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A policy landscape analysis of demand flexibility driven building decarbonization: a case study of New York City, USA

Abigail M. Andrews, Rishee K. Jain
Urban Informatics Lab, Department of Civil & Environmental Engineering, Stanford University, California, USA.

ABSTRACT

Building electrification and decarbonization are a focus of municipalities around the world as part of their long-term sustainability initiatives. In order to meet ambitious climate goals, buildings will need to minimize energy use through energy efficiency and be grid-interactive through demand flexibility (DF). While mechanisms to understand the relative energy efficiency of buildings are well established, the literature currently lacks mechanisms to score the performance of grid-interactivity and demand flexibility in urban buildings. This is substantial as the carbon intensity of electricity can vary substantially for different parts of the day as renewable energy penetration rises. In response to this, we conduct policy landscape analysis for integrating DF disclosure in energy performance standards and develop a roadmap for enabling DF driven building decarbonization. We focus on New York City as a case study given its current policy push for rapid building decarbonization and conduct an extensive literature review on measuring DF of buildings. Specifically, we aim to: (1) identify the limitations of current policy, (2) determine barriers to adopting DF disclosure, (3) ascertain potential policy recommendations and the potential impact such policies could have on New York City's building decarbonization goals. Overall, this work aims to demonstrate the decarbonization potential of DF disclosure and in turn catalyze the adoption of similar policy roadmaps for cities around the world.

Keywords: demand flexibility, grid-interactive efficient buildings, energy performance standards, urban decarbonization

NONMENCLATURE

Abbreviations	
ConEd	Consolidated Edison
DF	Demand Flexibility
DER	Distributed Energy Resource

1. INTRODUCTION

In the United States the building sector is responsible for 40% of greenhouse gas (GHG) emissions [1]. In response to the high carbon intensity of the built environment, cities across the world are adopting ambitious decarbonization goals to minimize the emissions from the building sector [2]. Strategies to meet decarbonization goals go beyond energy efficiency to include high penetration of renewables on the grid, incentives for building level distributed energy resources, and the adoption of building electrification mandates [3][4][5][6]. These decarbonization strategies will require flexible electricity use and load coordination to keep the grid stable and minimize building GHG emissions. To maximize decarbonization buildings ought to use energy plentifully when the carbon intensity of electricity is low and shed or shift load when the carbon intensity of electricity is high, this is possible through demand flexibility (DF) [5]. The carbon intensity for electricity can vary significantly. For example, in summer months in California, USA the marginal carbon intensity for electricity can vary from 397 lbs/MWh to 659 lbs/MWh.

DF is the strategic shedding or shifting of energy use to reduce peak demand and associated GHG emissions [7]. In other words, DF strategies aim to optimize energy use to meet building needs while accounting for grid conditions. While DF and demand response are similar –both strategies encourage the shedding and shifting of energy use– demand response is primarily a single event triggered by a third party and can be thought of as a strategy for DF. Instead, DF reaches further to aim for the consistent and continuous shifting of energy use.

In municipalities that have decarbonization goals, the mandates often do not incorporate the impact DF will have on building decarbonization [8]. For example, New York City, USA passed the landmark Local Law 97 (LL97) that mandates buildings larger than 25,000 ft^2 have to cap emissions and reach an 80% emission reduction by 2050 [9]. The method to calculate individual building level emissions for LL97 primarily uses annual energy data $[{}^{kbtu}/_{ft^2}]$ and an average annual emission factor $[{}^{tCO2_e}/_{kbtu}]$. There is no consideration of what

DF a building may employ to reach the emissions target. For example, if have two 200,000 ft^2 office buildings both with an annual electricity demand of 6,000,000 $^{kwh}/_{yr}$ will have emissions counted the same even if they consume energy at varying times. LL97 does not distinguish between the first office building that employs DF strategies (by using energy plentifully when the grid is clean and conservatively when the grid mix is dirty) and the second office building with inflexible energy demand (by using energy without consideration of time-varying grid emissions). Policymakers recognized this timescale misalignment and LL97 was amended with an opt-in time-of-use emissions path provided building managers can provide hourly electricity data [9]. However, the amendment does not provide details or a method for the opt-in path and instead, the amendment states that New York City will further investigate the option [9].

Given the introduction of LL97 and the proposed time-of-use amendment, we use New York City as a case study to analyze the current policy landscape and provide policy recommendations for integrating DF into energy performance standards.

