HURON-SUSSEX LANEWAY HOUSING:
A Net-Positive Community

University of Toronto Campus as a Living Lab of Sustainability ENV461H1F
Final Report

Presented to: University of Toronto Campus and Facilities Planning

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Huron-Sussex Neighbourhood 2018
Photograph by author

Contents

Brook McIlroy, 2014

INTRODUCTION

The increasing populations of cities in North America has led city builders to seek new ways of increasing density while reducing urban sprawl. The University of Toronto Campus and Facilities Planning has been exploring laneway housing's potential to increase density in the Huron-Sussex neighbourhood without compromising its existing character. A network of infill (laneway) houses in the Huron-Sussex neighbourhood holds the potential to become a net-positive community, and contribute to Toronto's sustainable development while establishing the University of Toronto (U of T) as a leader in sustainability initiatives (DSF, 2017).

The Huron-Sussex neighbourhood planning project is currently in Phase 3. Three pilot buildings (two of which are laneway houses) have been designed by Baird Sampson Neuert Architects to a net-zero standard. The original intention in their design was to achieve 'passive house', a higher sustainability target, however, unforeseen limitations in terms of site and building orientation prevented achieving the more aggressive goal.

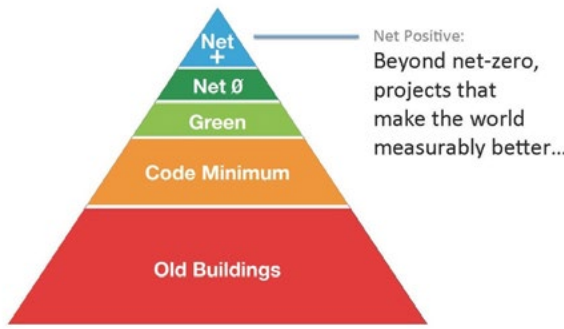
This report was developed with the aim of presenting leading-edge sustainability as an achievable priority in future development of the Huron-Sussex neighbourhood. The top recommendations for each potential aspect of net-positivity are presented and analyzed independently, and offered as a part of a more comprehensive recommendation toolkit.

Extensive research within existing literature, current sustainability standards and framework, site visits, and several case studies, has developed a strong foundation upon which analysis and recommendations are based. Interviews with several practicing and academic experts in sustainability, architecture, and energy fields have informed the system of strategies and toolkit recommendations.

A Net-Positive Community

What is net-positive?

Simply put, net-positive means giving back more than what is taken. Applied to sustainability, net-positivity commonly refers to energy usage, i.e. a building or community generating more energy than it uses through efficient design and renewable energy generation such as photovoltaic cells (Cole and Fedoruk, 2015). However, this definition is limiting in terms of what builders strive for, and accomplish. To holistically address net-positivity, five areas (pillars) of net-positivity have been identified: energy, carbon, water, waste, and social well-being. These categories were chosen because improvements to energy, water, waste, social wellbeing and buildings infrastructure are critical components of comprehensive environmental sustainability (Robinson, et al. 2013).



Lanefab, n.d.

Regenerative Sustainability

Sustainability often involves an approach that includes doing less damage, reducing negative impacts, and sacrifice- this is not particularly motivating (Robinson, et al. 2013). Regenerative sustainability is an emerging different approach that can be expressed in the question: “To what degree can human activity actually improve both environmental conditions and human quality of life?” (Robinson, et al. 2013). Waldron and Miller’s (2013) “regenerative sustainability paradigm” involves a collaborative partnership with nature and human activities to restore and regenerate the global social-ecological systems. Regenerative sustainability at the neighbourhood level includes the creation of places with the capability to increase potential ecological restoration and improve social cultural wellbeing through ongoing restoration and regeneration beyond neighbourhood boundaries (Waldron and Miller 2013). Regenerative sustainability also involves a social learning process among different actors, structures, and transition levels to change institutional and cultural views and practices toward sustainability (Waldron and Miller 2013). It is important that sustainability be deeply embedded in institutions to become self-perpetuating and not dependent on external conditions (Robinson, et al. 2013).

Literature Review

Net-Positive Buildings and Energy Systems: Case studies, local and international, are considered with regard to advanced and novel methods for improved efficiency and energy generation as well as global best practices in sustainability. As net-positive energy buildings become more common, the need for new sustainability assessment methods begins to arise in consideration of economic viability and benefit, and strategies for achieving net-positive energy exchange systems (Davidson, 2014).

Existing Frameworks

Buildings:

- LEED: Leadership in Energy and Environmental Design - One of the oldest and most recognizable sustainability frameworks (LEED, 2018). LEED has come under fire in recent years due to underwhelming performance of LEED-certified buildings (Orr, 2018).
- Net-zero: Buildings produce as much energy as they consume over the course of the year.
- Passive House: Buildings attain a higher level of energy efficiency than net-zero using highly insulated envelopes and high-performance windows, solar optimization to provide warmth from passive solar heat, and balanced ventilation (Freeman, 2015).
- Living Building Challenge (LBC): Comprehensive, holistic framework that aims for net-positive actual performance over 12 consecutive months in each mandatory imperative (ILFI, 2018).

Neighbourhood Development:

- LEED-ND: LEED-Neighborhood Development applies the LEED standards to multiple buildings together to evaluate the sustainability of a developing neighbourhood based on location, neighbourhood design, and infrastructure (Welch et. al., 2011).
- Living Community Challenge (LCC): Akin to the LBC, but at a community scale (International Living Future Institute, 2016).
- EcoDistricts: Protocol and certification framework for environmental and social sustainability, considers how to build neighbourhoods using three imperatives: equity, resilience, and climate protection (Ecodistricts, 2018).

Toronto-Specific:

- Zero-Emissions Buildings Framework (ZEBF): Represents the City's plan for reducing city-wide GHG emissions to 80% below 1990 levels by 2050 by providing comprehensive targets and requirements (City of Toronto, 2017).
- Toronto Green Standard (TGS): Consists of four tiers and sets out mandatory sustainable design requirements for new private and city-owned developments (City of Toronto, 2018).

Infill/Laneway Housing: Significant scholarly research focuses on Infill Housing's potential in the Greater Toronto Area (Government of Canada, 2009). Planning issues such as adequate open space, privacy, servicing and code issues are discussed in documents from working professionals in the field, while Master's Theses offer potential solutions and feasibility analysis.

Social and Regenerative Sustainability: An inclusive design process, equitable engagement, design for flexibility, and infrastructure provisions have been identified as key factors in social sustainability (Palich and Edmonds, 2013). System designs to induce sustainable behaviour has been considered, along with how social sustainability can be incorporated into building and neighbourhood assessment.

The Huron-Sussex Neighbourhood

Overview

Today, the Huron-Sussex neighbourhood is primarily made up of low density residential buildings with some small-scale commercial buildings. In the report by Brook McIlroy + NBLC (2014), many of the neighbourhood's buildings require ongoing maintenance. While a small number of privately owned commercial, community, and residential buildings exist, U of T owns a majority of properties in the neighbourhood. Open space is provided by rear yard space, a series of informal green spaces, and formal park space. The neighbourhood is pedestrian-friendly and the laneway system provides a network for rear access and servicing with some parking that supplements what is available on-street and underground.

Challenges

In creating infill housing to supplement the current low-density housing stock, a significant portion of open space is lost. This includes rear yards, parking spaces, and vehicular circulation and servicing paths. Associated challenges include: how lost private or semi-private open space can be supplemented; how the previous, more comprehensive vehicular network can be supplemented and what measures should be taken to increase lost parking spaces; and determining to what extent addressing these challenges will be important factors for future liveability.

