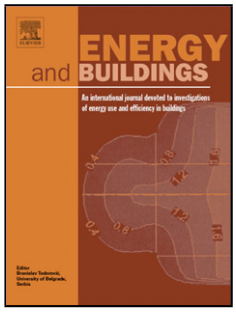

Title: Applications of machine learning methods to identifying and predicting building retrofit opportunities

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<AT>Applications of machine learning methods to identifying and predicting building retrofit opportunities

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<ABS-HEAD>Highlights► Cities want to accelerate building energy systems retrofits to reduce energy use. ► New York City energy audit data is applied to estimate energy retrofit eligibility. ► An interpretable classifier is trained to identify retrofit opportunities. ► Retrofit eligibility determined from only the most relevant building features. ► Building stakeholders can use results to rapidly identify retrofit opportunities.

<ABS-HEAD>Abstract

<ABS-P>Building energy conservation measures (ECMs) can significantly lower greenhouse gas (GHG) emissions from urban areas; however, uncertainties regarding not only ECM eligibility, but also associated costs and energy savings have slowed adoption of ECMs. To encourage ECM implementation, local governments have implemented a range of policies designed to increase the available information on building energy use. Energy audit mandates, such as New York City (NYC)'s Local Law 87 (LL87), require energy consultants to analyze installed building systems and provide building stakeholders with cost effective ECM recommendations on a multi-year cycle. However, complete audits are costly and time consuming. To accelerate ECM implementation, policymakers are exploring ways to utilize available data to target ECMs across a city's entire building stock. In this study, energy audit data for over 1,100 buildings in NYC, submitted in compliance with LL87, are analyzed to identify opportunities for ECMs across building system categories (e.g. distribution system, domestic hot water, etc.). A machine learning classifier, specifically a user-facing falling rule list (FRL) classifier based on binary features derived from LL87 data, is developed here to predict ECM eligibility given a specific set of building characteristics. Overall, the trained FRL classifier performs well (ROC AUC 0.72 – 0.86) for predicting cooling system, distribution system, domestic hot water, fuel switching, lighting, and motors ECM opportunities, which represent a majority of the auditor-recommended ECMs in the sample. Additionally, linear decision lists developed by the model allow building stakeholders to easily conduct streamlined audits of building systems and identify possible ECM opportunities by limiting input to the most relevant factors and prioritizing likely retrofit candidates. The implications of this work are significant in accelerating the adoption of building ECMs and catalyzing energy use and GHG emissions reductions from buildings.

<KWD>Abbreviations: BMS = Building Management System, DHW = Domestic hot water, ECM = Energy conservation measure, EER = Energy efficiency report, EMS = Energy management system, FRL = Falling rule list, GGBP = New York City's Greener Greater Buildings Plan, HWH = Hot water heater, LL84 = New York City's Local Law 84, LL87 = New York City's Local Law 87, MOS = New York City's Mayor's Office of Sustainability, NYC = New York City, ROC AUC = Receiver operating characteristic – area under the curve, TRV = Thermostatic radiator valve, VFD = Variable frequency drive

<KWD>Keywords: building energy; energy retrofit; predictive modeling; machine learning; urban sustainability