2. METHODOLOGY

Our research methodology undertakes a qualitative case study of New York City's building energy landscape. We methodologically analyzed the barriers to integrating DF at three scales: building, utility, and government (Figure 1). To do this our methodology can be described in three steps. First, identification of current policy limitations through detailed review of local laws, statutes, and mandates from New York City's Council with Notice of Proposed Rulemakings from New York State's Public Service Commission. Informed by our policy identification, next we performed an extensive literature review on DF technologies and measurement to identify what barriers existed towards adopting DF disclosure. Finally, we formulated potential policy recommendations for barrier mitigation. These policy recommendations are the product of the extensive literature review required for steps one and two with additional research on the potential decarbonization benefits of DF.

The results provide barrier identification, mitigation strategies, and policy at each of the three scales (building, utility, government). Recommendations include regulatory measures, economic incentives, and data sharing practices. The short- and mid- term outcomes of mitigation strategies and policy recommendations are summarized and are intermediary steps to meet (or exceed) the long-term goal-decarbonize New York City's building stock 80% by 2050.

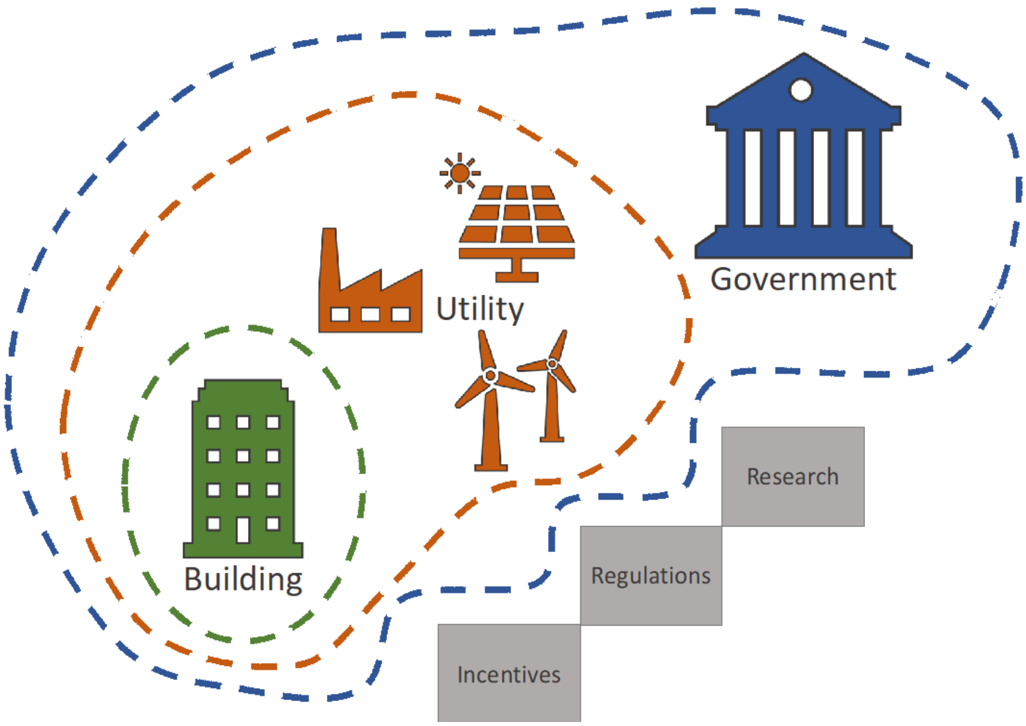

Figure 1: Conceptual approach of policy landscape for New York City's building energy policy objectives

3. OVERVIEW OF BUILDING ENERGY POLICY IN NYC

New York City leads the United States in designing and implementing building energy policies [10]. In 2009, New York City passed the *Greener Greater Building Plan* [11]. This first-of-its-kind policy package includes both LL84 and LL87. LL84 requires energy disclosure, or benchmarking, for all buildings larger than 50,000 ft^2. LL84 has since been amended with LL133 to also require buildings between 25,000 ft^2 and 50,000 ft^2 to annually benchmark their energy use [12]. LL84 has been an effective mechanism to lower energy use in New York City [10]. It is estimated that between 2011 and 2015 energy use in covered buildings decreased by 14% and building owners avoided $267 million in energy costs [10,13,14]. LL87 requires large buildings to have a professional perform an energy and retro-commissioning audit every 10 years. The audit surveys equipment to evaluate the installation and energy performance. LL87 is complementary to LL84 by providing building managers with information on building systems.

