MAY 2021

UBC SMART CITY

ANNUAL REPORT

PHOTO BY JOEL FILIPE ON UNSPLASH

2020-2021

DEPARTMENT OF CIVIL ENGINEERING

FOREWORD

As our inaugural year comes to a close, our team at UBC Smart City is pleased to say that we have created something new, learned in the process, and exceeded our own expectations. Our team entered into four competitions, attaining podium finishes in two. We built two projects that reflect our mission to up-skill engineering students with hands on learning, while stepping towards innovative solutions to real world problems. Following our successes, two of our team members were invited as panelists at a transportation conference where they shared the stage with senior engineers and planners from regional planning agencies. Finally, we connected with industry leaders to build a professional network for our team, and in the process received a generous sponsorship for next year.

This report contains some of the highlights from our past year, along with plans for the next. Thank you to all of our supporters, and most of all, to our dedicated team members who are the lifeblood of our organization.

- Hamed Barkh, Captain.

UBC Smart City

SPONSORS

Our team would like to warmly extend our thanks to our first sponsor: Bunt & Associates Engineering Ltd. Bunt & Associates sponsored us at the end of the 2020-2021. Out of gratitude for their for their generous donation, we have included them in our 2020-2021 report. Given the timing of the donation, their funds will be used to support our 2021-2022 team, and as such Bunt & Associates Engineering Ltd. will receive gold sponsor benefits throughout the 2021-2022 year in addition to a special mention in this report.

GOLD

https://www.bunteng.com

A description provided by our sponsor:

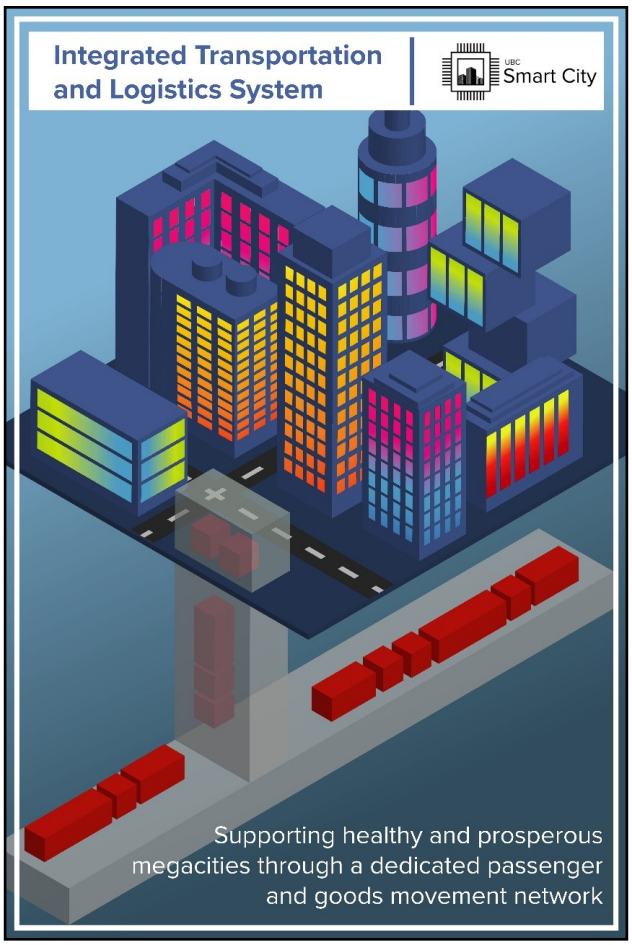
"Bunt & Associates Engineering Ltd. is one of the largest specialist transportation planning and engineering consulting companies in Western Canada. Our team is represented by over 50 of the finest transportation planners, engineers, technologists, and support staff in the industry. We place high value on outstanding service, building long-term client relationships, and fostering a family-friendly and supportive culture within all of our offices located in Calgary, Edmonton, Vancouver, and Victoria.

