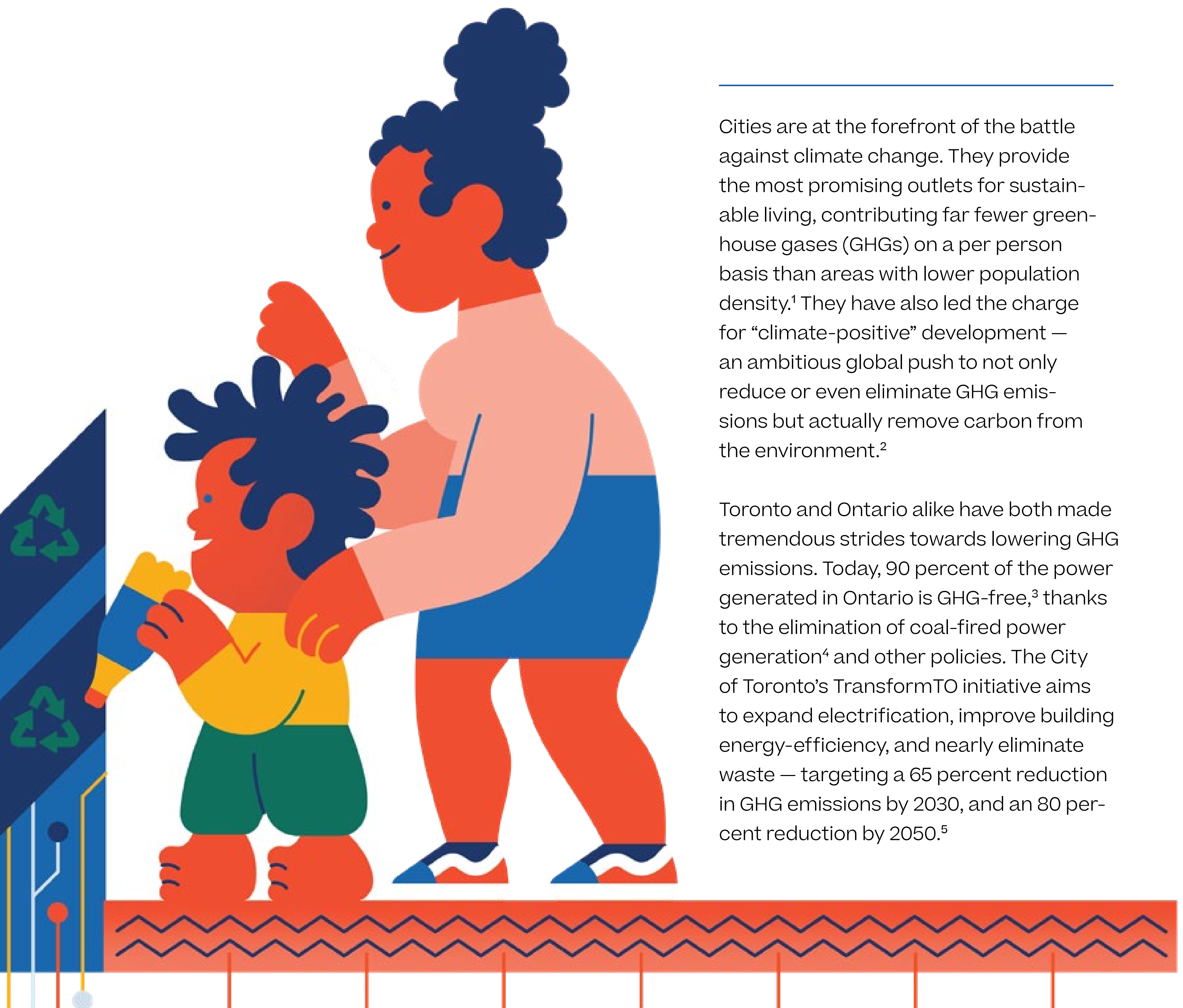
Chapter 4

Sustain-ability

Introduction

The Vision

A new standard of **sustainability** that creates a blueprint for truly **climate-positive communities.**



Cities are at the forefront of the battle against climate change. They provide the most promising outlets for sustainable living, contributing far fewer greenhouse gases (GHGs) on a per person basis than areas with lower population density.[1] They have also led the charge for "climate-positive" development — an ambitious global push to not only reduce or even eliminate GHG emissions but actually remove carbon from the environment.[2]

Toronto and Ontario alike have both made tremendous strides towards lowering GHG emissions. Today, 90 percent of the power generated in Ontario is GHG-free,[3] thanks to the elimination of coal-fired power generation[4] and other policies. The City of Toronto's TransformTO initiative aims to expand electrification, improve building energy-efficiency, and nearly eliminate waste — targeting a 65 percent reduction in GHG emissions by 2030, and an 80 percent reduction by 2050.[5]

These and other ambitious programs have helped Toronto reach per capita emissions of 6.3 tonnes per year.[6] But Waterfront Toronto wants to do even better with new developments under its stewardship, and has established a public policy goal of achieving a climate-positive community along the eastern waterfront that can demonstrate a path forward for other large-scale urban developments to follow.

The Sidewalk Toronto project provides a unique opportunity — at a moment of renewed urgency — to tackle climate challenges. Incremental changes have been unable to eliminate GHG emissions, let alone achieve climate-positive development in a replicable way. Instead, reaching this goal requires a comprehensive approach to designing, operating, and managing energy systems that integrates new physical infrastructure with emerging digital tools.

At the core of this approach is using clean electricity for all heating, cooling, and power needs. Today, Toronto's buildings account for roughly 60 percent of the city's GHG emissions,[7] with the vast majority of those emissions (87 percent) attributed to burning natural gas for heat or hot water.[8] In other words, the clearest path towards positivity is through full electrification. But electricity could become more expensive for households and businesses, given that electricity tends to cost more than natural gas, unless a system were deployed at a wide enough scale to spread the costs.

The innovation plan.
Building on concepts from Waterfront Toronto's existing precinct plans, Sidewalk Labs proposes a six-part pathway to achieve climate-positive development that can only be effective and financially feasible when applied across a broad area and supported by strong cooperation between the public and private sectors.

First, Sidewalk Labs proposes to reduce overall energy demands through energy-efficient building designs. These designs would maintain interior comfort by incorporating building features inspired by the global "Passive House" movement, such as airtight wall systems. These proposed designs would achieve or exceed the highest levels of the Toronto Green Standard (the city's energy code) for GHG intensity.

Second, Sidewalk Labs plans to eliminate energy waste through digital management tools. A proposed suite of energy "Schedulers" would actively manage energy systems for residents, businesses, and building operators, ensuring that buildings operate in the most efficient way possible.

Third, Sidewalk Labs plans to use a district energy system called a "thermal grid," which could provide heating, cooling, and domestic hot water without relying on fossil fuels. This grid harnesses clean energy from a variety of sources — including geothermal (underground) energy, building waste (or excess) heat, and wastewater (sewage) heat — and operates using electric heat pumps, eliminating the need for boilers powered by natural gas.

Benefits of implementing the vision

- Establish a global model for achieving climate positivity
- Reduce carbon emissions by 89 percent over the current city average
- Improve recycling and organic waste processing, with a landfill diversion rate of 80 percent
- Protect water quality, lower costs, and create a more beautiful public realm through a green stormwater system

Fourth, Sidewalk Labs proposes to design an advanced power grid that uses solar energy, battery storage, and real-time energy pricing to reduce reliance on the main power grid during periods of peak demand, when the grid requires fossil fuels to meet needs. This grid could draw on solar or battery energy at peak moments or, combined with the Schedulers mentioned above, defer energy consumption until off-peak hours, when fossil fuel-fired power plants are not in use.

Fifth, to reduce GHG emissions from garbage trucks and the impact of landfill waste, Sidewalk Labs proposes a smart disposal chain that could dramatically improve recycling rates and organic waste processing. This chain would include real-time feedback to improve waste sorting, "pay-as-you-throw" chutes that encourage households and businesses to reduce waste, underground vacuum tubes that help reduce contamination and centralize trash hauling, and connections to anaerobic digestion facilities.

Finally, to protect the water quality along the waterfront while also incorporating more nature into the public realm, Sidewalk Labs proposes a combination of green infrastructure and digital stormwater management systems that could help capture, reuse, and, if necessary, treat stormwater that might otherwise contaminate the Don River basin.

The Sidewalk Toronto project could become the largest climate-positive district in North America.

The impact.

Together with mobility initiatives that encourage cycling, walking, and the use of electric vehicles, this comprehensive plan represents a dramatic reinvention of how major infrastructure systems are built and operated, as well as the way energy is generated, managed, and consumed — all in pursuit of the greater goal of climate-positivity.

In Quayside, Sidewalk Labs estimates that this integrated plan could make the neighbourhood nearly carbon neutral, achieving per capita emissions of slightly over 0.9 annual tonnes.[9] That represents a reduction of more than 85 percent from Toronto's citywide average, the equivalent of removing over 100,000 cars off the road each year. But the initiatives proposed in Quayside are only economically feasible when part of a broader approach that spans a large enough development area to support inventing, implementing, and operating this new sustainable energy ecosystem.

At the proposed full scale of the IDEA District, Sidewalk Labs estimates achieving emissions of 0.7 annual tonnes per capita, or an 89 percent reduction from the city's current average.

That scale represents a sufficient size to amortize the capital costs of major new infrastructure and keep utility bills comparable to existing standards for households and businesses.

This broader scale also makes it possible to achieve Waterfront Toronto's climate-positive objective. At the full scale of the IDEA District, in collaboration with the city, it could become economically feasible to tap into the Ashbridges Bay Wastewater Treatment Plant, a source of clean energy potential unmatched across North America. The energy potential of Ashbridges would create a surplus of clean energy in the project area that could then be exported to buildings in other parts of the city — fulfilling the mandate of climate positivity by reducing the city's overall emissions.

With public-sector support, the Sidewalk Toronto project could become the largest, densest climate-positive district in North America and the third largest in the world[10] — establishing a credible path forward for cities to follow.

IDEA District

The 77-hectare Innovative Design and Economic Acceleration (IDEA) District, consisting of Quayside and the River District, provides sufficient geographic scale for innovations to maximize quality-of-life impact and to become financially viable.

The path to achieving a climate-positive district

Sidewalk Labs has proposed a set of on-site and off-site initiatives that, when combined, would produce the largest climate-positive district in North America.

Sidewalk Labs estimates that, at the proposed full scale of the IDEA District, all the sustainability initiatives described in this chapter, combined with planned mobility initiatives, would reduce GHG emissions to 0.72 annual tonnes per capita, or roughly 89 percent less than the city's current average of 6.3 annual tonnes.

These efforts would make Quayside a nearly carbon-neutral neighbourhood, and make the proposed full scale of the IDEA District even closer to carbon neutrality. But these initiatives alone cannot realize a climate-positive community, because achieving that goal requires exporting clean energy or actively reducing Toronto's current GHG emissions.

Achieving the goal of exporting clean energy would require both a large scale of development and the strong partnership of the city, but it is possible. The best path Sidewalk Labs has found is to tap the large store of energy in Toronto's own wastewater, which would allow the proposed heating and cooling system to serve areas beyond the project borders. Such an effort would be as ambitious as Toronto's "deep lake water cooling" project was 20 years ago, and it would fulfill a climate-positive vision that not only benefits Toronto but provides a model for other cities around the world.

Tapping the full potential of wastewater from Ashbridges Bay would enable the project to give back 70,444 annual tonnes of CO2, or nearly 1.31 tonnes per person. Sidewalk Labs could achieve an additional 0.1 tonnes per capita offset through the creation of biogas from anaerobic digestion.

The role of mobility plans in reducing GHGs.

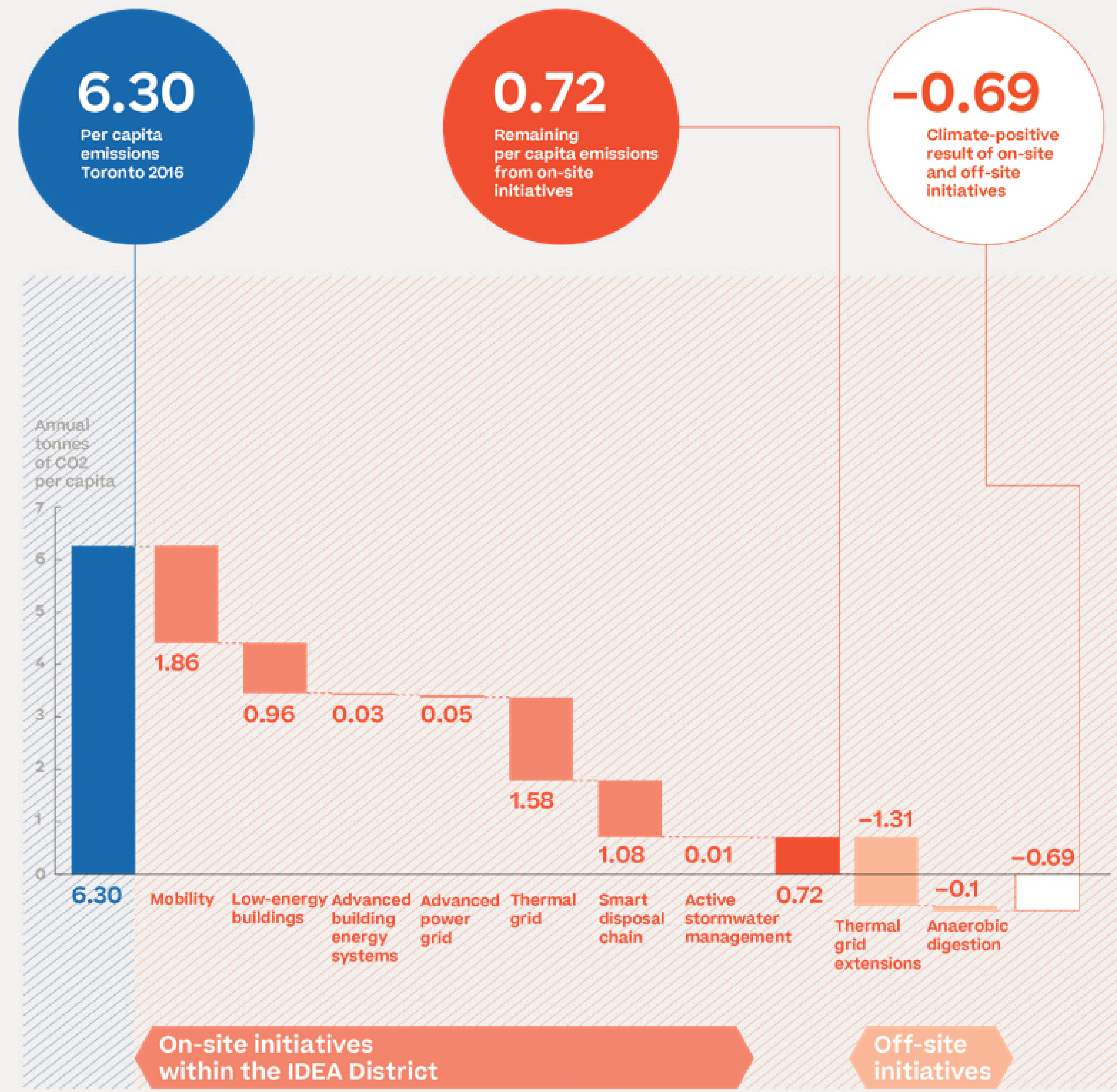
Sidewalk Labs' approach to mobility also plays a key role in realizing a climate-positive goal by providing alternatives to private automobile use, which is the second-largest source of Toronto's GHG output.[11]

Given the proposed light rail extension, walking and biking options, shared vehicle services, and mobility management system, this plan would translate into an estimated 30 percent reduction due to mobility-related GHG emissions.

Additionally, by encouraging electric vehicles, Sidewalk Labs expects that 30 percent of all the vehicle kilometres travelled by residents would be by electric vehicles in Quayside, and up to 100 percent across the IDEA District over time.

Altogether, these efforts would reduce transportation-related GHG emissions by 1.86 tonnes per capita at the full scale of the IDEA District.

See the "Mobility" chapter in Volume 2, on Page 22, for the full electric vehicle plan.



Note: Because the estimated GHG reductions shown here are based on a combination of design, technology, and behaviour change, Sidewalk Labs expects unforeseen shortfalls at the neighbourhood scale of Quayside.

The sustainability systems proposed in this plan include self-correction and learning mechanisms (such as advanced energy management tools and a smart disposal chain) that should reduce these variations as development proceeds across the IDEA District.

As a result, Sidewalk Labs has reduced the sustainability plan's expected GHG outcomes 10 percent in Quayside and 5 percent at the full scale of the IDEA District.

Ch–4

Part 1

Creating Low-Energy Buildings

Key Goals

1
Deliver Passive House–inspired buildings

2
Improve modelling through real-time metering

3
Use digital tools to tie energy outcomes to energy codes

The first step towards achieving a climate-positive community starts with reducing how much energy building tenants need to heat and cool their homes and offices.

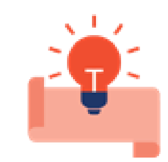
While there are many potential sources of high energy usage, two stand out. One is inefficient building designs and construction quality, which waste opportunities to conserve energy and improve comfort. The other is the inability of cities to determine how well energy is managed in a building once it is in actual operation. Instead, cities use models based on pre-construction design drawings to determine whether or not a building meets energy code, with no way to ensure a building's *actual* energy performance meets its *expected* energy performance.

Toronto and Ontario have made strides to tackle these challenges. The Toronto Green Standard (TGS), the city's sustainable design requirements for new development, sets targets for measurements such as energy use intensity and GHG intensity that get progressively more ambitious over time. TGS includes four tiers of performance, with Tier 1 as a code requirement, Tier 2 as a stretch goal with incentives, and Tiers 3 and 4 voluntary higher levels working towards zero emissions. And in February 2017, Ontario passed Energy and Water Reporting and Benchmarking legislation, in an effort to better track building energy use.[12]

But a study commissioned by Sidewalk Labs found that buildings in Toronto have not performed in line with modelled projections, using 13 percent more energy than modelled on average. The study also sampled 95 multifamily buildings that sought code compliance between 2015 and 2017; while these projects were not obligated to meet the new TGS targets, which went into effect in May 2018, only 5 percent would meet the equivalent of today's TGS-Tier 1 target for energy use intensity. (See Page 311 for more study details.)

Such results suggest that buildings in cities around the world, including Toronto, are struggling to keep pace with energy-efficiency goals, let alone exceed them.

Improving construction quality and tightening building design standards can conserve energy while preserving comfort for tenants.



To help improve building energy performance, Sidewalk Labs proposes to require that all buildings in the Sidewalk Toronto project area meet rigorous energy-efficient building design standards inspired by the Passive House movement, and plans to apply its factory-based approach to improve construction quality. Sidewalk Labs also proposes to develop new digital tools for evaluating energy performance in real time and implementing operational improvements as a critical step towards significantly reducing energy demands within the IDEA District.

At the scale of Quayside, this approach would produce buildings that meet the latest TGS-Tier 3 standard for energy use intensity and Tier 4 for GHG intensity. In Quayside, this achievement would reduce building energy use by 40 percent and GHG emissions by 75 percent over TGS-Tier 1 construction.

At the proposed full project scale, energy-efficient designs — reinforced by real-time energy measurements — could reduce GHG emissions by 0.96 annual tonnes per capita (or 15.2 percent) from the city's current average, on the path towards climate positivity.

Meeting Toronto's highest building sustainability standards

The Toronto Green Standard sets targets for new development around total energy use intensity, greenhouse gas intensity, and thermal energy demand intensity. Across all three measures, the Sidewalk Labs proposal meets ambitious TGS targets, outperforming the industry standard.

Goal 1

Creating Low-Energy Buildings

Deliver Passive House-inspired buildings

Low-energy buildings could reduce GHG emissions by

0.96

annual tonnes per capita.

A Passive House approach to building design maintains a comfortable interior temperature "passively" — that is, with less need for active heating and cooling devices.

A Passive House uses substantial wall insulation, airtight exteriors, and higher-quality windows to maintain a consistent, comfortable interior temperature. Ventilation systems circulate fresh, filtered outside air, while recovering heat from older, stale air before it is removed. Together these efforts reduce the "loads" of buildings — heating, cooling, ventilation, and other systems needed for people to be comfortable.

While this approach is not new, and in fact has deep roots in Canada (see sidebar on this page), Passive House has been applied to multifamily structures more frequently in relatively recent years.

For the IDEA District, Sidewalk Labs proposes to establish construction design standards inspired by Passive House and consistent with TGS-Tier 3 performance targets. These design standards would focus on envelope insulation, thermal bridging, air tightness, balanced ventilation, and unconditioned shared spaces. (See the visual on Page 308.)

Low-load buildings could reduce GHG emissions by 15.2 percent or nearly 95,500 tonnes — equivalent to removing more than 20,000 cars off the road.

Innovation case study

Passive House's Canadian roots

Passive House is the most rigorous voluntary standard for energy efficiency in the design and construction industry. The standard is established, maintained, and promoted globally by the Passivhaus Institut in Germany, with satellite associations in countries around the world.

