NEW YORK UNIVERSITY

CENTER OF URBAN SCIENCE + PROGRESS

CAPSTONE PROJECT

A Finance Map of NYC: Reducing Carbon and Driving Large Scale Energy Efficiency with a Public Database To Support PACE Lending

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Abstract

The Center for Sustainable Business (CSB) from New York University (NYU) Stern Business School is supporting the commitment of New York City (NYC) to limit carbon emissions under the Paris Agreement, collaborating closely with the NYC Mayor's Office of Sustainability (MOS) and the NYC Clean Energy Efficiency Corp. (NYCEEC) to bring low cost, long term financing (PACE) for energy efficiency retrofits and renewable energy to buildings. To achieve NYC carbon neutrality by 2050, Invest NYC SDG, a two-year Stern CSB initiative, wants to guide priorities and outreach to building owners and lenders by creating a public database with visual interface mapping to present GHG emissions, potential penalties, and open liens of almost 40,000 buildings.

As the CUSP group, this project aims to help Invest NYC SDG to implement a website available to the public and develop an interactive map of NYC that displays CO2e emission level by building, contact details for the building owner or managing agent, and a list of lien holders. We expect this critical tool will empower driving energy efficiency in NYC buildings and deliver a completed user-friendly database that will be a valuable tool for all New Yorkers in the drive to reduce carbon emissions in NYC in the face of climate change.

INTRODUCTION

How does New York City respond to the UN Sustainable Development Goals (SDGs) environmental protection initiative? The Paris Agreement, which was adopted by the United Nations, is a climate change agreement signed by 178 countries from around the world. It is a unified plan for global climate change action after 2020. The Paris Agreement's long-term goal is to limit the global average temperature rise of 2 degrees Celsius above pre-industrial levels to within a range, with the goal of limiting the temperature rise to 1.5 degrees Celsius. New York City passed the Climate Mobilization Act in 2019, the most ambitious climate legislation of any city in the United States. Local laws 97, Greenhouse Gas Emissions from Buildings, and 96, Commercial Property Assessment of Clean Energy, are examples. Furthermore, New York City's long-term goal is to reduce its 2005 carbon emissions by 80% by 2050 (Gao, Gao and Zhang, 2017).

What was NYU Stern's original motivation for launching the Invest NYC SDG, and how does the project contribute to the achievement of NYC's related goals? As a business leader, first and foremost, NYU Stern is a trusted partner of business leaders who want to drive change and redesign capitalism so that business and society can continue to grow for years to come. The Invest NYC SDG is a two-year initiative to promote private-sector-funded projects, fund the public sector and communities, and assist in the development of a sustainable, inclusive, and resilient future economy in New York. Food and health, the built environment, climate resilience, sustainable transportation, waste, and renewable energy are all priorities (World Economic Forum, 2021).

The initiative is focusing on six areas: the built environment, food and health, waste, climate resilience, renewable energy, and sustainable mobility. It is the built environment that presents special challenges and opportunities. NYC's one million buildings represent 70% of the city's greenhouse gas emissions (from heat, power, and A/C). Newly enacted legislation, the Climate Mobilization Act of 2019 (CMA), requires the city's 30,000 largest buildings to meet reduced emission guidelines by 2024 or face substantial fines (Local Law 97). A new "Property Accessed Clean Energy" (PACE) lending program (Local Law 96) was also created with the CMA to finance 100% of the cost of energy efficiency retrofits and clean energy projects.

Property Accessed Clean Energy (PACE) is an innovative form of financing that is only becoming available in NYC in 2021. Administered by MOS and NYCEEC, broad uptake of PACE requires prioritized outreach to building owners to seek the lending and to underlying mortgage holders to cede priority to PACE loans. CSB wanted to help overcome obstacles to using PACE financing and accelerate the building retrofit process in NYC. A database and map that shows the GHG emission level by building, overlaid with building ownership and the underlying mortgage holder will help prioritize energy retrofits and PACE financing to the largest carbon contributors, and guide strategic intervention with mortgage lenders accordingly. In doing so, CSB brings private finance to help reduce carbon emissions and create a more sustainable future. Invest NYC SDG has been working closely under a memorandum of understanding (MOU) with both the Mayor's Office of Climate and Sustainability (MOCS) and the New York City Energy Efficiency Corporation (NYCEEC) since June 2020 to support the rollout of a robust PACE program. That support includes data collection and analysis, a lender engagement strategy and process, and market development.

Invest NYC SDG has created a public database that combines building benchmarking data required by city law (Local Law 84) and NYC Department of Finance data from ACRIS and other records and shows those buildings subject to Local Law 97 of the CMA, with their total GHG emissions, GHG intensity, ownership, mortgage holder(s), and applicable LL97 penalties (absent emission reductions). Moreover, if there is federal infrastructure and economic stimulus funding forthcoming, this database can help provide a roadmap to identify the biggest contributors to GHG emissions in NYC, with the greatest need for financial support, and highlight funding opportunities to address climate change issues.

Working with Invest NYC SDG, the CUSP team has supported them at a critical phase of development of the LL97-PACE open access data platform and additional visualization support to (1) build out the most user-friendly and free public data platform and website, and (2) develop an effective, free, remote energy audit tool to include on the website. The City and NYCEEC launched the PACE program in June 2021 and the initiative plans to launch the initial version of the website by September.

Therefore, there are many audiences related to the project. The Center for Sustainable Business (CSB) at New York University's Stern School of Business launched this public data tool, with the NYU Furman Center, as part of its multi-year initiative Invest NYC SDG. Working in close collaboration with the Mayor's Office of Sustainability (MOS) and the NYC Energy Efficiency Corporation (NYCEEC), this public data tool was created to support NYC's PACE lending program, aimed at financing energy efficiency and clean energy projects for buildings subject to Local Law 97. This data tool is also designed to help all building owners who seek to reduce carbon emissions. Together we can help reduce greenhouse gas emissions (GHG) from NYC's one million buildings, which create nearly 70 percent of the City's GHG emissions, and help

NYC achieve an 80 percent reduction of carbon by 2050. And together we can help achieve the goals of New York City's sustainability plan One NYC: 2050, as well as the United Nations Sustainable Development Goals.

LITERATURE REVIEW

New York City, the first city in the world to align the Sustainable Development Goals with the United Nations, has led the world in achieving the Sustainable Development Goals, and our goal is to identify and develop opportunities through the New York Agenda and partnership that combines private and public investment, to address the four challenges facing the world:

- Sustainable migration
- Building a better world
- Addressing climate change
- Building a better world

McKinsey has identified energy efficiency as "the single most attractive and affordable component of the necessary shift in energy consumption." (Creyts,2010) The buildings sector is not, however, keeping up with population growth and the increased demand for energy. In many cities, New York included, the built environment is quite old, which leads to wasted heat and electricity, putting further demands on resource consumption. Approximately sixty-seven percent of total citywide greenhouse gas emissions come from NYC's building stock.20 This is not surprising, given that one of New York's defining characteristics as a city is its buildings -- it is home to over one million buildings over 300 square miles. But the city needs to make an

ambitious effort to improve energy efficiency in order to achieve its goals of 80% reduction in greenhouse gas emissions by 2050 (New York City Mayor's Office of Sustainability ,2014).

Close collaboration between the New York office and MOS/NYCEEC to create a common database and prioritize the "worst" buildings for qualifying LL97/PACE mapping, as well as develop/implement a "key" promotion strategy to (a) get potential clients to agree to mortgage holders qualifying for PACE loans, and (b) increase owner participation in PACE (USGBC, 2021). Extensions for critical players to meet New York's Sustainable Investment Goals: Support the New York Computer Equipment Action Partnership's financing program, which aims to provide New York City property owners with more efficient clean energy/energy investment infrastructure. This technique creates an application that allows users to navigate it easily by choosing the filter graph that will be used to display a subset of the data. To describe New York City buildings, we use data visualization tools to create visual representations of large amounts of data. In addition, where did the data used to develop technology that "pierced" the LLC's veil to identify carbon-intensive buildings? Penalties will be imposed every year in accordance with carbon emission targets.

Financial Data: To reduce carbon emissions, improve large-scale energy efficiency, and use public databases to support Computer Equipment Action Partnership loans. In 2019, New York City passed the Climate Mobilization Act, the most ambitious climate legislation enacted by a city in the United States. Local laws 97, Greenhouse Gas Emissions from Buildings, and 96, Commercial Property Assessment of Clean Energy are examples. In the future, New York City intends to cut its 2005 carbon emissions by 80% by 2050 (Bergland, 2019).

The NYU Stern Center for Sustainable Business's contribution to the SDGs project is developing an operational mechanism. The New York Sustainable Development Goals investment is a two-year initiative that will allow the private sector to fund public sector and community-supported projects within the United Nations Sustainable Development Goals framework, and to assist New York in developing a future economy that is sustainable, inclusive, and resilient (Nations, 2021). We intend to work with financial partners to identify compelling, specific demonstration projects in these areas, accelerate the rollout of proven technologies and business models, recommend any necessary government policies or financing mechanisms, and document a roadmap.

Innovative technology Access to a new financial derivative, Access to clean energy assets, is a novel method of financing that New York City will introduce in 2021. The International Monetary Fund and the New York Economic Community use the Computer Equipment Action Partnership, which requires priority contact with building owners for loans and priority contact with primary mortgage holders for priority access to Computer Equipment Action Partnership loans (Gomber, Kauffman, Parker and Weber, 2018). The Empty Office hopes to assist in overcoming the barriers to using PACE financing to accelerate building renovations in New York City. A database and map showing GHG emissions levels from buildings, covering building owners and potential mortgage holders, assist the largest carbon contributors to priorities energy retrofit and computer equipment action partnership financing and guide mortgage lenders' strategic interventions. The space agency is raising private funds to aid in the reduction of carbon emissions and the creation of a more sustainable future. Furthermore, suppose federal infrastructure and economic stimulus funds are made available as soon as possible. In that case, the database will assist in providing a roadmap to identify the countries in

New York City that contribute the most to GHG emissions, the most significant financial support needs, and financing opportunities to highlight climate change issues.

