Dalhousie University Campus – March 2019

Sustainability Map Tour Details

Renewable Energy	Energy & Water	Waste Management
Storm Water Management	Gardens and Natural Environment	Cycling & Transit
Green Buildings	Sustainability Offices/Curriculum	Vehicle Share

** This document provides details on items highlighted on the Sustainability Map Tour guides. Please refer to the overview map tour document to identify locations.*

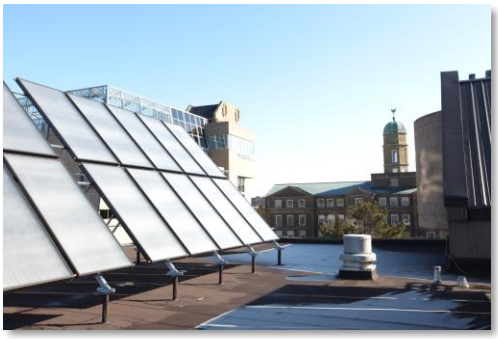
This detailed guide provides more information for each of the spots listed on the Sustainability Tour Guide Map. Page 34 provides some sample spots to visit for a 30 min to 1 hour guided tour.

Halifax Campuses

Renewable Energy

1. 40 solar thermal panel system:

The Life Sciences Centre solar thermal panel system has 4500 liters of hot water storage, designed to preheat the facility's domestic hot water and save 402 GJ (105,000 kWhe) of gas per year that would have been used to heat the water.



2. Solar Wall on the Mona Campbell Building:

This solar wall is comprised of a double-walled metal cladding system that absorbs heat and draws the outside air up between the two walls. The heat from the backside of the metal preheats ventilation air, thus reducing the need for mechanical heating. The solar wall is projected to provide a 15% reduction in energy needed to heat ventilation air which is a predicted energy production of 166 GJ (46,111 kWh per year).

3. Solar PV and Solar Duct system on the Computer Science Bld:

80 Solar Photovoltatic (PV) panels (20 kw) are installed on top of a solar duct system on the Computer Science Bld. This is the largest system of its type in Canada at time of installation in 2014. Meters have been installed to track performance of the system. Annual projected energy production for the solar pv system only - 22,036 kWh [66,357 kWhe for pre-heating air]

4. The LeMarchant Place Bld. has 46 flat-plate solar hot-water collectors mounted on the roof, with a total collector area of 136 m^2. Three shell and tube water-to-water heat exchangers are piped to 16 domestic hot water storage tanks that each hold 435 litres. The system is anticipated to produce 120,750 kWhe worth of energy annually.

5. A) 43 solar photovoltaic (PV) roof and wall mounted on the Student Union Bld (SUB) approximately a 14 kw system. Annual energy production is anticipated as 14,979 kWh annually.

b) 16 solar (PV) panels on the top of the Weldon Law Bld projected to produce 5022 kWh.

6. Solar Thermal and PV Panels are mounted on C Building for research.

7. 12 solar PV panel systems in the soccer field for a 3 kw system. Projected annual energy production (4434 kWh)

8. 469 solar PV panels are providing power to the EMERA IDEA and Richard Murray Design Blds. Projected to provide 159,335 kWh of power annually.

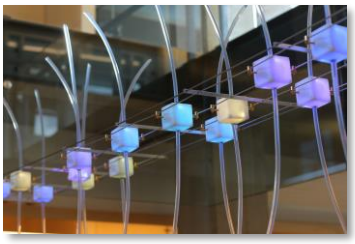
Energy & Water Efficiency

9. Energy & Water Upgrades:
Many projects have been completed to reduce the energy university's energy and water consumption including district energy scale upgrades, building retrofits and campus-wide measures. Several projects have been implemented including switching from steam to hot-water in the district energy system, campus-wide lighting and water fixture upgrades, energy performance upgrade of the LSC, SUB, and Tupper Bld, commercial kitchen upgrades, recommissioning projects, fridge-freezer exchanges, house energy retrofits, compressed air upgrades, and steam pipe insulation, and more.

Green Buildings

10.Mona Campbell Building (LEED® GOLD certified):

The Mona Campbell Building has many sustainable features, including:



Sustainability dashboard and interactive art piece:
Located on the third floor, *Patches* by Stephen Kelly is a 3-dimensional digital piece comprised of LED lights and subtle movements components that respond in real-time to the digital 'smart' systems that monitor and control the building's internal environmental conditions and energy use.

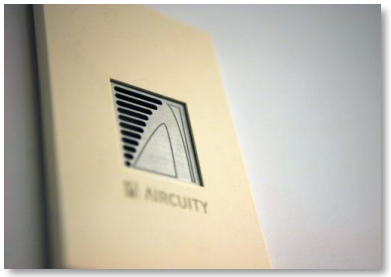
Cycling facilities:
The building has a bike room with two showers, 36 lockers and 32 indoor bike hanger racks. There are also 24 staple racks outside of the building, totaling over 72 bike parking spots for the building.

BubbleDeck concrete:
The concrete slabs in this building use BubbleDeck technology, which is concrete filled with hollow recycled plastic balls that reduce material and energy consumption. The BubbleDeck requires 30 percent less concrete, leading to further structural weight reduction throughout the building. This is the third installation of this technology in North America.

Construction and demolition waste recycled:
Approximately 90 percent of construction and demolition waste materials was diverted from landfills, including aggregates, wood, metals, cardboard, glass, asphalt shingles and salvaged building components. These materials were delivered to a local recycling facility (Halifax C&D Recycling).

Maple paneling:
Most of the wood products in this building were harvested from certified Forestry Stewardship Council (FSC) sources in Canada and the U.S. FSC certified wood is third-party verified as originating from well-managed and sustainable forests. Producers all along the supply chain must be FSC certified: from harvesting, to manufacturing, to distribution and to installation.

OptiNet sensors in classrooms:
OptiNet sensors are used to monitor and document indoor air quality factors such as carbon dioxide, total volatile organic compounds (TVOCs), carbon monoxide, humidity and small particles. Detrimental changes in any of these factors trigger an increase in the fresh air supply.



Low-flow water fixtures and rain cistern:
This facility utilizes low-flow faucets (1.9 litres per minute) dual-mode toilets (4.2 and 6 litres per flush) urinals (0.5 litres per flush) [4 – 11+], and low-flow showerheads (5.7 litres per minute. It is projected that potable water use will be reduced by 67% compared to a typical building. A cistern located in the basement can hold 77,000 litres of rainwater used for toilets, urinals, and green roof.

Low emitting sealants and paints:
Most of the finishes have zero or low emissions. These materials reduce the release of significant pollutants, such as volatile organic compounds (VOCs), into the indoor environment. All manufactured wood products are produced with no added urea formaldehyde (NAF). These measures make for a healthier indoor environment.

Heat pumps:
85 heat pumps provide a portion of the heat load. A heat pump extracts heat from one location and transfers it to another. The heat pump system is projected to consume 55% less energy for heating and cooling than a typical building.

