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A framework to analyze inclusion in smart energy city development: The case of Smart City Amsterdam

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ABSTRACT

In response to unprecedented global urbanization, the smart city concept has emerged, leveraging ICT to enhance municipal efficiency and improve the quality of urban life. The concept of smart energy city (SEC) is closely related to smart cities, however, energy system development in a smart city context is often found eluding certain segments of society, which calls for more attention to inclusion in SEC development. In this paper, the research question is: How can inclusion be effectively integrated into a framework of SEC design? A framework is developed comprising three key principles - energy conservation, energy efficiency, and renewable energy. These principles are aligned with collaboration among stakeholders, smart energy solutions applications, and integration of these solutions. The framework is illustrated using two real-world cases of demonstration projects in the City of Amsterdam, the Netherlands. The paper concludes by presenting several strategies for fostering inclusion in SEC development. They pertain to including utilization of the framework as a guideline to promote inclusion, establishing a clear understanding of inclusion, and involving all relevant stakeholders, including citizens' rights from the project's inception, and fostering transparency regarding the objectives, interests, and individual stakeholders' value.

1. Introduction

In recent decades, the global landscape has witnessed an unprecedented wave of urbanization, fueled by both demographic expansion and concomitant population agglomeration within urban centers (Janda et al., 2019). Urban environments function as crucibles of creativity and intricate ecosystems, wherein heterogeneous stakeholders, driven by disparate agendas, converge to foster sustainable ecological parameters and an enhanced quality of life. This synergetic interplay of knowledge, technological acumen, and innovative prowess has given rise to the "smart city" paradigm (Macke et al., 2018; Tura & Ojanen, 2022). Conceptually, a smart city entails an urban milieu that harnesses a spectrum of information and communication technologies (ICT) and related innovations to augment the efficiency of conventional municipal operations and elevate the standard of services rendered to urban denizens (Silva et al., 2018). A Smart Energy City (SEC) represents an urban landscape leveraging technological advancements to improve residents' quality of life while addressing pressing energy challenges. Rooted in energy conservation, efficiency, and renewable integration principles, SECs aim to reduce energy demand, enhance service energy provision, and foster sustainable urban development. This involves collaboration among stakeholders, implementation of smart energy solutions in the "hard domain," and integration into "soft domains," encompassing aspects like energy management and collaborative planning. The SEC framework guides the intricate interplay between technological and behavioral dimensions (D'Adamo et al., 2024; Javed et al., 2022; Mosannenzadeh et al., 2017; Shtjefni et al., 2024).

When adeptly managed, the process of urbanization unveils prospects conducive to heightening citizens' quality of life and catalyzing economic expansion. However, while urbanization serves as a catalyst for global economic advancement, it concurrently instigates the specter of inequality and marginalization (Huovila et al., 2019). Smart city planning models, though imbued with transformative potential, often remain beyond the grasp of a segment of the populace. Consequently, the priority to engender inclusive smart cities has been duly recognized (de Oliveira Neto & Kofuji, 2016; Giffinger & Lu, 2015; Meijer, 2018; Nederhand et al., 2023; Trencher, 2019).

To effectively discern and address multidimensional challenges

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associated with inclusion, it becomes imperative to cultivate a precise comprehension of the prevailing contours of urban accessibility (Pérez-Delhoyo et al., 2017). The inexorable progression of urbanization, coupled with population surges, gives rise to ever-increasing energy demand, prompting the implementation of smart energy solutions as a remedial strategy. However, not everyone is able to benefit from using these new technologies or services, marginalizing specific segments of society from engaging with these progressive innovations.

Therefore, ensuring that no one is excluded in smart city contexts remains a significant challenge. There is a distinct lack of information regarding the development of inclusive smart cities, and related innovations, where various social groups can actively participate and reap smart city benefits. The objective of this paper is to develop a framework for enabling inclusion into the development of Smart Energy City (SEC) projects. The main research question is: How can inclusion be effectively integrated into a framework of SEC design?

The paper is structured as follows. Section 2 addresses theoretical concepts on inclusive cities, and SECs. Section 3 presents the research design and methodology. Section 4 presents the theoretical framework, including inclusion and SEC development. Results of the case study of two SEC projects in the City of Amsterdam are presented in Section 5. They are discussed in section 6. Finally, Section 7 concludes the paper, addressing limitations, while providing suggestions for future work as well as policy recommendations.

2. Theoretical background

2.1. The inclusive city and its dimensions

Debates on the effective management of modern urbanization and the equitable distribution of benefits while mitigating adverse consequences have acquired significance in the development of future cities. To achieve this, policymakers should pay attention to diversity, particularly to ensure inclusion of a wide variety of citizen groups in society (Janda et al., 2019). This is also addressed in efforts to establish inclusive cities, which necessitates meticulous planning and urban design to not disadvantage vulnerable social groups or exclude them from access to essential urban service provision or jobs (Espino, 2015). Powers (2017) concurs with this notion by highlighting *spatial inclusion*, which fundamentally opposes the stratification of urban spaces. Spatial inclusion encompasses the imperative of ensuring equitable access for all individuals to fundamental living environments, comprising land, streets, housing, communal infrastructure, and amenities (Makushkin et al., 2016; Powers, 2017). The realisation of spatial inclusion is often contingent upon the degree to which public spaces, both physically and societally, remain accessible to all (Cass et al., 2005). Here, the infusion of ICT is considered critical in determining the level of accessibility and sustainability of urban landscapes (Liang et al., 2021).

Silver (2015) delineates the concept of social inclusion as a process aimed at fostering social interaction among individuals with diverse socially relevant attributes. It can also involve the implementation of impersonal institutional mechanisms to facilitate access and participation in all spheres of social life (ibid). While Silver's definition is overarching, it seems to correspond with Espino's (2015) notion of inclusive cities, encompassing urban environments within the realms of "social life" because social inclusion revolves around ensuring equitable rights and participation for all citizens, encompassing even the most vulnerable social groups (Anttiroiko & De Jong, 2020). Moreover, it emphasizes the promotion of equitable development opportunities for all, while accommodating the unique needs and preferences of social constituents. Furthermore, equitability demands that every individual and social group possesses sufficient access to resources, with their rights safeguarded and upheld even in circumstances of vulnerability, encompassing health issues, criminality, violence, food security, and accidents. Notwithstanding, these advantages come with corresponding responsibilities and risks, thereby necessitating smart utilization of societal resources (Anttiroiko & De Jong, 2020; Liang et al., 2021). Therefore, *social inclusion* refers to ensuring that all individuals and groups in a society regardless of their background have equal opportunities to participate fully in economic, social, and cultural life and access (public) service delivery.