It can be concluded that, following the United Nations Sustainable Development Goals, the New York City government standardizes the compliance carbon emissions of enterprises within its jurisdiction through legislation, and, in close collaboration with MOS/NYCEEC, it uses big data to monitor the carbon emissions of enterprises, akin to piercing the corporate veil. Among these, NYU's assistance has improved the way enterprises control their voluntary fulfilment of obligations through financial loans and other means.

PROBLEM STATEMENT

PROBLEM DEFINITION

The general problem of CUSP group is how to help Invest NYC SDG Initiative to support the implementation of a website available to the public and develop an interactive map of NYC that displays:

- CO2e emission level by building, contact details for the building owner or managing agent, and a list of lien holders.
- the results of a series of queries -- either run in advance or possibly user-defined.

The initial version of the data tool, LL97-PACE Database, is intended to help us guide and prioritize PACE outreach - The data is supposed to be used to prioritize outreach based on carbon levels and portfolios. The data can also inform strategies for obtaining the consent from underlying mortgage holders to a PACE financing. The data can be used to identify lien holders that hold large portfolios of LL97 buildings, who themselves may be persuaded to become

PACE originators and obviate the consent barrier to PACE financing. Moreover, the database can provide a useful roadmap for federal infrastructure funds - The data can show buildings with high carbon emissions in EJ (Environmental Justice) communities and help direct subsidies earmarked for energy efficiency retrofits.

RESEARCH QUESTIONS AND EXPECTED OUTCOMES

Based on the expectation, then the team decides to employ data visualization tools such as a dashboard with tableau and the public LL97 database to create visual representations of large datasets that describe NYC buildings. During the research process, the group divides the problem into four research questions (Table1), and we have an expected value for each question.

Firstly, when the group deals with our datasets, the group always finds that an address can be written in different ways, which is called Fuzzy Matching or Fuzzy Address Matching. For example, 5th Avenue, Fifth Avenue, Fifth AV., 5 Av., Fifth av, etc. Moreover, we realized that no matter which way the address was written, the search results were the same. In addition, we found much software like The USPS API and Address Validation API has developed the methodology into an application for the public of the United States. Therefore, during our process of designing the website for the people, the group needs to apply the methodology into our project to make automatic corrections on how the address was written in the database to make the final application easily used for the users.

Secondly, if the team wants to design an application that interacts information of NYC buildings with emissions data, we are supposed to identify the actual owners of carbon-intense buildings to get an accurate result. In other words, the group plans to develop techniques to “pierce” the LLC veil and identify the actual owners of carbon intense buildings. However, when a landlord buys a

building, they often use Limited Liability Corporations (LLCs, AKA shell companies) to hide their identities, creating a tangled web of associations and businesses. It then becomes difficult to pinpoint precisely which landlord or company is causing issues across many buildings and makes it even harder to prove that a landlord is refusing to respond to issues, creating unsafe conditions for tenants, overcharging for rent, and other discriminatory practices. Moreover, it is also challenging to identify the actual owner of buildings and observe the portfolio of buildings owned by the same owner. In addition, the group found there are many categories such as condo/co-op, corporation, individual, and partnership in the ownership. Therefore, the team decided to explore the research question to identify the ownership of buildings in NYC specifically.

After we find the actual ownership, we need to add some additional information about the true owner. As there are different ownership and categories about each building in NYC, we need comprehensive information about them in the research process. We have 'id' as the joining point, Select Building Information such as Borough-Block-Lot (BBL), Owner Information (LLC, True Owner), Geographic Information, Property Information, and from different files Energy information. In the visualization, what we want to achieve is that we can click on the property information in our application first to display the true owner information, and then click again for more information to get other essential information about the property. Therefore, the group needs to research how to make a specific and comprehensive data analysis about the true ownership.

Then we plan to support Invest NYC SDG to make a specific and visualized map with the public database for users after the group finishes the data processing. However, during the process of looking for references, we found it is challenging to integrate so many datasets about buildings

and emissions of NYC and determine the filters that should be used to display subsets of the data on a map. For one thing, there are many data columns and values such as the address, year built, owners of buildings and other carbon, greenhouse gas emission data to link into one database. For another, there are so many data visualization tools such as Carto and Tableau to select the most suitable one. For example, the group found a reference about energy and water data analysis of New York City (Patel,2020). Therefore, the group should research how to How to employ data visualization tools to create visual representations of large data sets with interactive filters that describe NYC buildings.

Table1. Research Questions & Expected Outcomes

Research Questions	**Expected Outcomes**
How to find the address that the user is searching, no matter the way it is written?	Make automatic corrections on the way the address was written in the database.
How to know the portfolio of buildings owned by the same owner and identify LLC ownership?	Develop techniques (scrap from websites and search the data in NYC open data) to identify the actual owners of carbon intense buildings.
How to determine the filters that should be used to display subsets of the data on a map.	Choosing the useful columns and using tableau to visualize them on the application.
How to employ data visualization tools to create visual representations of large data sets that describe NYC buildings.	Use the consolidated LL97-PACE database to create a dashboard with interactive filters.

DATA

Final Database:

LL97-PACE Database: The database contains various kinds of information about NYC buildings including BBL, ownership information and emission information. The database has been used to create the final map after merging with other useful datasets and data processing. The data will identify both the owner of the property and the holders of any mortgage liens on the property and, if a lien has been securitized, whether the securitization is a “private label” or a U.S. Agency securitization. Based on the comprehensive and specific of the datasets, we can employ data visualization tools such as Tableau to create visual representations of large data sets that describe NYC buildings.

Supporting Databases:

DOB Job Application Fillings: The job application data of NYC Department of building is the most used data at this stage. This data mainly includes job application information and housing related information. Although this data is about job application, we find valuable information about the owner of the house in it. The owner's last name and owner's first name in this data are exactly the true owner information we want. Therefore, we need to integrate and sort this data, extract it, and add it to the original database.

Ownership of NYC Land: The Primary Land Use Tax Lot Output (PLUTO™) data file contains extensive land use and geographic data at the tax lot level in an ASCII comma-delimited file. DCP has created additional fields based on data obtained from one or more of the major data sources. PLUTO data files contain three basic types of data:Tax Lot Characteristics; Building Characteristics; and Geographic/Political/Administrative Districts.

Property Valuation and Assessment Data: Real Estate Assessment Property data. Data represent NYC properties assessments for purpose to calculate Property Tax, Grant eligible properties Exemptions and/or Abatements.

Multiple Dwelling Registrations Data**:** Pursuant to New York City's Housing Maintenance Code, the Department of Housing Preservation and Development (HPD) collects registration information from owners of residential rental units.

HPD Registration Contacts: It contains information about organizations or individuals listed on a Multiple Dwelling Registration form.

METHODS

Firstly, an address can be written in different ways. For example: 5th Avenue, Fifth Avenue, Fifth AV., 5 Av., Fifth av, etc. Therefore, we're going to use free software or "fuzzy matching" codes to make corrections on the way the address was written in the database.

- Fuzzy Matching
    - Levenshtein Distance
    - FuzzyWuzzy
- Fuzzy Address Matching
    - Address-matcher
    - Software: USPS API, Alteryx, etc.

Secondly, we need to find a portfolio of buildings owned by the same owner. Usually a building (ABC) has a registered owner (ABC LLC), so we need to find who owns ABC LLC, that has a portfolio of buildings around the city. After that we'll sort buildings into groups of buildings under common ownership and occupancy groups. In the end, we can form a new database, which

contains building information (id, BBL), owner information (LLC, true owner), geographic information, property information and energy information. The group used toolkits such as Justfix.nyc, NYCityMap and Acris.

Then the group plans to merge the found data, which should include BBL information, owner information, geographic information, and the newly found data that can reflect the real owner information. Therefore, we need to get data sources from different websites and papers and use Python and SQL to clean and analyze the data, and finally put the useful information into one database.

Thirdly, the group plans to create visualizations such as a dashboard with Tableau to display the results. Firstly, the group has created various graphs about general building information and community profile. For example, ranking buildings by LL97 total carbon emissions (metric Tons CO2e) and sorting community boards by LL97 total carbon emissions (metric Tons CO2e). After creating these graphs, we made a Tableau dashboard by creating total emissions by key categories such as city-owned buildings and construction dates.

Finally, the group plans to use Tableau and Wix.com to create the open website and display the information about the finance map of NYC.

RESULTS

Fuzzy Matching

Fuzzy Matching is a technique used in computer-assisted translation as a special case of record linkage. It works with matches that may be less than 100% perfect when finding correspondences between segments of a text and entries in a database of previous translations.The concept of Fuzzy Matching is to calculate similarity between any two given strings. And this is achieved by making

use of the Levenshtein Distance between the two strings (see Figure 6 in Appendix). FuzzyWuzzy is a library of Python which is used for string matching. Fuzzy string matching is the process of finding strings that match a given pattern. FuzzyWuzzy has many powerful functions that allow us to deal with more complex situations such as substring matching (see Figure 7-8 in Appendix).

We also tried to achieve Fuzzy Matching by Ruby. We used a geocoder gem to make a more educated guess by comparing the latitude and longitude of two addresses and returning true if they are close enough. It connects to more than 40 API worldwide so it is very powerful. We also used the address matcher library in Ruby to achieve our functions. Specifically, we first created an address library with all of the known address strings we wanted to match against, then called match to find the closest matching address. For instance, we can use our library to measure whether "1000 5th Ave, New York, NY 10028" and "1000 5th Avenue, New York City, NY 10028" is the same address (see Figure 9 in Appendix).

Identifying LLC Ownership

Building and Merging of Database

We need to organize different databases and constantly increase information about owners. So based on the data of the Pluto website, according to the information of the BBL column and the registration information of the HPD data column, we used Python to combine the data of HPD and Acris website. Without changing the order of basic data, we added new information about owners, including gas emission information, geographic information, tax information, mailing information and housing use information.After we found the DOB database, we added the real owner information. Our database already has real owner information, but now the problem is that a BBL will correspond to many different owners. We are summarizing data through different

owner types and business names.So then we use SQL to make classification and adjustment, and classify the same BBL according to the house type.