Lights:
All lighting in the building is modeled at being 57% better than the national model energy code. This is achieved through efficient lighting fixture placement, the use of high efficiency T8s, exterior LED canopy lighting, maximizing natural light, and lighting controls.

Solar wall:
The solar wall is projected to provide a 15% reduction in energy needed to heat ventilation air. The wall is comprised of a double-walled metal cladding system that absorbs heat and draws the outside air up between the two walls. The heat from the backside of the metal preheats ventilation air, thus reducing the need for mechanical heating.

Green roof and white roof:
The vegetative green roof helps filter pollutants from the air and rainwater, increases biodiversity, reduces stormwater runoff, reduces heat loss, and increases the roof's life span. The plants on the green roof include varieties of Chives, Blue Fescue, Stonecrop, and Sedum. Soil depth is approximately 4-6 inches. The white roof reflects heat instead of absorbing it, reducing air conditioning use during summer months. The roofs help mitigate the "Urban Heat Island Effect".

11. Steele Ocean Sciences Building (LEED® SILVER certified):

Sustainable features of the Oceans Sciences include:

Electric charge station:
The first Dalhousie electric charge car station is located at the Oceans Science Building. The charge station uses 6 kilowatt-hours of power to charge a vehicle providing a full charge in four to six hours.

Permeable pavement:
A strip of permeable pavement is installed at the back end of the Ocean Science Building parking lot. The lot is designed so that water is directed towards this section of the parking lot. Water slowly percolates through the pavement, reducing run off.

Lighting:
Passive lighting design is used to help light parts of the building such as the Atrium. LED lighting is used in interior and exterior fixtures along with high efficiency T8s. Spaces throughout the building utilize either occupancy or vacancy sensors to reduce the amount of energy used for lighting. Light level sensors with automatic dimming controls are installed where natural light is available, further reducing the amount of energy used for lighting.

Cycling facilities:
Bicycle racks and provided indoors (10 spots) and outdoors (30 spots). Inside a shower is provided, 20 lockers, and a water fountain. With the outdoor racks a bicycle Fixit station is available.

Green building education:
A green building video was created in 2014 that highlights the green features of the Ocean Science Building.

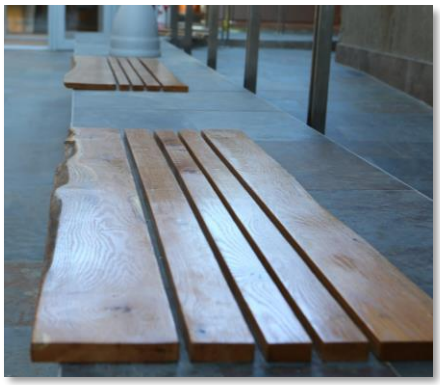
Green cleaning and waste management:
Green cleaning products and practices outlined in Dalhousie's green cleaning policy are used in the building. Four-bin waste management systems are used throughout the building (paper, recyclables, organics, and waste). Universal and hazardous waste are also collected and recycled when possible.

Water: Low flow fixtures (1.9 lpm) and low flow toilets (4.8 lpf) are installed in the building. A prominent drinking water fountain (hydra-station) is showcased in the atrium to encourage reusable drinking water containers.

Air quality:
Most building finishes have zero or low emissions. These materials reduce the release of significant pollutants, such as volatile organic compounds (VOCs), into the indoor environment. As well, all manufactured wood products are produced with no added urea formaldehyde (NAF). These measures make for a healthier indoor environment.

Energy:
Seawater is pumped from the northwest arm to be used in research. Pumps and fan motors are 'premium efficiency'. The chilled beam HVAC system reduces energy consumption using conditioned outdoor air ducted from a central system and chilled water to condition air in the building. The air and the water are supplied at higher temperatures than a conventional system, which makes chilled beam more efficient and the spaces it, conditions more comfortable. Heat is also recovered from exhaust air. Controls on fume hoods and motors use Variable Frequency Drives so that the appropriate power can be supplied for a function rather that running a motor 100% power all the time.

Wood reuse and biomass replacement policy:
Approximately 47 trees of various sizes were removed to create space for this building. As part of Dalhousie's natural environment policy and guidelines an equal amount of biomass needed to be replaced. Money for this replacement was calculated and provided to replant biomass material on campus (trees and shrubs). The trees that were removed were shipped to a local non-profit organization. Some of this wood (oak, maple, birch) was dried in a solar kiln. This wood was used to create five benches in the Oceans Science Building atrium.



Other relevant building features include preferred parking for car-pooling, native species landscaping to provide biodiversity and bird habitat, and convenient bus access.

12. LeMarchant Place Building (LEED® GOLD certified):

Construction and Demolition Waste:

Four houses were on the site where the building stands. In each house over 86% of materials were diverted from the landfill through salvage and recycling efforts. In one of the four houses, deconstruction processes were used. This involves dismantling the house systems to achieve cleaner material and higher diversion rates. In this particular house, deconstruction achieved a 93% diversion rate. On the full project including construction and demolition (C&D), approximately 88% percent of C&D materials were diverted from landfills. This includes aggregates, wood, metals, cardboard, glass, asphalt shingles and salvaged building components.

Renewable Energy: Solar Domestic Water:

The building has 46 flat-plate solar hot-water collectors mounted on the roof, with a total collector area of 136 m^2. Three shell and tube water-to-water heat exchangers are piped to 16 domestic hot water storage tanks that each hold 435 litres. The system is anticipated to produce 127,180 kWhe worth of energy annually. A BTU meter measures the flow rate and the temperature into the system versus the temperature out. This information is used to calculate energy production.

Energy Efficiency:

Key energy efficiency measures used in the building are projected to save 42% of the energy compared to a typical building. Measures include:

• Ventilation heat recovery through the use of multiple energy recovery ventilators (ERVs).

• Variable Refrigerant Flow (VRF) heat-recovery heat-pump system. VRF systems can be 25% more efficient than traditional systems. System compressors can be controlled to match the exact load of the room conditions as opposed to running in either off or on mode. This system also utilizes heat

recovery by removing energy from one zone that doesn't need it, and applying it to a different zone that does.

• Variable speed drive pumps and fans. Controls on these units adjust the work level of the pumps and fans to match the required power requirements.

• Premium efficiency motors are typically 5% more efficient than standard motors. These motors have lower losses through enhanced insulation and design features such as more copper and efficient cooling.

• Reduced lighting power density with occupancy and daylight sensor controls are used throughout the building. LED lighting is utilized for exterior lighting. Inside, LED lighting is used in accent lighting, reception areas, vestibules, and quite areas. Through-out the rest of the building high efficiency T8s lamps are employed.

• High-performance, argon-filled, double-glazed windows with a low-e coating are used throughout the building.

• Enhanced, third-party, full building commissioning was utilized.