In 2019, New York City passed one of the most ambitious urban sustainability policy package in the world the *Climate Mobilization Act* [15]. This sweeping legislative package includes LL97, a building performance standard that places GHG emissions limits on buildings larger than 25,000 ft^2 [9]. Buildings that exceed emission limits will be subject to fines starting in 2024. The emission limits will become more conservative as New York City approaches the 2050 80% decarbonization target. Emission limits are specific for building use type and individual building emissions are calculated by design professionals. It is anticipated that Energy Star Portfolio Manager (ESPM) will compute and report emissions. Buildings are authorized to deduct emissions to meet emission limits through the purchase of renewable energy credits, purchase of GHG offsets, or output of clean DERs at the building [9]. The rules and deduction calculation are not yet set for these alternative compliance pathways.

ESPM uses energy and building characteristic data input by a building manager to compute a benchmarking score and will annual emissions. ESPM is the standard for energy disclosure and performance standards in the United States [16]. Building managers can link their utility account with ESPM to automatically upload energy use data and minimize human input error, however additional building characteristic information (i.e., building gross floor area) must be input manually.

4. BARRIERS TO DF DISCLOSURE

The purpose of this policy landscape analysis is to identify how current New York City building energy policy does not encapsulate DF and propose strategies on how building energy policy can become better aligned for DF disclosure. The landscape summarizes policy at three scales: building, utility, government. Each scale has a jointly agreed policy objective- meet 80% decarbonization by 2050 however the instruments available and implementation strategies are unaligned. Our proposed policy strategies will increase DF at the building level and therefore provide policymakers and researchers data to measure and verify DF role in decarbonization. The policy intervention will be successful if incorporating DF in New York City's building energy policy accelerates the path for New York City to meet decarbonization target (Figure 2)