We are proud of our involvement in all types of transportation projects ranging from high profile, dense, and complex urban sites and corridors to individual sites and intersections. When not in the office, our staff can be found in the many communities we serve collecting traffic counts, analyzing transportation patterns, or presenting at open houses and public hearings."

COMPETITIONS

ASCE BLUE SKY INNOVATION CONTEST

What will our cities' infrastructure needs look like in 2040, 2050, or even 2070, and how can we start preparing today? UBC Smart City took on this challenge by entering the American Society of Civil Engineers (ASCE) Blue Sky Innovation Contest. Our proposal, the Integrated Transportation and Logistics System, or ITLS, meets this challenge by providing fast and efficient people and goods movement across a polycentric megacity of 50 million people. By removing congestion from streets, the ITLS will help create high-quality public spaces that foster spontaneous human interaction. Our solution outperformed its competitors in the Rocky Mountain Student Conference to secure a first place victory, and will head on to the national ASCE Convention in October 2021. Be sure to check out our plaque on our website or in CEME!

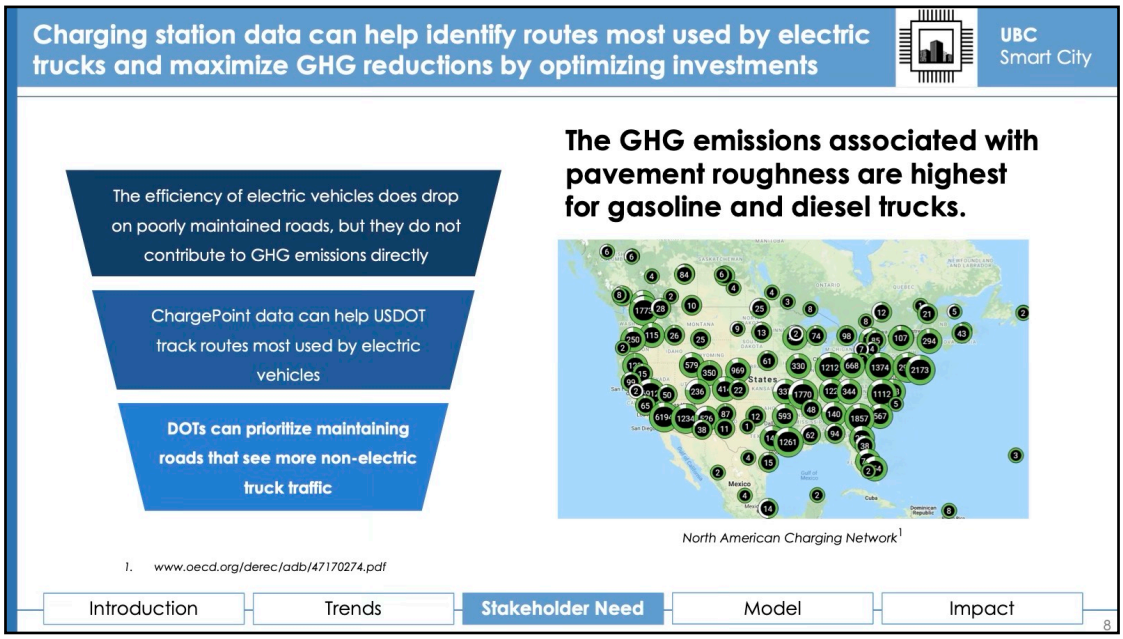


ASCE Blue Sky Submission Graphic

MIT ENERGYHACK

MIT EnergyHack is a virtual hackathon which presents teams with real-world challenges from companies of the energy industry. Our team pitched to ChargePoint, an electric vehicle infrastructure company, a unique idea of how vehicle charging station data can be used. With data including truck arrival and departure times, as well as battery level information, routes favoured by electric trucks can be determined. Since the US Department of Transportation (DoT) knows roughly how many trucks drive on major roads, this data would tell them the fraction of electric trucks on each road.

