Improving Residential Energy Programs Using GIS and Geospatial AI Analysis

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ABSTRACT

Utilities have traditionally limited the use of geospatial analysis and Geographic Information Systems (GIS) tracking to maintaining and operating their built infrastructure. Yet while tracking outages and managing vegetation continues to be the primary use for GIS, some utilities have started to utilize mapping and data visualization software to improve the performance of their energy efficiency programs. New GIS tools, like ArcGIS Business Analyst, allow utilities to draw insights from their service territory's demographic and geospatial characteristics, while GeoAI enables utilities to model savings potential and recognize patterns in program participation. Together, these innovations are rapidly changing the way utilities respond to and serve the needs of customers and regulators alike. These new ways of deploying mapping technology also coincide with the evolution of many residential and low-income programs to accommodate an increasingly electrified residential landscape. Moreover, many utilities are simultaneously contending with increasing customer bill impacts and regulatory scrutiny surrounding serving moderate-income customers, environmental justice communities (EJCs), and hard-to-reach populations like renters. GIS offers energy efficiency program managers (PMs) an opportunity to better understand who their customers are, identify areas where customers have acutely high energy burdens and gives them the ability to better determine which measures to prioritize to maximize energy and greenhouse gas savings. As we pursue more affordable, equitable, and decarbonized energy systems, it is clear GIS offers residential PMs the capability to not only understand where their programs are having an impact, but to also improve future program engagement.

Introduction

Leading utility programs put equity front and center in their energy efficiency plans. At the same time, utilities are also being asked to identify which of their residential customers are most impacted by high energy burdens, evolving climate risks, and environmental justice issues. Yet while utility operations teams use GIS extensively, few electric or gas distribution companies have deployed the GIS tools necessary to address these concerns. It is well established that utility-led energy efficiency programs reduce customer energy consumption, cost of energy bills, and building CO2 emissions (EIA 2025). What is less well recognized is that utilities are juggling competing goals within an energy landscape that looks little like the industry of yesteryear. Many utilities acknowledge that significant recent development of data centers and AI training workloads are compounding challenges posed by widespread electrification of the residential, commercial and industrial (C&I), and transportation sectors

(Keefe et al. 2025). Many state governments are encouraging displacement of natural gas and delivered fuels (such as heating oil and propane) with electric heat pumps (Mass Save 2024). While high efficiency heat pumps have the potential to considerably reduce energy consumption, heating bills, and CO_2 emissions; heat pump adoption is constrained by local grid capacity, as electrification driven load growth (especially during winter peaks) can exceed existing distribution infrastructure limits, requiring ratepayer funded upgrades or reliance on demand flexibility strategies not yet deployed at scale. Moreover, heat pump adoption is complicating utility energy affordability programs because higher-income households are disproportionally capable of absorbing the upfront capital costs and increased electricity bills from full gas displacement (University of Michigan 2024).

Subsequently, ratepayer funded incentive programs can inadvertently force lower-income customers to shoulder costs while primarily benefitting those with greater financial means. Many utilities are also managing concurrent goals to reduce CO_2 emissions, increase capacity on the grid, maintain cost effectiveness, electrify gas and delivered fuels customers, connect electric vehicle and photovoltaic customers to the grid, and maintain reliable flow of power, all while reducing costs for ratepayers. To successfully fulfill each of these goals individually requires a utility to possess an intimate understanding of its territory. Together, these numerous goals constitute a Gordian knot of conflicting challenges that demand a herculean level of knowledge regarding where different kinds of customers live, where capacity is constrained, who is in threat of falling into arrears, and most importantly, how all these factors impact one another. Some of these aims don't align and in fact sometimes actively undermine the success of each other. It is within the context of balancing these different factors that utilities must consider the impacts their decisions have on their most vulnerable customers. Utilities largely seek to deliver safe, reliable, clean power that doesn't place an undue financial burden on customers, yet they also must maintain financial solvency and regulatory compliance. Climate change upends this paradigm by imposing risk and uncertainty extended not over quarters or term plans, but over decades. Since 2016, the US has experienced over 200 $1 billion loss weather and climate-related disasters, accounting for over $1.5 trillion in total losses (Climate Central 2026). Meanwhile, between 2019 and 2025, the US saw residential retail electricity and gas prices jump approximately 40 percent (EIA 2025). The intersectionality of increased energy burden and greater climate risk is pushing utilities to pay more attention to customer vulnerability and seek new ways of connecting with their customers.