While the Passivhaus Institut was founded in 1996, the Passive House movement has its roots in Canada — specifically in the 1977 construction of the Saskatchewan Conservation House in Regina, built as a response to the OPEC oil crisis. Using triple layers of insulation and windows oriented to capture sunlight, Conservation House heating requirements were only 1/28th of the average Regina home.[13]

Today, projects built according to the Passive House standard use the latest technologies in window design, panellized construction, insulation, and air sealing, and can range from detached homes to multi-storey towers. The world's largest Passive House building — a 26-storey dorm on the Cornell Tech campus in New York City — opened in 2017.[14]

Five design strategies to create low-energy buildings

Smarter building designs can lower the amount of energy required to heat, cool, and ventilate buildings, while keeping interiors just as comfortable for tenants. That approach includes improving insulation around the building, preventing unwanted air leaks and heat loss, venting fresh air, and applying passive comfort methods to shared spaces.

A Envelope insulation.
In standard buildings, gaps in envelope insulation can lead to unintended interior temperature changes. Sidewalk Labs proposes to require highly insulated building "envelopes" — basically, walls designed to resist heat loss and preserve interior temperature, like a thermos. This continuous insulation prevents the unwanted interior-exterior exchange of heat or cooling (known as "thermal bridging"). Sidewalk Labs would also provide criteria for window designs to reduce heat loss in winter and heat gain in summer.

B Thermal bridging.
Heat in a building finds the path of least resistance to cold outside air. If there is a pathway for the heat to transfer, it transfers — for example, steel-reinforced concrete slabs can transfer heat from the inside of a building to the exterior, which can be the reason some parts of some rooms always seem colder than others. In addition to ensuring continuous insulation, Sidewalk Labs plans to add gaskets and manufactured "thermal breaks" (non-conductive inserts in a chain of conductive materials) to stop building heat from escaping unintendedly.

C Air tightness.
In standard buildings, even small air leaks can cause drafts and interior temperature changes that lead to greater heating and cooling needs. These leaks often come from basic construction errors, such as incomplete caulking around a window or pipe penetration through a wall.

To meet Sidewalk Labs' energy-efficient standards, buildings would need to significantly reduce air leakage around windows, doors, and mechanical systems using airtight designs, along with other measures, such as special tapes and sealants. Factory-produced building parts that snap into place can also help limit air leakage. During construction, infrared cameras can help detect tiny air leaks.

The target rate of air tightness would be a maximum of 0.6 air changes per hour (at 50 Pascals pressure), as prescribed by Passive House.[15] To ensure this rate is achieved, Sidewalk Labs proposes to require Passive House-inspired air infiltration testing after construction. This testing is typically done through a "blower door test": fans are placed in doorways to blow air inside and pressurize the building, which is then measured for how well it holds this new pressure.[16] If the test fails, the contractor must identify and correct the source of air leakage, or the building cannot be certified.

D Balanced ventilation.
Sidewalk Labs proposes to require buildings to vent fresh air directly to living areas and bedrooms (in residential units) and to office or retail spaces (in commercial units). One way to achieve this goal is with a ventilation system that has two ducted air streams: one provides filtered, outdoor air to living areas, and one removes older, stale air from warmer rooms, typically bathrooms or kitchens.

Additionally, Sidewalk Labs proposes to require building ventilation systems to have "heat recovery" devices to transfer heat between the warm and cool air streams. On cold days, this system would transfer warmth from the older interior air to help the cool outdoor air reach the desired temperature with minimal energy use; on hot days, the system would transfer warmth and moisture from the incoming hot and humid outdoor air to the exhaust air, cooling and drying the new air supply and reducing the need for supplemental air conditioning.

E Unconditioned shared spaces.
Traditional buildings provide continual air conditioning or heating to transitional spaces, such as corridors and lobbies, regardless of the actual occupancy of these spaces, wasting an enormous amount of energy in the process. Sidewalk Labs' buildings would not provide continual conditioning to these spaces, but rather rely on heat exchange in building ventilation systems to keep a comfortable temperature, requiring no additional conditioning. (Corridors would be designed to easily add systems to condition air in these spaces if necessary.) Buildings would include small lobbies that offer a blast of cold-air as people enter or exit.

Goal 2

Creating Low-Energy Buildings

Improve modelling through real-time metering

Designing Passive House-inspired buildings should reduce their energy demand. But if the design details, construction quality, and systems operation are different in practice from what is initially planned, the building's actual energy use in operation can be far greater than shown by a model submitted for energy code compliance.

This disconnect is known as the "performance gap." In its study of nearly 100 buildings in Toronto, Sidewalk Labs found the performance gap to be 13 percent, meaning buildings use more energy when actually up and running than when modelled prior to construction.[17]

That overall performance gap belies a number of much larger gaps from a variety of sources (see charts). The study found that, on average, multifamily buildings in Toronto are using 39 percent more gas for heating, 21 percent more gas for domestic hot water generation, 61 percent more energy for pumping, and 94 percent more energy for common areas than modelled.

Meanwhile, the study found that residents used 26 percent less electricity than projected — likely due to outdated plug load guidelines in the code, which date back to 1997, but also possibly due to inaccurate occupancy assumptions (meaning units were unoccupied more often than the model suggested). It also found that cooling energy was 26 percent less than modelled.

The diagnosis for these gaps includes optimistic modelling of exterior wall construction and underrepresenting heat loss through metal components that bridge exterior walls and roofs, as well as incorrect assumptions about the operation and energy intensity of building systems and equipment.

To help improve energy modelling, Sidewalk Labs first plans to incorporate findings from its study into modelling assumptions. Further, Sidewalk Labs proposes that buildings in the IDEA District be required to deploy real-time metering of all energy systems (such as heating, cooling, lighting, and equipment). This ongoing measurement could help to improve the accuracy of building modelling two ways: first, by providing feedback on how tenants and operators actually operate systems in practice, and second, by enabling comparisons between the energy performance of those systems and the design-based projections.

Over time, the availability of real-time building energy data should dramatically improve the accuracy of performance-based models used to validate building codes. It should also create a feedback loop of performance to help architects, engineers, and developers improve their next designs — and, in so doing, help close the performance gap and improve the energy efficiency of buildings.

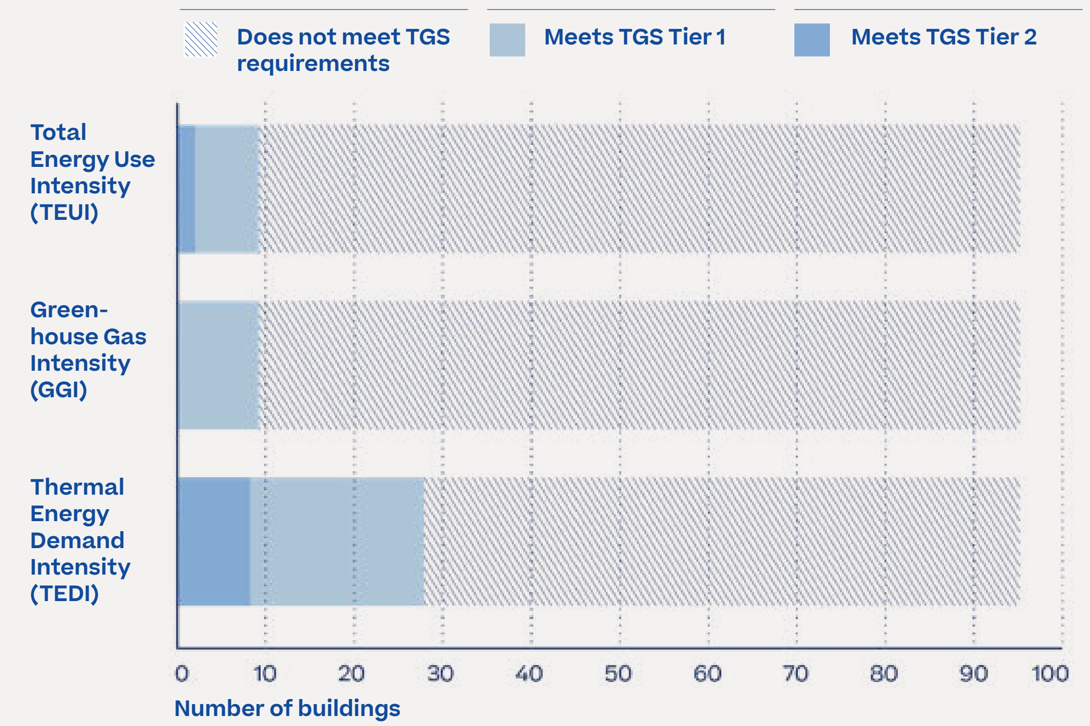
All proposed digital innovations would require approval from the independent Urban Data Trust, described more in the "Digital Innovation" chapter of Volume 2, on Page 374.

Analyzing the challenges to sustainable development

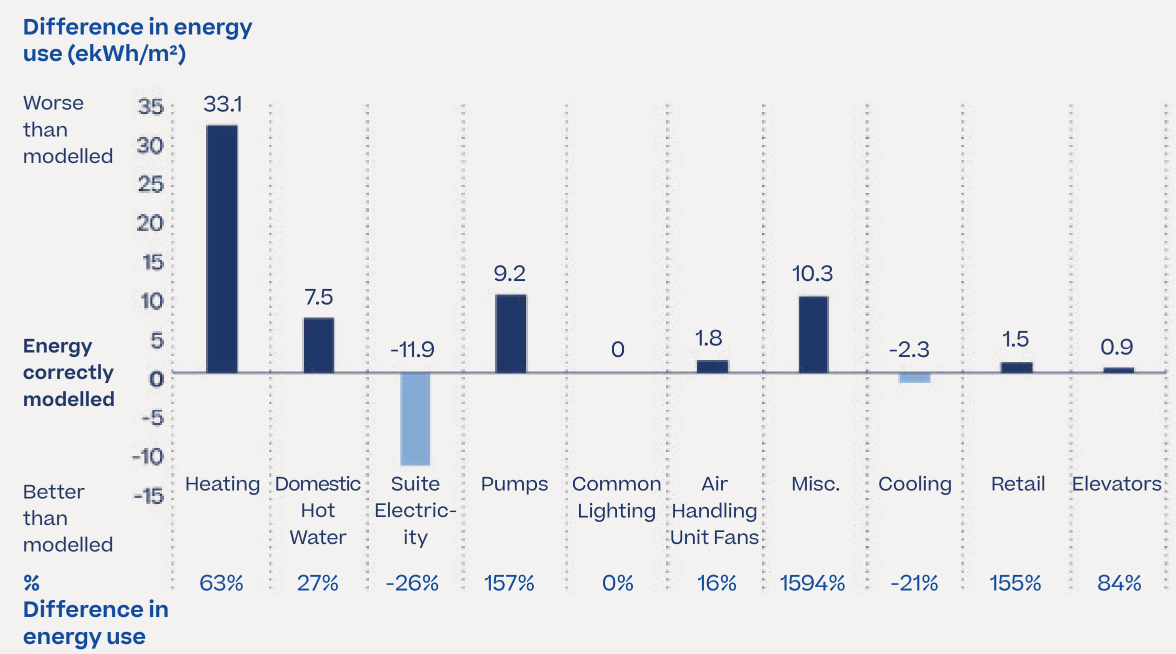
Sidewalk Labs engaged EQ Building Performance and Urban Equation to understand how design-based energy models differ from actual building energy performance in Toronto. The full report can be found at sidewalktoronto.ca.

Only 5% of buildings would meet new TGS-Tier 1

One aspect of the study looked at 95 multifamily buildings whose energy use was modelled between 2015 and 2017. All the buildings conformed to Tier 1 of the Toronto Green Standard code at the time the models were generated. But the study found that only 5 percent of the buildings analyzed would meet the new version of TGS-Tier 1 across categories, and none met all of the criteria for Tier 2, the city's first level of stretch goal beyond code.



Across many building systems, actual energy use does not match predicted use



This chart comes from a sub-sample analysis of 19 buildings already in operation from the Sidewalk Labs building study. For these buildings, the median metered (or actual) energy use intensity was 13 percent higher than the energy use intensity projected by the original models, or a total of about 50 energy units (ekWH/m2). This performance gap was supported by larger data sets: the average energy use intensity of 83 existing buildings (age 1998–2017) was 12.5 percent higher than the average energy use intensity of 95 models (2015–2017). The chart shows the various sources of this gap across building energy systems.

Real-time building energy data can help architects, engineers, and developers create more energy-efficient designs and close the performance gap between a building's projected and actual energy use.

Use digital tools to tie energy outcomes to energy codes

All proposed digital innovations would require approval from the independent Urban Data Trust, described more in the "Digital Innovation" chapter of Volume 2, on Page 374.

Even as real-time metering would help to close the performance gap and inform better building design, cities still need the ability to audit energy performance once a building is in operation, and create more responsive codes.

To help tackle this challenge, Sidewalk Labs proposes to develop and deploy a tool called "Perform" that would enable more effective enforcement of energy targets. Perform could incorporate factors that have an outsized impact on energy use, such as occupancy, tenant type, and weather, to create dynamic targets for acceptable energy use intensity. For instance, the tool would know that if the building is unoccupied in the evening, it should be using a fraction of the energy that it uses during the day.

Creating a system that could account for building use and tenant type would be essential, because some tenants use more energy than others for good reasons. For example, a building floor filled with video graphic artists using multiple screens and high-performing computers all day would likely consume more energy than a painter's art studio. Measuring precise patterns across various tenant types can help inform more realistic goals for energy usage in buildings that have a mix of homes, offices, and shops, and can help determine how to balance individual tenant goals with overall city and community goals.

If Perform were validated in practice in Quayside, Sidewalk Labs would plan to work with the city to require a tool like it with the IDEA District and to establish operational energy limits based on real-time metering for new buildings — not on pre-construction designs. At the full scale of the IDEA District, with a large number of buildings, this tool could form the basis for a real-time energy code that adjusts dynamically for occupancy, tenant type, and weather to ensure fair and appropriate energy use regulation.

Part 2

Optimizing Building Energy Systems

Key Goals

1
Create automated "Schedulers" for offices, homes, and building operators

Reducing overall energy demands through low-energy building designs and real-time energy measurement tools represents an important first step on the path towards climate positivity. But designs are not enough if buildings do not operate in an energy-efficient way — say, if the air conditioning stays on full blast when no one is around.

Three main groups are responsible for a building's energy use on a daily basis:

Office tenants seemingly control their space and all of the energy uses associated with it. But in practice, office tenants actually control very little in their space. Commercial thermostats are often remotely controlled and require a call to the facilities manager or building operator for adjustment. Ventilation fans often run on whatever schedule the building operator has set. And equipment and devices are commonly left on because no one is in charge of turning them off.

Residents typically control thermostats for heating and cooling, lighting, and plug loads in their units. Leaving the lights on or setting a thermostat too high are decisions that can add up to significant energy waste. Additionally, residents may unconsciously operate electric appliances during times of peak power demand (when GHG intensity is highest, and utility prices are also highest) that could run later without impacting their schedule.

Building operators make dozens of decisions about how to manage the centralized heating, cooling, lighting, ventilation, and other systems that serve tenant floors as well as common areas in commercial and residential buildings. These systems consist of lots of different equipment, including fans, pumps, motors, dampers, chillers and heat pumps distributed throughout buildings to serve different spaces. Operators commonly set a static schedule for the entire system based upon the building's regular hours, which assumes that each day is the same and that each tenant floor is the same. This approach can result in unnecessary energy use; for example, a fixed-schedule cooling system might run at times when an office is empty, increasing utility costs and wasting energy.

Optimizing building energy systems could reduce GHG emissions by 0.03 annual tonnes per capita.

Currently, none of these groups has the tools to take smart, easy, cost-effective, and energy-efficient actions. While the challenges vary for each group, existing tools share a number of common limitations.

Existing building management systems typically struggle to coordinate (or integrate) every system in a building: one system might control lighting and another might control heating and cooling, making it difficult to use data to improve efficiencies across both systems. They typically have limited ability to incorporate external data streams, such as weather forecasts and utility prices that can help create energy-efficient operation schedules. Energy management overlays that pull data from the building's myriad systems to provoke operator insights using charts and graphs rarely deliver significant savings, because the information is incomplete and still requires the operator to study, interpret, and act upon it.

To address these challenges, Sidewalk Labs proposes to deploy a suite of energy "Schedulers" for building managers, office tenants, and residents.

As their name suggests, Schedulers would help schedule and manage systems, equipment, and appliances that impact energy use and GHG emissions. They would do so by integrating relevant data from building systems to improve coordination; incorporating external data sources, such as tenant temperature preferences, operating budgets, building occupancy, weather forecasts, and real-time energy prices; and making decisions to improve equipment control and scheduling consistent with monthly energy cost goals.

At the small neighbourhood scale of Quayside, Schedulers would help office tenants, residents, and building operators alike stay within their energy budgets, eliminate energy waste in unoccupied spaces, and help the neighbourhood meet its climate goals. At the full scale of the IDEA District, the power of this suite of Schedulers would grow with a significant amount of baseline information about energy patterns.

Sidewalk Labs estimates that, in addition to conserving energy, the Schedulers could reduce building energy costs — already low thanks to Passive House–inspired techniques — by roughly 20 percent when used in concert. Those savings occur due largely to reductions in waste from turning off equipment when not in use, from turning on equipment just prior to use, and from dynamically controlling set points for heating, cooling, and ventilation equipment to align with demand.

Applied within the IDEA District, Schedulers would enable already highly efficient, low-energy building designs to achieve their full potential — maintaining that low energy usage and reducing GHG emissions by an additional 0.03 annual tonnes per capita (or 0.5 percent) from the city's current average, on the path toward climate-positive. (These savings include those of the Perform tool described on Page 313.)

Consistent with Sidewalk Labs' belief in open digital services, Schedulers would be designed to integrate with the existing ecosystem of building control systems, including those made by leading Canadian companies in this area, such as Ecobee, Encycle, and SHIFT Energy. Consistent with its role as catalyst, Sidewalk Labs would aim to leverage or support existing capabilities that could achieve Scheduler objectives, and would only develop its own if the market has not already developed an adequate option.

Goal 1

Optimizing Building Energy Systems

Create automated "Schedulers" for offices, homes, and building operators

All proposed Schedulers would share a set of core features, designed to derive insights from a coherent stream of data on building- and neighbourhood-level infrastructure. These insights would build on several initiatives underway in the building controls industry, including the furthering of a standardized naming scheme, the incorporation of external factors, and a shift toward automation.

Standardized naming system.
Today's building data is not standardized or integrated across energy and other operational systems, making it difficult, and often impossible, to collect and analyze real-time information in one place. This isolation can make it difficult for a building management system to determine the most energy-efficient practices.

Take a hypothetical example: a company that leases space on the 19th floor of an office building wants to reduce energy use in its conference rooms by powering off video screens when the room is empty. To do this automatically, a system would need to coordinate information from the audio-video system, the lighting system, and the calendaring system. But since those systems tend to be operated by different vendors, standardizing or integrating this data would be prohibitively time-consuming, costly, and difficult to maintain over time.

Sidewalk Labs proposes to require buildings to adopt a standardized open-data naming scheme called "Brick" that would enable the Schedulers an unprecedented degree of coordination to help achieve building energy goals (see sidebar on Page 317).

Incorporating external factors.
Existing energy management tools for buildings typically cannot adjust their schedules based on external factors, because they lack both real-time access to external information and bi-way communication capabilities. Sidewalk Labs' Schedulers would be designed to consider a range of external factors, including building occupancy, weather forecasts, and energy prices, and to send direction to equipment.

Automating for energy-efficiency.
Existing energy management tools often come with dashboards that present energy data in new ways and are intended to prompt action on the part of users. But even full-time building operators have little hope of making sense of the thousands of data points a commercial and multifamily building collects every minute and presents on a dashboard — let alone residents or office tenants who rarely wish to think about energy management.

Sidewalk Labs' Schedulers would have automated capabilities to optimize a far broader set of variables than tenants or operators can, establish new energy practices, respond more quickly to competing demands, and learn preferences over time.

For example, this type of automation could reduce air conditioning on a summer Friday afternoon when an office is closing early. Or it could open or close window treatments while adjusting the lighting levels to balance light and temperature on a sunny day. Or it could turn off the lights, turn down the air conditioning, and "hibernate" all of the screens and video conferencing equipment in a conference room when a central calendar shows no meeting scheduled.

In addition to these general properties, Schedulers have many features that respond to the unique concerns of a particular user group. These are described in the following pages.

Standardized building data would give Schedulers an unprecedented ability to coordinate energy systems and improve performance.

Data Innovation

A digital "Brick" in the wall

Smart buildings must be able to recognize every last room, hallway, motion sensor, key fob reader, light bank, thermostat, and appliance inside them and to network them together.

Until recently, establishing such a system typically required massive coordination between the building's audio-video, lighting, and IT vendors to connect all these systems to a converged internal network — an expensive and time-consuming process. At best, some building subsystems can "talk" among themselves but not to each other, and never to other buildings.

Hence the development of Brick, a "metadata schema for buildings" created and tested in 2016 by research teams from seven universities or institutions (five American, two European).[18] Brick establishes a standardized naming scheme in which all devices are named by floor, room number, device type, and an index, so that TVs are identified as 19-301-TV-1, 19-302-TV-1, and so forth, while thermostats could be identified as 19-301-TSAT-1 and 19-302-TSAT-1. Such a naming schema allows a computer to understand which room a TV is in and how to control the lights and thermostat in that room to prepare for a presentation.

