An Introduction To

Tools4Cities

Developed at CERC team

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1 Introduction

The CERC team is developing an integrated urban simulation platform called Tools4Cities. The main focus is on simulating urban areas to create better, more sustainable cities and help decision-makers perform more effective interventions. Additionally, researchers will be able to explore new scenarios and methodologies using this platform. The platform will handle and analyze large and heterogeneous urban data sets from various domains, with a particular emphasis on energy and transport infrastructure optimization for smart cities. It will cover multiple scales in both time and spatial domains, ranging from long-term population and land use changes to the hourly or sub-hourly matching of renewable energy supply with urban energy demand.

Tools4Cities will allow city planners and decision-makers to model urban scenarios using cities' digital twins and involve citizens and stakeholders in the decision processes through its graphical user interfaces. At the same time, it allows researchers to model new scenarios or test ideas through its comprehensive back-end or create new tools by using the libraries, catalogs and APIs.

This document serves as an introduction to Tools4cities, its components, and its overarching mission: to empower urban stakeholders, organizations and researchers with the tools and insights needed to create smart, sustainable, and resilient cities.

1.1 Tools4Cities' capabilities

Tools4Cities is an integrated Urban Simulation Platform. It is a set of tools to simulate different aspects of a city. The platform functions as an interface between different 3rd party software tools, enabling a wide range of computations customized for specific use cases. The results of these computations are then used to represent and visualize various interactions that underpin human society. In simpler terms, the platform helps us grasp and visualize how different elements interact in a community, providing a user-friendly way to understand these dynamics. It acts as a bridge, bringing together various tools to see the bigger picture of societal interactions.
Operating at varying levels of abstraction, contingent upon the specific use case, the platform embodies a comprehensive repertoire of systems and processes. It offers invaluable simulation, optimization, Hardware-in-Loop testing, and forecasting capabilities across various sectors. Through these functionalities, the platform aids in identifying opportunities for retrofitting and strategic enhancements, targeting diverse objectives such as greenhouse gas emissions reduction and cost optimization, that are then presented via meaningful user interfaces and gamified applications.

1.2 About the developers

The platform is developing under the Canada Excellence Research Chairs (CERC) program, funded by the Government of Canada, that supports Canadian universities in their efforts to expand Canada's growing reputation as a global leader in research and innovation. The CERC award offers an incredible 10 million in research funding and is among the most prestigious research grants available around the world. Concordia University received this honour in 2017 and began the search for the new chair holder to spearhead the team in Smart, Sustainable and Resilient Communities and Cities research. Dr. Ursula Eicker was inaugurated as the new chair and is the leader of the ever-growing CERC Team at Concordia University. As a physicist with a history in international research projects relating to energy efficiency and sustainable energy supply systems, Dr. Eicker has built an interdisciplinary team to provide innovative solutions to solve complex urban issues. The mission of the CERC team is to transform our cities through innovative technologies and nature-based solutions into zero-carbon, smart and vibrant neighbourhoods. We work on solutions for the highest building efficiency, integration of renewable energy systems, sustainable transportation and circular economy concepts. All developments feed into an urban data and modelling platform that allows us to build future-proof scenarios. A new focus is on better user interaction via gamification concepts. In the rest of this document, concepts and definitions of the platform's components are provided.

2 Tools4Cities

The purpose of this section is to provide definitions and concepts to understand the basics of Tools4Cities. The platform has several parts, each of which has various sections that work together, making the simulation, optimization, and modelling possible. Figure 1 illustrates the platform and its different parts. A description of its different parts is provided below.