By deploying mapping technology, many residential and low-income PMs can accommodate an increasingly electrified residential landscape, identify opportunities to weatherize delivered fuels customers, and hyper target customers with the greatest potential for energy savings.[1] Moreover, some utilities are utilizing GIS to mitigate increasing customer bill impacts and to respond to regulatory scrutiny surrounding serving moderate income customers, EJCs, and hard-to-reach populations like renters. GIS offers utilities the ability to integrate customer addresses or coordinates with demographic indicators to pinpoint exactly who their

[1] A PM is an energy efficiency professional responsible for either planning, evaluation, and/or the implementation of initiatives designed to reduce energy consumption within their utility's territory.

customers are through the communities and buildings they live in. PMs can subsequently adjust their offerings to customer need(s) and identify previously unknown participation barriers, such as language or presence of pre-weatherization health and safety issues like asbestos (Pope 2024). Yet, the key advantage of adopting GIS is that by mapping customers, PMs can see the story behind the data. For example, a spreadsheet could indicate that a recent *Main Street Initiative* designed to target small businesses with retrofit offerings severely underperformed expectations.[2] By pairing that spreadsheet with a neighborhood map where canvassing took place, PMs might quickly see that the educational materials distributed were provided in a language inappropriate for that community. In short, mapping provides a visual context allowing PMs to make connections and conclusions previously occluded from view.

Historically, utilities have primarily used GIS for operations work like tracking outages, map meter connections, managing vegetation, and planning for added capacity. Even today, most utilities use GIS exclusively among their operations teams alongside advanced data modeling or integrated with distribution management systems or supervisory control systems (Meehan 2024). However, this also means utilities often already have GIS software licensing agreements in place to be leveraged across non-operations teams. This makes it relatively easy to integrate with a PM's existing toolkit to enhance program performance tracking systems, provide critical visual context to tables and their program dashboards, and even merge with Microsoft 365 using add-ins. Recently, a few utilities have adopted GeoAI to perform predictive analysis or propensity modeling using machine learning. These geospatial AI algorithms are capable of building accurate models of a utility's territory to optimize program outreach (ESRI 2026). GeoAI can even map which customers are most likely to participate in specific energy efficiency programs and forecast their potential savings if they installed certain energy-saving measures (Plentiful.ai 2026).[3] GeoAI does this by pulling in a combination of utility consumption data, publicly available building data, and participation history of past customers to build a predictive model of future participation. Between the rise of GeoAI, the increased user friendliness of GIS and its ability to be seamlessly integrated into all aspects of program planning and implementation, GIS is expected to become a defining feature of future energy efficiency programs.

Methodology: Quasi-Experimental Program Evaluation

The geospatial analysis behind this research was conducted by a utility's Planning, Evaluation, and Data Analytics team in coordination with utility benefit cost-effectiveness modeling advisors. This research began as part of an effort to improve the quality of equity reporting and to boost program participation among the utility's operating companies. The

[2] Main Street Initiatives are community-wide business canvassing and educational initiatives that bring information on components of the Small Business Energy Advantage (SBEA) program directly to tenants, small business owners, and property owners/landlords. The SBEA program provides turnkey services, on-bill financing, and incentives to small C&I customers. (EnergizeCT 2024).

[3] A "measure" in energy efficiency refers to specific building upgrades or technologies implemented to reduce a building's energy consumption. This could include upgrades such as installing heat pumps, conducting air sealing, upgrading HVAC systems, or replacing incandescent light bulbs with LEDs.

analysis focuses on how some utilities across Connecticut (CT), Massachusetts (MA), and New York (NY), utilized GIS to improve equity-related regulatory compliance responses, identify where their most vulnerable customers are located, and enhance performance of their energy efficiency programs against their term plan goals.

This study's methodology can best be categorized as having a *Quasi-Experimental Program Evaluation* (QEPE) design as its research "lies between the rigor of a true experimental method […] and the flexibility of observational studies" (Capili and Anastasi 2025). This methodology is traditionally used in the healthcare sector; however, its design can be applied to research outside of medicine. Furthermore, as these Northeast utilities were seeking to demonstrate their capability to meet new equity requirements and apply geospatial targeting to improve performance, a true experimental method (using random sampling) was deemed an inappropriate use of ratepayer funds to measure causal impact of GIS interventions on improving program performance. Simply put, QEPE takes a treatment group (either the energy efficiency program or the geographically defined area where GIS was applied) and compares it to a similar control group (comparable geographic area or energy efficiency program not subject to GIS influence).

Among the NY utilities (both gas and electric) included in this study, GIS interventions were prioritized for households in census tracts identified as being Disadvantaged Communities (DAC).[4] The NY comparison groups were non-DAC designated census tracts as well as customers on a standard market rate (rather than a low-income discounted rate). Although DAC designation and rate class represent different forms of segmentation, both serve as mechanisms for comparing targeting of program benefits toward underserved populations against normative groupings. In both CT and MA, the treatment group for utilities included in this study (both gas and electric) were GIS interventions targeted toward EJC block groups, Distressed Municipalities (DM) (called Designated Equity Communities or DECs in MA),[5] and low-income customers, with additional deeper interventions toward delivered fuels customers residing within distributed gas territory.[6] For MA alone, an energy burden analysis was also conducted for the DEC of Pittsfield. Deeper GeoAI-enhanced interventions were implemented toward delivered fuels customers residing within distributed gas territory due to the high potential for

[4] DACs are defined by scores across 45 criteria "represent[ing] the environmental burdens or climate change risks within a community" (NYSERDA, pg. 1, 2024). Census tracts were "scored based on relative burden, risk, vulnerability, or sensitivity." DACs also include "households with annual income at or below 60% of State Median Income" regardless of whether they are located in a DAC designated community (NYSERDA, pg. 2, 2024).

