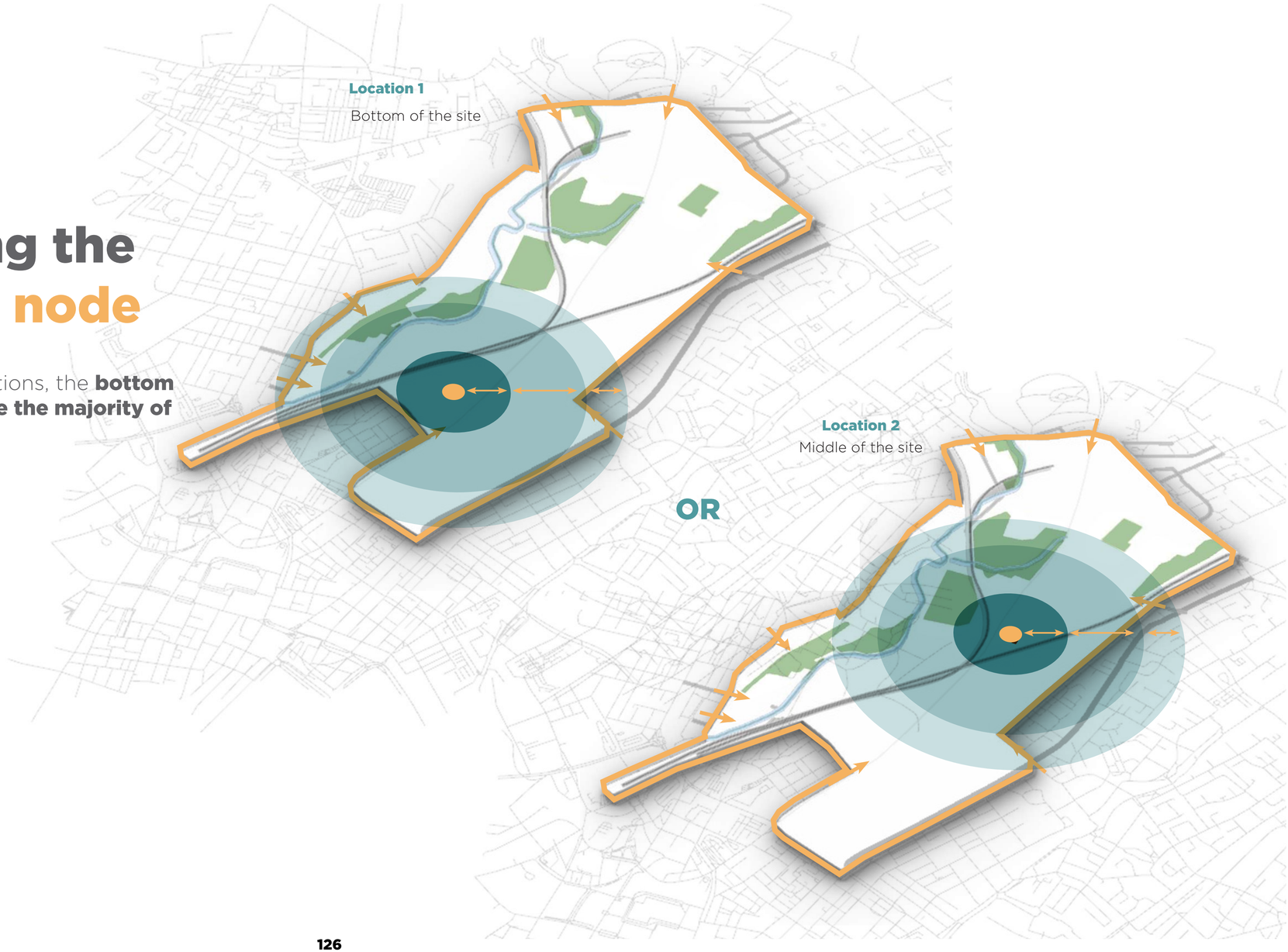
Allowed Transport Type(s)

Testing different provisions of transport type, e.g. active or public allows the user to view the changes on site based on the availability of a type of transport options

Lets begin by choosing the location of the transit node

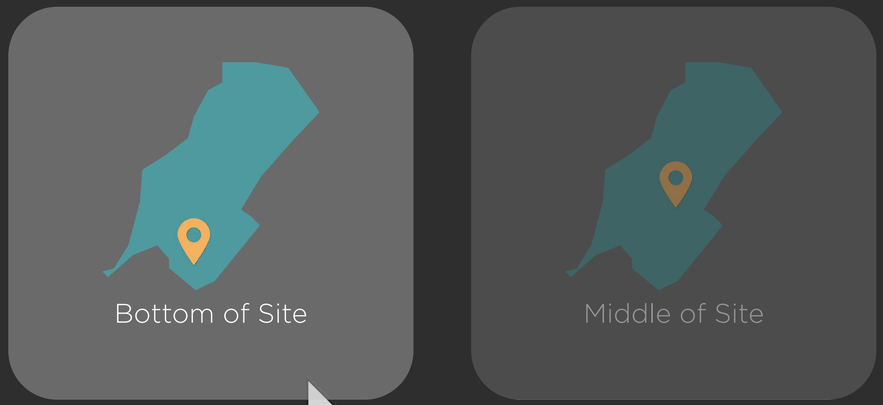
The location of the node has been classified into 2 options, the **bottom or the middle of the site.** The node **determines where the majority of city development will agglomerate.**

Bottom or Middle



How to pick
Node Location

The user can choose between top or middle node location under **Node Location.**



INPUTTING TRANSIT NODE

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Carbon Neutral Mobility

Quit Generate

Create Your Victoria North

Select a Node Location:

Bottom of the site | Middle of the site

Step 1

Select Urban Strategy:

Transit Oriented Development

Pedestrian Oriented Development

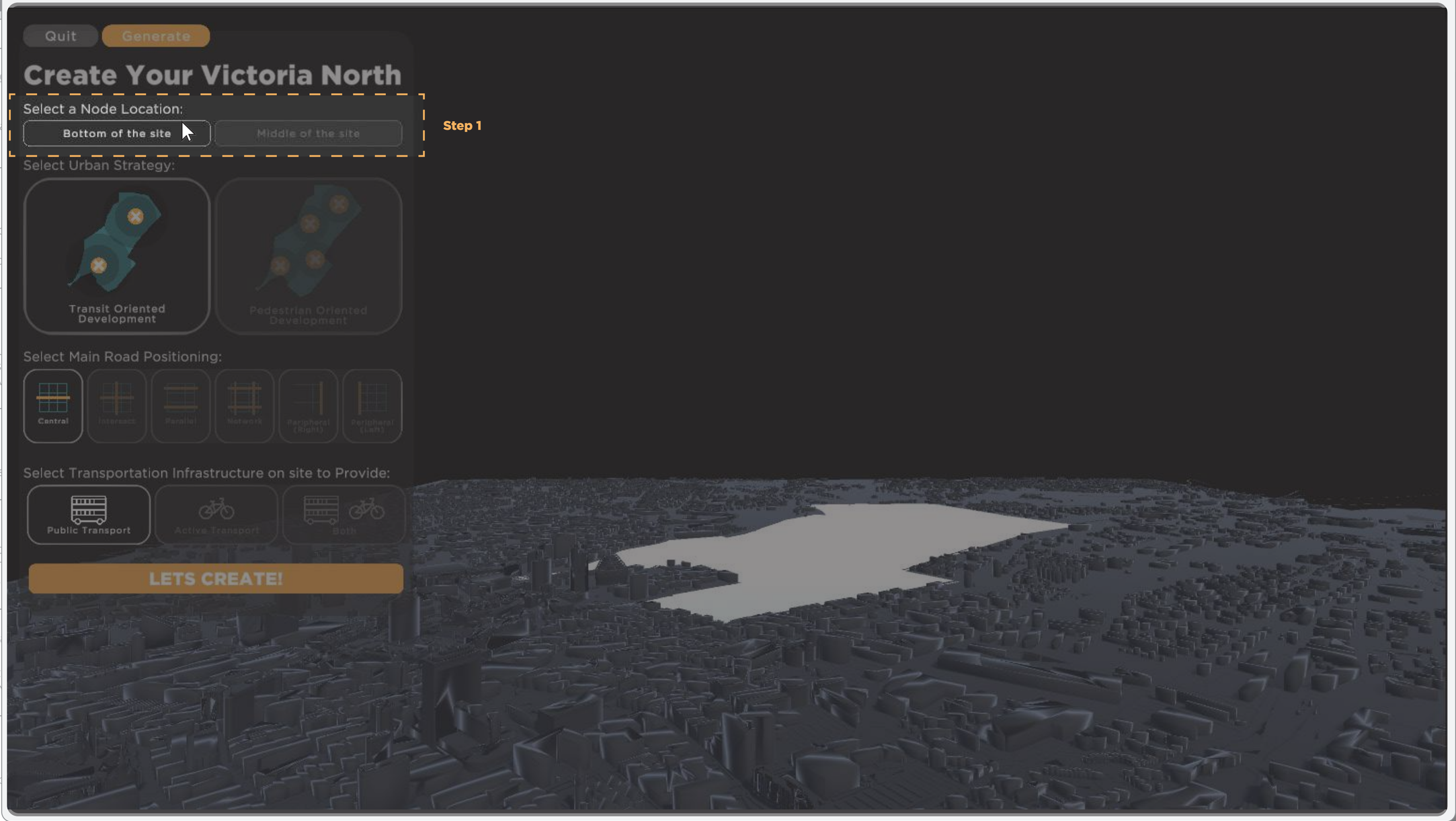
Select Main Road Positioning:

Central | Intersect | Parallel | Network | Peripheral (Right) | Peripheral (Left)

Select Transportation Infrastructure on site to Provide:

Public Transport | Active Transport | Both

LETS CREATE!

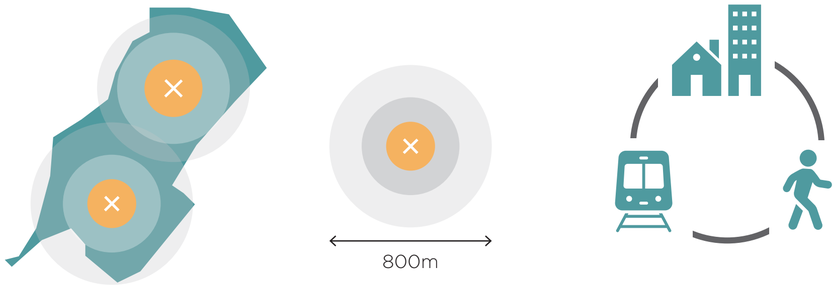


Next, we choose an Urban Strategy

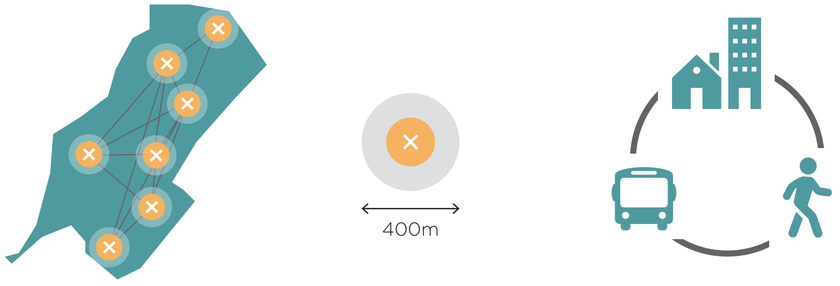
There are two choices for Urban Strategies:
Transit Oriented Development (TOD) or **Pedestrian Oriented Development (POD)**

This will affect the **density, size and frequency** of neighbourhoods and the infrastructure as **TOD is tram reliant** whereas **POD is bus reliant.**

PICKING YOUR STRATEGY



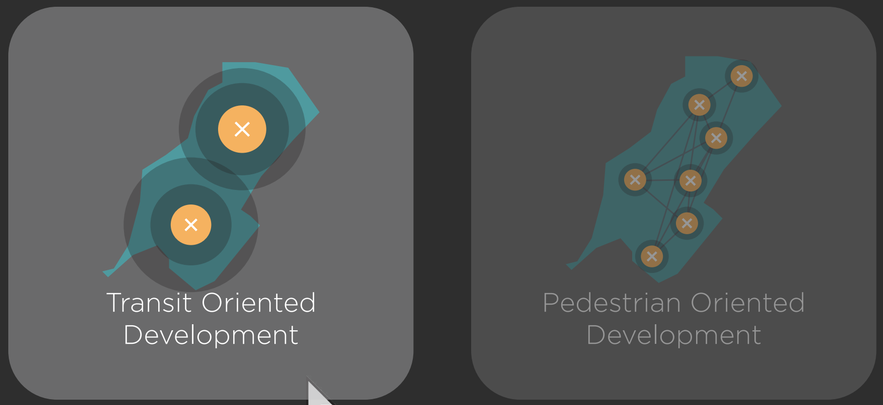
Transit Oriented Development (TOD)



Pedestrian Oriented Development (POD)

How to pick an Urban Strategy

The user can choose between Transit Oriented Development (TOD) or Pedestrian Oriented Development under **Urban Strategy.**



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please.

Carbon Neutral Mobility

Quit Generate

Create Your Victoria North

Select a Node Location:

Bottom of the site | Middle of the site

Select Urban Strategy:

Transit Oriented Development

Pedestrian Oriented Development

Step 2

Select Main Road Positioning:

Central | Intersect | Parallel | Network | Peripheral (Right) | Peripheral (Left)

Select Transportation Infrastructure on site to Provide:

Public Transport | Active Transport | Both

LETS CREATE!

Selecting the
Main Road Positioning

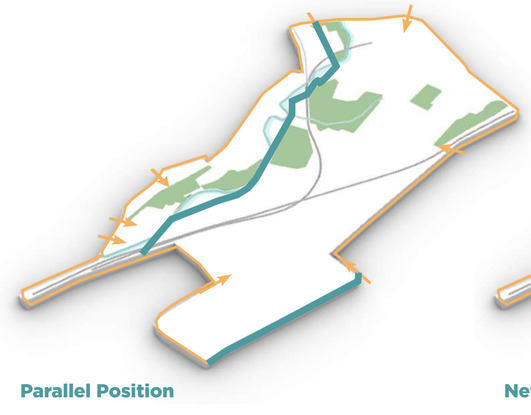
There are six choices for Road Positioning:
**Central, Intersecting. Parallel, Network,
Peripheral (R)** or **Peripheral (L)**

This will affect the **generation of the secondary roads** and subsequently the **parcellation of the remainder spaces** and **the building plot spaces.**