Identify and Analyze LLC Ownership

As mentioned in 'Building and Merging of Database', we put the data into MySQL for classification.There are four kinds of owner types, which are partnership, corporation, condo and individual respectively. They were originally in one column (see Figure in Appendix). In order to identify owner name and business name, we used sql queries to select them, for instance, corporate owner name, corporate business name, partner owner name, partner business name, condo owner name, condo business, etc. In this way, we can better identify the business name and owner name in each type, and have a deeper understanding of our dataset. From our database, we can see corporations take the largest proportion among the four types while individuals are the smallest, which is very reasonable.

Rank the Top Owner in NYC

We compared the owners with the largest number of buildings in New York City mentioned in the ’Who owns all of New York’ article (Small,2018). As shown in the figure 1, "No. buildings / vacant parts" is the data mentioned in the article, and "owner in our merged file" is our own data. We found that our own data is quite different from those mentioned in the article. After analysis, we think that we mainly use the real owner data in DOB data, while the data used in the article is only the business name or company name, so we have more data. Moreover, our data do not count the buildings of the whole NYC, so these two reasons lead to great differences.

Rank of NYC Property Owners				
RANK	FIRM/ENTITY	TOTAL SQUARE FEET	NO. BUILDINGS/ VACANT PARCELS	Owner in our meged file
1	NYC (government)	362.1M	4941	25956
2	Vornado Realty Trust	29.7M	77	428
3	SL Green Realty	28.7M	73	851
4	Tishman Speyer	20.5M	36	813
5	Blackstone Group	20.1M	31	3
6	Related Companies	18.7M	156	30
7	Columbia University	17.9M	246	174
8	Brookfield Property Partners	17.5M	19	611
9	RXR Realty	16.5M	22	2300 (RXR)
10	New York University	14.3M	111	214
11	Durst Organization	14.1M	49	25

Figure 1 Top Owners in NYC

Create the Tableau Dashboard & Analyze Graphs

Before creating the dashboard, the group made some graphs to support the development of the map and analyze the important values. For example, we want our users to perform ranking buildings, user types and efficiency grades by LL97 total carbon emissions and other information. Therefore, we made a table (Table 3 in Appendix) to describe all the questions and expected results. Then we made all the graphs with Tableau following the questions. For example, Figure 9 in Appendix shows the top 50 buildings ranked by the LL97 Total emissions (Metric Tons CO2e) and we found that Warren Weaver Hall has the maximum carbon emissions in New York City. In addition, we put other graphs (Figure 10-21) into the Appendix. The group will select useful information to develop the following map according to these graphs.

Then we created a Tableau dashboard (Figure 2) to demonstrate total emissions by four key categories, as to find some insightful results. One graph is displayed by different construction dates, one is by different kinds of city owned BBL, one is plotted by different fuels, the last one is by low-income housing tax credit qualified census tracts. As for construction dates, we divided the construction period into four parts, 1749-1840, 1841-1920, 1921-1945, 1946-1990 and 1991 to now respectively (Figure 10 in Appendix). It is apparent from our graph that most buildings (10,202) in NYC were constructed during 1921-1945 while only 4,580 buildings were built currently. We displayed them in a pie chart. As for city-owned buildings, we utilized the horizontal bar chart for demonstrating (Figure 11 in Appendix). From our graph, most buildings are not owned by cities. Among them, multifamily housing takes the largest percentage, reaching 24,020, and office makes up the second largest percent, with 2,265 number of BBL. Comparingly, K-12 schools account for the largest proportion of city-owned-buildings, with 1,582 BBL. In addition, for fuel part (Figure 12 in Appendix), we divided fuels into 9 categories, Fuel Oil #1 Use, Fuel Oil #2 Use, Diesel #2 Use, Kerosene, Natural Gas, and so on. Beyond that, we also displayed these kinds of fuels in 6 boroughs in NYC since we wanted to find the different performances of fuel consumptions in different boroughs. It is very clear that Manhattan consumes most fuels whereas Staten island consumes least, which is very reasonable considering the characteristics of the two boroughs. In all boroughs, natural gas use accounts for the largest proportion of total fuel use. Lastly, from our dashboard, 68.03% records are not low-income housing tax credit qualified census tracts, we used a pie chart to display it (Figure 13 in Appendix).

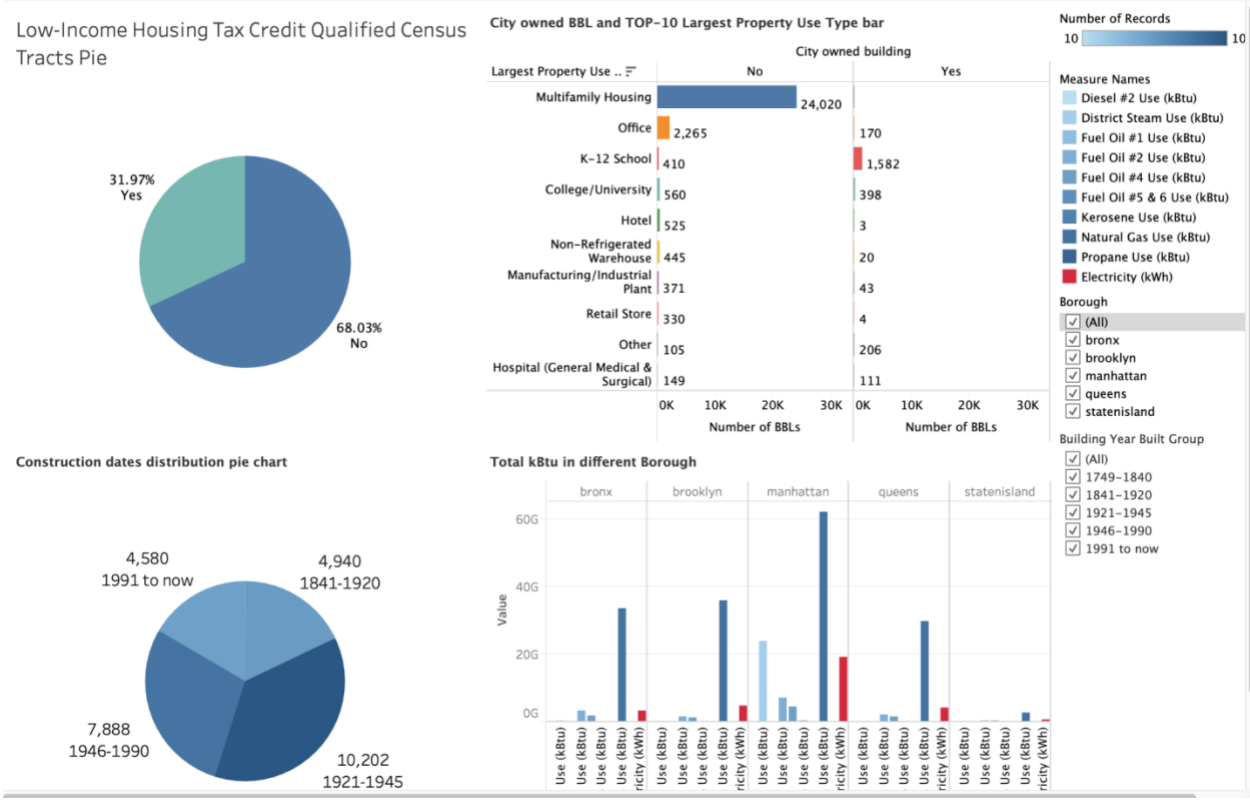

Figure 2 Dashboard

The Beat Version of NYC Buildings Map

After the group created the graphs and dashboard with tableau, CSB launched this public data tool, with the NYU Furman Center, as part of its multi-year initiative Invest NYC SDG. This public data tool was created to support NYC's PACE lending program, aimed at financing energy efficiency and clean energy projects for buildings subject to Local Law 97. This data tool is also designed to help all building owners who seek to reduce carbon emissions.

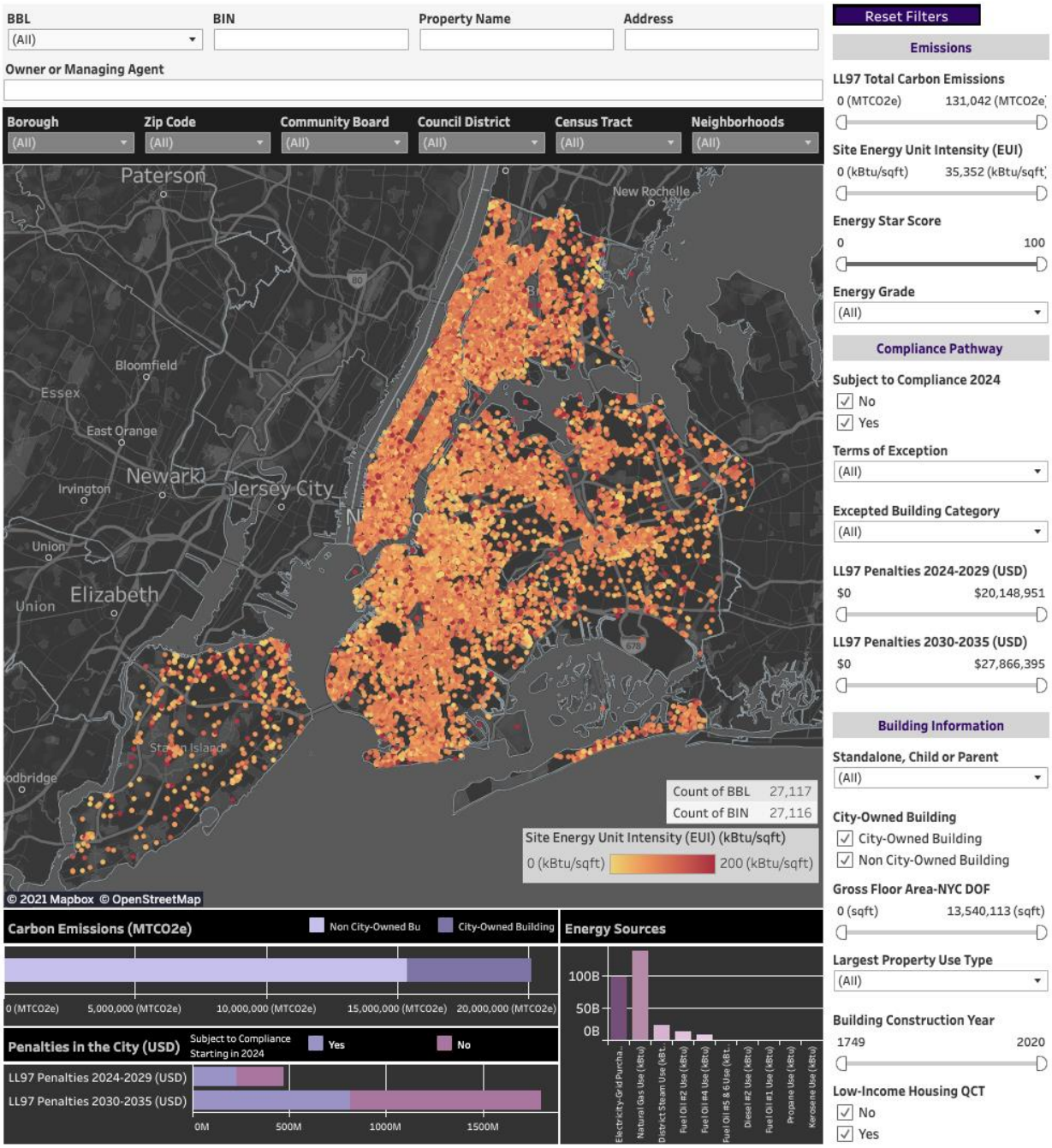

Figure 3 NYC Buildings Map

The data tool has the following three functions (see in Figure 22 in Appendix). First of all, you can search BBL, BIN, Property name and Address to screen out the buildings that meet the requirements. In addition, in the process of CO2 emission data filtering, total CO2 data, Site