[5] DEC stands for a Massachusetts Designated Equity Community. Mass Save defines a DEC "as neighborhoods across MA with a high percentage of customers, particularly renters and landlords, whom the Mass Save programs have not previously reached. These communities are identified in the Plan to receive prioritized support, including streamlined access to energy-saving services and upgrades." (Mass Save 2026).

[6] EJCs combine all persons residing within either an EJC designated block group or a Distressed Municipality. EJC block groups are defined as a "U.S. census block group where 30% of the population is living below 200% of the federal poverty level" (CT DEEP 2026). Distressed Municipality measures the "fiscal capacity of each municipality" and based on their (1) tax base, (2) personal income of residents, (3) residents' need for public services," designate those with the poorest economic scores as "distressed" (CT DECD 2026).

weatherization-related energy savings in this population. Across the EJC and DM treatment groups, the same comparison group was used as a control: either non-EJC or market rate customers. For the delivered fuels group, the comparison group was non-delivered fuels customers since both low-income and market rate customers had GIS interventions implemented.

Lastly, this study also conducted research for a gas utility in MA, where GIS interventions were used for an energy burden analysis. The treatment group contained block groups within that gas utility's territory where the average customer experienced energy burdens categorized as being Moderate, High, or Severe (ACEEE 2020).[7] There were two control groups: the first group were block groups where the utility determined the average customer did not experience energy burdens meeting or exceeding 4 percent. The second control group was EJC census block groups within the utility's territory, selected in order to determine whether energy burdens and EJC status were correlated. This specific experiment included GIS analyses of gas-specific energy burden as well as energy burden from the combined cost of gas and electric rates.

As utility PMs on Conservation & Load Management (C&LM) teams are constantly evaluating, measuring, and verifying the performance of their programs, it felt natural to have this study's methodology follow a "Pre-test and Posttest Design with a Control Group" research strategy and design (Capili and Anastasi, pg. 3, 2024). This means we initially evaluated both the control and treatment groups to establish a program performance baseline, afterwards implementing a GIS intervention for the treatment group (whereas the control received standard attention), and later evaluated both groups to determine the impact of the intervention. The team implemented the following process: (1) evaluated the performance of energy efficiency programs against their existing term plan savings goals; (2) targeted specific programs for GIS-related interventions (the controls were treated by PMs per usual); and (3) assessed whether the targeted programs saw positive impacts through regulatory reporting and savings performance tracking. This is a widely used design strategy in QEPE methodologies because it "frequently yields ordered categorical outcome data" (Zou et al 2023). By doing both pre- and post-evaluation of the groups and ensuring consistency between the treatment and control groups, "any differences in posttest scores can be attributed to the intervention received by the treatment group" (Capili and Anastasi, pg. 4, 2024). For interventions meant to test GIS's capability to improve equity-related regulatory compliance, rigorous testing was conducted. For program performance-related GIS interventions, post-GIS performance tracking using program management tracking systems such as eTrack+, a widely used program saving tracking software, was used (ANB 2026).[8]

Methods

The QEPE methodology of this research involves multiple GIS intervention methods. This includes the use of ESRI's ArcGIS (ArcMap and ArcPro) to geocode customer addresses,

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[7] Energy burdens can be defined as Moderate at ≥4% median household income (MHHI) spent on energy; High at ≥6% of MHHI spent on energy; or Severe at ≥10% of MHHI spent on energy (ACEEE 2020).

[8] eTrack+'s developer, ANB, considers it a "Highly scalable workflow management software for utilities to develop and manage operations workflow for energy efficiency and demand-side management programs" (ANB 2026).

ArcGIS Online to interpret and share results, GeoAI to conduct propensity score evaluation, and ArcGIS Business Analyst to address spatial dependence by modeling variations in economic conditions across geographic subdivisions (Census Tracts and Block Groups). Figure 1. details this study's partition into the pretest (Pre-GIS Initiation), intervention (GIS Intervention), and posttest (Results) phases from the methodology.

