Decarbonizing Single Family NYC:

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Learning **Goals**

Geospatial Analysis

Improving my geospatial analysis skills by developing a strong conceptual foundation in GIS and mastering the manipulation of various types of spatial data using tools such as ArcGIS, QGIS, and Python

Energy Transition Planning

Gain an understanding of the key components necessary for decarbonization and reducing GHG emissions, in order to transition towards a net-zero future

New York Climate Leadership and Community Protection Act **(CLCPA)** mandates a **40%** reduction in GHG emissions by 2030 and **85%** by 2050 statewide

Buildings

Contribute to 68% of the total GHG emissions in the city

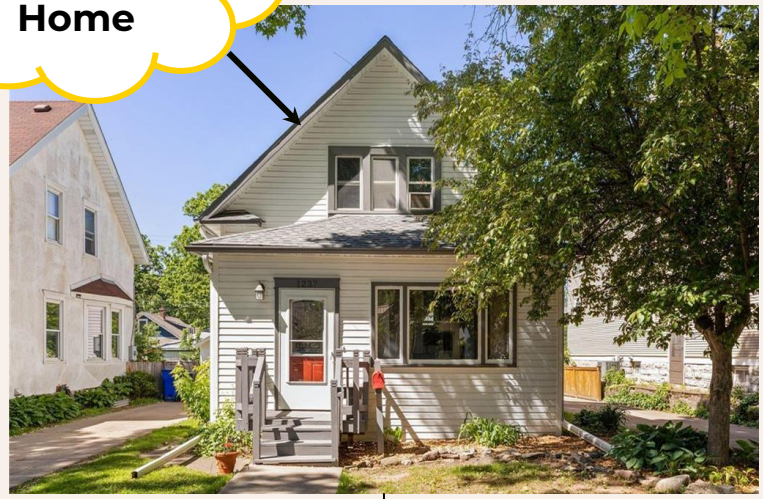
68%