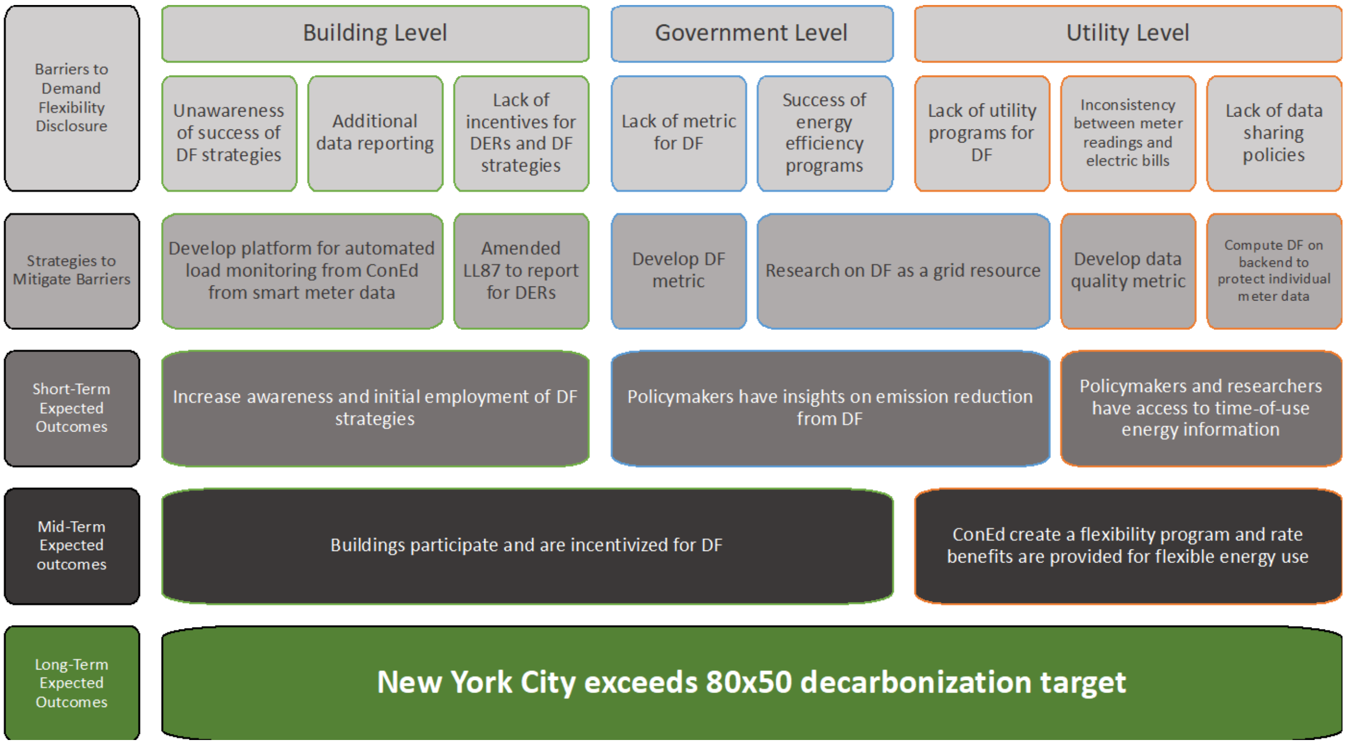

Figure 2: New York City's LL97 Policy Barriers and Outcomes Landscape

4.1 Utility Level Barriers

The prevailing notion among electric utility providers is that energy efficiency is the highest priority for decarbonization and other demand-side management programs (DF or demand response) are secondary separate entities [17]. This prioritization has acted as a natural barrier to research on the deployment of synergetic energy efficiency and DF programs [6]. New research [6] on the relationship between energy efficiency and DF as well as research on DF as a resource is emerging that is beginning to challenge this prioritization. Specifically, recent work [6] quantified that co-deployment of DF and energy efficiency could yield grid-scale impacts of 800 TWh of avoided generation and 208 GW of avoided daily net peak demand in the United States. This work [6] also found that deploying both DF and energy efficiency would yield load impacts larger than deploying just one of these programs independently. As renewables further penetrate the grid and building electrification mandates come into effect the importance of DF for decarbonization will likely grow exponentially. Therefore, incentivizing DF programs (such as pre-cooling/heating and plug load management) in addition to quantifying DF through integrating DF into the existing energy performance standards such as LL84 and LL97 remains an untapped opportunity for New York City and other municipalities.

Granular data is necessary to fully exploit the power of DF as a decarbonization tool. For this to occur advanced metering infrastructure (such as smart meters) is necessary in New York City's large buildings. This barrier is actively being addressed. In 2016, the New York State Public Service Commission approved ConEd's(the investor-owned utility serving the New York City metropolitan area) plan to distribute smart meters in New York City's building stock [18]. Smart meter installation is planned to be completed in New York City by Summer 2022. Smart meters transmit near real-time energy use data between a customer and ConEd. Data on electric and gas use is available for customers, the utility, and authorized third parties at the 15-minute interval scale.

Individual utility customer data is kept confidential under rules established by the New York Public Utilities Commission. Currently, customers may approve the transfer of energy use data to specified authorized third-party companies. Authorized third parties must be registered with ConEd and meet data security standards. Additionally, energy use data is accessible to DER suppliers that meet the New York State Department of Public Service requirements and data security standards [19]. Granular interval meter data is necessary for an energy performance standard to robustly integrate DF. If this data is not available evaluating DF in a building would be limited to an annual scale. To expand data sharing New York Public Service Commission issued an order "Adopting a Data Access Framework and Establishing Further Process" to provide safe access to energy data in the Integrated Energy Data Resource [20]. The Integrated Energy Data Resource is planned to be accessible in late 2022. Under the Integrated Energy Data Resource Energy Service Entities once certified will be able to access interval meter data for the entire State. The Integrated Energy Data Resource does not provide de-anonymized interval meter and customer data access. New York Public Service Commission can develop a process for granular data to be processed for each customer in the back end and summarized DF metrics could be shared with ESPM and accessible to the public as it is for energy use and efficiency data.

4.2 Government Level Barriers

The success of LL84 in reducing energy use in addition to the already well laid out roadmap for LL97 acts as a potential barrier for encouraging building energy policy to go beyond efficiency and incorporate DF. Because energy efficiency programs are already well established, measured, and verified government officials may not see the immediate need to change the status quo. Additionally, because the research on DF as a decarbonization tool is limited, albeit emerging, there may be a lack of incentive to allocate a budget for DF research and disclosure pathways. As the grid mix becomes cleaner, peak demand grows, and building electrification mandates kick in there will be increased pressure on understanding how DF impacts decarbonization pathways. Such barriers can be reduced through the continuation of research on DF as a grid resource and the mutually beneficial relationship between decarbonization from the co-deployment of energy efficiency and DF [6].