PICKING THE POSITION

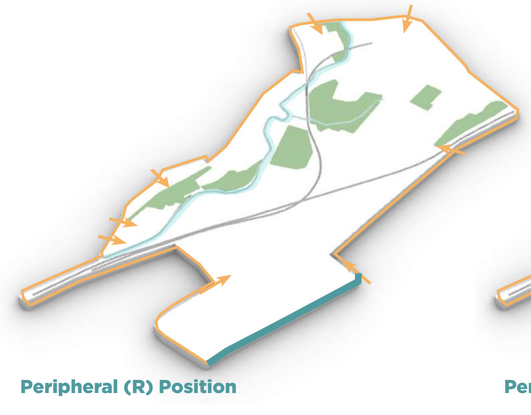
Central Position

Intersecting Position

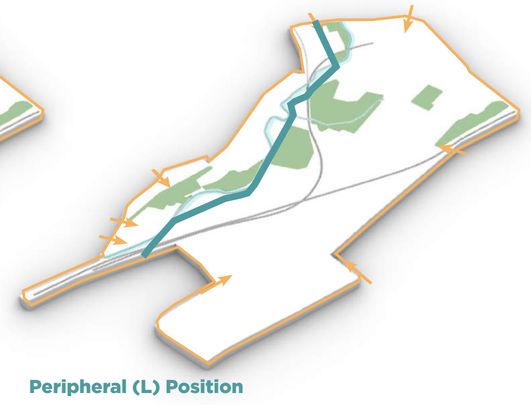


Parallel Position

Network Position



Peripheral (R) Position

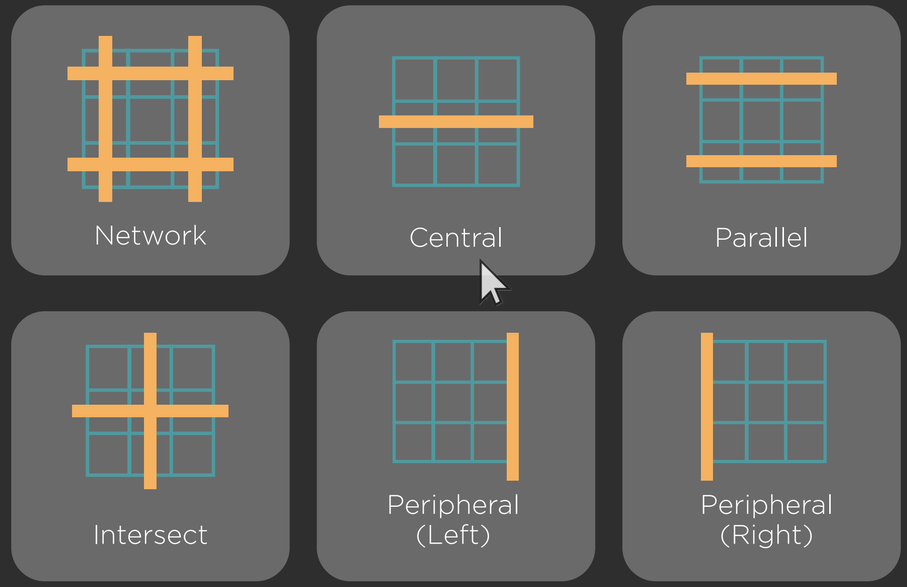


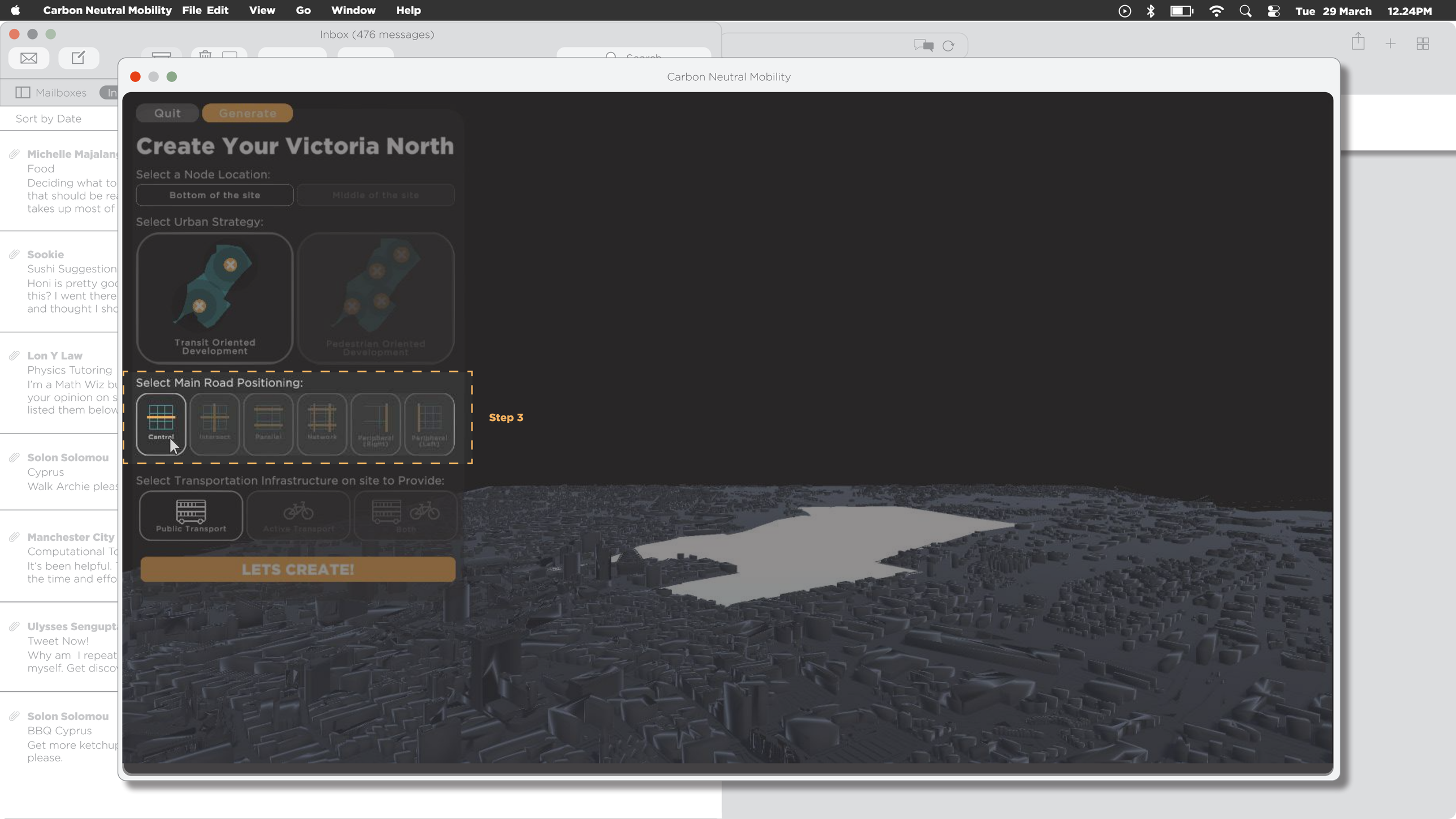
Peripheral (L) Position

How to select the Main Road Positioning

The user can choose between the 6 positions in the control panel of the tool

START DESIGNING

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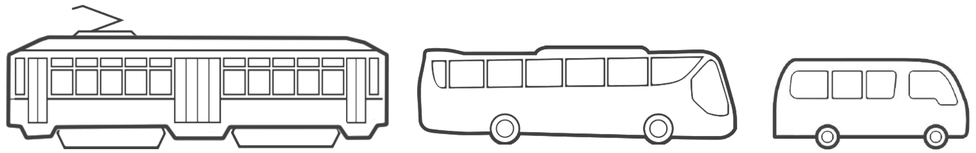
Middle of the site
Select Urban Strategy:
Transit Oriented Development
Pedestrian Oriented Development
Select Main Road Positioning:
Central
Intersect
Parallel
Network
Peripheral (Right)
Peripheral (Left)
Step 3
Select Transportation Infrastructure on site to Provide:
Public Transport
Active Transport
Both
LETS CREATE!