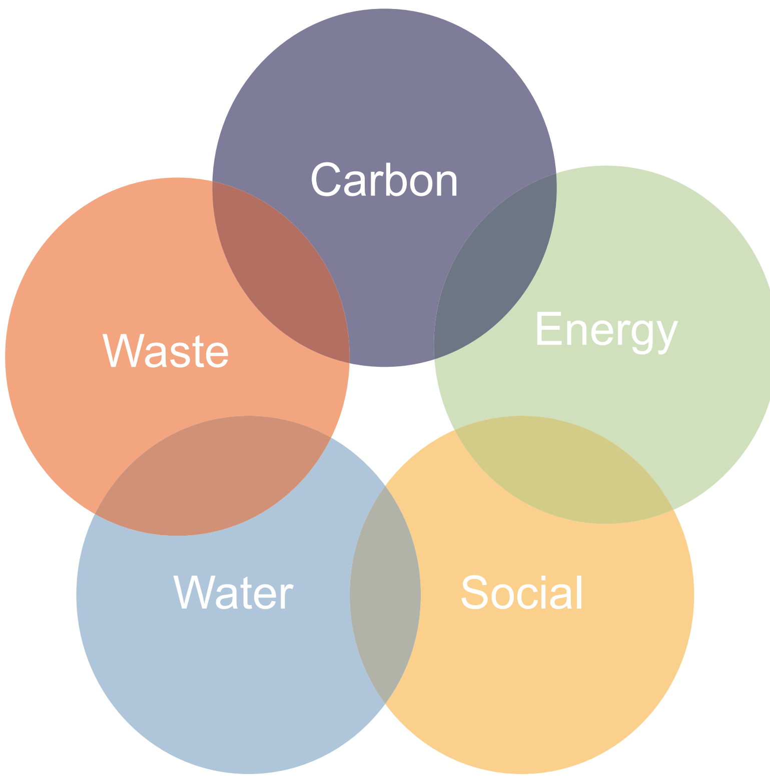
Preliminary Opportunities

The neighbourhood's walkability offers a significant advantage for its potential as a net-positive community, and the current land use for infill housing sites (mostly paved roadway or parking) is not of significant environmental benefit. The community as a whole can be designed under principles of regenerative sustainability.

Alternative models for vehicular use such as a car-sharing system for community members or autonomous vehicles could reduce the need for parking. Shared (semi-)private yards, where adjacent properties share rear yards, are already in use in the neighbourhood and could become more commonplace (Brook McIlroy + NBLC, 2014). Creating a mobility network that prioritizes pedestrians and cyclists while allowing motor-vehicle circulation for servicing on some lanes or parking in others during off-peak hours could be investigated, as could creating common drop-off points for services such as garbage pickup for residents of infill housing.

U of T's role as owner of a majority of properties in the neighbourhood allows for a systems-based approach to the design of the neighbourhood's features. This project has the potential to implement sustainability initiatives on a significant scale, that enables the whole community's positive environmental impact to be greater than the sum of its parts.

TOP RECOMMENDATIONS AND ANALYSIS



The following section includes the top three recommendations for each area of net-positive and their limitations, and identifies co-benefits between them (where one solution contributes to additional areas).

WATER

1. Wastewater treatment systems

a) Rainwater and stormwater to potable water

It is recommended that water captured from the rainwater/stormwater harvesting system outlined in (1) above be collected into an underground cistern and actively treated into potable water. This is being done in UBC's Centre for Interactive Research on Sustainability (CIRS) where the collected water is treated through a six-step process which includes filtration and disinfection (Appendix D). This would allow the community to become self-sufficient when it comes to drinking water.

Pre-treatment could also be done for this water before it enters the underground water collection cistern. For stormwater collected from the pavement, the gardens and natural landscaping within the community, it could first be pre-treated through bioswales, which are multi-layered water cleansing method that uses resilient plants and filtering granules to separate streetscape contamination from the water (Ma, 2013). For rainwater collected from East-West oriented rooftops, pre-treatment will be done through green roofs, which works similarly to bioswales, by pre-treating the water through soil, vegetation, and multi-tiered substrate fabric (Ma, 2013).

This approach would require the university to collaborate and work with regulators given there are standards when it comes to safe drinking water. A backup system needs to be in place to source water at the municipal level in the event that there is insufficient rainwater harvested or the quality is not up to the City's standards.

b) Greywater and blackwater to non-potable water

Greywater from showers and kitchens and blackwater from toilets could go through an on-site, decentralized wastewater treatment system such as the Solar Aquatics system that processes sediments and waste via an aquatic greenhouse. This has been used successfully in the CIRS building (Water Canada, 2010) and works by mimicking the natural purification process of streams, meadows, and wetlands via aeration, nitrifying bacteria, algae, and plants, and a series of filters (Eco Tek, n.d.-a). Specific details on the treatment process can be seen in Appendix E. According to Eco Tek (n.d.-b), if the entire life cycle assessment of wastewater treatment is taken into consideration, the Solar Aquatics system can pay for itself within ten years; this is done through water savings as well as the sale of compost biomass (anything not used by the Huron-Sussex neighbourhood) and the sale of plants grown through the aquatic greenhouse water treatment system.

CO-BENEFITS (Recommendation 1)

- Waste: The solids that are removed from the water can go towards a compost system such as an aerobic worm composter (Eco Tek, n.d.-a).
- Social: The compost produced through this system can contribute to the community garden, and the system itself is an aesthetic to add to the community (Ecological Engineering Group, n.d.).
- Energy: This system is designed to be adaptable to source its energy from the most suitable renewable energy in a given location (Eco Tek, n.d.-b), which can be solar panels in this case.
- Carbon: Renewable energy can lead to reduced greenhouse gas emissions (GHG) through the installation of solar panels on the Solar Aquatics system.

Canadians use 1,131m³ of water per person per year (CBC News, 2013). This amount of water consumption will be used as the baseline for each person living in the Huron-Sussex neighbourhood for the purpose to calculating net-positive water consumption, with the recommendations aiming to conserve more water than is consumed. The recommended strategy for Huron-Sussex neighbourhood to achieve net-positive water conservation is detailed below along with details on amount of water conserved where possible and case studies (if applicable).

2. Rainwater and stormwater harvesting

The first step to achieving net-positive water conservation is through capturing water before it reaches the ground (rainwater) and capturing water from the ground (stormwater). This is one of the water-saving approaches suggested in the LEED-ND framework. The water that is captured can feed into an on-site wastewater treatment system further discussed in (2a) below and converted into potable water that is safe for consumption. This approach is recommended for all infill sites within the Huron-Sussex neighbourhood, where buildings with an East-West orientation will have green roofs while sites with North-South orientation will collect rainwater through gutters and downspouts as most of the rooftop surface will have solar panels installed for energy generation. Stormwater can be collected from the living lane where permeable paving can be placed on the road surface. Additional stormwater can be collected in the garden and natural landscape portions in the townhouses and garden suites planned for this neighbourhood (Brook McIlroy + NBLC, 2014). It is roughly estimated that this rainwater/stormwater harvesting strategy can collect 4,020m³ of water from the neighbourhood each year, enough to offset the potable water consumption of 35 people per year (Appendix C). This recommendation requires minimal partnership and its installation and implementation is within university's control.

3. Water-efficient installations and education

Additional water savings could be achieved through the installation of features such as more efficient faucets and showerheads, dual flush toilets, and educating residents on water saving strategies such as the use of the City of Toronto's water management guide and MyWaterToronto to track and manage water consumption (City of Toronto, 2017).

LIMITATIONS

Through the above recommendations, the Huron-Sussex neighbourhood can be on its way to achieving net positive water. The proposed recommendations cannot guarantee net positive water in the neighbourhood but it will be on its way to net-zero at the minimum. One limitation in this recommendation is that the amount of precipitation in the City of Toronto varies from month to month (The Weather Network, n.d.), and water collected will differ between months, so the community may still need to supplement additional water from the municipal sources in those months. Another limitation is that water collection and treatment is only being done for new infill units, but additional water savings can be generated if the existing homes in the neighbourhood are also brought into the picture. Doing so would require collaboration with the current residents- retrofitting their pipes to direct the flow of rainwater, stormwater and wastewater to the community's wastewater treatment systems may also be a costly and time-consuming process that requires a lot of back-and-forth with the residents. Therefore, it can be seen that there is benefit in planning for sustainability early on in a site's development phase, as is possible with the infill sites but not with the existing sites.

CARBON

The definition of net-positive carbon refers to sequestering more carbon emissions than produced in the Huron-Sussex neighbourhood and beyond. The average Torontonian's carbon footprint measures 8.6 tonnes per year (CBC, 2008) and will be used as a baseline in calculating net-positive carbon. It is important to note that most of Ontario's energy comes from non-fossil fuel sources (renewables and nuclear) with only a small percentage (8.2% in 2016) from the fossil fuel source natural gas, therefore reductions in carbon emissions has to be achieved in other areas (NEB, 2017). The recommended strategy to achieve net positive carbon in the neighbourhood is outlined below.