New York City utilizes the ESPM platform for evaluating building energy performance. ESPM inputs are either non-time varying or approximated (from nationally representative data). Energy use data can be input at either an annual or monthly scale, the number of occupants and operating hours is approximated, and the GHG emission intensity factors for energy are an annual average from the NYISO grid mix. These inputs fail to consider the time-varying nature of energy use, emissions, and occupancy. Because there is neither an input for DF nor a widely accepted method to model DF (akin to the ordinary least squares regression used for energy benchmarking) ESPM fails to model the impact weight DF strategies. Overall, ESPM in its current form represents a barrier to integrating DF into energy performance standards. A metric for DF that is widely accepted is necessary to incorporating DF. After this metric is established an input field for DF must be added and the regression model must be modified with a (or multiple) term(s) for DF. Additionally, ESPM should allow hourly energy data and emissions factors for more accurate time-of-use modeling.

Building benchmarking serves as a market mechanism to drive energy efficiency [21]. LL84 does not penalize buildings for poor energy performance and buildings are only fined if they do not report benchmarking data [14]. LL97 has shifted towards a penalization structure. Buildings will be fined at $\$268\, /_{tCO_{2e}}$ for exceeding annual emissions limits [9]. Individual buildings' emissions are calculated with annual data and credit cannot be provided for DF strategies. A barrier to incorporating DF in building performance standards is that the timescale of DF (granular data) and current energy policy (annual data) are misaligned. Buildings should be incentivized to use energy when renewables are plentiful, and the grid mix is clean. Buildings should be disincentivized to use energy when demand is high and dirty peaking plants will be brought online to meet energy demand. In other words, a building must be incentivized to optimize electric load to align with the carbon intensity of the electricity grid.

As stated in the introduction LL97 has been amended to allow building managers to opt-in for time-of-use emissions factors rather than an annual average; however, this option is neither well outlined nor advertised and is still in the exploratory research stage [9]. If LL97 is to calculate most emissions based on the annual energy use the added value of DF strategies will be diminished. Without measuring the impact of DF strategies building managers that are active in shedding load to non-peak times will not be rewarded for their actions. Instead, they run the risk of expensive fines if annual values are used. The lack of incentive structure to encourage DF acts as a barrier to widespread grid-interactivity. To mitigate this barrier the equation to calculate emissions under LL97 could be modified to either use granular emissions factor and energy use data or ESPM could add a weighting variable for each building's DF.

4.3 Building Level Barriers

Buildings have adapted well to LL84 and have been successful in lowering energy use since the policy came into effect [10]. Regularly benchmarked properties are estimated to have reduced emissions by 23% between 2010 and 2019 [22]. Based on the success of such mandates, buildings are likely to rapidly adapt to DF strategies if a DF disclosure mandate (or amendment) is passed. While a myriad of barriers exists towards this goal buildings are particularly burdened by a lack of technology to monitor DF strategies. Buildings shifting towards energy efficiency have a well-established set of tools (such as energy conservation measures) and feedback mechanisms (energy audits) to successfully reduce a building's absolute energy load. Without smart technologies and access to data (smart meters, data on grid conditions/emissions, occupancy counts) a building manager will be unable to evaluate whether a chosen DF strategy is optimal for the grid and the building's needs. Increased access to data can improve optimization models. This barrier may be mitigated through New York City and ConEd establishing a platform that allows building managers to see real-time energy use and real-time grid conditions.

Additionally, a barrier for building level DF is the additional reporting burden that it may add to building owners. An automated data sharing and collection system (e.g., ConEd's automated data sharing with ESPM) may be used to reduce this burden. For example, ConEd and ESPM could develop a model to compute DF with electric load data and thus limit the additional resource burden for building owners and operators.

Through mandated energy audits LL87 has helped reduce New York City's energy use and GHG emissions. However, these audits do not ask for information beyond traditional building systems. There is no data collected on DF strategies, on-site generation, storage, or DERs. Additionally, this data is not made public therefore researchers are unable to analyze the impact of LL87 and energy use. Policymakers and researchers alike will be unable to understand how building characteristics align with DF and grid interactivity without this vital information. Because there is no centralized database for DERs in New York City's building stock individual building managers may be improperly penalized if avoided emissions from DERs are not self-reported to the city (as allowed in LL97). Programs and databases for building systems in New York City exist beyond data from LL87. For example, there exists a database for boiler and water heating equipment in New York City buildings [23]. To mitigate this barrier LL87 could be amended to require auditors to collect information on building systems such as DERs and DF strategies or New York could develop a database for DERs in buildings.

