

How Current Energy Policy Instruments Meet the Needs of Smes for Ai-driven Energy Efficiency? Opportunities, Expectations, and Gaps

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Abstract

Small and medium-sized enterprises are not only economically important but also account for a substantial share of energy consumption. Improving energy efficiency in small and medium-sized enterprises increasingly depends on the adoption of technologies. However, because small and medium-sized enterprises often face financial, technical, and organizational constraints, they require effective policy support to facilitate the adoption of energy-efficient technologies. This study identifies areas of alignment and mismatch between the policy needs of small and medium-sized enterprises and the availability of existing policy instruments. It achieves this goal through two complementary analyses: First, this study conducts a needs assessment of small and medium-sized enterprise decision-makers regarding energy efficiency policies and technology adoption through qualitative interviews. Second, it analyzes existing energy policies and programs to assess the extent to which they meet the identified needs of small and medium-sized enterprises. By comparing the needs and expectations of small and medium-sized enterprises with the existing policy landscape, the study identifies policy gaps and misalignments and offers recommendations for strengthening future energy policies and programs.

INTRODUCTION

Small and medium-sized enterprises (SMEs) constitute the majority of businesses worldwide (Thurik & Wennekers, 2004; Gherghina et al., 2020) and collectively account for a substantial share of energy consumption (Fresner et al., 2017). Energy-efficient technologies play a critical role in improving energy performance and business sustainability (OECD/IEA, 2015; Fresner et al., 2017). More recently, artificial intelligence (AI) has emerged as a promising tool for reducing energy use and emissions. AI applications can lower energy consumption and emissions by 8%–19%, and when combined with supportive energy policies, could reduce energy consumption by around 40% and carbon emissions by up to 90% by 2050 (Ding et al., 2024). However, despite these benefits, the high cost of adopting energy-efficient technologies remains a major barrier for SMEs (Howarth & Andersson, 1993; Bressler et al., 2011; Bremer et al., 2024). Consequently, energy efficiency policies and programs are essential for supporting technology adoption, improving energy performance, and promoting sustainable business practices (OECD/IEA, 2015).

Despite their economic importance, SMEs often receive less attention in energy efficiency policies and programs than larger organizations (Bradford & Fraser, 2008; Janda et al., 2014; Hampton & Fawcett, 2017). SMEs differ from large firms in their resources, capabilities, and capacity to prioritize energy management, respond to policy initiatives, and adopt new technologies (Kumar et al., 2012; Hampton & Fawcett, 2017; Henschel & Heinze, 2025). Effective technology adoption therefore depends not only on the availability of technologies but also on a supportive policy environment that encourages SMEs to engage with energy efficiency. Understanding this relationship remains an important research gap (Bradford & Fraser, 2008; Janda et al., 2014; Hampton & Fawcett, 2017).

Accordingly, this study analyzes the needs and expectations of SMEs regarding energy efficiency and technology adoption, identifies the policy instruments most relevant to these needs, and explores existing policy gaps and misalignments. New York State was selected as the case study because of its large SME sector and strong commitment to energy efficiency. SMEs account for approximately 99% of all businesses in the state, making New York a relevant context for examining policies that support technological transformation (Office of the New York State Comptroller, 2026; U.S. Small Business Administration Office of Advocacy, 2022). In addition, New York has a well-developed energy policy framework and relatively low per capita energy consumption compared with many other U.S. states (Energy Information Administration, 2025), making it a valuable setting for analyzing how policy supports energy efficiency and technology adoption in SMEs.

The study focuses on SMEs operating in commercial buildings and excludes home-based and fully online businesses to examine organizations with direct and measurable contributions to commercial energy consumption. Commercial buildings account for approximately 18% of total energy consumption in the United States (U.S. Energy Information Administration, 2018), with SMEs representing a substantial share of this demand. Within commercial buildings, the study specifically examines heating, ventilation, and air conditioning (HVAC) systems because they account for approximately 35% of total building energy consumption (U.S. Department of Energy, 2025) and offer one of the greatest opportunities for reducing energy use and operating costs (Markis & Paravantis, 2007; Jing et al., 2017; Ryu & Yoo, 2025).

BACKGROUND

This study focuses on the policy needs of small and medium-sized enterprises (SMEs) and the energy policy instruments surrounding them. Although the terms *small businesses* and *small and medium-sized enterprises* are often used interchangeably, they represent distinct organizational categories. To maintain conceptual clarity, this study consistently adopts the term *small and medium-sized enterprises (SMEs)* which is defined using quantitative criteria, particularly the number of employees and annual revenue (Independent Evaluation Group, 2008; Berisha & Pula, 2015). In the United States, SMEs are for-profit, independently owned businesses with fewer than 500 employees. Depending on the industry, service-sector SMEs typically have annual revenues of up to \$7 million, although some sectors, such as computer services, have thresholds of up to \$25 million (United States International Trade Commission, 2010). SMEs must also maintain a physical presence in the United States and contribute to the domestic economy through their operations, employment, or tax payments (U.S. Chamber of Commerce, 2023).

Energy efficiency is important for SMEs because, although individual firms consume relatively small amounts of energy, their collective energy demand is substantial (Fresner et al., 2017). Defined as delivering the same level of output with less energy input (Patterson, 1996), energy efficiency is a central objective of energy policy and contributes to economic competitiveness, energy security, environmental sustainability, and improved resource use (Pérez-Lombard et al., 2013; Herring, 2006). Given their high collective energy demand in SMEs (Janda et al., 2014; Hampton & Fawcett, 2017; Fawcett & Hampton, 2020), improving energy efficiency of them is essential for reducing environmental impacts and advancing sustainability goals (Henriques & Catarino, 2016; Agrawal et al., 2023; Herce et al., 2024).

Technology adoption is essential for the survival, competitiveness, and long-term sustainability of SMEs (Das et al., 2020; Mishrif & Khan, 2023; Kurniasari et al., 2023). However, SMEs often face barriers to adopting new technologies, including limited technical expertise, financial constraints, and insufficient access to information (Durst & Runar-Edvardsson, 2012; Alford & Page, 2018; Gherghina et al., 2020). These challenges are particularly pronounced in the adoption of energy-efficient technologies, where high upfront costs, low awareness, organizational limitations, perceived low returns, and resource constraints discourage investment (International Energy Agency, 2015; Markis & Paravantis, 2007; Gennitsaris et al., 2023). Nevertheless, advanced technologies can help SMEs overcome resource limitations and improve energy performance (Hesselink & Chappin, 2019). In this context, energy policy instruments play a critical role by encouraging and supporting technology adoption through regulatory frameworks that increase investment confidence and AI uptake (Dixon et al., 2010; Yahchouchi & Rotabi, 2025) and through financial incentives, such as tax credits, grants, and subsidies, that reduce investment costs and risks (Shaik et al., 2024).

AI applications in HVAC systems enable adaptive, data-driven energy management by optimizing temperature, airflow, humidity, ventilation, and indoor air quality in real time (Yayla et al., 2022; Ibrar et al., 2024; Ahmad & Alhulayil, 2025). Demand-based and occupancy-controlled HVAC systems further improve efficiency by adjusting operations to real-time building conditions, achieving energy savings of 7%–52% compared with conventional systems (Peng et al., 2018; Yayla et al., 2022; Devaraj, 2024). AI also enhances energy performance through predictive maintenance, fault detection, automation, and energy forecasting, reducing downtime while improving system reliability and operational efficiency (Yan et al., 2020; Dai et al., 2020; Es-Sakali et al., 2022; Himeur et al., 2022; Akhai & Khang, 2024; Tejani, 2024). Empirical studies further demonstrate AI's effectiveness, with projected reductions in building energy use and emissions of 8%–19% by 2050 (Ding et al., 2024), heating demand reductions of approximately 16.7% through deep reinforcement learning (Zhang et al., 2019), and average HVAC energy savings of 23% using predictive modeling (Dai et al., 2020), highlighting AI's strong potential to improve energy efficiency in commercial buildings.