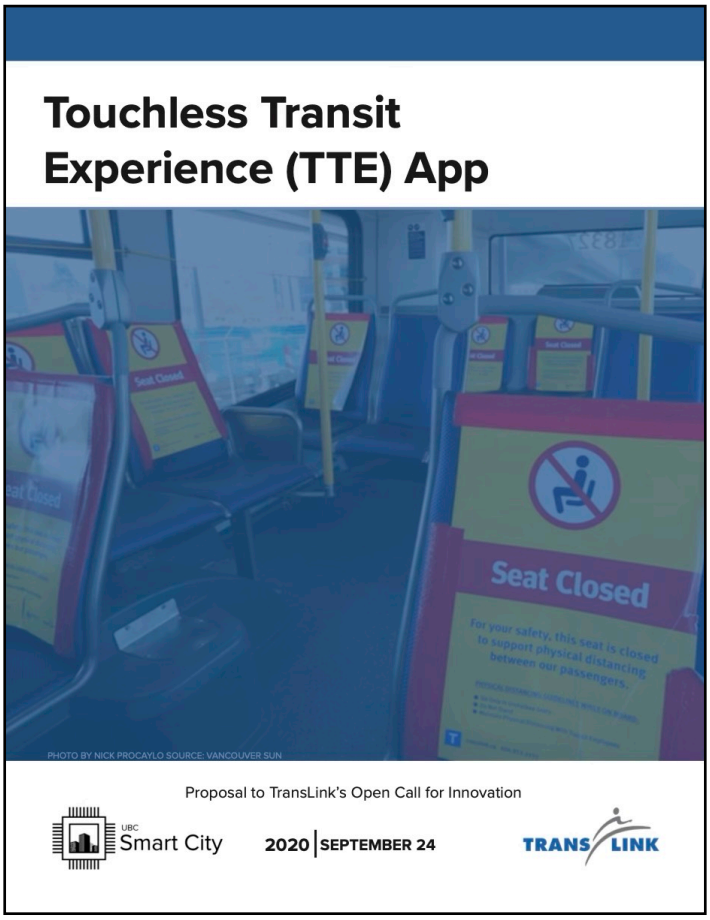
Knowing that subpar pavement decreases fuel efficiency, it may be desired to use cleaner vehicles on rough roads to save on greenhouse gas emissions. Thus, when determining which roads to maintain, the DoT can elect to improve roads with a lower fraction of electric trucks (I.e. a higher fraction of internal combustion engine trucks) to maximize greenhouse gas reduction per highway maintenance dollar spent. This is an example of how data can be used to inform infrastructure policies, and UBC Smart City was given the "Most out-of-the-Box" award for our submission.



MIT EnergyHack Submission Slide 8/22

TRANSLINK OPEN CALL FOR INNOVATION

Despite plummeting ridership in Spring 2020, public transit continues to be an essential public service and is key for efficient movement of people in cities around the world. However, low ridership is threatening the viability of this system, and solutions are needed fast. To help restore public trust in public transit, Metro Vancouver's transportation agency, TransLink, issued their 2020 Open Call for Innovation. UBC Smart City responded to the Call, by proposing our Touch-less Transit Experience App. This solution reduces touch-points on transit vehicles and provides riders with useful information to take their safety into their own hands. These features will deliver a more accessible and enjoyable transit experience and help build a sustainable post-pandemic recovery.