By using standardized labelling and classification, Brick can itself be automated, making the process far less time-consuming. Brick also allows developers to create applications that make building subsystems work together: suddenly, a building can learn to turn down the heat in a crowded midwinter boardroom before the thermostat rises.

How Schedulers create more energy-efficient buildings

Building Schedulers would manage systems, equipment, and appliances that impact energy use by incorporating real-time data that includes external factors, such as weather, and building system information, such as occupancy levels.

External data sources

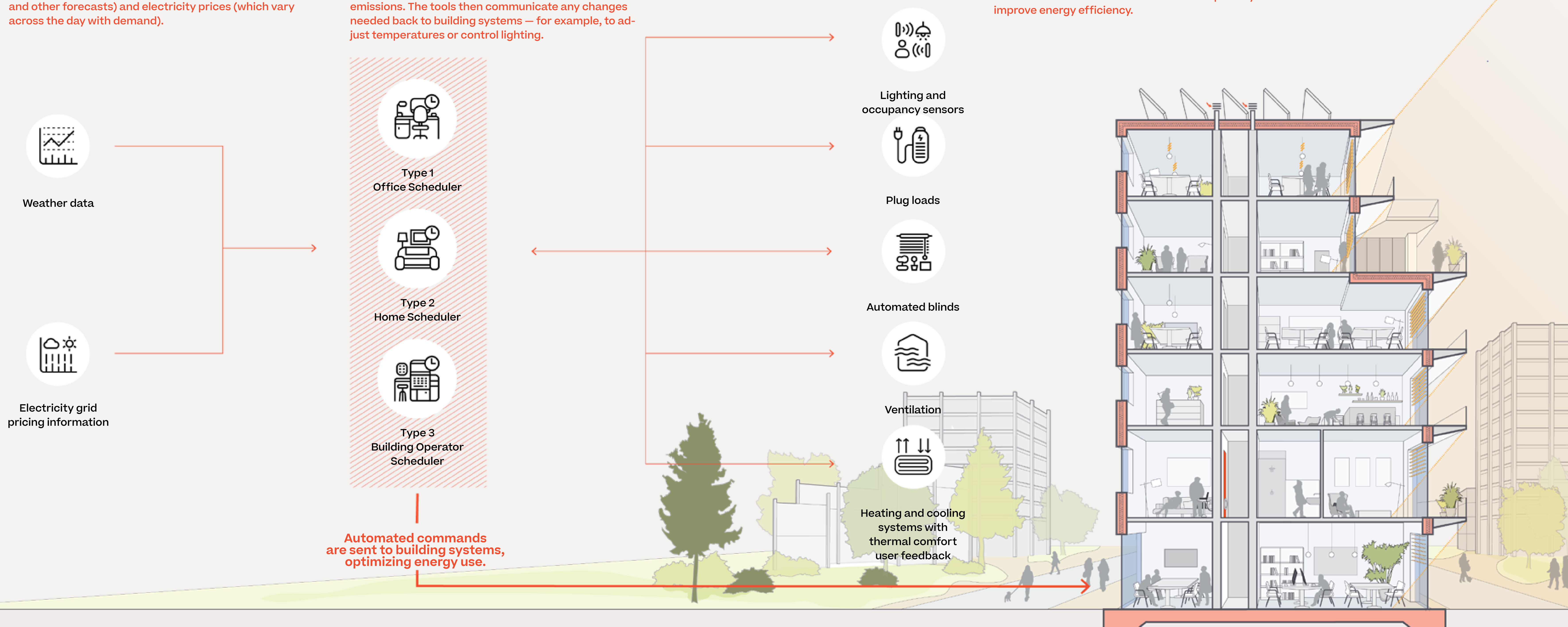
The Schedulers have insight into external data that can impact building energy use, including weather data (such as temperature, precipitation, sunlight, wind, and other forecasts) and electricity prices (which vary across the day with demand).

Building Schedulers

The Schedulers combine information from the external sources with insight into the operations of building systems to optimize energy consumption and reduce GHG emissions. The tools then communicate any changes needed back to building systems — for example, to adjust temperatures or control lighting.

Building systems

Building systems track a variety of real-time metrics about energy use and communicate that information to the Schedulers, including data on occupancy, interior temperature, airflow, and electricity usage. The Schedulers can use this information to help the systems improve energy efficiency.



Scheduler Type 1

Office Scheduler

The Office Scheduler is designed to manage energy use in offices, where no one is really in control of energy systems and thermostats and there are many competing demands.

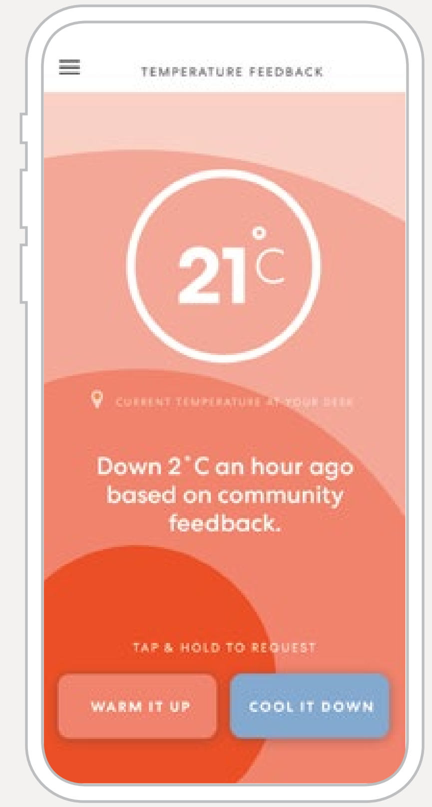
Commercial offices provide a great opportunity for energy savings. A study of commercial buildings in Toronto commissioned by Sidewalk Labs found that the 10 percent of office tenants with the highest energy consumption (on a per square basis) used about three times more than average, and the bottom 10 percent used only a third of the average. In other words, there is a wide range of energy consumption among commercial tenants, and a whole lot of waste at the top.

But today, no one is focused on saving energy in commercial tenant spaces. Existing energy management programs that could optimize thermostats and ventilation systems in commercial spaces are under the control of the building operator — not the tenant. The result is that spaces in many commercial buildings are operated based on default system schedules that do not match the tenant's needs.

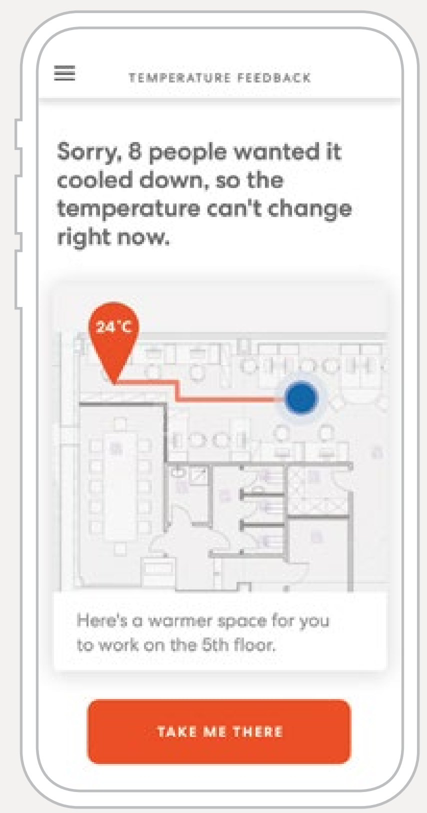
For example, an old lease provision might dictate that a cooling system run on Saturdays, because it was envisioned to be a working day by whichever lawyer drafted the lease, when in fact the office is always empty on weekends — incurring unnecessary costs for the tenant and wasting energy. It is rare for tenants to notice these operational hiccups, and even if they do, the process for updating a setting is complicated. Often it requires communication between office managers (who may not understand the implication of a change or feel empowered to make the decision) and building operators (who may feel similarly disempowered to override a lease).

The Office Scheduler would help tenants manage energy consumption and costs by optimizing all the systems under tenant control, based on factors such as energy prices. Some example capabilities of this tool could include:

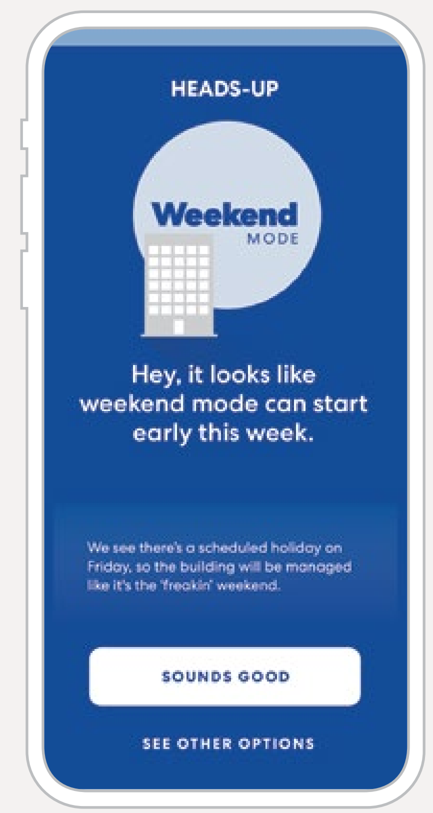
- Adjusting space temperature set points before, during, and after the day, based on insights such as weekly and daily occupancy trends, number of out-of-office calendar notifications, weather during the morning commute, and hot or cold requests throughout the day.
- Detecting what devices are plugged in and hibernating those that would not be needed for a while, based upon usage trends and occupancy.
- Starting up and shutting down heating, cooling, and ventilation devices based on factors such as how long the space takes to heat or cool relative to the outdoor temperature, when the first occupants are likely to arrive that day, and the desired thermostat setting.
- Responding to tenant hot and cold complaints with an explanation of the action taken, and, if no action can be taken because of competing requests from colleagues or system design limitations, identifying what area of the office might be more comfortable and whether there is a free desk or table there.



The Office Scheduler would be responsive to workers' needs, enabling them to provide feedback on things like the temperature of their space.



Tenants could get immediate feedback on a request that they make concerning the conditions in their space, and if their demand cannot be met, they could be guided to a new location where they may be more comfortable.



The Office Scheduler could keep facility managers updated about what is happening (and why) in a space while enabling them to override actions if necessary.

Scheduler Type 2

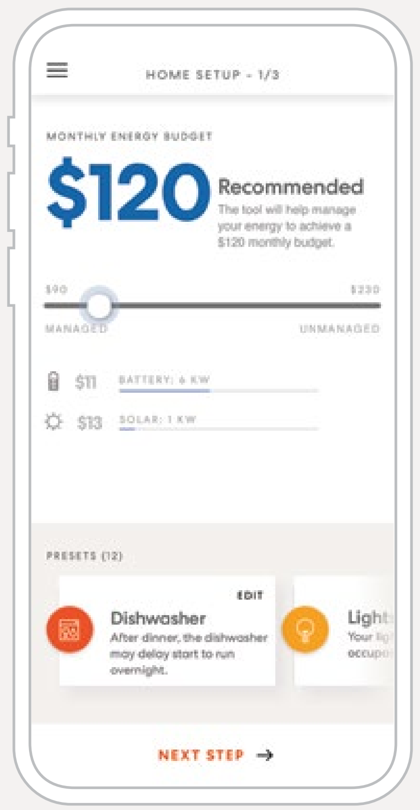
Home Scheduler

The Home Scheduler is designed to help homeowners manage their utility costs to suit their budgets.

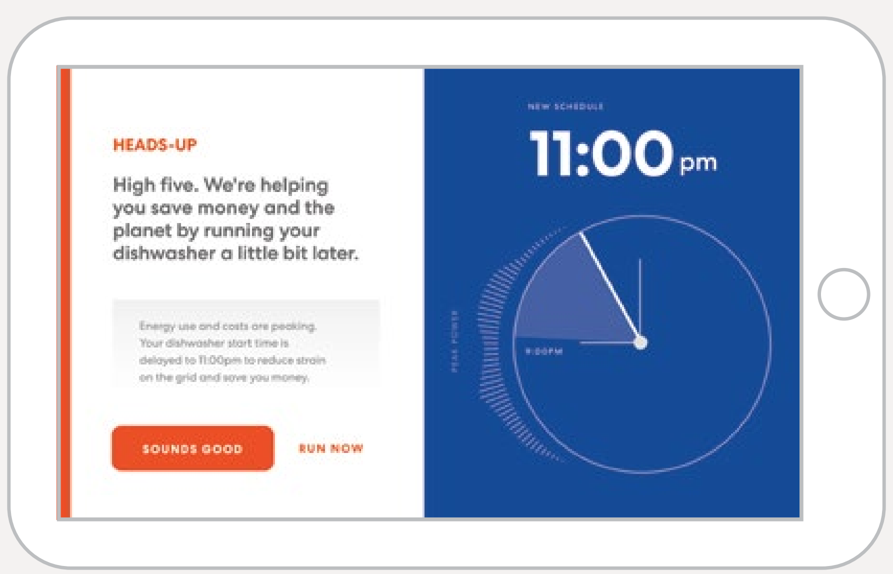
A typical smart home controller can do things like use motion detectors to know when a space is unoccupied and adjust interior temperature accordingly. The proposed Home Scheduler would go beyond these abilities to manage a full spectrum of household energy consumption. The tool could be tied into major appliances and devices that use the majority of the home's most expensive power. It also could have full visibility into the household's energy resources as well as real-time utility rates.

As a result, the Home Scheduler could take a proactive role in managing the home operating systems, devices, and appliances when costs are low or the grid is cleanest (which is usually the same time). The proposed tool would also generate a data feed for households to understand the actions being taken — and to override them, if they wish.

For example, a resident might load the dishwasher, press start, and walk away. Knowing the household's monthly utility budget, the Home Scheduler might automatically delay operation of the dishwasher for a few hours to avoid peak-time power pricing. In that case, the system would then inform the resident, who would have the option to reverse the decision and run the appliance anyway. Over time, the system could learn individual household preferences to reduce settings it recognizes as undesirable. (See Page 330 for more details on innovative bill structures and monthly energy budgets.)



The Home Scheduler would optimize systems to help households stay within their established monthly budget for energy costs.



Scheduler Type 3

Building Operator Scheduler

The Building Operator Scheduler is a tool specifically for building operators, designed to work in tandem with an existing building management system by adding all the automated features mentioned on Page 317.

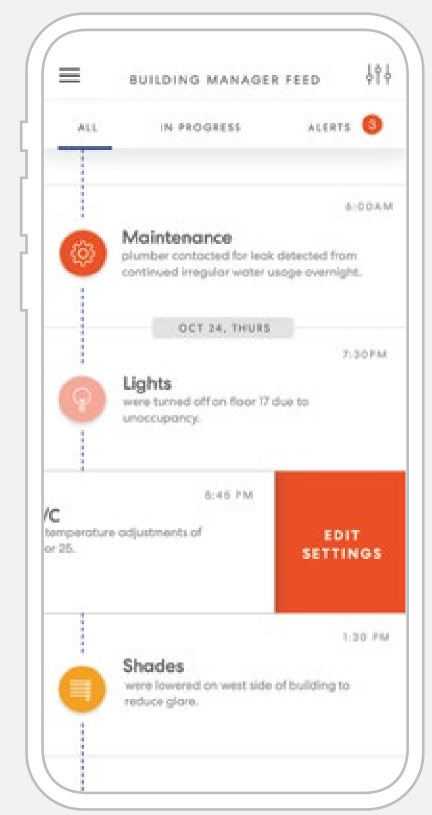
These automated capabilities could free operators from their building management screens, which are cluttered with as many as 100 new system alarms each day — many of which are not urgent but are difficult to distinguish from the important ones. These alarms include notices such as "the outside air fan status has returned to normal."

One of the primary advantages of the Building Operator Scheduler would be its ability to automate ordinary tasks and distinguish real alarms that require the building operator's prompt attention from the numerous alarms that identify irregularities of no consequence. Rather than rigidly adhere to predefined rules, the Building Operator Scheduler would be programmed to learn by adopting beneficial actions from other buildings connected to the system as well as from the actions of other building operators in resolving similar alarms. As a result, many of today's current "alarms" could be screened and addressed before they are brought to the operator. Reducing the alarm load on operators would enable them to focus on things that require more personal attention, like doing preventive maintenance or addressing tenant complaints.

In addition to its broad access to base-building data, the Building Operator Scheduler would use energy more efficiently by soliciting information from the Office and Home Schedulers and would better predict and respond to the needs of tenants in a dynamic and real-time manner.

The broad ability to share building systems data across a neighbourhood of buildings could help communities benefit from operational best practices and lessons learned. This unprecedented degree of sharing could be transformational for the energy performance and operational efficiency of buildings and their staff as well as for the comfort of tenants.

All proposed digital innovations would require approval from the independent Urban Data Trust, described more in the "Digital Innovation" chapter of Volume 2, on Page 374.



The proposed Building Operator Scheduler would provide a continuous feed of its actions to maintain transparency for building operators, but only important actions would be raised for an operator's attention.

Ch–4

Part 3

Making Full Electrification Affordable

Key Goals

1
Design an advanced power grid

2
Implement an innovative “monthly budget” bill target

Low-energy building designs and active energy management systems should help reduce energy demand and energy waste, but they would not eliminate the need for heating, cooling, and electricity. As mentioned at the start of this chapter, Sidewalk Labs’ approach towards reducing GHG emissions and creating a climate-positive community involves going 100 percent electric and establishing a viable path towards creating a community that runs exclusively on carbon-free energy.

In Toronto, as in most cities, residents, workers, and visitors draw power from a main, centralized electricity grid. Strong public policy programs have helped Toronto and Ontario achieve very clean electricity generation that is 90 percent GHG-free.[19] At off-peak times (such as overnight), when few people and businesses are using electrical appliances, this grid can run primarily on clean energy sources, including nuclear, hydro, and renewables.

But at peak times, when electricity demand is high, this grid must use a greater portion of natural gas–generated power to meet the task, increasing the GHG intensity of the grid power supply as a whole. In addition to being the most expensive power to produce (in terms of marginal cost), natural gas–generated power also has 15 times the GHG intensity of the Ontario grid’s current average,[20] so increasing its supply would increase both utility costs for households and businesses and GHG emissions for the community.

Adding to the challenge, the modern electricity grid faces new energy-hungry demands, including electric-vehicle charging and 24/7 access to digital streaming and computing power. To accommodate all these new uses, an electricity company typically would expand the size of its grid, which would increase utility bills as the company seeks to recover its investment.

To accommodate total electrification in the Sidewalk Toronto project area without increasing grid size relative to typical development, Sidewalk Labs plans to collaborate with Toronto Hydro (the public electrical utility) and technology providers to design an advanced power grid. This advanced power grid would go beyond a typical neighbourhood grid connection by integrating a novel “monthly budget” bill target, energy management tools, solar power, and battery storage to reduce the need to draw from the main grid at peak times.

Creating an advanced power grid could reduce GHG emissions by 0.05 annual tonnes per capita.

At the small neighbourhood scale of Quayside, the advanced power grid could help residents and tenants minimize their use of the grid’s most expensive and GHG-intensive power and serve as a proof-of-concept for new utility rates and automated energy management tools. But as mentioned at the start of this chapter, such a system would require a greater scale of development to make economic sense and spread the cost of electric infrastructure among enough households and businesses to keep costs comparable to current utility bills.

Deployed at the full scale of the IDEA District, the advanced power grid could reduce GHG emissions 0.05 annual tonnes per capita (or 0.8 percent) from the city’s current average, while maintaining comparable utility costs. These GHG benefits would be driven by an increased amount of space suitable for solar panels and batteries, specifically large open roofs on buildings in other development boundaries — as identified and volunteered for use by Waterfront Toronto — whose solar panels could feed into the system. Additionally, a greater share of buildings with automated energy systems would optimize loads and push non-urgent usage to off-peak hours.

At that scale, the advanced grid could also set a new paradigm for how utility companies manage and distribute local power, reducing the use of fossil fuels and the need to expand grid infrastructure while still keeping pace with substantial new electrification needs like vehicle charging, heating, and hot water.

Goal 1

Making Full
Electrification Affordable

Design an advanced power grid

Sidewalk Labs' proposed advanced power grid would consist of two connections to the main Toronto electricity grid supplemented by local solar generation and battery storage, as well as by backup biodiesel generators for emergencies. These local options could help the neighbourhood reduce its demand on the larger Toronto power grid, provide clean energy to buildings at periods of high demand, and provide protection against outages.

In recent months, Sidewalk Labs has worked closely with Toronto Hydro to explore potential designs for an advanced power grid with the following capabilities:

- The availability of community-sited solar and batteries that can be priced for customers to purchase shares each month based on supply and demand across the neighbourhood
- The ability to move power from the site on which it was generated or stored to another site with greater demand for it during a larger grid outage
- The ability to disconnect from the larger grid ("islanding") through switching and connections, so on-site energy resources could be fully used during a larger grid outage
- The ability to enhance grid reliability with distributed energy management visibility, control, and coordination into the neighbourhood (often called "behind the meter" insight) through a distributed energy resource management system
- The ability to use energy storage to handle peak usage in lieu of larger capacity (and more expensive) distribution infrastructure
- The ability to allow for greater quantities of intermittent renewable power generation to be installed or imported into the local distribution grid than typically permitted by utilities
- The ability to have a dynamic power rate to better incentivize and reward load shifting and conservation during peak times (see Page 330)

All of these provisions would contribute to the creation of a resilient and affordable all-electric neighbourhood.