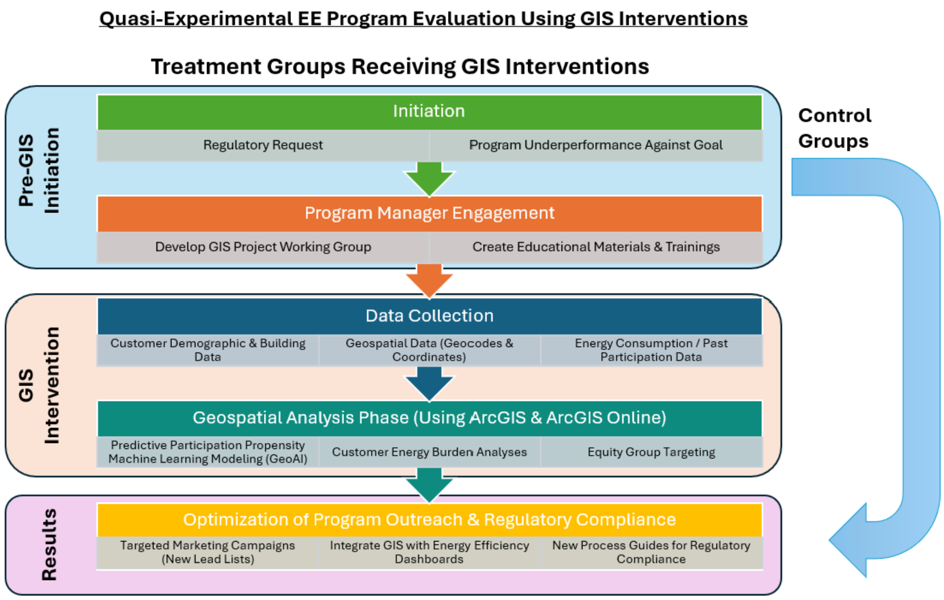

Figure 1. Depicts the Quasi-Experimental Program Evaluation (QEPE) analytical framework used to explore GIS intervention impact on energy efficiency programs for "treatment" and "control" groups.

During Pre-GIS Initiation, research was started across the three states under either one of two conditions: (1) there was a regulatory request from a state agency; or (2) the performance of a specific program or population of interest underperformed in relation to the plan. The initiating events for the GIS projects occurred across 2024 and 2025 in response to real regulatory requests or performance shortfalls. Each project was conducted independently of one another and moved along its own timeline.

After a project was initiated, the utilities' Planning, Evaluation, and Data Analytics / C&LM / Energy Efficiency teams would engage with PMs implementing programs through the creation of multi-stakeholder working groups focused on undertaking a GIS intervention. These working groups would meet monthly for at least an hour. Almost none of the participants in these working groups had prior experience in the use of GIS, let alone its application toward program delivery or regulatory compliance. Therefore, supplemental GIS "How to" and "FAQ" guides were created. Additionally, as PMs and the planning team would later be expected to engage with the outputs from the geospatial analyses conducted during GIS interventions, multiple trainings (at least one quarterly) were held on ArcGIS Online, ArcMap, and in interpreting geospatial data. During these sessions, teams identified which variables would be selected for GIS analysis—those variables ultimately selected being EJC, DAC, DM, DEC, Low-Income Customers, Energy Burdened, Delivered Fuels, and Clean Heat program customers. The teams also determined what level of granularity to conduct the analyses, with NY teams ultimately deciding to use census tracts, whereas both the CT and MA teams used census block groups and municipalities.

Across all three states, most GIS interventions took place using ESRI's GIS software: ArcGIS. ArcGIS is considered the industry standard for geospatial analysis and is internationally trusted by many institutions, companies, and governments. Across all states, large datasets of customer addresses needed to be geocoded. In these instances, ArcMap was used for geocoding as the utilities did not have access to the more recent update to ArcGIS: ArcPro.[9] Most geospatial analysis was conducted using ArcGIS Online or through energy efficiency dashboards supported by PowerBI. ArcGIS Online and PowerBI were selected for the analysis and presentation of geospatial data as they had the most user-friendly interfaces, allowing PMs to quickly learn how to interpret and share geospatial data.

The team conducted secondary phase geospatial analyses to dive deeper into specific program performance in CT and NY. In CT, a powerful third-party GeoAI was used to develop a machine learning model using a combination of utility customer consumption data and publicly available demographic and building data (Plentiful.ai 2026). This model analyzed the propensity a residential building owner using delivered fuels (propane or oil) to heat their home had to participate in the single-family Home Energy Solutions℠ (HES) or Home Energy Solutions–Income Eligible (HES-IE).[10] This GeoAI also analyzed whether a customer had a high energy savings potential from the installation of weatherization measures. In each instance, the AI assigned scores to each customer and then the propensity model combined the two scores to categorize groups across a propensity spectrum, which can be seen below in Figure 2.

[9] Geocoding connects addresses to coordinates using an Address Locator Manager (an index of all possible addresses within a constituency) by calculating the center point of known property boundaries and assigning a "match" value when both the input address and the indexed address share the same coordinates.