Energy Unit Intensity, Energy Star score and Energy Grade can be used for filtering. In Compliance Pathway screening, you can do this by selecting the type of building and the age of the building. In the filtering of building information, information such as the category of all people, the area occupied by the building, the year of building construction, and whether the building is inhabited by low-income people can be screened.

LIMITATIONS

For one thing, in the process of identifying the true ownership of NYC buildings, there was one limitation called purpose limitation which is a principle that data collected for one specified purpose should not be used for a new, incompatible purpose. In order to be consistent with the principles, personal information must be limited to the information that is relevant for the purposes of processing. Therefore, we may not process personal information in a way that is incompatible with our purposes for which it has been collected or subsequently authorized by the individual. To the extent necessary for those purposes, we must take reasonable steps to ensure that personal data is reliable for its intended use, accurate, complete, and current.

For another, one impediment to PACE is the cost of an energy audit, which can exceed the 2024 LL97 penalty, so building owners may simply choose the penalty. Remote energy audits (or "outside-in analyses") have had varying accuracy but are more reliable when applied to residential buildings. Invest NYC SDG is partnering with NYU Tandon School professor, Constantine Kontokosta, who developed NYC benchmarking data systems for the City and who can develop a more accurate digital remote energy audit model for our data platform. His work will likely use models developed by the US DOE, and data developed by NYSERDA for the Rocky Mountain Institute (RMI).

CONCLUSIONS

Summary

In this project, the group mainly worked on identifying LLC ownership and support Invest NYC SDG to implement the public data tool by providing the work of data visualizations. The data tool will inform building owners, managers, architects, engineers and vendors of energy efficiency solutions of the CO2e produced by a property and the potential LL97 fines facing the property. The data will identify both the owner of the property and the holders of any mortgage liens on the property and, if a lien has been securitized, whether the securitization is a "private label" or a U.S. Agency securitization. The user interface allows the user to easily identify portfolios of buildings under common ownership, with common mortgage lenders, or that are located in the same neighborhood.

The data tool will also identify those properties covered by LL97 whose mortgages have are held by a CMBS (Commercial Mortgage Back Security) trustee and indicates whether the securitization is a U.S. Agency CMBS (Fannie Mae, Freddie Mac) or a "private label" CMBS. Private label CMBS trustees and/or servicers are unlikely to cede priority to a PACE financing. We estimate that there are more than 8,000 CMBS buildings -- nearly one third of LL97-covered buildings. This data can be used to show the total carbon produced by buildings where the mortgage is held in a CMBS and spearhead conversations to change the securitization documents and new provisions regarding PACE in workouts of distressed buildings.

Implications

Combating Climate Change: NYC's one million buildings produce 70% of the City's GHG emissions. Supporting energy efficiency retrofits by building owners is the single largest opportunity to reduce carbon in NYC. Local Law 97 will drive retrofits with mandated emission reductions and penalties for ~28,000 buildings beginning in 2024.

Creating Green Jobs: Energy efficient retrofits are predicted to create as many as 140,000 NYC green jobs in the next decade.

Economic Development: Local Law 97 is predicted to create $16.6 B to $24.3 B in private investment. PACE lending provides long-term, low-cost financing, and could generate revenue for the City.

Building Catalytic Free Public Data Infrastructure to Scale and Replicate.

Future Development of the Data Tool

The group has finished all research questions from start to now such as making a dashboard to display the information by different categories and in order to achieve our goal, the group is still supposed to find the true ownership of the buildings of NYC to demonstrate the final finance map more specifically. However, a BBL or a building corresponds to many different owners, and we want to find out the specific information and accurately arrange them. In the future phase, the group will still work on exploring true ownership behind BBL.

Enable building owners and their advisors to perform cost benefit analyses of Energy Efficiency and Clean Energy Projects and drive demand for PACE - The initial version of the data tool identifies the carbon produced by a building and the potential fines facing the building in both 2024 and 2030. But it cannot estimate the approximate cost of implementing energy efficiency (EE) measures. Invest NYC SDG is working to include a free remote energy audit tool on its data

platform that will enable building owners to perform cost/benefit analysis of a potential project -- that includes the avoided fines, the estimated cost of the project, and the estimated future energy savings.

TEAM ROLES

Project

About the project, the group has specific team collaboration and divisions, as shown in the Gantt chart (see in Figure18-20). Besides weekly meetings twice a week among our group, we make a weekly report to our mentor from the Center for Sustainable Business. Moreover, we modify our results and start new tasks according to the suggestions from our mentor. Then we make a specific division of work and a unified conclusion when we finish our respective studies.

- Haiqiang An: Fuzzy Matching, Identifying LLC Ownership, Data Visualizations
- Huanran Kong: Data Processing, Identifying LLC Ownership, Data Analysis
- Yuanzhe Luo: Data Processing, Identifying LLC Ownership, Creating the Website
- Yuetong Zhou: Fuzzy Matching, Identifying LLC Ownership, Data Visualizations

Report

About this report, we also made a specific division of tasks. In the part of the problem statement, data, methods and results, each of us wrote corresponding reports based on our own research problems, methods and results.

- Haiqiang An: Abstract, Introduction, Literature Review, Problem Statement, Datasets, Methodology and Results
- Huanran Kong: Problem Statement, Methodology, Datasets and Results

- Yuanzhe Luo: Problem Statement, Datasets, Methodology and Research Plan
- Yuetong Zhou: Datasets, Methodology and Results

* Every team member had the same workload.

LINKS

- GitHub: https://github.com/Haiqiang7/2021capstone_A-Finance-Map-of-NYC

ACKNOWLEDGEMENTS

Invest NYC SDG is an initiative of the Center for Sustainable Business at NYU Stern School of Business, working to develop investable projects to advance NYC's sustainability goals, using the UN SDGs as a framework. The initiative is focusing on six areas: the built environment, food and health, waste, climate resilience, renewable energy, and sustainable mobility.

Thanks to our mentor, Marianna Koval, the director of the Invest NYC SDG Initiative at the NYU Stern Center for Sustainable Business. She helped us gain an insight into driving financing toward creating a more sustainable, inclusive and resilient New York City. Moreover, she inspired us to show the beta version of their LL97-PACE.nyc database to CUSP students.

We would also like to thank our other mentors, Miles Draycott and Gary Friedland, and our associates from Invest NYC SDG Initiative, Alejandro Cardona and Carleigh McFarlane, for guiding us throughout the course of our project and giving invaluable insights to develop our project to this stage.

APPENDDIX

Datasets

Datasets	Link
Ownership of NYC Land	https://www1.nyc.gov/site/planning/data-maps/open-data/dwn-pluto-mappluto.page
True Owner Data	http://a810-bisweb.nyc.gov/bisweb/bsqpm01.jsp
Property Valuation and Assessment data	https://data.cityofnewyork.us/City-Government/Property-Valuation-and-Assessment-Data-Tax-Classes/8y4t-faws
Multiple Dwelling Registrations data	https://data.cityofnewyork.us/Housing-Development/Multiple-Dwelling-Registrations/tesw-yqqr
CO2 Emission Dataset	https://nyc-ghg-inventory.cusp.nyu.edu/#data
HPD Registration Contacts	https://data.cityofnewyork.us/Housing-Development/Registration-Contacts/feu5-w2e2
DOB Job Application Fillings	https://data.cityofnewyork.us/Housing-Development/DOB-Job-Application-Filings/ic3t-wcy2

Table3. Descriptions for Graphs

	Description	**Top**	**Type of Chart**	**1_Name of the Column**	**2_Name of the Column**	**3_Name of the Column**
	Rank buildings (property name) by total LL97 carbon	Top 50	Bar Chart	Property Name	The LL97 total emissions	

					(Metric Tons CO2e)	
	Rank buildings (property name) by LL84 Carbon Intensity	Top 50	Bar Chart	Property Name	Site EUI (kBtu/sqft)	
	Rank buildings (property name) by Penalties to pay in phase 1 (Show also the penalties on phase 2)	Top 50	Bar Chart	Property Name	LL97 penalty for 2024-2029 (USD)	
	Rank buildings (property name) by Penalties to pay in phase 2 (Show also the penalties on phase 1)	Top 50	Bar Chart	Property Name	LL97 penalty for 2030-2034 (USD)	
General Building Information	Rank Use types by total LL97 carbon		Pie Chart	Largest Property Use Type	The LL97 total emissions (Metric Tons CO2e)	
	Rank Efficiency grade by total LL97 carbon		Bar Chart	Energy Grade	The LL97 total emissions (Metric Tons CO2e)	
	Total carbon of NYC owned buildings as % of total carbon of all NYC buildings (or all NYC buildings > 25k square feet).		Pie Chart	City building (yes)	The LL97 total emissions (Metric Tons CO2e)	
	Total carbon of NYC owned buildings in each borough as % of total carbon of all buildings in the borough (or all buildings in the borough > 25k square feet).		Vertical Stacked Bar Chart	City building (yes)	The LL97 total emissions (Metric Tons CO2e)	Borough
Community Profile	Sort Community Board by LL97 carbon	Top 10	Bar Chart	community_board	The LL97 total emissions (Metric Tons CO2e)	
	Sort Council district by LL97 carbon	Top 10	Bar Chart	council_district	The LL97 total emissions (Metric Tons CO2e)	
	Sort NTA by LL97 carbon	Top 10	Bar Chart	nta	The LL97 total emissions (Metric Tons CO2e)	