Residential Buildings

Space and water heating are the primary sources of residential emissions

31%

Single-Family Home

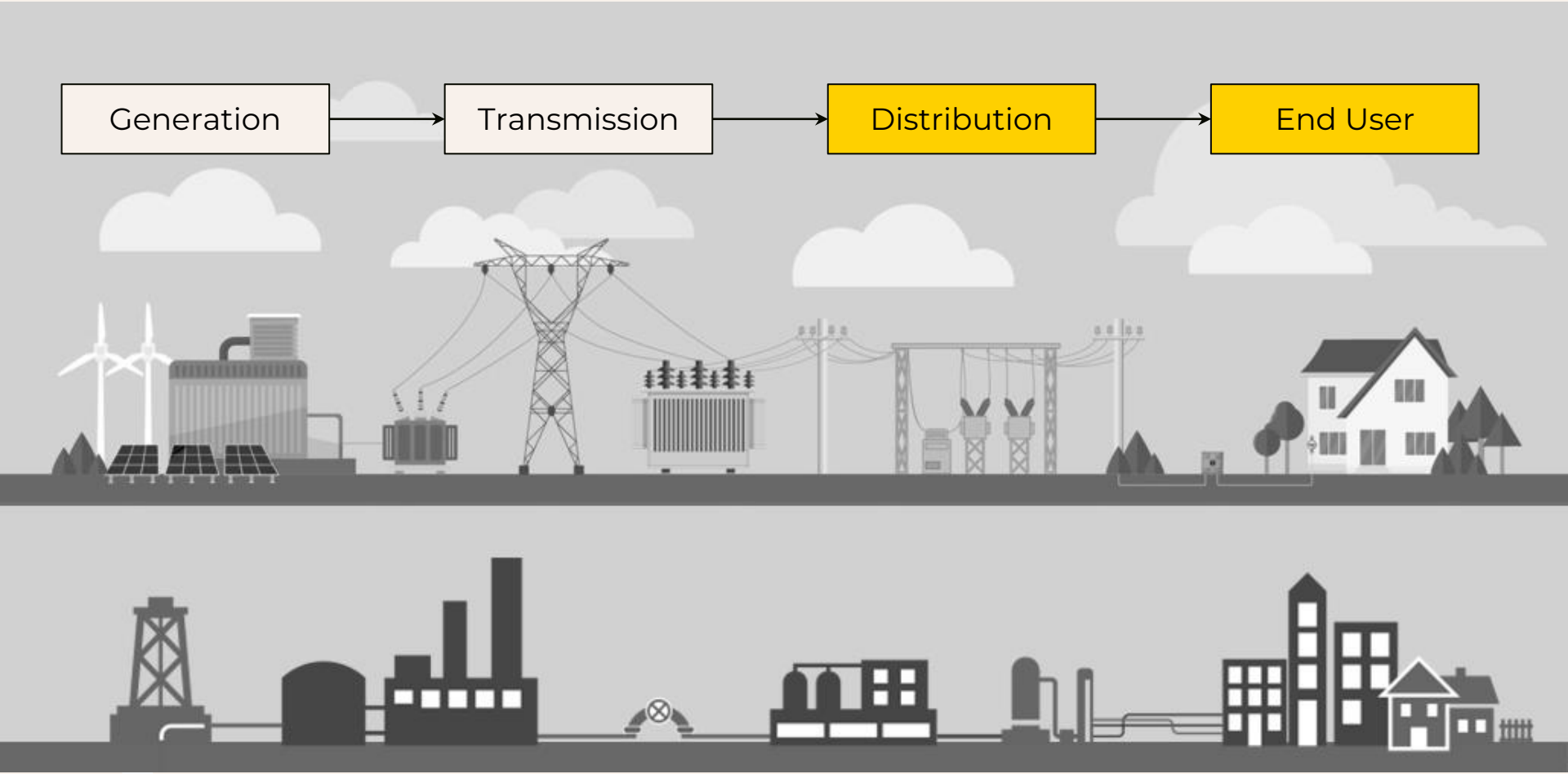


66%

How does this home get powered?

What does energy transition in these neighborhoods look like?

Generation → Transmission → Distribution → End User



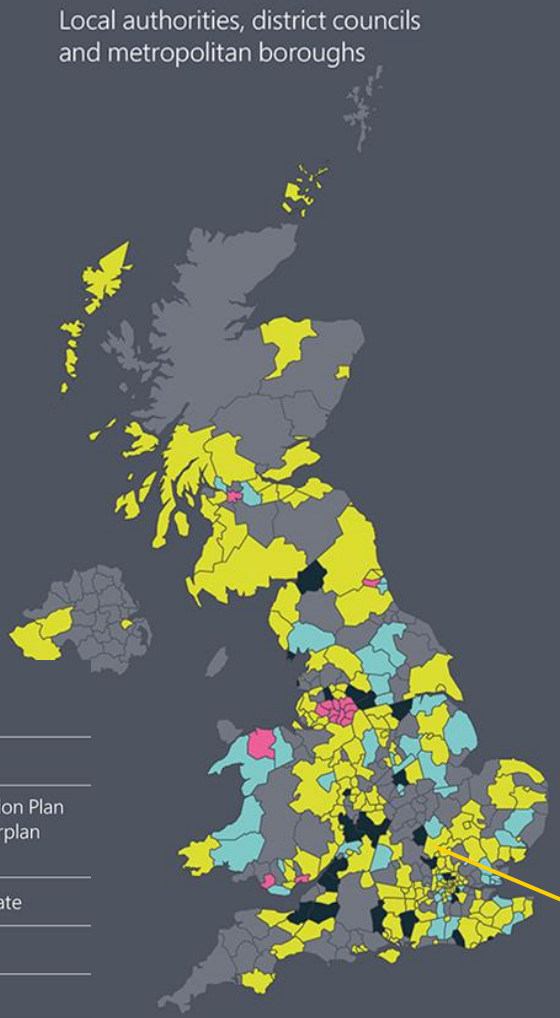
Project **Objective**

Our goal is to develop a comprehensive **playbook for Local Area Energy Planning**, which entails identifying the essential components of energy transition, establishing standards for data products to be utilized, and devising a tool to integrate disparate concepts into a **single urban planning resource** capable of providing an equivalent level of detail for an area as an outline design or master plan.

