Environmental Remediation with Negative Emissions (MSc only)

The globe faces many environmental challenges including climate change and long term industrial pollution. The legacy of fossil fuel consumption means that most emissions scenarios for the 21st century include negative emissions. The UN scenarios for net zero includes billions of tonnes of negative emissions in the form of BECCS (biomass energy with carbon capture & storage) and biochar, amongst others. The challenge to pure negative emissions from biomass range from land diversion through fugitive emissions, most of which can be mitigated by combining these concepts with phytoremediation.

Phytoremediation refers to growing plants on contaminated soils in order to concentrate the pollutants in the biomass. After harvest, the biomass can be treated to recover the pollutants and produce biochar. The biochar can then be used in a BECCS facility or added as a soil amendment to increase soil carbon. This project is based on remediation of lands polluted through warfare with the objective of removing gunshot residue (Pb, Ba, Zn) and producing a clean biomass solid. The work will then consider the wider implication of these technologies in Canada and how they would integrate into the current energy infrastructure. There are laboratory and techno-economic aspects to this project.

Zero Emission Cities (MSc or PhD)

Urban centers are a complex mix of people, materials and energy all generating their own types of waste. These wastes, in turn leave by air, water or land depending on the source and include water discharges, gaseous emissions from fuel consumption and solid waste sent to landfills. This is combined with the reality that renewable energy systems require land and cities are full of buildings. The challenge is then to consider the available carbon resources within the urban center and devise a utilization plan to minimize fossil CO_2 emissions. This will done by considering the electricity grid, waste management and energy storage.

The project will focus on modelling the integration of these mass flows to determine the available avenues and necessary scale of energy storage. The work will utilize MS Excel for data analysis. Using publicly available data, we will consider the importance of adding renewables to the grid and how best to integrate energy use in buildings. For example, currently there is 5 GW or installed wind energy in Ontario and only 500 MW of solar PV. These technologies have different capacity factors and peak production periods that would require different forms of energy storage. Wind energy requires seasonal storage whereas solar is more weekly storage. The biggest energy storage option is biomass, in the form of food, food waste and sewage.

The future possibilities will be investigate by considering existing green designs such as the Conde-Nast building at 4 Times Square in NYC. Here the building contains a dedicated bioreactor and heat exchangers to minimize waste disposal and fuel use. Expanding this concept to smaller buildings and neighborhoods can lead to significant GHG reductions by, for example, returning bio-methane to the natural gas network for space heating. By considering the overall material flows in the urban environment, the optimum path to net-zero can be identified.