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A Review of Building Energy Benchmarking Policies Across the U.S. Cities

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***Abstract*—** Climate change, population growth, and increasing peak electricity demand highlight the importance of the sustainable use of energy in our communities. Residential and commercial buildings account for almost 40% of the total energy use in the United States, putting building energy efficiency among the main objectives for energy planning and policy. To reinforce their sustainable energy plans, many cities across the United States have adopted energy transparency ordinances in recent years. The data released under these energy benchmarking laws enable researchers to investigate the performance of residential and commercial buildings. Using these data sources, many studies have been performed, notably to help municipalities meet their energy efficiency and carbon emission reduction goals. The main goal of this work is to present a comprehensive review of the energy benchmarking policies across the United States to pool together the lessons that were learnt. In particular, the work reviews the characteristics and implementation of the building energy benchmarking laws, it identifies the benefits of adopting energy transparency laws, and it assesses the potential challenges that can hinder their effective use.

Keywords—energy benchmarking, sustainability, building, energy policy, energy transparency.

I. Introduction

Buildings in the United States account for almost 40% of the overall energy use [1]. Considering the natural resource depletion and population growth, efforts toward improving building energy efficiency [2-4] are paramount. Different building types have their own specific function and each study should consider its scope (e.g. office buildings [5], educational buildings[6], hospital buildings [7], etc.). However, regardless of the building type there is a consensus that improving building efficiency using data-driven tools can decrease the demand for urban infrastructure [8].

Although the overall energy use in residential and commercial buildings can be tracked in each state and city [9], it would be more beneficial for both authorities and communities to have the energy information of individual buildings available. Two decades ago, continuous tracking and recording of the energy information of individual buildings in cities seemed unfeasible and expensive. Nevertheless, nowadays, by enforcing energy benchmarking laws in big cities like Washington D.C., municipalities succeeded to record the energy performance for a portion of city buildings larger than a threshold size. To date, more than 30 jurisdictions across the U.S. have adopted various types of energy laws, which authorize them to release energy performance of individual buildings to the public [9].

The main goal of adopting these energy laws is generally to encourage lower energy consumption in buildings and pave the road for having more energy efficient buildings in the future. Regulations, auditing, and certification are primary tools for the regulatory bodies to advance energy efficiency in buildings [10]. Authorities have been using the regulations (i.e., energy codes) to set minimum requirements in the design of buildings. However, the new benchmarking laws can provide a basis for cities to rate buildings based on their energy consumption and issue energy certifications; e.g., after a full adoption of Chicago energy benchmarking ordinances, the City is planning to label buildings based on their energy performance using its self-defined four-star scale. This study reviews building energy benchmarking laws across the U.S. to briefly present the characteristics of these policies adopted by different municipalities and to identify their benefits and challenges.

II. Background and Definition

A. Building Energy Benchmarking

First, the term "building energy benchmarking" was initially implemented in the 1990s to compare energy use in different categories of buildings [11]. Building energy benchmarking compares the energy performance index (EPI) of a building to a sample of similar buildings. Although multiple EPI can be defined in this process, the most common benchmarking metric used for the residential and commercial buildings in the U.S. is annual energy use per unit area known as energy use intensity (EUI).

Four major steps have been proposed for the benchmarking process: (1) build a categorized database (by building type and size) of energy performance, (2) collect related energy information of the actual building, (3) conduct a comparative analysis between the buildings in the categorized database and the building to evaluate the energy performance of building, and (4) recommend corresponding energy efficiency improvements for future implementation; These steps are illustrated in *Fig. 1.* [11, 12].

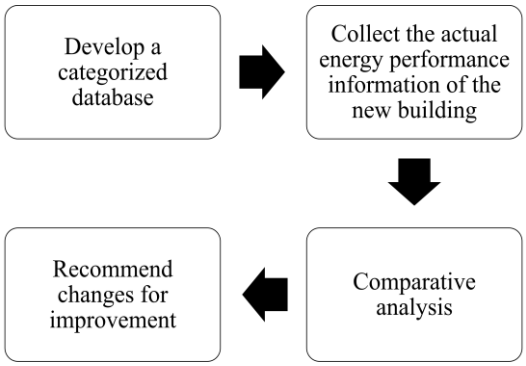

Fig. 1. The process of building energy benchmarking.

B. Building Energy Transparency

Building energy transparency ordinances are the ones that enforce the municipalities to share the energy benchmarking information to the public in a timely manner. By adopting building energy benchmarking, cities can gather the energy information of buildings in a database. However, if the municipalities want these information lead to positive changes they should release the energy performance data to the public. Such transparency has the potential to affect the decisions of building owners, investors, and tenants.