How to control the **Transportation Provisions**

There are 3 options for the type of public transportation to provide on-site **in addition to private cars.**

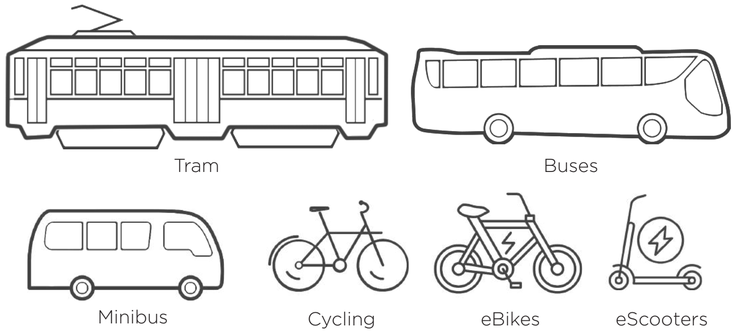
This controls what the inhabitants, or agents, are able to choose during their daily routine.

SELECTING TRANSPORT



Public Transportation Only

Active Transportation Only

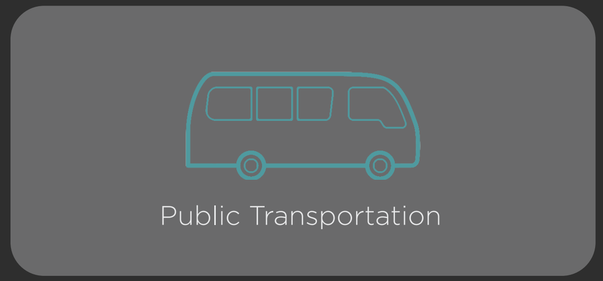


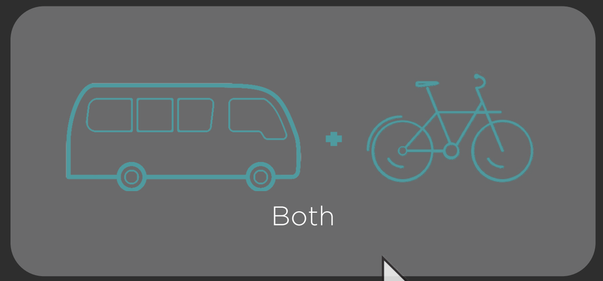
Both

Controlling the available
Public Transportation Options

A Computational Tool that helps councils design the optimum city for high accessibility and low carbon emissions

START DESIGNING





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Carbon Neutral Mobility

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Create Your Victoria North

Select a Node Location:

Bottom of the site | Middle of the site

Select Urban Strategy:

Transit Oriented Development

Pedestrian Oriented Development

Select Main Road Positioning:

Central | Intersect | Parallel | Network | Peripheral (Right) | Peripheral (Left)

Select Transportation Infrastructure on site to Provide:

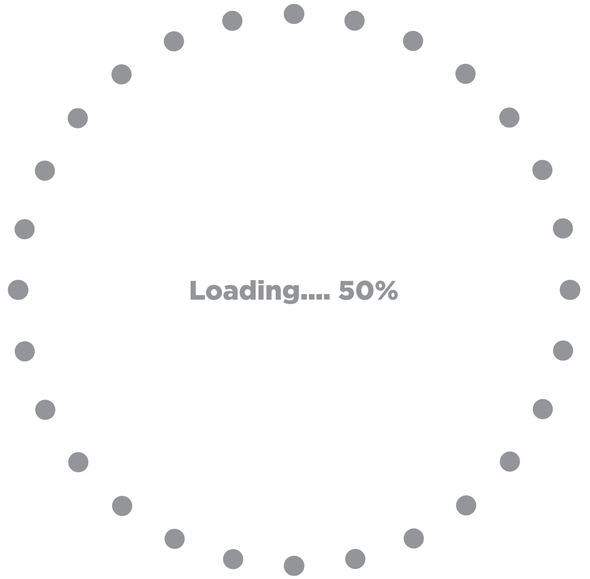
Public Transport | Active Transport | Both

LETS CREATE!

Step 4

The Generation of Mode of Transport

The tool then generates both the city as well as the results of the agent based modelling and the various performance criteria related areas such as **Accessibility, Carbon Emissions from Transportation, Power, PV Cell Cost, Population Make-up, No. of households generated.**



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Ulysses Sengupt
Tweet Now!
Why am I repeat
myself. Get disco

Solon Solomou
BBQ Cyprus
Get more ketchup
please.

Carbon Neutral Mobility

Quit Generate

Create Your Victoria North

Select a Node Location:

Bottom of the site | Middle of the site

Select Urban Strategy:

Transit Oriented Development

Pedestrian Oriented Development

Select Main Road Positioning:

Central | Interlock | Parallel | Network | Peripheral (Right) | Peripheral (Left)

Select Transportation Infrastructure on site to Provide:

Public Transport | Active Transport | Both

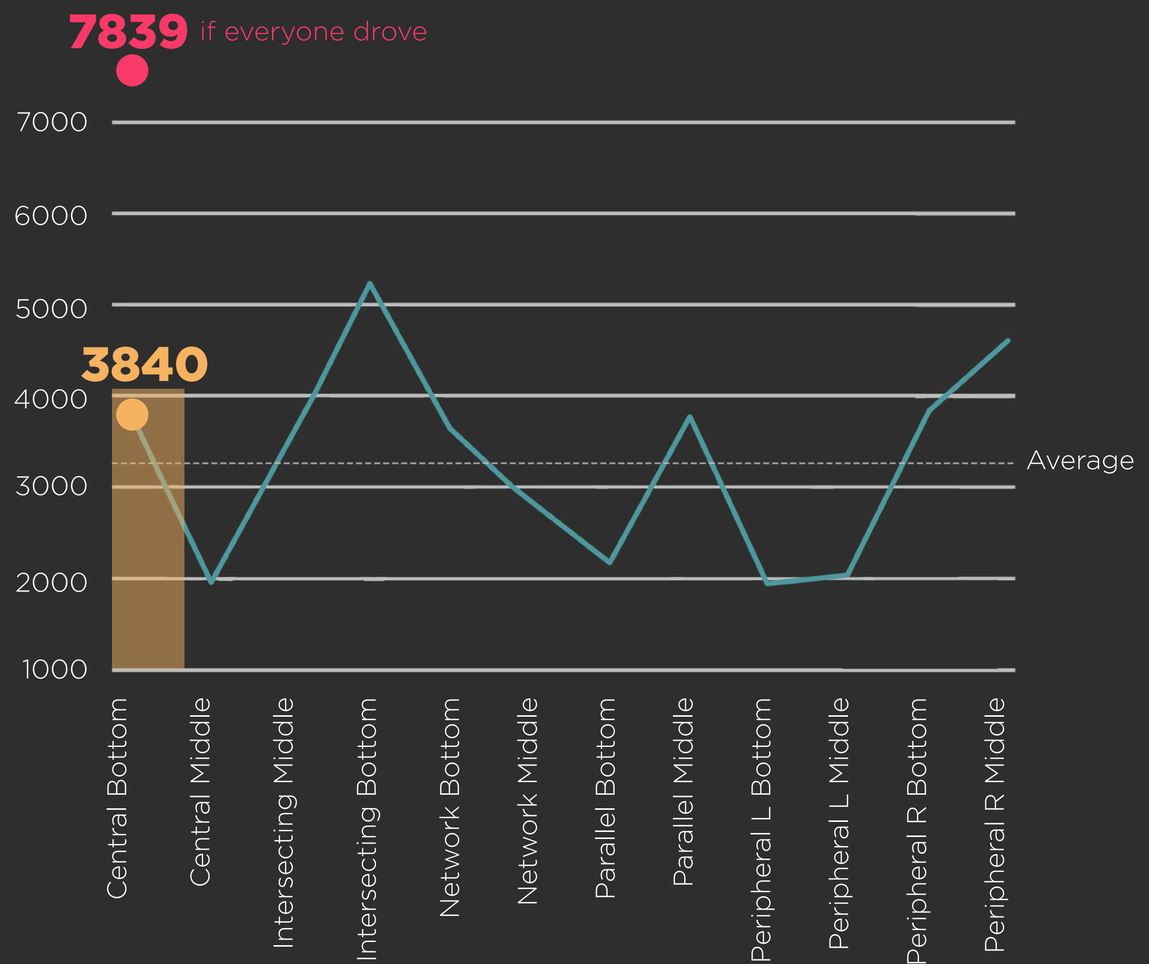
LETS CREATE!