Green Cleaning and Waste Management:

Green cleaning products and practices outlined in Dalhousie's green cleaning policy are used in the building. Four-bin waste management systems are used throughout the building (paper, recyclables, organics, and waste). A specific waste bin space guideline was created for campus spaces. The LMU is the first building to apply these standards on campus.

Cycling Facilities:

28 bike spots are provided directly outside building entrances. Indoors two bike rooms are provided with end-of-trip facilities. One room is for student services employees. It includes 4 bike spots, 18 lockers, and 2 showers. Another shower is accessible in the main floor of the building. The second bike room is for residences and includes 61 bike spots. Students have access to showers and storage in residence areas.

Water: Low-Flow Fixtures and Rain-Water Cistern: This facility utilizes low-flow faucets (1.9 litres per minute); toilets (in residence dual flush 3/4.8 litres per flush and podium/public 4.8 litres per flush); urinals (0.5 litres per flush); and low-flow showerheads (7.5 litres per minute). A 20,000 litre rainwater cistern is located in the basement. Rainwater is used for the toilets, urinals, and green roof leading to a 48% reduction in potable water use.

Finishes: Most building finishes have zero or low emissions. These materials reduce the release of significant pollutants, such as volatile organic compounds (VOCs), into the indoor environment. As well, all manufactured wood products are produced with no added urea formaldehyde (NAF). These measures make for a healthier indoor environment. FSC certified wood was used in architectural trim, reception desks, and residence kitchen areas.

Green Roof: Once final commissioning of the roof has been complete, there will be On level three, four vegetative green roofs help filter pollutants from the air and rainwater, increases biodiversity, reduce stormwater runoff, reduce heat loss, and increase the roof's life span. In total the green roofs cover an area of 218 square metres. Over 10 varieties of sedums are used. The roof soil depth is between 7.5–12.5 centimeters. The system helps to mitigate the "Urban Heat Island Effect".

13. Wallace McCain Learning Commons: (LEED® Silver certified):

Transportation:
The WMLC is conveniently located near local transit with three bus routes servicing stops within a 300 m distance. 40 bike parking spots are prominently located at the front of the building, acting as a bike parking hub for the Commons and the Life Science Centre. Ride Share spots are made available in any of Dalhousie parking lots including the lot beside the WMLC.

ENERGY EFFICIENCY: Key energy efficiency measures used in the building are projected to save 56% of the energy compared to a typical building. Measures include:

- Being the first building on campus to use all LED lighting inside and out.
- Variable Refrigerant Flow (VRF) heat-recovery heat- pump system is used in the building. VRF systems are more than twice as efficient as fossil fuel based heating systems. System compressors can be controlled to match the exact load of the room conditions as opposed to running in either off or on mode. This system also utilizes heat recovery by removing energy from one zone that doesn't need it, and applying it to a different zone that does.
- C02 sensors have been installed to enable more accurate control over ventilation.

Finishes: Forest Stewardship Council (FSC) certified wood was used in finished carpentry and architectural woodwork. Most building finishes have zero or low emissions. These materials reduce the release of significant pollutants, such as volatile organic compounds (VOCs), into the indoor environment. As well, all manufactured wood products are produced with no added urea formaldehyde (NAF). These measures make for a healthier indoor environment.

NATURAL ENVIRONMENT

50% of the roof has an accessible green roof consisting of a seed mix considered adaptive and drought tolerant in our climate. Some trees on the site infront of the building were protected. Of the trees that were cut the university biomass replacement guideline will be used to replace an equivalent amount.

WATER: LOW-FLOW FIXTURES AND BOTTLE FILL FOUNTAIN: This facility utilizes low-flow faucets (1.9 liters per minute) and 4.8 liter low-flow toilets. A shower is located nearby in the Life Science facility. A refillable bottle station and fountain are prominently displayed.

CONSTRUCTION AND DEMOLITION (C&D) WASTE: On the full project, including construction and demolition (C&D), over 75% of C&D materials were diverted from landfills. This includes aggregates, wood, metals, cardboard, glass, and salvaged building components. These materials were delivered to local recycling facilities.

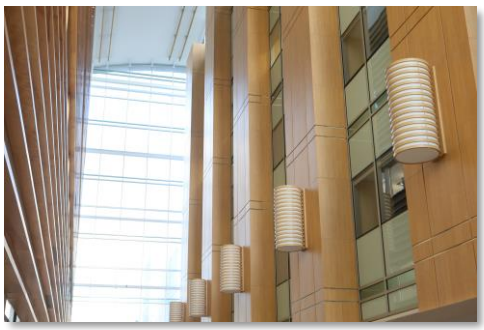
GREEN BUILDING EDUCATION: WMLC green features will be outlined in the Campus Sustainability Tour map. In addition green building tours will be provided for this building accompanied by a two-page fact sheet.

GREEN CLEANING AND WASTE MANAGEMENT: Green cleaning products and practices outlined in Dalhousie's green cleaning policy are used in the building. Four-bin waste management systems are used throughout the building (paper, recyclables, organics, and waste).

ONGOING ENERGY MANAGEMENT: Utility meter information from the building will be used for ongoing energy and water management. Also, allowances were made for future installation of sub-metering equipment.

14. Life Science Research Institute (LEED® SILVER Certified)

The Life Science Research Institute (LSRI) has a number of sustainable features, including:



Lighting: Passive lighting design is used to help light parts of the building such as the Atrium. LED lighting is used in interior and exterior fixtures along with high efficiency T8s. Occupant sensors and daylight-sensing dimming are used for lighting controls.

Cycling Facilities: Bicycle racks are provided indoors (33 spots) and outdoors (46 spots). Showers are on the main floor of the building, to encourage the use of bicycles by staff and visitors.

Green Building Education: A green building video will be created in 2014 that highlights the green features of the Ocean Science Building and LSRI. This information will be added to our online Campus Sustainability Tour map. In addition, green building tours of this building will be provided.

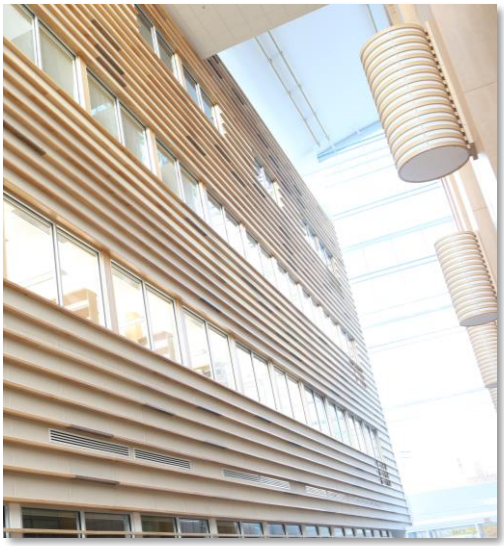
Green Cleaning and Waste Management: Green cleaning products and practices outlined in Dalhousie's green cleaning policy are used in the building. Four-bin waste management systems are used throughout the building (paper, recyclables, organics, and waste).