Longworth et al. (2019) introduced a third dimension of inclusion that is imperative for ensuring that all groups contribute to economic growth and reap benefits from urbanization. It relates to the concept of economic inclusion encompassing equitable distribution of economic growth throughout society, while fostering equal opportunities to all. This includes how all groups in society, particularly those who are disadvantaged and typically situated in the more vulnerable socio-economic segments, can equitably participate in the upward trajectory of (financial) prosperity. This participation entails a stake in the resultant gains in overall wellbeing and contributes to the enhancement of welfare (Liang et al., 2021; Longworth et al., 2019; Makushkin et al., 2016).

Additionally, there are two more dimensions to inclusion, pertaining to environmental and political inclusion (Liang et al., 2021). The fourth dimension, environmental inclusion endeavors to satisfy present generations' natural resources and environmental requisites without compromising the interests of posterity. The fifth dimension, political inclusion, or inclusive governance, encapsulates legislative and regulatory frameworks indispensable for materializing an inclusive urban milieu (Kostetska et al., 2020; Liang et al., 2021). In this case, inclusion is mainly associated with issues of democracy, human rights, participatory policymaking, and the right to have a voice for all groups of society. Here, political inclusion at the city level mainly refers to the interaction between local government and local residents. Normatively speaking, citizens of inclusive cities feel a sense of belonging and identity within the city they reside in, particularly if they are also entitled to fully participate in decision-making (i.e., by co-creating or co-designing policy), in this way to a certain degree governing the city (Anttiroiko & De Jong, 2020; Liang et al., 2021).

Liang et al. (2021) developed a theoretical framework covering the five different dimensions of inclusion mentioned. This framework aids in understanding the degree to which different forms of inclusion appear in urban contexts. Upon dissecting the five dimensions of inclusion, it becomes apparent that there are certain overlaps between them while predominantly complementing one another. Therefore, the effort to foster inclusive cities is inherently complex, requiring both intellectual insight and political cognizance. This multidimensional nature stems from the diversity of intertwining dimensions of inclusion at play, which demands cohesive orchestration encompassing governance, policy formulation, and management. This is also crucial to accommodate the manifold, albeit partially divergent, stakeholder interests.

Whereas inclusive cities are predominantly discussing adopting an inclusion perspective, Anttiroiko and De Jong (2020) do the opposite; they consider the concept of the inclusive city from the very perspective of exclusion. They discern five types of capital in which exclusion can be found, i.e.: i) human and cultural; ii) social; iii) financial; iv) physical; and (v) natural capital. In their definition, natural capital is, "comprised of all those natural resources that are or should be available to residents and users of urban space, such as fresh air, water, land, and greenery" (p.46). In their view, exclusion from such natural capital, or any of the other four forms of capital, prevents a city from becoming inclusive (Anttiroiko & De Jong, 2020, p. 46). Consequently, challenges associated with exclusion – hence problematic to inclusion - manifest within each of these five dimensions. Based on these five inclusion pillars, the marginalized or vulnerable social groups can be identified as:

- Groups facing physical barriers to accessing smart energy solutions, such as people in remote or underserved areas, and those in urban neighborhoods with limited infrastructure.
- Socially marginalized groups, including ethnic minorities, the elderly, people with impairments, and those who may not have

access to tailored or adequate Smart Energy solutions that meet their specific needs.

- Groups disproportionately affected by environmental degradation or resource scarcity, specifically young or future generations, who will face the long-term environmental consequences of current SEC policies.
- Low-income/ no-income individuals or households, unemployed persons, and people living in poverty, who cannot afford smart energy solutions or technologies.
- Other social groups and stakeholders that are underrepresented in decision-making processes.

Notably, Makushkin et al. (2016) acknowledge the intricate nature of inclusivity within contemporary cities. These challenges encompass issues such as disparities in infrastructural development and incomplete social policies, as well as challenges stemming from migration and demographic dynamics.

2.2. The Smart Energy City

A Smart City refers to a developmental process that utilizes ICT and data assets to govern a city, offering efficient and effective, user-based urban solutions to achieve sustainable development goals (Noori, de Jong, et al., 2020a). The concept of Smart City encompasses various aspects, with the smart energy sector holding particular significance (Thornbush & Golubchikov, 2021). A *Smart Energy City* (SEC) refers to an urban area at the city level that leverages recent technological and economic advancements to enhance residents' quality of life, which is achieved while simultaneously tackling pressing urban energy issues such as climate change (mitigation), energy resource scarcity, or deterioration of energy infrastructure (Mosannenzadeh et al., 2017).

The fundamental principles underpinning a SEC can be subdivided into three key elements: energy conservation, energy efficiency, and the integration of renewable energy sources (Mosannenzadeh et al., 2017). Energy conservation involves reducing the demand for energy while maintaining the same level of useful energy services. This entails eliminating unnecessary energy consumption. Meanwhile, enhancing energy efficiency translates to lowering energy demand while upholding the same level of services or maintaining the existing energy consumption while providing higher-quality services.

Mosannenzadeh et al. (2017) argue that a SEC requires having a vision that entails three tenets: (1) to foster collaboration between stakeholders; (2) to implement smart energy solutions in the hard domain; (3) to integrate these smart energy solutions in (so-called) 'soft' domain. On the one hand, the "hard domain" refers to several smart energy technologies that collectively contribute to forming smart grids or smart energy systems. The "soft domain", on the other hand, refers to other dimensions and activities, including energy and data management, consumer behavior and collaborative planning (Javed et al., 2022). Mosannenzadeh et al. (2017) developed a theoretical framework including both the "hard" and "soft domains".