	Sort US CENSUS tract by LL97 carbon	Top 10	Bar Chart	census_tract	The LL97 total emissions (Metric Tons CO2e)	

property_name	borough	block	lot	owner_type	corporate_owner_name	corporate_business	partner_owner_name	partner_business	condo_owner_name	condo_business	individual_owner	individual_name
1720 KINGS HIGHW	BROOKLYN	6780	22	PARTNERSHIP	0	0	NORMAN FRIEDMAN	AVALON REALTY	0	0	0	0
1720 KINGS HIGHW	BROOKLYN	6780	22	CORPORATION	DAVID LEVINE	AVALON REALTY CO. L	0	0	0	0	0	0
1720 KINGS HIGHW	BROOKLYN	6780	22	CORPORATION	JEFF OLESEN	RITE AID	0	0	0	0	0	0
1720 KINGS HIGHW	BROOKLYN	6780	22	CORPORATION	Akiva Kobre	Touro College	0	0	0	0	0	0
1720 KINGS HIGHW	BROOKLYN	6780	22	PARTNERSHIP	0	0	Norman Friedman	Bighton Norse Rea	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	CONDO/CO-OP	0	0	0	0	GABRIEL HARVEY	WF NYC HOME TR	0	0
1 Central Park West	MANHATTA	1113	7502	OTHER GOV'T AGENCY	0	0	0	0	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	CONDO/CO-OP	0	0	0	0	SUZIE MILLS	TRUMP INTERNAT	0	0
1 Central Park West	MANHATTA	1113	7502	CONDO/CO-OP	0	0	0	0	TULUHAN FATMA K	1 CPW UNIT 34D,	0	0
1 Central Park West	MANHATTA	1113	7502	CORPORATION	SUZIE MILLS	TRUMP INTERNATIONA	0	0	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	PARTNERSHIP	0	0	SUZANNAH MILLS	TRUMP INTERNATI	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	CORPORATION	SUSANNAH MILLS	TRUMP INTERNATIONA	0	0	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	CORPORATION	SUZANNAH MILLS	TRUMP INTERNATIONA	0	0	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	CORPORATION	SUSAN MILLS	TRUMP INTERNATION.	0	0	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	PARTNERSHIP	0	0	SUZANNAH MILLS	TRUMP INTERNATI	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	CORPORATION	SANJIV AHUJA	TRUMP INTERNATIONA	0	0	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	CORPORATION	MEL KARMAZIN	TRUMP INTERNATIONA	0	0	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	CORPORATION	SIMON CLAUSEN	TRUMP INTERNATIONA	0	0	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	CORPORATION	THOMAS PIENKOS	TIHT COMMERCIAL LLC	0	0	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	CORPORATION	SUZANNAH MILLS	TRUMP INTN'L HOTEL &	0	0	0	0	0	0
1 Central Park West	MANHATTA	1113	7502		0	0	0	0	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	CONDO/CO-OP	0	0	0	0	JUDITH HAIMOVIC		0	0
1 Central Park West	MANHATTA	1113	7502	CONDO/CO-OP	0	0	0	0	JUDY WORTSMANN	1CPW26A LLC	0	0
1 Central Park West	MANHATTA	1113	7502	CORPORATION	FRANCIS VON SEILERN-ASP	LIGHT AND SOUND PR	0	0	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	CORPORATION	SUZIE MILLS	THE TRUMP ORGANIZA	0	0	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	CORPORATION	RUCHIR SHARMA	CORONA ON THE PARI	0	0	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	CORPORATION	SUZIE MILLS	TRUMP INTERNATIONA	0	0	0	0	0	0
1 Central Park West	MANHATTA	1113	7502	CONDO/CO-OP	0	0	0	0	HO BENG CHENG	HAMPDEN DEVEL	0	0
1 Central Park West	MANHATTA	1113	7502	CONDO/CO-OP	0	0	0	0	MIKE LOYA	TRUMP INTNL TO	0	0
1 Central Park West	MANHATTA	1113	7502	CONDO/CO-OP	0	0	0	0	BARBARA ULLMAN	FIFTEEN CWP CO	0	0
1 Central Park West	MANHATTA	1113	7502	CONDO/CO-OP	0	0	0	0	LACHMAN PAUL	PREF CPW 43C LL	0	0
1 Central Park West	MANHATTA	1113	7502	CONDO/CO-OP	0	0	0	0	DORIS COLEMAN		0	0
1 Central Park West	MANHATTA	1113	7502	CONDO/CO-OP	0	0	0	0	SUZANNAH MILLS	TRUMP INT'L HOT	0	0

Figure 4 Ownership Database Analysis

```
Strfth="Fifth Avenue"
Str5th="Fifth av"
Distance = levenshtein_ratio_and_distance(Strfth.lower(),Str5th.lower())
print(Distance)
Ratio = levenshtein_ratio_and_distance(Strfth.lower(),Str5th.lower(),ratio_calc = True)
print(Ratio)
```

```
The strings are 4 edits away
0.8
```

Figure 5 Example in Levenshtein Distance

```
Str18 = "5th Avenue"
Str19 = "Fifth Avenue"
Ratio = fuzz.ratio(Str18.lower(),Str19.lower())
Partial_Ratio = fuzz.partial_ratio(Str18.lower(),Str19.lower())
Token_Sort_Ratio = fuzz.token_sort_ratio(Str18,Str19)
Token_Set_Ratio = fuzz.token_set_ratio(Str18,Str19)
print(Ratio)
print(Partial_Ratio)
print(Token_Sort_Ratio)
print(Token_Set_Ratio)
```

```
82
90
55
82
```

```
Str20 = "fifth av"
Str21 = "Fifth Avenue"
Ratio = fuzz.ratio(Str20.lower(),Str21.lower())
Partial_Ratio = fuzz.partial_ratio(Str20.lower(),Str21.lower())
Token_Sort_Ratio = fuzz.token_sort_ratio(Str20,Str21)
Token_Set_Ratio = fuzz.token_set_ratio(Str20,Str21)
print(Ratio)
print(Partial_Ratio)
print(Token_Sort_Ratio)
print(Token_Set_Ratio)
```

```
80
100
80
80
```

Figure 6-7 Example in FuzzyWuzzy

```
addresses = ['30 Lincoln Center Plaza, New York, NY 10023',
             '1000 5th Ave, New York, NY 10028',
             '1001 5th Avenue, New York, NY 10028',
             '1002 5th Avenue, New York, NY 10028'
             ]

library = AddressLibrary.build(addresses)

library.match('1000 5th Avenue, New York, NY 10028')
#=> 1000 5th Ave, New York, NY 10028
```