Local Area Energy Planning (LAEP)

"LAEP is a **data driven and whole energy System tool**, that sets out to identify the **most effective route** for the local area to contribute towards meeting the national net zero target, as well as meeting its local net zero target."

Local Area Energy Planning (LAEP) in the UK



Recommendations made using LAEP playbook

- Develop shared & individual heat networks (ground/air source heat pumps)
- Implement framework for improving energy efficiency of properties at scale
- Submit full capital investment estimation
- Leverage government grants & community bond offers for development costs

On-site energy survey of 50 properties representative of the 399 properties in the village

Crowhurst

What is **LAEP Stack?**

01
Current Local Energy System

02
Develop Target Questions

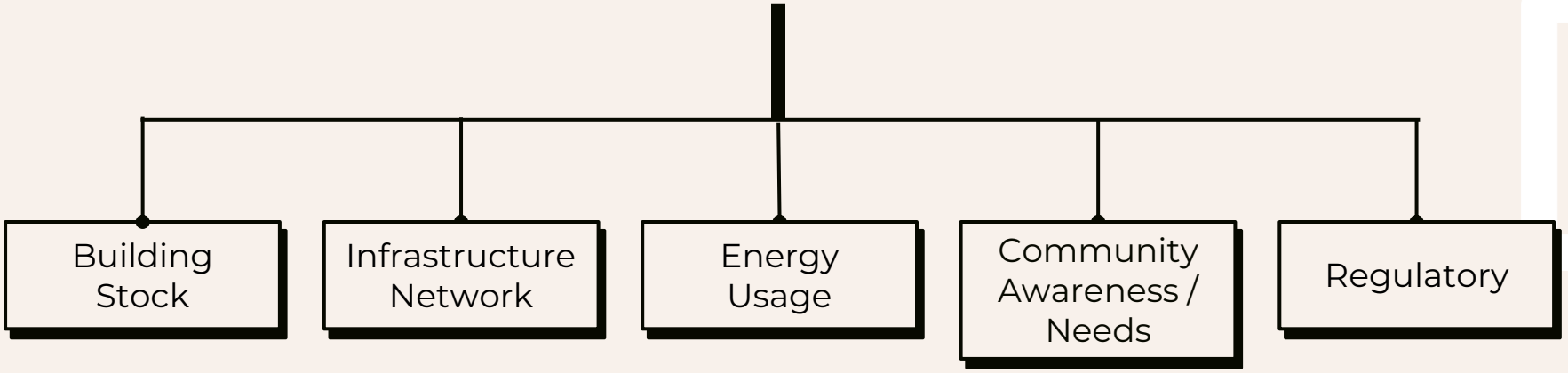
03
Build a LAEP Framework

04
Collect Data & Identify Gaps

05
Build Data Products

06
LAEP Configuration Language

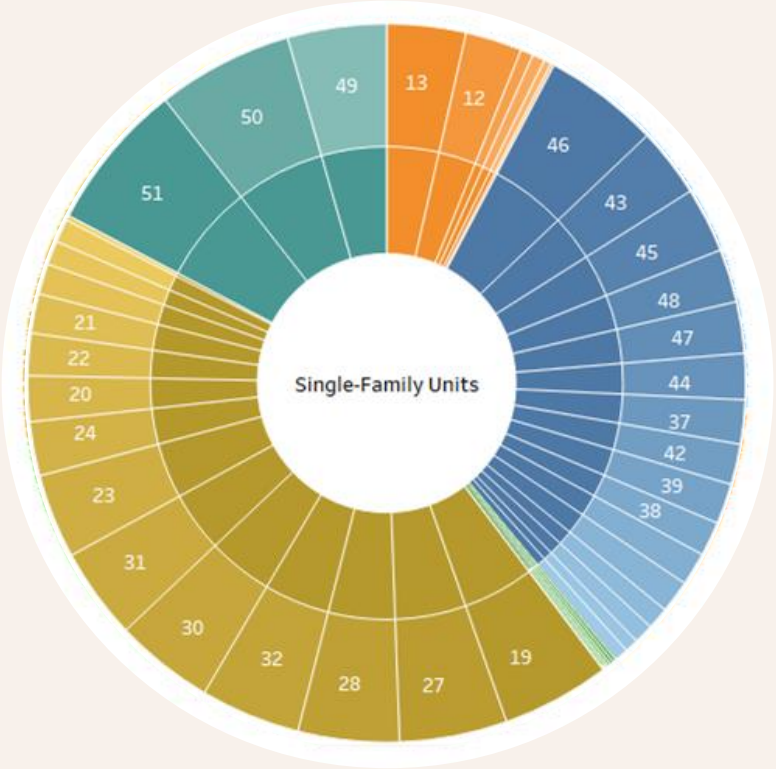
LAEP **Framework**



