# Waterfront Toronto
# Villiers Island Precinct Plan
# Climate Positive Assessment Report

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WATERFRONToronto

prepared by:

SSG SUSTAINABILITY SOLUTIONS GROUP

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# Executive Summary

Villiers Island is an ambitious plan to develop a new, sustainable neighbourhood on Toronto's waterfront. It is one of 17 global pilot cities committed to meeting the Climate Positive standard. This study sought to determine the magnitude of the efforts required to achieve this goal, based on the current neighbourhood design and plans. The current design is projected to produce 16,541 $tCO_2e$/year (tonnes carbon dioxide equivalent per year) of greenhouse gas emissions. A very challenging endeavour, achieving the Climate Positive target would entail reducing these emissions beyond zero through a combination of on-site and neighbouring site measures. Given that the vast majority of the neighbourhood's emissions will be from building and transportation energy use, these were the focus areas of the study.

An optimization model was used to determine the best combination of emissions reduction strategies for Villiers Island, based on site constraints and costs. Strategies evaluated included building energy efficiency, solar photovoltaic (PV) electricity generation, combined heat and power (CHP) generation using renewable energy sources, transportation mode shifting to non-vehicular modes, and electrification of transportation with electricity provided by solar PV and CHP. The exercise determined that maximizing building energy efficiency is the most inexpensive and effective way to reduce emissions. The model's recommended level of building energy efficiency approaches that of the Passive House Standard, which would save over 92% of building heating and cooling energy use in the neighbourhood.

Other optimization strategy recommendations include maximizing the site's photovoltaic electricity production (estimated 30% of total roof area covered by PV arrays) to cost-effectively supply some electricity; supplying the remaining electricity and thermal energy (heating and cooling) with a CHP system; shifting most travel from cars to walking, cycling and transit; using only electric vehicles; and producing at least 3,000 GJ of excess renewable energy to export to buildings neighbouring Villiers Island as an offset that achieves the Climate Positive goal.

The findings indicate that the appropriate design of the CHP system for provision of electricity and thermal energy for buildings, and electricity for vehicles is a key consideration in the design of Villiers Island. The capacity and heat to electricity output ratios must be carefully considered in order to balance CHP and PV electricity generation.

Varying building sizes and arrangements were considered to determine how different neighbourhood configurations would affect solar energy gain for all of the buildings. The more free energy buildings can absorb from solar energy, the less need to heat the buildings in the winter. Architectural features can minimize solar gain in the summer months. This modelling showed that providing solar access to buildings could decrease heating demand by up to 28.4%, if the buildings are designed to capture and use the solar energy.

The Villiers Island design was assessed versus LEED for Neighbourhood Development and EcoDistricts design standards, providing considerations required in meeting and exceeding these standards en route to achieving the Climate Positive target (appendices).

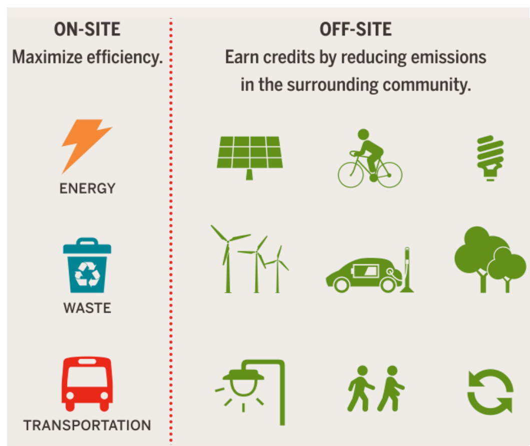
## The Climate Positive Framework

New neighbourhood developments mean more buildings to use energy, more people travelling in cars, and more waste being produced in a community.

The Climate Positive Framework is a high-level, non-prescriptive roadmap that leads new developments to reduce their emissions beyond zero by reducing the emissions they create and offsetting the remainder by removing emissions from their adjacent communities. Climate Positive developments reduce overall emissions in the communities in which they are built.

The program addresses building energy use, transportation, and waste emissions. It also accounts for local offsets resulting from the preservation, creation and regeneration of parks and green spaces (carbon sinks), and the local export of clean energy generated in the new development.

CLIMATE+
Climate Positive Development Program



Based on the modelling and research performed, six major neighbourhood design recommendations were determined whose actions would close the emissions reduction gap between the current plan and the Climate Positive target:

| | |
|---|---|
| Design to Passive House Standards | Designing to Passive House standards saves over 92% of building energy use, compared to that used by buildings built to Waterfront Toronto Minimum Green Building Requirements. This standard is currently being successfully applied to tall buildings and entire neighbourhoods in projects in the United States and Germany. |
| Optimize the urban form for energy harvesting and conservation | Solar access modelling indicates that placing the tallest buildings on the north side of the site, while stepping buildings from shorter on the south side of the site to taller on the north side yields the best results for solar access and thus a reduction in mechanical heating requirements. This reduction increases the viability and lowers the cost of achieving Passive House levels of performance. |
| Maximize photovoltaic (PV) capacity | Optimization modelling shows that after building energy efficiencies, PV is the next most cost-effective energy strategy. Generating 30,000 GJ of electricity (or more) from photovoltaics is possible on-site. |
| Meet remaining energy demand with district energy including cogeneration | Once the Passive House standard is applied and the photovoltaic energy systems are maximized, district energy can provide the remaining energy needs for the neighbourhood, producing heating, cooling, and electricity, drawing on a combination of energy sources. |
| Reduce car travel to 25% of trips or less and/or restrict the Island to electric vehicles | Optimization modelling recommends reducing gas-powered car travel to only 25% of trips, shifting most trips to transit, walking and cycling. Alternatively, Villiers Island vehicles could all be EVs, in which case 3% of trips shifted to transit, walking and cycling would achieve the best cost balance of transportation strategies in attaining the Climate Positive target. |
| Design with the Climate Positive goal in mind | Achieving the Climate Positive target is incredibly challenging. Every sustainability consideration must be made as early as possible during the remaining design process. From this point forward, it is imperative to consider energy, efficiency, transportation, water, waste, and natural systems in a comprehensive, interrelated manner in order to achieve the most cost-effective and emissions-effective outcomes. |

# Introduction

## Context

Villiers Island is the first complete mixed-use community to undergo precinct planning in Toronto's Port Lands. With the naturalization of the Don River, Villiers Island will be surrounded on all sides by water and presents a unique opportunity to create a new island community. Precinct planning commenced in earnest in 2014 and has been presented to the community on several occasions.

Showing global leadership in sustainable development, Waterfront Toronto has planned the island as a complete sustainable community that will include many active transportation opportunities, public transit access, ample public realm, and access to small craft launches. 20% of residential units will be affordable rental housing (ARH), and there will be a public school, a community centre, two daycares, and a fire hall.

Villiers Island is one of the 17 inaugural projects included in the C40 Climate Positive Development Program launched by the Clinton Climate Initiative in 2009. The goal of each project in the program is to reduce greenhouse gas emissions below zero: to be Climate Positive. To meet this ambitious goal, Villiers Island needs a forward-looking, inclusive set of infrastructure technologies, building systems, habitat restoration strategies, and other carbon reduction strategies.

In collaboration with the C40-Climate Positive Development Program, and with funding support from the Ontario Power Authority, Waterfront Toronto developed a Carbon Tool to help understand the challenge of achieving a Climate Positive Neighbourhood target. The tool was used to compare a neighbourhood plan that implements Waterfront Toronto's Minimum Green Building Requirements (MGBR) and best practices, with a baseline build-as-usual scenario. The tool estimated a 23% emissions reduction potential for the planned development.

### Minimum Green Building Requirements (MGBR)

Waterfront Toronto's MGBR standard achieves increased sustainability performance in new buildings. Compared to the Model National Energy Code for Buildings (MNECB), it requires:

- LEED Gold certification
- 50% energy cost savings
- 65% reduction in peak heating demand
- 30% reduction in peak cooling demand
- 3% of a building's annual energy cost come from on-site renewable energy systems
- In-suite sub-metering for electricity, natural gas, and water (hot and cold)

### Toronto Green Standard (TGS)

The TGS is a two-tier (mandatory and voluntary) set of performance measures, with supporting guidelines for new development. Its purpose is to promote sustainable site and building designs that address Toronto's urban environmental pressures: air quality, climate change and energy efficiency, water quality and efficiency, ecology and solid waste.

# This Report

This document reports the study and modelling outputs of conducting an audit of the Villiers Island Precinct Plan's gap between current design and achieving Climate Positive status—the 77% emissions gap. The report identifies strengths and weaknesses of the current Precinct Plan in this regard and makes recommendations that ensure that at this stage in the design process there are no fundamental flaws that might preclude a Climate Positive outcome, and that there are no critical elements missing from a global best practices perspective.

The major audit areas are based on the Climate Positive Frameworks' requirements and include:

- Urban Design
- Buildings
- Energy
- Transportation
- Water and Wastewater
- Solid Waste
- Natural Systems
- Carbon Offsets

Recommended design, operation and programming considerations have been made in each of these areas to address any deficiencies and identify additional strategies that would help make the Villiers Island Precinct Plan a model framework for livable, accessible, healthy, resilient, and low carbon community development.

# Current Neighbourhood Design
# Climate Positive Target Report Card

Climate Positive target grading scheme

A: Excellent
B: Good
C: Fair

| Aspect | Planned Characteristics | Comments | Grade |
|---|---|---|---|
| **Urban Design** | | | |
| Scale | • 54 acres of developable area<br>• 40 acres of parkland<br>• Homes for 8,200 people<br>• 2,800 jobs | The planned population is sufficient to support a wide mix of uses, facilitating walking and cycling. | A |
| Density | • 242 units/ha (98 units/acre)<br>• 413 people/ha (167 people/acre)<br>• 420,000m$^2$ GFA/4,820 residential units<br>• 105,000m$^2$ GFA of non-residential space<br>• Major buildings: 5-7.8 FSI | Planned population density exceeds key transportation and district energy thresholds. The compact urban block lends itself well to energy efficiency. | A |
| Urban structure | • Energy synergies are considered.<br>• Various street types for a mix of car, transit, bicycle, pedestrian, and pedestrians.<br>• A variety of space types including park, square, active, passive, programmable, heritage, retail, transit hub, and courtyard.<br>• Majority of buildings are oriented 30$^{O}$ counter clockwise from an east-west axis. | The plan excels at human scale, walkability, mix of uses and variety of experiences, contributing to use of low carbon transportation and short trips. Tower buildings on the south of the site hinder solar gain on buildings to the north. Building configuration, heights and articulation should be optimized for solar gain, passive heating, and energy efficiency. | B |
| **Buildings** | | | |
| Building types and envelopes | • Buildings of varying heights, arrangements and massing forming a continuous, human-scale streetscape.<br>• Green roofs required for 60% of available space; PV and solar thermal installations count towards this requirement. | The buildings have not been optimized for energy efficiency or solar energy gain. The building shapes and designs should show consideration for the thermal effects of prevailing winds, passive solar gains, optimization of solar energy generation, etc. to maximize their energy performance. | C |
| Building systems and equipment | • MGBRs provide some guidelines for plug loads and building equipment.<br>• Buildings are to be certified LEED Gold.<br>• Residents are to be able to monitor their energy consumption. | The MGBRs provide a systematic approach to optimizing buildings, however, they are not sufficient to achieve the Climate Positive outcome. | B |
| Unit sizes | • Average home sizes are 87m$^2$ (940 sq. feet).<br>• A mix of units: 25% 2BR, 10% 3Br, with affordable housing requirements. | More details on unit types, mixes, and flexibility over time will need to be addressed in the architectural design stages. | B |
| Accessibility/ proximity | • 30 minute walk from downtown<br>• Mixed-use neighbourhood includes residential, commercial, office, government, heritage, and institutional spaces. | Proximity and connectivity to adjacent neighbourhoods, downtown, entertainment, and amenities is very good. To ensure transit use, amenities and services could be increased. | B |
| **Energy** | | | |
| | • Onsite renewable energy will provide 5% of annual building energy.<br>• Buildings to reduce energy use costs by 50%.<br>• Appliances must be Energy Star Compliant.<br>• There could be neighbourhood energy systems and microgrids.<br>• Buildings must be built to standards required by Energy Services Agreements. | Potential energy systems and strategies are in the Port Lands Energy Plan but do not appear to have been incorporated in the Precinct Plan. Strategies to achieve the Climate Positive outcome need to be identified. Sites for DE need further assessment following the precinct plan and planning framework. | B |

| Aspect | Planned Characteristics | Comments | Grade |
|---|---|---|---|
| **Transportation** | | | |
| | • 2% of parking spaces will have EV infrastructure; parking lots will be "EV ready".<br>• Two Streetcar lines will serve the neighbourhood.<br>• Dedicated truck routes have been explored and further assessment is required.<br>• There is an existing bike lane on Cherry St.<br>• Villiers St. and Commissioners St. will have physically separated bike lanes.<br>• 1.2 secure and covered bike racks per home.<br>• Street design prioritizes transit use and pedestrians.<br>• Pedestrian-only bridge on island's south west corner. | The plan has a high level of transit access but the current planning does not include a strategy to achieve the Climate Positive outcome, which will require a high level of innovation and leadership. Considerations like multi-modal transportation, trip planning, and mobile technology, as well as much enhanced level of ambition with respect to electric vehicles will be required. Although there is a transit plaza planned, its singular use as a streetcar stop limits its potential for greater Climate Positive transportation outcomes. | C |
| **Water and Wastewater** | | | |
| | • Efficient water consumption has been considered for irrigation requirements, equipment, leaks, process, cooling, and flushing.<br>• Evapotranspiration and rainfall have been considered in calculating natural water introduction to and exit from the site. | Energy consumption of different wastewater management strategies has not been evaluated. A pump-free system using gravity for wastewater conveyance is ideal. Ashbridges Bay Treatment Plant is nearby and will be considered in servicing the neighbourhood. Some considerations have been made for water efficiency, but they are preliminary. | C |
| **Solid Waste** | | | |
| | • Waste generation rates are estimated for household (1.67 kg/household/day) and retail/office (0.026 $kg/m^2$/day).<br>• Construction and demolition waste is estimated to be 8.9 $kg/m^2$.<br>• Diversion rates have been estimated at 26% for residential and 18% for retail.<br>• Residential and office/retail in-suite diversion considerations have been made. | Very little holistic consideration has been given to how consumption will be minimized, or to how different types of potential waste will be reused, repaired or redistributed, or how and where waste will be treated. References to a vacuum waste system were included in some preliminary public consultation materials, but there is no design or assessment of such a system in the materials. Waste management will be a Port Lands-wide strategy. | C |
| **Natural Systems** | | | |
| | • Green infrastructure is used wherever possible.<br>• Tree-lined streets.<br>• Development regenerates the ecosystem. | Natural areas are used for flood management and extensive green space is included in the plan. More trees could be added to increase carbon uptake potential. Some green space could be allotted for urban agriculture, which would have implications for carbon sequestration, local economy, local food consumption, and reducing emissions associated with food transportation. | B |

**Summary Comments**

The public consultations and urban design efforts on the Precinct Plan have resulted in a neighbourhood design that has human scale, offers positive and varying experiences of place, fosters a variety of uses, includes transportation options, and balances residential and jobs density with enjoyable urban form and open spaces. The master planned neighbourhood has made many important considerations that will result in a highly liveable and desirable neighbourhood for live, work and play. As indicated, further design considerations need to be made from a deeper sustainability perspective in order to achieve the Climate Positive target.