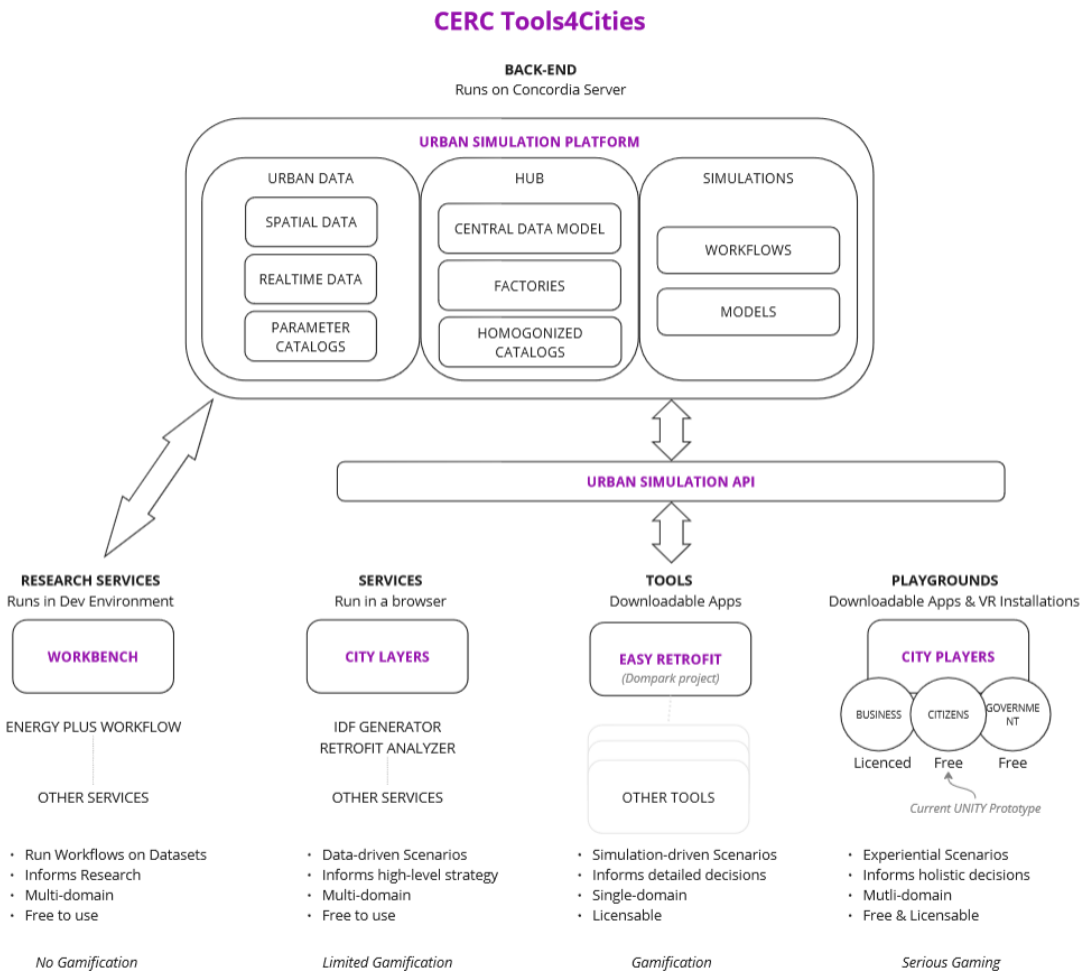

Figure 1: Backends and frontends of the Tools4Cities

2.1 Front-ends

A front-end is a program or web page that allows the user to interact with the platform by using a graphical interface. It serves as the gateway, providing users with a user-friendly way to access and engage with the platform's functionalities. Currently, we have two front-ends under development: City Layers, which is an interactive webpage, and City Players, a gamification interface. These front-ends are designed to be used by city planners and decision-makers to explore and utilize the platform's capabilities effectively. With City Layers, users can visualize and analyze urban data in an interactive manner, while City Players offers a gamified approach that adds an element of fun and engagement to the decision-making process.

City Layers

City Layers is an online tool that provides users access to a wide range of spatial data layers for cities. It allows users to explore and visualize various geographic datasets, such as land use, transportation networks, parks, and infrastructure, within a user-friendly interface.
With City Layers, users can interact with the map interface, zoom in and out, and navigate to specific locations of interest. They can overlay different data layers to gain insights into urban planning, development, and decision-making processes. The tool offers the ability to toggle between different datasets, customize the visibility of layers, and analyze spatial patterns.
City Layers serves as a valuable resource for urban planners, researchers, policymakers, and anyone interested in exploring and understanding the spatial dynamics of Canadian cities. It provides a platform to explore and analyze data that can inform various urban-related initiatives, including urban design, transportation planning, and environmental assessment.