Water: Landscaping was designed to eliminate the need for permanent irrigation by using drought tolerant native species. Low-flow fixtures (1.9 lpm), low-flow toilets (3 lpf), dual-flush toilets (6/4.5 lpf) and low-flow urinals (1.9 lpf) are installed in the building.

Air Quality: Most building finishes have zero or low emissions. These materials reduce the release of significant pollutants, such as volatile organic compounds (VOCs), into the indoor environment. As well, all manufactured wood products are produced with no added urea formaldehyde (NAF). These measures make for a healthier indoor environment.

Energy:

- Energy savings through Demand control ventilation controlled by an Optinet system sets the outdoor air ventilation rate based on the measured concentration of contaminants within rooms. Increased ventilation effectiveness with Aircuity Optinet system monitors air quality and adjust ventilation as required versus traditional systems. A run around heat recovery system is installed in the Air Handling Units that allows heat to be recovered from the exhaust air and used to preheat the fresh air to the building during the heating season.
- Motors for mechanical equipment (fans and pumps) are premium efficiency.
- The cooling system incorporates variable speed drives on the pumps and the cooling tower to more closely match the energy consumed with the load.
- The AHU fans are driven by Variable Speed Drives, which adjust the fan speed as the system pressure requirements change (as measured downstream of the AHU). For instance, as the filters gradually get dirtier the fan is speeded up to compensate for the increased pressure drop. When the building is unoccupied the fans run at a much lower speed to maintain a low air circulation in the building. A smaller air volume flow rate uses less electrical energy to drive the fan as well as requiring less energy to heat / cool / humidify the air. The filter life is also extended.
- Building envelope with R-20 walls and R30 roof, argon filled, low E double-glazing with non-metallic thermal break on curtain wall glazing.



Materials: To encourage environmentally responsible forest management, emphasis was placed on using sustainable wood products that meet FSC (Forestry Stewardship Council) certification. **68% of all wood in LSRI is FSC certified.**

Construction and Demolition: Throughout construction, a high priority was placed on sorting recyclables from construction waste, leading to 93.2% of waste diversion from landfills. Diverted construction and demolition materials include aggregates, wood, metals, cardboard, glass, asphalt shingles and salvaged building components. These materials were delivered to local recycling facilities, including Halifax C&D near Exhibition Park.

Other green features include preferred parking for car-pooling, native species landscaping to provide biodiversity and bird habitat, convenient bus access, building materials selected on basis of maximum recycled content, and regionally manufactured.

15. Collaborative Health Education Bld (CHEB) (LEED® Gold candidate)

GREEN BUILDING FEATURES

TRANSPORTATION

CHEB is conveniently located near local transit with nine bus routes servicing stops within a 400 m distance. Thirty-two bike parking spots are located at the entrance of the building and eight spots are located inside. Public shower facilities are available in the connected building beside CHEB. Ride Share spots are made available in any of Dalhousie parking lots. Car share spots are located across the street and around the corner.

ENERGY EFFICIENCY

Key energy efficiency measures used in the building are projected to save 40% of the energy compared to a typical building. Measures include:

- Reduced lighting power density with occupancy sensor controls are used throughout the building. LED lighting is utilized for exterior lighting and most public areas inside the building. High efficiency T8 fluorescent lamps are utilized in service spaces.
- A “dual-core” heat recovery air handling unit recovers up to 90% of the heat from the exhaust air leaving the building; this energy is used to heat the incoming outdoor air entering the building.
- The ventilation air is ducted to “active chilled beams” within each space; the primary air is used to induce room air from the space which mix together to satisfy the space cooling loads. The primary airflow passing through the chilled beams is typically 1/3 to 1/2 of the air required by conventional HVAC systems; this equates to smaller air handling units, smaller ductwork, and results in significant fan energy savings.
- All heating/cooling pumps and all air handling unit fans are equipped with variable frequency drives (VFD’s) that reduce the motor speed when loads are reduced thereby reducing the building’s electrical consumption.
- “Carbon dioxide (CO2) demand-control ventilation” is utilized throughout the facility to measure the CO2 levels within each of the spaces and adjust (decrease/increase) the amount of outdoor air (which has to conditioned - filtered, heated, cooled, humidified & dehumidified) supplied to the space.
- Enhanced commissioning was performed on the CHEB. This includes third-party comprehensive document review, commissioning of major energy systems, building walk through and preparation of systems manual. Post occupancy energy data will be analyzed against energy models to identify performance, trends, and opportunities.

FINISHES

CarbonCure concrete blocks were used in the basement level of the building. CarbonCure’s technology captures C02 from industrial sources and uses this in the production of new concrete blocks. The blocks become carbon sinks as the injected C02 reacts with cement to produce limestone. This makes the blocks stronger with less cement and permanently locks the GHGs into the block.

Over 36% of the material in the building were made from recycled content including steel, aluminum framing, pre-finished metal panels, and carpet. Forest Stewardship Council (FSC) certified wood is used in millwork and doors. Most building finishes have zero or low emissions. These measures make for a healthier indoor environment.

NATURAL ENVIRONMENT

A number of native and adaptive species have been planted including sugar and red maples, dogwood and lavender. Of the trees that were cut on site, the new plantings on the site and the university biomass replacement guideline will be used to replace an equivalent amount. 100% of the roof is light-coloured to help reflect incoming sunlight and reduce the roof temperature and associated air in the summer time.

WATER: LOW-FLOW FIXTURES AND FOUNTAIN

This facility utilizes low-flow faucets (1.9 liters per minute) and dual-flush low-flow toilets (4.2/6 Liters/flush). A shower is located nearby in the connected building. A refillable bottle station and fountain are prominently displayed.

CONSTRUCTION AND DEMOLITION (C&D) WASTE AND SITE REMEDIATION

On the project, including construction and demolition (C&D), over 89% of C&D materials were diverted from landfills. This includes aggregates, wood, metals, cardboard, glass, and salvaged building components. These materials were delivered to local recycling facilities.

GREEN CLEANING AND WASTE MANAGEMENT

Green cleaning products and practices outlined in Dalhousie's green cleaning policy are used in the building. Four-bin waste management systems are used throughout the building (paper, recyclables, organics, and waste).

GREEN BUILDING EDUCATION

CHEB green features will be outlined in the Campus Sustainability Tour map. In addition green building tours will be provided for this building accompanied by a two-page fact sheet. Utility meter information from the building will be used for ongoing energy and water management.

16. EMERA IDEA and Richard Murray Design Bld. - (LEED® Gold candidate)

Energy Efficiency through Design and Systems

IDEA & Design Building Envelope:
The building roof systems has an average R value of 40; the wall systems R value of 30. Combined with the high-performance curtain wall system, the building's envelope is dramatically more energy efficient than an equivalent code compliant commercial building. With the increased insulation and construction of the building, the HVAC and controls systems have been designed to utilize the building's mass as thermal storage, further reducing peak heating and cooling demands. Most of the building windows are double-glazed; however, the north side of the Design building has triple-glazed windows.