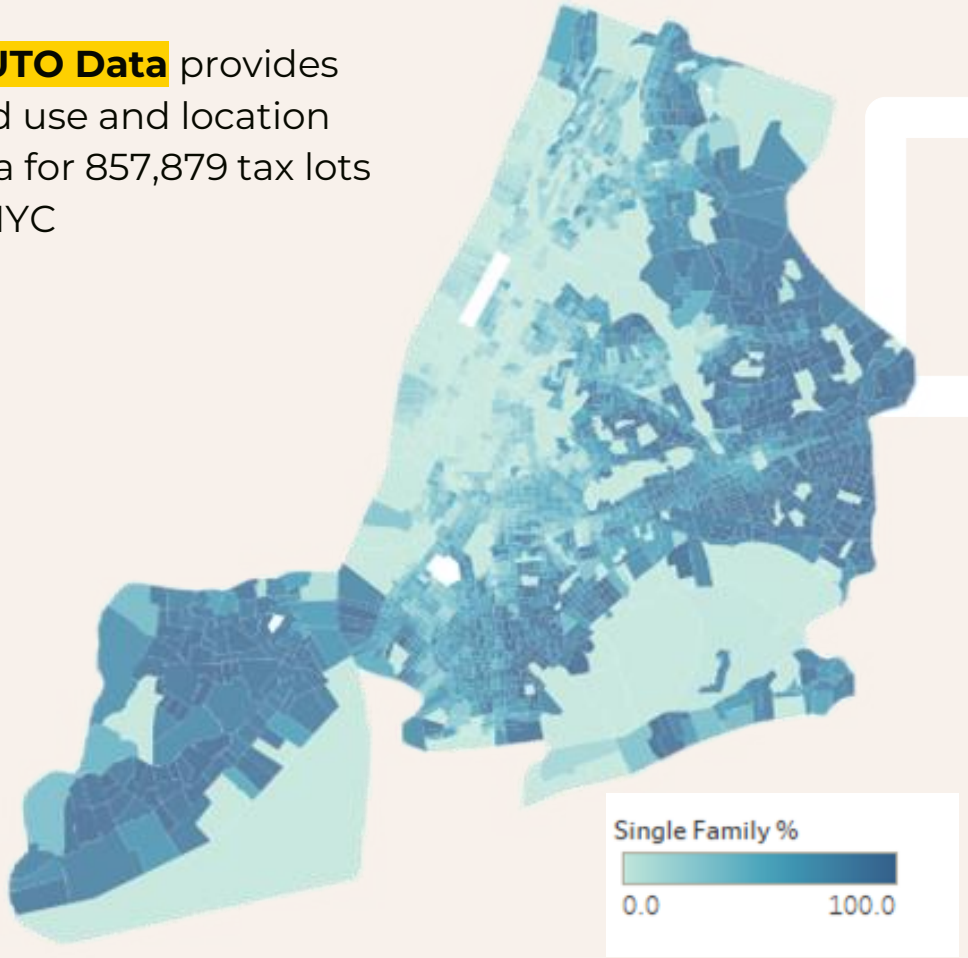
- Land use and Geographical Data of Buildings
- Location and Age of Utility /Street Networks
- Length of Pipework to estimate costs
- Energy Usage /Utility bill data
- Heating Fuel for space and water heating
- Surveys on energy retrofit awareness, investment motivation, and long-term savings potential
- Documentation of relevant energy regulations and policies at the national, state, and local levels

Building Stock

Knowing the geographic distribution allows us to be **more precise** with our analysis on decarbonization of single-family homes in NYC



PLUTO Data provides land use and location data for 857,879 tax lots in NYC



Brooklyn and Queens have the most Single-Family residential buildings in NYC

Infrastructure Network

To gain a **spatiotemporal** understanding of the **energy system** currently serving Single-Family neighborhoods in NYC, down to the **hyper-local level**, to identify opportunities to reduce reliance on fossil fuel-based energy sources for residential space and water heating.