Within the framework of Mosannenzadeh et al. (2017), stakeholders are categorized into four groups: decision makers, service providers, consumer groups, and influential stakeholders. Decision-makers are politicians and policymakers operating at various administrative tiers, responsible for formulating policies and outlining action plans. Service providers are entities, business firms, or individuals that provide energy-related or energy management services to others for a fee. Consumers refer to individuals or groups targeted by SEC policies to influence how they receive and use provided goods, services, or technologies. Influential stakeholders are those guiding future directions, strategies, and attitudes (Mosannenzadeh et al., 2017).

Collaboration among key stakeholders holds significant importance in the context of a SEC. The presence of advanced communication infrastructure and collaborative tools enhances the quality of collaborative relationships (Hollands, 2008; Kitchin, 2014; Noori, de Jong, et al., 2020b). These relationships facilitate mutual understanding and consensus-building among stakeholders, leading to joint decision-making in order to find acceptance among target groups and are efficiently put into practice (Mosannenzadeh et al., 2017; Noori, de Jong, et al., 2020b). The concept of a SEC stresses citizen participation. In addition, a SEC aims to bridge spatial and sectoral divisions in urban governance by establishing rules, while addressing the challenges of collaboration between the public and private sector actors. However, in practice, collaboration often centers around shared investments and the development of new business models (Mosannenzadeh et al., 2017).

Technologically, there are three categories of smart energy solutions: integration of decentralized renewable energy sources (low-carbon generation), efficient distribution, and optimized consumption (Mohanty et al., 2016). Renewable energy sources, such as wind, solar, and hydrogen energy, play a significant role in sustaining energy resources that are not renewable, while concurrently mitigating negative environmental impacts (Silva et al., 2018). Furthermore, efficient distribution infrastructure is required in a city using technological innovation, particularly enabled by ICT, which collects energy consumption data, analyzes data, and facilitates exchange rate information. This foundational structure enables the establishment of a smart grid, functioning as the fundamental backbone of the entire smart energy system (Mohanty et al., 2016). Notably, smart grids adeptly incorporate energy from renewable and non-renewable sources, effectively enabling a bidirectional exchange of information and electricity through the grid. This opens doors to techno-economic activities, including energy trading and the utilization of Aquifer Thermal Energy Storage (ATES) technology (Rodríguez Bolívar, 2015). Smart energy systems also require system optimization, which also refers to optimization of energy consumption. This entails the employment of efficient energy storage, smart metering, and e-mobility to optimize energy usage efficiency (Mohanty et al., 2016). Establishing a cohesive SEC, revolves around interconnecting these three blocks, so that they effectively communicate with one another, ultimately forming a unified system (Mohanty et al., 2016).

Integrating smart solutions in (smart) governance arrangements involves collaborative planning, consumer behavior management, as well as proper energy and data management (Mosannenzadeh et al., 2017; Noori, de Jong et al., 2020b). Collaborative planning refers to solutions encompassing tools and technologies facilitating coordination, communication of data, knowledge dissemination, and the exchange of ideas among stakeholders (Secinaro et al., 2021). Consumer behavior management focuses on enhancing stakeholders' understanding and awareness of their energy consumption patterns. This also involves implementing demand management strategies aimed at curbing energy demand by influencing consumer behavior. Energy and data management concentrates on optimizing the overall energy system across energy supply and demand fronts (Javed et al., 2022). This encompasses an extensive array of tools, instruments, and technologies designed to facilitate the management, analysis, forecasting, and monitoring of various aspects within a SEC framework. These tools enable the comprehensive collection, storage, processing, and transformation of data to enhance the understanding of SEC dynamics (Mosannenzadeh et al., 2017).

3. Research approach

3.1. Research design

A comprehensive approach involving theoretical development preceding qualitative research is adopted. This approach integrates a literature review and theory building, leading to the development of a theoretical framework addressing integration of inclusion into the SEC concept. For illustrating the use in practice, the framework is applied to the real-life empirical case, the case study of Amsterdam, The Netherlands, utilizing the framework to assess the inclusivity of smart energy projects. Therefore, this research relies on an embedded case study design chosen for its suitability in studying real-world situations and addressing pertinent research questions. This involves multiple sub-units of analysis within the overarching case of Amsterdam, providing a robust understanding of the phenomenon (Baxter & Jack, 2008; Miles & Huberman, 1994; Yin, 2009). The selection of a single embedded case study methodology is motivated by the study's environment and the need for more compelling evidence from various sub-units. The case selection of a smart energy domain of Amsterdam reflects the city's proactive stance in transitioning to carbon-neutral status.

3.2. Case study

Amsterdam's approach to the energy transition is not only ambitious, encompassing rapid growth in local solar and wind energy as well as the electrification of heating, cooling, and mobility, but also comprehensive, with clear climate neutrality goals for 2050 that emphasize a full circular economy and enhanced citizen health and quality of life (Dobbelsteen et al., 2019). Within this context, two specific sub-units—the LIFE and Lighthouse projects—were selected to explore inclusion in Amsterdam's smart energy projects. These projects were chosen based on their prominence and relevance to Amsterdam's sustainable energy goals and the broader research question on inclusion within smart energy development. Specifically, both LIFE and Lighthouse represent flagship initiatives that integrate a wide range of smart energy solutions and engage multiple stakeholders, including residents, local authorities, and private organizations. The selection criteria involved scope and impact, the stakeholders' diversity, and the projects' alignment with Amsterdam's inclusive climate and energy objectives. The LIFE project exemplifies inclusion through its community-centered approach, emphasizing accessibility and affordability in energy transition measures for diverse social groups. Similarly, the Lighthouse project demonstrates innovative integration of smart energy solutions aimed at improving urban quality of life while minimizing environmental impacts. By studying these projects, this research captures two leading examples of Amsterdam's inclusive energy transition, allowing for an in-depth understanding of both participatory and distributional aspects of inclusion within smart energy initiatives.