Step 5

Visualising the Carbon Emissions

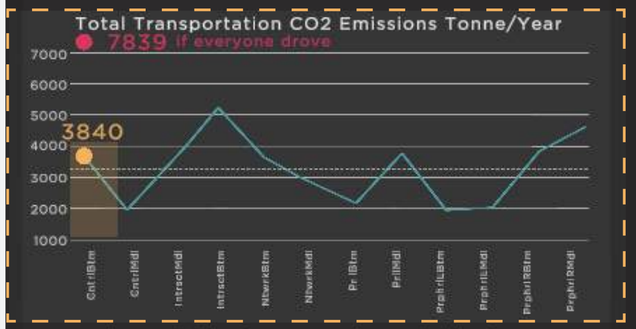
A graph comprising the Total Carbon Emissions (Tonne/Year) of the same inputs (eg. TOD, bottom of site, public transportation only) but different road placements is visualised to highlight the differences in emissions of each iteration.

CONTINUE



Carbon Neutral Mobility

Quit Generate



Accessibility to Daily Amenties

Avg 41.4 **34.8**

Power Needed (GWh)

Avg 14.1 **16.5**

% Roof Coverage for PV Panels

Avg 24.5 **28.8**

Accessibility to Public Transport

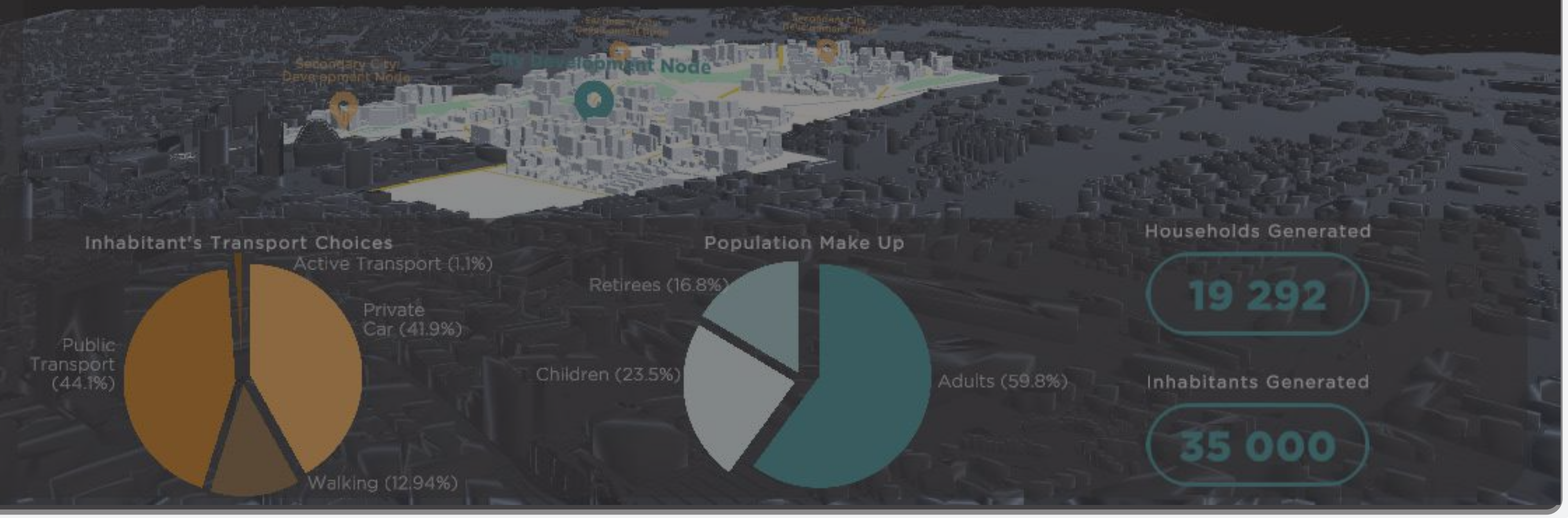
Avg 2.77 **2.70**

Avg Dist Travelled in Site (m)