- New York's **gas utilities invested $5B** in expanding their gas networks in the past decade."
- Average cost of installing new gas distribution main is over **$60K per ratepayer**.
- Due to the aging gas system, almost **90%** of installed distribution mains are replacements
- Decline in gas ratepayers will **significantly raise gas rates**.

We need a **Hyperlocal Infrastructure Network Dataset**

LION shapefile is a digital map of all the streets in New York City

Provides a Street Code for each street but **NOT for a Street Segment**

Street Opening Data provides permit information for construction or repair work that temporarily obstructs streets or sidewalks

Provides information on the purpose of street opening, such as for **electrical, water, or natural gas pipelines**

OFT Code for Street Opening with length of Street Opening on the segment

New Dataset with Street Segments, Purpose of Street Opening, and Length of Street Openings from 2017 - 2022 in NYC

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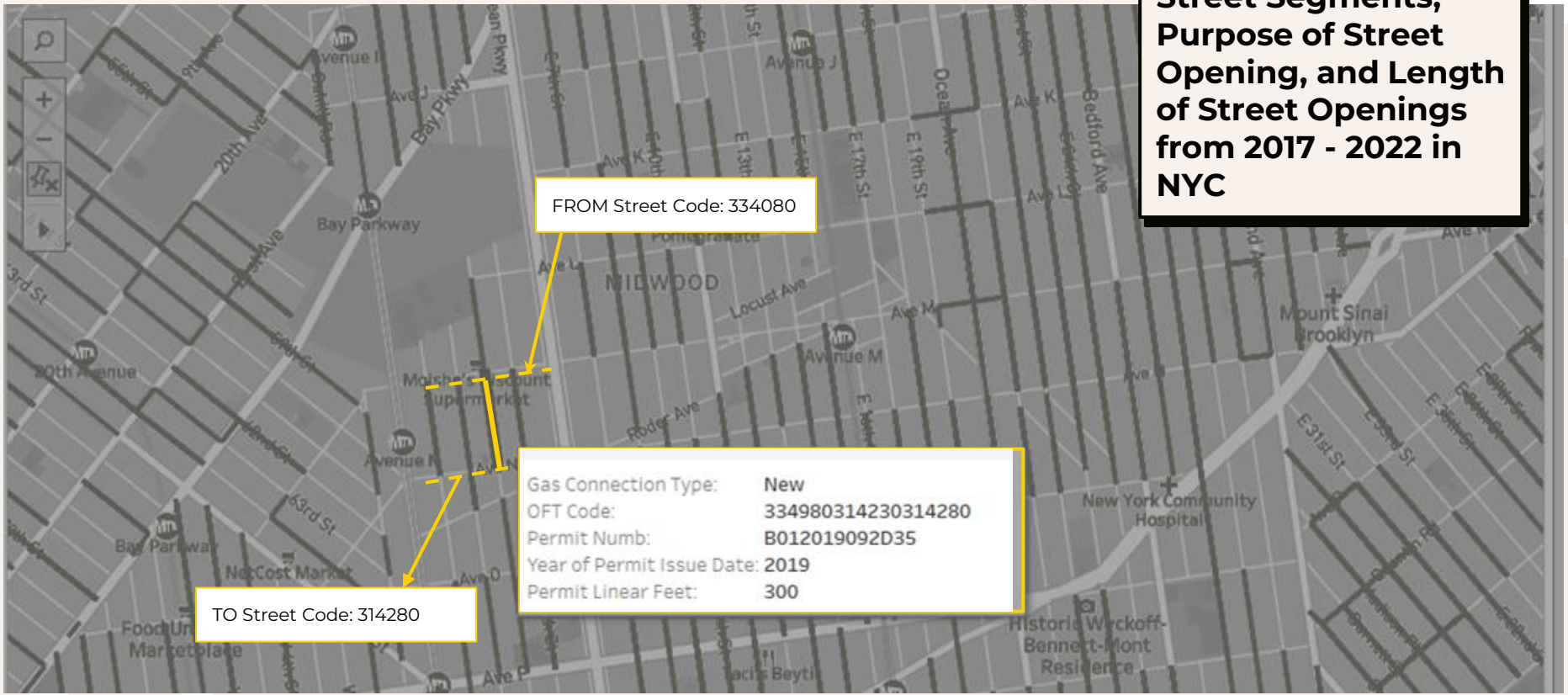
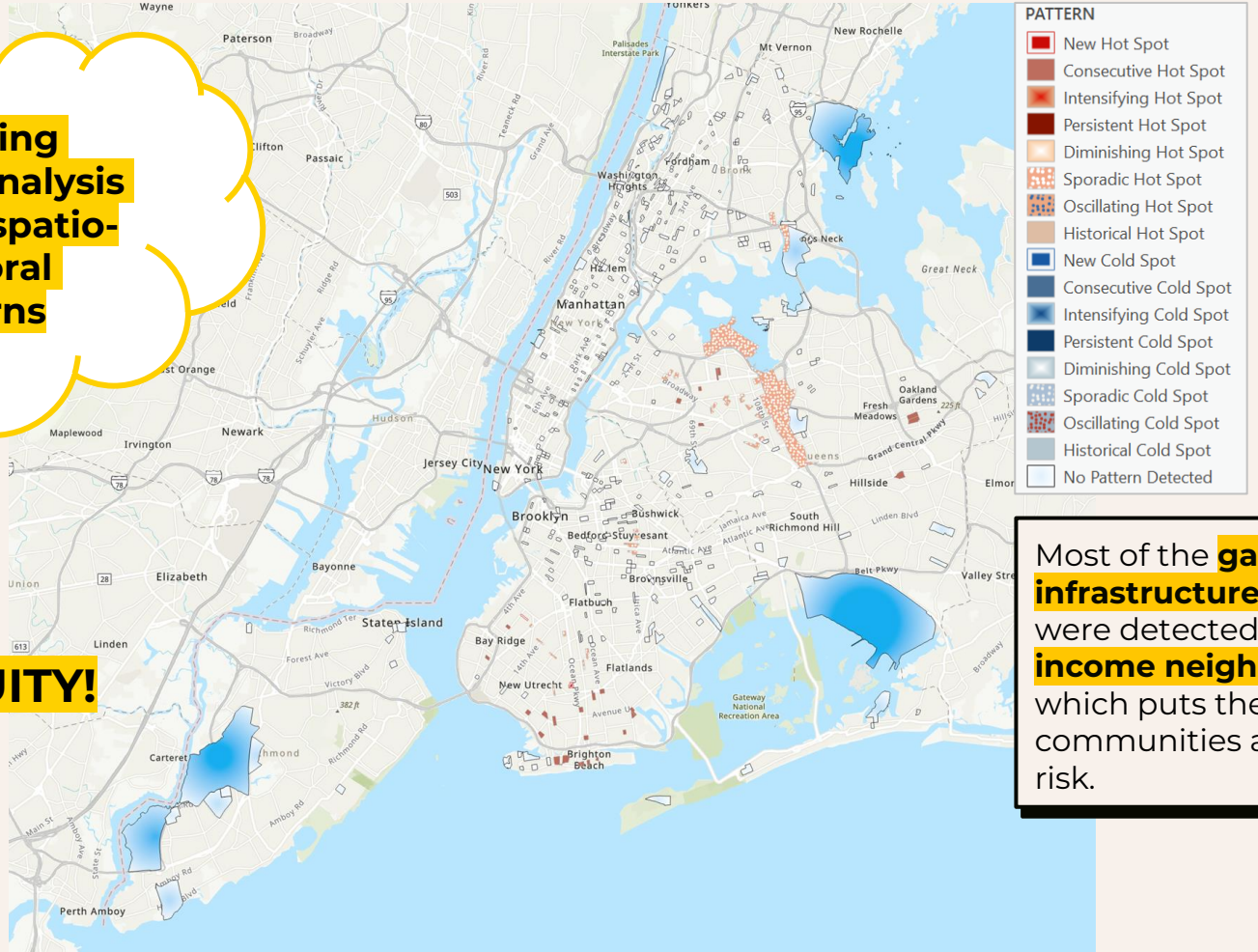