Figure 8 Example in Ruby

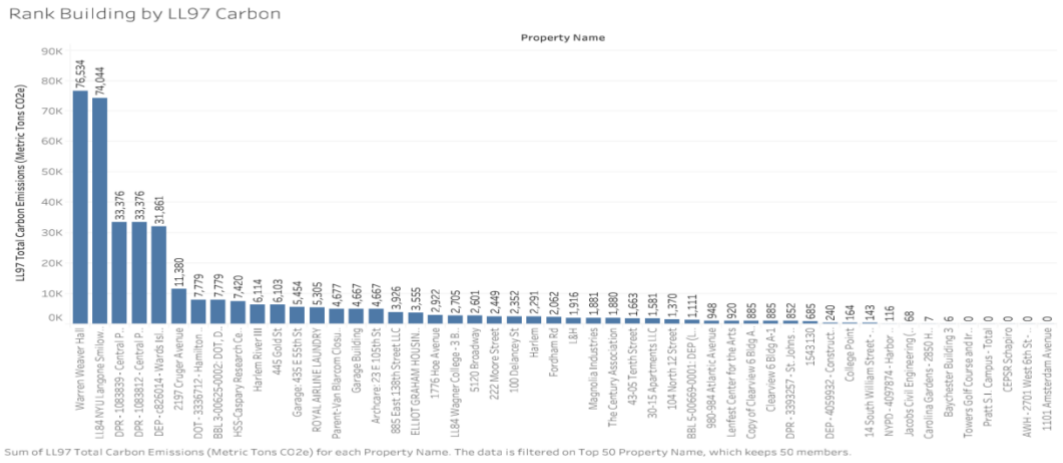

Figure 9 Rank Building by LL97 Carbon

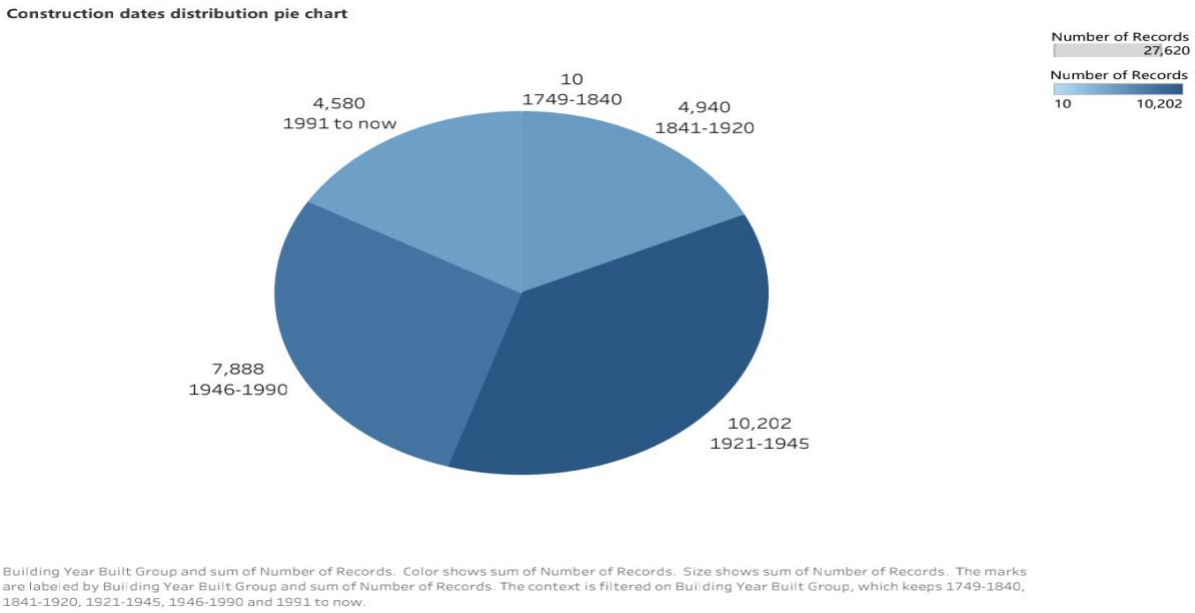

Figure 10 Construction Dates Distribution Pie Chart

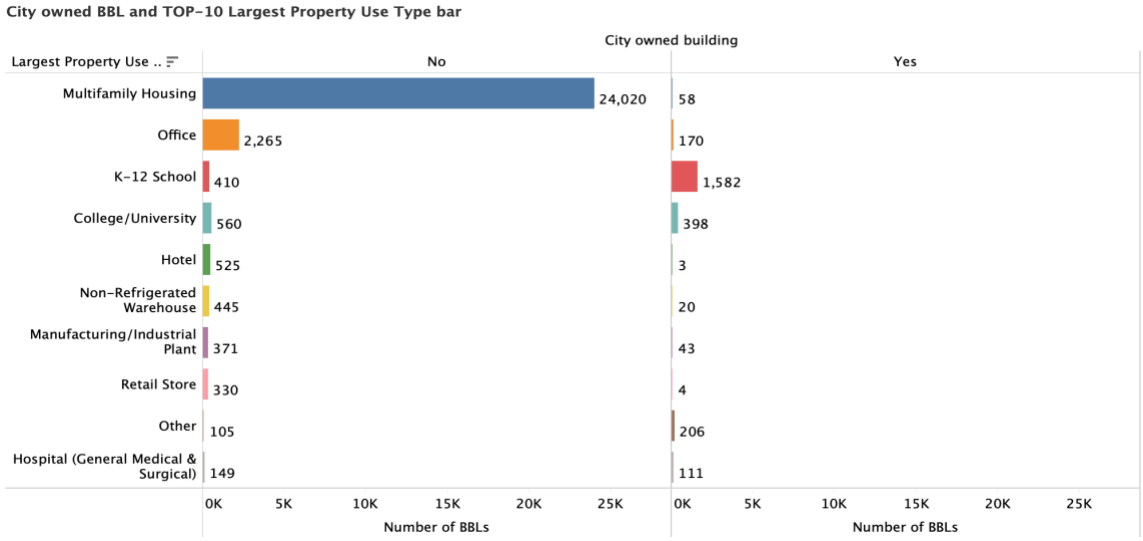

Figure 11 City Owned BBl and Top 10 Largest Property Use Type Bar Chart

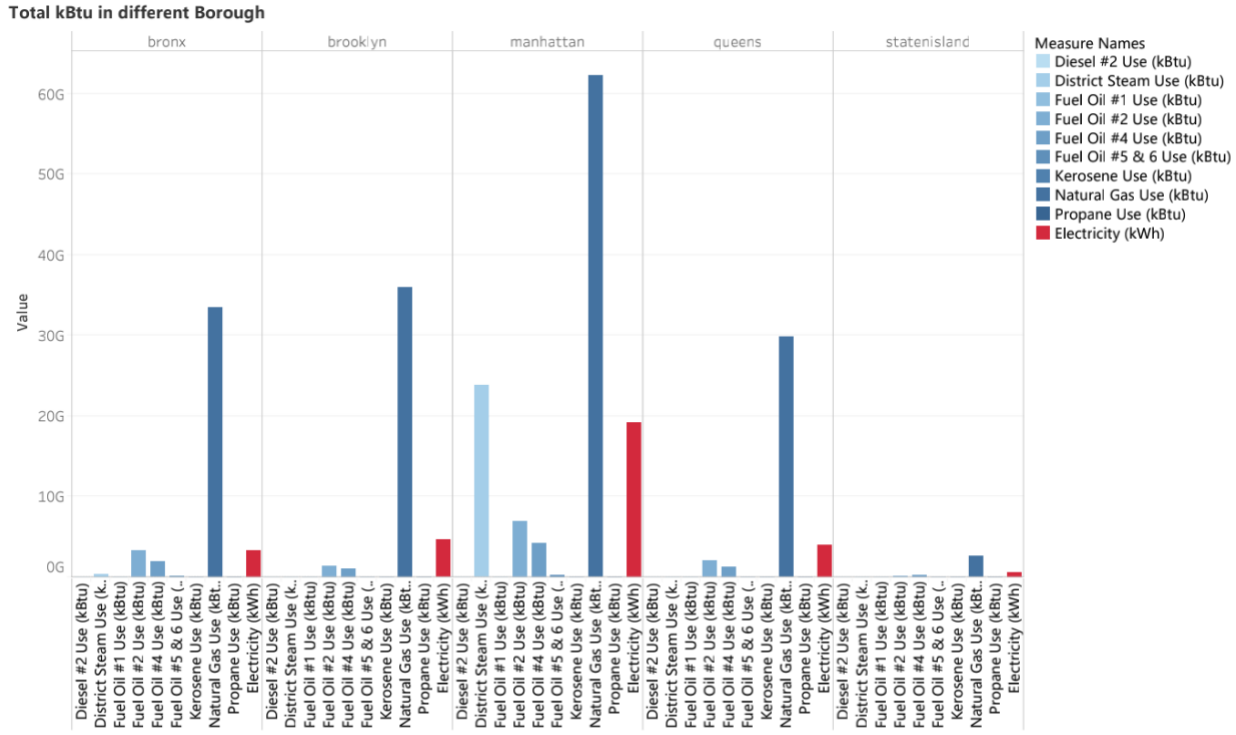

Figure 12 Total kBtu in Different Borough

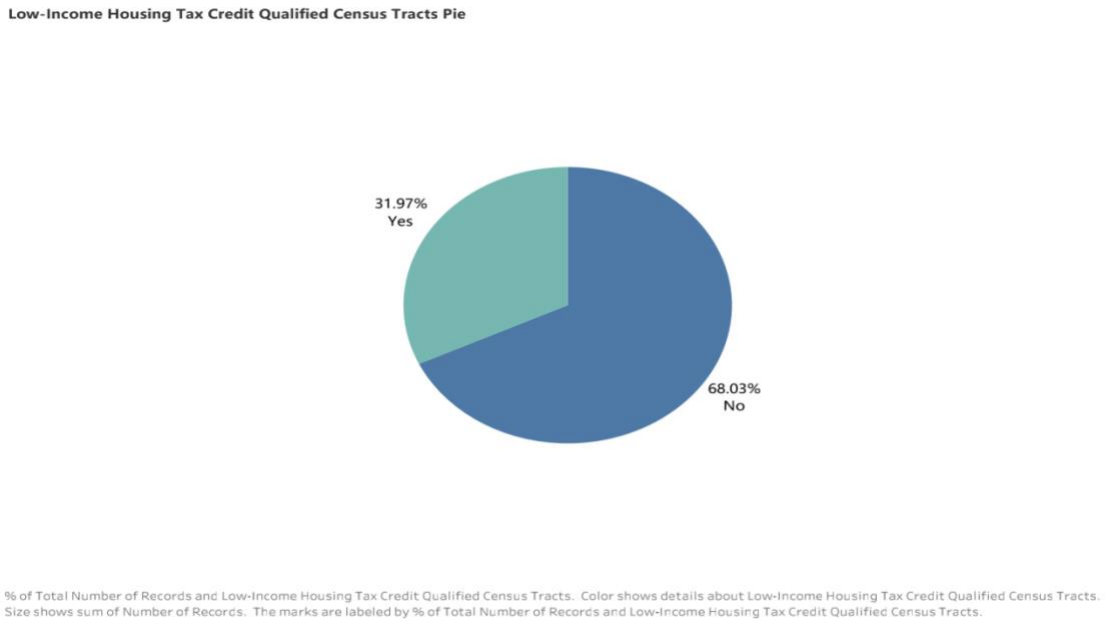

Figure 13 Low-Income Housing Tax Credit Qualified Census Tracts Pie Chart

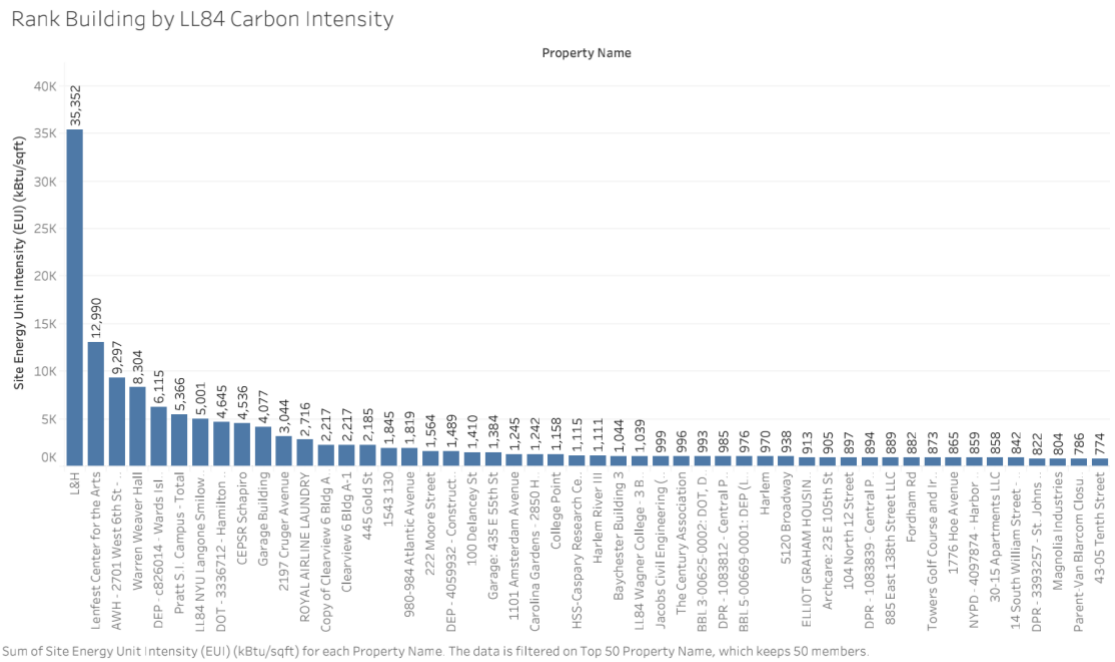

Figure 14 Rank Buildings by LL84 Carbon Intensity