# Neighbourhood Emissions Assessment

The initial emissions assessment performed with Waterfront Toronto's Carbon Tool determined that if constructed as currently designed—exceeding TGS energy efficiency standards using even the more ambitious MGBRs—Villiers Island will still produce 16,541 tonnes of carbon dioxide equivalent (tCO2e) emissions annually (this excludes carbon embedded in materials). Although this amount is a 23% reduction in emissions compared to the same development built to TGS, there remains a 77% emissions gap in achieving the Climate Positive neighbourhood target of lowering emissions beyond zero.

Table 1 describes the energy (black) and emissions (orange) estimates for three neighbourhood development scenarios: Build-as-Usual, Current Plan and Climate Positive. The Build-as-Usual and Current Plan values are those used in the Waterfront Toronto Carbon Tool. Climate Positive scenario targets were identified through a combination of technical analysis (described later in this report) and drawing on best practices. The table does not address offsets, which are considered later in the report.

*Table 1. Summary of characteristics for Villiers Island neighbourhood development built to different sustainability standards.*

| | | | Build-as-Usual (BAU) | Current Plan | Climate Positive | | |
|---|---|---|---|---|---|---|---|
| | | | | | Target | % from BAU | % from Plan |
| | | | TGS | MGBR | Climate Positive Framework | | |
| | Total annual emissions (tCO2e)[1] | | 21,772 | 16,541 | 197.3 | > 99% | > 98% |
| Buildings | Electrical EUI[2] (kWh/m²/yr) | Residential | 90 | 64 | 33.2 | 63% | 48% |
| | | Commercial/Gov | 86 | 61 | 33.5 | 61% | 45% |
| | Thermal EUI (kWh/m²/yr) | Residential | 170 | 121 | 117.6 | 31% | 3% |
| | | Commercial/Gov | 103 | 73 | 73 | 29% | 0% |
| | Buildings emissions (tCO2e/yr) | | 15,408 | 10,418 | 0 | 100% | 100% |
| Transportation | Transportation emissions (tCO2e/yr) | | 5,476 | 5,075 | 0[3] | 100% | 100% |
| | Mode split (%) | | | | | % Difference | % Difference |
| | Drive | | 71 | 28 | 25[4] | -46 | -3 |
| | Transit | | 29 | 62 | 50[5] | +21 | -12 |
| | Walk | | 0.02 | 5 | 10[6] | +10 | +5 |
| | Bicycle | | 0.12 | 5 | 15[6] | +15 | +10 |
| Waste | Waste landfilled | kg/person/yr | 594 | 442 | 90[7] | 85% | 80% |
| | | tCO2e/yr | 1,382 | 1,036 | 211 | 85% | 80% |
| Water | Water use (L/person/day) | | 394 | 224 | 125[8] | 68% | 45% |
| | Wastewater (L/person/day) | | 262 | 179 | 100 | 62% | 56% |
| | Water-related emissions (tCO2e/yr) | | 82 | 58 | 32.4 | 60% | 44% |
| Natural Areas | Carbon sequestration (tCO2e/yr) | | -578 | -46.1 | -46.1[9] | -92% | 0% |

[1] The emissions totals include all emissions cited in this table, with the exclusion of emissions originating from materials use. Materials emissions are included in Waterfront Toronto's Carbon Tool, however, they are not considered in the C40 Climate Positive Framework. In order to most accurately compare the scenarios, materials emissions were excluded.
[2] Energy Use Intensities (EUI) for the Climate Positive scenario are based on optimization analysis, as described in this report.
[3] All transportation energy is electrified. Electricity is provided by renewable sources.
[4] Based on the optimization analysis there is a target of 25% car mode share.
[5] Transit use decreases from the Plan as biking and walking trips are increased.
[6] Walking and biking mode share numbers in the Carbon Tool are very low. These numbers have been estimated for the Climate Positive scenario, based on car mode share reduction, transit proximity and neighbourhood walkability.
[7] Based on best practice in Scarborough apartment building and in Metro Vancouver case study.
[8] Based on a 50% reduction (as achieved in neighbourhoods like Olympic Village) from the average Canadian residential daily volume usage (2011 Census).
[9] This number can be modified to indicate greater carbon sequestration by natural areas, however the difference is negligible. It is uncertain how the BAU biomass carbon sequestration was deduced; it seems high.

# Getting Beyond Zero Emissions

Getting to Climate Positive requires major design and operation challenges. At this stage in the design process, it is most appropriate to consider neighbourhood design elements that affect energy, building, and transportation related emissions.

**Emissions Path From Current Precinct Plan to Climate Positive Outcome**

The Climate Positive framework has six major objectives:

- Reducing building emissions to zero;
- Reducing transportation emissions to zero;
- Reducing solid waste production by 80%;
- Reducing potable water use by almost half;
- Reducing wastewater production by more than half; and
- Producing more clean energy than will be consumed by the neighbourhood for export as a local carbon offset.

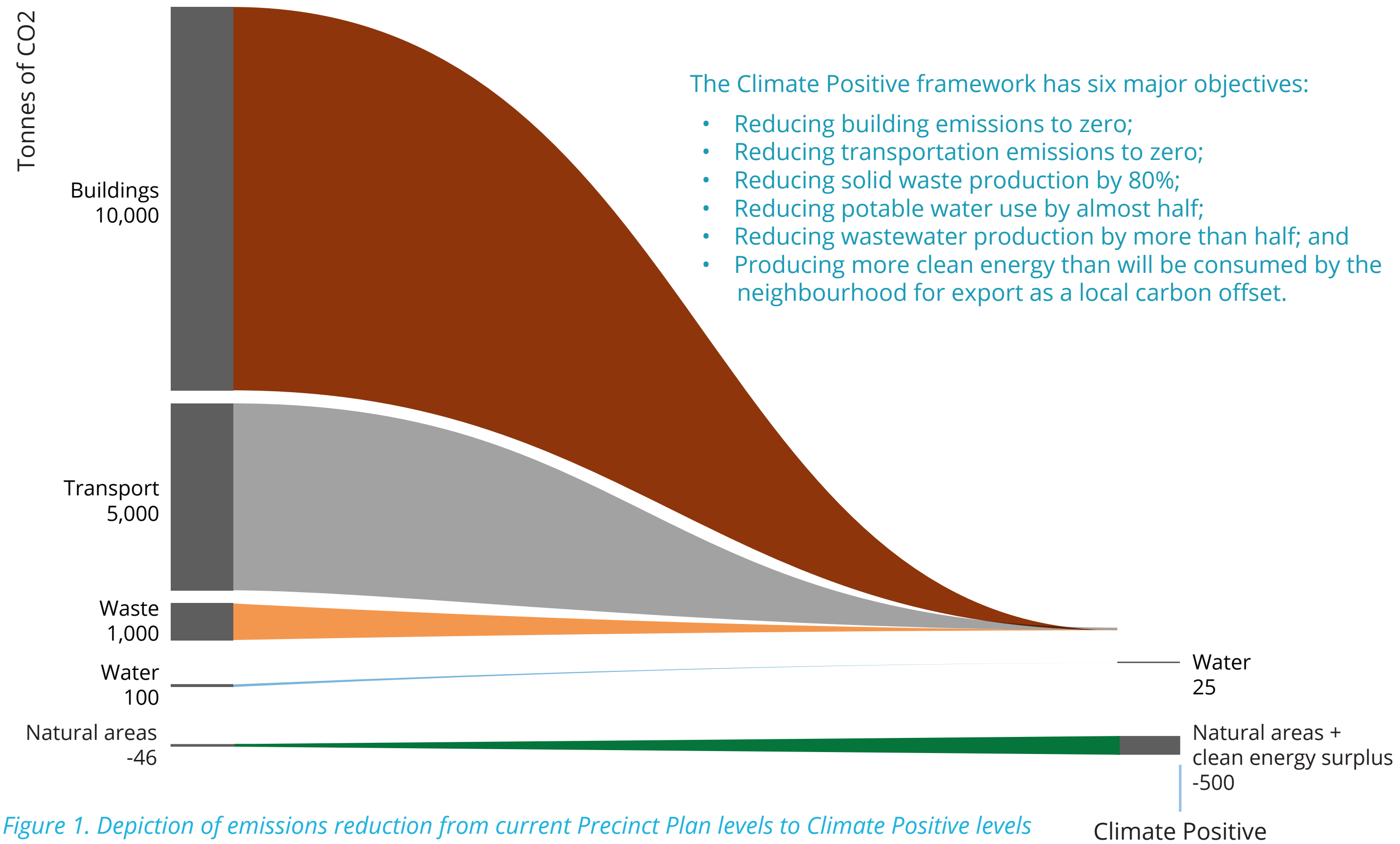



*Figure 1. Depiction of emissions reduction from current Precinct Plan levels to Climate Positive levels*

## Best Practice Community Energy Approaches

From a community energy and emissions perspective, the most important decisions affecting energy use and emissions production are those which last the longest, and are therefore the most expensive and most challenging to change in the future. For Villiers Island, these decisions include the configuration of buildings (urban structure and morphology), followed by building typology, followed by considerations of infrastructure, materials and equipment (Figure 2).

| Minimized Building Loads | | | | Efficient Building Operations | | Power Production |
|---|---|---|---|---|---|---|
| Context | Urban Structure | Urban Morphology | Building Typology | Optimized Operations & Appliances | Occupant Behaviour | Renewable Energy |
| Climate<br>Topography | Configuration<br>Mobility<br>Density | Massing<br>Public space<br>Streetscape | Building type<br>Architecture | HVAC<br>Lighting<br>Hot water<br>Appliances | Lights<br>Room temperature<br>Plug loads<br>Water use | Type<br>Proximity |

Increasing Costs →

*Figure 2. Community energy planning framework*

# Climate Positive Modelling Methodology

An **optimization model** was developed to assess combinations of neighbourhood design and renewable energy technology strategies. The model determined the most cost-effective combination of building efficiency, transportation, electric vehicle, and PV and district energy renewable energy systems strategies in achieving the Climate Positive outcome. The Climate Positive framework can be expressed as an equation:

$$GHG_{Buildings} + GHG_{Transportation} + GHG_{Water+Wastewater} + GHG_{Solid\ Waste} + GHG_{Land} < 0$$

There are two approaches to satisfying this equation:

1. Each sector must reduce more emissions than produced (Table 2); and
2. Emissions produced in one or more sectors must be more than offset by absorption of emissions in other sectors.

*Table 2. Achieving Climate Positive status by individual sector approaches*

| Sector | Approach |
|---|---|
| Buildings | Building energy efficiency is maximized. Clean energy produced exceeds buildings' energy requirements. |
| Transportation | Transportation energy use efficiency is maximized and individual vehicle use is minimized. Clean energy produced exceeds the energy requirements for transportation. |
| Water & Wastewater | Water use is reduced through efficiency measures and potable water offsets (e.g. rainwater use for irrigation); thus water-related emissions are minimized. Emissions from wastewater are reduced via treatment approach. Clean energy produced exceeds the energy requirements for potable water provision and wastewater treatment. |
| Solid Waste | Products and material consumption is minimized. Diversion of reclaimables, recyclables and organics is maximized. Waste resources are reused as materials or converted to renewable energy. |
| Natural Systems | Vegetation carbon absorption capacity exceeds the vegetation emissions produced on site (i.e. by decomposition). |

The primary opportunity for a Climate Positive outcome is in generating more clean energy than needed in the neighbourhood:

$$Energy_{gen} > Energy_{consumed}$$

As noted in Figure 2, efficiency design measures are typically cheaper than renewable energy generation. In order to decrease energy demand, building and transportation efficiency must be maximized, after which the remaining energy demand can be met by renewable energy sources. The challenge is to determine to what extent efficiency and energy production approaches should be taken, considering site and design opportunities and constraints, and costs.[1]

## Building Energy Efficiency Considerations

The goal of building energy efficiency is to reduce thermal and electrical energy use intensity (EUI), the measure of energy use per meter squared of building area ($kWh/m^2$). Building-specific and neighbourhood-wide energy modelling is required to precisely determine the optimal combination of insulation, mechanical systems, thermal bridging prevention approaches, passive solar heat gain technologies, and optimal building orientation for solar heat gain.

Maximizing passive solar gain will help minimize the mechanically-produced thermal energy supply needed in buildings. The best urban structure for solar gain is buildings facing solar south[2] (within ±20°) with enough space between buildings arranged along the north-south axis to allow for maximum solar exposure, with shorter buildings to the south of taller buildings. The current orientation of almost all buildings in the neighbourhood plan is +20° from solar south. This puts the buildings at the very edge of the recommended range of orientation for optimal solar exposure. The optimization model assumes that building orientation and arrangement has been optimized for solar exposure. Further exploration of solar gain and building heating requirements is summarized later in this document.

1 Building and transportation energy use will account for the vast majority of Villiers Island emissions, and are thus the primary Climate Positive design considerations. Although design and operations considerations for solid waste, water, and wastewater are important, their specifics will be determined during a more detailed design phase, and were not modelled here. Also, although Villiers Island incorporates many natural areas, their carbon absorption potential is negligible compared to other energy and emissions strategies, and thus they were not considered in the modelling.

2 Toronto has a 10° magnetic deviation to the west of magnetic north. This means that true north is -10° of magnetic north. This is an important consideration for determining solar south and orienting buildings appropriately. The currently planned orientation of Villiers Island buildings is a 30° counter clockwise rotation from facing due magnetic south, or a 20° counter clockwise rotation from facing due solar south.

# Solar Electricity Considerations

Solar photovoltaic electricity generation is a flexible and proven technology for providing renewable energy to buildings. The most efficient use of PV-produced energy is by electrical loads (i.e. not thermal, due to energy conversion losses). The National Renewable Energy Laboratory (NREL) tool, PVWatts,[3] was used to calculate the potential electrical generation of both the site area and the total building roof area. NREL assumes that 20% of total roof area or 40% of total site area can be effectively used by solar panel arrays. The total energy required by Villiers Island buildings is around 67,700,000 kWh/year (243,720 GJ).

For the purposes of the optimization model, somewhere in-between the site and roof potential generation numbers was used: 8,333,000 kWh/year (30,000 GJ). This would supply ~12% of the neighbourhood's energy demand and be achieved through a combination of PV roof and site coverage.

# District Energy Considerations

After maximizing the solar energy potential of the neighbourhood, the remaining energy demand could be flexibly and efficiently met with a district energy (DE) system producing thermal and electric energy (often called cogeneration heat and power, co-gen or CHP). District energy systems consist of one or more energy centres connected to buildings via a network of pipes. The system could use a combination of technologies such as deep water cooling (thermal), geothermal (thermal), building or industrial waste heat (thermal), and biomass (thermal and electric). A detailed feasibility study is needed to identify the optimal combination.

DE will have implications for the design of Villiers Island and the rest of the Port Lands, such as:

**Technologies**: Many DE technologies can be integrated seamlessly into the existing built environment. Biomass CHP, however, requires stacks and needs to be located so as to minimize the impact of delivery vehicles. There are valid concerns about air quality impacts. Properly designed systems use appropriate filtration media to minimize impacts.

**Location**: To reduce distribution costs, energy centres should be centrally located, closer to significant heating or cooling loads. The location is also influenced by the source of energy. If waste energy is used, the energy centre is located in proximity to the waste energy source.

**Size**: The size of the energy centre is determined by the technologies used. Energy centres can be aesthetically pleasing and can be integrated with other uses. Inclusion of thermal storage would increase the efficiency of the system, but also increase its size.

**Distribution infrastructure**: Piping for heating and cooling will need to be incorporated into the infrastructure planning for Villiers Island. The design of the distribution system is influenced by the location of the energy centres, the size of the heating and cooling loads being served, and the configuration of the system.

## PV Systems + Green Roofs

Maximizing roof space for PV systems does not mean foregoing green roof requirements. Sawtooth solar panel rows maximize panel sun exposure while leaving gaps for plants. Pairing green roofs with solar panels yields energy production, stormwater management, and building temperature control services. Rooftop rainwater collection is also still possible.