1. Sustainable building materials and methods

The first recommendation toward achieving net-positive carbon in this neighbourhood is using sustainable building materials and methods to capture and reduce carbon. This includes the use of building materials that are recyclable and locally-sourced (Reddy, 2009). There is a significant amount of embodied carbon in the creation and transport of materials from long distances (Reddy, 2009) therefore selecting locally sourced building materials will be significant toward reducing the carbon footprint of the neighbourhood. Using locally-sourced wood, (avoiding the use of concrete and steel), is important for sequestering carbon and contributing to net-positive carbon (Gustavsson et al. 2006). Finally, sustainable building methods that reduce carbon emissions should be used, including green building design that includes use of fresh air ventilation, energy efficient operable windows, low energy appliances and lighting, and consideration of daylighting and solar orientation (Ken Pirie, 2010, 2013). This will maximize the efficiency of the townhouses and garden suites towards achieving net-positive carbon.

CO-BENEFITS (Recommendation 1)

- Waste: Reduces waste generation; encourages recycling and reusing of building materials
- Energy: Reduces energy consumption
- Social: Encourages more environmentally-friendly behaviour
- Water: Reduces water consumption

2. Reduce vehicle dependency

Reducing vehicle dependency is a significant component toward achieving net positive carbon which can be achieved through higher urban density (Farr, 2018) that is inherent in laneway housing. Increases in residential density can decrease vehicle trips by up to 55% (Farr, 2018). Increases in mixed-use buildings, including a mix of residential, retail, commercial and offices, where jobs, housing, retail and services are all within walking distance can further reduce vehicle trips by up to 11% (Farr, 2018). To reduce vehicle dependency in this neighbourhood, LEED-ND suggests prioritizing the use of a living lane to create a neighbourhood with a high degree of internal connectivity, which is part of the university's plan for the neighbourhood. LEED-ND also suggests implementing a vehicle sharing program to reduce individual vehicle dependence and alleviate parking concerns, especially as population density increases.

3. Encourage biking

Encouraging biking contributes towards the goal of net-positive carbon. LEED-ND suggests providing secure and sufficient bicycle parking for residents and visitors, and covered bike storage should be given priority given the winters in Toronto. LEED-ND suggests designing streets in the neighbourhood to be bicycle-friendly through the living lane and continuous paths that can be shared by cyclists and pedestrians.

CO-BENEFITS (Recommendations 2 and 3)

- Social: Encourage residents to live more active and healthy lifestyles by using alternative methods of transportation

LIMITATIONS

Focusing on these recommendations will be significant toward achieving overall net-positive carbon this neighbourhood. The main limitation of the reducing vehicle dependency recommendation is that the neighbourhood itself can be designed to reduce vehicle dependency, but residents may still prefer to use personal vehicles outside of the neighbourhood. Moreover, carbon emissions generated by activities outside the neighbourhood (e.g. airplane travel) is a significant limitation toward achieving net-positive carbon. As for cycling, it may not always be an viable option due to limitations such as weather and distance. Lastly, there is a limit to how much sustainable building materials and methods the neighbourhood can use, and it is also difficult to measure the amount of carbon sequestered.

WASTE

Canadians create a vast amount of waste- 777kg per year per citizen (CBC, 2013). Waste causes major environmental issues including polluting the ocean and creating methane which is a GHG (Green Choices, 2013). Attempting to burn waste materials such as plastic creates toxins which are detrimental to both environmental and human health. Toronto also has its own municipal issues with waste as most waste goes to the landfill that could be diverted, due to contamination by food products and a lack of resources to recycle certain materials (Benzie, 2017). The Huron-Sussex neighborhood has an opportunity to decrease environmental issues created from waste.

1. Community Garden Compost

Compostable materials currently account for 24% of waste which could be redirected out of landfills (Wills, 2010). Composting bins should be an integral part of the community garden. People will either need to be hired or volunteer for both compost collection and for turning over the compost. It might be an idea to provide some compost soil to participating residents as an incentive. The residents also need to be educated on what can go into the compost.

2. Recycling Organizations

Recyclables count for half of people's waste (Folz, 1991). There are programs that will up-cycle a community's recycling. One of these businesses is TerraCycle which will work with communities to make a drop-off centre for recyclables (TerraCycle, 2018). By pairing with a business that processes recyclable materials (specifically if that business is close to Toronto) travel costs will be cut, along with contamination risks. There are also programs such as Wasted which help communities set up their own sites to recycle plastics into benches or planters (WASTED, 2018). The neighborhood could recycle waste from surrounding communities with this resource, increasing the area's positive impact. The residents will need to be educated on the specific rules that the business follows in recycling, a drop-off location or storage location might need to be built, and services for recycling pick up should be provided.

3. Swap Shop

A swap shop where people can donate clothes, furniture, and other usable goods which will then be provided to others for free will further decrease waste. A program to donate these goods to students, organizations and stores within Toronto could also be set up. UofT currently has a swap shop for furniture and books, so forming a partnership would be a good idea. The remaining 25% of waste that cannot be recycled or composted can often be re-used such as microwavable containers and hardcover books (King County, 2018), which makes providing a swap shop particularly important in decreasing waste.

CO-BENEFITS

- Social: Composting provides people with good food and gardening; Wasted can recycle plastic for personal use; Swap shop reduces expenses

- Energy: Reduced energy consumption as energy use of waste facilities are no longer necessary.

- Carbon: No methane release from waste at landfill; Less use of vehicles to pick up garbage

LIMITATIONS

There are limitations in decreasing waste. A large portion of proper waste disposal and reuse is the actions of residents. Residents will need to compost and recycle properly which requires education, incentives, and accountability. Also, there is no accounting for their actions outside the neighborhood where they are still disposing of waste. It also hard to control people's creation of waste which is why is it is important to have the ability to reuse and recycle the waste that is created.

ENERGY

1. Smart grid implementation/retrofit

The first and most vital tool to implement is the retrofit of the existing grid system to a smart grid. Nodes that connect to the electrical energy grid which meet the current energy capacities of the community could have smart grids systems built around them (M. Sanjay, personal communication, November 11, 2018). These systems use algorithmic and AI technology to monitor and adjustment usage of electrical in the system for optimal performance (M. Sanjay, personal communication, November 11, 2018). According to a study by Clastres (2011), the integral quality of this system which contributes to net positive energy is the able for the system to allow for two-way communication between energy production and consumption. These types of systems allow for easier integration of renewables into a network and promote the addition of new technologies to be included in the future. A smart grid network is self-adaptive and capable of balancing supply and demand, particularly thanks to scope for selective load-shedding at peak hours. The result is a network the improves energy production, energy storage, promotes innovation of renewables and even prevents power outages.

LIMITATIONS

The success of the system relies on the interconnectivity of all features to overcome existing fossil fuel networks. To bring into perspective the results of the recommendations “collectively, distributed energy systems and smart grids can accommodate an increased share of renewables, a decreased need for additional grid capacity, decreased transportation, reduced peak demand, lowered costs, reduced emissions, and providing new options for consumers in how they interact with the energy utility” (Cole and Fedoruk, 2015)

2. Transitioning from District Energy to Distributed Energy

A system with net-positive production will need an outlet to distribute its excess energy. This is why Huron-Sussex’s energy system must be connected to UofT’s district energy system (DES). The current system, with a 6 megawatt (MW) generation capacity, already provides existing infrastructure to connect various buildings on campus for heating and cooling purposes (UofT Faculty Services, 2014). The current system is powered by natural gas (UofT Faculty Services, 2014) which adheres more toward a net-zero policy of less harm than net-positive principals. It is necessary to then consider this an opportunity for improvement of the community. Assuming Huron-Sussex as a focal point for energy generation would allow for the eventual reduction in use of boiler plants thanks to renewable energy generation and smart grid management. Surrounding buildings will be able to use heating and cooling energy provided by Huron-Sussex’s renewable energy sources thanks to the existing network built for the DES. U of T’s Faculty Services (2014) states that the busy campus is currently not an ideal space for biomass energy generation. Should the feasibility of this change, the DES system will provide the network needed for this option. Energy storage is necessary component for smart-grid systems which can be meet with the existing DES (Clastres, 2011). The scale of the DES ensures that excess energy from the community can be managed, stored and distributed via electrical heating, steam and hot water systems (U of T Faculty Services, 2014). This shift from the existing district energy system can convert the network to a distributed energy system where various forms of inputs causes an expansion of spatial borders, rather than segregation (Cole and Fedoruk, 2015).