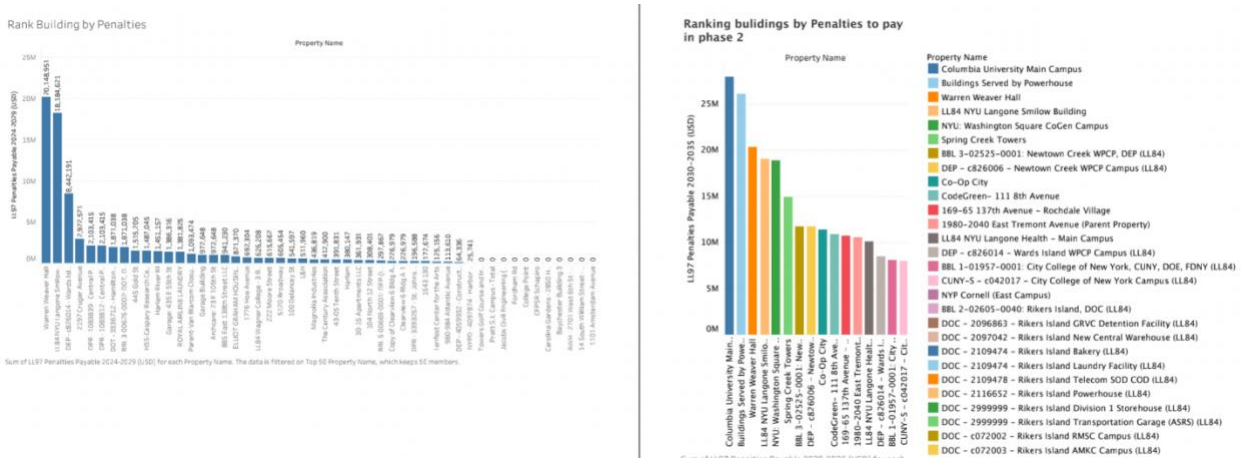

Figure 15 Rank Buildings by Penalties & to Pay in Phase 2

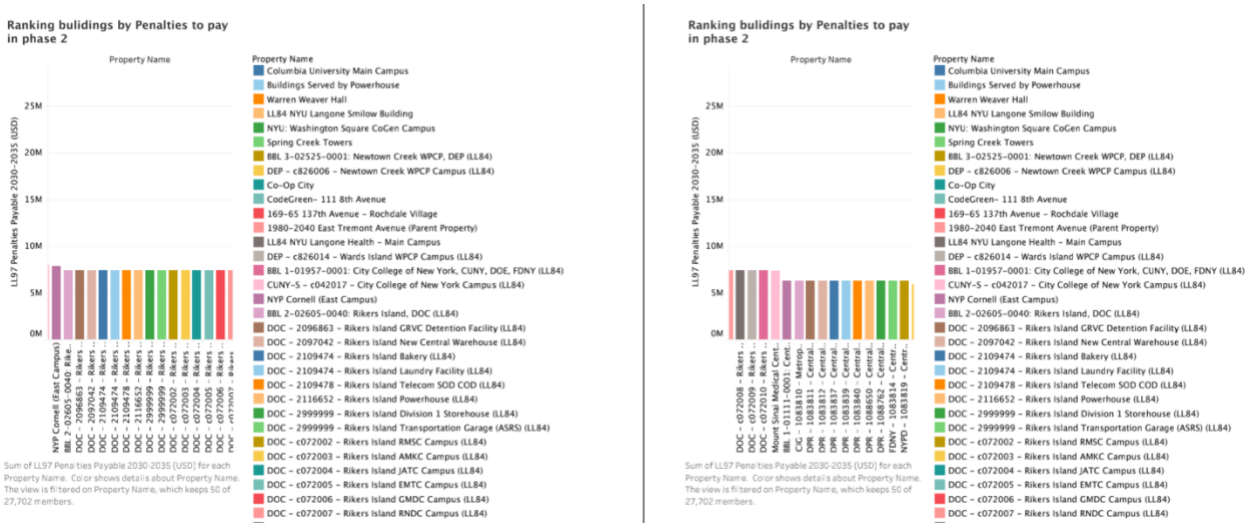

Figure 16 Rank Buildings by Penalties toPay in Phase 2

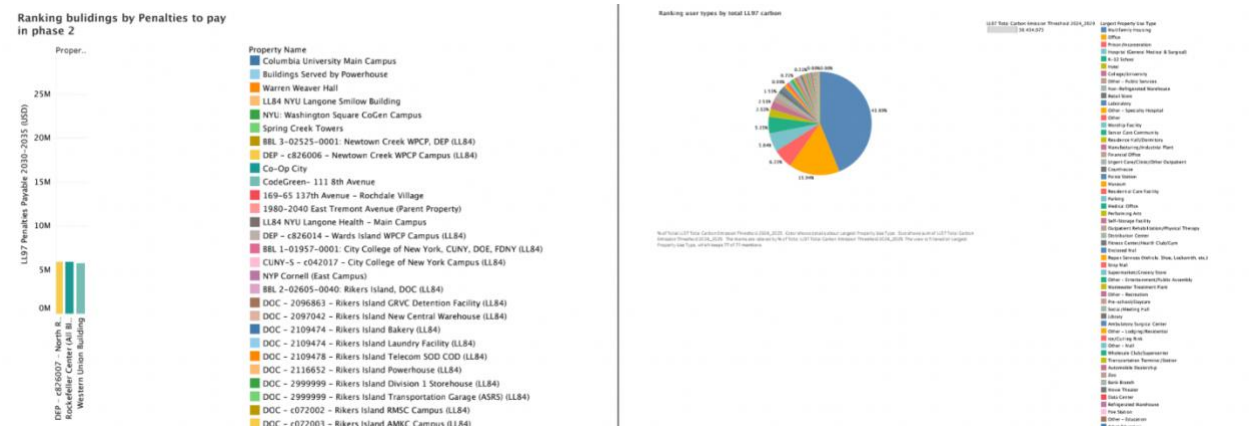

Figure 17 Rank Buildings by Penalties to Pay in Phase 2 & Ranking User Type by Total LL97 Carbon

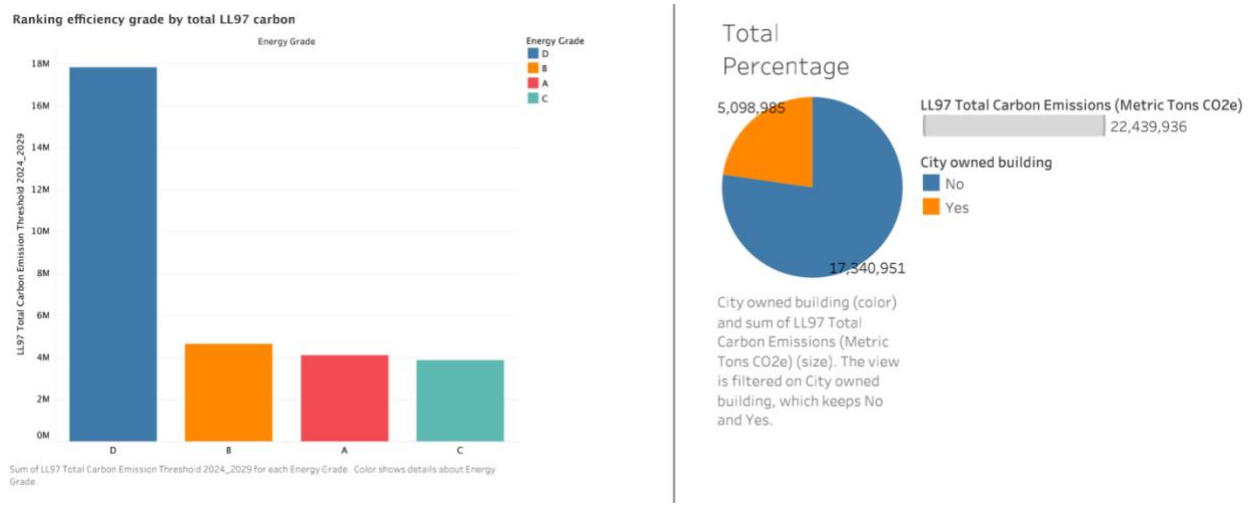

Figure 18 Rank Efficiency Grade by Total LL97 Carbon & City-Owned Buildings

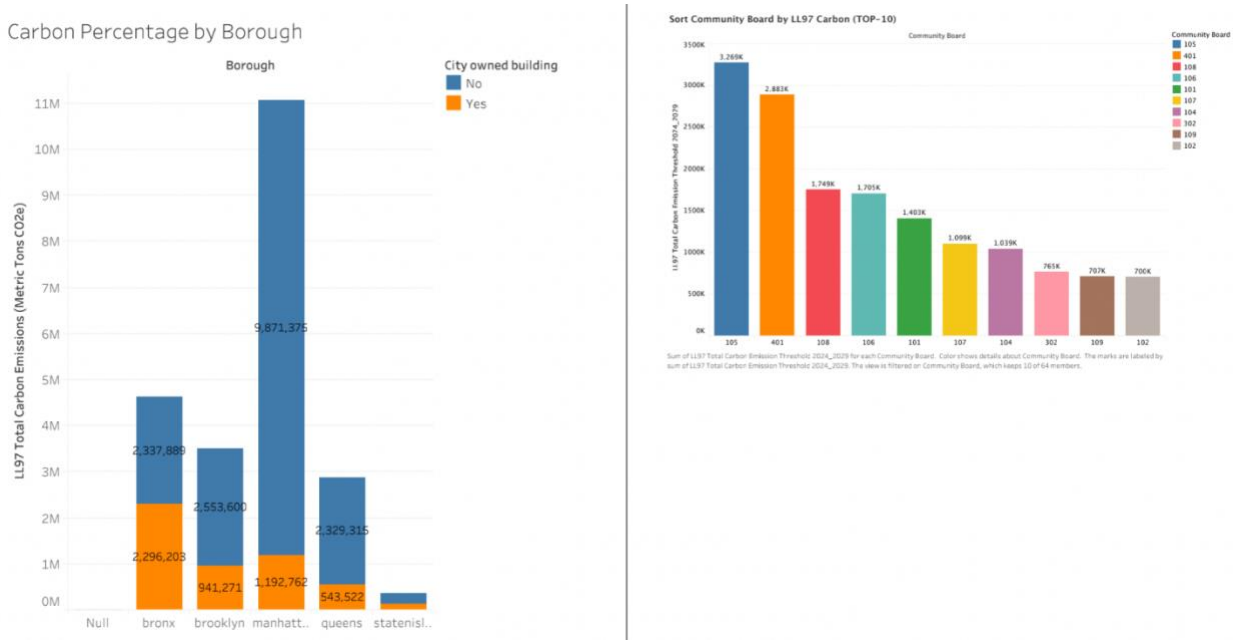

Figure 19 Carbon Percentage by Borough & Sort Community Board by LL97 Carbon(Top-10)