An advanced power grid, featuring solar panels and battery storage, could set a new paradigm for locally managing and distributing electricity.

To help reach its energy targets on the path to climate positivity, Sidewalk Labs proposes that all new construction in the project zone be required to participate in this advanced power grid. Based on ongoing discussions, Sidewalk Labs expects that Toronto Hydro would (at a minimum) build and own the wires connecting Quayside to the main electricity grid. Sidewalk Labs plans to issue a request for proposals for a grid operator (which could be Toronto Hydro) to operate the distributed energy resources outlined below.

Solar.
In Quayside, Sidewalk Labs proposes that every tower have a photovoltaic array (solar panels) generating on-site renewable power, with an estimated 40 percent roof coverage. While solar power has extremely low GHG emissions, it is unpredictable: solar panels must receive sunlight to generate power. On a day that is hot and humid but also overcast, the solar panels may not be generating much power, nor would they be generating power after dark. They are also limited by the surface area on a tower.

The expected peak demand of Quayside would be a bit more than 5.4 megawatts. The roofs would support 747 kilowatts of photovoltaic, or solar energy equal to about 14 percent of the total load. At the proposed full scale of the IDEA District, solar energy could cover 19 percent of expected demand (101 megawatts).

Battery.
To help handle peak demands, the advanced power grid would use batteries to store power from the main Toronto grid during overnight hours, when it is relatively cheap and clean due to low demand. This battery power could be consumed during the hours of peak demand when natural gas–fired peaking plants are required and when power is generally the most expensive.

In Quayside, Sidewalk Labs plans to deploy a total of 4 megawatts of battery storage with 4 hours of capacity, totalling 16 megawatt hours of energy. Each battery would range in storage size from 0.25 to 1 megawatt; they would occupy in total 315 square metres of space in and around Quayside buildings. Altogether, the batteries would support about 74 percent of peak load in Quayside and the same share of peak load at the full scale of the IDEA District.

Backup power.
As a general rule, buildings that meet Passive House energy standards maintain habitable temperatures longer than conventional buildings without mechanical heating and cooling. If the main Toronto Hydro grid experiences a disruption, each building in Quayside could continue essential operations (such as domestic water pumping, toilet flushing, emergency lighting and limited cooling through fans) using biodiesel generation located at each building. Three days' worth of biodiesel would be stored on site and supplemental sources would be secured for refilling during an extended outage.

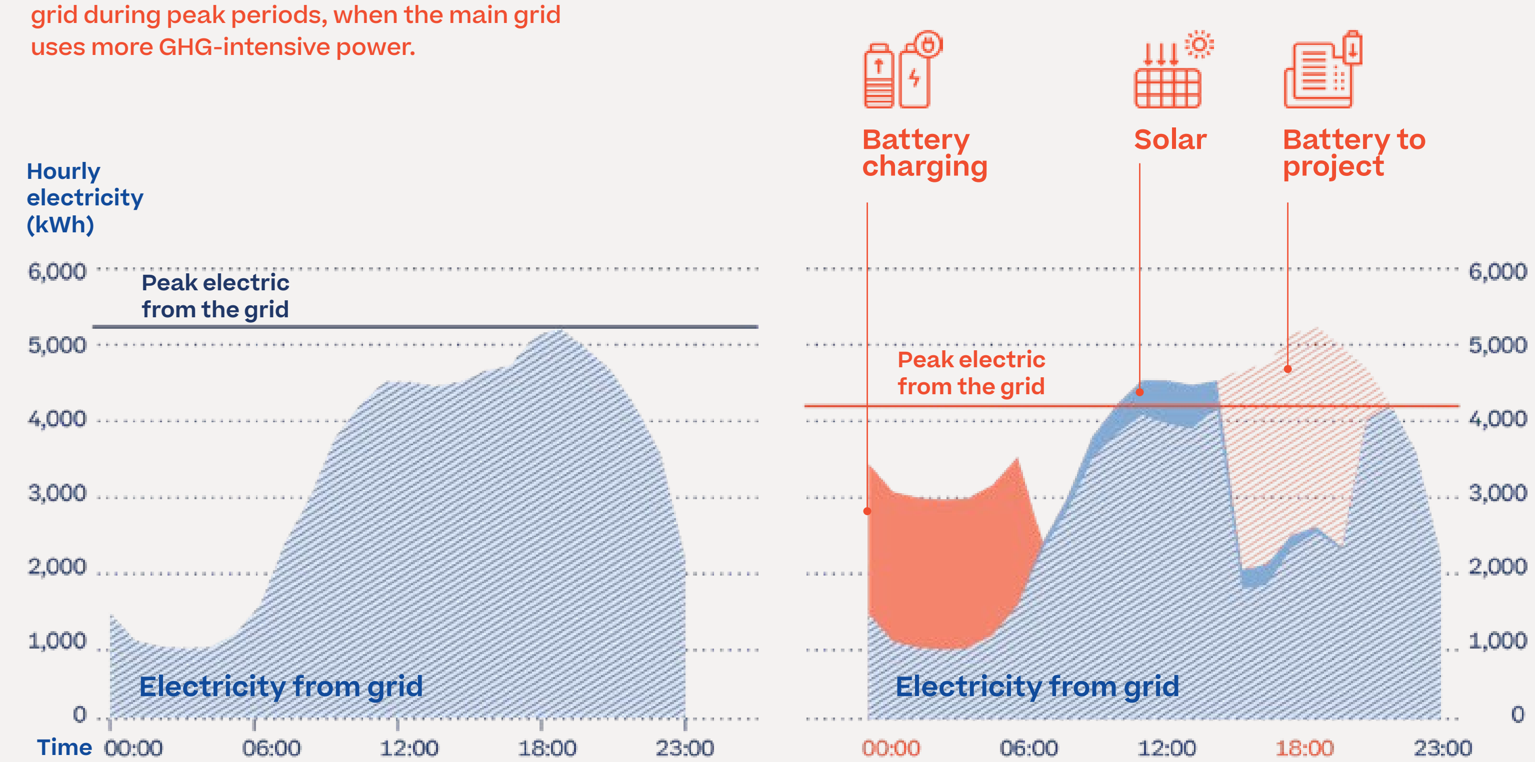
Grid flexibility and control.
To optimize the use of these community-sited energy resources, Sidewalk Labs plans to work with Toronto Hydro to develop and operate an innovative grid design that includes smart connections to solar arrays and batteries as well as switches. Switching would enable the community to be served by one or both of the Toronto Hydro grid connections; it would also enable the community, or portions of it, to disconnect from the main grid in the event of a broader power outage and share use of on-site solar and battery storage among buildings.

The distributed energy resource management system and other tools could allow the grid operator and Toronto Hydro to manage and control the community-sited energy resources and the thermal grid, and send price and other information signals to the building Schedulers to help manage overall community electricity demand, minimizing utility costs for customers and overall GHG emissions.

This approach to grid design and management could enable Toronto Hydro to integrate the operation of distributed energy resources like solar and batteries into its planning and management of the grid as a whole. These tools, together with the innovative utility bill described on Page 330, also would allow Sidewalk Labs and Toronto Hydro to build an advanced power grid that could be smaller than a typical grid — accommodating an all-electric development and changing electricity uses over time without enlarging grid infrastructure.

Reducing peak demand on Toronto's power grid

Solar energy and battery power would enable Quayside to rely less on Toronto's main power grid during peak periods, when the main grid uses more GHG-intensive power.



Without battery and solar, a development needs to draw heavily from the electricity grid during peak hours.

Batteries can be charged overnight, when power from the electricity grid is cleaner and cheaper. This stored energy, along with solar power, can be used to reduce demand on the grid during peak hours.

Goal 2

Implement an innovative "monthly budget" bill target

To enable full electrification in an affordable manner, Sidewalk Labs plans to design an innovative customer bill structure that would give customers the chance to select their budget in advance — just like they do with mobile phone data plans. This bill structure would be designed around the following energy goals:

- Reducing GHG emissions that result from power use at peak times, when fossil fuel generators are operating
- Establishing transparency into rates and energy supply choices
- Creating predictable monthly power costs for customers
- Ensuring that residents who manage their energy can have bills equal or lower than business as usual
- Managing the demand for electricity to reduce the need for infrastructure expansion and to accommodate the electrification of vehicles and heating systems
- Offering customers the ability to own or lease the economic and environmental benefits of community-sited solar and battery

Onboarding tenants and businesses. Sidewalk Labs proposes that when residents or businesses move into a building in the Sidewalk Toronto project area, an onboarding team could help them set their utility budgets based on their energy goals around cost and GHG emissions. This team would explain dynamic power rates as well as the other tools used to help manage monthly budgets: solar capacity, battery capacity, and the Scheduler management tools described on Page 314.

Implementing dynamic rates. In Quayside, Sidewalk Labs proposes that customers pay for electricity through a dynamic hourly rate that is based on the hourly price of electricity in the Ontario market. Costs would be appreciably higher at times of peak demand, when the grid needs natural gas–fired peaking plants, and prices would be much lower off-peak, when the grid has ample nuclear, hydro, and renewables generation to meet demand.

Existing "time-of-use" rates in Ontario are only an approximation of the true cost of generating electricity, since in reality, the price changes hourly in the market based upon the marginal cost of generation (meaning the cost to generate the last electron, based upon the generator that produced it). The goal of the dynamic rate in Quayside is to provide transparency and encourage actions to reduce electricity use during peak hours.

Managing monthly budgets. A combination of Scheduler automation and the availability of shares in the community's solar and battery capacity for purchase would enable residents and businesses to select their preferred monthly bill within a given scale. Selecting an amount at the lower end of the cost scale would result in a high level of intervention from the automated Scheduler tools, which would steer electricity use towards off-peak, low-cost periods in line with the monthly budget.

For example, a dishwasher turned on at 8 p.m. could automatically wait until 2 a.m. to run the wash, when power would be cheaper and cleaner. Customers would always be able to override the scheduler and pay more for utilities that month. Selecting a budget at the upper end of the cost scale would mean less Scheduler control.

The Schedulers could also recommend and facilitate the purchase of shares of the community-sited solar and battery capacity by customers who typically use electricity while the sun is shining or when the batteries would be discharged. Owning (or leasing) shares of these distributed energy resources would provide customers with the same economic and environmental benefits of having them in their home, reducing their use of peak time electricity.

All told, customers would have total control and visibility into their utility costs, choice of power generation sources and storage, and predictable monthly utility bills — without the headache of having to manage all of it.

See the "IDEA District" chapter of Volume 3 for more details on Sidewalk Labs' proposal for a public entity (called the Waterfront Sustainability Association) to oversee rate structures for the advanced power grid.

Innovation case studies

The power of automation to reduce energy bills

In Ontario, since 2014, roughly 90 percent of the province's 4 million residential customers have been buying their energy through an option that includes a three-period time of use rate.[21] Such a rate structure encourages customers to shift energy use, as they are able, from peak times to off-peak times. Under this scheme, customers have reduced their peak demand by as much as 3 percent[22] as part of the province's electricity system transformation, which included reducing its need for fossil fuel–based generation and lowering GHG emissions and costs.

In recent years, a number of other North American utilities have piloted or rolled out similar time-varying power rates — some coupled with automated control tools such as smart thermostats. Studies of these programs have shown that the automation produces larger demand reductions by customers.

For example, in 2013, Baltimore Gas & Electric, a Maryland-based utility, began its Smart Energy Rewards program, which couples rebates for peak demand reductions with smart thermostats, opt-in utility-controlled air conditioner switches, smart appliances, and other energy management tools. Some 80 percent of customers have taken advantage of the rebates, reducing their energy demand by more than 16 percent and saving a combined total of $40 million USD on their utility bills.[23]

In Oklahoma, Oklahoma Gas & Electric initiated a variable peak pricing plan coupled with a smart thermostat. For the approximately 130,000 customers on variable peak pricing, the average peak load has dropped by approximately 40 percent and average bill savings have been as high as 20 percent.[24]

Sidewalk Labs anticipates that all energy needs would be served by the advanced power grid (and the thermal grid described in the next section). As a result, Quayside residents and businesses would not need gas accounts, which can average $30 to $150 a month depending on the season. Although electricity costs more than gas in Toronto, average customers should have utility bills comparable to those of households or businesses in a typical Toronto neighbourhood, with much cleaner energy consumption.

This proposed integrated power plan would cover the majority of commercial and household electricity costs, but not all of them. For example, electric vehicle charging could have a different pricing structure for residential and commercial customers to account for the parking space that the car is taking up while charging and to strongly discourage full charging at times of peak demand.

Residents and businesses would be able to set monthly energy budgets and receive clear utility bills that identify power sources and associated costs. (Bill shown here for illustrative purposes only.)

Resident Utility Bill

On Budget!
You have selected a budget of $150
Your total cost this month is **$143.91**

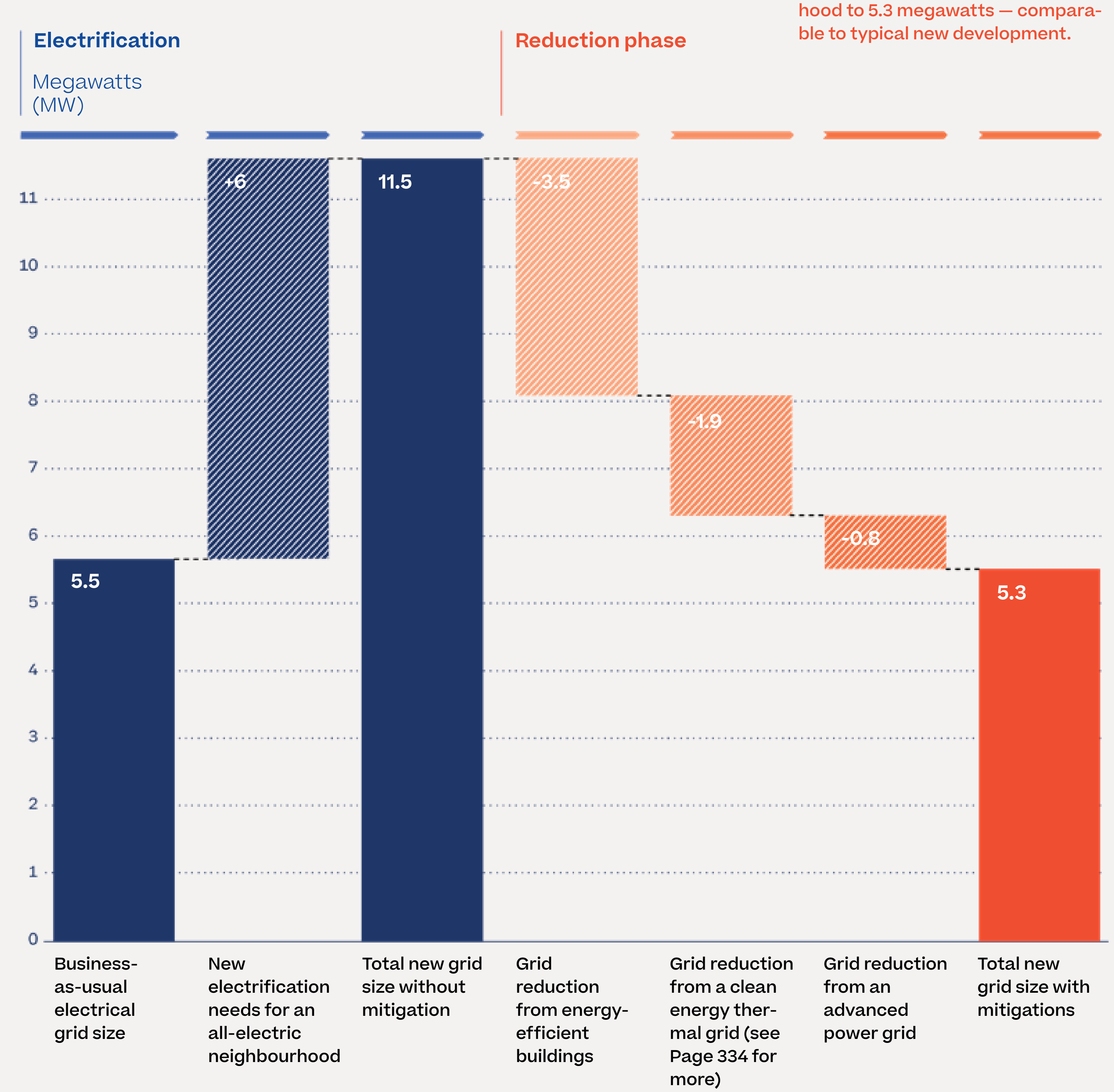
Electricity	$84.67
Thermal Energy Heating, cooling, and domestic hot water	$44.65
Community-sited Solar **0.23 kW** (**$13.17**/kw/month) Your solar shares avoided 1.4 kg of GHG emissions this month.	$3.03
Community-sited Battery **5.61 kW** (at **$1.87**/kw/month) Your battery shares avoided 1.9 kg of GHG emissions this month.	$10.48
Advanced Energy Grid Rebate **$3.44** savings was from your solar capacity **$41.59** savings was from you battery capacity	-$45.03
Thermal Grid Capacity Charge	$41.11

Amount due
$143.91

Achieving affordable electrification without a larger grid

A typical new development would require a power grid of 5.5 megawatts. An all-electric neighbourhood requires electrifying new things like vehicles and heat pumps. Unless mitigated, these additional uses would increase the size of the grid to 11.5 megawatts.

Sidewalk Labs proposes to mitigate the size of that grid while still serving these new electricity demands through efficient building envelopes, a thermal energy grid, and an advanced power grid. Together, these initiatives reduce the grid size necessary to serve the neighbourhood to 5.3 megawatts — comparable to typical new development.



Ch–4

Part 4

Using Clean Energy to Heat and Cool Buildings

Key Goals

1
Design a thermal grid to distribute clean energy

2
Capture building "waste" heat, geothermal energy, wastewater heat, and other clean energy source

A combination of low-energy buildings and active energy management systems would dramatically reduce the need for heating and cooling, but these efforts alone cannot eliminate that need, especially in a cold-weather climate like that of Toronto. Weather aside, neighbourhoods with a mix of residential and commercial spaces need heating and cooling year-round: residents take hot showers even on the hottest days, and many businesses with lots of computers or on-site fabrication and light manufacturing equipment run air conditioning even on the coldest days.

A handful of cities have long tried to meet some of their heating, cooling, and hot water needs more efficiently by using district-wide energy systems. Very early district energy systems, dating back to the 19th century, burned fossil fuels like coal to boil water in centralized plants to produce steam for heating buildings.[25] Today, a handful of innovative systems aim to tap clean energy sources; for example, Toronto itself uses water drawn from Lake Ontario to help cool about 60 buildings downtown.[26]

But even new district-energy systems face challenges at both the neighbourhood and building levels when trying to reduce or eliminate their reliance on fossil fuels.

Often the systems cannot access sufficient clean energy (in a financially viable manner) to meet peak heating and cooling demands, like in the dead of winter. District energy systems that use a central heat generation plant typically pipe their energy a long way to buildings and back to the plant again, leading to heat losses along the way. Traditional building construction requires substantial heating, which warrants high-temperature water, but high-temp systems cannot make use of available "low grade" (not very hot) clean heat sources, such as wastewater heat.[27]

To deliver heating and cooling to residents and businesses without using fossil fuels, Sidewalk Labs proposes to deploy a type of district energy system called a thermal grid, designed to help realize full electrification in an affordable way and to achieve a climate-positive community.

The proposed thermal grid provides buildings with clean sources of heat energy through a network of water pipes (or loops). Electric heat pumps can use heat energy from these loops to provide tenants with heating or domestic hot water, or the pumps can reject heat energy into these loops to provide cooling. The thermal grid is designed as a zero-fossil fuel system that relies on clean energy from a variety of sources, including geothermal (underground) energy, building waste (or excess) heat, and wastewater (sewage) heat.

The thermal grid has two core design features that help improve its efficiency. One is its distributed network of water-pipe loops at the building, site, and neighbourhood levels, which creates more flexibility in growing the system over time by adding new thermal energy sources. The other is its ambient (or low) temperature water loop, which reduces heat losses through the pipe network, thereby enabling the grid to rely on a wide variety of clean energy sources that might otherwise go untapped.

The thermal grid could reduce GHG emissions by 1.58 annual tonnes per capita.

When exploring the potential for such a thermal grid, Sidewalk Labs took scale into account from the start for three key reasons.

First, such a system would be prohibitively expensive to create without scale, because a five-hectare neighbourhood provides limited opportunity to spread the cost of the upfront investment required to develop, operate, and maintain a large infrastructure system while keeping costs affordable to customers. Second, a thermal grid needs to be able to grow with development and serve new buildings and neighbourhoods as they are constructed and as new energy sources become available. And third, the full scale of the IDEA District creates the potential to tap into clean energy sources that can be exported to other parts of the city — thus fulfilling Waterfront Toronto's objectives for a climate-positive community.

Deployed across the proposed full scale of the IDEA District, the thermal grid could recover its costs across dozens of development sites and tap into multiple large energy resources in and adjacent to the IDEA District. This approach would reduce the community's GHG emissions by 1.58 annual tonnes per capita (or 25.1 percent) from the city's current average.