Net-positive energy can be defined by the ability to produce more energy that what is consumed. Energy recommendations will include reduction principals to accompany design features that seek to enrich both human and environmental livelihood through regenerative sustainability (Cole and Fedoruk, 2015). Achieving net positive energy for the Huron-Sussex community primarily requires the use of renewables to surpass the annual kilowatt-hours (kWh) deficit (Davidson, 2014). The existing design for the laneway housing units already implements multiple sustainability features such as passive house envelope design, photovoltaic solar arrays, earth tubes, and heat recovery ventilation (Sasaki, 2018). However the energy input required is still 32 kWh/m2yr, meaning that additional tools need to be included which surpass this figure (Sasaki, 2018).

3. Use of Renewables

As previously expressed, the most valuable input for excess energy production is the use of renewables. Through conversation with our client from U of T's Campus and Facilities planning, limitations on the planned solar array due to orientation have been made apparent (Sasaki, 2018). A site visit to the neighbourhood provided visual confirmation of shading as a limitation. Solar PV use necessary, however the renewable recommendations of this toolkit serve the purpose of expanding those options to mitigate low input levels such as shading and seasonal changes in daylight. In general, since access to improving technology and capital are the only limiting factors for replacing panels in the future, the most efficient solar panels available to the university should be selected for the time being (Keith, n.d.).

Geothermal energy is currently being used at U of T's Mississauga (UTM) campus for it's Instructional Building (UofT Faculty Services, 2018). This system does not directly generate electricity for the building, instead it provides heating and cooling for the entire 31,035m² facility using 117 vertical boreholes that are installed 550ft deep (C. Dalton, personal communication, December 7, 2018). "The system provides 100% of the space heating needs and most of the cooling" during the summer months which also works in combination with building features that reduce the thermal envelope of the structure, eliminating the use of the building's natural gas line. (C. Dalton, personal communication, December 7, 2018). By eliminating the need for energy generated by other renewables to be used in electrical expenditure towards heating and cooling, this reduces the kWh use of laneway housing units. The only necessary electricity use of the system is the operation of the pump, which combined with smart metering (a feature common with European smart grid systems), could regulate the heat exchange with limited energy consumption (Yaqoot et. al., 2016). With the space provided by the living lane there is ample room to implement such a system which can also be built underneath units if necessary. It is recommended to include this feature before building construction rather than retrofitting both form a theoretical and practical standpoint (C. Dalton, personal communication December 7, 2018).

The renewable option for generating electricity is the inclusion of Vertical Axis Wind Turbines (VAWT). [Table 1 in Appendix F] shows the distinct characteristics that differ between vertical axis wind turbines and the more widely known horizontal axis wind turbines (HAWT) (Bhutta et. al. 2012). Micro-scale turbines of varying designs and capacity are available as 'plug and play' technologies in the UK where they have also been tested for performance (using a 400W turbine) in residential buildings and analyzed academically [See Appendix F] (Bahaj et. al., 2007). At almost 4 times the size and greater, turbines of 1.5 or 2.5 kW capacities can achieve net-positive energy generation in beneficial weather conditions (Bahaj et. al. 2007). This renewable option with a very low barrier to implementation provides varying but reliable input of energy to Huron-Sussex electrical grid.

CO-BENEFITS

- Waste: DES may be retrofitted or implemented for biomass use
- Social: Stable electrical system with less power outages
- Carbon: Not reliant on fossil fuels
- Water: Renewables are tool of features such as Solar Aquatics

SOCIAL WELL-BEING

Social sustainability is an important and often overlooked aspect of sustainability. Sustainability has the potential to enhance human life through the health and happiness of humans. A neighbourhood that is net-positive in terms of social well-being has physically active residents that have a strong sense of belonging. Many Canadians do not feel at one in the communities in which they live (Chief Public Health Officer, 2016). All of the amenities should be developed in a way which fosters social wellbeing, encourage physical activities and environmentally-friendly behaviour, and allow residents to have a strong sense of community in the neighbourhood.

1. Community centre

Community centres are places for residents to network, create and learn together. The addition of a building with multi-use spaces would be ideal as these activities can be take place at this one location that is convenient for all residents. Notably, the university has already planned for this building on Sussex Avenue. Activities that can take place in such building will encourage the development of social well-being and create a sense of belonging. Furniture or book swaps, art classes, rentable multi-purpose meeting spaces (e.g. for a birthday party), and technology lounges are examples of what a community centre can provide. This building should be built using regenerative sustainability principles, akin to the CIRS building at the University of British Columbia (UBC), that encourages sustainable behaviour on a larger scale. A community website with information on health and wellness education should be developed, providing sustainable living guidelines and information about the design and operations of the neighbourhood.

2. Pocket plaza or park in the living lane

Studies have shown being outdoors helps build a strong relationship to nature (Palmberg & Kuru, 2000). Akin to the community centre, having a multi-use space to congregate outside would be beneficial residents. People are generally happier being in natural environments as opposed to urban environments (MacKerron & Mourato, 2013). While the living lane has already been planned in the neighbourhood, it should be an area for activities apart from walking and cycling. Drawing from examples in other cities such as Philadelphia, this area could be a pocket park, where the park occupies a portion of the laneway. Outdoor activities like farmers markets, movie projections and block parties can be done in this area too as a pocket plaza. Community centre activities could be held in this area when the weather is agreeable.

3. Community garden

The Huron-Sussex neighbourhood already has a community garden at the south-west corner of Glen Morris Street and Huron Street. However, it can be expanded to fulfill the LCC food-to-area ratio production goal (International Living Future Institute, 2016), and space is permitting too. According to research done, people choose to community garden as it is an opportunity to interact with nature, and have a space for well-being and mental health (Beer, 2017). Having this garden allows residents to grow their own food and be connected with nature and encourage environmentally-sustainable behaviour. Rainwater captured can be used here, as the garden will not require potable water, contributing to net-positivity. To have food production in the colder months, a greenhouse can potentially house the community garden. A coordinator will be necessary for this and harvest/planting schedules can be integrated on the community website.

CO-BENEFITS

- Waste: Encourages environmentally-supportive behaviour, educates residents on composting and recycling
- Energy/Carbon: Less distance travelled by gas-powered vehicles and pedestrian behaviour is encouraged

LIMITATIONS

The measure of social wellbeing is limited to how it can be quantified- it is tricky and usually qualitative. There are many ways that it can be measured but there is no one way to do it. Individuals will certainly differ in what they consider to be wellbeing as well so this becomes very subjective and difficult to measure.

CONCLUSION

Limitations

Though limitations have been addressed throughout the top recommendations, the development of this report has been subject to several overarching limitations. The most prominent of these limitations are the scope of research and current technology. For example, renewable energy technologies are not always as efficient or reliable as traditional forms of energy (or are not perceived to be), but inefficiencies are rapidly being overcome. Moreover, this issue is far beyond the scope of our current research. We have attempted to create a robust system of recommendations, ready for practical application (see appendix B), however certain recommendations may be high-level, or require further analysis based on site, availability of materials, and economic feasibility.

Future Considerations

The Huron-Sussex neighbourhood has the opportunity to become a testbed for sustainability within the University of Toronto campus. For example, an area of the neighbourhood could be dedicated to testing new sustainable technologies developed by the University that would benefit from being tested in city sites (e.g. permeable paving, lighting systems, etc.). Successful pilots could be applied elsewhere.

The neighbourhood should be designed for long-term sustainability from the beginning. Sustainability is a rapidly developing field, and the development should be adaptable by design as new technologies become widely available. Laneway housing development should be implemented with the knowledge that these recommendations will achieve meaningful steps toward achieving net-positive goals over time.

In conclusion, the above recommendations, and those in the toolkit, in each of the five areas of net-positivity are significant toward achieving the goal of developing net-positive laneway housing in the Huron-Sussex neighbourhood.