3.3. Data treatment and analysis

Multiple data sources are employed, including documentation, archival records, and interviews (Alshenqeeti, 2014). These sources contribute to a comprehensive understanding of the case, aligning with case study research principles. Thirteen interviews (see the Appendix) were conducted during May–June 2021 in a semi-structured, open-ended manner, guided by the research questions and the theoretical framework (see the Interview guide in the supplementary material appended to this research paper). Interviews were conducted with thirteen experts and practitioners involved in the two Amsterdam SEC projects and documentation was reviewed over time till 2024. In 2024, there was contact with selected researchers to gather updated insights into the projects. All interviews were recorded and transcribed, and ATLAS.ti was employed to conduct qualitative analysis. The approach to analysis facilitates a semi-deductive coding approach based on research questions and theoretical pillars, contributing to a systematic and in-depth analysis (ATLAS.ti, 2018). Data analysis involved coding, with codes derived from the research questions and theoretical framework. The results were linked back to key concepts and relations between them in the theoretical framework (i.e., Fig. 1), allowing for a comprehensive interpretation of the empirical findings. The methodology employed integrates theoretical and empirical components, ensuring a rigorous and comprehensive exploration of the ISEC paradigm in Amsterdam. This includes a stakeholder analysis of the key actors involved (Schmeer,

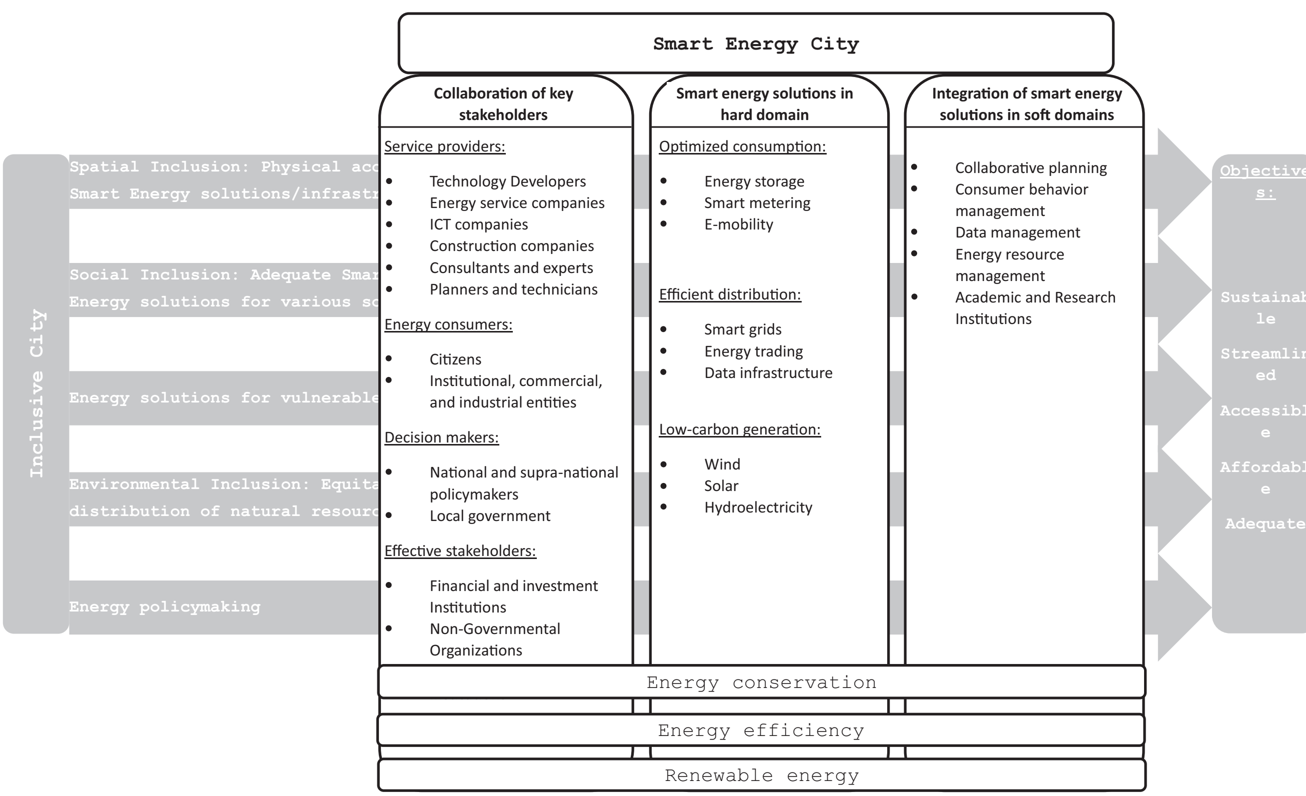

Fig. 1. Inclusive Smart Energy City framework.

1999).

4. Mapping the concept of inclusive city in the context of smart energy cities

From the five dimensions of inclusion identified by Liang et al. (2021), several challenges related to inclusion can be identified within the context of a SEC. As previously mentioned, spatial inclusion is often regarded as a process aimed at ensuring equal access to essential urban services, solutions, and infrastructure. In the context of a SEC, this dimension of inclusion pertains to equitable access to smart energy solutions, primarily within the domain of infrastructure (Rodríguez Bolívar, 2015). Social inclusion revolves around ensuring equal opportunities for citizens to access urban services and facilities. Within the SEC framework, this dimension pertains to the degree to which solutions are adaptable and accessible to diverse social groups (Borg et al., 2019). Economic inclusion aims to enable all citizens, particularly those who are disadvantaged, to participate in increasing prosperity, including providing access to secure and affordable energy. In the context of cities pursuing to become a SEC, this involves joining in and contributing to the benefits derived from smart energy solutions. However, such solutions often require substantial investment and installation costs, which are often not within the financial reach of all citizens. Nevertheless, they might contribute to a more sustainable utilization of energy resources, resulting in reduced energy costs, which in turn enhances the capacity to participate in welfare improvements (Steffen et al., 2020).

Environmental inclusion refers to the concept of satisfying the needs of present-day generations for natural resources and a healthy environment while ensuring that future generations' interests are not compromised. This idea highlights the interconnections among resource allocation, environmental pollution, and societal responsibilities (Liang et al., 2021). In the context of smart energy cities, it is essential that these technologies actively contribute to environmental inclusion.

Political inclusion primarily addresses significant matters related to democratic institutions, human rights, and political engagement. The concept of an inclusive city revolves around how urban areas can enhance their inclusivity by effectively involving local stakeholders and allowing each of them to contribute uniquely towards achieving inclusive urban prosperity (Liang et al., 2021). Challenges related to political inclusion, as well as challenges linked to other aspects of inclusion within the SEC framework, can be addressed through the participation of various stakeholders and social groups that aid decision-makers in pledging inclusion policies, rules, and regulations. Consequently, inclusive governance and policy should encompass multi-actor collaboration, forming partnerships, involving citizens, and promoting active participation in decision-making on SEC-related issues.