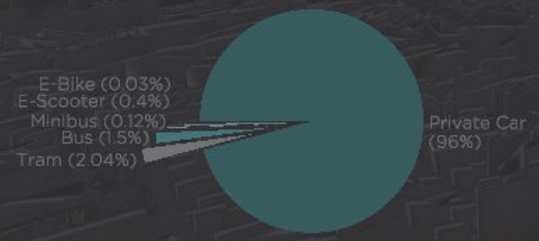
Avg 653 **717**

Cost of PV Panels

Avg 13 **15.3m**



Transportation Emission Make Up



Inhabitant's Transport Choices

Population Make Up

Households Generated

19 292

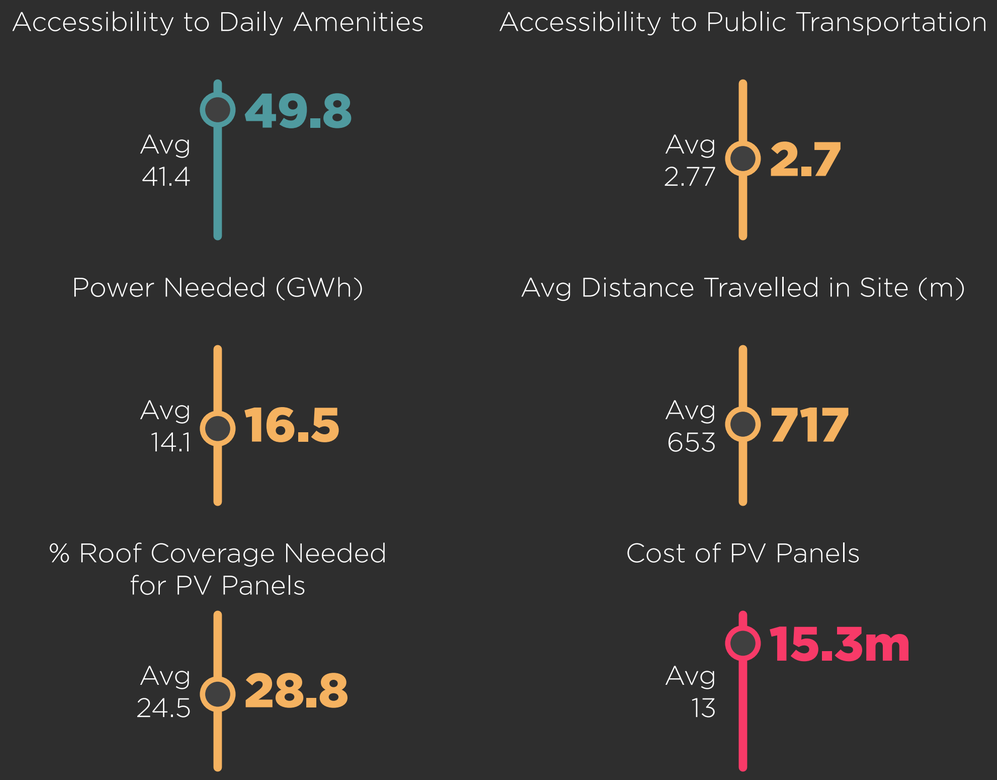
Inhabitants Generated

35 000

Visualising the
Accessibility and Power Score

The accessibility and power scores are then visualised on sliders with colours representing how well they fare when compared to the other iterations of the same inputs, but different road positioning.

CONTINUE



Carbon Neutral Mobility

Quit Generate

Total Transportation CO2 Emissions Tonne/Year

7839 if everyone drove

3840

Accessibility to Daily Amenities

Avg 41.4 34.8

Power Needed (GWh)

Avg 14.1 16.5

% Roof Coverage for PV Panels

Avg 24.5 28.8

Accessibility to Public Transport

Avg 2.77 2.70

Avg Dist Travelled in Site (m)

Avg 653 717

Cost of PV Panels

Avg 13 15.3m

Secondary City Development Node

Transportation Emission Make Up

E-Bike (0.03%)
E-Scooter (0.4%)
Minibus (0.12%)
Bus (1.5%)
Tram (2.04%)
Private Car (96%)

Inhabitant's Transport Choices

Active Transport (1.1%)
Private Car (41.9%)
Public Transport (44.1%)
Walking (12.94%)

Population Make Up

Retirees (16.8%)
Children (23.5%)
Adults (59.8%)

Households Generated

19 292

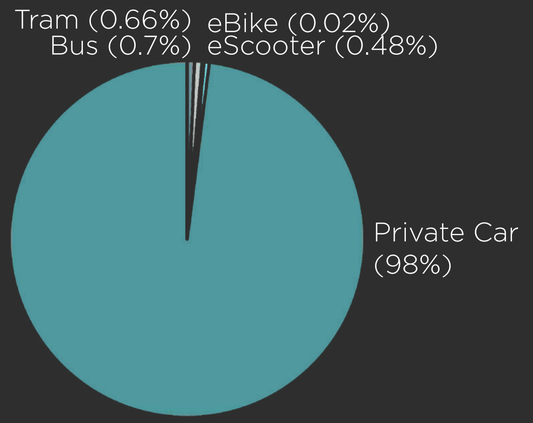
Inhabitants Generated

35 000

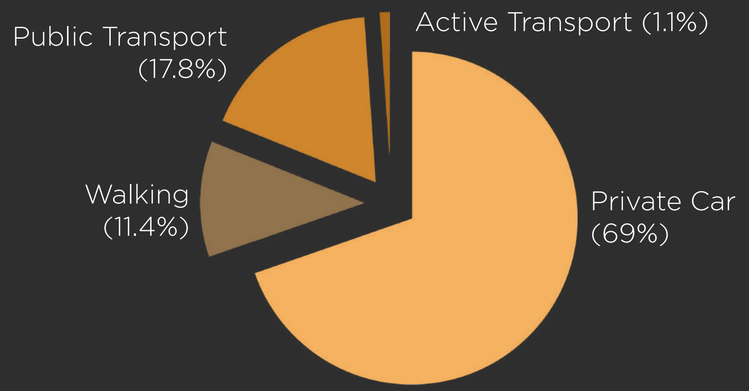
Visualising the
Population and Carbon Data

Further data on the inhabitant's profile and travelling choices are visualised to highlight the success or limitations of the city's goal to encourage either public, active, or both type of transportation.