In this study, energy policy instruments are analyzed using the Carrot–Stick–Sermon (CSS) framework (Vedung, 1998), which classifies policy instruments into three categories: (1) economic instruments (carrots), which influence behavior through financial incentives and disincentives; (2) regulatory instruments (sticks), which rely on rules, standards, and enforcement mechanisms; and (3) informational or normative instruments (sermons), which seek to shape behavior through communication, knowledge dissemination, guidance, and persuasion.

According to Leeuw (1998), the carrot metaphor refers to economic policy instruments that influence behavior through financial incentives and disincentives, including subsidies, grants, and taxes. In contrast, Lemaire (1998) defines the stick as regulatory instruments that use government authority, legal rules, standards, and enforcement mechanisms. Finally, according to Vedung and Doelen (1998) the sermon refers to informational policy instruments that influence behavior through communication, education, guidance, and persuasion by providing knowledge and recommendations that encourage stakeholders to act in accordance with policy objectives.

The CSS framework provides a useful analytical lens for understanding the motivational basis of energy policies and programs targeting SMEs, as well as the types of policy instruments and the mechanisms through which they promote energy efficiency and technology adoption. This policy analysis is further integrated with interviews conducted with SME decision-makers to explore their expectations and experiences regarding energy policy instruments and technology adoption. Combining policy analysis with stakeholder perspectives enables the identification of policy gaps, misalignments, and needs, providing insights into how policy design can be strengthened to better support SMEs in their transition toward greater energy efficiency.

METHODOLOGY

The main aim of this qualitative policy analysis is to explore the policy environment in New York State, United States, related to SMEs, with a particular focus on their energy efficiency through the adoption of advanced technologies, especially AI innovations. The research question is, *how do energy policy instruments (economic, regulatory, and informational) align with the needs and expectations of SMEs for improving energy efficiency through technological adoption (such as AI), and what gaps exist between policy design and SME expectations?* This study therefore consists of three analytical units: (1) *existing policies and programs*, (2) *SMEs' expectations of policies*, and (3) *the identification of gaps in the policy field*. The study consists of two complementary components: (1) interviews with SME decision-makers and (2) a policy analysis.

Interview Component

The first component of this study consists of interviews with 22 SME decision-makers in New York State. Decision-makers were selected because they play a central role in organizational strategy and decision-making processes (Huang, 2009; Musso & Francioni, 2012). The interviews were conducted following the approval by the Institutional Review Board (IRB) of Stony Brook University in August 2025. Prior to the interviews, participants received the informed consent documents and voluntarily agreed to participate. This research received no external funding. Stony Brook University is committed to conducting research with the highest regard for the welfare of human subjects. It upholds and adheres to the principles of The Belmont Report: Ethical Principles and Guidelines for the Protection of Human Subjects in Research by the National Commission for the Protection of Human Subjects in Biomedical and Behavioral Research (1979).

Semi-structured, in-depth interviews were conducted with SME decision-makers to gain deeper insights into their policy awareness and their interpretations of the policy environment surrounding them (Seidman, 1998; Edgar & Manz, 2017; Knott et al., 2022). A purposive sampling strategy was employed (Barratt et al., 2015; Rai & Thapa, 2015), including only SME decision-makers (owners, managers, co-owners, partners, or full-time employees with decision-making responsibilities) operating in commercial buildings in New York State and served by electricity utility providers.

Data were collected between October 1 and December 15, 2025. Participants were asked about their awareness, use, needs, and expectations regarding energy policies and programs, including their knowledge of available initiatives and whether they had utilized them. All interviews were conducted in English

via Zoom, recorded, and transcribed using Zoom's automated transcription feature. The transcripts were verified through a two-pass review process (Clark et al., 2017), during which the researcher checked transcript accuracy, anonymized participants (e.g., P1, P2), and corrected any remaining errors before data analysis.

To enhance reliability, this study employed (1) multiple coding and (2) transparency methods (Coleman, 2022). Four randomly selected anonymized transcripts were independently coded by two external reviewers, achieving coding agreement rates of 92% and 90%, while transparency was strengthened through the inclusion of direct participant quotations. To enhance validity, the study used (1) mechanical recording and (2) respondent validation (Coleman, 2022). Interviews were video recorded, transcribed, and verified for accuracy, and four randomly selected participants confirmed that the findings accurately reflected their views. NVivo 15 was used to code, organize, analyze, and visualize the qualitative data, supporting a systematic and transparent coding process (Dhakal, 2022; Kraiwani et al., 2023). The data were analyzed using thematic analysis to identify recurring patterns of meaning related to SME policy awareness and knowledge (Braun & Clarke, 2006). Following initial coding, similar codes were grouped into subcategories, which were then examined to develop the main themes emerging from the data (Braun & Clarke, 2006; Joffe, 2011).

Policy Component

The second component of the study is policy analysis. Although the United States has a federal system of government, policymaking is highly decentralized, with substantial authority exercised at the state and local levels (Ward et al., 2010; Mullin, 2021). Accordingly, this study focuses on energy policies and programs in New York State, particularly in New York City and Long Island, where SMEs are highly concentrated. Federal policies are included selectively, most importantly the Inflation Reduction Act (IRA), because of its targeted energy-related incentives for SMEs. Given the uncertainty surrounding recent federal policy priorities (Aron-Dine et al., 2026), the analysis primarily emphasizes state and local policy instruments supporting SME energy efficiency and technology adoption.

Data were collected through a systematic online search of secondary data to identify relevant energy policies and programs (Bowen, 2009; Creswell & Creswell, 2018). Conducted between September 2025 and March 2026, the search covered federal agencies, New York State and its agencies, NYSEDA, New York City agencies, and utility providers, including National Grid, Con Edison, and PSEG Long Island. The dataset includes both public policies produced by governmental bodies and organizational policies developed by utilities and other relevant institutions (Cardno, 2018).

Policies and programs were identified through five complementary methods: (1) a systematic review of publicly available government, utility, and organizational websites and documents; (2) AI-assisted searches (e.g., ChatGPT, Gemini, and Copilot) for initial identification, with all results verified using official sources; (3) direct communication with relevant organizations via email and telephone; (4) consultation with field experts to validate and identify additional programs; and (5) verification of programs referenced by interview participants.

The use of publicly available data enhanced transparency, while the multi-source approach improved the comprehensiveness of the analysis. Policy selection was guided by the study's focus on active New York initiatives supporting SME energy efficiency. Accordingly, policies were included if they (1) were applicable in New York, (2) were relevant to SME energy efficiency, (3) provided sufficient information through official sources, and (4) remained active through March 2026 (the end of data collection). Official websites, PDF documents, and other online materials related to policy instruments were used as secondary data sources (Cheong et al., 2023).

Content analysis was used to examine the identified policy instruments (Drisko & Maschi, 2016; Perry & Bodkin, 2000). Policies were coded according to (1) their stated objectives, (2) policy instrument type (economic, regulatory, or informational) based on the carrots, sticks, and sermons framework, and (3) references to energy-efficient technologies and AI-based solutions. A coding matrix documenting the policy name, governance level, objectives, instrument type, and technology references was developed to ensure consistency and transparency. The dataset is intended to be representative rather than exhaustive, capturing a diverse range of policy instruments supporting technology and AI adoption in SMEs. The final sample of 30 policies provides a sufficient basis for qualitative analysis of policy instruments.

Dataset

This policies and programs analyzed in this study are demonstrated in Figure 1. At the federal level, 3 programs are included under the Inflation Reduction Act, representing the only federal instruments considered in this study. At the state level, 12 policies and programs are identified from NYSEDA, National Grid, and other state agencies. The local level shows the highest concentration, with 15 programs implemented by New York City agencies and utility providers. Due to uncertainty and ongoing changes at the federal level, only one relevant energy efficiency policy was included in the analysis.