Vancouver's neighbourhood energy utility hides under a bridge and has elements that change colour with energy use. (Francl Architecture)

3 See: http://pvwatts.nrel.gov. The 40% (i.e. covering 40% of the entire site in PV panels) and 20% (i.e. covering 20% of each building's roof in PV panels) coverage numbers are NREL standard assumptions. It is assumed that 1m$^2$ of PV panels generates 1kWh of electricity at 16% efficiency (light converted to energy).

## Transportation Considerations

The Climate Positive approach to transportation is to make it as energy efficient as possible by reducing demand and increasing efficiency, then meet the remaining energy demand with renewable energy.

Shifting as many trips to active transportation modes and public transit is the first step, achieved by jobs and amenities proximity, as well as provision of frequent and excellent public transit service, and active transportation infrastructure like bike lanes. The island context provides unique transportation options. Aerial trams, like those used in Portland or on New York's Roosevelt Island, can carry over 100 people per tram. Two 200-person ferries could shuttle people between the western Villiers Island dock and the Jack Layton Ferry Terminal downtown. Transit or private ferry services could also service other nearby islands.

All trips requiring personal vehicles must be increasingly made in EVs. A variety of EV incentives could be offered, including “congestion charges" for non-electric vehicles, priority parking for EVs, and EV car sharing. EVs are 82% more energy efficient than gas-powered vehicles.

The optimization modelling considers all vehicles to be electric and accounts for this electricity demand in assessing energy use and sources. The model also considers active transportation and public transit mode splits based on costs of energy used for all transportation types.

A transit aerial tram Portland, OR.

## Total Neighbourhood Energy

The total annual neighbourhood energy use (buildings + vehicles) shifts from 430,000 GJ in the BAU scenario to 300,000 GJ in the Climate Positive scenario, once efficiency measures have been implemented.

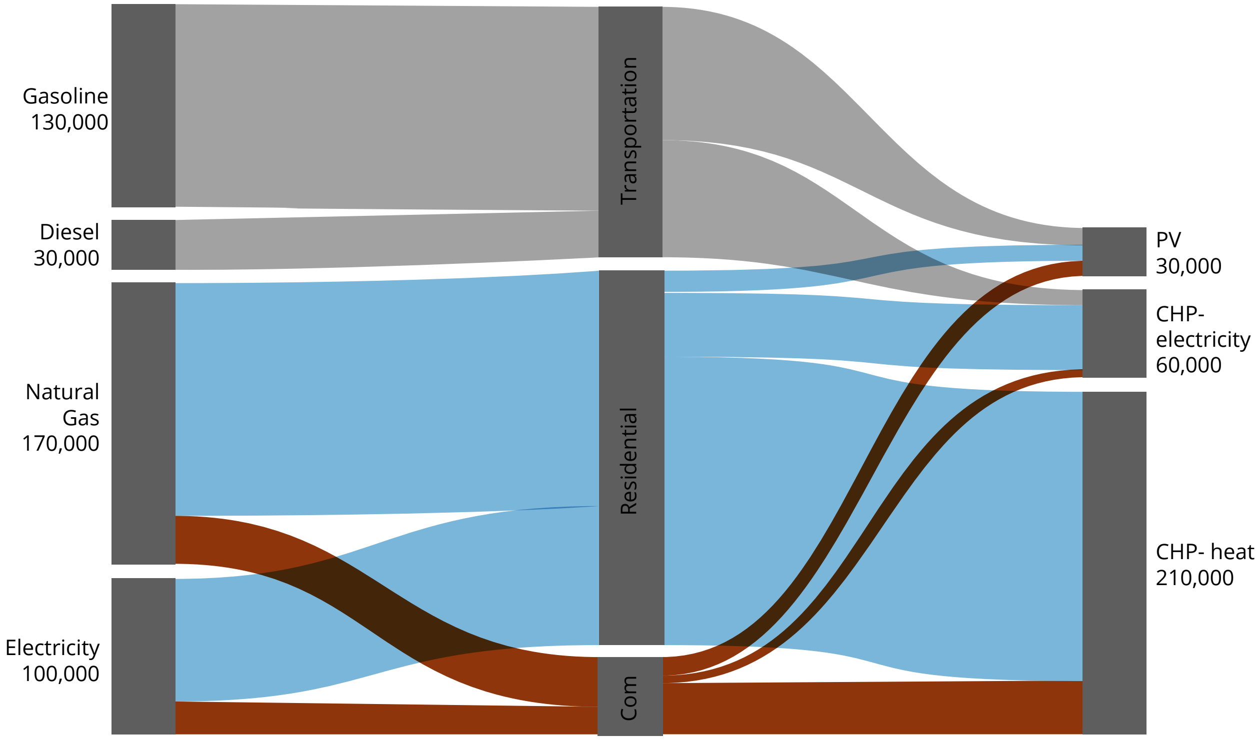



*Figure 3. A Sankey energy diagram depicting annual energy use and the shift in energy sources between the current Precinct Plan and the Climate Positive outcome ('Com' = commercial buildings).*

# The Optimization Model

An optimization model was designed to determine how much effort (money) to invest in renewable energy generation versus passive design versus transportation options. It calculated electricity, heating and cooling loads for residential and commercial buildings, transportation electricity, combined heat and power capacity, and solar PV generation capacity based on the costs per gigajoule (GJ) of each strategy. PV and CHP supply electricity, and the CHP fuel source would be sustainable biomass, with possible contributions from waste heat capture from nearby industrial processes, and deep water lake cooling. Transportation was assumed to be entirely electric. The model used these conditions:[4]

| | |
|---|---|
| Electricity surplus > 0 GJ | More electricity is produced than is consumed in the neighbourhood. |
| Heating & cooling surplus > 0 GJ | More heating and cooling is available than that required by the neighbourhood. |
| PV capacity < 30,000 GJ | The maximum PV capacity (based on maximum roof area) is 30,000 GJ. |
| Heating & cooling load reduction < 0.95 | Heating and cooling loads are reduced up to 95% (in line with Passive House). |
| Plug load reduction < 0.85 | Plug loads are reduced up to 85% (efficient appliances and behaviour change). |
| Transportation load reduction < 0.90 | Transportation energy use is reduced up to 90% (vehicle electrification + mode shift). |

The modelling outcome (Table 3) emphasizes reductions in heating, cooling and transportation energy demand. Note that the thermal EUIs identified in the model do not quite meet the Passive House Standard (15 ekWh/m$^2$/yr), nor does the total EUI (thermal + electricity) (120 ekWh/m$^2$/yr). The transportation reductions represent a major shift away from private vehicles.

*Table 3. Modelling emissions reduction outcome*

| Sector | % reduction over Current Plan | Target EUI (ekWh/m$^2$) |
|---|---|---|
| Residential electrical | -37% | 33.2 |
| Residential heating and cooling | -69% | 117.6 |
| Commercial electrical | -39% | 33.5 |
| Commercial heating and cooling | -72% | 76.5 |
| Transportation load | -74% | n/a |

## Modelling Conclusions

The design considerations that can achieve these energy use reductions are listed in Table 4, along with their emissions reduction effects.[5] Building energy efficiency achieving Passive House levels and electrification of vehicles accounts for the majority of emissions reductions. PV generation is at maximum capacity of 29,902 GJ/year. District Energy provides 208,160 GJ/year for heating and cooling, and 52,814 GJ/year for electricity. Just under 3,000 GJ of renewable electricity is exported each year to the rest of Toronto (an offset). The sum of these efforts reduce Villiers Island emissions below zero.

*Table 4. Summary of building and vehicle emissions reduction by strategy*

| | Emissions (tCO2e) | Percentage Reduction |
|---|---|---|
| **Current Plan total** | **16,541** | |
| Passive House energy efficiency | -8,270 | 50% |
| Vehicle electrification | -4,466 | 27% |
| Mode shift | -331 | 2% |
| CHP system | -3,143 | 19% |
| PV system | -331 | 2% |
| **Total reductions** | **-16,541** | **100%** |
| **CHP exported energy offset*** | **-42** | **100.3%** |

4 Note that these conditions are not the only potential strategy to achieve the Climate Positive outcome. Other solutions could involve providing 100% of the electricity for heating, cooling, plug loads, and transportation using offshore wind generation, or using biomass CHP only, etc.

*Based on National Inventory Report: emissions per kWh of generated power in Ontario (50 grams CO2e/kWh). *This amount of exported energy is arbitrary and could be increased by increasing the generating capacity of the CHP system.*

5 One challenge with modelling is that the input assumptions change over time and performing the same modelling one or two years from now can yield different recommendations. Example inputs that will change include the cost of PV decreasing or the efficiency of electric vehicles increasing.

# Access to Solar Energy Modelling

A simple strategy to reduce energy requirements, passive solar design harnesses free solar energy to heat buildings. Solar energy modelling was performed on 3D renderings of several Villiers Island building configurations to evaluate the impact on their passive solar energy uptake and overall neighbourhood energy demand.[6] Ultimately, three key configurations were tested:

1. Original Precinct Plan, designed to MGBR standards (Figure 4)
2. Original Precinct Plan, designed to Passive House standards (Figure 4)
3. Tower buildings on the North side of the site + some stepped storey buildings + Passive House standards (Figure 5)

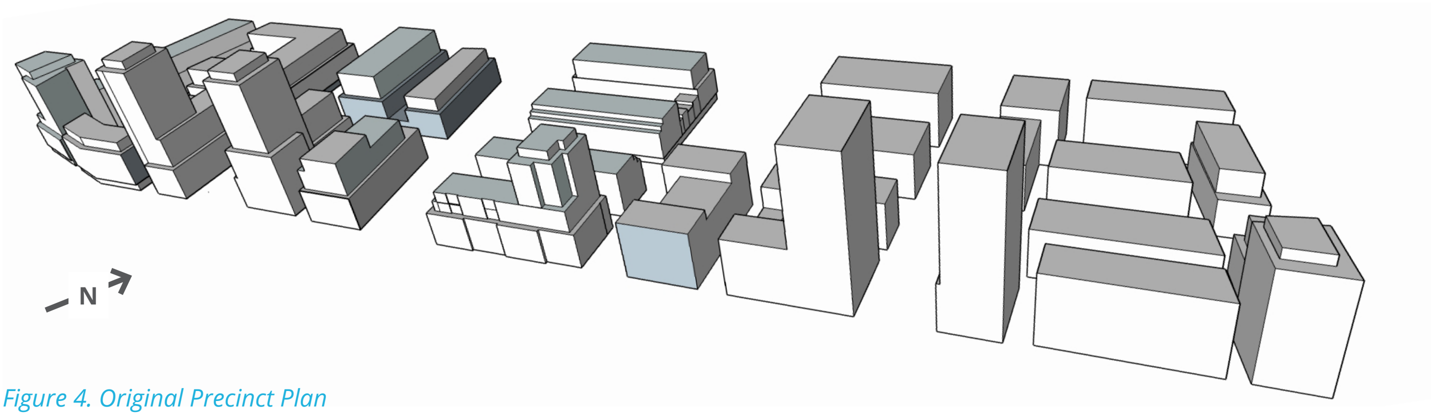



*Figure 4. Original Precinct Plan*

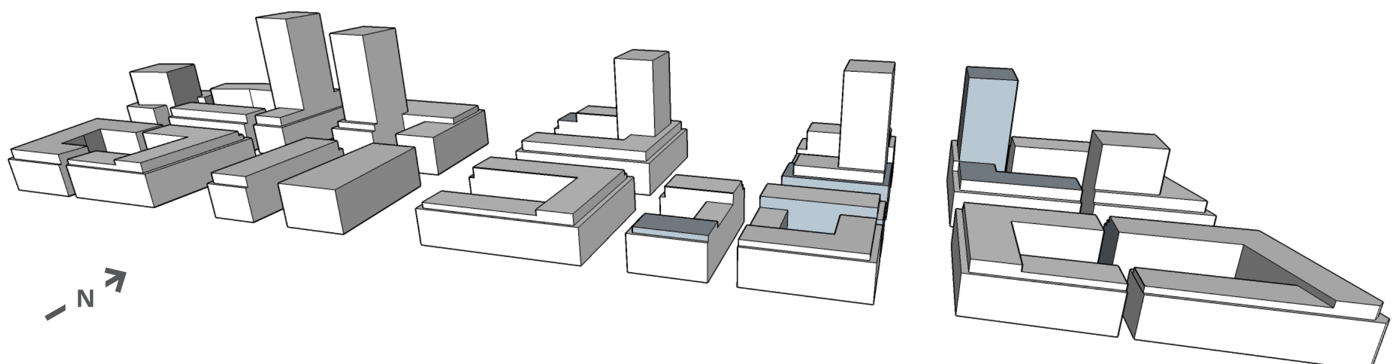



*Figure 5. Rearranged and stepped buildings*

Heating requirements were translated to energy use intensity (EUI) measurements in order to compare energy requirements across neighbourhood designs with different floor space areas. These EUIs are only relevant within this modelling exercise—they cannot be accurate compared to building EUIs outside of the model. The modelling determined that using Passive House standards can reduce the heating energy requirements of the entire neighbourhood by over 92% (5,172 Passive House standard homes' worth less energy). It further determined that the rearranged and stepped building design that allows more solar exposure requires over 28% less heating energy requirements compared to the original precinct plan designed to Passive House standards (1,602 Passive Hosue homes' worth less energy). Table 5 summarizes the solar access modelling results.

6 Additional modelling methodology and output details can be found in Appendix 2. It is important to note that there was no rigorous energy modelling done on the buildings themselves (e.g. HVAC systems, individual building envelope performance). Each building was considered a box with no detailed architectural design features other than those required for energy modelling purposes (e.g. representative windows).

*Table 5. Solar access modelling results summary*

| | Precinct Plan | Precinct Plan + Passive House (PH) | | | Passive House + Rearranged & Stepped Buildings | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | Total | Change over Precinct | % Change over Precinct | Total | Change over Precinct | % Change over Precinct | Change over PH Design | %Change over PH Design |
| Heating Demand (kWh/year) | 10,730,767 | 802,331 | | | 572,446 | | | | |
| Solar Gain (kWh/year) | 9,920,425 | 24,292,843 | 14,372,418 | 144.9% | 26,596,052 | 16,675,627 | 168.1% | 2,303,209 | 9.5% |
| Heating EUI (kWh/m2/year) | 22.06 | 1.650 | -20.4 | -92.5% | 1.182 | -20.9 | -94.6% | -0.468 | -28.4% |
| Equivalent Res. Units of Heating | | 5,172 | | | 1,602 | | | | |

# Climate Positive Design Recommendations

The Villiers Island neighbourhood Climate Positive assessment determined the best design considerations in achieving the ambitious Climate Positive target. There are six major focus areas in proceeding from the current precinct plan.

## 1. Design to Passive House Standards

Building to Passive House standards will dramatically reduce the heating and cooling energy demand for Villiers Island buildings. The standard is being proven in more and more types of buildings worldwide, including a 25-storey residential tower At Cornell University in New York[7] and a neighbourhood in Heidlberg, Germany.[8] This design consideration provides half of the energy efficiency needed to get to the Climate Positive target.

## 2. Optimize the urban form for energy harvesting and conservation

Solar access modelling confirms that configuring buildings to harvest free solar energy greatly reduces heating energy needs, when the buildings are built to Passive House standards. Granting solar access will make achieving Passive House energy efficiency levels easier and less costly.

## 3. Maximize photovoltaic (PV) capacity

After achieving Passive House levels of building performance, optimization modelling indicates that maximizing PV electricity generation is the next crucial, cost-effective strategy. Generating 30,000 GJ of energy (or more) from photovoltaics is possible on-site, providing buildings and vehicles with electricity.