And if the thermal grid were to be extended to Ashbridges Bay Wastewater Treatment Plant on the eastern edge of the Port Lands, it could secure enough energy to export to existing (and planned) developments in the eastern waterfront, removing carbon from the environment in these areas. With 170 megawatts of energy potential, Ashbridges alone could heat up to 85,000 homes.[28]

A thermal grid would deliver heating and cooling to residents and businesses without using fossil fuels.

Goal 1

Design a "thermal grid" to distribute clean energy

Key Term
Heat exchanger
Devices that separate the thermal grid's building, site, and neighbourhood loops. Heat exchangers enable these loops to transfer heat energy, as needed, across metal plates.

Key Term
Heat pump
Electric devices that serve as primary means of controlling the temperature of hot and cold water loops in buildings.

Canada is home to some of the most innovative district energy systems in the world, as exemplified by Toronto's deep lake cooling system. To build on this foundation while exploring a thermal grid concept, Sidewalk Labs paired the experience of Kerr Wood Leidal, a Vancouver-based district energy design firm, with the research excellence of Lawrence Berkeley National Laboratory, a U.S. national research lab. The goal was to provide Toronto with new heating and cooling approaches that could be pursued in developments across the city.

For Quayside, the initial design under serious study (although not yet finalized) is — in technical terms — a two-pipe, ambient-temperature, water-source system. In simpler terms, the thermal grid consists of a network of water pipes that circulate heat energy across the building, site, and neighbourhood levels. These pipe loops can transfer energy to one another through "heat exchangers," or devices that enable heat to cross into a new pipe without losing energy.

These separate loops provide several advantages over a single pipe network. They enable the thermal grid to conserve energy, by reducing the need to carry a single heat source long distances. They enable multiple buildings to exchange thermal energy, which is important in mixed-use developments that have simultaneous heating and cooling demands. And they enable the grid to tap a wider variety of clean energy sources across a greater geography.

Electric heat pumps in buildings can draw energy from a warm pipe or reject energy into a cool pipe as needed for space heating, space cooling, and domestic hot water. It is the heat pumps that provide the temperature control for the whole system — they are the "brains" of the thermal grid. Sidewalk Labs' initial designs include heat pumps at the site level (to provide appropriate space heating/cooling water temperatures and share energy between buildings) as well as at the building level (to raise the water temperature enough for domestic hot water).

The sections that follow describe the thermal grid's core infrastructure in greater detail.

Building loops would heat and cool residential and commercial spaces by circulating through radiant ceiling panels.

Building loop.
The proposed thermal grid would begin in the buildings, with each building having its own loops of hot and cold water. These building loops would heat and cool residential and commercial spaces by circulating conditioned water through radiant ceiling panels.

For domestic hot water uses that require even higher temperatures (60 degrees Celsius), such as showers, small electric heat pumps in the buildings would provide an extra boost. (Additional heat could be extracted from each building's sewage lines using these heat pumps.)

Site loop.
The thermal grid's second loop would exist at the site level to circulate hot and chilled water to multiple buildings, connecting into the individual building loops via heat exchangers. Heat pumps located at the site-level would get the water in the site loops to their desired temperature (around 45 degrees Celsius for the hot loop, and around 5 degrees for the chilled loop). During off-peak seasons, these temperatures could be adjusted to reduce heat losses and thus reduce the amount of work required by the heat pumps to reach the desired temperature.

Each site plant would use a geothermal field to exchange thermal energy with the ground. These geothermal fields would act much like big thermal batteries. On a cold day, the ground remains warmer than the outside air, enabling site-level heat pumps to draw thermal energy from wells in the fields; on a warm day, the ground is cooler than the outside air, enabling the pumps to deposit heat into the ground. The bedrock beneath Quayside has excellent thermal properties for geothermal heat exchange.

The buildings connected via the site loops could share energy as necessary. In many cases, the simultaneous heating and cooling needs across these buildings would be sufficient to meet energy demands.

Neighbourhood loop.
The thermal grid's neighbourhood loop would connect all of the site plants and allow for the transfer of energy among sites. For scenarios where site-level energy sources proved insufficient, the site heat pump plants could extract or deposit heat into the larger neighbourhood loop via heat exchangers. In some cases, one site would be depositing heat into the neighbourhood loop that another site could use.

The neighbourhood loop would transport heat from a variety of clean energy sources at an ambient temperature (a max of 32 degrees Celsius in cooling season and a minimum of 12 degrees in heating season). The neighbourhood loop also would connect the sites to other clean energy sources (such as industrial waste heat or data centres) and could tie into adjacent neighbourhood district energy systems, which may have complementary heating and cooling demands.

Finally, the neighbourhood loop would have a shared balancing plant to control the movement of heat through the neighbourhood. If the neighbourhood loop had more energy than any site needed — for example, in the peak of summer — the excess would be exhausted via a cooling tower. Connections for a roll-up temporary boiler would be available for emergency backup needs.

The system's two most innovative features are its distributed infrastructure and its ambient temperature loop.

Distributed infrastructure.
Some district energy systems heat or chill water in a single central plant before piping it back out to sites and buildings, requiring the water to travel long distances and thus causing it to lose some of its thermal energy prior to reaching the building. Further, if the building does not need the heat, the water is returned in a continuous loop, requiring more energy for pumping. Such a system must also be sized at the master planning stage, making it hard to expand with new development.

In Quayside, Sidewalk Labs plans for each site of buildings to have a mini plant tied into a geothermal field and for excess geothermal capacity to be shared among the sites through the neighbourhood's thermal grid. At a full scale of the IDEA District, the thermal grid could be expanded and tied into new site plants, other neighbourhoods, or additional heat sinks and sources like the Cherry Street sewage pumping station and waste heat from Enwave's deep lake cooling system.

Ambient temperature.
The other major advance of this design is its ability to go fossil fuel–free by using ambient temperature. This approach enables the system to leverage low-grade heat sources that would be considered too cool to be heat sources for a high-temperature hot water system.

In short, the idea behind ambient temperature water loops is to capture as many sources of heat as possible, and the idea behind the distributed system is to get these sources where they need to be with as little loss of energy as possible.

The flexibility of this system enables the grid design to change as the development materializes. For example, if Sidewalk Labs becomes able to tap into a new fossil fuel–free source of energy (or into neighbourhoods with complementary energy loads), it might reduce or eliminate the energy sources from the design that are very expensive, such as geothermal, without any impact on the greater system.

Integration with the advanced power grid.
To enable optimal energy and utility cost management, Sidewalk Labs proposes to combine the active energy management capabilities of the power and thermal grids, and to bill customers from a single utility.

This approach stands in contrast to the separation of gas and electric services that is the model in Toronto (and other cities) today. But it also recognizes that, in an all-electric development, thermal energy systems would become a major user of electricity and something that the grid operator (responsible for managing the neighbourhood's peak electrical demand) should be able to control and optimize in concert with other electrical loads. The thermal grid could even become a resource for generating and storing thermal energy when electricity costs are low and could be used later when electricity prices are high.

As is the case for its management of power, Sidewalk Labs plans to use the Office, Home, and Building Operator Schedulers to manage thermal energy consumption and costs for residents and businesses. The proposed Schedulers would play a critical role in allocating the cost of domestic hot water, heating, and cooling to customers. For example, in summer, a hot shower might effectively operate on "free" heat energy, by drawing on the heat rejected by air conditioning. But in winter, a hot shower might contribute to a peak-period heat demand that should account for the real-time cost to generate that heat. The intent of such pricing is to create transparency around the true cost of energy generation and delivery, which would change based upon the competing or complementary heating and cooling demands of other tenants in the neighbourhood.

Sidewalk Labs plans to issue a request for proposals to design and develop (or co-develop) the thermal grid and anticipates responses from leaders in the field, such as Enwave and Creative Energy, or an established utility in Toronto with a growing geothermal business, such as Enbridge.

Ongoing design exploration.
As part of its ongoing consideration into how best to achieve climate positivity, Sidewalk Labs plans to explore alternative thermal grid solutions to those proposed in the MIDP before selecting a final design. Specifically, Sidewalk Labs plans to evaluate alternatives in the hopes of finding systems with equivalent core performance while achieving even better performance in terms of embodied energy, ozone depletion, and lifecycle costs.

Capture building "waste" heat, geothermal energy, wastewater heat, and other clean energy sources

To start, the proposed thermal grid would incorporate at least three primary types of clean energy sources: on-site and off-site building waste heat, on-site geothermal heat, and off-site wastewater heat recovery. The system would also be designed to accept off-site industrial waste heat (such as heat rejected by data centres, local manufacturing, and power generation plants) to help reduce costs.

Building waste heat (on-site and off-site).
Buildings generate all sorts of heat throughout the day. This heat comes from the equipment and appliances residents and tenants use, such as computers and television screens, as well as from hot showers.

Sidewalk Labs plans to capture and repurpose building waste heat to provide energy for heating and domestic hot water systems. For example, buildings would use heat recovered from their own wastewater systems to pre-heat domestic hot water, reducing the amount of energy needed by the building's heat pump to increase the temperature further.

At the full scale of the IDEA District, Sidewalk Labs estimates that, given its proposed mix of residential and commercial uses within buildings, 27 percent of the cooling and 31 percent of the heating would happen simultaneously.[29] This usage would enable waste heat captured from one space in a building (such as a server room) to be used to heat another space in the same site (such as an apartment), once transferred through the site's heat pump plant.

If the site has excess heat, it could be transferred to other sites to heat buildings or help generate domestic hot water. It could also be stored in the site's geothermal wells for use when it becomes colder. Finally, it could be exhausted through a shared neighbourhood cooling tower plant.

An off-site source of building waste heat could be available from the "chilled water return loop" operated by Enwave Energy Corporation, which provides hot and chilled water to many downtown Toronto buildings. Enwave has a sizable portion of customers who require air conditioning even during the winter, and the waste heat extracted by these buildings would be enough to meet the supplemental heating requirements of development in Villiers Island, if tapped for Sidewalk Labs' proposed thermal grid.

Geothermal (on-site).
In many ways, the earth is like a big underground battery that stores up energy. The ground is normally 10 degrees Celsius, which means it is warmer than a cold day but cooler than a hot day. Sidewalk Labs' proposed thermal grid would capture this geothermal energy via underground wells — sometimes called "geoexchange" — and use it to extract heat during the winter and store heat during the summer. Geothermal wells are good at providing heat on a cold day and extracting heat on a hot day.

The amount of building heating and cooling that could be supported by geothermal wells depends on the amount of available and suitable space located beneath buildings or in parks and open spaces. It also depends on the availability of significant upfront investment capital, as geothermal is high cost. In Quayside, Sidewalk Labs expects to serve most of the development's heating and cooling loads with 0.5 hectares of geothermal field space that would be located beneath the development parcels, as well as parts of Silo Park.

For all its benefits in a small neighbourhood like Quayside, geothermal energy is very expensive to harness, and therefore would not serve as a scalable clean energy source across a significant development area of the IDEA District. Geothermal energy could be used strategically in later phases of development, but as a secondary option to avoid fossil fuels.

Industrial waste heat (off-site).
Commercial and industrial processes can also generate enormous amounts of waste heat that have the potential to serve as yet another source of clean energy for a thermal grid. Sidewalk Labs has initiated explorations into accessing the waste heat of a data centre near Quayside, where computer servers generate considerable heat year-round. Another potential energy source is the Portlands Energy Centre, an electrical generating station near the Hearn in the lower Port Lands area.

Due to the flexible and expandable design of the proposed thermal grid, new sources of energy can be connected in as they become available.

Wastewater heat recovery (off-site).
All the wastewater flushed down dishwashers, shower drains, and toilets travels through sewers at just below 15 degrees Celsius in winter and 25 degrees in summer. As is the case with geothermal energy, this moderate temperature makes sewers good potential sources of heat on a cold day and good potential "sinks" of heat on a hot day.

Sidewalk Labs' proposed thermal grid could use this wastewater energy to help heat up or cool down buildings in an odour-free and sanitary way. As mentioned, wastewater within buildings could be recaptured to pre-heat domestic hot water. But Toronto's waterfront is home to broader sources of wastewater energy that could tie into the neighbourhood loop: the Cherry Street Sewage Pump Station and the Ashbridges Bay Wastewater Treatment Plant.

The Cherry Street Sewage Pump Station has the capacity to add pumping equipment for heat recovery purposes right at Lake Shore Boulevard and Cherry Street, near Keating Channel. The size and location of this pumping station would make it an excellent heat source and sink for a development expansion from Quayside further east along the waterfront.

Planning process

Why biomass is not an initial thermal grid source

Sidewalk Labs explored the use of biomass (such as wood pellets and solid waste) for its thermal grid, but ultimately determined it was not a good fit. Broadly speaking, the process of burning biomass fuel sources creates high-temperature heat that cannot be efficiently integrated with the low-temperature waste heat captured from Toronto's geothermal and sewer water sources. Individually, the sources of biomass each had challenges that offset their potential:

- Biosolids generally have a high ash and nitrogen content, which can create challenges in managing air emissions.
- Wood pellets are highly processed, which increases their GHG intensity and their environmental cost.[30]
- Existing natural gas demand that could be served instead with biogas well exceeds the potential for commercial biogas production, so biogas is not an ideal climate-positive solution for new development.

For all these reasons, Sidewalk Labs did not select biomass fuels as the preferred source of low-carbon heating.

Tapping wastewater energy to realize climate positivity. Sidewalk Labs' proposed thermal grid could supply energy needs to Quayside and other parts of the IDEA District without the enormous supply of sewer heat that is available from the Ashbridges Bay Wastewater Treatment Plant, the second-largest secondary wastewater treatment plant in Canada, with a service population of roughly 1.5 million people. But this source is important to consider tapping for its potential to remove carbon from the environment in other parts of Toronto.

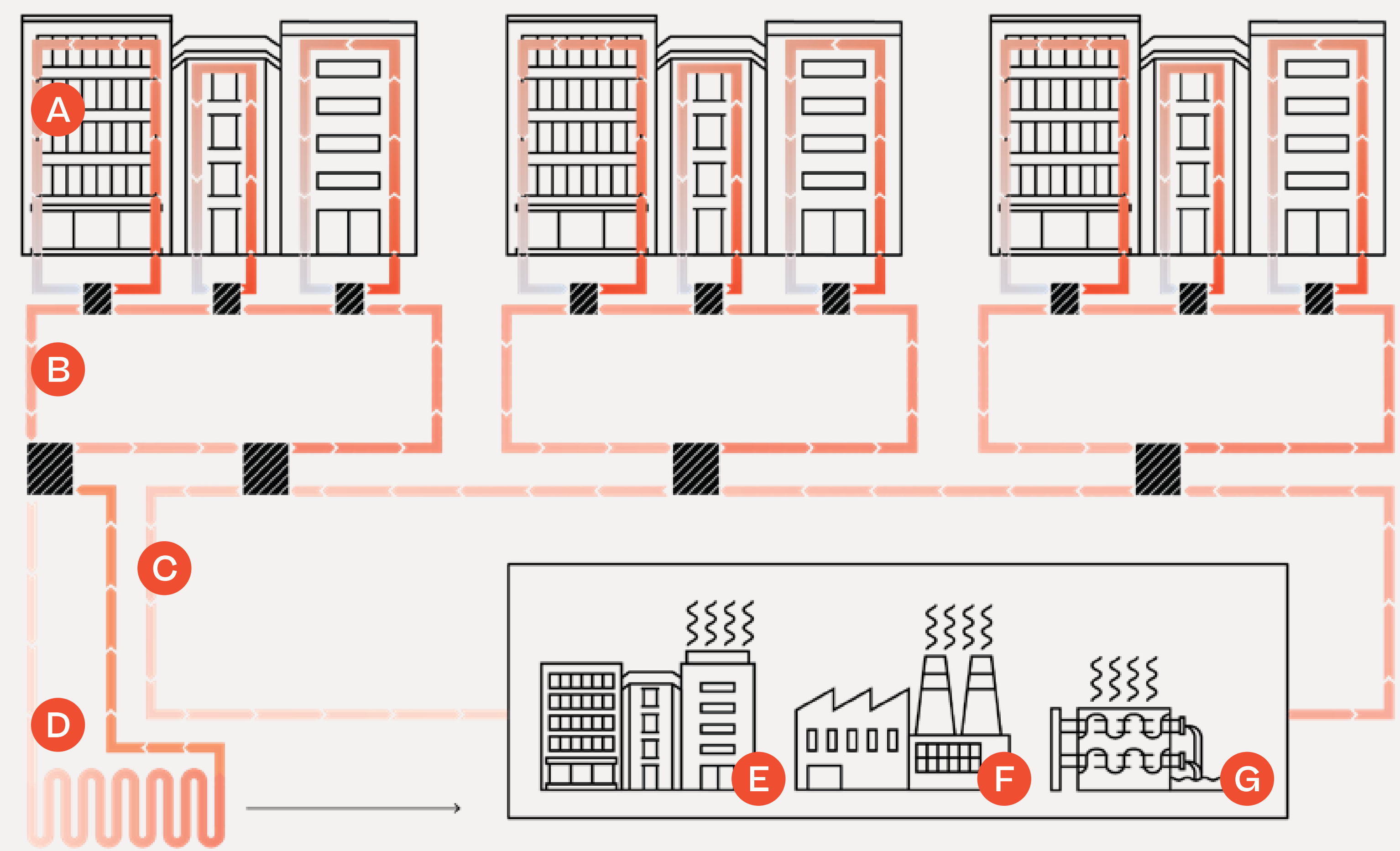
Located within 2 kilometres of the Port Lands, the Ashbridges Bay plant is in continuous operation, meaning it can provide a steady source of heat from treated (or "cleaned") sewage year-round. With an enormous 150 to 200 megawatts of thermal energy potential, Ashbridges alone contains enough thermal energy to heat some 35 Quaysides. At that scale, Ashbridges would be among the largest sewer heat recovery projects in the world.[31]

Tapping this source, with support of the city, would enable the Sidewalk Toronto project to go from meeting its energy needs to offering a clean source of energy to surrounding neighbourhoods, thereby achieving ts climate-positive ambitions.

Ashbridges would be among the largest sewer heat recovery projects in the world.

Explainer: How the thermal grid works

The thermal grid's flexible design uses three loops to exchange energy across a network of buildings and clean energy sources, including geothermal, building waste heat, industrial heat, and wastewater heat.



Distributed Infrastructure

- A Building loop
- B Site loop
- C Neighbourhood loop
- D Geothermal
- E Building waste heat
- F Industrial waste heat
- G Wastewater heat recovery

Ambient temperature

Heat exchanger

Note: Loop reverses direction in summer.

Ch–4

Part 5

Reducing Waste and Improving Recycling

Key Goals

1
Improve waste sorting through responsive digital signage

2
Implement “pay-as-you-throw” smart waste chutes

3
Reduce contamination during removal with vacuum tubes

4
Convert organic waste into clean energy

Reducing GHG emissions is not just about consuming less energy associated with heating, cooling, or electricity. It is also about wasting less and diverting recyclable (glass, metal plastic, paper, and cardboard) and organic (food) materials from landfills, where their decomposition has a significant climate impact. For example, food waste that ends up in a landfill produces methane, a GHG 25 times more potent than carbon dioxide.[32]

Toronto’s 2016 solid waste management plan sets a citywide waste reduction target of diverting 70 percent of recyclables and organics from landfill waste by 2026.[33] But mid- and high-rise buildings along the waterfront and downtown have a long way to go to achieve those targets. Multifamily buildings currently divert only 27 percent,[34] and commercial buildings do even worse, at 13 to 19 percent.[35]

The biggest challenge to achieving that diversion rate is what waste experts call “source separation” — making sure that recyclables and organics go into separate containers from the very start and that they stay separated throughout the entire waste removal process. Source separation is essential to reduce the contamination that undermines recycling efforts; for example, paper cannot be recycled unless it is very clean.

Sidewalk Labs proposes to integrate a series of technological, policy, and infrastructure advances to exceed Toronto’s goals for landfill diversion and to demonstrate an innovative path forward for neighbourhood waste. This plan would involve using digital signage to communicate proper sorting practices, deploying “smart” trash chutes in buildings to separate waste and allocate cost fairly by waste stream, and conveying waste to a centralized location through underground tubes to reduce contamination. Finally, this process would incorporate anaerobic digestion, a process in which organic waste is turned into a slurry and digested by microorganisms that dispel biogas, a form of clean energy.

A smart disposal chain could reduce GHG emissions by 1.08 annual tonnes per capita.

In Quayside, this plan could build on the City of Toronto’s long-term diversion rate of 70 percent and result in a landfill diversion rate of 80 percent. Some multi-family residences in Toronto have already achieved such rates through tenant education and operations. As an added benefit, this plan would dramatically reduce the amount of garbage truck traffic on neighbourhood streets by centralizing waste pick-up.

Applied at the full scale of the IDEA District, Sidewalk Labs’ approach to waste sorting could reduce GHG emissions by 1.08 annual tonnes per capita (or 17.1 percent) from the city’s current average, largely thanks to anaerobic digestion, which controls the release of GHGs for beneficial use instead of emitting it into the atmosphere.[36]

Sidewalk Labs pilot

Using data to improve recycling habits

Much of the contamination of waste streams is believed to be the result of “wish cycling,” in which customers assume that certain materials (such as a bio-plastic container or a coffee cup) are compostable or recyclable, when in fact they are not. These are not unreasonable assumptions, and they can only be corrected with direct feedback. But such feedback is difficult to provide to tenants in multifamily buildings.