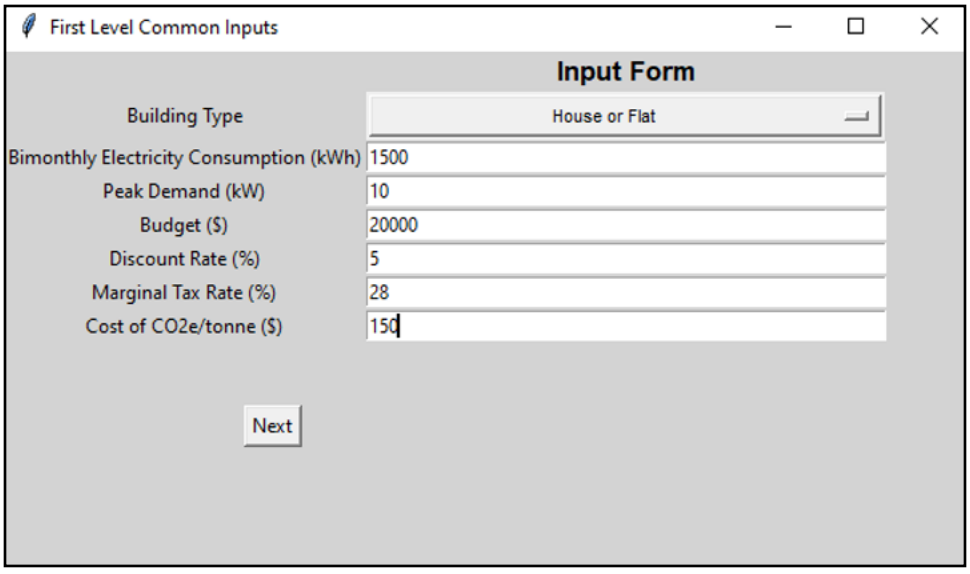
TTE App Submission Cover Page

PROJECTS

ENERGY OPTIMIZER

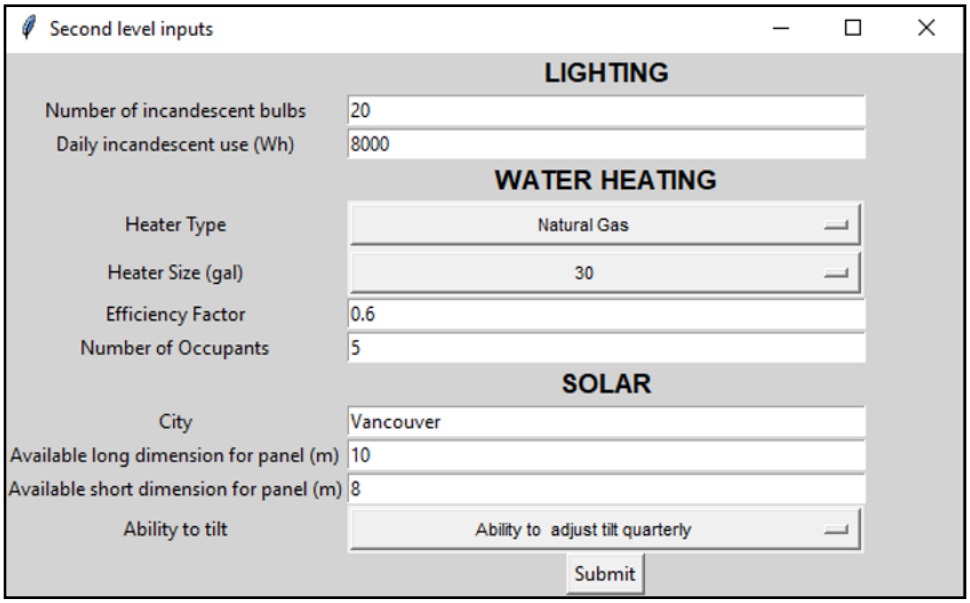
The energy optimizer is a tool which helps users improve their building's energy performance. It does this by asking users for their inputs pertaining to their current building situation and constraints, and then by using linear programming recommends products for the user to implement to maximize their energy savings.

Our team built this product as buildings account for roughly 40% of energy use and contribute to one third of global greenhouse gas emissions, making their operations a critical component of the energy sector. However, a challenge for building owners seeking to improve their energy use is identifying where to start when making retrofitting decisions. Software currently exists to analyze and improve buildings' energy performance, but they typically involve many variables, require skilled users and auditors, and are expensive to use. We sought to create a simple tool that allows non-experts to make expert-like decisions to retrofit their buildings, for free.