Emerging Hotspot Analysis to reveal spatio-temporal patterns



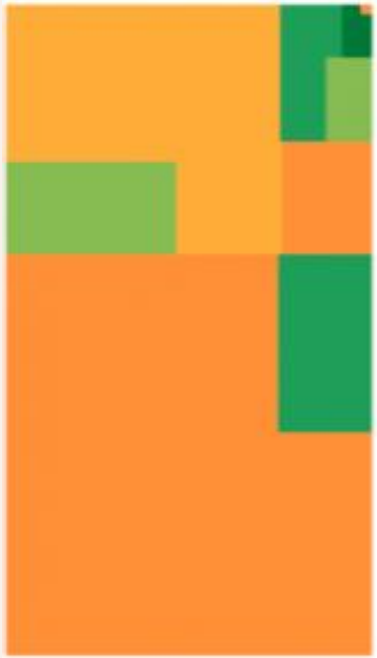
COST! EQUITY!

Most of the **gas infrastructure hotspots** were detected in **low-income neighborhoods**, which puts these communities at a higher risk.

Energy Usage

Studying energy consumption at the parcel level, including peak demand, is crucial for **identifying areas that require rapid infrastructure upgrades** to accommodate the surge in energy usage during electrification.

Coarse-grain stock model



ResStock

Building Characteristics

Census Data

Costs

Climate Locations

10s–100s of thousands of **statistically representative models**

Baseline Buildings

Efficiency Upgrades

Supercomputer or Cloud

Fine-grain stock model

NREL ResStock provides modeled Energy Use Data

Building ID/End Use Load Profile

- Building class
- Number of units
- Number of floors
- Year Built
- Square Foot
- Roof Material