## 4. Meet remaining energy demand with district energy including cogeneration

Using a combination of energy sources, district energy can satisfy the remaining energy needs, producing heating, cooling, and electricity. The DE system would complement the solar PV system in providing 100% renewable energy for the neighbourhood. By exporting energy to adjacent neighbourhoods, the essential local carbon offset would achieve the Climate Positive target.

## 5. Reduce car travel to 25% of trips and/or restrict the Island to electric vehicles

Assuming vehicles are gas-powered, optimization modelling recommends reducing vehicle use to only 25% of trips by shifting trips to biking, walking, and public transit. If all vehicles were electric, shifting only 3% of trips to other transportation modes would be required to help meet the Climate Positive target.

## 6. Design with the Climate Positive goal in mind

From this point forward in the remaining design process, it is imperative to consider energy, efficiency, transportation, water, waste, and natural systems in a comprehensive, interrelated manner in order to achieve the most cost-effective and emissions-effective outcomes required to attain Climate Positive status.

7 http://www.businessinsider.com/the-worlds-tallest-passive-house-will-be-in-new-york-city-2015-7
8 http://heidelberg-bahnstadt.de/files/documents/hd_imagebroschure_2015_englisch_web_0.pdf1

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The following documents were also reviewed:

- The Waterfront Toronto Carbon Tool
- A day on Villiers Island – public presentation materials
- Lower Don Lands Master Plan Environmental Assessment Addendum & Environmental Study Report
- The West Don Lands Precinct Plan
- The Minimum Green Building Requirements and the Toronto Green Standard
- Draft Resilience & Innovation Framework for Sustainability – Guiding Principles for the New Framework
- Port Lands Energy Plan: Guidelines for a Net Zero Community
- The Villiers Island Plan draft Sustainability Section
- The Central Waterfront Secondary Plan
- Toronto Global Best Practices in Energy Efficiency Policy
- A variety of other public engagement materials
- A variety of images, designs and mockups of the neighbourhood

**Notice:** The calculations performed in this report are illustrative and based on assumptions which have not necessarily been validated for the context of Villiers Island. This information should not be used for investment decisions, until detailed modelling is able to be completed once a more advanced design phase is reached.

All Villiers Island neighbourhood design images courtesy of Urban Strategies Inc.

# Appendix 1: Optimization Modelling

Figure 6 illustrates the relationship between net zero energy and Climate Positive, with the premise that all energy generated does not result in GHG emissions. As described above, if energy is used that results in emissions, offsets are then required. When $y_1$=x, the result is net zero, as defined by curve a. When $y_2$>x, the result is Climate Positive, as defined by curve b.

The position on the curve can shift downwards as the energy consumed is reduced, from $y_2$ to $y_3$ resulting in a corresponding reduction in the requirement for generating energy, from x to $x_1$ (Figure 7).

What is the optimal position on the Climate Positive curve—where the costs of saving energy and the costs of generating clean energy are optimal? From the perspective of Villiers Island, the question is: how much effort should be invested in generating renewable energy versus how much effort should be invested in reducing the energy consumption of buildings and transportation?

Figure 8 illustrates the optimal points between design for efficiency and costs of renewable energy. Curve *a* represents the costs of solar PV, which has a cost of $y_1$. Renewable energy has a flat cost intensity as the costs are constant irrespective of the number of panels installed. Buildings' maximum roof areas impose a limit on the size of the PV system (solar PV panel window shades could be installed, although at great cost and challenge for building thermal envelopes), represented by $x_2$. Curve *b* illustrates the cost of renewable district energy, also a flat cost. Curve *c* represents the cost of energy efficiency in building design. This cost increases as the energy performance increases towards 0, reflecting the diminishing returns of energy efficiency investments in buildings.

From an optimal cost perspective, the aim is to supply 100% of the precinct's energy for the lowest cost. Until Point *A*, the lowest cost is curve *c*: efficiency. After Point *A*, the lowest cost is curve *a*: solar PV. However, the PV potential is limited by roof area, represented by Point *B*. After Point *B*, the lowest cost is curve *b*, or district energy. In summary, energy efficiency measures are employed up to the point where PV is more cost effective ($x_1$), then solar PV is employed up until district energy is more cost effective ($x_2$). Note that in this illustration PV is prioritized over district energy as a preferred technology, whereas in the optimization model district energy is considered more cost effective than PV, up until the point at which the electricity exceeds the ratio of thermal production.

The relationship between these three major energy and emissions factors is the core consideration of the optimization model for building energy.

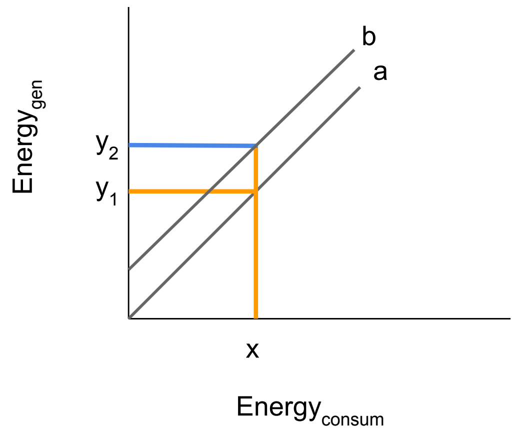



*Figure 6. The relationship between net zero and Climate Positive energy generation and consumption*

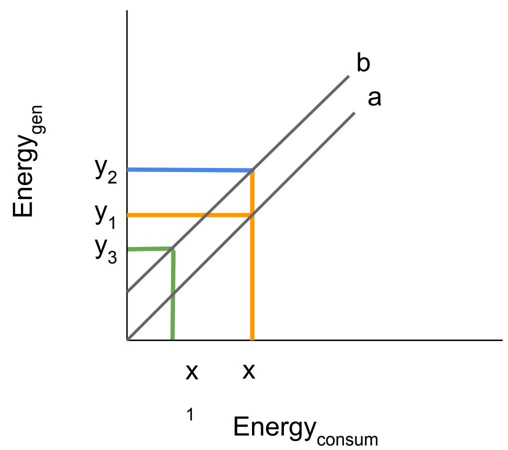



*Figure 7. Downward shift on the Climate Positive curve resulting from decreased demand.*

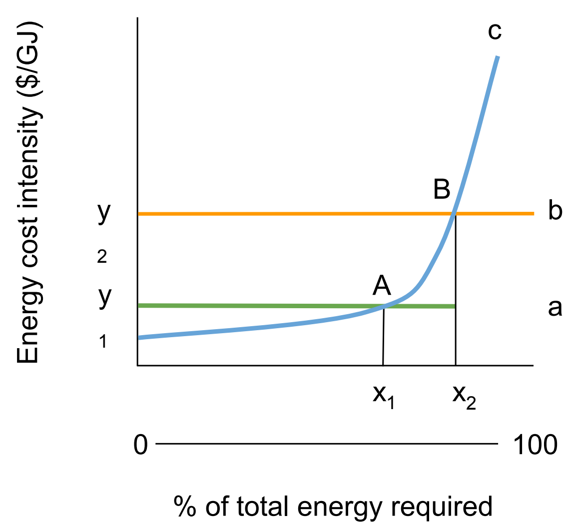



*Figure 8. Cost intensity of Climate Positive buildings*

## Levelized energy costs

In order to compare the costs of relationship between building energy efficiency, transportation energy efficiency, and renewable energy generation, a common variable is required. Levelized cost of energy (LCOE) represents the per-unit cost of energy over an assumed financial life and duty cycle (US Energy Information Administration, 2015). By translating energy and efficiency factors for each sector into LCOE, the optimization model is able to address all sectors using 'apples to apples' comparisons and calculations.

$$LCOE = \frac{Total\ lifecycle\ cost}{Total\ lifetime\ energy\ production}$$

### The Efficiency Curve

A more accurate description of efficiency is the levelized costs of *avoided* energy, but for the purposes of this analysis, levelized cost of energy will be used, represented by $/GJ. Note that detailed building energy modelling would be required to identify an accurate curve for the Villiers Island buildings. The Build-as-Usual assumption for Villiers Island is as follows:

*Table 6. BAU energy use by building type [ekWh/m$^2$/yr (GJ/m$^2$/yr)]*

| | Housing | Commercial/Government | Retail |
|---|---|---|---|
| Electricity | 90 (0.324) | 86 (0.3096) | 41 (0.1476) |
| Thermal energy | 170 (0.612) | 103 (0.3708) | 110 (0.396) |

The cost of increasing the performance of these buildings (reducing the EUIs) increases as energy demand decreases because the opportunities to save energy become increasingly expensive, resulting in diminishing returns.

A study of buildings in Austria, France, Belgium, and Portugal found that up to 90% energy savings can be achieved in high performance buildings for less than $70/GJ (Salazar, 2014). While additional improvements in efficiency can be achieved at little or no cost on a lifecycle basis, the marginal cost of additional efficiency increases exponentially as the percent reduction over the business as usual case increases towards 100% (Jakob, 2007). This economic notion of diminishing returns does not always hold true as in some cases additional energy savings can reduce capital requirements and increase the return on the investment, an idea that can be characterised as “tunnelling through the cost barrier” (Hawken, Lovins, & Lovins, 1999). Since detailed building-scale modelling has not been performed for this project, a traditional energy efficiency supply curve has been used for buildings and transportation (Figure 9 and Figure 10). Figure 10 was calculated based on the cost of delivering a program in the UK that successfully resulted in a mode shift, without modifying physical infrastructure (Sloman et al., 2010).

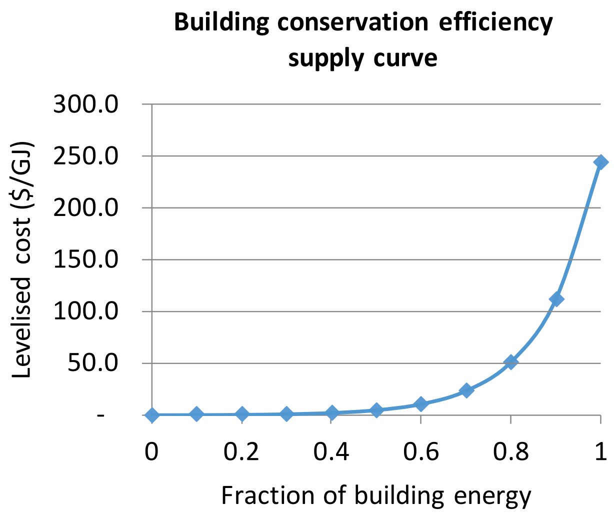



*Figure 9. Building conservation supply curve*

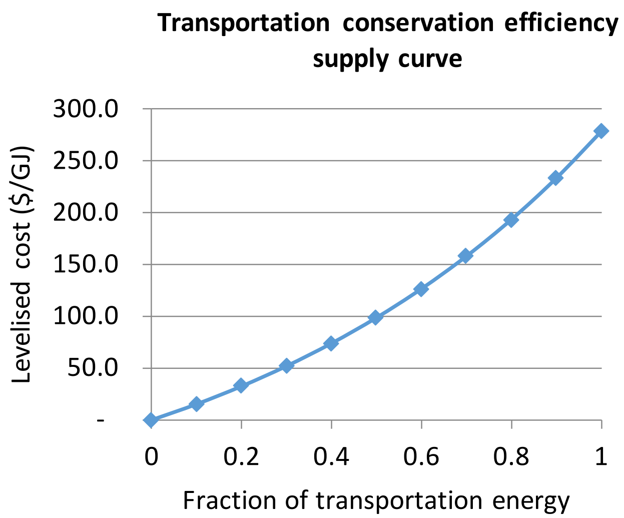



*Figure 10. Transportation conservation efficiency supply curve*

# Optimization Modelling Physical Assumptions

*Table 7. Physical assumptions*

| Scenario Physical Parameters | Assumption | Source |
|---|---|---|
| Residential electrical load intensity | 0.32 GJ/m²/year | Precinct Plan |
| Residential heating and cooling load intensity | 0.61 GJ/m²/year | Precinct Plan |
| Residential floor space | 419,301 m² | Precinct Plan |
| Commercial electrical load intensity | 0.31 GJ/m²/year | Precinct Plan |
| Commercial heating and cooling load intensity | 0.38 GJ/m²/year | Precinct Plan |
| Commercial floor space | 111,381 m² | Precinct Plan |
| Transportation intensity | 0.006 GJ/km | (US DOE & US EPA, 2016) |
| Total trip length | 41,616,028 km/year | Precinct Plan |
| Transportation load | 26,065 GJ/year | Precinct Plan |

*Table 8. Financial assumptions*

| Scenario Financial Parameters | Assumption (in USD) | Source |
|---|---|---|
| Energy conservation cost intensity | Defined by a curve | See Appendix 1 for more information. |
| Transportation load conservation cost intensity | $50/GJ | Based on the cost of reducing travel in a UK program at $0.07/km (Sloman et al., 2010) |
| CHP | $30/GJ | Does not include cost of network. (IDEA, 2013) |
| PV | $30-$54/GJ | (Lazard Ltd, 2015) |
| Fixed cost of DE system | $1,000,000 | Analysis by SSG |

Figure 11 illustrates the components of energy demand and supply for the modelled Scenario.

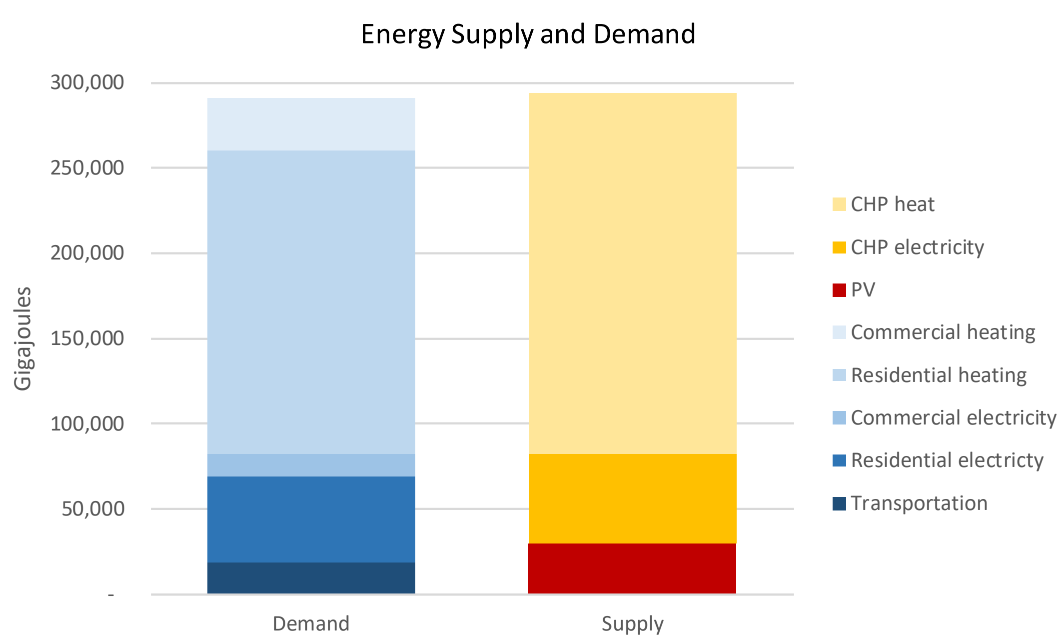



*Figure 11. Illustration of modelled energy demand and supply for Scenario 1*

# Sensitivity Analysis

A sensitivity analysis (Table 9) explored the impact of changing the assumptions of key modelled variables. Sensitivity analysis adjusts variables in order to see the effect on the model outcomes. This helps to identify those variables that have the greatest impact on the outcome, and thus merit particular consideration in the design process. For example, the first row of Table 9 shows the effect of increasing residential floor space by 25%. In this case, the most cost effective strategy to achieve a Climate Positive outcome is to supply the associated increase in heating, cooling and electrical load with increased energy production from the CHP facility. The third row shows an effect of increasing the modelled cost of PV by 25%: the most cost effective strategy to achieve the Climate Positive outcome in this case is to reduce vehicle use and increase residential buildings energy efficiency. These examples illustrate how the optimization model seeks the most cost effective strategies to achieve the Climate Positive outcome as variables are adjusted.