[10] The HES (market rate customers) and HES-IE (low-income customers who qualify during income verification) programs in CT are the flagship energy efficiency programs for residential customers that provide in-home energy assessments and associated home upgrades.

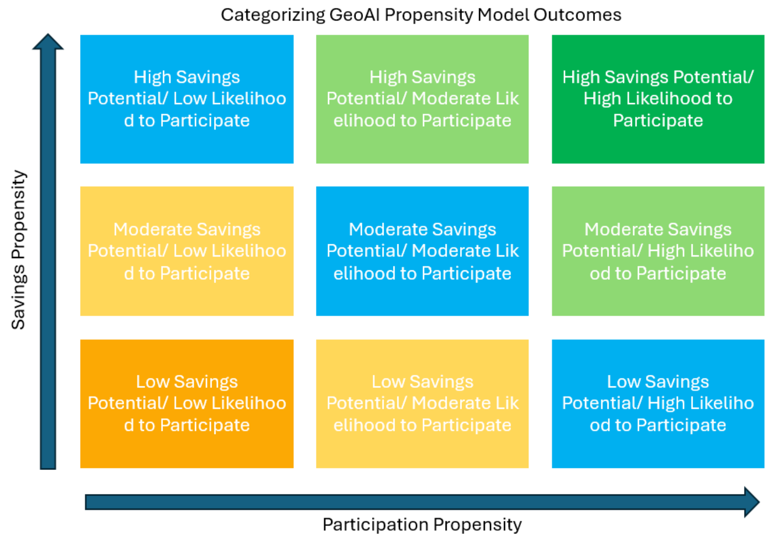

Figure 2. Categorizing outcomes from propensity models created using GeoAI. *Source*: Plentiful.ai

Meanwhile in New York, the ArcGIS extension Business Analyst was used to combine utility data and insights from the geospatial analyses created in ArcMap to its suite of "demographics, property locations, consumer spending [behavior], and market potential" at the census tract level (ESRI 2026). By combining this data in ArcGIS Business Analyst, internally facing dashboards built on infographics and reports were created for PMs to track program engagement and to direct outreach to disproportionally underserved areas.

Results of Geospatial Analyses

New York: Disadvantaged Community Analysis

In the NY DAC analysis where PMs first engaged with GIS to respond to data requests from the New York Public Service Commission (DPS), the team provided a successful assessment of what percent of their total customers resided in DACs. This has important consequences not only for helping state regulators identify what percent of utility resources should be directed toward DACs but also informs the utility whether their past outreach to low-income populations was targeted to the correct communities. The team accomplished this task through coordinating in the GIS working group and by developing a process where geocoding was split out by program (Clean Heat, Low Income, etc.) before being spatially joined across census tract ID number. After all customers had census tract IDs identified, PMs were able to assign the DAC designation where applicable and create "hot spots" areas of DAC-status customers. The team was able to demonstrate that DPS's initial goal for DAC distribution of benefits/ investment of ~45% of total was too high by pointing to maps indicating that DAC customer populations represented approximately 25% of electric customers and 36% of gas customers, making a target of at least 35% to DACs and a goal of 40% more appropriate (NYSEG and RGE 2025).

New York: Clean Heat Program Demographics Analysis

Following the initial DAC analysis in NY, DPS agreed with the utilities that to best target equity populations they'd need to "identify and prioritize new outreach efforts within DAC census tracts" on a program-by-program level (NYSEG and RGE, pg. 6, 2026). For the Clean Heat program, which "facilitates the adoption of efficient electric heat pump systems for space and water heating," PMs believed a more granular GIS analysis was needed to improve customer participation (NYSEG and RGE, pg. 8, 2026). Using the software ArcGIS Business Analyst, PMs were able to create a suitability analysis for the Clean Heat program that identified the most suitable sites in the utilities' territory for increasing community engagement. The suitability analysis entailed ranking and scoring locations within the utilities' territory based on weighted demographic (median household income, average age, neighborhood sustainability scores, etc.), past participation (% of customers in arrears, customers on discounted rates, past participation status, presence of previous weatherization, home energy assessments, or barrier mitigation measures installed, etc.), and building characteristics (house style, avg sq. ft., building age, existing home heating source, etc.) criteria to determine which areas were most suited for electric heat pump adoption. See Figure 3 for an inset map of a suitability analysis for the Clean Heat program. Since conducting this secondary analysis, PMs have been able to plan "community events and educational sessions; provide enhanced support for small businesses, multifamily properties and houses of worship located in DACs; and are now prepared to work with New York State Energy Research & Developmental Authority's (NYSERDA)Clean Energy Hubs in advancing the state's climate and equity objectives" by improving customer access to eligible incentives (NYSEG and RGE, pg. 6, 2026). [11]