The collected policy instruments are systematically presented in Table 1. The table outlines key characteristics of each policy, including its *governance level*, *source* (governmental or private organizations), *objective*, *type of policy instrument*, *official website*, and *technology and AI relevance*. The dataset includes 4 regulatory measures, 4 tax credits, 3 financial incentives, 6 rebate programs, 9 technical assistance initiatives, 2 cost-sharing schemes, 1 performance-based incentive, and 1 loan program. In terms of institutional origin, 17 of the policy instruments are implemented by public sector entities across federal, state, and local levels, while 12 are offered by private organizations, and 1 is delivered through public-private collaboration.

Table 1. Description of Energy Policies and Programs

Governance Layer	Organization	Name	Purpose	Policy Instrument Type	Website
Federal	U.S. Federal Government - Inflation Reduction Act (IRA)	Energy Efficient Commercial Buildings	It offers tax credits to encourage building owners and designers to improve energy efficiency in new or existing commercial buildings.	Tax credit	https://www.irs.gov/forms-pubs/about-form-7205
		Geothermal Heat Pumps	It offers tax credits to encourage the adoption of geothermal heat pump systems and promote energy-efficient heating and cooling solutions.	Tax credit	https://www.nyserda.ny.gov/All-Programs/Inflation-Reduction-Act/Bu
		Solar Technology	It offers tax credits to encourage the development and adoption of solar energy projects.	Tax credit	https://www.irs.gov/forms-pubs/about-form-3468
State	New York State Climate Action Counsel	The Climate Leadership and Community Protection Act	It establishes a comprehensive framework to reduce greenhouse gas emissions, transition to a clean energy economy, and promote equity, job creation, and environmental sustainability across New York State.	Regulation	https://climate.ny.gov/resources/scoping-plan
	New York State Public Service Commission	Clean Energy Standard	It establishes a standard that requires utilities and energy providers to procure increasing amounts of renewable and zero-emission electricity to meet New York's clean energy targets.	Regulation	https://dps.ny.gov/case-15-e-0302-clean-energy-standard
	New York State Legislature	Solar Energy Products Warranty Act	It establishes protections and standards to promote the adoption of solar energy systems, by ensuring product quality, preventing deceptive practices, and providing warranty	Regulation	https://www.nysenate.gov/legislation/laws/ENG/A12

		protections to consumers.		
New York State Fire Prevention and Building Code Council	The All-Electric Buildings Law	It establishes requirements for new buildings to use electric heating and appliances instead of fossil fuels in order to reduce greenhouse gas emissions, combat climate change, and promote a cleaner, more sustainable energy system.	Regulation	https://nyassembly.gov/all-electric-buildings/
NYSERDA	Small Commercial Energy Assessments	It offers free energy checks to small businesses to help these organizations make smart energy choices and save energy.	Technical assistance	https://nyc-business.nyc.gov/nycbusiness/description/nyserda-small
	Flexible Technical Assistance Program (Flex Tech)	It offers technical assistance to building owners to identify, evaluate, and implement clean energy and energy efficiency solutions that reduce energy costs and support long-term planning.	Technical assistance	https://www.nyserda.ny.gov/All-Programs/FlexTech-Program
	On-site Energy Manager Program	It offers a cost-share for industrial, commercial, and multifamily facilities or buildings to hire a dedicated full-time or part time on-site energy manager.	Cost-share	https://www.nyserda.ny.gov/All-Programs/On-Site-Energy-Manager
	Real Time Energy Management (RTEM) Technology	It offers the combination of modern technology and human, expert technical services to act as the nerve center of a building, coordinating systems to maximize responsiveness of operations, and minimize energy consumption.	Technical assistance	https://www.nyserda.ny.gov/All-Programs/Real-Time-Energy-Manager
	Heat Pump Program (NYS Clean Heat)	It offers rebates, financing and tax credits to	Financial incentive	https://www.nyserda.ny.gov/All-Programs/Heat-Pump-Program

			lower your bills and stay comfortable year-round with state-of-the-art heating and cooling technology.		
		Regional Clean Energy Hubs	It offers help to New Yorkers to understand, access, and navigate clean energy opportunities, resources, and incentives through local hubs.	Technical assistance	https://www.nyserda.ny.gov/All-Programs/Regional-Clean-Energy-Hub
		NY-Sun/Paying for Solar	It offers a combination of incentives, tax credits, and low-interest financing can make your business's solar project more affordable.	Financial incentive	https://www.nyserda.ny.gov/All-Programs/NY-Sun/On-site-Solar/Busi
	National Grid	Small Business Program	It offers energy-saving solutions and assessments to help small businesses reduce energy costs, improve operational efficiency, and enhance overall facility performance.	Technical assistance	https://www.nationalgridus.com/NY-Business/Energy-Saving-Program
Local	NYC Department of Finance	Property Industrial & Commercial Abatement Program (ICAP)	It offers property tax abatements for up to 25 years for eligible industrial and commercial buildings that are built, modernized, expanded, or otherwise improved.	Tax credit	https://www.nyc.gov/site/finance/property/benefits-industrial-and-coi
	Municipal Electric Utilities Association of New York State	Independent Energy Efficiency Program - IEEP	It offers New York municipal utility members the opportunity to "tailor-make" an energy efficiency program built to the specific needs of that system.	Technical assistance	https://www.meua.org/ieep/ieep-program-options/

NYC Department of Small Business Services (SBS)	Energy Cost Savings Program	It offers reduced energy and natural gas costs for businesses over a set period to lower operating expenses and support business growth.	Financial incentive	https://nyc-business.nyc.gov/nycbusiness/description/energy-cost-savings-program
NYC Department of Small Business Services (SBS)	Business Incentive Rate	It offers discounted electricity delivery rates to eligible businesses to reduce energy costs.	Rebate	https://nyc-business.nyc.gov/nycbusiness/description/business-incentive-rate
Con Edison NYC	Commercial and Industrial (C&I) Energy Efficiency Program	It offers incentives for installing energy-efficient equipment and technologies.	Rebate	https://www.coned.com/-/media/files/coned/documents/save-energy-tax-credits-for-commercial-industrial-buildings-customers/commercial-industrial-energy-efficiency-program

Small Business & Nonprofit (Small Biz) Program Incentives	It offers incentives for approved equipment upgrades that can help to save energy and money.	Rebate	https://www.coned.com/-/media/files/coned/documents/save-energy-business/neighborhood-program/smb-neighborhood-program-factsh
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Small Business & Nonprofit Energy Efficiency Program	It offers to cover up to 70% of the upfront costs for eligible heating, cooling, and refrigeration upgrades, helping reduce energy and maintenance costs while improving compliance with local laws.	Cost-share	https://www.coned.com/-/media/files/coned/documents/save-energy-business/smb-reference-guide-digital.pdf
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Smart Usage Rewards for Businesses	It offers rewards to businesses for reducing their electricity usage during periods of high demand to	Performance-based incentive	https://www.coned.com/en/save-money/rebates-incentives-tax-credit
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		support grid reliability and lower energy consumption.		
	Advanced Cooling and Pumping Equipment	It offers access to high-efficiency cooling and pumping equipment to help businesses reduce energy and maintenance costs while improving system performance and efficiency.	Rebate	https://www.coned.com/en/save-money/rebates-incentives-tax-credit/buildings-customers/save-on-building-and-water-heating
	Financing as Low as 0%	It offers low- or zero-interest financing options to help businesses and building owners afford energy-efficient upgrades and clean energy projects.	Loan Program	https://www.coned.com/en/save-money/rebates-incentives-tax-credit
	Heat Pumps for Small Businesses & Nonprofits	It offers incentives and support to help small businesses and nonprofits install energy-efficient heat pump systems to improve comfort and reduce energy costs.	Rebate	https://www.coned.com/en/save-money/rebates-incentives-tax-credit/for-your-business
PSEG Long Island	Commercial Rebates	It offers incentives and support for HVAC-related upgrades such as ventilation, heat pumps, refrigeration, and weatherization to improve	Rebate	https://www.psegliny.com/businessandcontractorservices/businessa

energy efficiency, reduce energy costs, and enhance system performance in buildings.