Air and water leakage can be a significant contributor to the designed performance of building envelope systems. Dalhousie has air leakage standards that were used to test some window/wall assemblies.

Efficient Systems:

Key energy efficiency measures include:

- Reduced lighting power density using natural daylighting, occupancy sensor controls, and LED lighting.
- A radiant heating and cooling system reduces energy use compared to air based systems by using small horsepower pumps rather than large horsepower fans.
- Heat is recovered from exhaust air with energy recovery wheels and transferred to incoming ventilation air reducing heating and cooling requirements.
- All heating/cooling pumps and all air handling unit fans are equipped with variable frequency drives (VFD's) that reduce the motor speed.
- "Carbon dioxide (CO2) demand-control ventilation" is utilized throughout the facility to measure the CO2 levels within each of the spaces and adjust (decrease/increase) the amount of outdoor air.
- Enhanced commissioning was performed. This includes third-party comprehensive document review.

Renewable Energy

Earth Energy: The ground absorbs energy from the sun. It acts like a battery in storing relatively constant temperatures all-year round. A test well was used before the installation to determine the thermal conductivity of the ground and average ground temperature of 10.9 degrees Celsius.

A 60 borehole geo-exchange field provides a heat source/heat sink not only to the IDEA and Design Buildings but also to nearby buildings, thereby reducing the energy use and reliance of fossil fuels for the whole campus. The field is situated in the Sexton soccer field. Each bore hole is drilled 500 feet deep. The bore hole is filled with a conductive grouting compound to prevent surface water from penetrating the underground aquifier. Polyethylene piping is snaked through the bore holes. In the pipe, a food grade glycol/water solution is used to capture energy from the ground through heat transfer. This is a closed loop system so the same solution circulates repeatedly between the building and the bore holes.

In the summer, the cooler ground temperatures allow heat to be rejected from the fluid into the near-by ground and in the winter the warmer ground provides heat to the piping fluid for heating. Near the surface, three boreholes are connected on one horizontal loop. Twenty loops are brought into the basement of the Design

building to a header. From the header heating or cooling energy is extracted from the fluid through a heat pump system within the buildings. The heat pumps can provide all the cooling and 95% of the heating energy.

Solar PV and Energy Storage: 469 solar photovoltaics (PV) panels are mounted on the IDEA and Design building roofs converting solar light to electricity. The system has the capacity to generate 150 kW of DC power and to deliver 125kW of AC power through its inverters. The PV panels are ballasted mounted at 10° angle to maximize energy production while minimizing shading between rows of panels. Annual electricity production is anticipated at 159,335kWh or roughly 25% of the annual electricity needs of the building. The solar PV system is connected to the building electrical system. Also connected to the building is an electrical battery energy storage system and software. This emulated micro-grid infrastructure will enable research investigation and peak saving opportunities for operations.

The L1000 Distributed Energy Storage, provided by Johnson Controls, consists of two 92 kWh battery units with two 50 kW inverters creating a total rated storage of 184kWh. The main chemistry makeup of batteries is Lithium Ion technology. The systems are integrated into the building automation system to improve monitoring and control.

Transportation

The Innovation and Design Buildings are conveniently located near local transit with over 15 bus routes servicing stops within a 400 m distance. Within 180 m of the two new buildings 94 bike parking spots are located and 10 spots are located inside in the new bike room area. Shower facilities are available on campus in the Sexton Gym. An on-campus Car Share spot is located in a campus parking spot next to the IDEA and Design Buildings along with a level 2 electric vehicle charge station providing a full charge in 4 – 6 hours.

As part of the IDEA project, the Green Corridor is designed to address issues concerning storm water, biodiversity, and active transportation. The corridor is approximately 300m in length, and serves to improve pedestrian and cyclist accessibility and safety from Spring Garden Road in the north to Morris Street in the South.

The corridor includes dedicated space and edging markings and symbols to denote the lane. Transportation counters will be used on the lane to conduct ongoing research. A new pedestrian and cycling pathway through the campus, replaces compacted earth and gravel at the first section of the corridor with permeable pavers and natural retention gardens. Permeable pavers include 150mm of base gravel and a minimum of 450mm of sub-base gravel; these layers are open-graded stone with approximately 20-30% void space for storage of rainwater. The subgrade is sloped to a low infiltration area.

Storm Water Management and Water Efficiency

Water: Low-Flow Fixtures and Fountain
This facility utilizes low-flow faucets (1.9 liters per minute) low-flow toilets (4.8 Liters/flush). Refillable bottle stations and fountains are prominently displayed to reduce single use bottle usage.

Rainwater Cistern: Rainwater is collected from roof drains on the Design building, is filtered, and stored in a 25,000 litre fiberglass tank in the basement of the building. Rainwater is treated with UV light before it is used for toilet and urinal flushing.

Green Roof: The extensive green roof, located on the Design building, provides biodiversity, heat island, and stormwater benefits. The roof is designed for testing various planting species, green roof applications, stormwater retention, and evaporative cooling trends. The green roof assembly five inches of growth medium, and sedum plantings.

Process Water: Connected to the IDEA building are other research buildings that were using once through potable water for cooling. With the installation of the geo-exchange system, cooling will be provided by this system instead thus reducing a significant amount of water annually.

Materials & Waste Management

Construction and Demolition (C&D) Waste and Site Remediation
On the project, including construction and demolition (C&D), over 79% of C&D materials were diverted from landfills .This includes aggregates, wood, metals, cardboard, glass, and salvaged building components. These materials were delivered to local recycling facilities.

C& D Depot: Wood, metal, and concrete materials are used extensively in the academic programs of the Sexton campus. An improved and consolidated area for Construction & Demolition (C&D) wastes has been created to make it easier to sort and store the materials for collection into the appropriate waste streams for recycling.

Green Cleaning and Waste Management
Green cleaning products and practices outlined in Dalhousie's green cleaning policy are used in the building. Four-bin waste management systems are used throughout the building (paper, recyclables, organics, and waste).

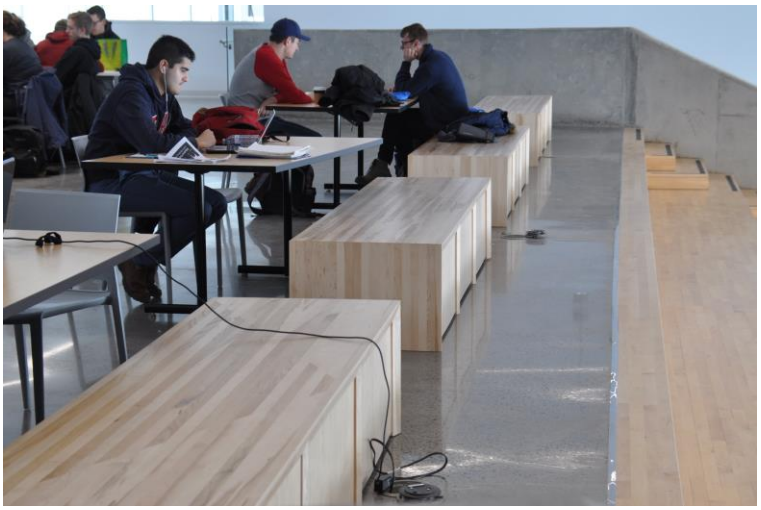
Finishes
Most building finishes have zero or low emissions. These materials reduce the release of significant pollutants, such as volatile organic compounds (VOCs), into the indoor environment. As well, all manufactured wood products are produced with no added urea formaldehyde (NAF). These measures make for a healthier indoor environment.