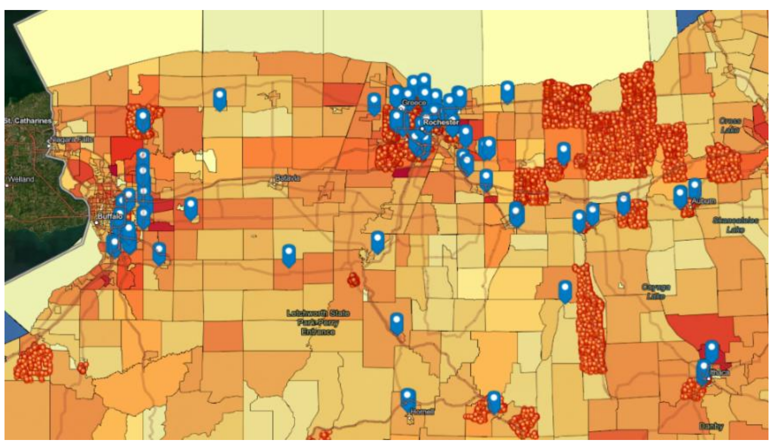

Figure 3. Inset map of a suitability analysis developed in ArcGIS Business Analyst for the Clean Heat program showing suitable sites with DACs for targeting customer participation.

[11] Clean Energy Hubs are defined "as regional outreach and engagement networks that provide education, technical assistance and connections to clean energy programs for residents, businesses and community organizations, with a strong emphasis on low-and-moderate-income customers and DACs" (NYSEG and RGE, pg. 6, 2026).

Massachusetts: Energy Burden Analysis

In MA, PMs initially found it challenging to identify areas where customers were suffering from the acute impact of high energy bills. The MA Department of Public Utilities (DPU) instructed utilities to target EJC block groups within DECs to address equity concerns in the energy efficiency programs. While the PMs continued to pursue interventions in these equity areas, they also sought to learn more about customers who barely failed to qualify for low-income discount rates (and therefore were not technically low-income or EJC customers but still had high energy burdens). Figure 4 demonstrates how, during the energy burden analysis, the team mapped market rate and low-income rate customers before conducting a customer comparison of annual energy consumption and energy rates.

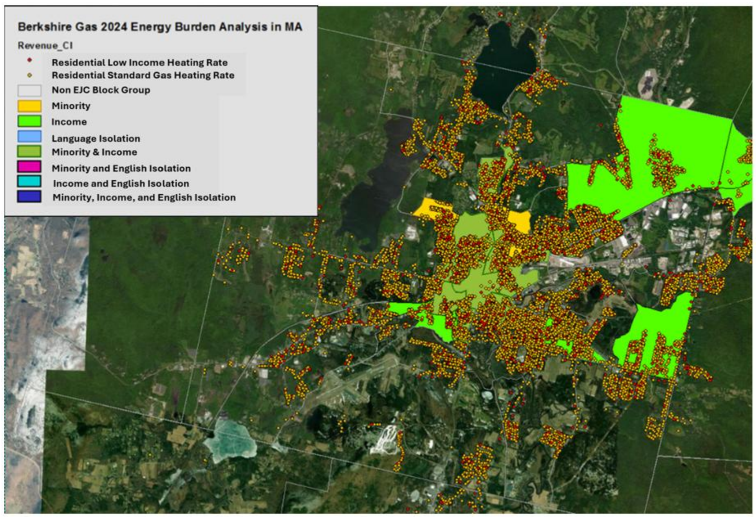

Figure 4. A map of Pittsfield, MA created in ArcMap to depict market-rate and discount rate gas customers across EJC census block groups.

PMs were able to determine the average energy burden of customers by block group, which is shown in Figure 5. They found that none of the top 10 block groups with the highest energy burdens were designated as EJC block groups. In fact, they discovered that customers who typically suffered from the highest energy burdens were moderate-income customers rather than low-income customers, as these customers did not benefit from rate discounts. This analysis resulted in recommendations to the state to replace the existing binary rate discount with scaled discount rates that would be better able to reduce customer energy burden. Moreover, this study encouraged PMs to instruct their lead implementation vendor to focus on the top high energy burden block groups when building out moderate-income customer participation.