Five dimensions were integrated in the SEC framework to encapsulate the essence of an inclusive city. They are presented in Fig. 1. We incorporated the five underlying dimensions of the inclusive smart city in connection with the three tenets of the SEC framework, alongside the objectives of developing an Inclusive Smart Energy City (ISEC). This integration is achieved by merging theoretical insights from the Inclusive City framework by Liang et al. (2021) with the SEC framework conceived by Mosannenzadeh et al. (2017). This framework assumes that the foundation for planning transformative change towards a SEC revolves around effectively addressing the need for inclusive access to energy services through collaborative planning. This is essential to ensure tangible benefits, usefulness, access to key energy services, and advantages for various groups of citizens. To fulfill the requirement for energy services, it is crucial to guarantee accessibility. However, mere accessibility is insufficient on its own; energy service provision should also be secure, safe, and affordable, in particularly for disadvantaged groups in society, and they should meet the required standards (Mosannenzadeh et al., 2017). This aligns with the fundamental concept of the Inclusive City. Consequently, in addition to the key goals of a smart energy system, the aims of an ISEC encompass optimization, sustainability, accessibility, affordability, and adequacy. Optimizing the energy infrastructure aims to enhance efficiency and streamline processes (Mohanty et al., 2016). Sustainability underscores the commitment to eco-friendly practices, minimizing environmental impact (Fieldman, 2014; McGee & Wenta, 2014; Silva et al., 2018; Smith & Kern, 2009). Accessibility ensures that energy services are readily available to all citizens (DiMaggio et al., 2004). Affordability is crucial, especially for socioeconomically disadvantaged groups, emphasizing the importance of cost-effective energy solutions (Pavlidis & Hawkins, 2015). Lastly, adequacy implies that the energy services provided meet the diverse and evolving needs of the city's inhabitants (Elumalai et al., 2021). Jointly, these elements contribute to the comprehensive vision of an inclusive and smart energy city.

5. Case study results

5.1. Case description

The challenges related to energy demands are generating ever-increasing pressure on public amenities and burgeoning infrastructural requirements. In response, the Dutch national government introduced the 'NL Smart City Strategy" in 2016, constituting a pivotal component of the overarching National Smart City Strategy (SmartCityHub, 2017). This strategic framework has played an instrumental role in formulating an array of initiatives tailored to specific geographic contexts within the nation. These diverse programs encompass a spectrum of objectives, including the enhancement of urban mobility and accessibility, the fostering of sustainable and energy-efficient residential edifices, improvements in air quality, and the advocacy of judicious for urban development (Noori, Hoppe, & de Jong, 2020). The ongoing transformation in the Netherlands towards carbon-neutral urban centers is progressing, evident in the notable expansion of local solar energy sources and the increasing adoption of electric-powered heating, cooling, and transportation systems (CityofAmsterdam, 2021).

Leading this transformative change in the country is the City of Amsterdam, spearheading advancements in the sphere of smart energy innovation. Amsterdam stands out as a leader in this transition, particularly in the realm of smart energy, due to its numerous smart energy projects. However, a pressing challenge lies in an assumed imbalance between energy supply and demand, partly due to the high penetration of distributed generation and related renewable energy technology, which causes reduced power quality and grid congestion (CityofAmsterdam, 2021).

Consequently, many smart energy initiatives are currently underway or planned for implementation and are designed to elevate the city's status as a smart energy hub. However, the ramifications of technological advancements on local communities and businesses remain ambiguous. It is imperative to ascertain how these technological shifts impact societal segments and practices and to ensure that vulnerable groups are not marginalized, endangered by, or excluded from crucial urban services, amenities, commercial activities, or employment opportunities (AMSInstitute, 2020).

According to forecasts by DSO Liander, 17 out of 25 substations in Amsterdam will experience peak overloads by 2030 due to increasing electrification. This necessitates costly grid reinforcement, impacting local communities through extensive construction, occupying public spaces, and raising electricity prices. Innovative energy systems that enable flexible energy storage and usage are imperative to alleviate grid congestion. In urban settings, buildings are the primary energy users, making coordinated flexibility across various electrical devices within buildings (e.g., heating, compressors, EV chargers, and storage systems) highly beneficial, particularly at a district scale (AMSInstitute, 2020). Several smart energy projects are planned or implemented to spur the adoption and scaling of innovative energy systems, obviously contributing to Amsterdam transitioning into a SEC. However, despite ample attention to how smart energy technologies work and perform in technical and economic terms, little attention is paid to how they affect end-consumers like local communities and business firms. Moreover, it is unclear what the impact of these technologies is on vulnerable social groups.

This case study aims to shed light on the extent to which inclusion and its five dimensions (i.e., spatial, social, economic, environmental, and political) are considered in Amsterdam's efforts to expedite its sustainability journey and become a future-proof city. Beyond providing an overarching perspective on this matter, we present case studies of two earmarked yet distinct SEC projects.

5.2. Stakeholder analysis

In the ISEC framework, four key groups of stakeholders are identified: decision-makers, service providers, energy consumers, and effective stakeholders. Fig. 2 and Table 1 provide an overview of the stakeholder analysis utilizing a power-interest grid (Ackermann & Eden, 2011), highlighting the power and interest levels of each key stakeholder group. The stakeholders within each group are listed with their corresponding power and interest ratings. More comprehensive results from the analysis are presented in the supplementary material.

5.3. Inclusion

Results show that stakeholders view inclusion differently. Most respondents associate inclusion with equitable, just participation and engagement of all relevant societal groups.

The Amsterdam Institute for Advanced Metropolitan Solutions (AMS institute) interviewee argues that inclusion involves two key aspects: engaging all stakeholders and addressing inequality. Firstly, finding a strategy to involve everyone in a smart energy project is crucial. Secondly, inclusion is seen as synonymous with addressing inequality. The interviewee from 'ATELIER' links the idea of inclusion in smart energy cities to gentrification. Swift urbanization attracts higher-income individuals, leading to the displacement of certain communities. The interviewee from 'Stichting CoForce' emphasizes the importance of

Table 1
Power and interest levels of key stakeholders in Amsterdam Smart Energy City.