Most wood products used throughout the building have been sustainably harvested as defined by third party forest certification bodies, such as the Forest Stewardship Council (FSC). From harvest, to manufacturing and distribution, FSC certification is given to companies and landowners to verify that they practice sustainable forestry that is consistent with FSC standards.

Biodiversity

Dalhousie has a Natural Environment Plan that requires biomass replacement. All 17 trees that come down for the IDEA project were replaced with and equal amount of biomass planted on Dalhousie campuses equalling 178 trees of 5 cm caliper.

Some of the trees on site were used to makes benches for the buildings. The bulk of the benches were made from maple, with the pattern accents in red oak.



For the stormwater retention areas in the green corridor, native plants have been selected with consideration of planting area micro-climate and enhancement of biodiversity. The plaza area “butterfly garden” attracts butterflies and other pollinators, and the Serviceberry plantings along the corridor provide food and shelter for birds.

Education

The central and subsystems of the building and the outdoor environments are used for operations, research and teaching purposes. Key features incorporated include:

- Sensors, meters, gauges have been installed to monitor electrical, water, temperature, precipitation, wind, heat, cooling, solar pv, geothermal, wall temperatures, and car/pedestrian/cycling movement. The data from sensors and meters are integrated into building automation software that can be accessible to researchers and students in enough resolution for research.

- sustainability features outlined in campus programs. Green building tours are provided for the buildings. A video about the sustainable features of the project has been created and used for teaching, community presentations, and certification purposes. Socially relevant building exhibits have been commissioned and installed regarding Black Nova Scotian and Mi’kmaw culture. Green building signage and dashboard have been created. Utility meter information from the building will be used for ongoing energy and water management.

17. Fitness Centre (LEED® Gold candidate)

Transportation

The Fitness Centre is conveniently located near four bus routes servicing stops within a 400 m distance. 24 bike parking spots are located at the front entrance of the building, an additional 32 are on the north side of the building on South Street, and 6 spots are located inside. Shower facilities are available in the Fitness Centre and at the Dalplex. A car share spot is located within 400 meters of the facility. Six Level Two electric charging outlets are available for campus and community members – bringing a car to a full charge in 4 hrs.

Energy

Key energy efficiency measures used in the building are projected to save 32% of the energy compared to a typical building. Measures include:

- High performance glazing systems and highly insulated walls and roofs complement this building shape. Walls achieve a thermal resistance of R25, while the roof is heavily insulated achieving R40 thermal resistance.
- Carefully located skylights and interior clerestory windows helps the Fitness Centre achieve daylight penetration deep into the core of the building.
- Occupancy sensor controls and LED lighting are used throughout the building.
- A heat recovery air handling unit recovers up to 85% of the heat from the exhaust air leaving the building. This energy is used to heat the incoming outdoor air entering the building.
- High efficiency fans and pumps are installed with variable frequency drives. The chiller has been installed with a free cooling system that will allow chilled water to be produced without using the compressors during the shoulder seasons.
- Cooling systems were specified with refrigerants that minimize ozone depletion and global warming.
- Enhanced commissioning was performed on the Fitness Centre.
- A post-occupancy measurement and verification plan will be employed to evaluate and verify the performance of the building.
- The building structure is designed to be “solar ready” meaning roof structures can hold the weight of future solar photovoltaics with the appropriate conduit already in-place.

Water: Low-Flow Fixtures and Fountain

The new facility reduces the use of municipal potable water use through low-flow plumbing fixtures. The project achieved a potable water use reduction of 36%. Installed low flow faucets, toilets urinals and showers. Water bottle filling stations and drinking fountains are conveniently located.

Construction and Demolition (C&D) Waste

On the project, including construction and demolition (C&D), over 84% of C&D materials were diverted from the landfill. This includes aggregates, wood, metals, cardboard, glass, and salvaged building components. These materials were delivered to local recycling facilities.

Materials from the existing houses and student residences on site were extensively salvaged, re-used and recycled. Over 4 tonnes of materials, such as doors, windows, exit signs and emergency lights were given for use at other local charity projects. 750 tonnes of foundation materials were reused as structural fill on site, offsetting the need for virgin material. Nearly 200 tonnes of asphalt was recycled at a local hot-mix asphalt plant.

Natural Environment
Native and adaptive species have been planted including spruce, poplar, hemlock, blueberries & sweetgrass. All plants were selected from the University Natural Environment Approved Species List. There are no irrigation systems for any of the site plantings.

A large bioswale approx. 90 meters long is installed at the front of the building which slows down storm and rain water and creates biodiversity with the planting of sweetfern, red fescue and sweet grass.

Finishes and Materials
Special care was taken in material selection to provide a sustainable, healthful and resilient building. Some measures include:

- Material in the building were made from recycled content including structural steel, reinforcing steel, pre-finished metal panels, athletic rubber and hardwood flooring systems, drywall, tiles, and metal lockers.
- All wood products in the building are certified under the Forest Stewardship Council (FSC) program.
- Paints, sealants, adhesives, and many other construction materials were specifically selected on this project for their low levels of VOCs.
- Indoor air quality testing will be conducted after the project's substantial completion to verify all pollutant levels at significantly lower concentrations than the LEED thresholds.

Green Cleaning and Waste Management
Green cleaning products and practices outlined in Dalhousie's green cleaning policy are used in the building. Four-bin waste management systems are used throughout the building (paper, recyclables, organics, and waste).

Green Building Education
Fitness Centre green features are outlined in the Campus Sustainability Tour map and in building signage. In addition, green building tours are provided. Utility meter information from the building will be used for ongoing energy and water management.

Storm Water Management

18. Permeable pavement:

There is a permeable pavement strip on the back of the Oceans Sciences building. The lot is designed so that water is directed towards this section of the parking lot. Water percolates through the pavement, reducing run off. The pavement needs to be cleaned to keep soil from blocking permeable aspects. A vegetative swale has been added below the installation to add an extra buffer.

19. Rain garden:

Found at the Corner of Coburg and Oxford, this rain garden was built as demonstration site for a residential rain garden. A partnership was struck between the Ecology Action Centre (EAC) and the Dalhousie University Office of Sustainability and Facilities Management to design a rain garden for stormwater.