*Table 9. Results of the sensitivity analysis*

| Optimization Model Sensitivity Analysis Variation | Primary Impacts of Variation (most cost effective approaches) |
|---|---|
| +25% increase in residential floor space | Increases the size of the CHP system (more energy required) |
| +25% increase in commercial floor space | Increases the size of the CHP system (more energy required) |
| +25% increase in the cost of PV systems | Decreases VKT (less PV available to power EVs)<br>Decreases EUI of residential buildings |
| Increase building energy efficiency from $51/GJ to $75/GJ (80% energy use reduction from current plan) | Decreases the size of the CHP system (less energy demand)<br>Decreases VKT |
| Increase transportation conservation measures from $193/GJ to $225/GJ to achieve an 80% emissions reduction from current plan | Decreases electrical EUI of residential buildings |
| Increase the fraction of CHP electricity output from 1/5 of total power (electricity + heat) to 2/5 of total power | Decreases thermal EUI of residential buildings<br>Increases electrical EUI of residential buildings<br>Decreases need for PV |
| +25% increase in cost of CHP production | Decreases EUI of buildings<br>Decreases VKT |

Figure 12 illustrates the aggregate EUIs (thermal EUI + electrical EUI) resulting from each sensitivity analysis variable modification (x-axis) in comparison with the aggregate Passive House Standard EUI (120 ekWh/m$^2$). In every case the residential EUIs are slightly higher than the Passive House EUI, while in the commercial case they are generally lower. The consistent results across variable modifications indicate that following the Scenario parameters (Table 7 and Table 8), Passive House Standard can be achieved by the development for any of the considered configurations.

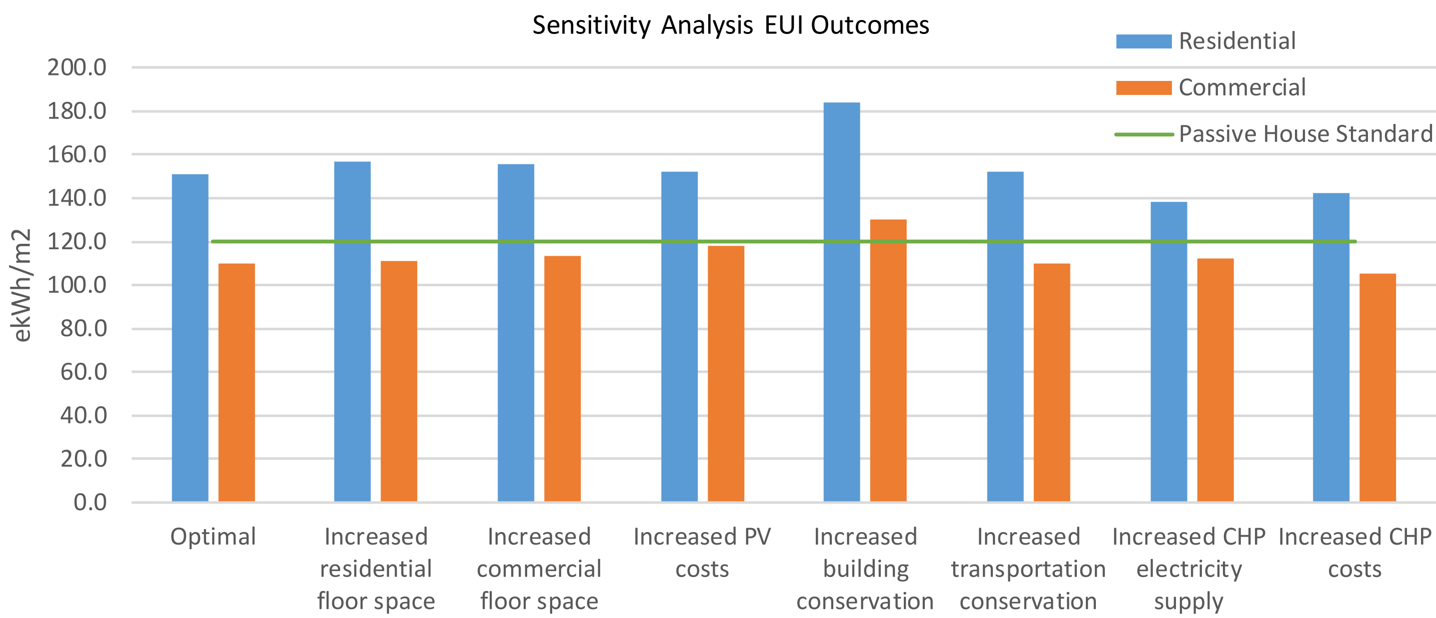



*Figure 12. EUIs of different energy and efficiency approaches (sensitivity analysis) versus the Passive House Standard EUI*

Figure 13 demonstrates the importance of district energy in providing clean power, and the physical constraint of roof area availability for PV, represented by the green line (max roof are PV deployment yields 30,000GJ/year). Note that if district energy can provide proportionately more electricity than heat, the PV load is decreased, indicating that if the thermal and electric loads can be balanced with demand, CHP may be more cost effective than PV. In all other cases, the model recommends maximizing PV production. Of course, if PV costs continue their decline, the case for PV-supplied electricity continues to strengthen.

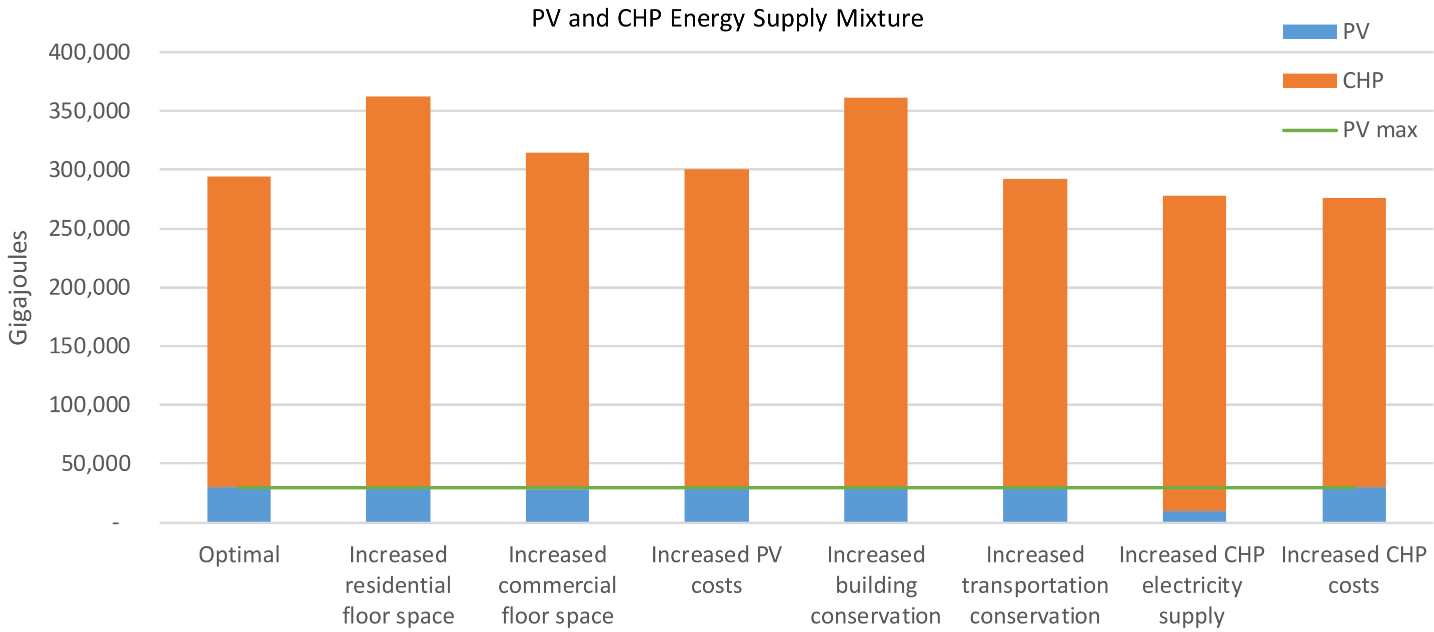



*Figure 13. Energy generation mix of different energy and efficiency approaches (sensitivity analysis)*

Figure 14 illustrates the difference in VKT between the modelled Scenario and the Build-as-Usual scenario, assuming only electric vehicles and that the electricity is provided from the combination of PV and CHP. These VKT reductions (difference between BAU VKT and VKT) are what is required to achieve a Climate Positive outcome for each instance of energy and efficiency approaches (x-axis). The VKT amounts (blue bars) indicate the maximum kilometres that can be travelled by all vehicles in the neighbourhood before using an amount of electricity that would create positive neighbourhood emissions (crossing the line back into 'Climate Negative' territory). Allowable VKT is relatively constant at approximately 60% of the BAU (in other words 40% less vehicular travel), except when the CHP facility is assumed to provide more electricity per unit of heat or there is more effort put towards building energy efficiency; in this case there is additional leeway for vehicular travel.

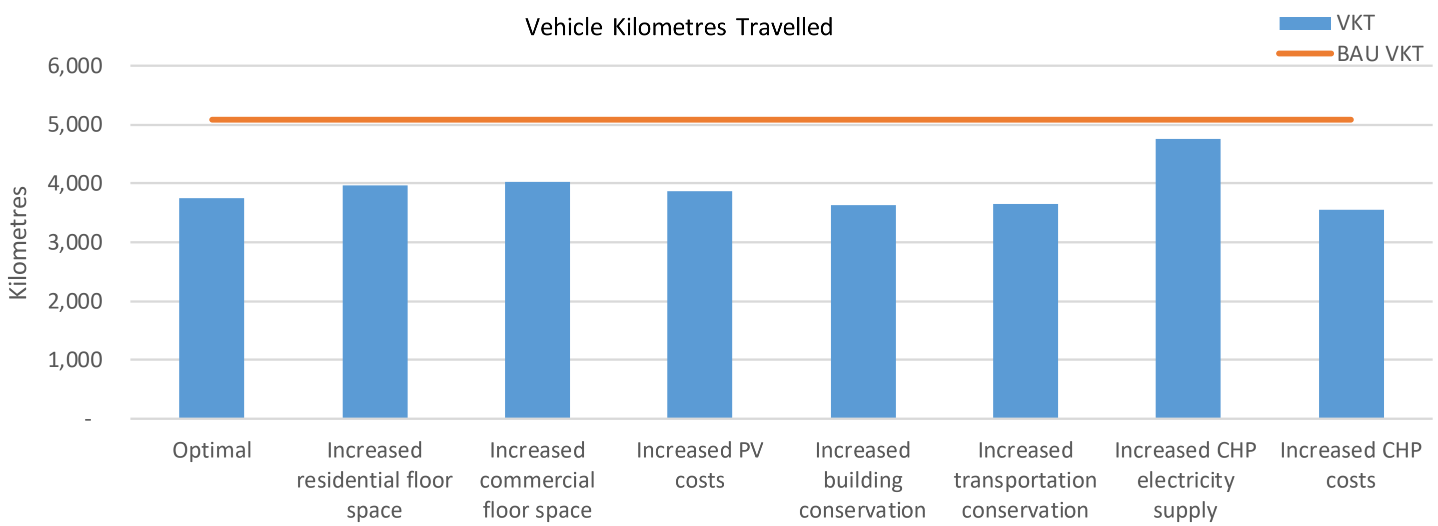



*Figure 14. VKT comparisons of different energy and efficiency approaches (sensitivity analysis)*

Figure 15 illustrates the annual costs of energy generation and the costs of conservation (avoiding energy consumption) for each sensitivity analysis variation. Total annualized costs are estimated to be between $7.4 and $8.8 million per year for implementing strategies to achieve energy efficiency and for generating clean energy to achieve the Climate Positive outcome. The most notable variation is if the ratio of electricity to heat can be increased in the district energy system, the provision of electricity is cheaper, resulting in lower costs for reducing vehicle kilometres travelled and energy usage in buildings.

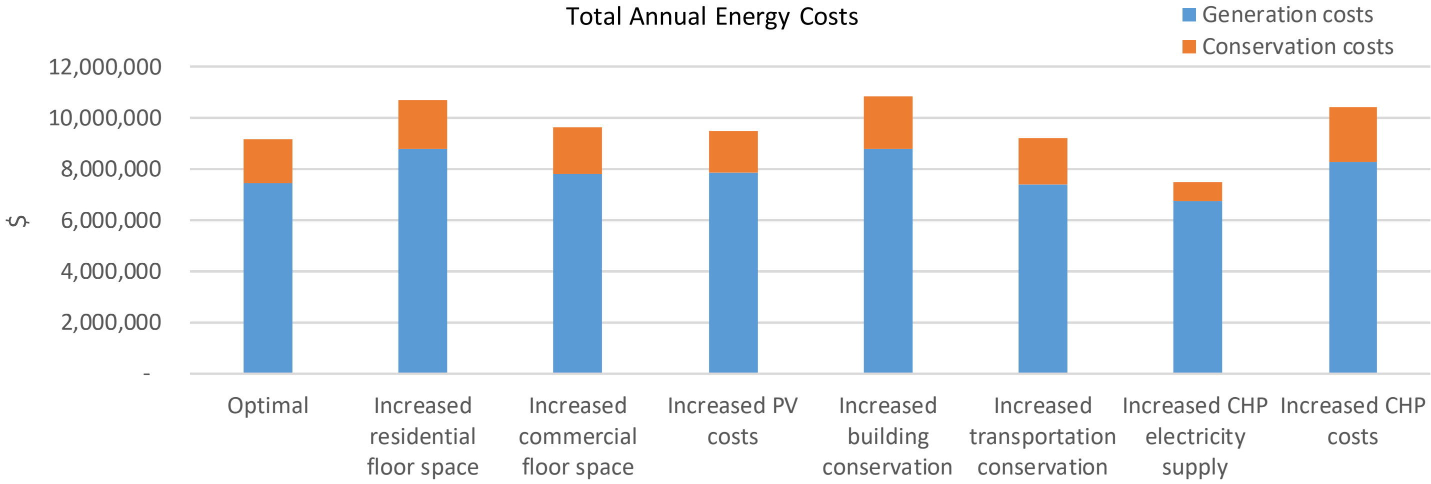



*Figure 15. Annual energy costs of different energy and efficiency approaches (sensitivity analysis)*

**Sensitivity Analysis Conclusion**

The sensitivity analysis tests the impact of key energy and emissions considerations on the outcome of the model. The general conclusions from these test are:

- The residential and commercial building efficiency and EUI modelling indicates that Passive House Standard exceeds the requirements for the Climate Positive outcome but may be desirable to adopt because it is an established standard (i.e.: as opposed to negotiating a new set of building energy efficiency conditions to apply to Villiers Island).
- The model is sensitive to the cost and performance of the district energy system. CHP can provide electricity at a lower cost than PV panels, if there is the appropriate ratio for heating energy. In the optimization, if the ratio of electricity to heat production can exceed 1:5 (i.e.: the system is designed to produce more electricity), the overall system costs will decline. If district energy costs are higher, the overall system costs increase as it becomes cost effective to spend more on increasing the thermal performance of the buildings and reducing vehicular travel (VKT).
- It is more cost effective to invest in strategies to reduce vehicle usage (improved transit, more neighbourhood amenities, behaviour change programs, active transportation opportunities) than to provide additional power from PV or CHP to power electric vehicles, except in the case when CHP can provide increased electricity to heat ratios.
- The most important consideration from this analysis is the design and costs of the district energy system and the role of CHP within that system (the electricity to heat production ratio). All other variables, including the size of the PV system, vehicular travel allowance, and energy performance of buildings can be determined once those numbers are identified.