Stakeholder group	Key stakeholders	Power	Interest
Decision Makers	European Union	High	Moderate to Low
	Dutch Government	Moderate to High	Moderate to High
	Municipality of Amsterdam	High	High
	Energy Authority Partners	Moderate	Moderate
Service Providers	System Integrator/ Technology Developers (Spectral)	Moderate to High	Moderate to High
	Grid Operators (Liander and Stedin)	High	Moderate to High
Energy Consumers	Residents	Low	High
	Local businesses and asset owners	High	Moderate to High
Effective Stakeholders	Knowledge Institutions and Universities	Moderate to Low	Moderate to Low
	Social Organizations and Associations	Moderate	High

involving everyone in a given cohort in decisions affecting their environment and interests. This includes businesses, residents, as well as established and local political parties. The other interviewee from the 'LIFE' project contends that inclusion primarily involves engaging the less affluent section of the population and considering their preferences. This aligns with the perspective of the interviewee from 'Spectral', who asserts that, from an energy transition standpoint, an inclusive energy system ensures participation and benefits for all layers of society. Most respondents were not familiar with the five dimensions of inclusion, but they could relate to them. Social inclusion is considered the most important recognized dimension. Economic inclusion is frequently mentioned within smart energy projects, as it raises questions about who bears the financial burden in each project.

The interviewee from 'Energy Lab Zuidoost' emphasizes the importance of ensuring everyone can participate in rising prosperity and local economic involvement. This applies not only to individuals but also to businesses and entrepreneurs who should have equal market

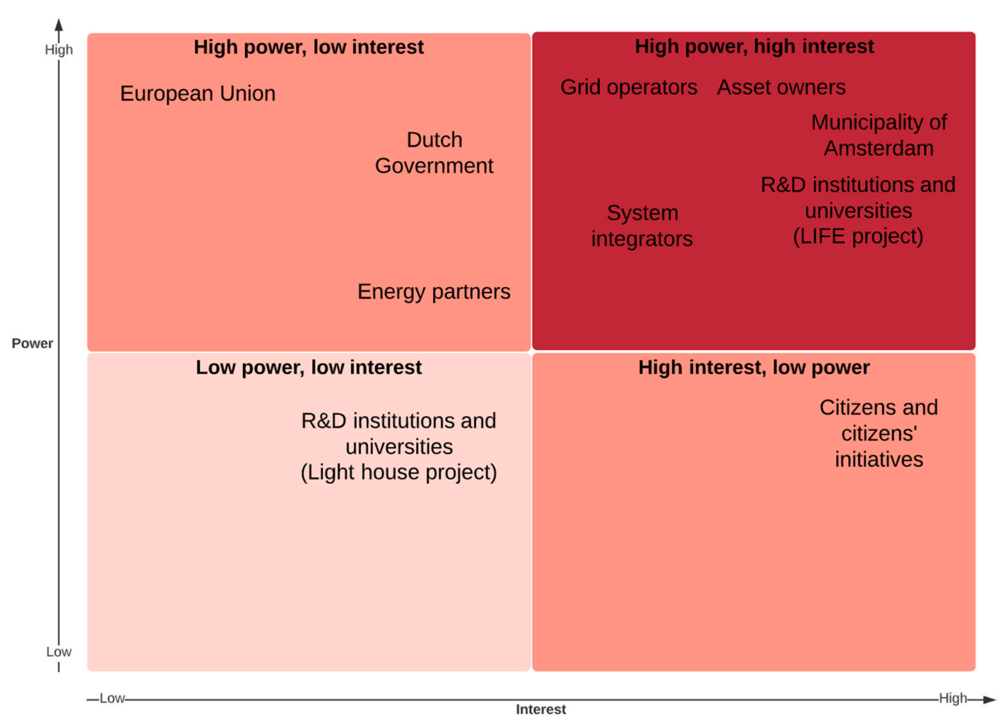

Fig. 2. Power-interest grid of the Amsterdam Smart Energy City stakeholders.

opportunities. The 'University of Utrecht' interviewee adds that no one should suffer from changes due to technological development; instead, everyone should benefit economically.

The 'Amsterdam Smart City' interviewees hold that political inclusion is key. This pertains to participating in public decision-making and cost sharing, but also addresses governance and provision of information. The 'University of Utrecht' interviewee sees this the same way and suggests that instructions be given on how to participate and benefit, even to those who can be classified as "energy poor". The 'Amsterdam Smart City' interviewee observed that social inclusion is sidelined among topics addressed in SEC projects and plans. The 'AMS institute' interviewee views political inclusion as the overarching dimension because governance and policies determine the rules and regulations in a specific area. He also argues that environmental inclusion is highly relevant to SECs, regarding civic needs to meet the needs of current and future generations, counter climate change, and reduce the use of fossil fuels.

The 'University of Utrecht' interviewee frames environmental inclusion differently, i.e., providing equal opportunities to improve one's living environment while preventing climate discrimination from happening. Several interviewees address the importance of spatial inclusion, stressing that everyone in a specific area is entitled to equal access to infrastructure and technology in the public space. The interviewee assumes that infrastructure adjustments resulting from technology development can impact people's living environment. Finally, the 'Municipality of Amsterdam' interviewee observes that the same groups in society are often left behind or left out, which holds for any of the five dimensions of inclusion.

5.4. Technology, inclusion, and the energy transition

The 'AMS institute' interviewee highlights the role of governance in determining if energy technology benefits everyone or leads to inequality. The interviewees from the 'Energy Lab Zuidoost' and 'Stichting CoForce' agree that proper technology development, usage, cost considerations, and market organization are crucial. The 'City of Amsterdam' interviewee notes that higher-income residents investing in technology can create economic disparities. However, the interviewee from 'ATELIER' points out that even without personal investments, residents in smart energy project areas benefit from improved environments.