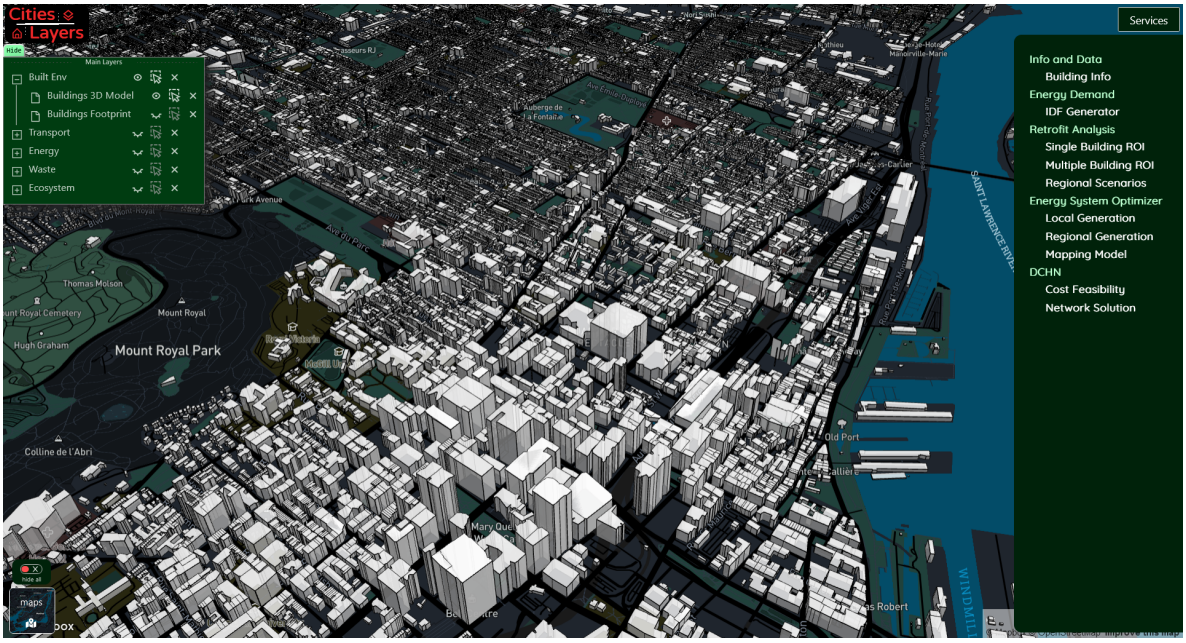

Figure 2: City Layers is an online tool and one of the Tools4Cities front-ends.

City Player

City Player aims to improve urban sustainability through serious gaming. By connecting simulations and data of urban neighbourhoods to an interactive, gamified 3D visualization, we enable city stakeholders to co-create and explore different future scenarios. This allows them to understand the consequences in terms of greenhouse gas emissions, livability, and costs over time. Through this process, stakeholders learn about innovative technologies, witness the knock-on effects of their actions, and realize the significant impact of minor changes at scale. They also receive recommendations for improved decision-making.
We believe that by incorporating playfulness and engagement into the exploration of data and future scenarios, we can effectively engage and influence stakeholders in ways that traditional methods cannot. Our vision is guided by principles such as being powered by science and research, involving multiple domains and stakeholders, focusing on neighbourhoods, prioritizing low emissions and high livability, and maintaining a playful and inspiring atmosphere. This approach aims to empower stakeholders to actively shape the future of their city.

2.2 Tools4Cities' Back-end

The back-end is the specialized part of the platform responsible for handling data and logic, performing heavy calculations, and facilitating interactions between different components. By efficiently managing

Figure 3: City Player is a gamified 3D visualization of data in neighborhoods

and processing data, the back-end empowers the platform to generate valuable insights and support decision-making processes geared toward sustainability. It works behind the scenes, ensuring smooth operations and seamless integration of various functionalities to achieve the common objective of creating greener, more environmentally friendly urban areas. Figure 1 illustrates the general overview of the platform, and it is created to help with readability and understanding purposes.

The platform incorporates various well-defined workflows, each tailored to simulate different modeling tasks. Every workflow is designed with specific input requirements, a clear purpose, and a set of outcomes it aims to achieve. Some examples of the workflows are:

1. Monthly Energy Balance (MEB): The primary purpose of MEB is to provide valuable insights into energy usage patterns and consumption trends, enabling city planners and decision-makers to explore viable retrofitting options to optimize energy efficiency and reduce carbon emissions. This tool provides sets of monthly values of each building's heating, cooling and domestic hot water demands in a region. It also provides monthly values of consumption of different fuels and electricity and the heating and cooling monthly peak loads.

2. EnergyPlus[1] workflow (EP): This workflow aims to produce idf files with the geometrical description af a building and its surroundings anywhere in the world. It enables the enrichment of the model as well, using construction and usage parameters based on archetypes. This file is saved and accessible to be imported by other tools for a more detailed description if required. Also, the workflow calls EnergyPlus to produce hourly values of heating, cooling, domestic hot water demands, together with lighting and appliances electrical consumption.

3. Costs Workflow: the goal of the costs workflow is to allow users to connect the energy demands and consumption from Urban Energy Modelling tools to its associated Life Cycle costs. This tool incorporates all typologies of costs, as well as the necessary economic parameters, and will allow city planners and decision makers to understand the economic implications of energy retrofitting, HVAC system renovation or even decentralized PV system implementation. Given the volatile nature of economic parameters, the parameters used by the tool are prepared to be used in sensitivity analyses. The results from the workflow are overall Life Cycle Costs divided by categories (CAPEX using UNIFORMATii, OPEX, Incomes and End of Life Costs) and yearly values for each of the costs in each of the detailed categories

[1]https://energyplus.net/