# Appendix 3: Solar Access Modelling

## The Neighbourhood Energy Model

Sefaira's Architecture Sketup Pro extension was used to perform the energy and daylighting analysis. Using the building's geometry, properties, orientation and location Sefaira is able to simulate energy requirements directly related to an architectural model of the building(s) in question.

## Building Geometry

The geometry of the building is the first piece of information required to process an energy and daylight simulation. The geometry for this analysis included any surfaces which separate environments of significantly different temperatures. The building envelope consisted of the parts of the building that separate the internal (conditioned) space from the outside air or ground including exterior walls, windows, curtain walls, doors, roofs, and the ground floor.

Interior partitions and floors that separate two spaces with different cooling and heating setpoints should also be included. In Sefaira the interior walls are treated as 'adiabatic' in nature and will not have any heat transfer through them. However, it is important to still include key elements inside the building like floors and internal walls, since these will have an impact on daylighting.

The building geometry was provided by Waterfront Toronto and was configured to meet the needs of the modelling software. Changes made to the Sketchup model included the addition of windows required for allowing solar energy into the buildings and the addition of floors to properly partition each story of the building. No internal walls were model as detailed architectural designs were not available at this time. There were no strict building guidelines used when adding these features, as they were added to satisfy the needs of model and the outcomes of this analysis. These assumptions with respect to the building design were held constant across scenarios to ensure the comparability of results.

Due to time constraints Villiers Island was divided approximately down the centerline and the half of the community to the east was modelled. The assumption was made that decisions for this part of the community will apply equally to the remaining half. Note that the towers on the west side of the community will have no significant shading impact on the buildings to the east and visa versa.

## Location

The second piece of information required is the location of the project, which enables Sefaira to incorporate climatic data. The climatic data is contained in the **E**nergy**P**lus **W**eather or .epw file format developed by the US Department of Energy. The epw file contains weather data for all 8760 hours of a 365-day year and includes:

- Location information
- Temperature, humidity and enthalpy
- Wind data
- Solar radiation data

Toronto was the location used in the model and the buildings were predominantly considered to be used as residential buildings. The .epw file used for this analysis can be found at https://energyplus.net/weather-location/north_and_central_america_wmo_region_4/CAN/ON/CAN_ON_Toronto.716240_CWEC

# Building Properties and Space Use

There were two sets of building properties used for this analysis as detailed in.

*Table 10. Building properties considered in the modelling.*

| | ASHRAE 90.1 - 2010 | Custom Passive |
|---|---|---|
| **Space Uses Parameters** | | |
| Lighting power density (W/m2) | 10 | 10 |
| Plug Load power density (W/m2) | 2.7 | 2.7 |
| Heating Setpoint (degC) | 19 | 19 |
| Cooling Setpoint (degC) | 22 | 22 |
| Occupant Density (person/37m2) | 1 | 1 |
| **Envelope Parameters** | | |
| Roof U-Value (W/m2.K) | 0.33 | 0.18 |
| Wall U-Value (W/m2.K) | 0.5 | .24 |
| Floor U-Value (W/m2.K) | 0.4 | .18 |
| Glazing U-Value (W/m2.K) | 2.00 | 1.41 |
| Glazing SHGC | 0.4 | 0.7 |
| Infiltration rate (m3/m2.h) | 7.2 | 1.96 |
| Visible Light Transmittance | 0.42 | 0.7 |
| **HVAC Parameters** | | |
| Heating Efficiency | 0.85 | 0.85 |
| Cooling Efficiency | 3 | 3 |
| Ventilation Rate (L/s-person) | 10 | 10 |

## Results

These results indicate that the Towers North Stepped scenario requires less energy to heat the buildings, using the Custom Passive building properties specified above. These results are not intended to be used as heating targets and this analysis should not be used for detailed building design purposes.

*Table 11. Annual Heating (kWh/yr)*

| | Towers South - baseline | | Towers North | | Towers North Stepped | |
|---|---|---|---|---|---|---|
| | | % change over baseline | | % change over baseline | | % change over baseline |
| Building 1 | 3,461 | 0% | 2,920 | -15.6% | 2,142 | -38.1% |
| Building 2 | 1,820 | 0% | 916 | -49.7% | 853 | -53.1% |
| Building 3 | 1,318 | 0% | 971 | -26.3% | 1,256 | -4.7% |
| Building 4 | 3,575 | 0% | 5,589 | 56.3% | 2,557 | -28.5% |
| Building 5 | 511 | 0% | 494 | -3.3% | 656 | 28.4% |
| Building 6 | 3,981 | 0% | 3,033 | -23.8% | 1,744 | -56.2% |
| Building 7 | 1,404 | 0% | 1,788 | 27.4% | 1,788 | 27.4% |
| Building 8 | 3,857 | 0% | 2,897 | -25% | 2,491 | -35.4% |
| Building 9 | 4,148 | 0% | 3,140 | -24.3% | 2,346 | -43.4% |
| Building 10 | 1,643 | 0% | 2,044 | 24.4% | 4,804 | 192.4% |
| Building 11 | 1,730 | 0% | 1,392 | -19.5% | 1,093 | -36.8% |
| Building 12 | 2,315 | 0% | 2,193 | -5.3% | 2,853 | 23.2% |
| **Total** | **29,763** | 0% | **27,371** | **-8.0%** | **24,853** | **-17.4%** |

*Table 12. Annual Solar Gains - kWh/yr*

| | Towers South | Towers North | Towers North Stepped |
|---|---|---|---|
| Building 1 | 742,350 | 784,422 | 834,322 |
| Building 2 | 1,117,038 | 1,283,043 | 842,399 |
| Building 3 | 646,499 | 739,922 | 781,692 |
| Building 4 | 714,498 | 906,128 | 676,541 |
| Building 5 | 859,180 | 951,897 | 818,947 |
| Building 6 | 617,363 | 689,229 | 653,992 |
| Building 7 | 998,426 | 1,123,494 | 1,123,494 |
| Building 8 | 746,149 | 744,056 | 858,541 |
| Building 9 | 282,936 | 290,084 | 310,412 |
| Building 10 | 3,078,034 | 3,308,051 | 4,166,843 |
| Building 11 | 730,420 | 770,554 | 829,887 |
| Building 12 | 1,578,055 | 1,631,187 | 1,959,016 |
| **Total** | **12,108,948** | **13,252,067** | **13,856,086** |

*Table 13. Floorspace ($m^2$)*

| | Towers South | Towers North | Towers North Stepped |
|---|---|---|---|
| Building 1 | 12,631 | 12,631 | 10,529 |
| Building 2 | 17,240 | 17,240 | 10,344 |
| Building 3 | 16,255 | 16,255 | 12,980 |
| Building 4 | 11,156 | 11,156 | 9,287 |
| Building 5 | 17,383 | 17,383 | 10,430 |
| Building 6 | 13,116 | 13,116 | 10,493 |
| Building 7 | 17,672 | 17,672 | 14,482 |
| Building 8 | 13,979 | 13,979 | 13,979 |
| Building 9 | 4,798 | 4,798 | 4,798 |
| Building 10 | 64,668 | 64,668 | 75,971 |
| Building 11 | 14,098 | 14,098 | 14,098 |
| Building 12 | 27,714 | 28,714 | 35,667 |
| **Total** | **231,410** | **231,410** | **223,058** |

*Table 14. Number of stories*

| | Towers South | Towers North | Towers North Stepped |
|---|---|---|---|
| Building 1 | 10 | 10 | 8 |
| Building 2 | 10 | 10 | 6 |
| Building 3 | 10 | 10 | 8 |
| Building 4 | 10 | 10 | 8 |
| Building 5 | 10 | 10 | 6 |
| Building 6 | 10 | 10 | 8 |
| Building 7 | 10 | 10 | 8 |
| Building 8 | 10 | 10 | 10 |
| Building 9 | 10 | 10 | 10 |
| Building 10 | Base - 10<br>Towers - 12 | Base - 10<br>Towers - 12 | Base - 15<br>Towers -12 |
| Building 11 | 10 | 10 | 10 |
| Building 12 | Base - 10<br>Tower -16 | Base - 10<br>Tower - 16 | Base - 16<br>Tower - 16 |

# Appendix 4: A Car Free Island

The optimization modelling results indicate that transportation energy needs to be significantly reduced to achieve the Climate Positive goal. This is achieved in part through the efficiency gains of electric vehicles, but mostly by shifting the transportation mode share away from vehicles to walking, cycling and transit. To achieve this outcome, Villiers Island will need to be an EV only zone, requiring some restrictive mechanism or disincentive for non-EVs to enter the island as well as incentives and mechanisms to provide access or ownership of EVs to residents.

This result gave rise to the question of making Villiers Island car free entirely. Wards Island is a successful nearby precedent. The implications of establishing Villiers Island as a car free zone are considered in Table 15.

*Table 15. Implications of Scenario 3: Villiers Island as a car free zone*

| Themes | Positive Aspects | Negative Aspects |
|---|---|---|
| Transportation | • Transportation planning is simplified.<br>• Major multifaceted effort to reduce vehicular mode share is no longer required.<br>• The geography of an island is suited to restricting cars. | • Enhanced transit strategies would be required such as a ferry and/or aerial tram (although these could be included in a design that includes cars as well).<br>• Shared access to vehicles may need to be enhanced. |
| Energy | • PV and CHP capacity can be reduced; and/or the performance of buildings can be reduced to account for the reduced vehicle energy consumption.<br>• Cost per GJ of achieving the Climate Positive outcome will decrease. | |
| Design | • Additional land is available for development.<br>• Public spaces can be expanded and enhanced.<br>• Social and health outcomes would improve significantly. | • Existing design would need to be revisited. |
| Buildings | • Additional land would be available for buildings.<br>• Space previously allocated to parking can be foregone and/or repurposed for more valuable uses.<br>• The cost per residential unit could decrease reflecting the absence of parking spaces associated with the unit. | |
| Development | • Developers may seek to participate for reputational reasons (e.g.: Zibi in Ottawa or Lend Lease in Australia/USA). | • The risk for a developer increases. |
| Marketing | • The project would have a significant marketing appeal.<br>• New demographics are less interested in vehicle ownership. | • The size of market would be constrained to those willing to live without vehicles. |
| Symbolic value | • The project would gain international attention as an important climate change symbol, putting Toronto on the map. | |

Establishing Villiers Island as a car free zone reduces the challenge and cost of achieving the Climate Positive outcome. This design parameter would give Villiers Island an international profile and demonstrate a serious commitment to mitigating climate change in the wake of the Paris Climate Change Agreement. This concept does represent a departure from existing design concepts and requires careful consideration from Waterfront Toronto.

# Appendix 5: Sustainable Development Standards Comparison

C40's Climate Positive standard is a guideline and purposefully lacks prescriptive approaches – it is the end goal of Climate Positive development that matters most; getting there is up to the design and development partners. There are other sustainable development standards that can be considered for guidance, some more prescriptive. Benchmarking the Villiers Island Precinct Plan against the LEED for Neighbourhood Development and EcoDistricts Protocol is a useful exercise to assess how the Plan measures up and what gaps exist if the Plan were also pursuing certification under either of these standards.

## LEED for Neighbourhood Development v4 Standard

Developed by the U.S. Green Building Council, LEED is a framework for identifying, implementing, and measuring green building and neighbourhood design, construction, operations, and maintenance. LEED is a voluntary, market driven, consensus-based tool that serves as a guideline and assessment mechanism. The LEED ND rating system was launched in May 2009 after four years of development and pilot testing by a partnership of the USGBC, the Natural Resources Defence Council, and the Congress for the New Urbanism. Waterfront Toronto participated as one of the 23 Canadian pilot communities and in 2009, Waterfront Toronto's East Bayfront, West Don Lands, and North Keating communities collectively achieved Stage 1 LEED for Neighbourhood Development Gold level certification under the pilot program. LEED ND is highly prescriptive, although it offers a variety of options for achieving the rating echelons. The system is very thorough in neighbourhood design element considerations.

LEED ND v4 has five categories (prerequisites|credits|credit points available): Smart Location and Linkage (5|9|28), Neighbourhood Pattern and Design (3|15|41), Green Infrastructure and Buildings (4|17|31), Innovation & Design Process (0|2|6), and Regional Priority (0|4|4).

LEED ND v4 has four levels of certification: Certified: 40-49 points, Silver: 50-59 points, Gold: 60-79 points, and Platinum: 80+ points.

### Smart Location & Linkage

| Prerequisites | Pass / Fail | Villiers Island Response |
|---|---|---|
| Smart Location | P | Locating the project on an infill site fulfills this prerequisite. |
| Imperilled Species and Ecological Communities | P | The project will have to perform a survey to determine if threatened or endangered plant or wildlife species are present. If they are present, a habitat conservation plan or habitat conservation plan equivalent is required. |
| Wetland and Water Body Conservation | P | Although the project is located on a waterbody, it is using previously developed land and will meet this prerequisite by respecting setbacks from the water and performing proper rainwater management. |
| Agricultural Land Conservation | N/A | This infill project does not develop any agricultural lands. |
| Floodplain Avoidance | P | The risk of flood should be removed with the re-naturalization of the mouth of the Don River. |

| Credits | 28 | |
|---|---|---|
| Preferred Locations | 10 | The project should earn full points for infill location and connectivity. |
| Brownfield Remediation | 2 | Soil contamination from previous industry exists, remediation of the site will earn these points. |
| Access to Quality Transit | 7 | 320 weekday and 200 weekend trips for transit services on the island will earn all 7 points in this category. |

| | | |
|---|---|---|
| Bicycle Facilities | 2 | Creating bicycle road infrastructure and storage options will earn these 2 points. The MGBRs fulfill the cycling storage requirements for this credit. |
| Housing and Jobs Proximity | 3 | The residential units, affordable housing content, and employment provision targets for the project earn all 3 points for this credit. |
| Steep Slope Protection | 1 | The project does not earn this credit as there are no slopes in excess of 15%. |
| Site Design for Habitat or Wetland and Water Body Conservation | 1 | The project's consideration of natural landscapes, waterbody creation and waterbody protection satisfies the criteria for this credit. |
| Restoration of Habitat or Wetlands and Water Bodies | 1 | As long as native plant species are used and maintained in the planned natural areas, the provision of greater than 10% of the developable project area dedicated to natural spaces satisfies this credit. |
| Long-Term Conservation Management of Habitat or Wetlands and Water Bodies | 1 | In order to earn this point, the project will have to create and commit to implementing a long-term (at least 10-year) management plan for existing or recently restored on-site native habitats, water bodies, or wetlands and their buffers, and create a guaranteed funding source for management. |