Table 1. Top 10 Pittsfield, MA Block Groups by Gas Energy Burden

Census Block Group ID	Gas Customers	Median AHHI	EJC Status	EJC Reason	City Name	AVG Annual Usage (Therms)	AVG Annual per customer ($)	Census AHHI (%)	50% of FPL	100% of FPL	200% of FPL
250093131004	156	$36,875	Yes	Income	Lenox	1494	$ 1,449	4%	11%	6%	3%
250093241003	23	$91,389	No	Not An EJC	Stockbridge	1308	$ 1,269	1%	10%	5%	2%
250093008001	308	$99,167	No	Not An EJC	Pittsfield	1299	$ 1,260	1%	10%	5%	2%
250093009005	217	$90,636	No	Not An EJC	Pittsfield	1293	$ 1,254	1%	10%	5%	2%
250093201021	29	$120,515	No	Not An EJC	Williamstown	1293	$ 1,254	1%	10%	5%	2%
250093131006	258	$59,230	No	Not An EJC	Lenox	1265	$ 1,227	2%	9%	5%	2%
250093215201	119	$75,102	No	Not An EJC	Great Barrington	1160	$ 1,125	2%	9%	4%	2%
250093005002	569	$92,669	No	Not An EJC	Pittsfield	1156	$ 1,122	1%	9%	4%	2%
250093131003	172	$91,250	No	Not An EJC	Lenox	1125	$ 1,091	1%	8%	4%	2%
250093121006	251	$110,750	No	Not An EJC	Dalton	1095	$ 1,062	1%	8%	4%	2%
			Key:	Low Energy Burden	Moderate Energy Burden	High Energy Burden	Severe Energy Burden				

Shows the 10 census block groups in Pittsfield, MA most impacted by household gas energy burden. Energy burden percent is broken out by median household income percent against federal poverty levels.

Connecticut Environmental Justice Community Analysis

PMs undertook the EJC Analysis after a CT Department of Energy and Environmental Protection (DEEP) request in 2024 that required the utilities to identify an appropriate equity performance incentive for their territory to improve targeting of vulnerable customer populations. This required the utilities to establish a target metric. Through the use of GIS to geocode customer participation, PMs identified an appropriate increase in EJC customer participation over a baseline of customer participation in both EJC and non-EJC census block groups. The team determined an appropriate baseline of EJC customer participation by analyzing how many customers living in block groups defined as EJC (under 2024 boundaries) participated in energy efficiency programs between 2019-2023 (CT DECD 2026). This exercise revealed that on average 35% of residential customers who participated in energy efficiency programs lived in EJC block groups (CT DECD 2026). After establishing a baseline, the team geocoded all active 2024 residential customers and found that 40% were currently living in EJC block groups. These findings influenced DEEP to require the utilities to direct at least 40% of their program benefits to EJCs and tied the statewide Equitable Energy Efficiency performance metric to the achievement of that target.

Connecticut Delivered Fuels Weatherization Analysis

Building on the EJC analysis, the team engaged with a third-party GeoAI company to boost low HES and HES-IE savings and participation performance in 2025 by hyper targeting delivered fuels customers with potentially high energy and CO_2 savings potential. The firm supported their objective to train an AI model on a combination of customer consumption behavior, past participation metrics, and publicly available demographic indicators. This resulted in the creation of a digital twin of all delivered fuels customers within the utilities' territory and after assigning them scores, which were mapped by adoption and savings potential in Figure 6, gave the PMs a list of targeted leads of customers who had a high propensity for both savings and participation, which was graphed in Figure 7.[12]

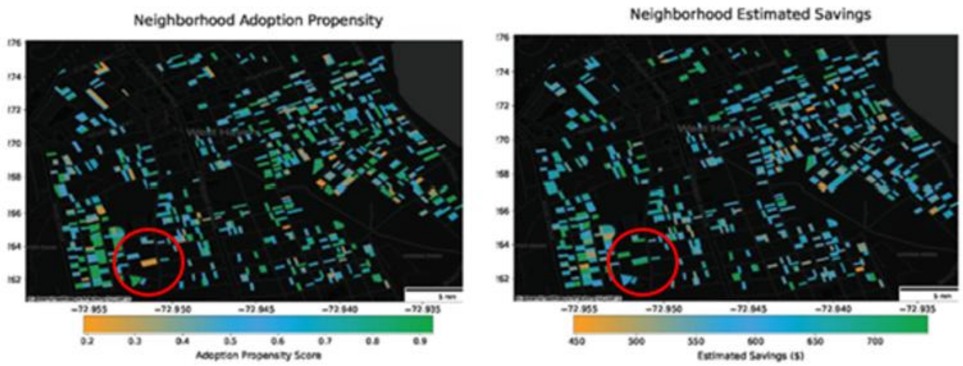

Figure 5. Displays two inset maps from the CT delivered fuels customers GIS analysis. The first depicts a neighborhood with buildings color coded by their propensity to adopt a weatherization upgrade if approached. The second map depicts the same neighborhood with buildings color coded by their propensity to see energy savings if a weatherization upgrade is installed. Of note is that while buildings might not have a high propensity to adopt an upgrade, they may still have high estimated energy savings *Source*: Plentiful.ai

This list was distributed among the residential program management team who are currently in the process of engaging with hyper-localized marketing to delivered fuels customers. Additionally, this exercise is being scaled to other programs in need of better outreach techniques or that are underperforming their equity or savings goals (like multifamily and HVAC programs).