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John Robinson: Professor, Munk School of Global Affairs and Public Policy, University of Toronto

Anjali Helferty: PhD Candidate University of Toronto, Adult Education and Community Development

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APPENDICES

APPENDIX A

Huron-Sussex Laneway Housing - Toolkit

Principal Sub-Category	Recommendation	Strategies in Huron-Sussex	Early Actions	Co-Benefitting Pillars	Reference Documents (Source)
BUILDING SCALE					
Energy Reduction and Efficiency	Passive House Design	A. Building envelope: a well-insulated, airtight building envelope will maximize efficiency and avoid signifiacnt potential energy loss (see **X** for material recommendations). The compact form of laneway houses offers an advantage by way of reduced envelope surface area and potential for thermal bridging.	Conduct sun/shade studies early in the community development stages to enable most beneficial use of this recommendation. Consider the layout and orientation of existing neighbourhood buildings relative to proposed massing for passive sunlight and ventilation uses.	Energy Carbon	Phipps Conservatory Centre for Sustainable Landscapes Attia 2016
		B. Overhang: design overhangs to block direct summer sun from warming the building but allow penetration by direct winter sun. The surrounding built form may pose a challenge for light and shade allowances.		Energy Carbon	Littman, 2009 LEED-ND
		C. Windows: place windows strategically to allow for passive solar heating and ventilation. Analyze wall-to-window ratio and window placement relative to surrounding massing early in design process. Double or triple-pane windows are recommended for improved insulation.		Energy Carbon Social	Attia 2016 Toronto Zero Emissions Buildings Framework LEED-ND
Water Management	Stormwater/rainwater management	A. Non-Potable Water: Captured/treated wastewater or rainwater can be used for toilet flushing, irrigation, cleaning streets and sidewalks. It can reduce neighbourhood freshwater demand by 36-75%. If the community water systems recommended are implemented, the Huron-Sussex community will use non-potable water for daily needs.	Design system for water collection that is feasible for the neighbourhood.	Energy Carbon Water Waste Social	Farr, 2018
		B. Green roofs/eco-roofs: These can be used for bioretention, reducing stormwater runoff, and offer additional thermal and noise insulation for buildings. It also provides pre-treatment for rainwater through soil, vegetation, and multi-tiered substrate fabric before the water enters the water treatment system. Applied in the Huron-Sussex neighbourhood, eco-roofs can contribute to system water harvesting, reduce the urban heat-island effect (visually soothing viewed from above, no glare), and offer social and psychological benefits. Extensive: Shallow, 1-6" lightweight vegetated cover of succulents and herbs (not for human access). Intensive: Heavier roof garden, 8-12" growing media for vegetable gardens or trees; human access allowed.	Determine the type of green roof that will work on the roofs of the houses in the neighbourhood.	Energy Carbon Water Social	Birkeland, 2008 Farr, 2018 LEED-ND Ma, 2013 Renger et al 2015
Carbon Intensity Management and Waste Conversion	Sustainable building materials	A. Salvaged/Reused/Adapted Components: Salvage components from existing buildings to eliminate the energy and resources that go into creating new materials. The scale of laneway houses makes potential reuse of construction materials more feasible, as they may have the potential to reuse components too small for other buildings.	Research materials that are needed for this construction early, and determine where to source them from only local and sustainable sources.	Energy Carbon Waste	LEED-ND
		B. Recycled Materials: a wide array of recycled and recyclable building materials are available. Using recycled materials can significantly offset net waste from construction. Focus on using materials that are recycled, recyclable, locally sourced and Cradle-to-Cradle certified.		Energy Carbon Waste Social	Attia 2016

Huron-Sussex Laneway Housing - Toolkit

Principal Sub-Category	Recommendation	Strategies in Huron-Sussex	Early Actions	Co-Benefitting Pillars	Reference Documents (Source)
		C. Plant/Bio-Based Materials: Using wood and other plant/biologically-based materials in building construction supports carbon sequestration and holds the potential to offset carbon produced by other materials. Maximize the amount of plant- or bio-based construction materials to offset environmental costs. Natural materials can also improve air quality within buildings and contribute to resident health and happiness.		Energy Carbon Waste Social	Gustavsson et al. 2006 Attia 2016
		D. Sourcing: A significant source of embodied carbon comes from transport for materials travelling far distances. The GTA is in close proximity to FSC-certified wood producers, and a wide array of other construction materials providers.		Energy Carbon	Reddy 2009 Renger et al 2015
Fostering Social Well-Being in High-Density Community	Accessibility and Privacy	A. Accessibility: Laneway housing provides additional housing type and size for higher affordability which encourage social and economic diversity. Development of accessible housing for all ages and abilities.	The need for privacy and outdoor semi-private spaces should be considered at an early stage in the design process to perpetuate social well-being and comfort.	Social	LEED-ND
		B. Privacy: Because laneway houses are so close to neighbouring houses, privacy is an especially important issue to consider.		Social	Birkeland, 2008
	Biophilic Design	Biophilic design should be used in the design of buildings and the community's public realm. Employing design that connects inhabitants with nature using natural materials such as wood and building-integrated planting has positive impacts on physical and mental health and well-being.	Begin the design process for houses, laneways, and open spaces with the aim of fostering beneficial connections to nature.	Carbon Water Waste Social	Birkeland 2015
Small-Scale Efficiencies	Efficient Fixtures	A. Energy-Efficient Fixtures: use of fresh air ventilation, energy efficient operable windows, low energy appliances and lighting, greener and healthier building materials (locally sourced), consideration of daylighting and solar orientation.	Install fixtures that are energy and water-efficient when building.	Energy Carbon Water Waste Social	Pirie, 2010, 2013
		B. Water-Efficient Fixtures: Additional water savings could be achieved through the installation of features such as more efficient faucets and showerheads and dual flush toilets.		Energy Carbon Water Waste Social	City of Toronto, 2017
Future Efficiency and Production	District-Energy Ready	A. Prepare infrastructure that is ready to incorporate district energy systems into the centralized existing network.	Before building, plan create a system that is ready to adapt to in the future if need be.	Energy Carbon Water Waste Social	University of Toronto Faculty Services
	Adaptable Design	B. Designing with adaptability in mind allows the system to be retrofitted in the future instead of having to be ripped apart.		Energy Carbon Water Waste Social	Birkeland, 2008
MULTI-BUILDING SCALE					
Positive Waste	Salvaged Components	A. During construction of the laneway houses in the Huron Sussex neighborhood, materials can be salvaged and re-used in other laneway houses.	Do a survey of local construction sites to see if there are usable materials. If so, they can be planned into use on certain laneway houses and other amenities in the neighborhood.	Energy Carbon Water Waste Social	LEED-ND
		B. Materials that were considered waste on other local construction sites can be re-used within the huron sussex neighborhood for laneway houses, fences, etc.		Energy Carbon Water Waste Social	LEED-ND