Free Energy Assessments	It offers free energy assessments and expert guidance to help businesses identify energy-saving opportunities and access rebates for efficiency upgrades.	Technical assistance	https://www.psegliny.com/businessandcontractorservices/businessa
Prime Efficiency Partners	It offers support by connecting businesses with approved partners who help implement energy efficiency projects and access available rebates and incentives.	Technical assistance	https://www.psegliny.com/businessandcontractorservices/businessa
Business First Advocate	It offers personalized guidance and support (advocates) to help small businesses identify energy-saving opportunities, access programs and incentives, and improve efficiency.	Technical assistance	https://www.psegliny.com/businessandcontractorservices/Events

FINDINGS

The findings are presented in two sections. The first examines the policy awareness of SME decision-makers, while the second presents the policy analysis.

Policy Awareness

The Table 2 presents the demographic and organizational characteristics of the participants. A total of 22 participants from 22 SMEs took part in the study (one decision maker per SME). The sample consisted predominantly of male participants (17 males and 5 females), with ages ranging from 21 to 62 years. In terms of educational background, most participants held a bachelor's degree (12), followed by master's degrees (5), high school diplomas (4), and 1 doctorate degree. The participants represented a variety of sectors such as food service and hospitality, construction and building services, fuel retail services, information technology services, healthcare services, education services, insurance and financial services, and retail trade. Many participants held ownership roles within their organizations, while others served as general managers or employees responsible for managerial operations. The number of employees in the participating firms ranged from 2 to 85, reflecting the diversity of SME sizes included in the study.

Table 2. Participants Characteristics (N=22)

P#	Gender	Age	Education	Sector	Role	Number of Employees
P1	Male	44	Master	Food Service / Hospitality	Owner, co-owner, partner	7
P2	Female	43	Bachelor	Food Service / Hospitality	Owner, co-owner, partner	8
P3	Male	57	High School	Automotive Repair Services	General manager, operational manager	11
P4	Male	30	Bachelor	Retail Trade	General manager, operational manager	6
P5	Male	44	Bachelor	Education Services	General manager, operational manager	42
P6	Male	31	Bachelor	Construction and Building Services	Employee responsible with management	3
P7	Male	46	Master	Energy Technology & Data Analytics	Owner, co-owner, partner	25
P8	Female	62	Doctorate	Healthcare Services	Owner, co-owner, partner	8
P9	Male	45	High school	Food Service / Hospitality	Owner, co-owner, partner	8
P10	Male	46	Bachelor	Information Technology Services	Employee responsible with management	85
P11	Male	48	Bachelor	Food Service / Hospitality	Owner, co-owner, partner	10
P12	Male	21	High school	Fuel Retail / Gas Station Services	General manager, operational manager	6
P13	Male	50	Bachelor	Construction and Building Services	Owner, co-owner, partner	9
P14	Male	51	Master	Real Estate Services	Owner, co-owner, partner	30
P15	Female	59	Bachelor	Food Service / Hospitality	Owner, co-owner, partner	13
P16	Female	29	Bachelor	Fuel Retail / Gas Station Services	General manager, operational manager	3
P17	Male	48	Master	Fuel Retail / Gas Station Services	Owner, co-owner, partner	6
P18	Male	45	Bachelor	Electronics Retail	Owner, co-owner, partner	4
P19	Male	22	High school	Electronics Wholesale & Retail	Owner, co-owner, partner	4
P20	Male	26	Bachelor	Food Service / Hospitality	General manager, operational manager	2
P21	Male	44	Master	Food Service / Hospitality	Owner, co-owner, partner	4
P22	Female	39	Bachelor	Insurance and Financial Services	Employee responsible with management	2

Participants were asked whether they were aware of any **energy programs involving the use of technology at the federal, state or local level**. If they were aware of such programs, they were further asked to share their opinions about these initiatives and their expectations for effective energy programs that address the needs of SMEs.

Table 3. Policy awareness

Awareness	Non-Awareness
P5 P7 P14 P17 P18 P20 P21	P1 P2 P3 P4 P6 P8 P9 P10 P11
	P12 P13 P15 P16 P19 P22

First, the level of participants' awareness was asked (Table 3), revealing that **the majority were not aware of existing energy programs**. Subsequently, their **needs and expectations regarding such programs** were analyzed.

"Some of our projects are... getting incentives from New York State's. Renewable energy incentives as well. And most of our customers (companies), used New York State's Green Bank. Financial... project finance for their solar projects. In several parts of the New York State..." P7

"I vaguely remember... PSEG...sending out some sort of mail talking about, energy efficiency, light replacements, and that they would come in and inspect, and then see if we qualify, and then that we would go forward with it. I guess some sort of awkward situation happened where we tried to do that, and... The inspector never came in, so it was some sort of a... How to say, like, a low-quality program, because it didn't really come into fruition at all..." P20

"For business-wise, I don't know, but for personal case, I've heard of these, solar panels in the houses that New York State or New York City is supporting, house owners to install. the solar panels. Other than that, I haven't heard any, policies..." P10

"Small business programs, I don't know of any, but I know New York has had some rebates for electric cars. Or hybrid vehicles, but regarding, like, small business, like, energy use, I don't know..." P12

According to the participants, the needs and the expectations of the SMEs are like given below; (1) *financial support programs*, (2) *outreach & communication programs*, (3) *technical assistance programs*, (4) *training & education programs* and (5) *tenant-landlord shared incentive programs* (Figure 2).

Some participants highlighted the importance of **financial support programs** in facilitating the adoption of energy-efficient technologies. Many emphasized that rebates, tax credits, grants, and government incentives would significantly encourage them to invest in energy-efficient equipment and renewable energy systems (P3, P11, P12, P13, P18). Several participants also stated that affordability remains the main concern, and financial assistance would help offset the high upfront costs of installations such as solar panels or HVAC upgrades (P12, P16, P17). P1 reported having received rebates or discounts but noted that the benefit was delayed. P8 and P16 expressed interest in additional forms of support, such as low-interest loans, cost-sharing programs, and substantial grants that could cover a large portion of installation costs. P21 was aware of existing incentives at the federal, state, and city levels, particularly in New York City for solar energy and battery storage, P18 indicated that they were unaware of available programs or had not utilized them. As a result, the participants suggested that stronger, more accessible financial incentives and clearer information about support programs would play a crucial role in encouraging businesses to adopt more sustainable energy solutions.

"They could support us with the solar panel programs; they could give some rebates... We can have some solar power installed to... Provides some of the electric service. And then it will help the environment..." P13

"Substantial funding, like grants or low-interest loans... would be key to convincing our business..." P16

A group of participants emphasized the need for **outreach and communication programs regarding energy efficiency and support initiatives**. P10 noted that awareness should be the first step, suggesting the development of dedicated awareness programs designed collaboratively with business owners to ensure their participation and relevance. P12 stated that they had never received information about available energy programs, such as through email or mail. P18 explained that they only learned about certain initiatives when organizations contacted them directly, indicating that existing programs are not well communicated. Additionally, P2 pointed out that many small business owners are often unaware of available support or lack access to information sources. Time constraints were also mentioned as a barrier for P4, as busy daily operations make it difficult for business owners to actively search for such programs.

"I mean, ... of course, clear information, and maybe, like, local hub. So, it has to be basic... And someone can visit and help check our systems, because we don't know about anything..." P2

"We are really busy on daily basis doing the basic things, and we really can't focus on those types of programs..." P4

The importance of *technical support* was also highlighted in facilitating the adoption of energy-efficient technologies. P16 and P21 emphasized that expert guidance such as site visits, system inspections, and professional consultations would help businesses better understand their energy use and identify opportunities for improvement. Collaboration with organizations such as utility companies and renewable energy agencies was also mentioned, including working with programs from Con Edison or engaging with institutions like NYSEERDA for renewable energy projects (P5, P7).