Sidewalk Labs plans to conduct a pilot prior to any Quayside development to study how well building residents respond to feedback about their waste sorting behavior, with the goal of helping people recognize the complicated dos and don’ts of correct sorting, and ultimately improve their recycling practices.

For the proposed pilot, the trash, recycling, and organic waste streams of three multifamily buildings in Toronto would be collected by a hauler and brought to the Canada Fibers materials recovery facility. Canada Fibers conducts ongoing waste audits for Toronto, as a regular waste tracking service.

In a conventional waste audit, workers at a recovery facility perform a contamination analysis of waste by categorizing it by hand. For the pilot, the waste would be placed along a conveyor belt and classified by computer vision sensors trained to identify materials and contamination, developed by AMP Robotics.

Continued on Page 347

Goal 1

Reducing Waste
and Improving Recycling

Improve waste sorting through responsive digital signage

There is no way around it: recycling correctly is hard. Even the most environmentally-aware person has reasonable questions standing in front of several different waste bins:

"Should I put this bio-plastic container in the organics bin?" *(No, put in the trash. Anaerobic digester preprocessing facilities cannot discern between bio and polymer plastics, and the container will be presorted and sent to landfill.)*

"Do I really need to rinse this honey jar to recycle it?" *(Yes!)*

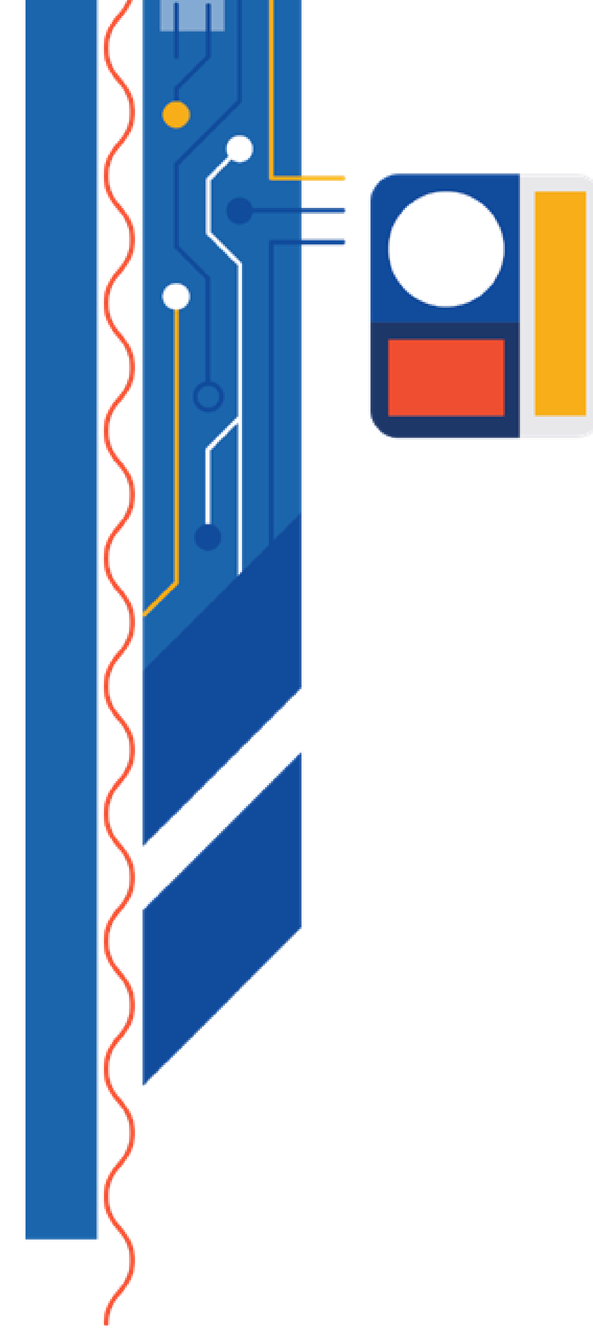
"Can I recycle this plastic garden hose?" *(Not in Toronto. Hoses often get caught in recycling machinery, occasionally leading to facility shutdowns.)*

To make matters yet more complicated, recycling rules often vary by municipality, neighbourhood, even home and office, meaning the right bin somewhere might not be the right bin somewhere else. And while many great online resources exist — including Toronto's Waste Wizard app, which tells building tenants which types of waste go where — office tenants have to seek out that information themselves.

Sidewalk Labs plans to tackle this challenge by meeting people right at the source of the problem — the building trash room — using dynamic signage to illustrate common sorting mistakes and explain their impact on waste-reduction goals. These digital signage campaigns could be informed by real-time waste characterization data communicated from a materials recovery facility (which sorts recyclable materials) or a recycling processor (which turns sorted recyclables into materials that can be resold).

The City of Toronto currently conducts ongoing waste audits to get a sense of current landfill diversion rates, but these audits are labour-intensive and expensive, and make up only a small sample of the city's overall waste practices. Sidewalk Labs proposes to automate these audits (sometimes called "waste characterization studies") using computer vision software developed by a company called AMP Robotics. (Sidewalk Labs is an investor in AMP.) Designed to be installed on waste conveyor belts in material recovery facilities, this software could classify waste and identify common recycling mistakes over time (see sidebar).

For example, the waste software might identify an increased rate of attempts to recycle to-go coffee cups, which are lined with polyethylenes that contaminate the recycling stream. This trend could then inform a digital signage campaign to encourage tenants to put these cups into the landfill trash chute — or better yet, to use a reusable cup! As an added



bonus, this real-time understanding of waste trends could help the city work with manufacturers to reduce or redesign problematic products, an effort that is consistent with the 2016 Waste Free Ontario Act.[37]

Additionally, digital signage could inform building tenants about city waste programs such as trash donations, mobile drop-off deposits, and clothing collections. These signs could also be used to display the pending disposal of specialty items like old appliances or furniture that other residents of the building or the neighbourhood might want to take.

Continued from Page 345

Over the course of three months, signage showing the week's waste diversion percentage and most common recycling mistakes would be posted to provide residents with feedback on their recycling effectiveness, based on the building's aggregate waste practices.

Residents who volunteer to have their waste bags individually audited and analyzed would receive personalized feedback on recycling effectiveness, but in general, the feedback would be delivered at an aggregate building level.

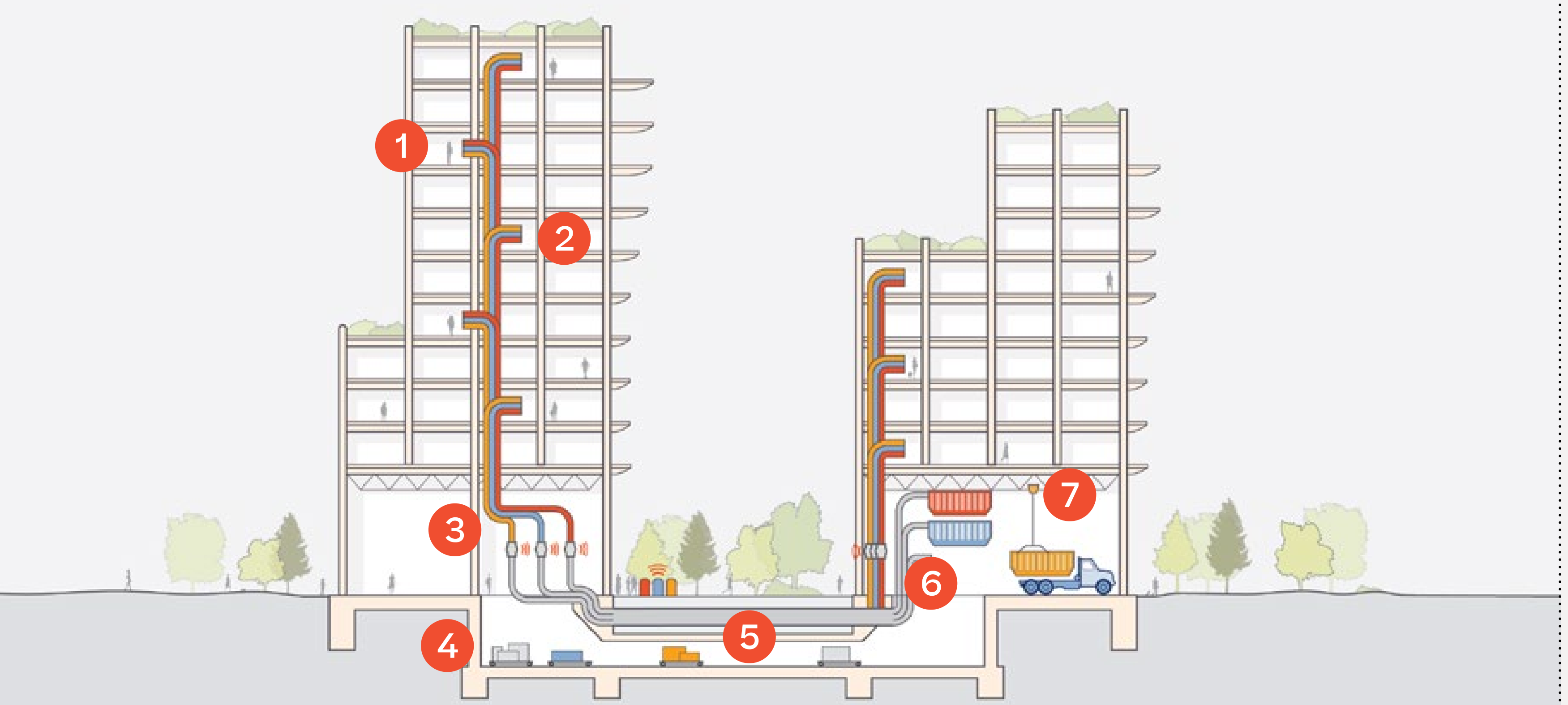
Additionally, the pilot would compare the waste analyses completed by workers at Canada Fibers with those from the computer visualization system to determine the effectiveness of such technology for ongoing waste characterization.

The pilot would conform to the same protocol used by the City of Toronto for its standard waste characterization studies, with the goal of ensuring that no waste could be identifiable to an individual. It would also follow Sidewalk Labs' proposed Responsible Data Use Guidelines, including by providing transparent signage about the program in participating buildings.

"Wish cycling" is a natural response from people who want to make their cities more sustainable. By helping residents recognize their recycling mistakes, this pilot can help create a real-time feedback loop in Quayside and beyond, making those wishes a reality.

Explainer: How the smart disposal chain works

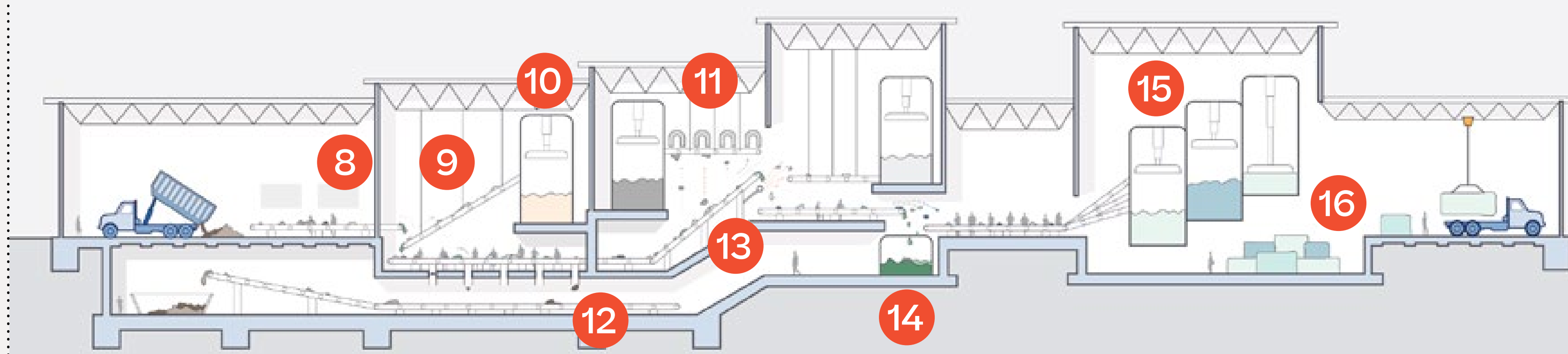
The proposed smart disposal chain begins with a set of three pneumatic waste chutes (one for landfill, recycling, and organic or food waste) that keep these streams separated, reducing contamination. These chutes transport the waste underground to an on-site neighbourhood collection point for truck removal.



The neighbourhood waste system helps to sort landfill, recycling, and organic waste.

1. Tenants unlock smart chutes to deposit their waste.
2. Three chutes (recycling, landfill, and organics) keep waste separate to reduce contamination.
3. A valve room manages the flow and release of material through the chutes.
4. Cardboard and oversized items that cannot go into the chutes are collected separately and transported via underground tunnels.
5. Pneumatic tubes transport waste underground.
6. Waste arrives at the neighbourhood collection point and is prepared for removal.
7. Crane systems load trucks with separated waste streams for off-site transport.

Trucks will transport recycling material to an off-site material recovery facility (MRF). The MRF helps to sort recyclable material further, separating out things like metal, plastic, and glass, as well as any remaining landfill waste. The resulting clean recyclable material then gets sold to manufacturers for reuse.



Recycling is processed at an off-site materials recovery facility.

8. A computer vision system categorizes data on recycling.
9. Screens and shakers further separate out small materials.
10. Powerful magnets pull metal items out of the recycling stream.
11. An eddy current (reverse magnet) pushes lighter-weight metals into a separate container.
12. Contaminants removed from the recycling streams are gathered for landfilling.
13. An optic eye conveyor is used to sort plastic types.
14. Heavy glass pieces remaining in the waste stream are sorted out via gravity.
15. Separated materials are compressed into bales.
16. The baled, recycled content is sent to market.

Goal 2

Reducing Waste and Improving Recycling

Implement “pay-as-you-throw” smart waste chutes

All proposed digital innovations would require approval from the independent Urban Data Trust, described more in the “Digital Innovation” chapter of Volume 2, on Page 374.

Like many cities, Toronto has improved its recycling rates with “pay-as-you-throw” waste management program. These programs charge residents for the amount of landfill waste they throw away each week while collecting recycling for free. Residents who fail to sort their waste correctly risk having it left uncollected. In single-family homes and townhouses, pay-as-you-throw is credited with diverting 66 percent of waste in Toronto,[38] achieving similar success rates elsewhere.

Pay-as-you-throw programs have not translated effectively to multifamily buildings, for an obvious reason: unlike in a single-family home, where waste is set out in front of a specific residence, a building garbage chute or trash room has no way of knowing which tenant is throwing out what. To address this challenge, Sidewalk Labs has designed a building “smart chute” that could account for waste by building unit and bring pay-as-you-throw programs into dense urban neighbourhoods.

To adapt pay-as-you-throw for multi-residential settings, Sidewalk Labs proposes that buildings be required to provide three waste chutes consistent with City of Toronto requirements: organics (food), recyclables (glass, metal, plastic, and paper), and landfill garbage. These “smart chutes” could be unlocked from an app or a touch screen to verify a tenant. Digital devices in the chutes would measure waste volume to charge tenants for what they deposited.

This approach differs slightly from the current municipal model; instead of no charge for recycling, there would be a lesser charge for recycling than for landfill waste to help avoid “wish cycling,” wherein residents recycle things they should not, potentially contaminating the recycling stream. In suburban areas, such attempts would result in waste collectors leaving a bin behind; in a building waste room, the recycling charge helps keep people honest and encourage source separation. Creating more transparency into the cost of waste per person should also help reduce overall household waste — the ultimate goal.

The cost of the whole recycling system itself could also decrease with such an approach. Currently, the need to truck waste to a materials recovery facility for sorting adds 28 percent to processing costs. But by keeping the waste streams clean, this cost would decline, even as recycling increases.[39]

Cardboard (which can clog chutes) would be collected separately at no cost. Oversized or heavy waste that cannot fit into the chute would also be collected separately.

Toronto’s pay-as-you-throw program has diverted 66 percent of waste in single-family homes. Sidewalk Labs plans to extend the program to multi-family buildings, with separate chutes for landfill, recycling, and organic or food waste.

For tenants, pay-as-you-throw costs would be commensurate with the actual cost of collection, transportation, and disposal of waste.

Enabling extended producer responsibility.

With enhanced capabilities for waste sorting and data collection, Sidewalk Labs can enable brand- or manufacturer-specific tracking of packaging and waste products and subsequently assign disposal costs accordingly, consistent with the direction of the 2016 Waste Free Ontario Act.

Initially, this data would be transparently shared with manufacturers, and could be used to “call out” issues with specific brands. For example, single-use coffee cups lined with polyethylene are known contaminants of the recycling stream. By tracking this brand-specific waste production data, Sidewalk Labs could help change packaging designs and hold major brands accountable. This approach is in line with the province’s policy goals as well as the city’s long-term strategy for creating a circular economy for waste.

Sidewalk Labs could also work with local retailers and restaurants to restrict the sale of materials that frequently contaminate the organics or recycling waste stream, such as plastic straws or black plastic coffee cup lids. Such efforts would not remove these products from the waste stream, but they could reduce contamination and offer a pilot district for City of Toronto Solid Waste Management Services to implement these restrictions more broadly.

Goal 3

Reduce contamination during removal with vacuum tubes

Once waste leaves a building, there are still many places where "source separation" can break down before that waste reaches its final destination, potentially undermining landfill diversion efforts.

The standard approach of transferring waste by hand from tenant to buildings to garbage trucks creates the potential to contaminate recyclables and organics — not to mention introduce odours and vermin or taking up limited street or building space. Once recyclables arrive at material recovery facilities, "pickers" stand along conveyor belts and pluck out non-recyclable material, but they miss a lot due to the sheer volume of waste. And foreign objects in the organics and recyclables waste streams can even break the specialized machinery used to process these materials.

Sidewalk Labs proposes to deploy two innovations to help ensure that waste stays separated between the time it enters a trash-room chute and when it reaches an underground neighbourhood collection point: pneumatic waste collection and self-driving dollies.

1

Pneumatic waste collection. Sidewalk Labs proposes to install an underground pneumatic tube system that would vacuum waste from the three building chutes (recyclables, trash, organics) to the neighbourhood's collection point. The pneumatic system would use pipes to send waste at up to 70 kilometres per hour.[40] Sidewalk Labs plans to issue a request for proposals to design the network and anticipates responses from leaders in the field, such as Envac, Transvac, and MariMatic.

2

Self-driving dollies. Sidewalk Labs proposes to have self-driving delivery dollies transport items that cannot go through chutes or underground tubes from buildings to the collection point. These items could include oversized and specialty waste (such as paint), as well as cardboard and paper. Cardboard balers or shredders could be installed at a building level to minimize transportation required. Special building pick-up for disposal could be arranged and charged on an as needed basis.

See the "Mobility" chapter of Volume 2, on Page 22, for more on waste removal via the neighbourhood freight system.

In Quayside, the proposed collection point would be located on the edge of the neighbourhood. At the collection point, waste would be shifted into airtight containers (separated by the three types) for pick-up by city or private trash haulers. Recyclables would go to a material recovery facility; compacted landfill waste would go to a landfill; and organic waste would head to anaerobic digesters (see the next section for more details).

In addition to dramatically reducing waste contamination, this underground removal process could reduce the space needed for in-building trash storage and remove truck traffic from local streets.

An underground waste system would dramatically reduce the space needed for in-building trash storage, remove truck traffic from local streets, and create a cleaner waste stream for more effective recycling.

Goal 4

Reducing Waste
and Improving Recycling

Convert organic waste into clean energy

Toronto is already a leader in properly disposing of organic (food) waste, such as banana peels or half-eaten vegetables, to create a more sustainable city (see sidebar). As noted on Page 344, when placed in landfills, organics decompose to produce methane emissions, which have a significantly greater climate impact than carbon emissions. Additionally, if placed in recyclable streams, organics can render recyclables like paper non-recyclable.

But when separated out from the start, food waste can be converted into a clean energy source through a process called anaerobic digestion, which breaks down organic material biologically, just like a stomach breaks down food, creating biogas (or renewable fuel). After the fuel is extracted, the dehydrated material can be used for nutrient-rich compost (or soil amendments).[41]

Sidewalk Labs proposes a two-phase approach to handling organics. In Quayside, organic material separated at a building would travel through pneumatic tubes to the neighbourhood collection point. It would then leave this point and head to an off-site pre-processing facility to remove contamination and (at the same facility) be processed by anaerobic digesters.

At the proposed full scale of the IDEA District, with sufficient food waste to generate an investment return through conversion into fuel, it becomes economically feasible to explore neighbourhood-adjacent facilities capable of fully processing organics. In such a facility, the resulting biogas could be captured and exported to the natural gas grid that serves surrounding neighbourhoods. With an estimated 45,149 tonnes per year of source-separated organics disposed, the anaerobic digestion process would provide clean energy to supplement buildings outside of the IDEA District — thus helping the project fulfill its climate-positive mandate of exporting clean energy to other parts of the city.[42]

By creating biogas, the anaerobic digestion process could provide clean energy to buildings outside of the IDEA District, helping the project achieve climate positivity.