Huron-Sussex Laneway Housing - Toolkit

Principal Sub-Category	Recommendation	Strategies in Huron-Sussex	Early Actions	Co-Benefitting Pillars	Reference Documents (Source)
	Shared Backyard Food Digestors	A. At the household level composting can be encouraged through the provision of food digestors in the resident's yards. These will turn compost into mulch that the surrounding plants can use, and the digestor runs off of solar energy.	Food digesters would need to be provided in each residential yard along with education for the residents on how to use their food digester.	Energy Carbon Water Waste Social	Compost Education Centre, n.d.
	Composting Toilets	A. Centrally located composting toilets can ensure zero liquid waste and allow the waste to be turned into mulch that can be used for certain plants.	Centrally located composting toilets will need to be installed (they look normal but the waste is sent to a local tank instead of city facilities. People to tend to the mulch will need to be hired.	Energy Carbon Water Waste Social	Lets Go Green, 2016
Energy Production	Co-Generation	A. The neighbourhood may not have the critical mass for co-generation. However exploring the opportunity to implement biomass generation into the District Energy System using sites that are less "busy" locations may be viable	Partner with TerraCycle or City of Toronto to discuss ways to create a closed loop generation of energy using waste/biomass and the natural gas output	Energy Carbon Water Waste Social	TerraCycle, 2018
COMMUNITY SCALE					
Regenerative Architecture	Whole Systems Design	A. Mutually Supportive Relationships: Multiplicity within and between all systems making up the building and community should be established. Utilize redundancy to address each pillar of net-positivity (more than one solution, which may be co-beneficial)	Create a plan/design for the community as a whole that incorporates sustainabiltiy throughout, using mutually supportive elements	Energy Carbon Water Waste Social	Littman, 2009
		B. Concentration: Design system elements to be placed where potential utility and space is maximized. Consider utilizing the Living Lane as the community's 'spine' for energy systems and water collection, and integrate necessary above-ground infrastructure at strategic points along the lane.	Consider system element's locations in relation to demand and each other, and maximize system capabiltiy based on relative location	Energy Carbon Water Waste	Littman, 2009
		C. Community Input: During the planning phase, create a multi-day "charrette" - design activity that brings together design professionals and local stakeholders to work together to address specific issues. This could take place at the community centre.	Continually reach out to residents, keeping them updated on the project and also have a system to receive questions and comments. This could be part of the proposed community website.	Energy Carbon Water Waste Social	LCC
Energy Production	Renewables Generation	A: Community Collaboration comes from making principles of regenartive sustainability inherent in neighourhood. Behaviours such as gardening, and strucutres like solar arrays, establish the area as place for sustainability.	Provide information in the community centre on how residents in non-infall housing can retrofit or design their homes to incorpate sustainabilty features such as solar PV and VAWTs	Energy Carbon Water Waste Social	Robinson, et. al., 2013

Huron-Sussex Laneway Housing - Toolkit

Principal Sub-Category	Recommendation	Strategies in Huron-Sussex	Early Actions	Co-Benefitting Pillars	Reference Documents (Source)
		B: Neighbourhood/Geothermal Systems reduce the energy consumption of buildings by providing heating and cooling through closed loops systems that include multiple structures.	Contact the Ontario Geothermal Association to build vertical loop systemwhich will provide heating to buildings to mitgate eletrical energy expenditure	Energy Carbon Water Waste Social	Dalton, personal communication, 2018
		C: Solar Panels/Photovotaic cells are widely available and affordable as one of the most widely accepted and viable forms of renewable energy.	Design solar array using current technology but with the capacity for adjustment as innovation improves panel efficiency	Energy Carbon Water Waste Social	Keith, n.d.
		D: Vertical-Axis Wind Turbines provides easy to implement energy generation at micro and residential scales. Also has an inverse relationship with solar since seasons with shorter daylight periods in Toronto have higher average and max wind speeds.	Install small scale micro-turbines to power public features with larger turbine built for each unit or share rooftop space for increase power capacity and efficiency	Energy Carbon Water Waste Social	Bahaj, et. al. 2006
Energy Efficiency and Management	Integrated neighbourhood energy system	A: U of T's existing district energy system should be retofitted to work with multiple input sources rather than a centralized natural gas source.	Ensure infill houses are built DE ready and with smart grid technology or metering so that the network can become a distributed energy system	Energy Carbon	Ken Pirie, 2010, 2013
		B: Smart Grids manage two-way communciation between electricity generation and consumption. Thier Alogrithm and AI technology ensure grid stability against power outages and cyber attack while managing energy sources.	Conduct a Technocommercial viability study to help retrofit existing electrical grid.	Energy Carbon Water Waste Social	Clastres, 2011
	Storage Batteries	A. Build Infrastruce to help manage generated energy flow. Use of batteries or energy stored in alternative forms are necessary for downstream control of energy consumption.	Ensure downstream energy storage is built, potentially connecting to DES for energy regulation with Smart Grid	Energy Carbon Water Waste Social	Clastres, 2011
Local Production	Stormwater Harvesting	A. Permeable paving: Reduce stormwater runoff by using green roofs and water-pervious paving materials. Permeable paving cost in USD per sq ft: $6.	Laneway houses can be built with green roofs and paving for the living lane can use water-pervious paving materials. For a house with a east-west orientation, a green roof is recommended	Energy Carbon Water Waste Social	Farr, 2018
		B: Bioswales: Pre-treatment of stormwater captured from Strategy A above could be done through the use of bioswales, which are multi-layered water cleansing method that uses resilient plants and filtering granules to separate streetscape contamination from the water.	Implement use of bioswales in planning and development to allow for pre-treatment of stormwater.	Energy Carbon Water Waste Social	Ma, 2013

Huron-Sussex Laneway Housing - Toolkit					
Principal Sub-Category	**Recommendation**	**Strategies in Huron-Sussex**	**Early Actions**	**Co-Benefitting Pillars**	**Reference Documents (Source)**
	Water treatment	C. Stormwater and rainwater potable water: The water collected from Strategy A above can be stored in an underground cistern and treated through a 6-step process: 1. Collection 2. Storage 3. Filtration 4. Disinfection 5. pH adjustment 6. Treated water tank	Implement use of underground cistern treatment system so that stormwater and rainwater can be treated and used in the neighbourhood.	Water Social	CIRS Technical Manual
		D. Greywater and blackwater to non-potable water: Through the use of an on-site, decentralized wastewater treatment system such as the Solar Aquatics system that is currently being used at UBC's CIRS, greywater and blackwater can be treated into non-potable water and reused.	Implement the use of an on-site, decentralized wastewater treatment system in planning and development so that greywater and blackwater can be treated into non-potable water and reused.	Energy Carbon Waste Social	Eco Tek
	Community Garden	A. Food production: currently, the neighbourhood already has one. However, there is quite a bit of space where the garden sits and it can certainly be enlarged to produce more crops. Future considerations of a greenhouse over it to produce food over winter months too.	Get more containers for the community garden and let residents decide what they would like to plant. There should be a system in place where harvest and planting days are coordinated by someone (this could be posted on the propsed community website).	Energy Carbon Water Waste Social	LCC, Masters Thesis by Teresa Looy and Naheeno Park Community Garden Research Project report
		B. Community Participation: According to research done, some of the reasons that people choose to community garden is that it is an opportunity to interact with nature, and have a space for well-being and mental health.		Energy Carbon Water Waste Social	Naheeno Park Community Garden Research Project report
Regenerative Waste Management	Community Compost	A. Provide compost bins in the community garden, which will both decrease waste and provide mulch for the garden. On the neighborhood scale compost can have accountability and incentives which will encourage people to properly compost. One such incentive would be to provide mulch from the compost to participating families.	A compost bin large enough for the neighborhood's waste needs to be built. People also need to be hired to collect compost and to tend to the compost bin.	Energy Carbon Water Waste Social	Community Composting, 2008
	Recycling Partnerships	A. Comprehensive Recycling: The Huron Sussex neighborhood can pair up with a business like TerraCycle which has better facilities for recycling than the city of Toronto. TerraCycle will work with the neighborhood to create a drop off location for recyclables which they then pick up and treat. On the neighborhood scale accountability to decrease contamination can be utilized and residents can be educated as to precisely what can be recycled.	The neighborhood would need to create a drop off station and then people for recycling collection will need to be hired. Education should be provided to residents from the onset (this might be provided by the business the neighborhood pairs with).	Energy Carbon Water Waste Social	TerraCycle, 2018