"So, I would like to use these kinds of programs, for, energy efficiency. But...I don't know what programs, or which technology are in the market to save some energy. I need a, like, assistance... Because if I don't know, there are some programs..." P6

"Installation and guaranteed technical support would be key to convincing our business... Maybe a simple and fast application process. And free expert consultation to monitor the AI system's performance for the first year..." P16

Some participants also emphasized the need for **education and training** to support the adoption of energy efficiency programs. P12 stated that the first step should be providing clear and basic information about available programs so that business owners can better understand their benefits and requirements. P2, P15, and P18 highlighted the importance of training opportunities, suggesting seminars, workshops, conferences, and structured training programs specifically designed for small business owners. So, guidance, training, and educational support would help businesses to build the knowledge and confidence needed to adopt energy-efficient practices and technologies.

"I think, like, baby steps, it would be a training, class. I would, expect them to give a lot of education on it, like, mainly seminars. I would, kind of, set up, like, I mentioned, a seminar, or... group up for training, conferences about it, and... To speak and demonstrate how... we can get closer to be using the tools, and how important that can be..." P15

"Maybe they can do the technical training... I am thinking, like, the education is the first thing. Because most of the people don't know, about the efficiency, or don't know about sustainability, so... They don't even know the, meaning of the word, actually..." P22

Lastly, P4 and P21 underlined the importance of *tenant-landlord shared incentives* in adopting energy-efficient technologies. They explained that they are not allowed to implement certain upgrades in their buildings because the systems are controlled by landlords. Even when tenants are interested in adopting energy-efficient solutions, they often lack the authority to make such changes. P21 emphasized that many renters would like to invest in energy-efficient improvements if they had the opportunity.

"I'm not allowed to use it (incentives) in my building. I would use it if I had a chance, but I couldn't... I wasn't allowed to use since I don't own the building. The incentives mostly help individuals, not the business. So, they need to expand those intensives, for renters, business. A lot of renters would like to do that, but they don't have control over the system, they cannot do it, so they should have a lot of incentive, along with the owner and renters..." P21

Policy Analysis

The next part examines the policy instruments contained in the dataset by classifying them according to the *carrot-stick-sermon framework* (Bemelmans-Videc et al., 2011; Vedung, 1998). As discussed in the literature review, economic instruments refer to policy measures that provide financial incentives to influence energy-related decisions. Regulatory instruments refer to legally binding rules and requirements, including laws, standards, bans, and enforcement mechanisms. Informational instruments refer to the dissemination of information, guidance, or persuasive strategies aimed at shaping behavior through awareness, education, or knowledge. In this analysis, each policy instrument in the dataset was categorized based on its primary mechanism (Table 4).

Table 4. Policy Instruments According to the Carrots-Sticks-Sermons Framework

Carrots	Sticks	Sermons
Energy Efficient Commercial Buildings	Climate Leadership and Community Protection Act	Small Commercial Energy Assessments
Geothermal Heat Pumps	Clean Energy Standard	Flexible Technical Assistance Program (Flex Tech)
Solar Program	Solar Energy Products Warranty Act	Real-Time Energy Management (RTEM)
On-site Energy Manager Program	All-Electric Buildings Law	Regional Clean Energy Hubs
Heat Pump Program (NYS Clean Heat)		Small Business Program (National Grid)
NY-Sun/Paying for Solar		IEEP Program
Property Industrial & Commercial Abatement Program (ICAP)		Free Energy Assessments
Energy Cost Savings Program		Prime Efficiency Partners
Business Incentive Rate		Business First Advocate
Commercial and Industrial (C&I) Energy Efficiency Program		
Small Business & Nonprofit (Small Biz) Program Incentives		
Small Business & Nonprofit Energy Efficiency Program		
Smart Usage Rewards for Businesses		
Save on Advanced Cooling and Pumping Equipment		
Financing as Low as 0%		
Heat Pumps for Small Businesses & Nonprofits		
Commercial Rebates		

The **carrot category**, as the first policy type, is the most dominant in the dataset. A total of 17 out of 30 policy instruments are classified as carrot-type, making it the prominent category. As a metaphor for reward-based mechanisms, this approach encourages the adoption of energy efficiency measures and technologies by providing financial supports. These instruments include a wide range of mechanisms, including tax credits, rebates, cost-sharing programs, discounted rates, and low-interest financing, reflecting a comprehensive strategy to reduce upfront costs and financial barriers for SMEs.

At the federal level, programs established under the *Inflation Reduction Act*, such as tax credits for energy-efficient commercial buildings, geothermal heat pumps, and solar technologies, provide strong financial incentives for investments that reduce energy consumption and carbon emissions. At the state level, initiatives led by NYSERDA offer opportunities such as cost-sharing rebates and low-interest financing to support SMEs in adopting energy-efficient solutions. At the local level, a variety of programs provided by New York City agencies, as well as utilities such as Con Edison and PSEG Long Island, aim to further lower costs and improve the return on investment for businesses implementing energy-efficient measures.

The **stick category** refers to regulatory and mandatory policy instruments. As a metaphor, it establishes obligatory requirements, with penalties imposed for violations. In the context of energy efficiency, stick-type instruments are designed to ensure alignment with standards to decarbonization goals by establishing enforceable obligations. In the dataset, 4 policy instruments are classified under this category: the Climate Leadership and Community Protection Act, the Clean Energy Standard, the Solar Energy Products Warranty Act, and the All-Electric Buildings Law. These policies do not rely on voluntary participation; instead, they mandate compliance by requiring actors to meet specified standards or face potential penalties. This approach has a critical role in driving systemic change in the transition toward energy efficiency and decarbonization.

The **sermon category** represents policy instruments that focus on the dissemination of information and the encouragement of desirable behavior. These instruments aim to influence actions through education, knowledge exchange, and awareness-raising. In the dataset, 9 policy instruments are classified as sermon-type. These are primarily implemented at the state and local levels and take the form of technical assistance programs. Such initiatives support SMEs by enhancing their knowledge and improving decision-making related to the adoption of energy-efficient measures. By providing guidance, information, and persuasive support, sermon-type instruments play an important complementary role in facilitating behavioral change and enabling more informed participation in energy efficiency initiatives.

Due to policy uncertainty and ongoing changes at the federal level, only the Inflation Reduction Act is included in the dataset. Therefore, stick policy instruments are underrepresented. However, the IRA provides substantial financial support for commercial buildings, workplace solar projects, and energy-efficient HVAC systems. Financial constraints remain one of the most significant challenges faced by SMEs, which frequently encounter budget limitations and financing difficulties. In this context, the predominance of carrot policy instruments is particularly important, as these programs directly address financial barriers.

At the same time, behavioral factors, such as limited awareness and low prioritization of energy efficiency among SME decision-makers, represent critical barriers to adoption. Sermon instruments included in the dataset play an essential role in addressing these challenges by providing technical assistance, improving access to information, supporting informed decision-making, and encouraging action. The presence of a wide range of economic incentives enhances motivation within the policy landscape, while informational instruments are crucial for fostering behavioral change.

The next stage of the analysis focused on how policy instruments support technology and AI adoption. The textual content of policy documents was analyzed to determine whether they explicitly reference energy efficiency technologies and to identify the types of technologies included. The content analysis was conducted using a keyword-based approach, focusing on technology-related terms such as solar technologies, thermal energy systems, heat pump technologies, high-efficiency HVAC systems, ventilation systems, and electric heating systems, among others. The list of the explicitly mentioned technologies is presented in Table 5 to support the verification of the coding process.

The findings indicate that 9 policy instruments do not explicitly reference specific technologies in their textual descriptions. These instruments include forms of technical assistance, cost-sharing mechanisms, energy-saving programs with advisory support, tax abatements, rebates, zero-interest financing schemes, and personalized guidance services.

Within the category of *carrot-type policy instruments*, 12 out of 17 policies explicitly promote the adoption of energy technologies through financial incentives and support mechanisms. These policies target technologies such as solar energy systems, geothermal heat pumps, energy-efficient buildings, and advanced cooling equipment. This pattern indicates a strong emphasis on financial incentives as a primary mechanism to encourage businesses to adopt specific energy technologies, reflecting a technology-driven approach to policy and program design.