## Neighbourhood Pattern & Design

| Prerequisites | Pass / Fail | Villiers Island Response |
|---|---|---|
| Walkable Streets | P | Current street and building designs meet the prerequisite criteria. |
| Compact Development | P | The planned dwelling units per acre count of the project meets the criteria for this prerequisite. |
| Connected and Open Community | P | The through streets and intersection density is sufficient to meet the criteria for this prerequisite. |

| Credits | 41 | |
|---|---|---|
| Walkable Streets | 9 | The building facades and entry, ground-level use and parking, sidewalks, and pedestrian and cycling considerations suffice to earn all 9 points for this credit. |
| Compact Development | 6 | At ~90 dwelling units per acre, this development earns all 6 points for this credit. |
| Mixed-Use Neighbourhoods | 4 | The space provisions for business, retail and services should suffice to achieve all points for this credit, provided that there is a diversity of basic needs amenities and that they are in place by the time of 50% residential occupancy. |
| Housing Types and Affordability | 7 | The number of points earned for this credit is not yet clear as the diversity of dwellings has not yet been determined. The affordable housing component will make up 20% of residences. |
| Reduced Parking Footprint | 1 | As surface parking will be very limited in the development, this point and credit will be earned. |
| Connected and Open Community | 2 | The number of intersections per square kilometre is probably insufficient to achieve this credit. |
| Transit Facilities | 1 | Planned transit provisions will suffice to achieve this credit. |
| Transportation Demand Management | 2 | A combination of providing one year of transit passes for residents, a vehicle sharing program, unbundling parking spots from residential units, flexible work arrangements, and employer-sponsored transit options will earn all points for this credit. |
| Access to Civic & Public Space | 1 | The planned public institution uses in the project and residential proximity to them satisfy this credit's requirements. |
| Access to Recreation Facilities | 1 | The indoor and outdoor recreation opportunities planned earn this credit. |
| Visitability and Universal Design | 1 | Design 20% of dwelling units to accessibility standards to achieve this credit. |

| | | |
|---|---|---|
| Community Outreach and Involvement | 2 | The public engagement and charrettes held in the development of this Plan satisfy the requirements for earning both points for this credit. |
| Local Food Production | 1 | Providing 5.5m2 of garden space per dwelling unit, purchasing shares in a community-supported agriculture program located within 150 miles (240 kilometres) of the project site for at least 80% of dwelling units, or having a farmers market within an 800m walk will earn this credit. |
| Tree-Lined and Shaded Streetscapes | 2 | Providing a tree every 12m for 60% of block lengths, providing sidewalk shade for 40% of sidewalk length, and obtaining a healthy plantings determination from a landscape architect will achieve these two points. |
| Neighbourhood Schools | 1 | The inclusion of an elementary school in the project earns this credit. |

## Green Infrastructure & Buildings

| Prerequisites | Pass / Fail | Villiers Island Response |
|---|---|---|
| Certified Green Building | P | The MGBRs satisfy the prerequisite condition of one building in the development being LEED certified. |
| Minimum Building Energy Performance | P | Designing and building all buildings in the development to LEED standards or better will ensure the energy efficiency requirements of this prerequisite are met. |
| Indoor Water Use Reduction | P | The MGBRs stipulation for water efficiency will meet the LEED ND water efficiency prerequisite of 20% reduction over baseline for each type of water fixture. |
| Construction Activity Pollution Prevention | P | An erosion and sedimentation control plan is required for all new construction projects in the development. |

| Credits | 31 | |
|---|---|---|
| Certified Green Buildings | 5 | Achieving LEED or other equivalent/superior green building certification for over 50% of the buildings in the development will earn all 5 points of this credit. |
| Optimize Building Energy Performance | 2 | Applying the MGBRs to at least 90% of the total floor area of buildings in the development will suffice to achieve both points of this credit. |
| Indoor Water Use Reduction | 1 | Water use in all new buildings must be reduced by 40% from baseline, on average. |
| Outdoor Water Use Reduction | 2 | Reducing irrigation requirements by at least 50% from baseline will earn both points for this credit. |
| Building Reuse | 1 | With more than 5 heritage buildings being retained on the site, obtaining this credit requires reusing at least 20% of all surface areas of the buildings. No historic building may be demolished unless approved by an appropriate heritage review body. |
| Historic Resource Preservation and Adaptive Reuse | 2 | The planned preservation of heritage buildings will earn the two points for this credit. No historic building may be demolished unless approved by an appropriate heritage review body. |
| Minimized Site Disturbance | 1 | This point is earned by virtue of developing on a 100% previously developed site. |
| Rainwater Management | 4 | If the site can manage at least 85% of each rainfall event on-site, the development can earn two points, plus one for developing on a previously developed site. Three and four points, plus one, can be earned for 90% and 95% management of each rainfall event on-site. |
| Heat Island Reduction | 1 | Between the planned plantings and green roof requirements, and the lack of large paved areas in the development, this credit should be earned. |
| Solar Orientation | 1 | If 75% of the blocks are oriented such that one axis is within ±15 degrees of geographical east-west, and the east-west lengths of those blocks are at least as long as the north-south lengths, this point will be earned. This point can also be earned on orientation of 75% of total building floor areas instead of the blocks themselves. |

| | | |
|---|---|---|
| Renewable Energy Production | 3 | If the development can provide 20% of the annual electrical and thermal energy costs via renewable energies, all three points can be earned for this credit. |
| District Heating and Cooling | 2 | Providing at least 80% of the project's annual heating and/or cooling consumption via district energy will earn both points for this credit. |
| Infrastructure Energy Efficiency | 1 | Achieving a 15% annual energy reduction below an estimated baseline energy use for this infrastructure (assuming the use of lowest first-cost infrastructure items) will earn this credit. |
| Wastewater Management | 2 | Treating and reusing at least 50% of wastewater generated on-site will earn both points for this credit. |
| Recycled and Reused Infrastructure | 1 | Using materials for new infrastructure such that the sum of the postconsumer recycled content, on-site reused materials, and one-half of the preconsumer recycled content constitutes at least 50% of the total mass of infrastructure materials will earn this credit. |
| Solid Waste Management | 1 | Application of the MGBRs and provision of frequent public spaces waste separation receptacles should suffice to earn this credit. |
| Light Pollution Reduction | 1 | Minimizing uplighting in outdoor luminaires and minimizing light trespass from interior and exterior building luminaires to the extents in the LEED requirements will earn this credit. |

## Innovation & Design

Having at least one LEED Accredited Professional (AP) with a speciality appropriate for the project (e.g.: LEED ND, LEED BD+C) as a principal participant of the project team will earn one credit.

Up to five additional Innovation & Design points can be earned through a combination of new and innovative sustainable neighbourhood development strategies; exemplary performance by doubling the performance for, or achieving the next iteration in performance for, any of the LEED ND credits; and achieving one pilot credit from USGBC's LEED Pilot Credit Library (or Canadian equivalent, when available).

## Regional Priority Credits

A maximum of four credits can be achieved for addressing priorities identified for the Toronto region by the Canadian Green Building Council. Regional Priority Credits are not typically additional credits to the rating system; rather they are credits of the rating system deemed to be of geographic priority.

## LEED ND Comparison Conclusions

The thorough urban planning process and borrowing from successful sustainable neighbourhoods has produced a Plan that meets all prerequisites and earns the vast majority of credits available under this standard. Villiers Island could be certified LEED ND Platinum with no major changes to its current design. Satisfying the parameters of LEED ND will result in a sustainable neighbourhood in most regards, although it is widely recognized that the LEED standard could go further towards ambitiously reducing GHG emissions.

# The EcoDistricts Protocol

The EcoDistricts Protocol is a sustainable neighbourhood development framework with a commitment to three Imperatives: Equity, Resilience, and Climate Protection. The Protocol has six Priority Areas: Place, Prosperity, Health & Wellbeing, Connectivity, Ecosystem Health, and Resource Protection. EcoDistrict certification follows a three-step process: Formation (building the necessary leadership, collaboration, and governance conditions), Roadmap (creating a performance baseline, establishing district or neighborhood-scale targets, and prioritizing a set of investments), and Action (implementing the EcoDistricts Roadmap, measuring and reporting performance, adapting, and facilitating ongoing district and neighbourhood enhancements).

The process begins with declaring a Manifesto. The Manifesto becomes a public statement of commitment to develop a project that is equitable, climate responsive, and resilient. After the Manifesto is declared, the project can proceed to Phase 1. Phase 1 (Formation) certification requires:

- A community-based asset map
- A collaborative governance readiness assessment
- A signed declaration of cooperation
- A short report summarizing activities and outcomes for each of the required actions

Phase 2 (Roadmap) certification requires:

- A completed context template
- A completed data plan
- A completed target setting template
- An EcoDistricts roadmap
- A short report summarizing activities and outcomes for each of the required actions

Phase 3 (Action) certification requires:

- An EcoDistricts roadmap
- An annual sustainability report

The following is an assessment of what would be required for the Villiers Island Precinct Plan to successfully respond to the EcoDistricts Protocol.

## Imperative 1: Place

**Goal: Engaged, inclusive, culturally rich, and vibrant communities**

| Principle | Objective | Villiers Island Response |
|---|---|---|
| Engagement & Inclusion | Engagement processes are inclusive and representative | Community consultation on the project has been strong so far. Continuing this through the rest of the planning stages and into development is important to the viability of the community. A variety of engagement means (in-person, online, via mail, pop-up, etc.) that focus on diverse demographics (e.g.: cultural, generational, by income) and the underrepresented (e.g.: marginalized and oppressed communities, single parent families, youth, etc.) are required to ensure resiliency in design and successful realization of the project. |
| | Civic engagement in the district is strong | Providing opportunities and encouragement for volunteerism and engagement in civic and community processes and events by residents and businesses is important for strong community. The Plan has a strong start with heritage preservation and public institution representation. Waterfront Toronto's ongoing efforts in this realm could include a street-front area planning office for WT and City activities. |
| | District is inclusive of households of different ages, incomes, sizes and types | Providing a variety of housing affordability options (rental and ownership), employment options, local amenities and institutions, and community spaces is crucial to encouraging diverse household composition. The Plan has a good start with some of these elements. A commitment to below-market affordability and rental options should be included. Provisions must be included in the zoning bylaws and development application process to achieve this. |
| | Power is shared through decision-making and accountability | The project has successfully engaged a variety of stakeholders and the community. The project should continue to include neighbourhood and community mechanisms to facilitate and encourage engagement in Plan completion and delivery (development), while transparently monitoring and reporting on project progress and performance. The implementation of the development needs a plan for decision-making and accountability going forward. |
| Culture & Identity | Strong participation in cultural events | The project has excellent considerations around heritage and public spaces. Further consideration for specific cultural spaces, public art, and event spaces should be made as well. The Plan needs to include considerations for encouraging the hosting of cultural events and community participation in those events. |
| | Historically and culturally significant places are preserved and celebrated | |
| | Cultural capital as an asset | |
| Public Spaces | Public spaces are accessible | The project has excellent considerations for public spaces. Maintaining accessibility for all demographics and abilities is crucial to meet this objective. The project should continue to ensure that the public spaces offered have a variety of potential uses and accommodate a variety of activities throughout the year (cold and warm seasons). The opportunity for unintended positive uses of public spaces and chance meetings between residents will add interest and build community. |
| | Public spaces within the district are engaging and active | |

## Imperative 2: Prosperity

**Goal: Prioritize education, employment, and economic opportunities that build prosperity and accelerate innovation.**

| Principle | Objective | Villiers Island Response |
|---|---|---|
| Access to Opportunity | Low levels of income inequality | The project should ensure a substantial supply of below-market rate housing ownership and rental opportunities. Marketing of housing to a culturally and income diverse ownership and rentership should be executed. The project needs to include provisions in condo association bylaws and dedicate a certain percentage of units across multiple buildings to this end. |
| | Quality education within the district (pre-k and k-12) | Provision of an elementary school directly addresses this objective. High school opportunities are few in the immediate neighbourhood and should be addressed in the area. The project's provision of play spaces and sports areas encourage positive childhood development. |
| | Low housing and transportation burden | One challenge may be the cost of utilities. District energy and local utilities often increase the cost of service for those utilities, rather than decrease it. Local utilities should be constructed and operated in such a manner that they do not constitute an undue financial burden on residents. Similarly, shared transportation options and public transportation accessibility should be omnipresent without imposing undue household costs. The planned transportation routes and residential and business proximity to transit stops should serve the residents and visitors well. Coordinating transit and utility affordability programming with employers, condo associations and not-for-profits is critical to achieving this objective. |
| | Career pathways and training accessible to district population | Community programming should include opportunities for job and skills training. Partnerships with local universities, colleges and businesses are needed to this end. Waterfront Toronto would have to spearhead these partnerships under the Waterfront Toronto Engagement Initiative. |
| Economic Development | Enhance employment opportunities within the district | Stewardship of the institutions and commercial outfits present on the island will be important to ensuring career opportunities for residents. Job creation should be considered in leasing or selling spaces to institutions and business. The project Plan includes flexible residential space, and should also include flexible commercial space to allow businesses to grow in place in order to retain successful businesses. Quality jobs with, at minimum, living wage incomes needs to be the norm in the neighbourhood. Residential units with the option for home offices and commercial spaces that could accommodate co-working should be included in the neighbourhood design to accommodate the self-employed and small businesses. |
| | Enhance job quality within the district | |
| | Encourage local economic development | |
| Innovation | Foster interaction between entrepreneurs in the district | Targeting innovative businesses, collaborations, incubator spaces, maker spaces, programming, and co-working spaces to locate in the neighbourhood will help develop an entrepreneurial presence. The business, institutional and commercial presence on Villiers Island should be highly strategic and thoughtful. |
| | Encourage job creation and growth in emerging sectors | |

## Imperative 3: Health and Wellbeing

**Goal: Create communities that nurture peoples' health and happiness.**

| Principle | Objective | Villiers Island Response |
|---|---|---|
| Active Living | Access to outdoor space and recreational facilities | The Plan includes impressive outdoor spaces and recreational offerings. Providing outdoor exercise equipment and ensuring commercial fitness businesses have space on the island will round out the physical fitness options. |
| | Enhanced walkability within the district | Sidewalks, naked streets concepts, diverse amenities, outdoor cafes, natural spaces, trails, and parks in the current Plan all contribute to an amazing walking experience. |
| Health | Health outcomes and life expectancy are not disparate by race and neighbourhood | The opportunities for physical activity in the Plan, especially through active transportation, will increase the positive health outcomes for residents. Thoughtful targeting of healthy commercial food options (restaurants, cafes, catering, and grocery stores) in the neighbourhood will contribute to life expectancy and low rates of diabetes. WT needs to target ethical and well-managed businesses to set up in the neighbourhood to help ensure health insurance coverage for employees. The natural features and attention to healthy built environments and healthy building design and construction will ensure low exposure to toxins and living environments that can be detrimental to health. Working with the light industry that will remain or be introduced to the area to minimize environmental and noise pollutions will be critical to resident health as well. |
| | Access to affordable, high quality healthcare | |
| | Non-toxic environments | |
| Safety | Safety and perceived safety of district participants | The human-scale of the urban design considered in the Plan should contribute to a feeling of safety, with eyes-on-the-street and enough population to be active around the clock (especially if population density can be increased). Special attention will need to be paid to some of the open and public spaces to avoid areas that provide too much secretive refuge – easily avoided through wise application of Crime Prevention Through Environmental Design (CPTED) principles. Attention to design details like street lighting, community gardens, playgrounds and inviting store fronts will help with the feeling of safety, as will community programming like LGBTQ and people of colour-positive retail campaigns and hiring practices, and public washrooms that cater to persons of all genders. Frequent transit, plenty of waste diversion receptacles to keep streets clean, and open space and shoreline monitoring and clean up programs will all contribute to resident feelings of safety. |
| | Design for safety within the built environment | |
| Food Systems | Access to healthy, affordable, and fresh food | Community gardens and intensive urban agriculture are natural considerations for this project. The greatest success in these endeavours will come with dedicated staff for maintenance, farming and community organization. Affordable, healthy grocery store options and farmers markets are also obvious inclusions. Partnering with not-for-profits to provide community programming for local food production and consumption will be a boon to the community. |
| | Encourage food production within the district | |

