On the Spatio-Temporal End-User Energy Demands of a Dense Urban Environment

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Introduction

Many growing major metropolitan centers face increased peak electrical load, especially during extreme heat events. This impacts the reliability of the electric grid raising the costs for energy demands. It is therefore imperative to better understand the energy consumption profile in the building sector for scales of large cities. This understanding is not only paramount to users to avoid peak demand charges but also to utilities to improve load management.

Objectives

Evaluate building energy consumption at an accurate spatio-temporal resolution for different categories of buildings using a high resolution weather forecast (uWRF model).It is a One-Way Coupling, data feeds from weather model to BEM.

Materials and Methods

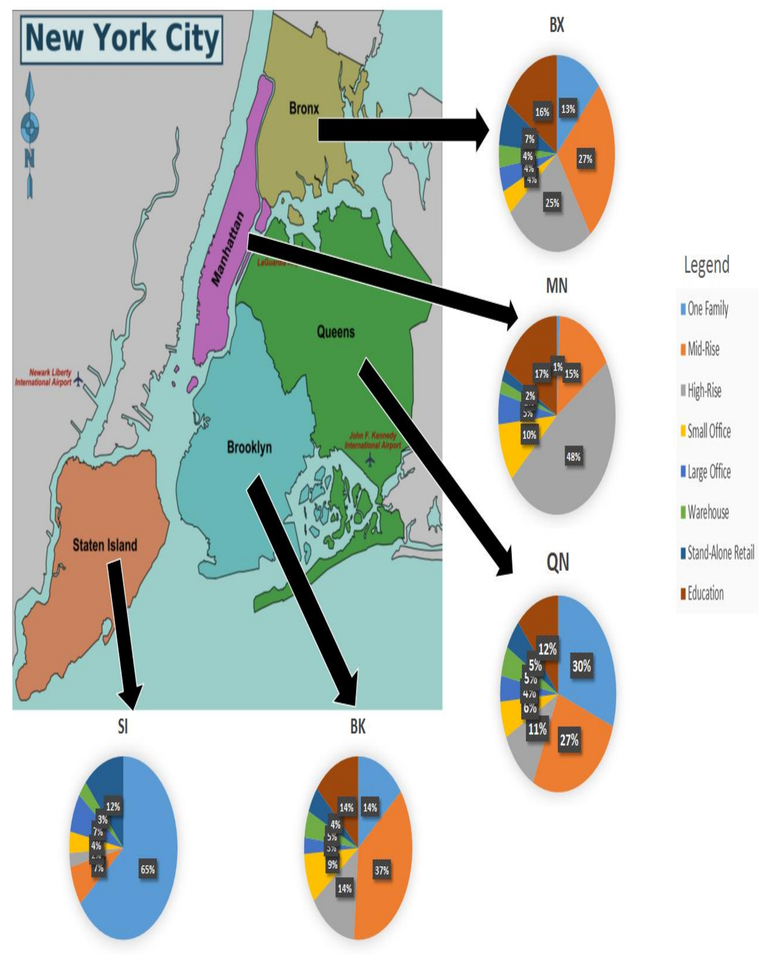

Figure 1: New York City map: Spatial building type distribution by borough (Manhattan, Brooklyn, Bronx, Queens, Staten Island)

Develop an energy-demand forecasting tool at a city scale using high resolution weather data interfaced with a single building energy model. We focused our work on New York City (NYC) which has a comprehensive building dataset. The building data set we used is called the Property Land Use Tax-lot Output (PLUTO), from which we identified 51 building archetypes, based on US DOE Reference Buildings Stock (residential, educational or office), the age of the building (before 1980, after 1980, after 2004), and the land use type.

The weather data period was from June to August 2015, including an extreme heatwave event during end July 2015 .

We compared a heatwave day to a non-heatwave to better understand the drivers of the consumption and localize them.

Results

- Validation phase at a city scale level : The discrepancy → transportation needs for electricity and many other services that were neglected.
- Adjusting the forecasted energy demand by this minimum value, the average error for the whole city decreases **from 29% to 10%.**
- Figure 3 shows the energy consumption intensities per building type during the summer period (mid July 2015).
- **HVAC** represents the main driver of the consumption during the summer in the residential sector. It consumes between **35% for One Family Building to 52% for High-Rise Building.**
- Heatwave day (21 July 2015) versus a non-heatwave one day (15 June 2015) : peak difference demand is 33 W/m² and the average difference is around 5W/m². Main discrepancies may occur for the cooling demand. Indeed, the electricity gap differences represents only 2 W/m² whereas the average HVAC Demand is 40 W/m². As for the building type, The Residential buildings (One Family, Mid-Rise, high-Rise) and some Small office buildings present the highest rate of HVAC Demand with an average of 25 W/m²

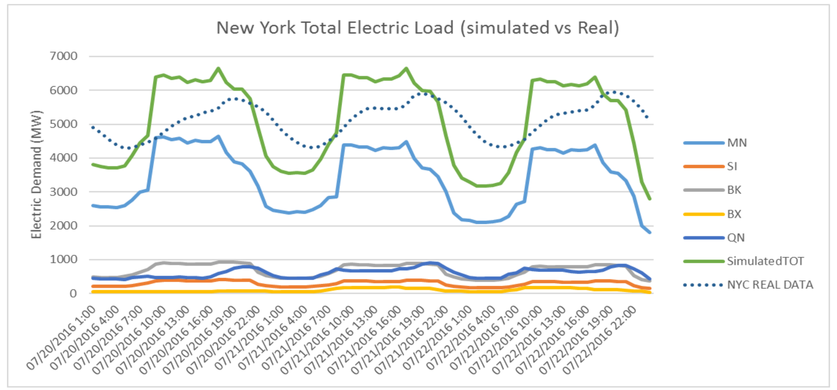

Figure 2: Validation of the City scale model of New York City (20th -22nd July 2015)