Table 5. Technology Inclusion

Carrot		Stick		Sermon	
Explicit Tech Inclusion	No Explicit Tech Inclusion	Explicit Tech Inclusion	No Explicit Tech Inclusion	Explicit Tech Inclusion	No Explicit Tech Inclusion
• Energy Efficient Commercial Buildings • Geothermal Heat Pumps • Solar Program • Heat Pump Program (NYS Clean Heat) • NY Sun/Paying for Solar • Commercial and Industrial (C&I) Energy Efficiency Program • Small Business & Nonprofit (Small Biz) Program Incentives • Small Business & Nonprofit Energy Efficiency Program • Smart Usage Rewards for Businesses • Advanced Cooling and Pumping Equipment • Heat Pumps for Small Businesses & Nonprofits • Commercial Rebates	• On-site Energy Manager Program • Property Industrial & Commercial Abatement Program (ICAP) • Energy Cost Savings Program • Business Incentive Rate • Financing as Low as 0%	• Climate Leadership and Community Protection Act • Clean Energy Standard • Solar Energy Products Warranty Act • All-Electric Buildings Law	-	• Flexible Technical Assistance Program (Flex Tech) • Real-Time Energy Management (RTEM) • Regional Clean Energy Hubs • IEEP Program • Free Energy Assessments	• Small Commercial Energy Assessments • Small Business Program (National Grid) • Prime Efficiency Partners • Business First Advocate

In contrast, the remaining 5 carrot-type policy instruments do not explicitly reference particular technologies. Instead, they provide support through broader financial mechanisms, including financing schemes, tax abatements, and energy pricing incentives. While these policies aim to improve energy efficiency, they do so indirectly and without specifying technological pathways. As such, their approach can be characterized as technology-neutral, relying on economic incentives rather than targeted technological promotion.

All *stick-type (mandatory) policy instruments* in the dataset explicitly include technological requirements. These policies include major laws and standards, such as climate leadership frameworks, clean energy mandates, solar energy requirements, and electric building regulations. They directly mandate or strongly enforce the adoption of specific technologies. This consistent inclusion of technological components indicates that mandatory compliance mechanisms are closely linked to technology adoption within the dataset. In other words, regulatory approaches appear to operationalize policy goals by requiring concrete technological transitions.

In the category of *sermon-type policy instruments*, which are based on information dissemination and advisory tools, 5 out of 9 policies explicitly reference specific energy technologies. These policies primarily take the form of technical assistance programs that provide targeted guidance to support the understanding and implementation of technologies. The remaining four policies do not explicitly mention technological adoption. Instead, they focus on providing general technical guidance, informational resources, and advisory support. Their emphasis is on awareness-raising, consultation, and facilitating behavioral change. The sermon-type instruments exhibit a mixed approach: while some directly support technology adoption through targeted technical assistance, others adopt a technology-neutral stance, emphasizing knowledge dissemination and capacity-building without prescribing particular technological solutions.

Table 6. AI Inclusion in Policies and Programs

Type	Policy/ Program	Relevant AI- or Smart Technology
Stick	The Climate Leadership and Community Protection Act	Smart thermostats; building energy management systems; high-efficiency HVAC systems
Sermon	Real Time Energy Management (RTEM) Technology	Predictive maintenance systems; automated analytics; fault detection systems
	Independent Energy Efficiency Program (IEEP)	Energy management systems; smart metering systems; SCADA systems
	Free Energy Assessments	Variable Refrigerant Flow (VRF) systems
Carrot	Commercial and Industrial (C&I) Energy Efficiency Program	Building automation systems (BAS); HVAC control systems; variable frequency drives (VFDs)
	Small Business & Nonprofit (Small Biz) Program Incentives	Advanced thermostats; Wi-Fi thermostats; Energy Management Systems (EMS); demand-controlled ventilation (DCV); variable frequency drives (VFDs)
	Small Business & Nonprofit Energy Efficiency Program	Energy Management Systems (EMS)
	Smart Usage Rewards for Businesses	Smart meters, smart thermostats
	Advanced Cooling and Pumping Equipment	Smart defrost controls; evaporator fan controls; floating head pressure controls; modulating compressor fan speed
	Heat Pumps for Small Businesses & Nonprofits	Variable Refrigerant Flow (VRF) systems

Table 6 represents the core component of the technology-focused investigation within the analysis and demonstrates how selected policies and programs include AI-related technologies. Among the 30 analyzed policies and programs, 21 explicitly mention technological applications related to energy efficiency and HVAC systems in SMEs workplace settings. More specifically, 10 of these 21 programs explicitly refer to AI-related, smart, or digitally enabled technologies. Majority of these programs are carrot type instruments.

Although AI remains a new innovation and is still in the early stages of diffusion, the findings suggest a noticeable integration of AI-based technologies into energy efficiency initiatives. In particular, one-third of the analyzed programs include references to AI-related advancements, indicating that intelligent and data-driven technologies are recognized within the policy landscape.

The identified AI-related technologies primarily focus on smart energy management, automation, monitoring, and optimization systems. These include smart thermostats, building energy management systems, predictive maintenance systems, automated analytics, fault detection systems, smart metering technologies, and variable refrigerant flow systems. The inclusion of these technologies reflects the growing role of digitalization and intelligent systems in improving HVAC performance, reducing energy consumption, and supporting operational efficiency in commercial settings.

The results indicate a **notable** inclusion of AI-related applications within HVAC and energy efficiency programs targeting SMEs. Traditional energy efficiency technologies continue to dominate the broader policy landscape, while there is also encouragement for the use of AI-based systems. However, the fact that only 10 out of 30 programs explicitly mention AI technologies suggests that the integration of AI into SME-focused energy policies is still at an emerging stage and has significant potential for further development.

DISCUSSION

Analysis of interview data yielded a robust needs assessment for SME decision-makers, identifying five key needs within the policy space. As demonstrated in Figure 3, the first need highlighted by SME decision makers was *financial support programs* to facilitate the adoption of energy efficient technologies. They identified affordability as their primary concern. Participants emphasized that financial mechanisms would significantly encourage investment in energy-efficient equipment and renewable energy systems. Furthermore, participants suggested that more accessible financial incentives, along with clearer and

more transparent information about available support programs, would play a crucial role in motivating businesses to adopt more sustainable energy solutions.

The second need identified by SME decision-makers is improved *outreach and communication programs* for energy efficiency. Participants emphasized that raising awareness should be the first step in increasing engagement. They highlighted that small business owners are often unaware of available support or lack access to reliable information sources. Time constraints were also identified as a significant barrier, as the demands of daily operations limit the ability of business owners to actively search such opportunities. In addition, participants expressed a preference for programs to be developed collaboratively with business owners to ensure relevance and encourage participation.

The third need identified by SME decision-makers is *technical support* programs to facilitate the adoption of energy-efficient technologies. Participants emphasized the importance of expert guidance, such as site visits, system inspections, and professional consultations, to help businesses better understand their energy use and identify opportunities for improvement. They also highlighted the value of collaboration with external organizations, including utility companies and renewable energy agencies.

The fourth need expressed by SME decision-makers is *education and training programs* to support the adoption of energy-efficient practices. Participants emphasized that the first step should be providing clear and accessible information about available programs so that business owners can better understand their benefits, requirements, and application processes. They also highlighted the importance of training opportunities, suggesting seminars, workshops, conferences, and structured training programs specifically tailored to small business owners. Participants indicated that guidance, training, and educational support would help build the knowledge and confidence needed to adopt energy-efficient practices and technologies more effectively.

Lastly, participants highlighted the importance of *tenant-landlord shared incentives* in facilitating the adoption of energy-efficient technologies. They explained that tenants are often unable to implement certain upgrades because key building systems are controlled by landlords. Even when tenants are willing and interested in adopting energy-efficient solutions, they frequently lack the authority to make such changes. As a result, many potential improvements remain unrealized. Participants noted that many renters would be willing to invest in energy-efficient upgrades if appropriate mechanisms or shared incentive structures were in place to enable collaboration with landlords.