Best practice

Toronto: A leader in organics processing

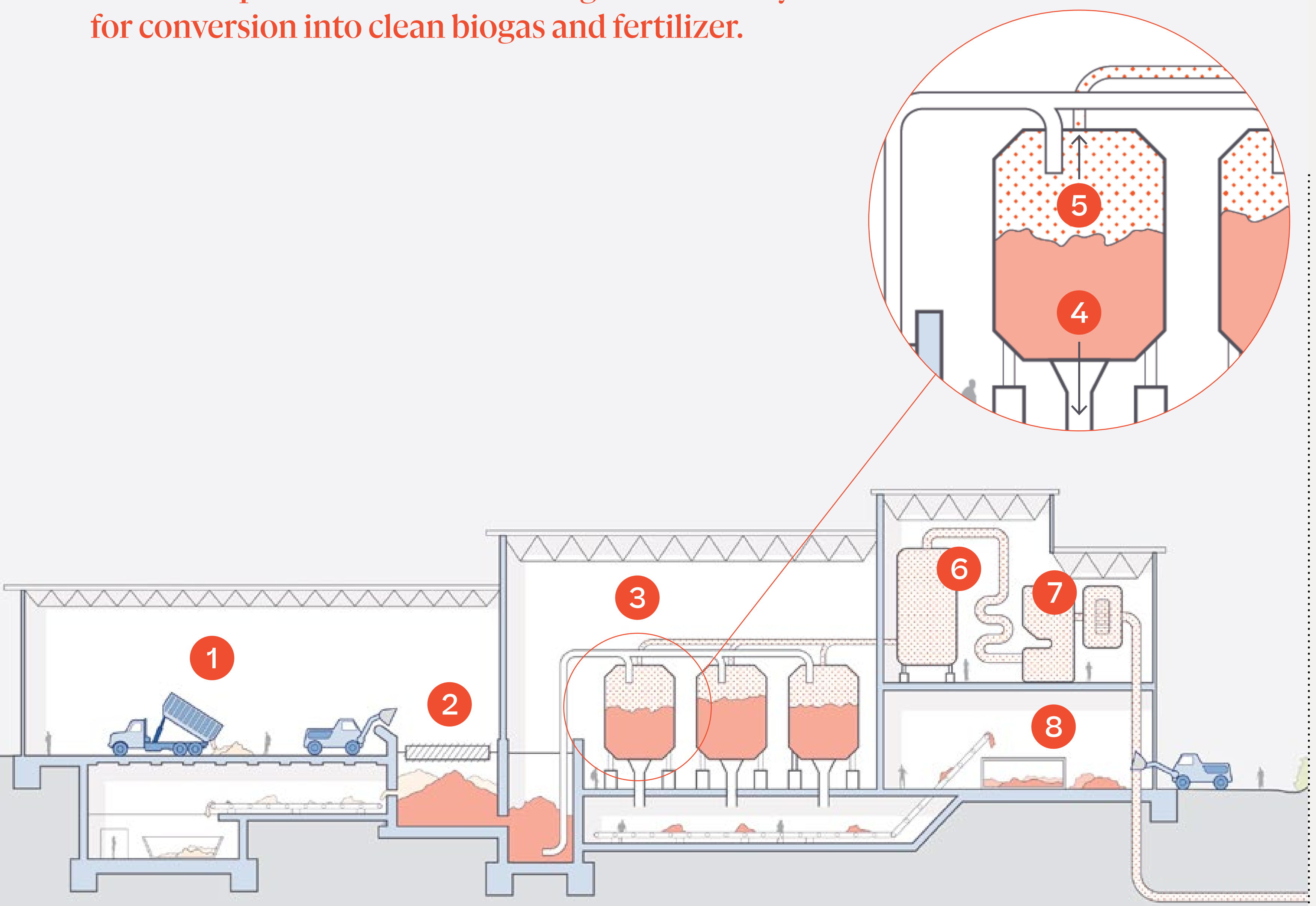
Built on a former landfill, Toronto's Disco Road Organics Processing Facility is a world leader in diverting food waste from landfill, using wet anaerobic digestion to process the city's organic waste. The end products of this anaerobic digestion process include compost, fertilizer, and flammable biogas (typically made up mostly of methane), which can be used as fuel for heating and cooking or compressed and used as vehicle fuel.

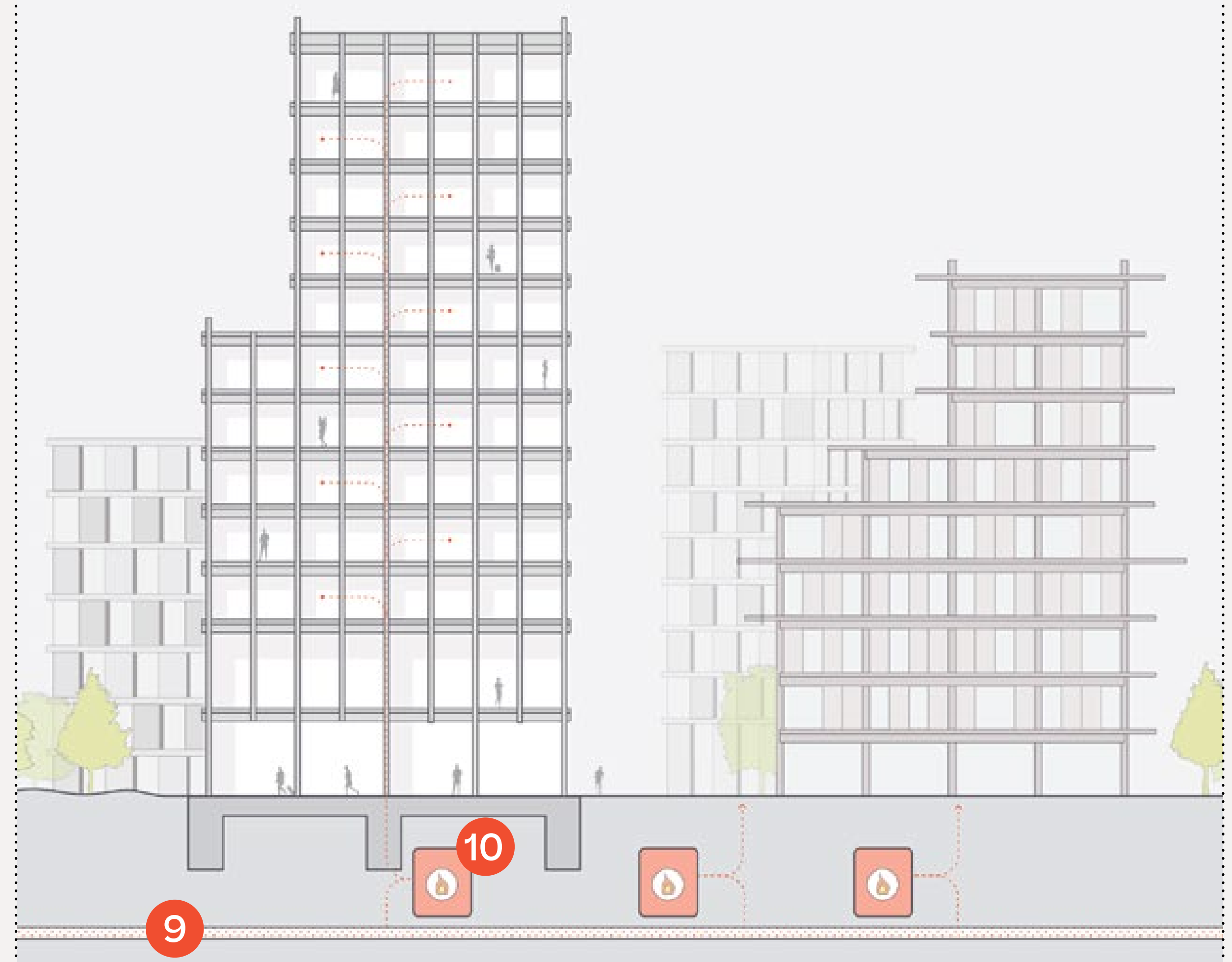
Organic material collected through Toronto's green bin program is shuttled daily to the Disco Road facility. After a round of pre-processing to remove plastics and other contaminants, the waste is blended into a pulp and fed to the system's anaerobic digesters, along with rainwater captured and collected on-site. After processing, the dried materials are shipped off for use in commercial compost while the liquids are treated in a wastewater facility. The biogas, meanwhile, is burned in an on-site boiler to keep the digesters operating at a steady temperature of 37 degrees Celsius.

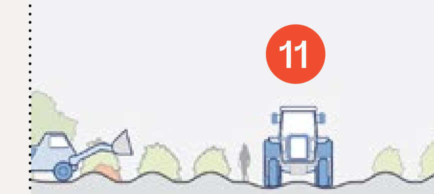
A 24/7 operation, the Disco Road digesters process 75,000 tonnes of organic material each year, the equivalent of 2,800 truckloads.[43]

Explainer: How anaerobic digestion creates clean energy

In the proposed waste system, organic waste would get transported from the neighbourhood collection point to an anaerobic digestion facility for conversion into clean biogas and fertilizer.







Clean biogas is created from organic waste.

1. Organics enter the facility.
2. Organics are macerated (or softened into a pulp).
3. Macerated organics enter digester tanks.
4. Nutrient-rich compost (fertilizer) is created.
5. Gas is created by the microorganisms.
6. Gas enters holding tanks.
7. Moisture and corrosive gases are removed.
8. Nutrient-rich fertilizer is sent to farms.

The Toronto energy pipeline could be supplemented by clean biogas.

9. Pipes carry biogas to off-site neighbourhoods via natural gas infrastructure.
10. Gas could be distributed in off-site buildings for heating and cooking.

Farm

11. Fertilizers are sent to local farms and markets.

Ch–4

Part 6

Managing Stormwater Naturally and Actively

Key Goals

1
Design green infrastructure into a neighbourhood

2
Monitor stormwater levels and quality with digital tools

No urban climate plan would be complete without a sustainable approach to managing stormwater. In recent decades, storms and rainfall have intensified around the world. Toronto has endured two 100-year storms in the past six years, including a 2013 flood that caused more than $850 million in property damage.[44]

Toronto has taken important steps to manage stormwater more effectively, given the potential of the city's combined sewer and stormwater infrastructure to contaminate Lake Ontario (whose drinking water serves 9 million people). Waterfront Toronto's groundbreaking $1.25 billion flood-mitigation program, announced in mid-2017, plans to renaturalize the Don River to help protect against stormwater overflows.[45] The city's Wet Weather Flow guidelines call for new development to reduce outflow of annual rainfall by 90 percent,[46] and the Toronto Green Standard's Tier 1 requirement calls for a minimum of 5 millimetres of stormwater retention.[47]

Building on these efforts can be as challenging as it is essential. Some cities invest in large treatment facilities to filter all stormwater for pollutants before sending it back out into rivers, streams, and lakes. This type of "hard" infrastructure is costly to implement and maintain; it also takes up valuable space that could be used for the public realm or other development uses. Meanwhile, standard practices for monitoring water quality occur manually, or not at all, and risk missing key outcomes.

To make matters tougher, most stormwater management plans occur on a parcel-by-parcel basis, leading urban landowners to build additional hard infrastructure (at great initial and ongoing expense) such as tanks and dual plumbing to meet stormwater regulations, rather to design for natural systems that require district-level planning.

The Sidewalk Toronto project presents an opportunity to think holistically about stormwater management and design *with* nature — rather than trying to control it.

Active stormwater management could reduce GHG emissions by 0.01 annual tonnes per capita.

See the "Public Realm" chapter of Volume 2, on Page 118, for more details on the Open Space Alliance.

Sidewalk Labs proposes to take a neighbourhood-level approach that integrates green infrastructure designs with digital monitoring tools to incorporate nature into stormwater management while minimizing the need for hard infrastructure. Green infrastructure (such as increased street and sidewalk plantings and green roofs) would help retain stormwater and purify it through natural means. Digital tools and an active control system could free up stormwater containers in advance of storms and monitor water quality in real time.

In a neighbourhood the size of Quayside, these practices would achieve Toronto Green Standard's Tier 3 for stormwater retention (25 millimetres). Sidewalk Labs estimates the system would reduce downstream energy costs by 50 percent (due to reduced pumping and UV filtration used in treatment facilities) and reduce stormwater moving into municipal systems by 90 percent (due to greater retention).[48] More broadly, this approach could create a public realm filled with green infrastructure that not only manages stormwater but provides secondary benefits to the community, such as increased tree canopy, landscape beautification, health qualities related to nature, and improved habitat for biodiversity and wildlife.

Deployed across the full scale of the IDEA District, these practices can help prepare the waterfront for a 100-year flood event and reduce GHG emissions by 0.01 annual tonnes per capita (or 0.2 percent) from the city's current average, thanks to expanded green space.

Sidewalk Labs proposes that a new entity called the Open Space Alliance operate and maintain the stormwater system.

Goal 1

Managing Stormwater Naturally and Actively

Design green infrastructure into a neighbourhood

See the “Buildings and Housing” chapter of Volume 2, on Page 202, for more details on biophilic design.

3,000 square metres

of heated pavement would reduce the need for street salting.

Green infrastructure encompasses an array of living systems that can include a wide variety of design components, such as green roofs, rain gardens, constructed wetlands, permeable pavement, and rainwater harvesting. Together, these systems can help regulate the flow of stormwater and naturally filter it for “total suspended solids” — particles that can pollute bodies of water.

They can also infuse nature in the public realm in ways that improve health and quality of life. Plants shade surfaces, reflect radiation, and release moisture to cool the urban environment, reducing the urban “heat island” effect. Natural landscapes have “biophilic” properties that can enhance well-being. And improved water quality can encourage people to reconnect with the waterfront.

Sidewalk Labs plans to design a neighbourhood-level stormwater system that recognizes that water should be managed right where it falls — with no single point of failure. The features of this system include:

Improved bio-retention.
The highest retention requirement of the Toronto Green Standard calls for development to retain 25 millimetres of stormwater, meaning this amount is held back from the municipal treatment system and reused on site. To meet — or exceed — this standard, Sidewalk Labs plans to incorporate mixed open plantings and expanded soil volumes into its public realm (specifically, along its sidewalks), which would increase infiltration of stormwater into the ground as well as evaporation into the air.

Expanded tree canopy.
Sidewalk Labs plans to add soil volume in large beds along streets and sidewalks, as opposed to small tree pits, enabling the growth of root structures for a larger tree canopy, as well as the ability to include mixed plantings that promote biodiversity in flora and fauna. These soil cells also maximize the filtration potential for captured water.

Advanced soil remediation.
Sidewalk Labs plans to incorporate plants known to respond well to salinity (high salt volume in water). For example, poplar trees absorb bacteria and other contaminants, preventing them from flowing into the water — a process known as “phytoremediation.”[49] Building on that insight, Sidewalk Labs plans to use principles for “inoculated phytoremediation,” an approach to soil remediation that uses plantings known to remove toxins in the soil. Such practices have the potential to absorb total suspended solids up to 80 percent, dramatically reducing potential for water contamination.[50]

Permeable pavement.
The notion of pavement that effectively absorbs rain and melted snow has been around since the Roman Empire, which used stone pavers set in sand to allow for water to seep through the street.[51] Today, precast permeable concrete has gone from a niche technology to a more common one, in line with increased climate awareness and stormwater management needs. Sidewalk Labs plans to incorporate permeability into some of its modular pavers, enabling water to flow through them via pores into native soils or underground systems.

Sidewalk Labs also plans to deploy approximately 3,000 square metres of heated pavers in Quayside, reducing the need for street salting, which poses a threat to the environment (as well as to wheelchair accessibility). Since the 1980s, salt (chloride) rates in the mouth of the Don River have exceeded the Canadian Water Quality Guidelines threshold for long-term effects on aquatic health; in recent years, they have exceeded the threshold for short-term effects on aquatic health. From 2011 to 2015, the mouth of the Don had the highest 75th-percentile chloride concentration of all river mouths in Toronto since measurement began 50 years ago.[52]

Extensive blue and green roofs.
On top of its tower roofs, Sidewalk Labs plans to deploy “blue roofs” designed to store rainwater under photovoltaics as one means of retaining and detaining stormwater runoff. On podiums and terraces, Sidewalk Labs plans to deploy green roofs to absorb stormwater, as well as to reduce the urban heat island effect by insulating buildings.

Minimal cisterns.
Even this extensive amount of green infrastructure may not be enough to retain stormwater at times. For these cases, Sidewalk Labs plans to create a minimal number of underground cisterns to collect and store excess stormwater. These cisterns would be equipped with controls (more details in the next section) that can help re-use the water for site maintenance and irrigation, reducing the need for standard sprinkler systems.

Green infrastructure can naturally filter stormwater and infuse nature into the public realm in ways that improve health and quality of life.

Goal 2

Managing Stormwater Naturally and Actively

Monitor stormwater levels and quality with digital tools

To support its green infrastructure and minimal hard storage containers, Sidewalk Labs proposes to deploy an active management and monitoring system across all the aspects of the stormwater system that collect water, including cisterns, blue roofs, and pavement cells.

This system would consist of active valves designed to retain water for on-site use (such as irrigation) or empty containers in advance of a storm, as well as non-personal stormwater sensors designed to measure the quantity and monitor the quality of stormwater when it leaves the site.

At the scale of the IDEA District, this combined approach could save Toronto from building physical infrastructure to manage stormwater and prevent flooding, such as large conveyance systems and treatment facilities with large tanks and power-consuming filtration processes. This approach would also offer capital cost savings to building developers of up to 10 percent, because they would no longer need to install large, costly retention tanks and additional plumbing on their properties.

Managing stormwater capacity. Stormwater sensors connected to management software can help neighbourhoods collect real-time data on things like stormwater levels, weather patterns, and water quality as well as manage stormwater infrastructure more actively.

For example, when stormwater software predicts heavy rains coming in a few days, volume meters on cisterns can make sure that valves in a stormwater system direct water to empty storage containers or into green spaces throughout the development, in preparation for the storm. All such storage containers would be connected to help the system coordinate stormwater response appropriately.

Additionally, stormwater management tools enable preventative maintenance by detecting potential leaks. They also enable an approach called "precision agriculture" that could monitor plant health and soil quality and determine when they need to be watered, using the water collected in the cisterns for these purposes rather than using potable water or over-watering via sprinklers.

See the "Public Realm" chapter of Volume 2, on Page 118, for more details on preventative maintenance.

Sidewalk Labs proposes to use software developed by OptiRTC, a leader in stormwater infrastructure controls, for its active stormwater system. (Sidewalk Labs is an investor in OptiRTC.)

Monitoring water quality. Sidewalk Labs' proposed stormwater system incorporates water-quality monitors to help identify any anomalies and trigger more aggressive testing. In addition to detecting potential risks related to drinking water, ongoing monitoring could track measures that contribute to ecological health issues, such as salt runoff. These monitors would be located in the soil and on the outflow pipes that would connect to municipal systems, and could potentially tie into Ontario's broader existing water-quality sensor network.

Stormwater monitors could also help cities understand which water collections need treatment, rather than filtering all water by default — reducing the space needed for the treatment facilities while also saving energy. As a potential alternative to large-scale facilities that treat stormwater with ultraviolet exposure, Sidewalk Labs plans to explore the use of "in-pipe" ultraviolet treatment.

Ongoing exploration. Beyond managing stormwater and waste within Quayside or the IDEA District, Sidewalk Labs is also exploring strategies to reduce source contamination and account for water and soil quality. For example, Sidewalk Labs plans to explore the potential to integrate new filtration or vacuuming technologies to reduce debris runoff from light rail tracks. Sidewalk Labs also plans to explore new policies that consider the overall environmental tradeoffs associated with contamination removal and take into account trucking of waste, among other factors.