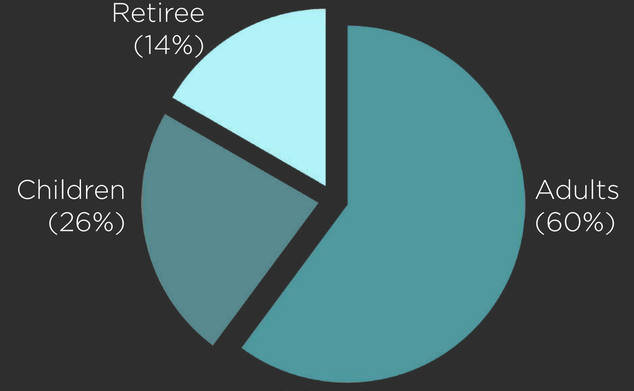
CONTINUE



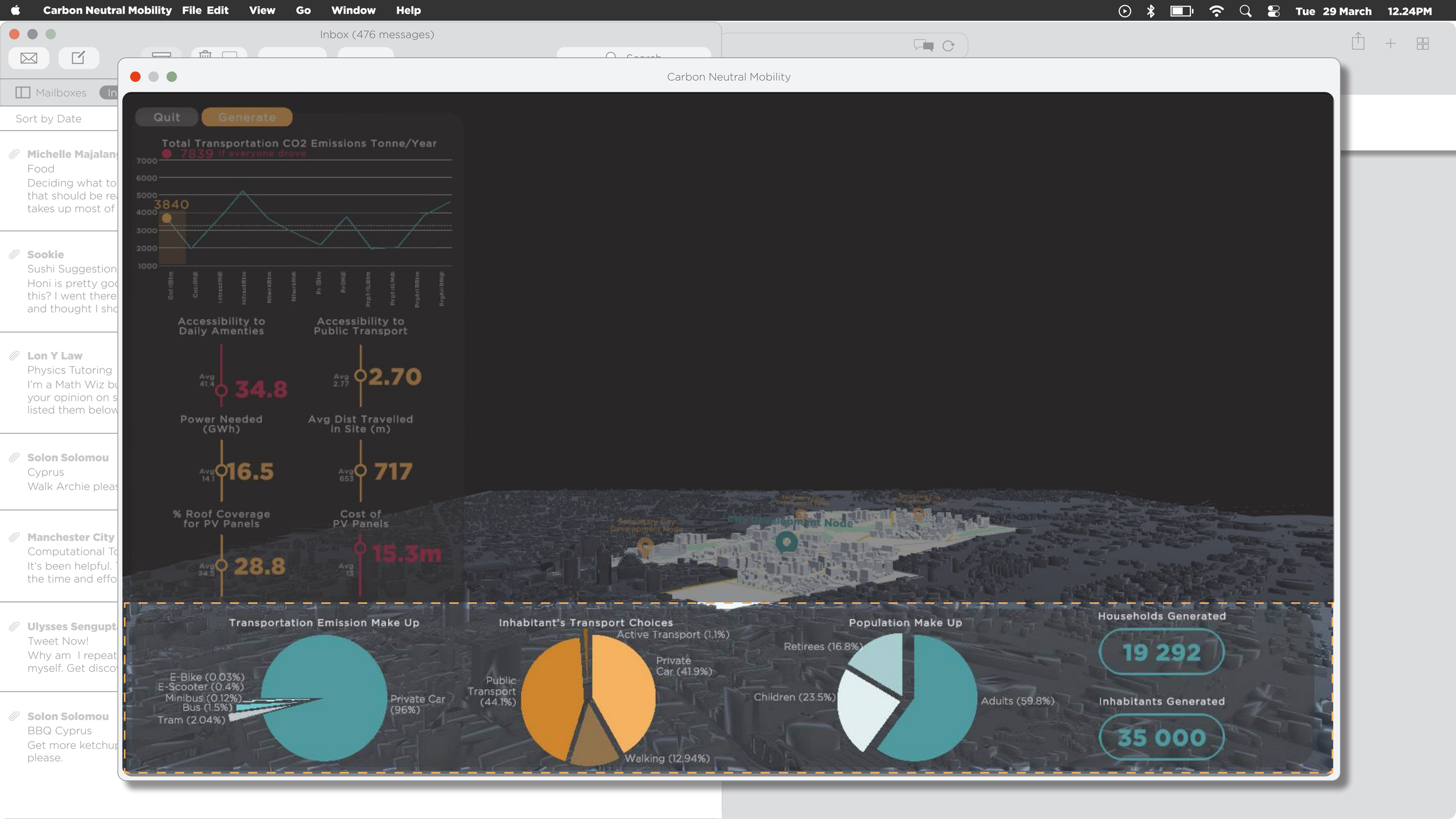
Transportation Emission Make-Up



Inhabitants Transportation Choices



Population Make-Up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Mailboxes
Sort by Date
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Food
Deciding what to
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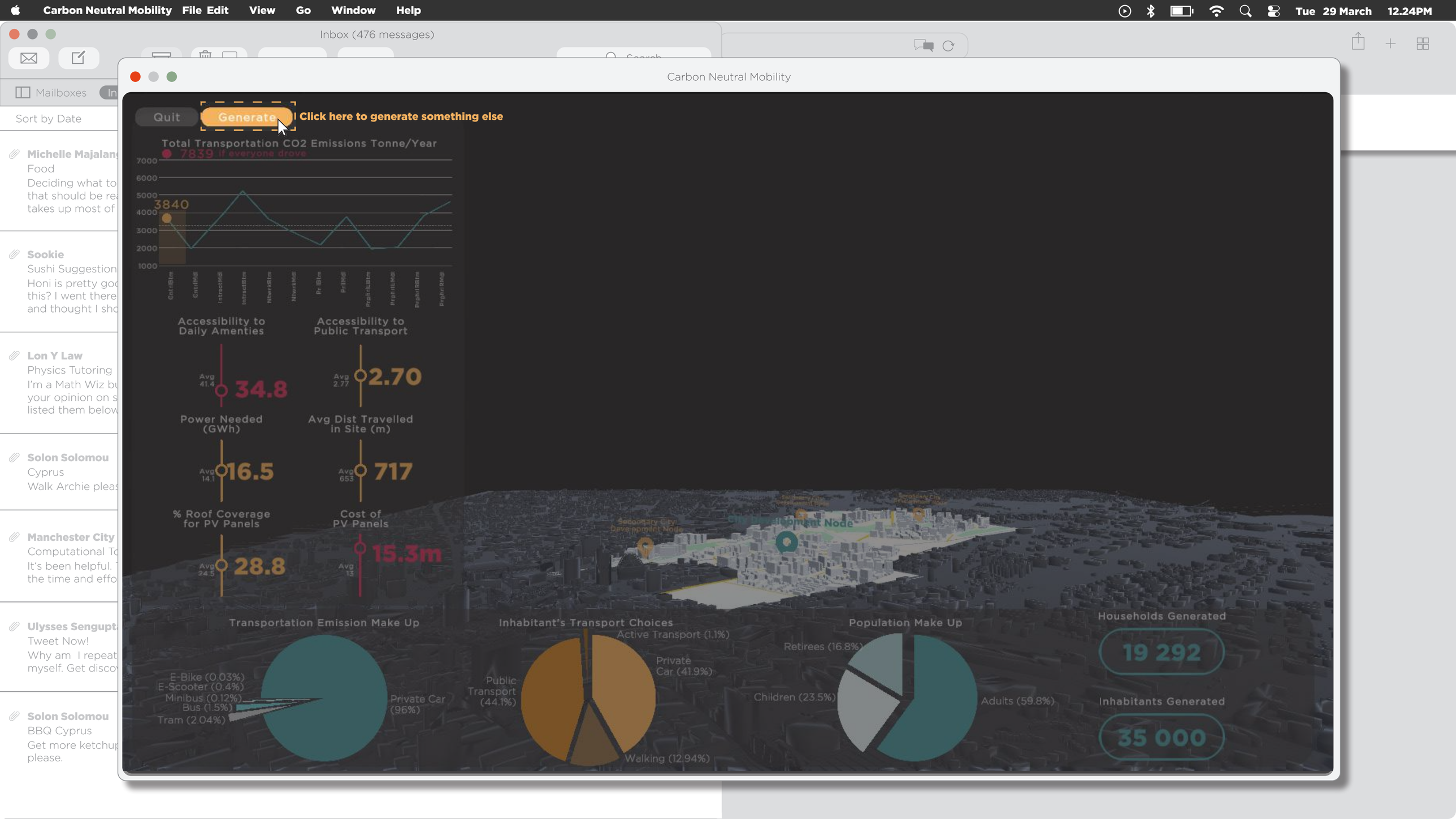
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Click here to generate something else
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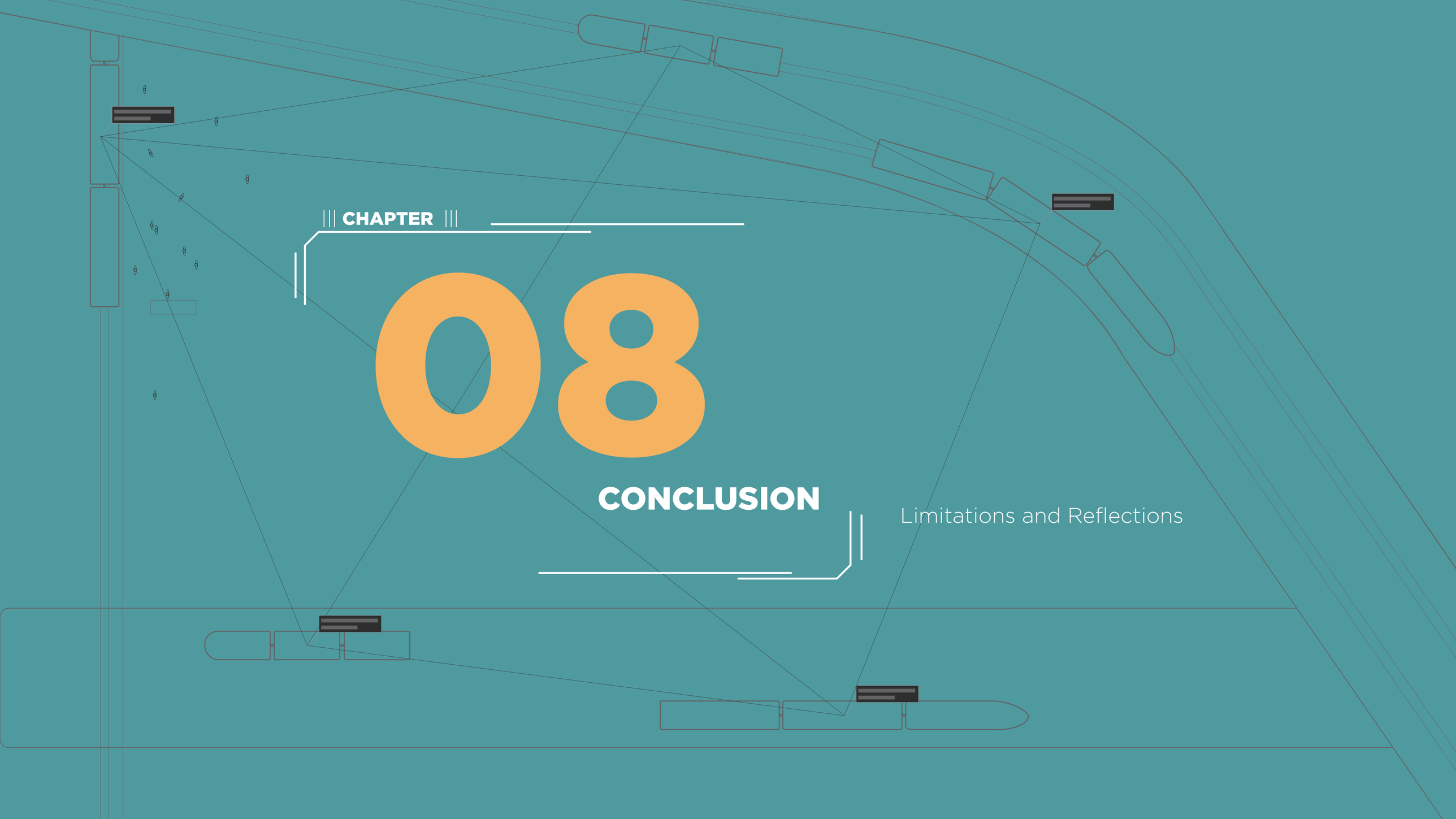