The findings reveal two major outcomes. First, the analyzed energy policies and programs demonstrate a *notable inclusion of technology- and AI-driven innovations*. Second, the analysis identifies *gaps and mismatches* between existing policy instruments and the actual needs and expectations of SMEs. Initially, the analyzed policies and programs generally support the adoption of technologies aimed at improving energy efficiency among SMEs. Across all three policy categories, there is a recognizable inclusion and encouragement of technological solutions within regulatory measures, economic instruments, and information-based initiatives. These policies promote the adoption of energy-efficient technologies through financial incentives, supportive mechanisms, advisory services, and mandatory regulations.

The findings further show that AI-related and smart technologies are being integrated into SME-focused energy efficiency programs. Technologies such as smart thermostats, building automation systems, predictive maintenance tools, energy management systems, and advanced monitoring technologies are explicitly referenced in several programs. However, AI-related technologies are primarily supported through carrot-type policy instruments. This orientation suggests that financial barriers are perceived as one of the major obstacles preventing SMEs (Danish, 2023; Pimenow et al., 2024) from adopting energy-efficient and AI-enabled technologies.

Table 7. Gaps between Existing Energy Efficiency Policies and SME Needs

Existing Support	Identified Gap / Mismatch	SME Needs / Expectations
Carrot (Economic): Various financial incentives exist, including grants, rebates, tax credits, financing schemes, incentive programs, and cost-sharing mechanisms supporting energy-efficient and AI-enabled technologies.	Awareness gap: Many SMEs are unaware of existing programs and opportunities. Low engagement: Limited participation and weak engagement reduce SMEs' awareness and utilization of available programs. Information asymmetry: SMEs often lack sufficient information and understanding regarding available policies, incentives, technologies, costs, and benefits.	Financial support programs
Stick (Regulation): Regulations exist.	-	Not explicitly mentioned by SMEs.
Sermon (Information): Technical assistance programs are available.	Diversified sermon-type instruments: Existing sermon-type instruments are largely limited to technical assistance, while broader informational and educational mechanisms remain underdeveloped.	- Outreach and communication programs. - Technical assistance programs (site visits, consultations). - Training and education programs (workshops, seminars, awareness campaigns).
Structural / General Context: Existing policies primarily target building owners and property-level energy improvements.	Split-incentive problem: Many SMEs operate as tenants and therefore have limited authority or motivation to implement building-level energy-efficiency upgrades. This creates a mismatch between policy design and SMEs' operational realities.	Tenant–landlord shared incentive programs

The second major findings highlight gaps and mismatches within the current policy landscape (Table 7). Of the five policy needs identified by SMEs, only financial support and technical assistance are adequately addressed by existing policy instruments. Significant gaps remain in outreach, communication, training and education, and tenant–landlord shared incentive programs. While SMEs identified five key policy needs, only two are currently supported by adequate policy mechanisms.

The majority of SME respondents do not know energy efficiency policies or programs, indicating limited awareness of and engagement with energy efficiency initiatives. This finding is consistent with previous research showing that SMEs often exhibit low engagement in energy efficiency due to multiple barriers (Kostka et al., 2013). It also supports the concept of an awareness gap, defined as the disconnect between the availability of energy policies and programs and SMEs' limited awareness of their existence (Chartier et al., 2025). Together, low policy awareness and limited engagement represent barriers to the effective implementation of energy-related policies among SMEs. While current policies align well with SMEs' expectations regarding *financial* support through carrot-type instruments, the effectiveness of these measures is constrained by information asymmetry (Liu et al., 2019) referring to an imbalance in access to, understanding of, or distribution of information among organizations.

At the same time, SMEs expressed a strong demand for broader sermon-type support mechanisms, including communication campaigns, awareness-raising initiatives, training programs, educational workshops, and ongoing advisory support. However, within the analyzed dataset, sermon-type instruments are largely limited to technical assistance programs, while other informational and educational measures remain comparatively underdeveloped. This finding highlights the need for *more diversified, information-based sermon-type programs* tailored to the expectations of SMEs. The findings also indicate that financial support alone is not sufficient to ensure successful technology adoption for energy efficiency in SMEs. Even well-designed incentive programs may have limited impact if SMEs lack the necessary information to implement energy efficiency solutions. This highlights the importance of combining economic incentives with stronger communication, outreach, and educational strategies.

In addition, the analysis also identifies structural challenges affecting SMEs' ability to adopt energy-efficient technologies. A particularly significant issue is the *split-incentive problem* (Bird & Hernandez, 2012), where many policies primarily target building owners, while a large proportion of SMEs operate as tenants. In such cases, SMEs may have limited authority or motivation to invest in building-level energy efficiency improvements, even when they would benefit from reduced energy costs. This creates a structural mismatch between policy design and the operational realities of SMEs.

The results holistically show that barriers to energy efficiency adoption among SMEs extend beyond purely financial constraints. Informational, behavioral, and structural challenges also play a significant role. SMEs need a diversified policy mix that combines financial incentives with stronger sermon-type measures focused on outreach, education, communication, and engagement. Expanding these supportive and informational mechanisms could improve awareness, increase participation in existing programs, and facilitate the wider adoption of advanced energy-efficient and AI-enabled technologies among SMEs.

CONCLUSION

By way of conclusion, this study examined the alignment between SMEs' energy policy needs and existing policy instruments. While current policy instruments provide financial and technical assistance, important gaps and mismatches remain in communication, outreach, training and education, and tenant-landlord policy instruments. As an academic implication, the study demonstrates that technology adoption among SMEs is not shaped solely by financial incentives or technological availability, but also by informational, behavioral, and structural factors such as awareness gaps, low engagement, information asymmetry, and operational constraints. The findings further contribute to research on policy instruments by showing the growing role of AI-driven and smart technologies within energy-efficiency programs and policy frameworks.

For SME practitioners, the results emphasize the importance of becoming more actively engaged with available energy-efficiency programs, financial incentives, and technology-support opportunities. The study suggests that SMEs may benefit from strengthening organizational awareness, information-seeking behaviors, and engagement with outreach, training, and advisory programs related to energy efficiency and AI-enabled technologies.

For policymakers, the findings suggest the need to move beyond narrowly focused financial incentive mechanisms and develop more integrated and diversified policy strategies for SMEs. Although carrot-type policy instruments remain essential and supportive, the study demonstrates that awareness gaps, low engagement levels, information asymmetry, and structural barriers significantly limit the effectiveness of these programs. Therefore, policymakers should strengthen sermon-type policy instruments through broader communication campaigns, awareness-building initiatives, workshops, educational programs, outreach activities, and ongoing advisory support integrated with financial support mechanisms. The findings also highlight the importance of designing policies that better reflect SMEs' operational realities, particularly the challenges faced by tenant SMEs affected by the split-incentive problem. More diversified and tailored policy approaches are needed to address SMEs' specific needs and expectations, which differ from those of larger organizations.

This study has three limitations that should be acknowledged. First, the dataset does not represent a complete list of all policy instruments within the target geographical area; rather, it reflects a snapshot based on publicly available online documents identified through targeted searches. Second, the analysis is limited to New York State, and therefore the findings may not be generalizable to other U.S. states with different policy contexts, economic conditions, and regulatory environments. Third, the study focuses primarily on policy design and textual information obtained from official websites and online documents, rather than examining actual policy implementation processes or real-world policy outcomes. Future research could expand this study by examining energy-efficiency policies and AI-related support programs across different states to compare policy approaches, implementation strategies, and SME engagement patterns in different regulatory contexts. Comparative studies may provide deeper insights into how regional, economic, and institutional differences influence the effectiveness of policy instruments for SMEs.

Declarations

CONSENT TO PARTICIPATE:

Informed consent was obtained from all individual participants prior to their participation in the study.