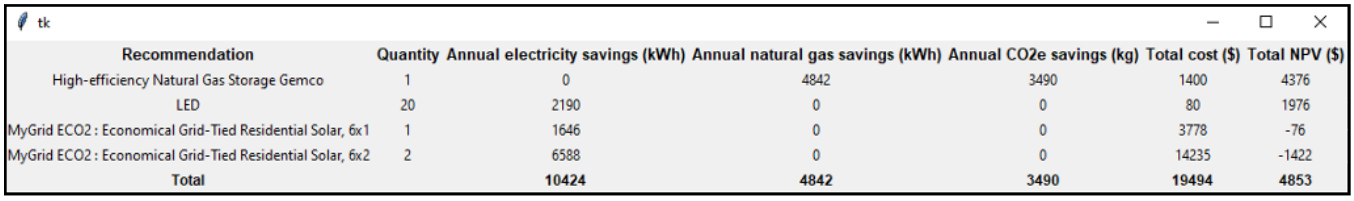
Energy Optimizer Preliminary Input Screen

Our software currently optimizes across three modules – water heating, lighting, and solar energy, as the use of these products have large impacts on a building's overall energy consumption and are relatively simple to model and quantify. The software's output contains, in addition to the recommended products and their associated costs, the estimated CO_2 emissions savings, energy savings, and net present value of each item suggested. These data are educational will allow users to note the impacts of the different products considered.



Energy Optimizer Second Input Screen

The software was created with Python and Microsoft Excel as a base platform that can be built upon in the future. The optimizer uses the PuLP library, which makes it very easy to incorporate additional modules to the optimizer without conflicts. UBC Smart City teams in the future could consider adding more modules, refining current modules, and upgrading the software's UI (and the accompanying software applications) to increase its capabilities and user friendliness.