Huron-Sussex Laneway Housing - Toolkit

Principal Sub-Category	Recommendation	Strategies in Huron-Sussex	Early Actions	Co-Benefitting Pillars	Reference Documents (Source)
		B. Plastic repurposement: The Huron-Sussex neighborhood could pair with an organization like Wasted which helps communities set up their own plastic recycling station. This station is about the size of a box car. All plastic can go into the station and will be made into usable goods for the neighborhood such as benches and planters.	Recycling disposal needs to be set up with a seperate area for plastics. A station for plastic treatment needs to be set up with the help of Wasted. Pick-up of plastics should also be provided to residents.	Energy Carbon Water Waste Social	WASTED, 2018
	Swap Shop	C. Swap shop: U of T has a swap shop but the community could have their own so it is nearer. Swaps allow residents to reuse and recycle their unwanted items instead of throwing it out where it goes straight to the landfill.	Have a swap page on the community's website where residents can post what they would like to swap. Swaps could also occur at the community centre!	Energy Carbon Water Waste Social	University of Guelph Sustainability Office furniture swap program
	Nexterra Biomass Plant	A. Nexterra Biomass Plant: converts locally sourced wood, biosolid disks from the neighborhood wastewater treatment plant, and compost into clean burning syngas to provide heat and hot water for the neighborhood and beyond. This treats waste but also significantly reduces greenhouse gas emissions and energy associated with wastwater treatment.	This plant could also be a future consideration that the Huron Sussex neighborhood should stay capable of implementing or using.	Energy Carbon Water Waste Social	Pirie, 2010, 2013
Regenerative Social Well-Being	Community Resources	A. Community Website: has health and wellness education information plus information about the design/operations of this sustainable community. Residents should be able to easily access online resources about sustainability (both social and environmental).	Have a website developed with each stakeholder in this project (Campus & Facilities Planning, the builders, the residents etc.) and decide what information should be put up.	Energy Carbon Water Waste Social	LCC
		B. Community Card: A card that allows people in the neighbourhood to access resources like libraries, gyms etc. This will help increase social sustainability in this neighbourhood.	Work out a deal with U of T libraries and the gyms (Athletic Centre, Hart House and Goldring Centre) for which residents could get access to them.	Energy Carbon Water Waste Social	SFU UniverCity case study (Girling 2010)
		C. Community Centre: this is already planned but it should be built with regenerative sustainability principles to reinforce sustainability. This centre wil act as a gathering space, to foster neighbourhood community, and networking opportunities.	Working with the community centre builders and designer, incorporating sustainability principles. Such principles are the ones found in this toolkit as well.	Energy Carbon Water Waste Social	Pirie, 2010, 2013
		D. Childcare: there is already a childcare centre in this neighbourhood, but given the amount of houses to be added, vacancies will be an issue. The childcare will need to expand to accomodate the needs of this neighbourhood.	Determine whether the current childcare can be expanded to allow for more children, or if a new facility has to be built entirely to accomodate.	Energy Carbon Water Waste Social	SFU UniverCity case study

Huron-Sussex Laneway Housing - Toolkit

Principal Sub-Category	Recommendation	Strategies in Huron-Sussex	Early Actions	Co-Benefitting Pillars	Reference Documents (Source)
		E. Water-saving education: Educating residents on water saving strategies such as the use of the City of Toronto’s water management guide and MyWaterToronto to track and manage water consumption	This can be a section on the community website. Educational tools can also be created to be used in the community centre.	Water Social	City of Toronto, 2017
	Enhanced Public Realm and Accessibility	A. Public Art: Community art for celebration of culture. There is potential for a collaboration with the Native Canadian Centre of Toronto (at Bloor and Spadina) to have some indigenous art installation/murals in the neighbourhood, ackowledging the land the University of Toronto sits on.	Have some discussions of what community art is desirable in the neighbourhood. Working with the Native Canadian Centre if the native art route is chosen.	Social	LCC
		B. Pocket plaza or park in the living lane: a multi-use space akin to the community centre but outdoors. It is an area for residents to congregate for activities such as farmers markets, movie projections etc. This reduces the need for residents to travel far to access these things.	The living lane area is already marked out, but what is left is to decide which portion of it will house the pocket plaza or park.	Carbon Energy Social	LCC
		C. Green Space: Establish ecological spaces and building-integrated vegetation such as green space frame walls (“green scaffolding”), inhabitable green roofs, and site landscaping using native and perennial plants. Green spaces sequester carbon while offering physical, cultural and psychological benefits	Determine if any sort of green walls can be installed. Have greenroofs on houses that are E-W facing. Make sure that the plants that are planned for planting are native species.	Carbon Water Social	Renger et al, 2015 Birkeland 2015 (‘Biophilic urbanism)
Transport-based Carbon Reduction	Reduce Private Vehicle Reliance	A. Internal Connectivity: Create a connected neighbourhood with a high degree of internal connectivity through street connections, internal pathways, living lane, pocket plaza/park to encourage walking and reduce dependence on driving. Implement multi-use buildings to provide access for people in neighbourhood to be within walking distance of daily activities, school, work, retail. Reduces vehicle dependence and carbon emissions from transportation, and fosters community.	Use of living lane in Huron-Sussex neighbourhood and implementation of multi-use buildings can achieve a high degree of internal connectivity.	Carbon, Social	LEED-ND
		B. Vehicle Sharing: Vehicle sharing can solve the Huron-Sussex laneway housing project's issue of reducing the number of parking spots. It also reduces depency on individual vehicles and reduces carbon emissions. It also improves social wellbeing by fostering community.	Vehicle sharing in the Huron-Sussex neighbourhood as an early action to solve parking issues and reduce individual vehicle dependence. This action reduces carbon emissions and fosters community.	Carbon, Social	LEED-ND

Huron-Sussex Laneway Housing - Toolkit					
Principal Sub-Category	**Recommendation**	**Strategies in Huron-Sussex**	**Early Actions**	**Co-Benefitting Pillars**	**Reference Documents (Source)**
		C. Alternative Parking Models: Existing parking spaces that are replaced by laneway housing need to be replaced. An alternative is to encourage residents to not use individual vehicles that require a parking space. New way of thinking is to use transportation demand management by encouraging travel via alternative modes of transport and at non-peak times. One strategy is to offer a cash benefit to people who choose not to drive (Victoria Transport Policy Institute provides additional techniques in transport policy and provides cost and benefit analysis; link); 10-30% reduction in parking demand. Another strategy is to provide transit pass subsidy (7.5% reduction).	Huron-Sussex neighbourhood should implement a transportation demand management system that encourages travel via alternative modes of transportation, away from individual vehicles. Program could include incentives for residents who chose not to drive. Encouraging biking and walking is also a viable early action.	Carbon, Social	Farr 2018
		D. Encourage Biking: Provide secure and sufficient covered bike storage in the Huron-Sussex neighbourhood. Design streets and laneways to be bicycle friendly with continuous bike lanes/paths that can be shared by cyclists and pedestrians (living lane).	Since vehicles will not be able to access the living lane and narrow streets in the Huron-Sussex neighbourhood, encouraging biking and walking is preferred. An abundance of covered bike storage will encourage cycling. The living lane can be used to design a continuous bike lane/path that can be shared by cyclists and pedestrians.	Carbon, Social	LEED-ND

APPENDIX B

Application - Garden Suite

Specific areas of garden suite site	Recommendations	Area of Net-Positivity
Roof	Green roof Gutter	Water: rainwater harvesting
Garden	Design for stormwater harvesting	Water: stormwater harvesting
Building structure	Locally sourced and recyclable building materials (e.g. use wood rather than steel and concrete) Build geothermal system under the site	Carbon: reduce embodied carbon from transport of goods from long distances; steel and concrete are carbon-intensive compared to wood. Geothermal can reduce reliance on separate heating and cooling system. Energy: Reduced reliance on heating/cooling system through the use of geothermal energy can save on energy use.
Building fixtures and appliances	Operable windows Low-energy appliances and lighting Water-efficient fixtures (e.g. dual-flush toilets) Diversion of water pipes to on-site water treatment system	Carbon: lowers the use of energy and reduces carbon emission Energy: energy-saving measure Water: reduce indoor water use Water: connect household water pipes to on-site water treatment system

Application - Neighbourhood

Specific areas of neighbourhood	Recommendations	Areas of Net-Positivity
Energy system	Smart grid implementation/retrofit District energy system ready Renewable energy implementation (solar photovoltaic cells, wind)	Energy: produce more energy than neighbourhood consumes Carbon: reduce carbon emissions from non renewable energy sources
Building connectivity	Multi-use buildings (work, retail shops, housing, entertainment) Living lane, pocket plaza/park	Carbon: reduce use of vehicles Social wellbeing: improve social wellbeing through multi-use buildings, neighbourhood residents can work, shop, live, in same neighbourhood Social wellbeing: living lane provides benefits to social wellbeing
Transportation	Reduce vehicle dependency Car sharing Encourage biking (build plenty of sheltered bike storage)	Carbon: reduce carbon emissions from individual vehicle transportation Social wellbeing: Improve health of neighbourhood by encouraging biking and walking
Wastewater treatment	On-site neighbourhood wastewater treatment system Rainwater and stormwater to potable water Greywater and blackwater to non-potable water Nexterra biomass plant	Water: neighbourhood wastewater treatment system increases water harvested to be greater than water consumed Energy: reduces potential energy use to treat wastewater Carbon: reduces potential carbon emissions from wastewater treatment Energy: reduces dependency on fossil fuel sources of energy