Planted berms are used to contain water in the garden. This garden highlights ten plant species that are native to Nova Scotia and that have performed well in previous rain gardens. Plants have also been selected for their ability to attract wildlife (such as pollinators and birds).

20. Green Roof at Dentistry is between Dentistry Building and Burbidge buildings to help slow down storm water.

Cycling and Transit

21. Sustainable Transport

Hundreds of bike racks are installed across campus. The Dalhousie Bike Centre located at the Studley Gym offers free bike loans, educational events and workshops, and help with minor bike repairs. Bike Fixit repair stands are located in front of the Student Union Building and with the bike racks at the Ocean Sciences Building and on Sexton campus beside the Mining Bld and O'Brien Hall.

Dalhousie has student and employee bus pass programs, which offer HRM Metro Transit bus passes at a reduced rate.

Dalhousie is also a site for the Guaranteed Ride Home Program (GRH) with the Halifax Regional Municipality. The GRH program is offered to employees who commute to work at least three times a week by carpool, vanpool, transit, bike, or walking. It provides those commuters with up to 5 free taxi rides per year in the event of a **personal emergency or unexpected overtime.**

Gardens and Natural Environment

22. Natural Environment:

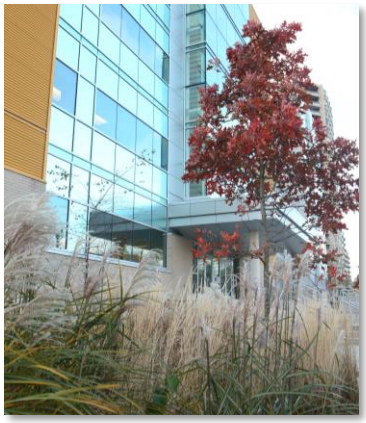
The Dalhousie Community Garden is located behind the Computer Science Building. It is run by the student society – Dalhousie Urban Garden Society. The Garden operates as an educational space for students, staff, and community members to learn about the possibilities of urban agriculture, with the produce going to volunteers and the Loaded Ladle. Students also take advantage of the Urban Roots farm space.

The Studley campus is home a long time functioning green roof system. In particular, a 40 year old at-grade green roof between the Henry Hicks Administration Building and the Life Sciences Centre planted with trees, shrubs, and turf.

In the southwest corner of the campus, behind Sherriff Hall, there is a naturalized oak stand that boasts a 250-year-old oak. Ocean Pond, a constructed wetland ecosystem, was installed to demonstrate on of Nova Scotia's natural wetland ecosystems. This pond is used for research and class work.

In 2009–2010, all trees and shrubs on the Halifax campuses were inventoried. **In total, there are 940 trees and 1040 shrubs on campus representing 113 species of woody plants**. Norway maple, an invasive European tree species, dramatically dominates the campus tree population. Tree management efforts have been initiated that will see improvements to tree species diversity and to balance tree age and size-class structure. An emphasis has been placed on the use of native and Acadian forest plant species.

Dalhousie requires that new infrastructure projects preserve existing trees. A tree protection plan is required when construction activity may negatively affect trees. A project that requires the removal of a tree must replace the tree with an equal biomass 1:1 ratio of new vegetation. Based on the implementation of this guideline, 462 native and adapted trees have been planted in the last five years (2013-2018) at and around the Halifax campuses and on the Agricultural campus.



Biodiversity replacement programs are in place that will restore native and adapted species. The corner of Summer St. and College St. is an example of a landscape that has been naturalized- planted primarily with native species.

Vehicle Share

23. Dalhousie has signed a workplace agreement with CarShareAtlantic. CarShareAtlantic provides access to cars that can be used for workplace travel and ride sharing. Dalhousie departments and faculties can access the fleet of cars around Halifax. Presently, there are three cars on campus; one car is located on the Studley campus by the Grad House and one is on the Carleton campus by the Dentistry Building and the other on Sexton campus. Car sharing supports sustainable transportation options for employees for their daily commute. Dalhousie offers reserved parking spots as part of our Ride Share program a reduced rate for vehicles with multiple occupants. Dalhousie has idle-free and vehicle share/green fleet guidelines and signs around campus.

Sustainability Offices/Curriculum

24. Curriculum: Dalhousie has hundreds of courses and programs on environment, sustainability, and society across faculties. Visit the **College of Sustainability** on the first floor of the Mona Campbell Building, Environmental Science Dept. 8th Floor LSC and School for Resource and Environmental Studies at the Ken Rowe Bld. as a few examples.

25. Operations: Located in the Central Services Building, the University Office of Sustainability supports solutions that create positive social, ecological and economic change in university operations. The Office works to incorporate sustainability concepts and criteria into policy and planning, building and retrofit projects, and campus action.

The Central Services Building hosts the heating plant the heart of the campus District Energy System. In 2011, the main heating plant which provides heat to over 95% of all three Halifax campuses was converted from bunker C to natural gas. High pressure steam is created through two large boilers and sent through steam tunnels to each building. In 2015-2016 the Sexton campus was converted to hot water. This saves energy in steam losses.

26. Student Engagement - The Dalhousie Student Union Sustainability Office (DSUSO): Located in the Student Union Building (SUB) on the 2nd floor, DSUSO engages the Dalhousie Student Union and the campus community with sustainability. There are also many Dalhousie student societies that have an environment and sustainability focus.

Waste Management

Dalhousie recycles and composts electronics, organic material, paper and cardboard, recyclables, construction and demolition material, white goods, universal and some hazardous waste items like batteries and paint on all campuses. Look for four-bin sorting systems in every

Agricultural Campus

Renewable Energy

1. **Solar panels on TREEhouse:**

Eight Solar PV are panels (1 Kw) are in installed on the TREEhouse. The TREEhouse is a space for research, teaching and design of sustainable building materials.

2. Central Heating Plant:

The main campus heating plant provides heating to 95% of the campus on a district energy system using biomass as the main fuel. Through the project, the steam distribution system has been replaced with a district hot water system which is 30% more energy efficient. The old wood biomass steam boiler has been replaced with a biomass fired based thermal oil heater. The thermal oil heat moves a 1 MW turbine used to create electricity. This efficient organic rankine cycle (ORC) system is a first installation of its kind at a University campus in North America. Process thermal energy is used for heating the campus. A new air emissions management system was added along with two fuel storage bays. High efficiency pumps have been integrated to circulate hot water. We have smart meters and controls installed to monitor and optimize plant performance.

Energy & Water

3. Many projects have been completed including campus lighting and housing energy upgrades. A renewable energy study for the campus has been completed. Energy efficiency projects such as high efficiency pumps and fridge-freezer exchange have also been implemented.

4. The Bio-Environmental Engineering Centre (BECC) is a research and demonstration site operated jointly by the Faculty of Agriculture's Engineering Department and Dalhousie University's Department of Biological Engineering. Established in 1992, BEEC is located at Perennia (AgriTech Park) in Bible Hill, just a few kilometers from the Agricultural Campus. Research is being conducted on projects such as wind energy and farm silos and grass fueled burners.