5. FUTURE WORK AND CONCLUSION

This paper undertook a policy landscape analysis across the building, utility, and governments levels to ascertain the barriers for implementing DF driven decarbonization strategies in buildings. We applied our analysis to a case study of New York City and identified barriers at the building level, utility level, and government level. Opportunities exist to reduce such barriers and implement broader DF driven decarbonization strategies as part of LL97 and other building related legislation in New York City. While New York City has begun this by considering time-of-use emission factors and deductions for DERs however, these alternative compliance pathways are still in an early stage of development. Our analysis aims to identify pathways and potential actions New York City can take to meet (or exceed) its 2050 the 80% GHG emission reduction goal and thereby catalyze other cities to implement policies that enable DF driven building decarbonization.

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REFERENCES

[1] Robinson C, Dilkina B, Hubbs J, Zhang W, Guhathakurta S, Brown MA, et al. Machine learning approaches for estimating commercial building energy consumption. Appl Energy 2017;208:889–904. https://doi.org/10.1016/j.apenergy.2017.09.060.

[2] Tozer L, University D. Catalyzing political momentum for the effective implementation of decarbonization for urban buildings. Energy Policy 2020;136:111042. https://doi.org/https://doi.org/10.1016/j.enpol.2019.111042.

[3] Krietemeyer B, Dedrick J, Sabaghian E, Rakha T. Managing the duck curve: Energy culture and participation in local energy management programs in the United States. Energy Res Soc Sci 2021;79:102055. https://doi.org/https://doi.org/10.1016/j.erss.2021.102055.

[4] Perry C, Bastian H, York D. Grid-interactive efficient building utility programs: State of the market. Am Counc an Energy-Efficient Econ Washington, DC, Tech Rep 2019.

[5] Steen M, Krarti M. A Review and Categorization of Grid-Interactive Efficient Building Technologies for Building Performance Simulation. ASME J Eng Sustain Build Cities 2020;1. https://doi.org/10.1115/1.4048975.

[6] Langevin J, Harris CB, Satre-Meloy A, Chandra-Putra H, Speake A, Present E, et al. US building energy efficiency and flexibility as an electric grid resource. Joule 2021;5:2102–28. https://doi.org/https://doi.org/10.1016/j.joule.2021.06.002.

[7] Satchwell A, Piette MA, Khandekar A, Granderson J, Frick NM, Hledik R, et al. A National Roadmap for Grid-Interactive Efficient Buildings. United States: 2021. https://doi.org/10.2172/1784302.

[8] Salimifard P, Buonocore JJ, Konschnik K, Azimi P, VanRy M, Cedeno Laurent JG, et al. Climate policy impacts on building energy use, emissions, and health: New York City local law 97. Energy 2022;238:121879. https://doi.org/https://doi.org/10.1016/j.energy.2021.121879.

[9] The City of New York. Local Law 97 2018.

[10] Meng T, Hsu D, Han A. Estimating energy savings from benchmarking policies in New York City. Energy 2017;133:415–23. https://doi.org/10.1016/j.energy.2017.05.148.

[11] New York City Mayor’s Office. Overview of the Greener, Greater Buildings Plan. 2014.

[12] The City of New York. Local Law 133 2016.

[13] Arjunan P, Poolla K, Miller C. EnergyStar++: Towards more accurate and explanatory building energy benchmarking. Appl Energy 2020;276:115413. https://doi.org/https://doi.org/10.1016/j.apenergy.2020.115413.

[14] The City of New York. Local Law 84. 2009.

[15] New York City Mayor’s Office. The Climate Mobilization Act, 2019 2019. https://www1.nyc.gov/site/sustainability/legislation/climate-mobilization-act-2019.page.

[16] Mims N, Schiller S, Stuart E. Evaluation of U.S. Building Energy Benchmarking and Transparency Programs: Attributes, Impacts, and Best Practices. Lbnl 2017.

[17] Wohlfarth K, Worrell E, Eichhammer W. Energy efficiency and demand response – two sides of the same coin? Energy Policy 2020;137:111070. https://doi.org/https://doi.org/10.1016/j.enpol.2019.111070.

[18] STATE OF NEW YORK PUBLIC SERVICE COMMISSION. Case Number 15-E-0050 2015.

[19] Northeast Energy Efficiency Partnerships. Sharing Load Profile Data: Best Practices and Examples. 2020.

[20] New York State. Order Adopting A Data Access Framework and Establishing Further Process. 2021.

[21] Beddingfield E, Hart Z, Hughes J. How Cities are Using Building Energy Data to Drive Efficiency. 2017.

[22] The City of New York, Urban Green. New York City’s Energy and Water Use Report. 2020.

[23] New York City Environmental Protection. Clean Air Tracking System 2022. https://www1.nyc.gov/site/dep/environment/clean-air-tracking-system.page.