Disclosing energy performance cannot improve a building's energy efficiency by its own, but it is a vital requirement to involve all stakeholders and leverage accountability and reputational pressure [13]. In addition, it can be used as a tool for providing feedback and rewarding.

III. Methodology

In this study, the review process includes four major steps:

- Perform a comprehensive keyword-based search: a comprehensive search of cities and municipalities across the U.S. that have building energy benchmarking policies in place.
- Screen the retrieved policies: the identified municipalities were screened based on the following criteria: (1) the benchmarking policy should be mandatory and be enforced by authorities, and (2) the municipality should have the population of more than 150,000
- Review the policies in all identified cities: all policies screened in the previous step were thoroughly reviewed to define their scope of coverage, level of enforcement, data collection and transparency, and benchmarking execution methodology.
- Analyze the results gained from the review: the review results were analyzed to identify the benefits and challenges of such policies.

IV. Scope and Timeline

After identifying the cities with building energy benchmarking laws in place, the ones that did not meet the screening criteria outlined in this study were removed. In the end, a total number of 22 cities across the United States were included in this study. Although there are similarities among all adopted laws, they are different from one another and have various characteristics.

A. Coverage Scope

There are multiple types of buildings within cities and each type should be treated based on its relevant legal, economic, and technical considerations. The reviewed energy laws grouped the buildings of their target. Some cities considered the functional use criteria and divided the buildings into two broad groups: residential and non-residential (e.g., Austin, TX and Boston, MA). However, in some cases, non-residential buildings were sorted by their type, such as commercial and recreation facilities. Furthermore, residential buildings can be divided into multi-family and single-family homes, and different laws can be applied to each group.

Other cities considered the ownership of buildings as the segregation criteria and enforced different laws to private-owned, city-owned, and public agency owned buildings. Moreover, in almost all cities the authorities determined a threshold size for buildings to be covered under these benchmarking laws; the only exception is the City of Austin, which considered the building age criteria other than building size for residential sector.

B. Timeline

It is not feasible for the cities to implement the benchmarking policies all at once and in one-step. Therefore, most of the municipalities adopted the full policy over a period of time; e.g., the City of Chicago phased in its benchmarking policy over three years. As indicated in Table I, only commercial and industrial buildings larger than 250,000 square feet were covered in the beginning. Each year, the City of Chicago has increased the coverage, leading to the full adoption of policy after 3 years.

Furthermore, not all cities enacted their benchmarking and disclosure mandates at the same time. Some cities were pioneer in adopting such policies and released the first data to the public; e.g., New York City, Washington D.C., and Austin, TX. Other cities enacted the disclosure laws more recently after observing the benefits gained by the other municipalities. Those cities have not fully adopted their policies yet; e.g., Columbus, OH, Reno, NV, and St. Paul, MN. Since there is no data released for such cities, there are N/A in front of their name in the Table. II.

After reviewing different building energy benchmarking ordinances and laws in all 22 screened cities [14-35], we have extracted their adoption timeline, affected types of buildings, and their coverage criteria in the Table. I.

TABLE I. BENCHMARKING POLICIES SCOPE AND TIMELINE

City	Building Type	Criteria	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Austin	Residential	>10 years old													
	Non-residential	>10k sf													
Atlanata	Public	>10k sf													
	Private	>50k sf													
		>25k sf													
Boston	All	>50k sf													
		>35k sf													
Chicago	Commercial	>250k sf													
		>50k sf													
	Residential	>250k sf													
		>50k sf													
Columbus	All	>100k sf													
		>50k sf													
Denver	Municipal	All													
Des Moines	All	>25k sf													
Kansas City	City-owned	>10k sf													
	Non-city owned	>100k sf													
		>50k sf													
Los Angeles	City-owned	>7.5k sf													
	Non-city owned	>100k sf													
		>50k sf													
		>20k sf													
Minneapolis	Municipal	>25k sf													
	Commercial	>100k sf													
		>50k sf													
New York	City-owned	>10k sf													
	Non-city owned	>50k sf													
		>25k sf													
Orlando	City-owned	>10k sf													
	Non-city owned	>50k sf													
Philladelphia	Non-residential	>50k sf													
	Residential	>50k sf													
Pittsburgh	Municipal	All													
	Non-residential	>50k sf													
Portland	Commercial	>50k sf													
		>20k sf													
Reno	City-owned	>10k sf													
	Non-city owned	>100k sf													
		>30k sf													
San Francisco	Non-residential	>10k sf													
	Residential	>50k sf													
St. Louis	All	>50k sf													
St. Paul	Multi-family & Commercial	>100k sf													
		>50k sf													
San Jose	Municipal	>15k sf													
	Private	>20k sf													
Seattle	All	>20k sf													
Washington D.C.	Government	>10k sf													
	Private	>500k sf													