Green Buildings

5. The TREEhouse project - the "TREE" part standing for technology for the responsible use of energy and the environment - represents an innovative project that combines applied research, teaching and innovative design in the creation of a sustainable working environment.

The goal of this project is to produce a research building that will allow modern, “green” building materials to be applied, compared and evaluated, while providing students with the opportunity to gain hands-on understanding in modern building practices, recycled products, and innovative designs. The TREEhouse has different types of insulation in it that is being monitored for thermal performance. Efficient lighting including LED tube lighting and low-flow fixtures have also been installed.

StormWater Management

6. Off campus at Perennia , research is underway on using natural vegetative systems to manage storm and wastewater. The AgriTech Park is located a few kilometers away from the Agricultural main Campus.

7. Bioswale: A bioswale was designed and implemented by the Master Gardens class of 2016 to deal with Stormwater run-off at the head of River Road. A variety of plants were used in the installation including Hosta, Daylilly, Coneflower, and Campanula.

Cycling/Vehicles

8. At the Athletics Centre, students can borrow a bike for free to get around. Bicycles located can be borrowed for up to one day at a time. Bike racks are provided around campus. A bike corridor (Cobequid Trail) passes through the back of campus. In addition, some of the campus fleet vehicles are electric.

Gardens and Natural Environment

9. The Agricultural Campus has numerous gardens, some of which are listed below, as well as a community garden for community and campus members. Friends of the Gardens was created to help maintain the specialist plant collections on campus, including the Alumni Gardens, Herb Garden, and Native Plant Garden.

The Rock Garden is a centre for education concerning alpine and saxatile plants, and how to create effective habitats in which to grow them. The Rock Garden is just over half an acre and not only beautifies the campus but also offers environmental horticulture students opportunities to gain experience with uncommon plants. The garden also features two cedar bridges constructed by students in the wood construction techniques class.

The Herb Garden has a combination of medicinal and culinary plants as well as some dye plants. It is laid out in a traditional “four-quarter" design, which predates medieval gardens. There are two quadrants with a blue/mauve/pink colour scheme, a white quadrant, and a gold quadrant.

The Butterfly Garden is half-acre site that will be managed for the creation of butterfly habitat. The vegetation will be allowed to grow long and the

already present wildflowers will be encouraged. Additional perennial flowers and shrubs, which provide the necessary nectar and foliage for butterflies, will be added. Native plants important for butterfly species that have been added include: Queen Anne's lace, yarrow, asters, goldenrod and clovers. Exotic species added for the butterflies include: Lilac, Monarda, Nepeta, and Evening Primrose.

The Alumni Gardens was originally a research nursery where the performance of plants and their winter hardiness under Truro conditions. Over time, the Alumni Association encouraged its development as a garden and the garden layout has changed as Landscape Horticulture students implement new projects.

The Chef's Garden enables the Agricultural Campus to supply our own vegetables for on-campus dining and education. The vision is for the garden to act as a living classroom that also acts as a collection space for plants. The Chef's Garden was started by a former student, Meghan Summers, who did her fourth year project on creating a market garden on campus.

Native vegetation is displayed throughout the campus. Some of the landscapes that host native species include the native plant garden around the McRea Library and the Cobequid trail system along the southern edge of the campus.

Curriculum

10. The AC campus offers a variety of programs and courses across the four departments. As an example visit Environmental Science and Integrated Environmental Management program at the Banting Bld.

Waste Management

11. The Waste Management Research program at the Agricultural Campus focuses on environmental sustainability and value-addition approaches to agricultural and non-agricultural by-products. Waste research at the Agriculture Campus has included:

- The impact of livestock manure storage conditions on greenhouse gas emission

- Monitoring of pharmaceuticals in soils and water from municipal bio-solids
- Composting of agricultural and non-agricultural organic by-products
- Conversion of organic wastes into biomass fuels
- The use of composts as containment systems for oil spills
- The development of commercial bio-fertilizers for use in organic agriculture

All Dalhousie campuses recycle and compost electronics, organic material, paper and cardboard, recyclables, construction and demolition material, white goods, universal and some hazardous waste items such as batteries and paint.

For a one-hour tour of Studley campus – consider the following stations. More information is provided about each station in the text above. The map provides direction.

Route 1: (30 min) Studley

- **Stop 3**: Computer Science Building Solar PV/Duct installation – 5 min.
- **Stop 22.** Dal Garden Student Society Plot – 5 min behind computer Science Bld
- **Stop 12:** LeMarchant Place Bld. (walk by): LEED Gold certified building – discuss some of the features – 5 min. Green building signage inside in the Atrium.
- **Stop 17.** Fitness Centre: LEED Gold candidate building. – discuss some of the features – 5 min.

Route 2: (30 min) – Studley

- Go through the Quad – **Spot 21.** Dal Bike Centre: discuss some of the features- 5 min
- Walk along alumni crescent to the path between the Steele Ocean Science Building and Sherriff Hall. 5 min (notice some of the new Hemlocks planted as part of biomass replacement policy and oldest tree on campus by Sherriff Hall)
- **Stop 11:** Steele Ocean Science Building (LEED Silver Certified)– Talk about some features – electric car station, permeable pavement. Green building signage is located at the main entrance. - 10 min. Could also talk about LSC Stop 6.
- **Walk along Stop 18: permeable pavement** and **Stop 19: rain garden installation**. Read the notes – 10 min finish.

Route 3: (30 – 1 hour min) – Carleton-Sexton [10 -15 min walk between campuses]

- **Stop 9.** Talk about the $12 million dollar energy performance project for the Tupper bld completed in 2018. Included water fixture and LED lighting upgrades, fume hood, air handler and ventilation upgrades closed water loop created for cooling and much more. 5 min. Video highlighting the project on the Office of Sustainability website.
- **Stop 14**: LSRI (LEED Silver Certified) – Talk about some features – high rates of construction and demolition diversion, energy efficient equipment, natural landscaping and LED lighting, permeable pavement. Green building signage is inside the building. - 10 min
- **Stop 15.** CHEB (LEED Gold candidate) – Talk about some of green features such as convenient bus and bike access, white cool rood, carbon cure concrete block, and chilled beam technology. 10 min. Green building signage is in the building close to the walkway to the Tupper bld.
- **Stop 16.** EMERA IDEA and Richard Murray Design Bld. Meet at the Atrium of the IDEA bld. Green building signage throughout the bld. Video highlighting the project on the Office of Sustainability website. Highlight geo-exchange heating and cooling, 469 solar PV panels and battery storage, green corridor – native plants, permeable pavers and active transportation corridor and much more. 20 min

Route 4: (30 min) – Agricultural

- **Stop 1**: Solar PV at the Tree House – 5 min.
- **Stop 9.** Chef's and community gardens – 5 min.
- **Stop 12:** District energy biomass co-generation system. 10 min
- **Stop 7.** Bioswale installation – 5 min.