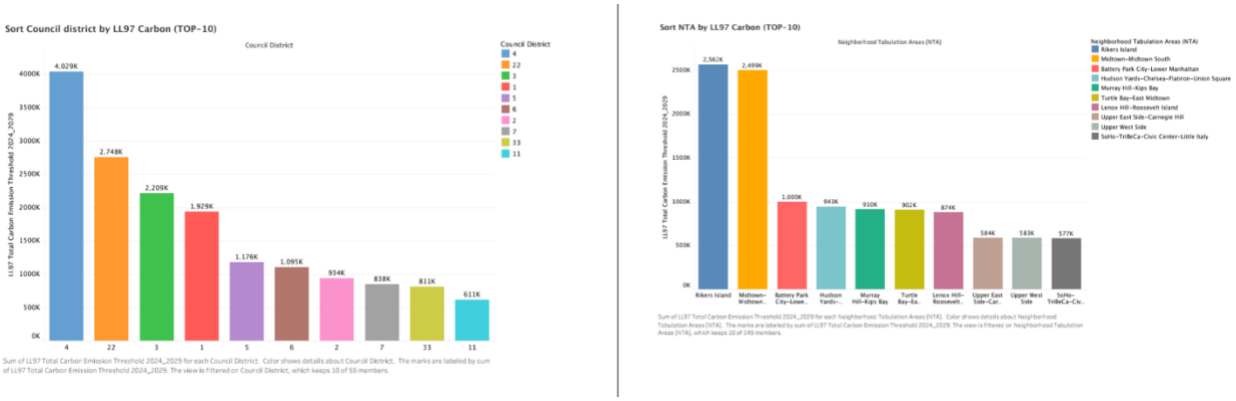

Figure 20 Sort Council District & NTA by LL97 Carbon(Top-10)

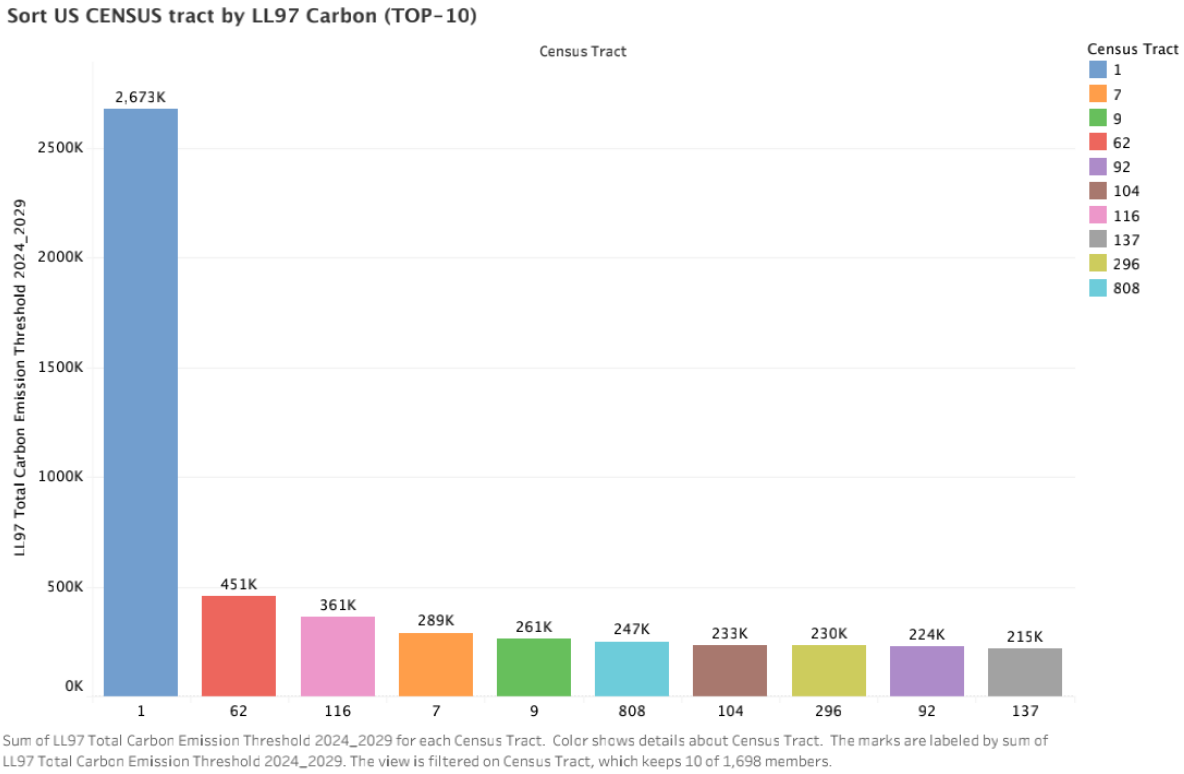

Figure 21 Sort US CENSUS Tract by LL97 CArbon (Top-10)

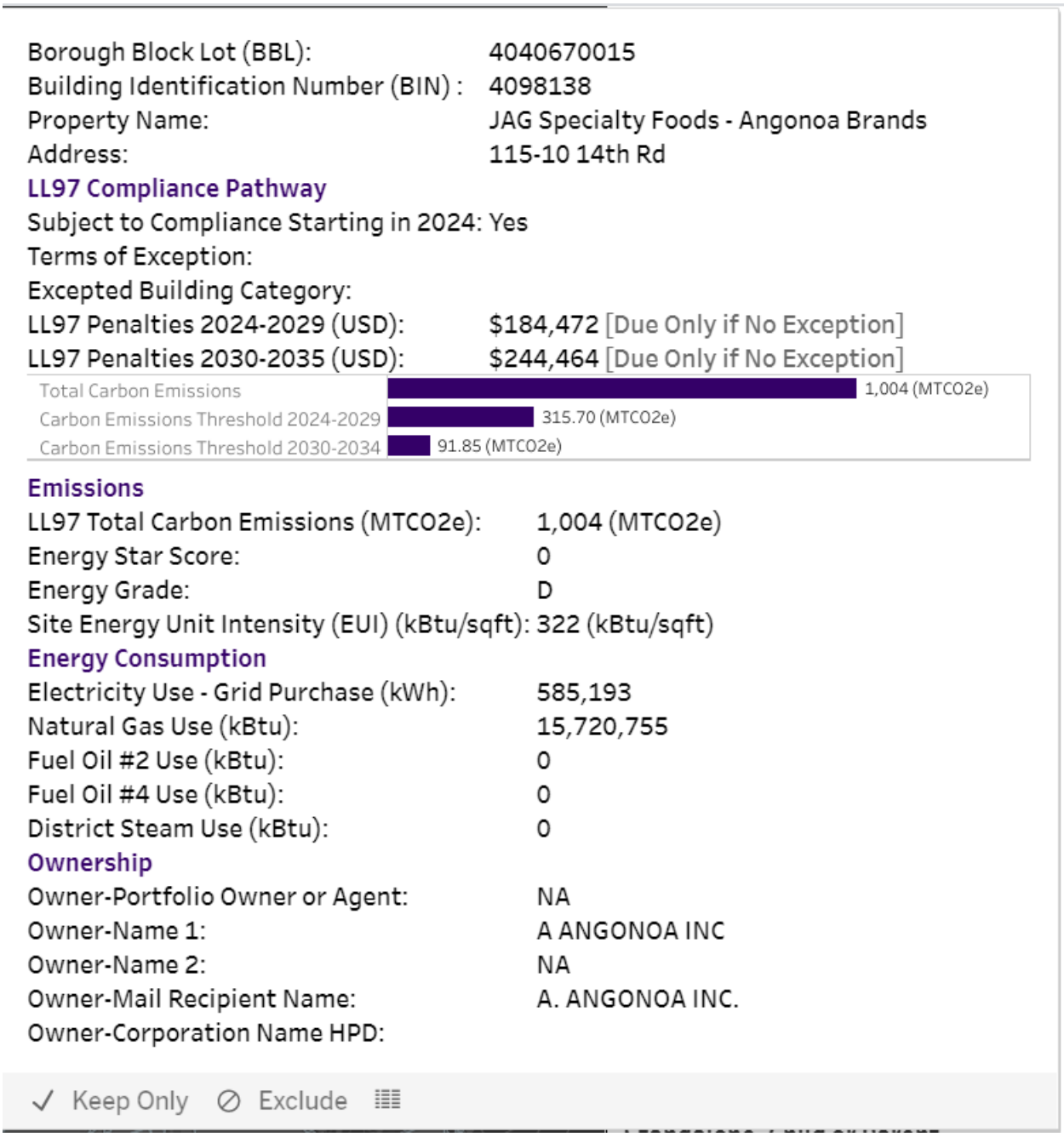

Figure 22 Information displayed on the NYC Buildings Map

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