Using a bottom-up energy systems model to analyze role of electrification in the end-use sectors in the urban areas

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Overview
Across the globe, urban planners and city agencies are developing strategies to shape their environmental futures. Strategies to protect cities include targeted emission reductions of pollutants that contribute indirectly to extreme weather events and sea level rise. While urban entities contribute to the collective global action around this challenge, well designed plans can radically transform cities, changing the way we use energy, move people and goods, design public spaces and engage the populace to create healthier, safer, more equitable and sustainable urban environments. Cities emphasize mechanisms that not only reduce energy consumption and air emissions, but also can promote sustainable and resilient practices across multiple environmental media. This paper will lay the groundwork on how New York City (NYC) is approaching these problems, and how using this as a baseline, our goal is to advance analytical tools and create guidances for other cities to future pathways achieving Growth, Equity, Sustainability, and Resiliency goals.

According to the United Nations, by 2050, almost 70% of the world population is expected to live in urban areas. This will present a tremendous challenge for cities in meeting their increased energy demand, and maintaining safety and integrity of natural resources such as water, land, and air. New York City (NYC) has one of the oldest infrastructures in the U.S. will require replacement, expansion and upgrades over the coming decades to serve a steadily growing population. In addition, building and transportation energy footprint of the city is significantly impacting air quality and presenting a public health issue.

This paper presents a scenario framework to capture two distinct uncertainties for NYC to achieve their 80% carbon reduction by 2050 goals. Each pathway will yield a combination EGU and end-use energy sector decarbonization possibilities and analyze cost and environmental implications.

Methods
The U.S. EPA’s Office of Research and Development has developed a database representing energy system of New York City in six regions (five boroughs of NYC (Brooklyn, Bronx, Manhatten, Staten Island and Queens) and New York State electric grid) for use within the MARKet ALlocation (MARKAL) modeling framework (Kaplan and Kaldunski, 2016). The MARKAL model is an engineering-economic mixed-integer linear programming model that solves for the least-cost system-wide solution for meeting end-use energy service demands, given primary energy resources defined for a region (Loulou, Goldstein, and Noble 2004). The database for NYC -hereafter referred to as the EPANYC6r database- is a derivative of U.S. EPA’s nine region U.S. energy system database (Lenox et al. 2013a) and calibrated to reported emissions and fuel consumption data (Fig.1).

Recent research on air quality studies indicate that social paradigms and technological advancements are two primary drivers of change, especially in the energy sector (Brown et al., 2018 and Gamas et al., 2015). We constructed a scenario planning methodology to be implemented in the EPANYC6r. The method is based on the framework presented in Brown et al. (2018) which includes a design and implementation algorithm four future energy scenarios in the MARKAL framework. The scenarios utilized expert opinion to identify underlying assumptions and describe the narratives. It characterized the two key uncertainties in the decision framework for NYC that could impact how the city achieves its GHG reduction goals: (1) speed of end-use demand technology decarbonization and (2) evolution of electric grid.
The four energy futures for this study are defined (Fig. 2) as follows: (1) Steady State (SST); (2) Headway (HDW); (3) Dependence (DEP) and (4) Revolution (REV). The goal of the scenario analysis is to evaluate a portfolio of technologies meeting the city’s goals in terms of resultant cost and air emissions outline plausible social perceptions and technical advancements that may occur in the future.

Results

Preliminary results we gathered from scenario analysis revealed following:

The REV scenario resulted in more renewables in the electric grid along with significant technology turnover to meet the building space heating end-use demand.

Both in REV and HDW scenarios, offshore Wind is prevalent. To achieve the CO2 reduction goals, model utilized energy efficient technologies as well as decarbonized the grid.

In buildings sectors, compared to 2010 baseline value, almost 62% of the CO2 reductions in 2050 for REV scenario can be attributed to switching to energy efficient technologies, and cleaner fuels, and around 17% of the reduction can be attributed to cleaner electric sector.

Conclusions

In summary, a formal framework to evaluate emission and energy reduction scenarios for urban cities is essential. The database and the scenario framework facilitate many studies in evaluating cost and benefit analysis of various energy options across multiple sectors of the economy; tradeoffs among pathways to air quality attainment and emissions reduction and energy consumption; and multi-modal transportation, economy, air quality, and public health issues.

References