The interviewee from the 'University of Utrecht' stresses that accessible smart grid technologies promote community involvement. The 'Stichting CoForce' interviewee adds that smart infrastructure, such as streetlights, contributes to inclusion. Effective technology deployment, like solar panels and batteries, may reduce community costs, fostering social cohesion. Smart grids and energy trading can enhance inclusion by optimizing energy consumption. Moreover, the 'AMS institute' interviewee stresses the impact of information technologies on inclusion, emphasizing the importance of accurate information to prevent exclusion, for example, by acknowledging climate change.

5.5. Promoting inclusion: approaches and progress

In the context of Amsterdam's smart energy domain, the concepts of inclusion and participation were frequently discussed by interviewees, with various strategies and organizations actively working to achieve these goals. One key contributor underscores the Municipality of Amsterdam's significant commitment to inclusion policies. An interviewee from the 'Municipality of Amsterdam' notes that the city of Amsterdam prioritizes inclusion policies, focusing on three pillars: affordability, sustainability, and adequacy. He emphasizes successful inclusion activities facilitated by intermediaries like the 'Woon' initiative. This initiative engages citizens through conversations, subsidized events, and technological initiatives to understand residents' needs.

Municipal projects undergo thorough approval processes due to public financing, emphasizing benefits for residents or the city. Another interviewee from the 'Municipality of Amsterdam' highlights solar roof projects, allowing tenants to access sustainable energy by joining an energy community at an affordable cost. The municipality also addresses gentrification concerns, ensuring a mix of affordable housing in new developments. The interviewee from 'Amsterdam Smart City' acknowledges Amsterdam's progress towards inclusion in smart energy projects, though challenges persist in practical implementation. The interviewee from 'AMS institute' also stresses the importance of personal engagement in the LIFE project, involving diverse stakeholders, while the interviewee from 'Stichting CoForce' emphasizes bottom-up energy transition and community involvement. In the LIFE project, which has been running since 2021, there have been several sub-studies focused on inclusion, including: inclusion in smart energy cities (Van der Werf, 2021), participation in smart energy cities (Van Malssen, 2023), and development of a business model for a neighborhood energy community (Lin, 2023). The latter two studies show in their results that there are many practical problems with broad inclusion and integration in the development of smart energy transition. This indicates that (abstract, technocratic) smart energy development is still far removed from the practice and experience of residents in the neighborhood. Residents indicate that they have other priorities (in particular 'survival'), feel unfairly treated, and do not have 'ownership of energy assets', let alone that they are sufficiently enabled to trade in energy (via the platform to be developed). A consulted researcher endorses this. He indicated that residents of the neighborhood lack the necessary flexible capacity from smart devices to meaningfully participate in the project. Furthermore, it appears that there are many practical objections: residents see the project as abstract, are little familiar with - let alone working on - smart energy applications; they view working on sustainability projects as a luxury while they have more urgent (socio-economic) problems. Moreover, and they tend to distrust the project and its researchers. The research suggests that concrete 'touchpoints' between local residents and the project should be examined, whereas they are fairly absent at the time of research. In addition, it is also considered problematic that the Energy Management System (EMS) platform was already made, although at the same time it remained unclear how residents and other local stakeholders will eventually make use of it (Van Malssen, 2023), and are actually not involved in its design and validation process. In that light, there are still pressing issues surrounding: user-friendliness of the digital tools to be used, dealing with the large variety and languages in the neighborhood (given the heterogeneity of the resident composition in terms of nationalities), (lack of) coordination with existing social initiatives, lack of 'prosumers' (the vast majority in the neighborhood is only 'consumer') (Lin, 2023). These points can be seen as tensions in relation to different forms of (recognitive, distributive, procedural) justice in smart energy projects that even the LIFE project, which can be considered a forerunner in inclusive design of smart energy projects in the Netherlands, energy justice is not yet sufficiently guaranteed in smart local energy systems (van der Wel & Akerboom, 2024).

The interviewee from the 'Municipality of Amsterdam's mentions using electric vehicles to engage local communities in the LIFE project, with energy coaches aiding technology understanding. Condominium associations and Delft University of Technology contributed to understanding preferences and ensuring fair distribution of costs and benefits. An interviewee from 'ATELIER' highlights the creation of energy communities in the Lighthouse City project, automatically involving residents in specific neighborhoods. The interviewee from 'Spectral' suggests that inclusion in the Lighthouse project might be easier due to its goal of establishing a local energy market accessible to all layers of society in Buiksloterham.

5.6. Identified challenges

The case study reveals that smart energy projects contend with challenges arising from the misalignment between technology and societal considerations. The prevalent focus on technological innovation often sidelines inclusivity, creating disparities between projects where inclusion is integral and those treating it as an afterthought. LIFE started with the goal to establish a smart, inclusive EMS. However, after the project started, it soon became clear that this would not work, and it was decided to set-up two separate tracks. One with an approach aimed at developing a smart energy trading platform and an energy hub. The other focuses on the establishment of an energy cooperative in the nearby Venserpolder city district. In the first track, several business companies participated in developing the EMS and energy hub, but no citizens or civil society were involved. Inclusion is mainly present in the second track, where the development of an energy cooperative aims to ensure local ownership and resident participation. Here, 'inclusive' was understood as allowing people from an underprivileged neighborhood to participate and benefit from the project, while involving a wide set of neighborhood residents. To achieve this goal, over ten co-creation sessions with residents were organized by LIFE project researchers. At the time of writing this paper the energy cooperative was still under development and not yet operational. Moreover, in practice LIFE project researchers were mainly working with local 'frontrunners' and board members of condominium associations. To reconnect the two tracks, the LIFE project management developed a plan where business companies involved in track one (with the EMS, energy hub) were encouraged to allocate part of the budget and earnings into a neighborhood fund that can benefit track two (i.e., the residents and the energy coopertaive in the underprivileged neighborhood). Other challenges include regulatory constraints, exemplified by the EU-funded Lighthouse project, hinder affordability and livability balance, excluding vulnerable groups. Inequality emerges as a consequence, with disparities in energy investments deepening the divide between privileged and less privileged segments of society.