V. DATA CHARACHTERISTICS

Most of the studied benchmarking policies have mandated the municipalities to disclose the energy information to the public. However, some cities like Denver did not enforce data transparency. Therefore, by having access to benchmarking data for majority of the studied cities we have evaluated the datasets detail and summarized what attributes are reported by each city in Table II. For the cities in which energy transparency is not enforced or they have not published any data so far, there are N/A in front of their names in the table.

Among the variables that are reported, some are derived from other variables and can be calculated by using coefficients and formulas, and we excluded them from the Table. II; e.g., Energy star score, GHG emission, energy use intensity (EUI), weather normalized EUI, and GHG intensity. On the other hand, some others are independent variables that can provide new information and enable researchers and authorities to study building energy efficiency in more depth.

Although the current energy benchmarking data report the general information, like energy use, gross floor area, and property type, one of the important variables that is missing in the majority of benchmarking datasets is occupancy rate. Only two cities (Los Angeles and New York City) report the level of occupancy for the covered buildings.

Moreover, the operational energy use of building is mostly related to the occupant behavior, facilities system, architectural and engineering design aspects (e.g., passive design, thick envelope, insulation material, windows type, and external shading devices.), and these variables are not provided by the current benchmarking data.

TABLE II. VARIABLES REPORTED TO THE CITY IN EACH BENCHMARKING POLICY

City	**Data Type**									
	Building Characteristics				***Occupant Behavior***	***Energy Consumption***				
	Building age	***Location***	***Property use type***	***Gross floor area***	***Level of occupancy***	***Electricity use***	***Steam use***	***Natural gas use***	***Water use***	***Total energy use***
Austin	*	*	*	*						*
Atlanata	*	*	*	*					*	*
Boston	*	*	*	*		*	*	*	*	*
Chicago	*	*	*	*		*		*		*
Columbus	N/A	N/A	N/A	N/A					*	*
Denver	N/A	N/A	N/A	N/A					*	*
Des Moines	*	*		*		*		*	*	*
Kansas City	*	*	*	*					*	*
Los Angeles	*	*	*	*	*				*	*
Minneapolis	*	*	*	*					*	*
New York	*	*	*	*	*	*		*	*	*
Orlando	*	*	*	*						*
Philladelphia	*	*	*	*		*	*	*	*	*
Pittsburgh	N/A	N/A	N/A	N/A					*	*
Portland	*	*	*	*						*
Reno	N/A	N/A	N/A	N/A					*	*
San Francisco	*	*	*	*						*
St. Louis		*		*						*
St. Paul	N/A	N/A	N/A	N/A					*	*
San Jose	N/A	N/A	N/A	N/A					*	*
Seattle	*	*	*	*		*	*	*		*
Washington D.C.	*	*	*	*		*		*	*	*

VI. Discussion and Conclusion

Buildings consume a significant portion of energy in the U.S., putting building energy efficiency among the main objectives for energy planning. More than 30 cities across the U.S. have adopted energy benchmarking laws as of 2020. Most of these laws enforce the municipalities to release the benchmarking information to the public through transparency ordinances. The data released under these energy benchmarking laws enabled researchers to investigate the performance of residential and commercial buildings.

The main goal of this work was to present a review of these energy benchmarking policies. Specifically, this study reviewed all the cities performing building energy benchmarking that met these two criteria: (1) the benchmarking is mandatory rather than optional and (2) have the population of over 150,000. After screening all cities, a total number of 22 were selected.

Adopting benchmarking laws have had benefits such as energy savings in reporting buildings, and raising community awareness. Moreover, it supported energy decision-making in cities. Although implementing such building energy disclosure policies has provided the data for some aspects of building energy use, to further influence building energy stakeholders (such as developers), data available for both operational energy use and embodied energy use is needed. However, the current available data does not provide important embodied energy use data such as building envelope, insulation, structural system, etc. at the urban scale.

Another concern regarding the benchmarking process is the accuracy of the reported data since most of the benchmarking data collected are self-reported. Although some variables like gross floor area in the Washington D.C. benchmarking dataset are verified by tax report documents, most of the benchmarking data have not been verified and it may lead to inaccuracies in the making of some decisions.

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