## Imperative 4: Connectivity

**Goal: Build the most equitable and efficient physical and digital connections between people and place.**

| Principle | Objective | Villiers Island Response |
|---|---|---|
| Street Network | Street network provides effective transportation choices | The project’s plan to accommodate all modes of transportation, continuous and accessible sidewalks, the number of intersections planned, presence of an elementary school, and proximity to diverse amenities and services satisfy the street connectivity and transportation choices objectives. Conscious attraction and implementation of shared mobility services, like car and bike shares, will help ensure a sufficient diversity of sustainable transportation options. Community and employer programming encouraging the use of these services, active transportation and public transit will further the use of sustainable transportation. |
| | Street network accommodates diverse ages and abilities | |
| | Enhanced connectivity within the district | |
| | Effective public transportation choices | |
| | Increase shared use mobility options | |
| Digital Network | Quality wired and wireless connectivity available throughout the district | Integrating digital services into new developments is a simple matter of proper planning. The infrastructure for digital technologies should be thoughtfully considered during development planning phases, and not just left to market forces to develop to minimum standards. Wise technological decisions will ensure the longevity of the digital infrastructure and avoid reliance on technologies at risk of becoming obsolete or outdated, and avoid reliance on proprietary corporate controls that risk cost competitive options, updating and upgrading options, free access to information and services, and security concerns. |
| | Open access to and integration of data for public consumption | Waterfront Toronto is addressing this element through its Intelligent Communities initiative. |

## Imperative 5: Ecosystem Health

**Goal: Build communities with flourishing ecosystems**.

| Principle | Objective | Villiers Island Response |
|---|---|---|
| Natural Features | Enhance the quality and function of habitat within the district | The natural systems planned for the neighbourhood respond well to these objectives. Maximizing the forest cover of the land and rooftops has numerous sustainability and ecosystem benefits. The Plan needs to specify the use of native and adaptive species. Maintenance of the landscape is an important consideration in order to replenish vegetation and exchange plant species that are struggling with those that will thrive while contributing environmental benefits. |
| | Increase urban forestry within the district | |
| Ecosystem Health | Capture, treat, and reuse water within the district | The Plan considers how to sustainably deal with storm water through its harvest and use. Critical site-wide decisions have to be made as to what infrastructure systems and investments will be made to use and manage storm water (e.g.: piping and storage for irrigation, non-potable use in residences and businesses). The site has large, pervious areas for storm water infiltration. Some of the land that has sustained industrial uses will have to be properly remediated to avoid further contamination from polluted soils. |
| | Increase the supply of healthy soil within the district | |
| | Maintain and improve water quality | |
| Connection with Nature | Maintain and improve access to nature | Residents' access to natural areas is excellent and several different types of available natural interactions are planned. |
| | Integrate natural processes in the built environment | Ensuring abundant green roofs, green walls, and plantings will bring life to traditionally lifeless urban forms. The Plan needs to include building design and construction requirements for buildings to achieve proper green roofs and walls, through application of the MGBRs. |
| Natural Processes | Mitigate the impact of urban heat island effect | Green roofs, urban forests, natural areas, and high solar reflective index materials should be used throughout the project. Building design approvals will have to enforce these elements. The lack of surface parking lots contributes to achieving this objective as well. |
| | Protect air quality from pollutant emissions | Sustainable, fossil fuel free transportation and energy production in the neighbourhood are critical elements to protecting air quality. The Plan needs to specify the elements of a fossil fuel free energy production strategy. Air quality requirements for building air effluent will also be needed in building design requirements, especially for commercial and industrial buildings. |

## Imperative 6: Resource Protection

**Goal: Create communities that eliminate pollution and restore natural capital.**

| Principle | Objective | Villiers Island Response |
|---|---|---|
| Greenhouse Gas Emissions Reduction | Greenhouse gas emissions reduced within the district<br>Generation of district-scale renewable energy | This is one of the most important and challenging objectives for the neighbourhood. Only careful and detailed consideration of energy, waste, water, and transportation systems will ensure carbon negative outcomes. Enforcing exceptional green building and energy efficiency standards is a must. Supplying clean, fossil fuel free energy is also critical. Energy systems such as sustainable biomass or anaerobic digestion biomethane combined heat and power, true geothermal, deep water heat exchange, and solar photovoltaic technologies need to be carefully considered and implemented in their provision of both electrical and thermal energy. Waste and water reduction strategies need to be implemented to excellent effect. Innovative sustainable transportation programs, such as supplying electric vehicles or bicycles or car/bike share memberships with residential occupancy, need to be created. Integrating EVs into the electrical infrastructure (as users and providers of stored energy) is also a key consideration in achieving these objectives. The Plan needs to include specific requirements for all of these items, considering the neighbourhood as a collection of interrelated closed-loop systems and a net exporter of energy. |
| Water Efficiency | Efficient use of potable water throughout the district<br>Alternative water sources for non-potable uses | Water efficiency, reuse of gray and black water, smart irrigation, stormwater storage and use strategies will all contribute to highly efficient water use. The Plan needs to ensure these considerations are built into building design requirements. |
| Waste Management | Minimal generation of waste<br>Capture the residual value of organic wastes | Minimizing waste production while maximizing waste diversion are critical infrastructure and behaviour considerations. Collecting, treating and using all wastes as resources on site is a best practice to employ (e.g.: compost, energy production). The Plan needs to specifically address the waste systems that are going to be used, from minimizing consumption through design and programming, through to waste source separation, waste collection programs, and waste end uses. |

## EcoDistricts Comparison Conclusions

The EcoDistricts Protocol has proven itself to be very different from LEED ND, even though it includes some of the same green building and sustainable development requirements, if less prescriptive. The EcoDistricts Protocol is as much about thoughtful and insistent program design and implementation as it is about urban design considerations. Its social considerations demonstrate the need to consciously curate and steward a neighbourhood in order to achieve the best holistic outcomes. Many of these considerations will have to be made during future stages of the planning process, as they are more programmatic in nature.

# Appendix 6: Future Design Considerations

There are many neighbourhood, building, transportation and energy systems design features that must be considered in making Villiers Island a Climate Positive neighbourhood. Here are some examples that surfaced during this project.

## Building Design

- Ensure the shapes of buildings are simple. Complicated building envelopes have more surface area and joints, creating opportunity for heat loss.
- Provide overhangs and automated/programmable (manual override) exterior solar shading devices (e.g.: external blinds) for south-facing windows to reduce solar gains in the summer.
- When the project has progressed to the architectural considerations stage, building envelope and glazing design requirements should be incorporated into the architectural and engineering design terms of reference. Later on, these requirements should be incorporated into the construction terms of reference. Strategies to consider (among many) include:
  - Building envelopes and walls with assembled insulation values in the R-40 range;
  - Ceilings with R-60 or greater rated assemblies;
  - Strict airtightness requirements;
  - High thermal mass materials for at least 40% of floor materials;
  - Minimized number and size of north-facing windows;
  - Triple-paned, low-e, argon/krypton-filled, warm edge spacer windows; and
  - Building facades with maximum 30-40% glazing area.

  All of these elements are to be optimized through the application of energy models in order to achieve energy intensity targets.

## Building Systems and Equipment

The next consideration for minimizing building energy loads is in optimizing building systems. This includes all building energy systems, lighting, heating, ventilation, and air conditioning systems and their controls.

- At the time of architectural design, building system requirements should be included in the architectural and engineering terms of reference. Later on, these requirements should be incorporated into the construction terms of reference. These considerations should include:
  - Best practice commissioning and testing;
  - Building systems optimization modelling;
  - Complete direct digital control (DDC) systems with 24/7 monitoring by building operators and reporting to residents via smart metering;
  - Air handling units with variable frequency drives;
  - Energy recovery ventilators;
  - Best practice heat transfer systems;
  - LED interior and exterior lighting;
  - Energy provision and transferring systems optimization (in-building and in-district);
  - Energy Star or better rated appliances (maximum energy and water use reduction);
  - Low-flow water fixtures (30-40% reduction);
  - Toilet flushing and irrigation using greywater and harvested rainwater; and
  - Optimized in-suite and common areas fan schedules.

## Transportation

- Dedicate at least one amenity space to a bicycle retailer and ensure the retailer has diverse and affordable offerings for commuting, recreation, family, cargo, and electric assist bicycles, with the ability to service all offerings on-site.
- Install shared bicycle tuning and repair stations in the bicycle storage room of each building, as well as several on-street stations.
- Ensure transit has the capacity to transport bicycles.
- Prioritize street clearing for transit and bicycle lanes.
- Dedicate space on Centre Street or Villiers Street near the New Cherry Street transit plaza for bike share infrastructure.
- Dedicate at least 10 underground parking spots per block (at least 50 spots in total) to electric car share services.
- Provide 20% of underground and on-street parking stalls with electric vehicle charging infrastructure and place these in premium locations. Rough in electric vehicle charging stations for 100% of parking. Dedicate an amenity space for electric vehicle servicing and battery swapping.
- Restrict underground and on-street parking to encourage active transportation and transit use.
- Consider making Villiers Island a low emissions vehicle zone or EV only zone.
- Consider including a choice of personal electric vehicle in the purchase price of a residential unit and company electric vehicles in the lease of office space.
- Partner with employers, condo associations and the TTC in providing transit and cycling incentives (e.g.: free/reduced fee transit passes, transit passes included in strata fees at reduced rates, company bike/e-bike fleets, shower facilities).
- Partner with the TTC, the City, data providers and mobile application programmers to create a mobile multi-modal travel information and planning platform for users to plan trips using the optimal combination of travel modes.
- Ensure the locally stationed emergency vehicles are electric vehicles.

## Water

Designing for water efficiency includes specifying low flow faucets and shower fixtures (which can achieve up to 50% efficiencies) in the design and construction specs. Water efficient appliances can save 30% water use. Low flow toilets supplied with water directly from washroom sinks and greywater (rainwater harvesting) or blackwater (on-site wastewater treatment) systems can reduce potable water usage in sewage conveyance to zero. Irrigation using harvested rainwater can reduce potable water used for irrigation to zero as well. These features must be considered during the architectural and engineering design stages for the neighbourhood and buildings.

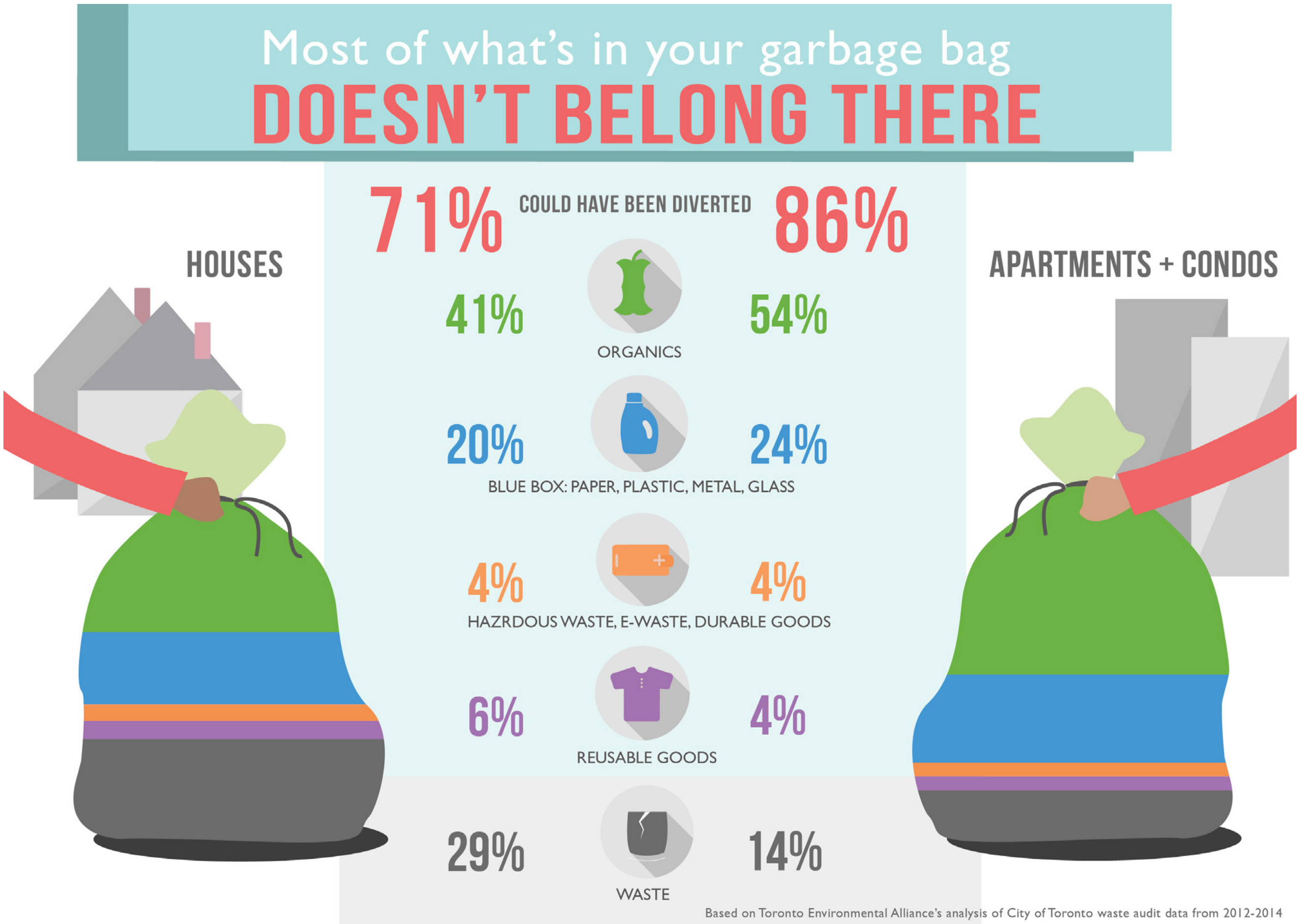
Installing smart water meters with occupant feedback displays is a key approach to behavioural change in water use. Water use reporting by building floor, building, block and neighbourhood basis, with comparisons to other benchmarks can be effective as well. Water use fees - charged by the City and/or the condo association - are also an effective incentive. Once occupied, Villiers Island will require a targeted behavioural change program for efficient water use.

## Solid Waste

The main waste minimization focus areas are consumables and diversion. Minimizing consumption of products with packaging, products with short usage and lifespans, and products made with unrecoverable materials is critical. Providing the means to repair, reuse, and redistribute items will also have a substantial effect on waste produced. For end-of-life items, easy to use and extensive diversion options must be available.

Capturing all organics for composting, diverting all recyclables, diverting all electronics, durable goods and hazardous waste for proper disposal and disassembly, and providing mechanisms for redistribution of reusable items would result in 71%- 86% reduction in waste going to landfill. The large majority of the remaining waste must be addressed by reducing demand for disposable items.

The majority of content in the average garbage bag in Toronto can be diverted:[1]




A comprehensive waste management strategy, including waste infrastructure needs to be developed. Elements of such a plan could include:

- Targeting zero waste grocery stores to locate in the neighbourhood.
- Targeting a green dry cleaner to locate in the neighbourhood.
- Providing for used cooking oil collection and sale.
- Establishing a neighbourhood shared tool library.
- Dedicating retail space to a repair café.
- Making residents aware of the Streetbank online sharing platform.
- Ensuring buildings have sharing/giveaway rooms.
- Designing buildings with waste diversion chutes that service all floors.
- Contracting a weekly large item pickup service.
- Ensuring all organics are diverted and collected weekly.
- Offering building manager training programs.
- Offering tenant education programs for waste minimization.
- Providing collection services for all types of waste diverted.
- Integrating organics composting into an urban agriculture service.

1 Holly Thompson, Toronto Environmental Alliance. July 30, 2015. *High-rise models a solution to waste crisis.* Retrieved from www.torontoenvironment.org/high_rise_models_a_solution_to_waste_crisis)

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# Villiers Island Precinct Plan
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