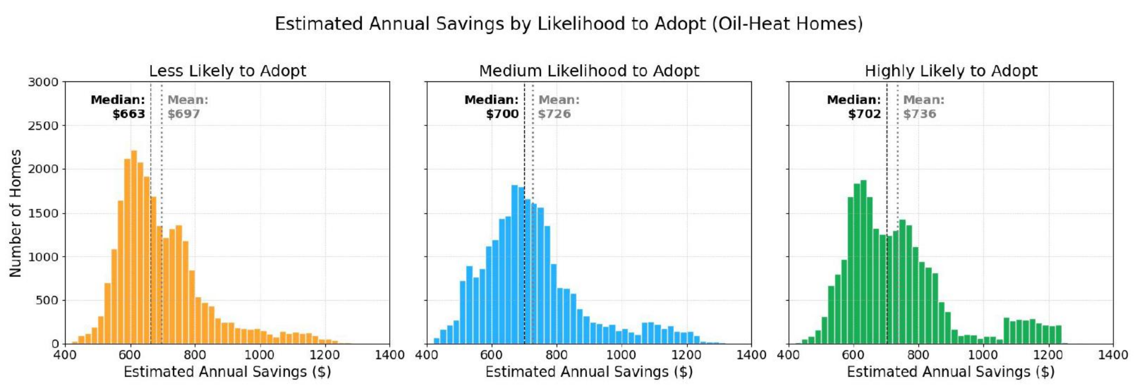

Figure 6. Graphs the proportion of oil-heat customers who could realize energy cost savings versus their likelihood to adopt a weatherization upgrade; with median cost savings identified per category. *Source*: Plentiful.ai.

[12] ESRI defines a digital twin as a virtual representation of reality, including physical objects, processes, and relationships. When built on a foundation of geography, it becomes a geospatial digital twin. (ESRI 2026).

Conclusions and Recommendations

Leading utility energy efficiency programs are dealing with a web of complex issues and competing goals that have evolved with new demands including keeping energy bills affordable, addressing climate change risks, and delivering equitable programs that address environmental justice issues. To reach these goals, utilities must engage their full customer base with creative and customized solutions that work for diverse customer groups. Understanding a utility's customer base is crucial to finding those solutions and delivering successful energy efficiency programs. Utility energy efficiency programs, which have been around for 40+ years, have become increasingly complex over time. GIS can help utilities layer data to better understand the interconnections associated with energy use, electrification, community demographics, and territorial aspects. Moreover, GIS visualizes where to direct resources to better serve all customers and conveys the story of how a utility's energy efficiency programs are performing.

The research concluded that utility PMs who adopted GIS-enhanced equity tools were better prepared to respond to equity-related regulatory compliance requests and could identify pathways for improving customer participation among vulnerable or hard-to-reach populations in underperforming programs. Additionally, these PMs were more prepared to establish equity-related performance incentive goals, could integrate GIS data to improve future program tracking, and developed the skillsets to leverage GeoAI to create hyper-targeted marketing outreach campaigns.

Furthermore, this research provides several recommendations for other utilities. First, utilities can expand energy efficiency program reporting to include EJCs (or equivalent equity metrics) at the census block group level to promote their program offerings, this data is often available through state regulatory sites; if not, federal GIS resources can assist. Other data layers that should be paired with energy efficiency program data include demographic data, income data, load data from internal operation teams, energy burden data, population, and language access. The utilities included in this paper's research expect to continue with exploring other data resources, break down intra-company silos, and enhance pairing their energy efficiency program data with data sources available from other utility teams.

Second, incorporating GIS better enables responses to regulatory requests. As regulators expand their purview and adjust priorities, GIS can help utilities pivot to more holistic, long-term energy strategies. Third, GIS can help PMs better match their program offerings with customers based on a propensity analysis. By identifying high propensity participation customers with similarly high savings potential, PMs can spend less time building out program pipelines while simultaneously ensuring their incentive spending is more cost-effective. A customer in an old, rural single-family home that utilizes oil heat requires different solutions than a customer in a newly-constructed multifamily home with a new gas-furnace installed. Using GIS helps utilities balance misaligned objectives including energy savings, electrification, bill impacts (affordability) and greenhouse gas emissions reductions that derive from the complexities associated with serving different customer bases.

Lastly, energy efficiency teams at utilities are in a unique position to adopt GIS to drive energy solutions for their customer base. Many utilities already extensively use GIS as part of their current operations and have software licensing agreements with GIS providers. While expanding the use of GIS to pair with energy efficiency program data may offer challenges, these can be mitigated through the creation of GIS working groups, the free distribution of GIS training materials, and the patience to engage with GIS in repeated, real-world scenarios. As part of the research presented in this paper, the team put together a roadmap and built relationships outside of its energy efficiency team over time, providing a learning opportunity for involved parties to understand the goals, opportunities, and challenges associated with building out these resources.

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