ETHICS APPROVAL:

This study was approved by the Institutional Review Board (IRB) of Stony Brook University in August 2025.

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Author Contribution

SD conducted the research, performed the analyses, and wrote the original manuscript. EH supervised the research, reviewed and revised the manuscript, and provided critical feedback throughout the study. All authors reviewed and approved the final manuscript.

Data Availability

The data supporting the findings of this study were obtained from two sources: (1) publicly available online data and interviews with human participants. The publicly available data used in the analysis are presented in the manuscript, along with the corresponding source website information for each dataset. The interview data are not publicly available to protect the privacy and confidentiality of the participants but are available from the corresponding author upon reasonable request.

AI-USE STATEMENT: ChatGPT was used only for grammatical corrections of this manuscript. ChatGPT, Gemini, and Microsoft Copilot were used only to identify relevant policy websites to support the researchers' policy search and help ensure the completeness of the list of policy sources, as part of a process that included the researcher searches and expert consultation (Researcher–AI–Experts approach).

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Figures

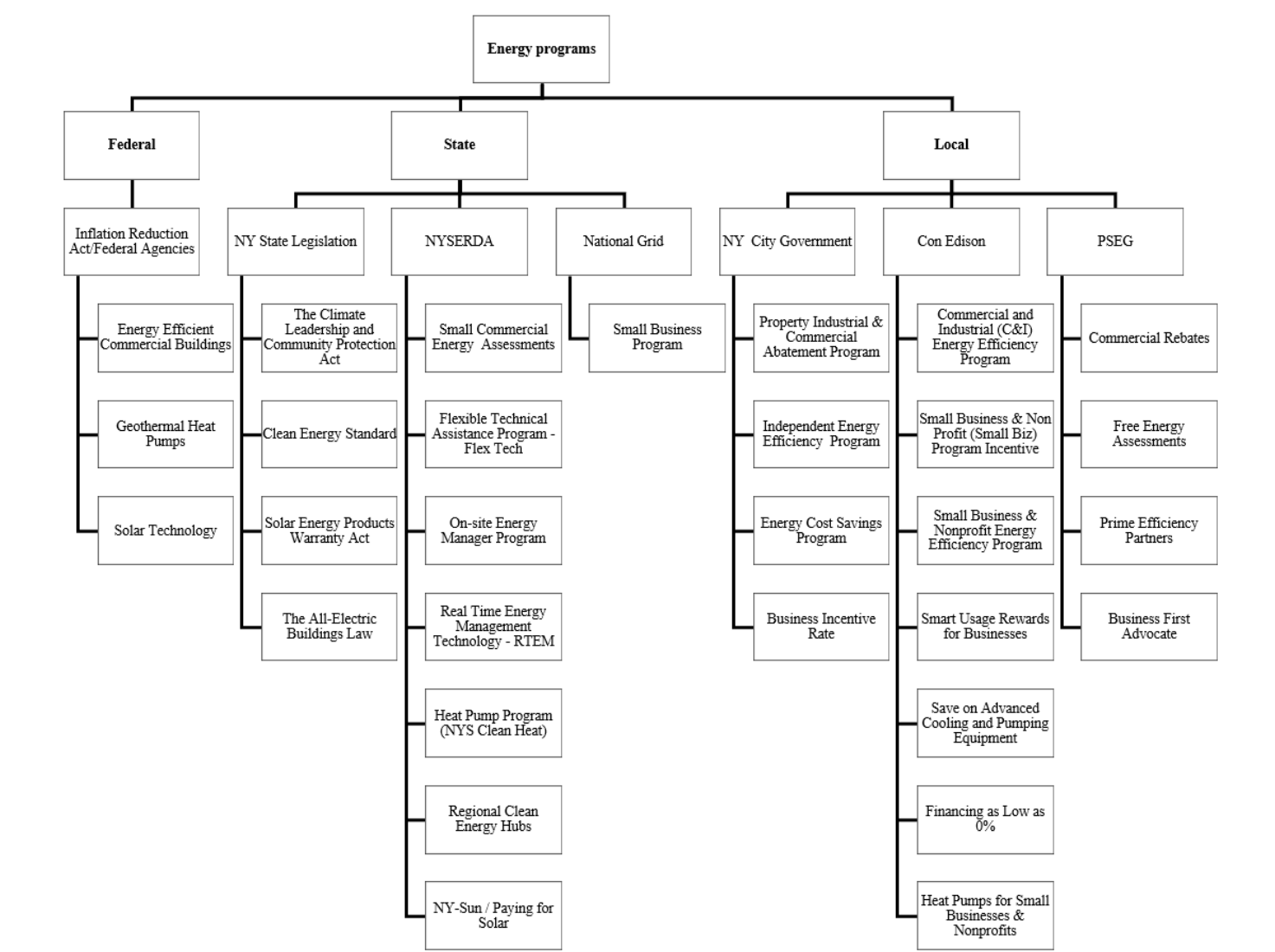


Figure 1
Overview of Energy Policies and Programs

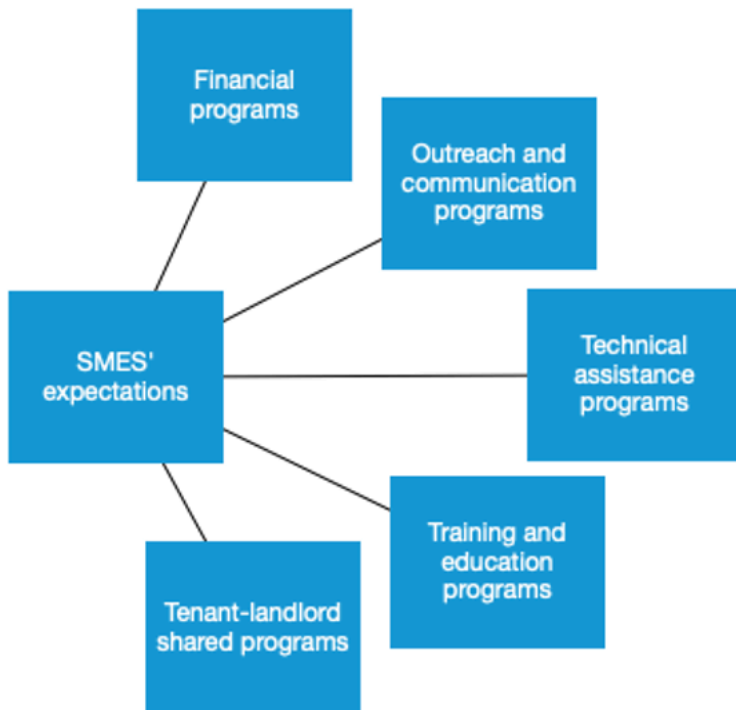


Figure 2

SMEs expectations about energy programs with technology adoption

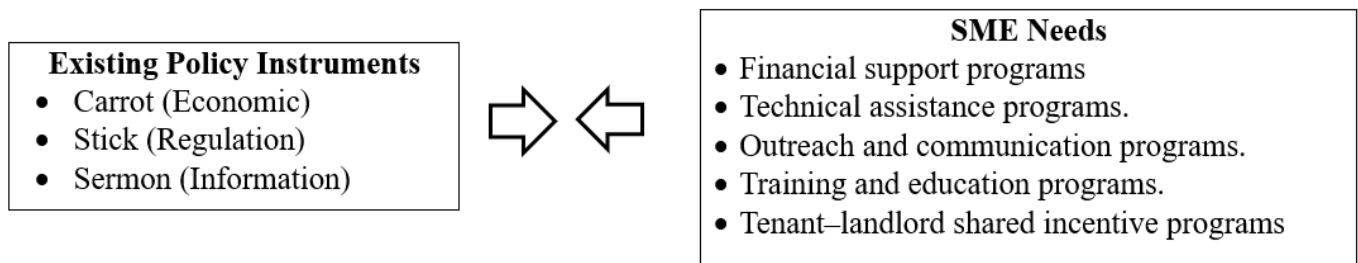


Figure 3

Alignment in the Policy Landscape