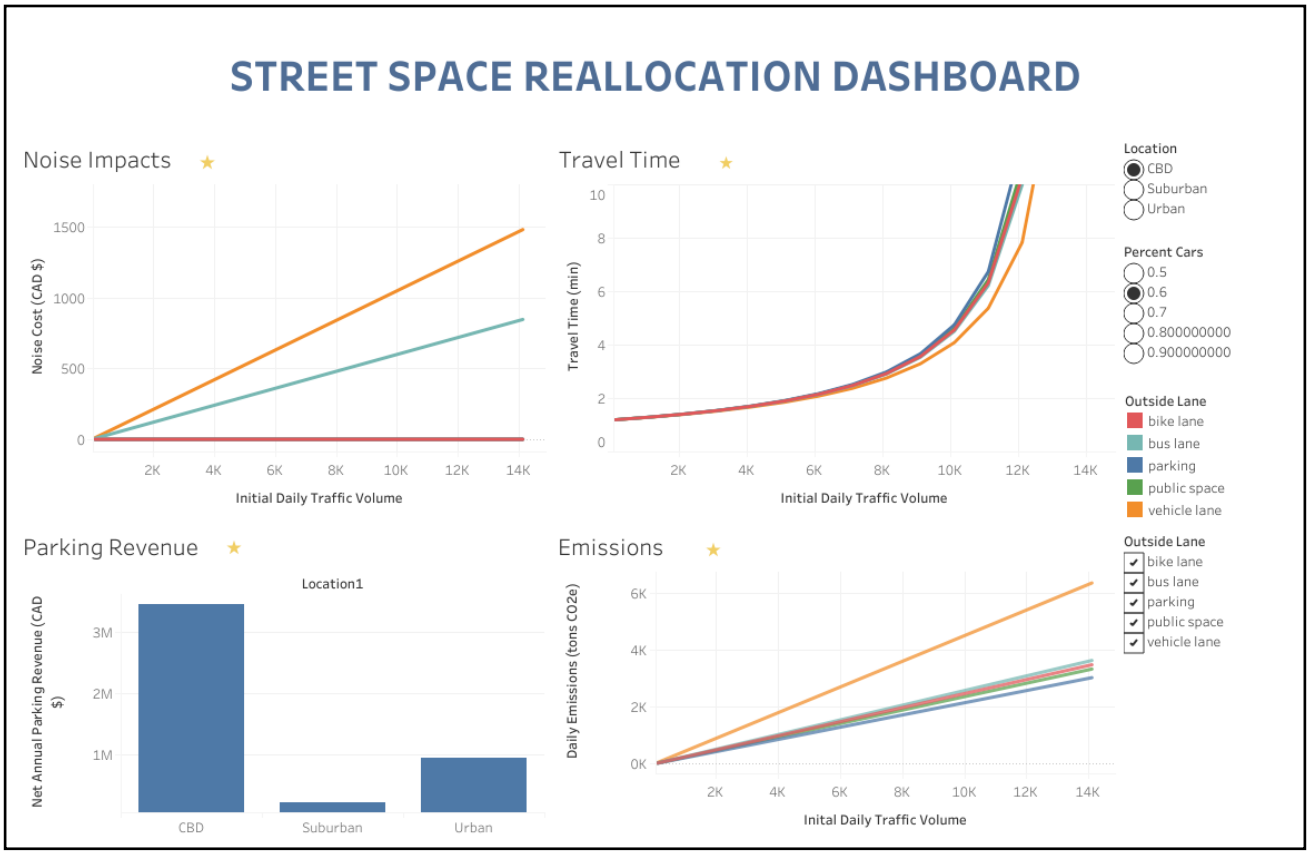
Recommendation	Quantity	Annual electricity savings (kWh)	Annual natural gas savings (kWh)	Annual CO2e savings (kg)	Total cost ($)	Total NPV ($)
High-efficiency Natural Gas Storage Gemco	1	0	4842	3490	1400	4376
LED	20	2190	0	0	80	1976
MyGrid ECO2 : Economical Grid-Tied Residential Solar, 6x1	1	1646	0	0	3778	-76
MyGrid ECO2 : Economical Grid-Tied Residential Solar, 6x2	2	6588	0	0	14235	-1422
Total		**10424**	**4842**	**3490**	**19494**	**4853**

Energy Optimizer Output

STREET SPACE REALLOCATION DASHBOARD

Streets serve many masters: pedestrians, cyclists, drivers, people using wheelchairs, delivery vehicles, transit buses, and more. But streets are flexible: they can be adapted to better suit local contexts. For example, during COVID-19, lower vehicle volumes have revealed empty pavement that could better be used as wider sidewalks, restaurant patios, or new public spaces. To better understand this potential, UBC Smart City has created a road space reallocation dashboard that explores some of the many factors, tradeoffs, and outcomes of projects that change how street space is used.

The team wrote a Python script to calculate these impacts, which are presented in an interactive Tableau visualization. The program considers a standard, 4-lane road with one travel lane and one parking lane in each direction. It compares this layout with four different uses for the parking lanes: general travel lanes, bus lanes, bike lanes, or multipurpose public space. The outcomes presented include traffic volumes, travel time, fuel emissions, noise pollution, and changes in parking revenue for the subject municipality. The results vary between different types of street environments, initial traffic volumes, and the type of vehicles on the street. The dashboard also accounts for additional traffic induced by changes in road capacity.



Street Space Reallocation Dashboard Built with Tableau

These impacts are difficult to quantify and highly context-specific, so the dashboard relies on estimates and generalizations. The results are inexact but should provide a reasonable comparison between options. The model is designed to allow for improvement, so next years' team can improve the model or add a larger range of projects and outcomes to the dashboard. Ultimately, we hope this project will contribute to a better public understanding of road space reallocation projects, and how they can be used to make streets better for the communities they serve.