		Carbon: reduces carbon emissions associated with energy generation Water: increases water harvested to be greater than water consumed Waste: reuses waste to generate energy Social: social wellbeing increases as a result of awareness that waste is being reused to generate energy
Waste management	Community Garden Compost Recycling organization (TerraCycle) Swap Shop	Waste: diverts waste away from landfill, increased recycle and reuse of waste. Carbon: reduce potential carbon emissions associated with landfills Energy: waste could be used to generate energy Social wellbeing: increased recycling and reuse of potential waste increases overall social wellbeing
Community building	Enlarge current community garden Community centre already planned for neighbourhood	Social wellbeing: increases social wellbeing, sense of belonging in neighbourhood, and encourages environmentally friendly behaviour Social wellbeing: can encourage healthy activities Carbon: reduce carbon emissions associated with transportation of food Carbon: reduce transit emissions from community potentially travelling to get to a community centre outside of the neighbourhood

APPENDIX C

Rainwater harvesting calculator:

> Rainwater collected (litres) = roof area (square metres) * precipitation amount (mm)

Source: Innovative Water Solutions (n.d.)

The Weather Network (n.d.) showed that the annual precipitation in Toronto is 709 mm while the roof area for the 29 Huron-Sussex infill sites with East-West orientation are around 63 square metres each based on the garden suite configuration in Planning Study created by Brook McIlroy + NBLC (2014).

So the final calculation is:

> Rainwater collected (litres) = 63 square metres * 709 mm
> = 44,667 litres

This is equivalent to 44.667 cubic metres per house, multiplied by 45 roofs for a final annual rainwater collection amount of around 2010 cubic metres; this number can be doubled to around 4,020 cubic metres to form the rough estimate for rainwater collected from the entire Huron-Sussex neighbourhood. This doubling would account for rainwater collected from permeable paving in the living lane and the gardens and natural landscape planned into the garden suite and the rest of the neighbourhood.

APPENDIX D

6-step process to turn rainwater into potable water (source: CIRS Technical Manual).

Step 1 – Collection

Rainwater is collected on the upper roof on the north and south wings of the building and channeled into the storage cistern underneath the building.

Step 2 - Storage

Depending on the potable water supply and demand, the rainwater is stored for up to three months (the cistern is 107,000 litres, sized to store a three-month demand). The longer storage time is possible due to the continual circulation of oxygen through the water, which reduces the growth of potential contaminant and the development of odour and discoloration.

Step 3 – Filtration

From the cistern, the rainwater is filtered through a three step process. The first step is a slow sand filter to remove larger particles, next is a fine filter to remove smaller particles and parasites, and finally an activated carbon filter which removes metals and organic contaminants from atmospheric contaminants.

Step 4 – Disinfection

After filtration, the water is disinfected through a two-step process. First, the water is exposed to ultra-violet light to kill any remaining pathogens, and then a small amount of residual chlorine is added.

Step 5 - pH adjustment
Rainwater in the lower mainland of British Columbia has a pH of about 4, which is below the regulated level for drinking water of between 6 and 9 ph. Sodium bicarbonate is injected into the water to adjust the alkalinity and reach the required pH level.

Step 6 - Treated water tank

After the water has been treated, it is stored intwo tank (for up to 12 hours, depending on demand) and delivered by pump through the building using a pressurized bladder system.

APPENDIX E

Four-stage treatment process of the Solar Aquatics wastewater treatment system (source: Ecological Engineering Group, n.d.)

The Treatment Process

The treatment process occurs in four stages that can be completed in one day for domestic wastewater. More concentrated wastes, such as septage and dairy wastes, require longer process time.

1. Aeration, Bioaugmentation and BOD Reduction
Air is diffused into the wastewater as it enters the facility. The naturally occurring bacteria are augmented with commercial strains of natural bacteria which, in the presence of air, break down soluble organic chemicals into carbon dioxide and water. The process also degrades fats, starches, and proteins into compounds which can be metabolized by other organisms downstream.

2. Nitrification and First-Stage Nitrogen and Phosphorus Removal
Nitrifying bacterial, algae, and higher plants begin to metabolize nutrients in the waste stream. Ammonia (NH3) is oxidized into nitrates (NO3). Nitrates, ammonia, and soluble orthophosphates are metabolized directly by green algae and higher plants. Snails and other zooplankton begin the process of sludge digestion.

3. Nutrient Removal, Reduction of Suspended Solids, and Nitrate Uptake
Higher plants on the surface, with their root masses reaching down into the water column, take nitrates and phosphorus from the waste stream to promote leaf and flower production. Very large populations of grazing zooplankton inhabit the extensive surface area of the roots where the water is filtered.

4. Pathogen Reduction, Filtration and Denitrification
As the water passes through the marsh, solids are filtered in the sand and stone substrate, nitrate is reduced to nitrogen gas and water, and certain pathogenic bacteria are destroyed by the action of the marsh plants, including bullrush, cattail, water iris, and reeds. An optional ultraviolet light at the discharge point disinfects the effluent.

APPENDIX F

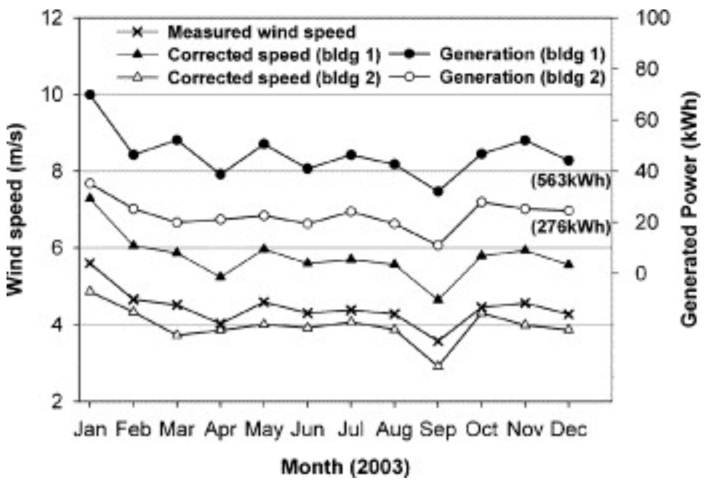
Table 1

Table 1. Merits of vertical axis wind turbines over horizontal axis wind turbines.

	Vertical axis wind turbine (VAWT)	**Horizontal axis wind turbine (HAWT)**
Tower sway	Small	Large
Yaw mechanism	No	Yes
Self starting	No	Yes
Overall formation	Simple	Complex
Generator location	On ground	Not on ground
Height from ground	Small	Large
Blade's operation space	Small	Large
Noise produced	Less	Relatively high
Wind direction	Independent	Dependent
Obstruction for birds	Less	High
Ideal efficiency	More than 70%	50–60%

VAWTs Technical Data

Where HAWTs need single wind directions and electricity to start their rotations, VAWTs can function with turbulent wind patterns and wind speeds as low as 1.25 m/s (Kumar et. al. 2018).



As observed, 400W wind turbines operating at average annual wind speeds below 9 m/s produced 563 kWh of energy annually (Bahaj et al. 2007). By comparison Toronto's lowest monthly maximum wind speed 10.278 m/s (GOC, 2018). The following is Toronto's maximum energy generation, assuming similar urban conditions with turbulent wind directions but at higher speeds and linear relationship (results based on design are typically exponential);

1981 to 2010 Canadian Climate Normals station data

Wind

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Maximum Hourly Speed (km/h)	64	69	**129**	64	80	43	48	37	42	55	64	72		

Converted to m/s

17.78	19.17	35.83	17.78	22.22	11.94	13.33	10.28	11.67	15.28	17.78	20

Annual Energy Output / Duration = Monthly Energy Output
563 kWh / 12 months = 49.61 kWh/month

Monthly Energy Output / Annual Avg. Wind Speed Measure = Urban Turbine Coefficient

49.61 kWh/month / 9 m/s = 5.21

Σ Monthly Energy Output * Urban Turbine Coefficient = Annual Energy Output

Total = 1110.2 kWh for 400W Turbine in Toronto (Assuming Linear Relationship)

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