Sidewalk Labs pilot

Using technology to improve green infrastructure

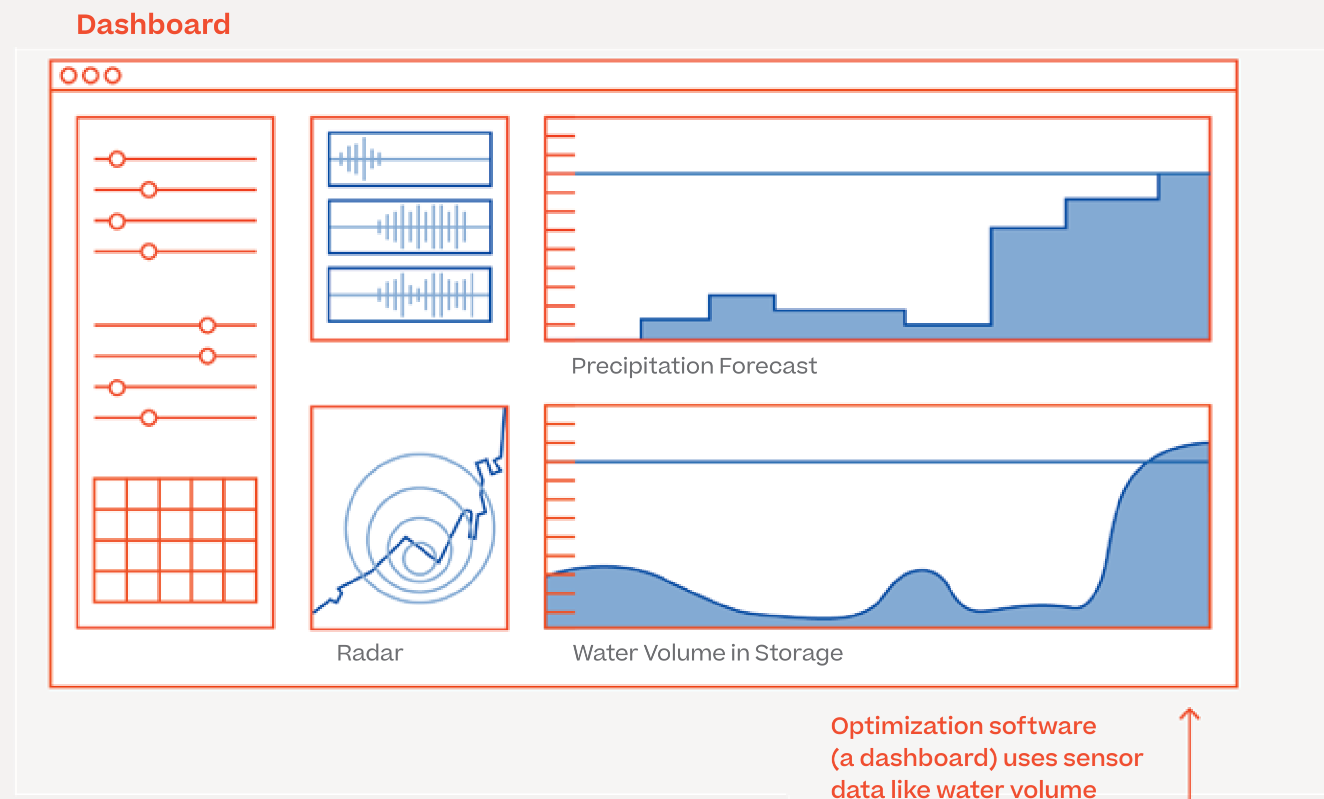
Sidewalk Labs aims to partner with the Natural Sciences and Engineering Research Council of Canada, University of Toronto, and Ryerson University on a stormwater pilot that would research the development, modelling, and maintenance of green infrastructure systems. The proposed pilot would use tools developed by OptiRTC.

Green roofs, for instance, are an increasingly common form of green infrastructure whose impacts have yet to be properly quantified. The pilot proposes to monitor measures such as water inflow, water outflow, and soil evaporation rates of green roofs to assess how they impact runoff volumes. The pilot would also use environmental (non-personal) sensors to assess the effectiveness of soil cells and permeable paving on stormwater retention.

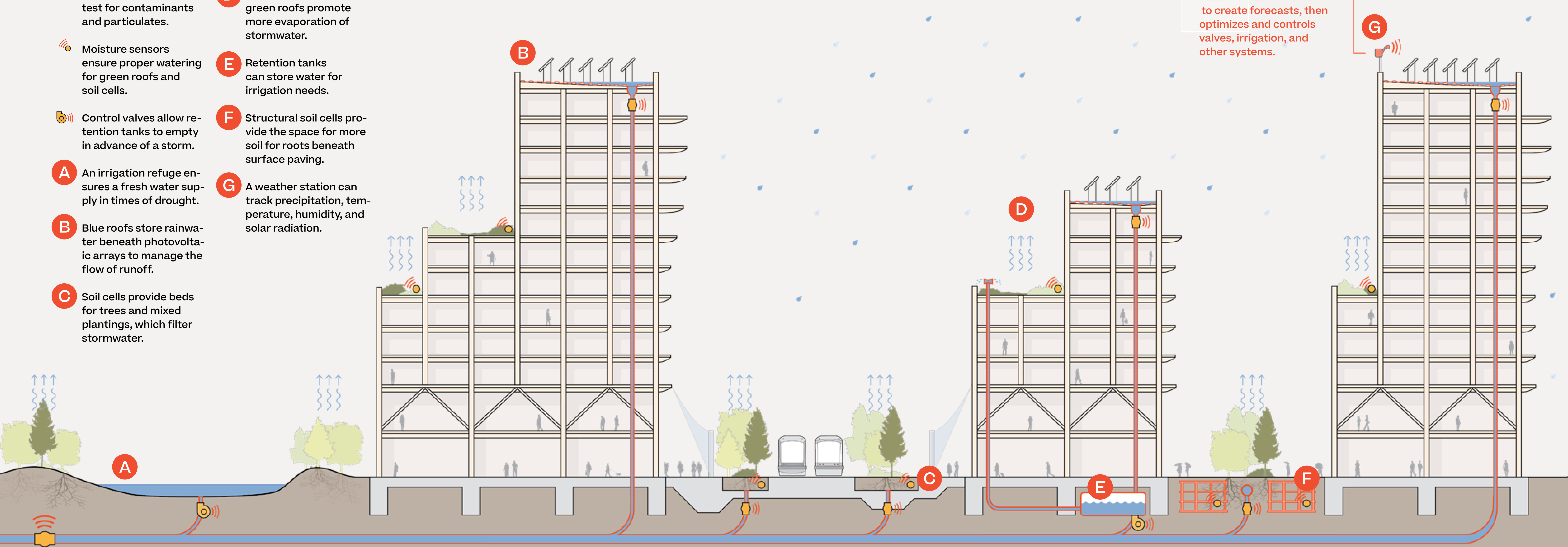
Monitoring stormwater flow quantities could help planners and engineers appropriately size future stormwater retention basins to save both space and infrastructure costs. Meanwhile, monitoring stormwater quality could help manage green roofs and reduce the amount of ultraviolet light treatment used to clean the runoff headed to Lake Ontario. Ultimately, these systems could help create more adaptable and effective water treatment guidelines than the building codes in place today.

Explainer: How the active stormwater management system works

The proposed system reduces the need for large underground tanks and pipes by using green infrastructure (such as tree plantings and soil cells) as a first line of stormwater retention. Digital tools help handle excess stormwater by proactively emptying storage tanks before a storm; they also help reuse stormwater for irrigation and monitor water quality.



- Water quality sensors test for contaminants and particulates.
- Moisture sensors ensure proper watering for green roofs and soil cells.
- Control valves allow retention tanks to empty in advance of a storm.
- **A** An irrigation refuge ensures a fresh water supply in times of drought.
- **B** Blue roofs store rainwater beneath photovoltaic arrays to manage the flow of runoff.
- **C** Soil cells provide beds for trees and mixed plantings, which filter stormwater.
- **D** Extensive plantings and green roofs promote more evaporation of stormwater.
- **E** Retention tanks can store water for irrigation needs.
- **F** Structural soil cells provide the space for more soil for roots beneath surface paving.
- **G** A weather station can track precipitation, temperature, humidity, and solar radiation.



Public Engagement

The following summary describes feedback related to **sustainability**, and how Sidewalk Labs has responded in its proposed plans.

As part of its public engagement process, members of Sidewalk Labs' planning and innovation teams talked to thousands of Torontonians — including members of the public, expert advisors, civic organizations, and local leaders — about their thoughts, ideas, and needs across a number of topics.

1 Be ambitious with sustainability, in Quayside and beyond

What we heard

At each Sidewalk Toronto public engagement event, participants were passionate about the urgent need to address climate change and invest in cutting-edge, sustainable technologies and infrastructures. As one Residents Reference Panel participant explained: "If we continue at the pace we are going, it will be devastation for everyone. So you have to think about things like renewable energy, like the use of plastic, like prefabricated materials for building. We have to think about a lot of things for the future that we did not think about before."

Sidewalk Labs was especially encouraged with positive responses to its proposed sustainability priorities — particularly its goal to reduce per capita carbon emissions in Quayside by 85 percent and to achieve climate positivity within the IDEA District. Other areas of strong support included proposals for building performance, thermal energy infrastructure, and stormwater.

Participants of the sustainability breakout session at Public Roundtable 4 further validated Sidewalk Labs' ambition for the project to be carbon positive via thermal grids, clean electricity, and other sustainable technologies. Residents emphasized the importance of thinking at scale and ensuring that solutions were not just for one neighbourhood but could be replicated across neighbourhoods to have significant impact. They encouraged Sidewalk Labs to work with the province and existing Toronto-based companies to make this goal a reality.

Sidewalk Labs Director of Sustainability Charlotte Matthews addresses the Sidewalk Toronto Residents Reference Panel about the project's emerging sustainability plans. Credit: David Pike

How we responded

Thinking holistically.
Sidewalk Labs proposes a comprehensive package of innovations that together cut carbon emissions in Quayside to 0.9 tonnes of GHG a year per capita from the city's average of 6.3 tonnes (see Page 301).

Exploring scale.
The Sidewalk Toronto project can dip below the carbon-neutral line and into climate-positive territory by scaling its sustainability initiatives; Sidewalk Labs proposes implementation across a larger development area in the IDEA District to achieve this goal (see Page 302).

Investing in infrastructure.
Sidewalk Labs proposes to create a thermal grid that would draw energy from a variety of natural and waste heat sources, including geothermal and building wastewater, to provide affordable, fossil fuel–free heating and cooling (see Page 334).

Advancing electricity.
Sidewalk Labs proposes to create an advanced power grid that could provide an alternative source of clean electricity when the main Toronto Hydro power grid is at peak capacity (see Page 324).

Working with others.
Sidewalk Labs has been in discussions with governmental agencies (including the City of Toronto and the Ontario Ministry of Energy) and private companies throughout the creation and development of its sustainability plans, and would continue to collaborate with the private and public sectors.

Reducing waste.
Sidewalk Labs proposes to divert at least 80 percent of recyclable or compostable material from landfills (see Page 344).

Optimizing energy.
Sidewalk Labs proposes to deploy digital energy management systems that could help buildings operate in the most efficient way possible (see Page 316).

2 Empower people to live more sustainably

What we heard

While recognizing that sustainable systems often require automation, participants encouraged Sidewalk Labs, whenever possible, to empower individuals to act more sustainably in their daily lives.

Participants were particularly excited by the role technology could play in raising awareness and gamifying positive environmental initiatives, such as dynamic signage or other kinds of "nudges" that could customize recycling feedback. Participants and experts also emphasized the need for jargon-free education, fee structures, and design.

As one Residents Reference Panel resident explained: "My condo building is only 10 years old, but it hasn't been designed to encourage energy conservation or recycling. … It's an additional hassle, and not a lot of people do it. But if you can design the building to make it easy to do, and even provide a tangible benefit like a rebate on condo fees, they'll do it. That's how people change."

Residents also emphasized the need for sustainable actions to be accessible to elderly residents and to be affordable, so as not to "hinder lower-income residents from practising sustainable behaviours." The Sidewalk Toronto Fellows went even further, encouraging the adoption of a system that would allow residents to visualize and manage local neighbourhood energy production and consumption.

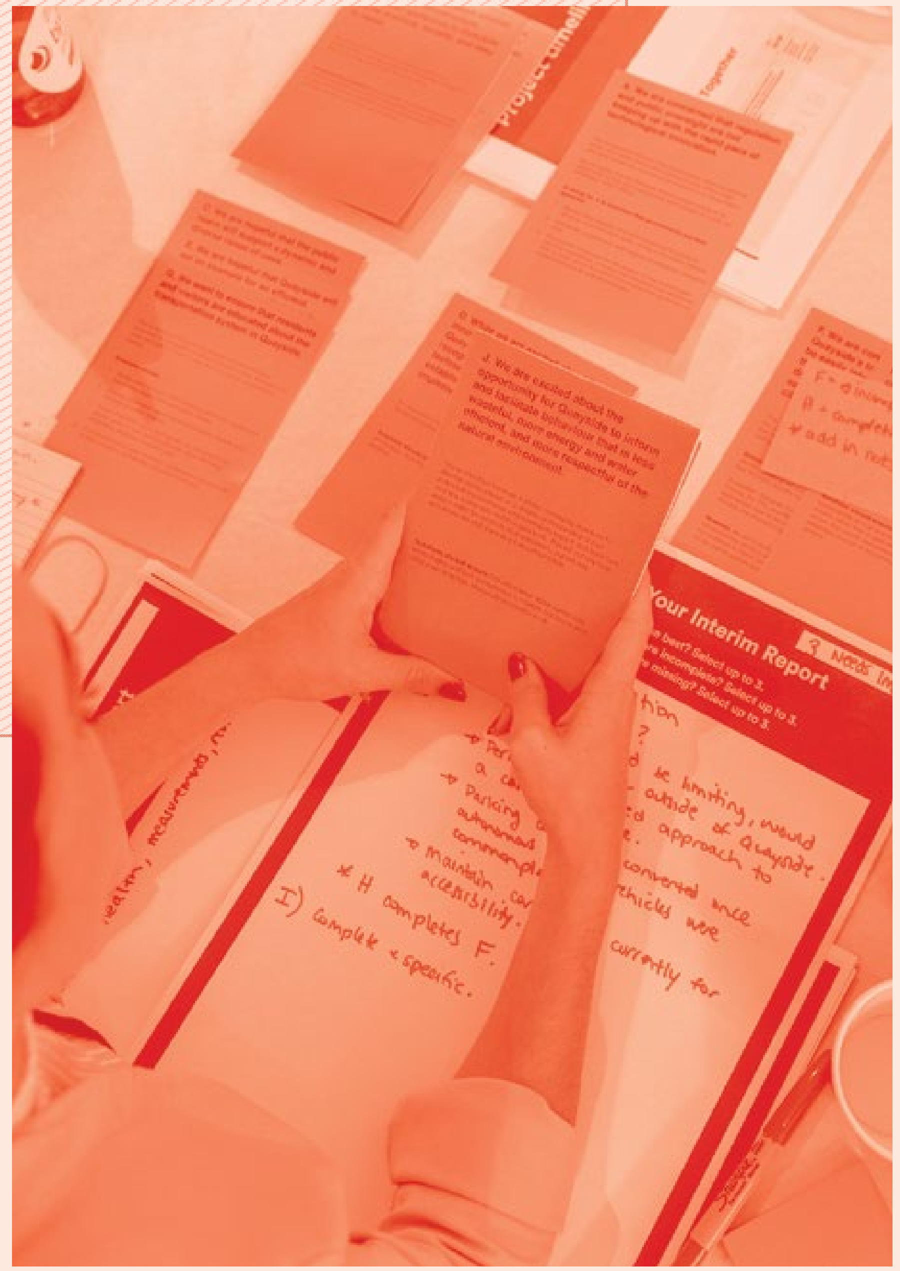
How we responded

Setting budgets.
Sidewalk Labs' proposed Home Scheduler would work within a household's monthly power budget to operate systems, devices, or appliances when costs are low and clean energy is available. The tool would also generate a data feed for homeowners to understand the actions being taken and to actively manage them, if they wish (see Page 330).

Encouraging accountability.
Sidewalk Labs proposes to implement a pay-as-you-throw model of waste that encourages households to reduce overall waste, as well as a modest recycling charge to help discourage "wish cycling" (see Page 350).

Informing decisions.
Sidewalk Labs proposes to run a recycling education pilot in multi-residential buildings in Toronto that are interested in helping residents improve sorting and recycling practices by using real-time feedback. This pilot partnership could help inform dynamic recycling signage in Quayside (see Page 345).

Maintaining affordability.
Sidewalk Labs supports a more distributed, resilient, and transparent economy underpinned by 100 percent renewable energy. The proposed advanced power and thermal grids would be designed to serve the community transparently and provide tools to make the right decisions around cost and carbon (see Page 324).



A Toronto resident considers the content of the Residents Reference Panel interim report, published in September 2018. Credit: David Pike

3 Be a steward of the environment

What we heard

The importance of environmental stewardship was a common theme at many public engagement events. Sidewalk Labs was urged by participants in the Indigenous Design Consultation to not only support the land and water ecology of the eastern waterfront but also to revitalize the plant life that originally thrived in the area. Members of the Sustainability Advisory Working Group also encouraged Sidewalk Labs to ensure sustainable forest management practices.

The Residents Reference Panel and participants at Public Roundtable 4 emphasized the need for climate change resiliency, particularly when it comes to creating functional, beautiful, and future-proofed stormwater infrastructure. The residents wanted to see an increase in focus on "softscaping" over "hardscaping." As one visitor to 307, Sidewalk Labs' Toronto headquarters, put it: "I see the waterfront as a unique and beautiful resource that should be primarily designated as parkland for the use of all Torontonians. I believe that as concerns about climate change rise, the importance of open green spaces, which can serve to mitigate extreme weather events like floods, will become ever more important."

How we responded

Integrating greenery.
Sidewalk Labs proposes a public realm in which parks act as green stormwater infrastructure, retaining and filtering stormwater through natural means (see Page 360).

Managing stormwater.
Sidewalk Labs proposes that green infrastructure would work in tandem with a digital management system that could, when needed, empty stormwater tanks or cisterns in advance of storms (see Page 362).

Planting native.
Sidewalk Labs plans for its plantings to be native wherever possible, with plant life chosen for its capacity for salt mitigation, resilience, evapotranspiration rates, and biodiversity (see Page 360).

Ensuring resiliency.
Sidewalk Labs plans to meet and surpass the City of Toronto's resiliency framework for flood management, as well as for and building services when power is lost.

Engagement spotlight

In early 2018, the sustainability team at Sidewalk Labs was brainstorming ways to help Toronto divert as much waste from landfills as possible. One big challenge the team identified is that even when consumers want to recycle, they often struggle to recycle correctly because they do not know what goes where. The team had an idea: What if people could just throw everything in one place, and robots in a waste or recycling plant could take care of the rest?

When the team presented this idea to the Sustainability Advisory Working Group, the group cautioned against the tactic for two reasons. The first had to do with contamination at the source: no robot can stop an open can of soup from contaminating and destroying what was once perfectly recyclable newspaper. The second reason was that the City of Toronto's entire system is designed to encourage consumers to separate materials; if one neighbourhood were different, it could confuse consumers and jeopardize the real progress being made, invalidating much of the time, energy, and resources the city and other non-profit organizations had expended in educating the public.

The Sidewalk Labs sustainability team went back to the drawing board and decided to ask a different question: How could technology help people to recycle correctly? Taking inspiration from the city's Waste Wizard app, the team developed a real-time feedback concept for multi-residential buildings that could let communities know how effectively they are sorting, empowering them to recycle better.

Visitors discuss conceptual visualizations of Quayside in the main hall of 307. Credit: David Pike

Acknowledgements

Sidewalk Labs would like to extend special thanks to the participants of the Sidewalk Toronto Sustainability Advisory Working Group, and to the staffs of the City of Toronto, Province of Ontario, and Government of Canada for their time and guidance.

Endnotes

General note: Unless otherwise noted, all calculations that refer to the full proposed IDEA District scale are inclusive of the entirety of its proposed geography, including all currently privately held parcels (such as Keating West). Unless otherwise noted, all currency figures are in Canadian dollars.

Charts note: Sources for the charts and figures in this chapter can be found in the accompanying copy for a given section; otherwise, the numbers reflect a Sidewalk Labs internal analysis. Additional information can be found in the MIDP Technical Appendix documents, available at www.sidewalktoronto.ca/midp-appendix.

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38. For Toronto's pay-as-you-throw fees and residential diversion rates, see the "Houses" and "Diversion Rates and Reports" pages on the City of Toronto's *Recycling, Organics & Garbage* website. https://www.toronto.ca/services-payments/recycling-organics-garbage/ (accessed February 25, 2019).
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40. Swachhcoin Foundation, "Pneumatic Waste System: Merits and Demerits." *Medium.com,* June 13, 2018.
41. The Official Information Portal on Anaerobic Digestion, *About AD*. http://www.biogas-info.co.uk/about/ (accessed February 25, 2019).
42. For more details on the clean energy potential of anaerobic digestion, consult the "Sidewalk Toronto Greenhouse Gas Model - Path to Climate Positive" section of the MIDP Technical Appendix.
43. City of Toronto, *Disco Road Organics Processing Facility*. Excellence Award entry, Solid Waste Association of North America, 2016.
44. Star Editorial Board, "Toronto politicians can't hide from the increasingly extreme weather." *The Toronto Star*, August 9, 2018; Carys Mills, Toronto's July flood listed as Ontario's most costly natural disaster." *The Toronto Star*, August 14, 2013.
45. Waterfront Toronto, *Waterfront Toronto Receives $1.25 Billion in Government Funding to Undertake Pioneering Project to Flood Protect Port Lands*. News Release, June 28, 2017.
46. *Low Impact Development (LID) Stormwater Management Guidance Manual*. Ontario Ministry of the Environment and Climate Change, April 2017. 46-48.
47. For details, consult the "Water Balance, Quality & Efficiency for Mid to High-Rise Residential & Non-Residential" page on the City of Toronto's *Green Standard* website. https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/ (accessed February 25, 2019).
48. For more information on energy savings from stormwater management in Quayside, consult the "Sidewalk Toronto Greenhouse Gas Model - Path to Climate Positive" section of the MIDP Technical Appendix.
49. United States Environmental Protection Agency, *A Citizen's Guide to Phytoremediation*. Technology Fact Sheet. EPA EPA 542-F-98-011, August 1998.
50. Schollen & Company Inc., Urban Forest Innovations, TMIG, & DPM, *Green Streets Technical Guidelines Version 1.0*. City of Toronto, November 2017.
51. Mark Cartwright, "Roman Roads." *Ancient History Encyclopedia,* September 17, 2014.
52. Toronto Region Conservation Authority, *Regional Watershed Monitoring Program: Surface Water Quality Temporal Trends Update 2011-2015*. TRCA Environmental Monitoring and Data Management Section, Restoration and Infrastructure Division, August 2017.