Travel Time

```
3 # Create a class to store traffic volume information

class tvol:

    def __init__(self, aadt = 0, k_factor = 0.08, percent_trucks = 0.02, percent_buses = 0):

        self.aadt = aadt
        self.k_factor = k_factor
        self.update_vph()

        self.percent_trucks = percent_trucks
        self.percent_buses = percent_buses
        self.update_percent_cars()


    # vehicles per hour (during peak hour)
    def update_vph(self):
        self.vph = self.aadt * self.k_factor

    # average annual daily traffic
    def update_aadt(self):
        self.aadt = self.vph / self.k_factor

    # percent of aadt that occurs during peak hour
    def update_k_factor(self):
        self.k_factor = self.vph/self.aadt


    # percent of aadt that is passenger vehicles
    def update_percent_cars(self):
        self.percent_cars = 1 - self.percent_trucks - self.percent_buses

    # percent of aadt that is buses
    def update_percent_buses(self):
        self.percent_buses = 1 - self.percent_trucks - self.percent_cars

    # percent of aadt that is trucks
    def update_percent_trucks(self):
        self.percent_trucks = 1 - self.percent_buses - self.percent_cars
```

```
4 # Create a class to store road segment information

class segment():

    def __init__(self, name = 'Unnamed', length = 1, location = 'Urban', speed_limit = 50, outsid

        self.name = name
        self.length = length # km
        self.location = location # 'CBD', 'Urban', or 'Suburban'
        self.speed_limit = speed_limit # km/hr
        self.outside_lane = outside_lane

        # Geographic-specific adjustments
        if location == 'CBD':
            self.parallel_routes = 5
```

Street Space Allocation Dashboard Code Snippet

2020-2021 ROSTER

Student Team Members

Name	Program	Contributions
Mustafa Adil Energy Team	Integrated Engineering	MIT EnergyHack; Energy Optimizer: UI, insulation and solar modules.
Hamed Barkh Captain	Civil Engineering	Team Organization; Social Media; Street Space Dashboard: Ideation, Programming Support; Energy Optimizer: Ideation, Programming Support; Open Call for Innovation: Ideation; Worlds Challenge-Challenge (1).
Joshua Chong Transportation Team	Civil Engineering	ASCE Blue Sky Contest: Ideation; Street Space Dashboard: Ideation, Parking Revenue Module.
Benjamin Corbett Transportation Team Lead	Civil Engineering	Open Call for Innovation; ASCE Blue Sky Contest: Lead Author, Ideation, Technical Solution Development, Oral Presentation; Street Space Dashboard: Lead Author, Ideation, Travel Time Module.
Fayaz Damani Energy Team Lead	Civil Engineering	MIT EnergyHack; World's Challenge-Challenge (2); Energy Optimizer: Lighting and solar modules, LP Optimizer.
Adriana Valentina Farias Transportation Team	Master of Community and Regional Planning	Open Call for Innovation; ASCE Blue Sky Contest: Ideation, Solution Development (Social), Graphic & Deliverable Preparation; Street Space Dashboard: Ideation.
Jasleen Kaur Energy Team	Civil Engineering	World's Challenge-Challenge (2); Energy Optimizer: UI, solar module.
Michelle Li Transportation Team	Engineering Physics	Open Call for Innovation; ASCE Blue Sky Contest: Ideation, Solution Development (Propulsion); Street Space Dashboard: Ideation, Programming Support, Travel Time Module.
Mohit Motwani Transportation Team	Economics	Open Call for Innovation; ASCE Blue Sky Contest: Ideation, Solution Development (Economics & Logistics); Street Space Dashboard: Ideation, Programming Support.
Parsa Shani Technical Teams Lead	Civil Engineering	ASCE Blue Sky Contest: Ideation, Technical Solution Development; Street Space Dashboard: Ideation; MIT EnergyHack.