Timeseries Data for Energy Usage
15 minutes intervals

Scenarios

Baseline: Gas / Propane/Oil Boiler

Package 1: Enhanced enclosure

Package 2: Enhanced enclosure

Package 3: Heat pumps, min-efficiency, electric backup

Package 4: Heat pumps, high-efficiency, electric backup

Package 5: Heat pumps, min-efficiency, existing heating as backup

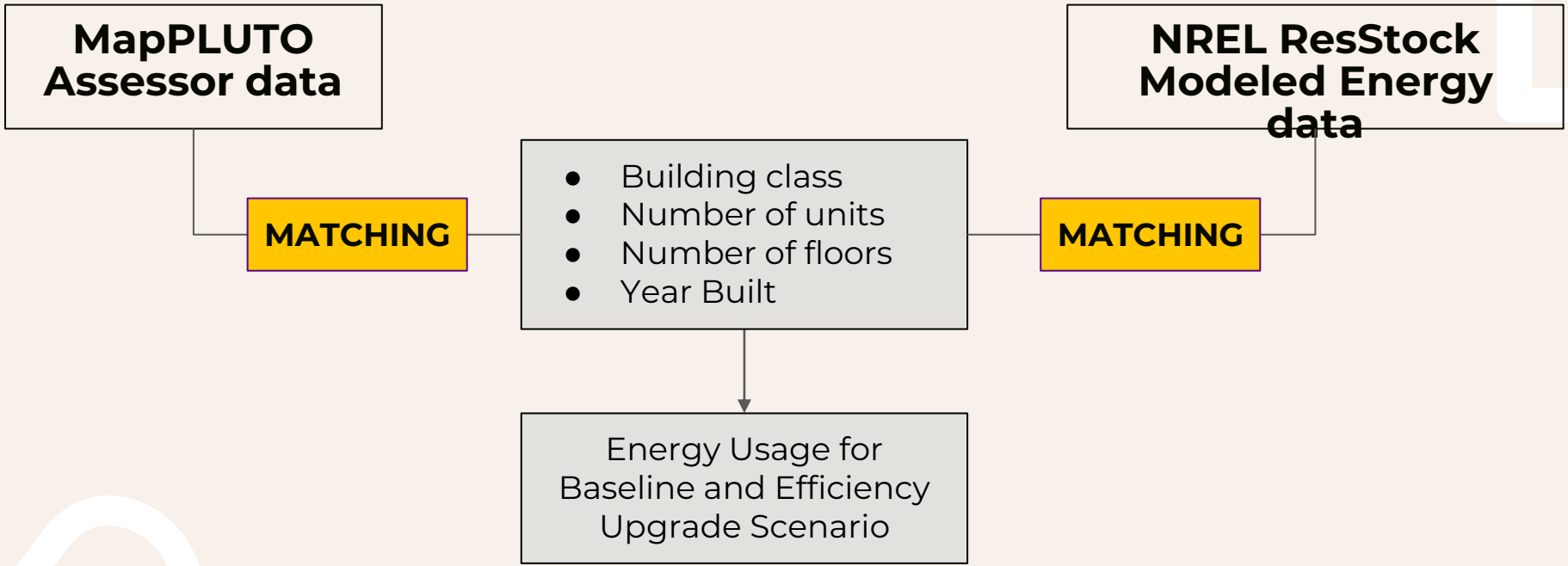
Package 6: Heat pump water heaters

Package 7: Enhanced enclosure

Package 8: Whole-home electrification, high efficiency

Package 9: Package 1 + Package 8
Package 10: Package 2 + Package 8

We developed a **Matching Algorithm** that connects parcel-level **MapPLUTO** data with modeled energy usage data from **ResStock**



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	bbl	bldg_id	num_bldg_ids
0	4123100076	[19444, 334917, 395521, 413604]	4
1	4123100077	[440019]	1
2	4123120036	[448038]	1
3	4123120044	[159588, 220720, 547059]	3
4	4123120045	[353104, 405740]	2
5	4123120050	[293350]	1
6	4123120051	[293350]	1
7	4123120055	[293350]	1
8	4123130030	[45479, 355283]	2
9	4123130050	[448038]	1
10	4123130056	[1592, 54135, 92023, 126908, 306206, 536623]	6
11	4123130074	[52325]	1
12	4123140095	[527058]	1
13	4123140097	[73820, 176842, 230996, 392162]	4
14	4123140099	[73820, 176842, 230996, 392162]	4
15	4123140101	[148922]	1

Next Step

Optimize by increasing more **one-to-one** matching

match	Count
3	3465
4	3394
1	3190
5	3021
2	1431
7	928
10	812
6	287
9	285

Summary

Parcel

We know where the **Single-Family Homes** are located in NYC

Infrastructure

We have **Spatio-Temporal Data** for Infrastructure Networks

Energy Usage

We have **time series energy usage data** for baseline and different upgrade scenarios

LAEP configuration language (LAEP-CL)

Data structures

End Use
[Space Heating, Cooking etc.]

Energy Load
[8,760 hours of fuel specific energy consumption for each end use]

Meter
[A collection of end uses] +
[A collection of loads]

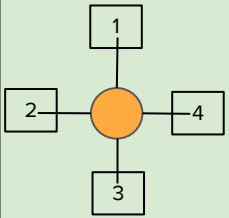
Parcel
[building/lot attributes] +
[A collection of meters]

Linear segment
[A road, a gas main, or electric line]

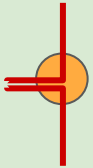
Network
[A collection of segments]

Network

GUSR
Generic Utility segment Representation



Road Network
[(r1),(r2),(r3),(r4)]

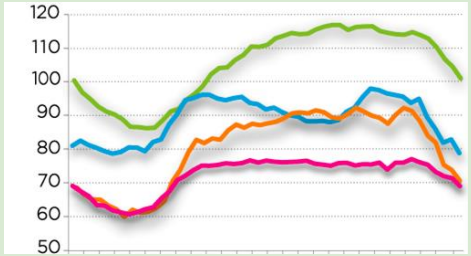


Electric Network
[(r1,r2),(r3,r4)]

Gas Network
[(r1,r3),(r2,r4)]

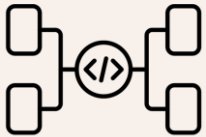
Time Series

Virtual Energy Meter
A representation of loads and transitions



A JSON representing annual metered energy consumption

Next Steps



Configuration Language

Scenario Planning

Electric Grid Capacity