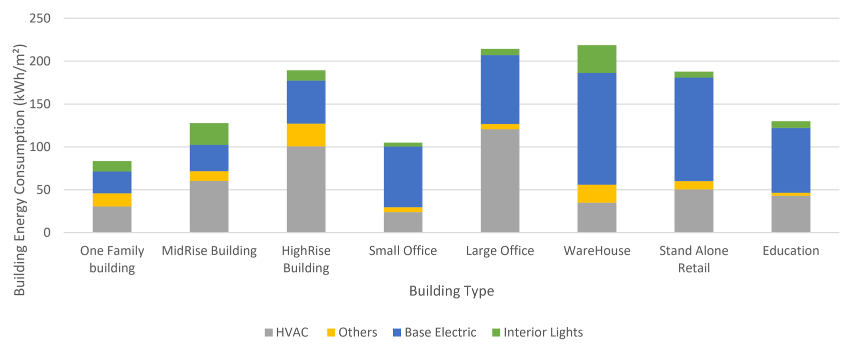

Figure 3: Distribution of the energy end-use consumption bybuilding function for the summer period (July 1st until July 22nd)

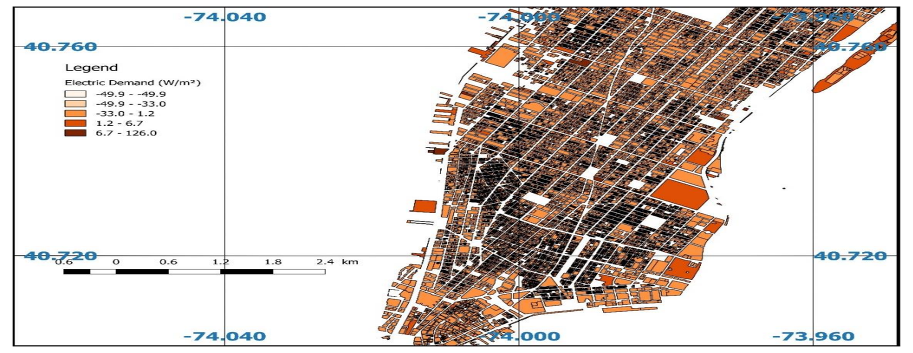

Figure 4: Difference of Energy demand between a heat wave case and a non-heat wave case: Zoom-in on the South of Manhattan

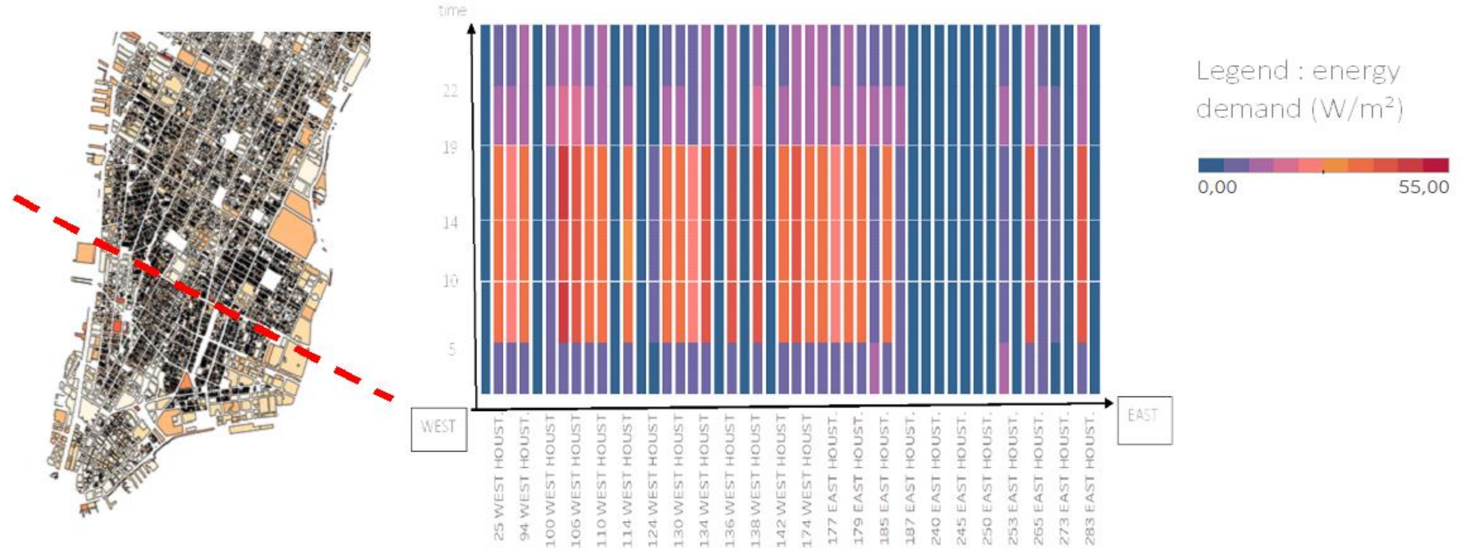

Figure 5: Hourly energy Demand from a cross section of Manhattan (Houston Street as shown in the first figure with the red line)

Conclusion

The hourly energy consumption profile for NYC determined in this analysis has many implications.

- Better understanding of how energy is distributed during a day, and how it is spatially distributed.
- Help facilities and urban planners to manage the electric grid and the power plant.
- Help building stakeholders for assessing a profitability of a project (ex : Estimating how much energy could be produced if solar panels are installed at a given location)
- Help policy makers to launch more efficient and reasonable GHG mitigation targets.

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