CHAPTER

08

CONCLUSION

Limitations and Reflections

ACHIEVEMENTS IN S3

All Considerations and Successes throughout Thesis

What we achieved in S3

- Successfully built planning tool that explores different urban strategies to achieve a Carbon Neutral Network on the Victoria North Redevelopment. This enables planning consultants and Manchester City Council to explore through 24 iterations and discover 72 results to help them get closer in achieving Zero Carbon Manchester

- Succesfully shown carbon emissions and access to transport and amenity levels for 6 different road generations and 2 different neighbourhood strategies

- Successfully scripted Agent Based Modelling based on different family class, interests and travel habits for 35,000 people residents
- Successfully simulated a typical day of these agents moving in and out of the city depending on the agent's set workplace, school or where they run errands

- Scripted various parametric typologies that would meet Victoria North's expected occupancy of 35,000 people. These include high rise, mid-rise & low-rise buildings, schools, terraced, semi-detached, detached homes. All high-rise, mid-rise & low-rise buildings cover residential and commercial sector

- Successfully scripted a parametric city script that can react and adapt to different input points. The city adapts based on a created logic that considers amenities distribution, density, proximity, and mixed-use and single use buildings.

- Successfully defined logic for road linkages and city generations based on different urban strategies

CHALLENGES & IMPROVEMENTS

Simulating Real World Scenarios

‘Real World’ Challenges & Tool Logic

Simulating Real Life

Every Agent’s workplace and locations as to where they run errands are random

The threshold for people to pick driving private vehicles over using public or active transport is comparatively high.

The diary of Agents lack in variety and assumes that the daily activities are the same everyday.

The Constant Change in Urban Realm

The current computational tool is designed for the proposed development in Victoria North Site. However, the growth or decline of an urban area within a certain timeline can be difficult to predict. The computational tool may not be applicable to Victoria North if

Improvements

The current tool explores through **72 results**, with more time the group would create an even more thorough tool that explores through **250 results**

MULTIPLE ROUTES TO ZERO CARBON MANCHESTER

How the Planning Tool helps Manchester City Council achieve their Goal

The Tool Provides Multiple Optimum Solutions Reduce Transportation Emissions

- With 24 iterations, each of the urban generations from 72 results encourages the residents of Victoria North to choose active transport and public transport over driving. From this, the city council can decide which urban strategies, road placements and Infrastructure provision they would like to provide in Victoria North. The Strategies, Road Placements and Infrastructure Provision they can analyse are:

a) Transit or Pedestrian Oriented Development
b) Central, Intersect, Parallel, Network, Peripheral Left or Peripheral Right
c) Active Transport only, Public Transport Only or Both

The Tool Provides Multiple Trade-Offs in Costs, Accessibility & Carbon Emission Levels

- The Manchester City Council will have to prioritise either costs, accessibility levels and carbon emissions as these elements all affect each other and no generated results will provide best results for all three

The Tool Considers Renewable Energy

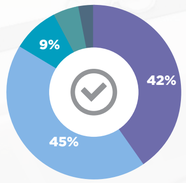
- In order to offset Carbon, the tool provides the number of wind farms or solar panels in which they can implement for Victoria North. This includes details such as the percentage of roof the solar panels will cover and the costs to cover it.

ROLES OF DESIGNERS & COMPUTATIONAL TOOLS

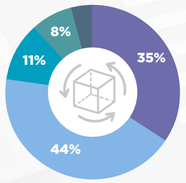
Where to go from here with the Planning Tool

It is not a matter of computational tools versus architects. However, computational tools will be able to replace a lot of work so architects can focus on the design aspect.

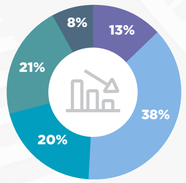
The Diagrams below show architects' opinion of adopting Computational Tools in their Design Work flow in England



Digital technologies are transforming the way we work now

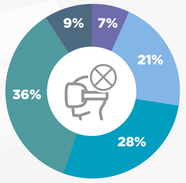


Digital technologies are transforming the whole construction industry

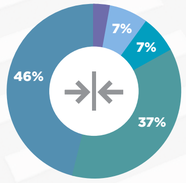


Architectural practices who do not adopt digital ways of working will go out of businesses

- Strongly Agree
- Tend to Agree
- Neither agree nor disagree
- Tend to disagree
- Strongly disagree



Architects are behind other construction professionals when it comes to adopting digital technologies



By 2030 the way that architectural practices operate won't be any different from how they operate now

Is Architecture changing for good? (RIBA&Microsoft, 2018)

The Diagrams below show the application of the Wicked Problem Theory and how Designers and Computational Tool handle different problems

Problems handled by Computational Tools

NON-WICKED

Solution is Possible

Clear Guidelines/ Rules

Known Requirements

A Universally Agreed Correct Answer

Homework, True or False

Problems handled by Designers

WICKED

Disagreement over outcomes

Not Repeatable

Unclear

Unable to Learn from Empirical Evidence

Economics, Politics & Planning

End of S3 Portfolio

Lon Y Law 20055742
Michelle C Majalang 16058429
Sook Wai Lee 19014204

MSA M.ARCH | CPU[AI] Studio 3 Submission

Copy paste the links below to your browser to watch the tool in action

https://www.youtube.com/watch?v=I6RCJ2ySIb8

https://www.youtube.com/watch?v=Qy7Vw4fb7Lo

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