Name	Program	Contributions
Justin Shou Social Media Lead	Civil Engineering	Social Media: LinkedIn, Facebook, Website.
Thien Tong Transportation Team	Civil Engineering	ASCE Blue Sky Contest: Ideation; Street Space Dashboard: Ideation, Data visualization, Noise Cost Module.
Sophie Varabioff Energy Team	Engineering Physics	MIT EnergyHack; World's Challenge-Challenge (1); Energy Optimizer: Water heating module.
Aliya Zhang Transportation Team	Civil Engineering	Open Call for Innovation; ASCE Blue Sky Contest: Ideation, Solution Development (Tunneling), Oral Presentation; Street Space Dashboard: Ideation, Emissions Module.

Advisors

Name	Position	Contributions
Omar Swei Faculty Sponsor	Assistant Professor - Department of Civil Engineering.	Organizational Support; ASCE Blue Sky Contest: Advisor; Energy Optimizer: Advisor.

ARCHIVES

To learn more about us and to see our complete submissions, as well as events and contest entries not found in this report: visit our website at https://smartcity.ubc.ca and navigate to our archives.

FORWARD LOOKING STATEMENT

Our team is pleased to announce that Benjamin Corbett (Ben) will be the Captain of UBC Smart City for the 2021-2022 academic year. Ben plans to build off of our current success by taking on a combination of projects and competitions to demonstrate the team's preeminence in the student-led smart city space. In particular, our team will work with new, highly specialized advisors to bring cutting edge analytics capabilities to our team. Using advanced Machine Learning, Reinforcement Learning, and Optimization techniques, we will take on more ambitious projects to carve out our niche as North America's finest student-lead engineering design team focused on smart cities.

BUDGETING

For the 2020-2021 our team spent under $200 in getting the team up and running thanks to the resourcefulness of our team members, support from our university, and reliance on open-source communities. This was possible in part due to the virtual work environment which kept recruiting and conference attendance costs to a bare minimum. For 2021-2022 the team will maintain it's parsimonious stance, but will require some working capital to build our brand and attend competitions in-person. Our team aims to create promotional products such as stickers, banners, and posters which can be used to build brand awareness at in-person recruiting events such as UBC's Imagine Day, Club Day's, and the Faculty of Applied Science's annual open-house. Additionally, conference registration fees which were in the double-digits this year due to remote delivery, are likely re-align with triple-digit historical norms, which may be difficult for students to fund out of pocket. Due to our team's digital focus however, we are, and will continue to be capital-light. Thanks to this low cost structure, companies have the opportunity to gain significant recognition at a low price tag by choosing to partner with us via sponsorships.

SPONSORS

Interested in sponsoring our innovators? Have your logo displayed alongside a message of gratitude on our future deliverables. For sponsorship opportunities contact Ben at UBCSmartCity@gmail.com. The list of available sponsorship packages for 2021-2022 can be found on the following page. We have three companies committed, and one has already donated, don't miss out!

2021 - 2022 Sponsorship Tiers

GOLD

Gold sponsorship is $500 and benefits include:

- Logo on all physical merchandise (T-Shirts, Banner)*
- Logo on all competition deliverables
- Logo placement on our team website
- Dedicated social media post
- Large logo + 130 word company description provided by sponsor in annual report**

SILVER

Silver sponsorship is $250 and benefits include:

- Logo on all competition deliverables
- Logo placement on our team website
- Dedicated social media post
- Medium logo + 75 word company description provided by sponsor in annual report

BRONZE

Bronze sponsorship is $100 and benefits include:

- Logo placement on our team website
- Dedicated social media post
- Small logo in annual report

* Specific merchandise contingent on team size and budget allocations

** All logos in our annual report and website will be hyperlinked to each organization`s website

UBC Smart City

Questions?
Contact ubcsmartcity@gmail.com