5.6.1. Gap between technology and society

Challenges to inclusion emerge from the misalignment of technological and social aspects within smart energy projects. The interviewee from 'Amsterdam Smart city' argues that there is a noticeable difference between projects where inclusion is fundamentally part of the initial plan and those where it is considered rather an afterthought. Typically, smart energy projects tend to be technology-driven, commencing with issues related to stakeholder collaboration. The technology itself is often considered the primary focus, with considerations about how communities will engage with and utilize the technology relegated to secondary importance. This disparity poses a consistent challenge to achieving true inclusion. This is confirmed by the 'Spectral' interviewee, who asserts that a project's supply-side actors (e.g., industry) tend to prioritize innovation over social aspects. This echoes sentiments that technology is often designed and implemented without considering social factors, only later realizing the need for inclusivity when a client or consumer addresses the matter. Moreover, many smart energy projects primarily focus either on technology or social aspects, but not on both.

5.6.2. Regulatory barriers

The interviewee from 'ATELIER' emphasizes that regulatory constraints significantly impact the ability to achieve inclusion. He highlights that the EU-funded 'LightHouse' project faces time, finances, and architecture constraints. In the Buiksloterham district, these constraints affect apartments, aiming to strike a balance between affordability and livability. Vulnerable groups, including low-income groups in society, migrants, and residents with impairments, often find themselves excluded due to these directives. Moreover, the Municipality of Amsterdam faces restrictions on inclusion. Communication in a different language is prohibited, and the associated costs are deemed outweighed by the benefits of using translators. The interviewee from the 'LIFE' project argues that the project is constrained by the subsidizing (government) agency, limiting it to academic innovative research rather than bottom-up and community-based initiatives. This constrained early citizen involvement and inclusion efforts.

5.6.3. Inequality

According to the interview from 'Energy Lab Zuidoost', the necessity of investments in sustainable energy solutions, like solar panels and insulation, to reduce energy costs creates a disparity between privileged an less privileged groups in society. Those unable to afford these investments contend with higher energy expenses, leading to unequal opportunities. Tenants and private property owners exhibit varying levels of motivation to invest, with private owners often more inclined to participate because they are investing in their own property (i.e., they experience actual 'ownership'). This disparity extends to neighborhoods, widening the gap between residents living in rental homes and homeowners (according to the interviewee from the 'Stichting CoForce').

5.6.4. Realizing inclusion

Achieving citizen participation in smart energy projects can be hindered by concerns about cost, sustainability of technological alternatives, decision-making, and the potential disruption to living environments, according to the interviewee from the 'Municipality of Amsterdam' who emphasizes the need for an affordable energy transition, especially for vulnerable groups. Costs and technology should be transparent, with collaboration between technology and society. The interviewee from the 'University of Utrecht' suggests considering inclusion from the project's outset, incorporating people's preferences and values. This involves community engagement, identifying problems, and understanding community members' views through surveys, interviews, or metadata.

The interviewee from 'Spectral' stresses the importance of unburdening people while ensuring clear communication about technology and shared responsibilities between housing associations and technology developers. Using tools like dashboards during informative meetings is considered essential, with a focus on translating technological concepts into everyday language. The challenge escalates when dealing with illiterate citizens, as seen in Amsterdam city districts like Venserpolder, where residents' unique circumstances and perspectives can significantly differ from those of more affluent areas. Overall, interest and enthusiasm for smart energy projects vary based on individual interests and not solely on income. Different neighborhoods present distinct challenges. Here, language barriers and budget constraints may impede efforts to encourage inclusiveness. An interviewee from the 'Municipality of Amsterdam' highlights the role of the system integrator in ensuring the intelligence is in the technology, not user-dependent, promoting accessibility regardless of education level. The 'Stichting CoForce' interviewee stresses the importance of involving people from the start, explaining societal changes and their impact on the living environment, fostering a sense of relevance and a voice for individuals.

The interviewee from the 'AMS Institute' outlines the importance of clear value propositions in smart energy projects, addressing problems, solutions, benefits, and alternatives. The interviewee who is involved in the 'LIFE' project adds that effective communication with local communities involves demonstrating tangible benefits, simplifying information, and using diverse channels, including social media in multiple languages. The 'Stichting CoForce' interviewee stresses the importance of personal contact, suggesting workshops and mind games and introducing smart energy concepts from a young age in (primary) schools as good ways to engage and educate communities.

Several strategies are highlighted by the interviewees to address inclusion challenges. First and foremost, the energy transition must be affordable, ensuring accessibility for vulnerable groups. Collaboration between technological parties and societal parties should commence from the project's inception, identifying people's preferences and values by engaging with the community and conducting surveys and interviews. Translating technological complexities into everyday language is considered vital, assuring that everyone can benefit regardless of their educational background. The involvement of local communities should begin early in the project, offering clarity on societal direction and encouraging active participation.

According to the interviewees, a well-structured value proposition should answer four critical questions: What problem is being solved, how will it be resolved, what are the benefits, and what alternatives exist? They argue that concrete, easily understandable incentives should be presented to communities to encourage participation, potentially through various channels, including social media and workshops. Additionally, introducing juveniles to these concepts in schools can build long-term awareness. Personal contact remains essential for reaching certain communities, with workshops, gaming, and early education playing crucial roles in fostering inclusion. According to the interviewees, these strategies should be introduced to bridge the gap between technology and society, address regulatory limitations, mitigate inequality, and align different perspectives, ultimately leading to more inclusive smart energy projects.

Table 2 provides an overview of the main results of the study. It addresses key themes and sub-themes related to inclusion in smart energy projects, based on the case study analysis. It begins with the concept of inclusion, detailing stakeholders' perspectives on equitable participation and addressing inequality, including preventing displacement through urbanization. Next, the table presents results on dimensions of inclusion, discerning the five particular types of social, economic, environmental, political, and spatial inclusion, each highlighting how inclusivity is perceived and applied in smart energy initiatives.

6. Discussion

The case study results indicate that while most interviewees are familiar with the term 'Inclusion,'; individual interpretations vary. Not all interviewees were aware of the five dimensions of inclusion (i.e., spatial, social, economic, environmental, and political) outlined in the theoretical framework (Liang et al., 2021). This suggests that these dimensions are not directly considered relevant in real-life smart energy projects. However, the interviewees acknowledge some of the inclusion-related issues highlighted in the theoretical framework. Commonly recognized problems refer to issues related to housing, unequal rights and participation, limited opportunities for the energy poor, environmental awareness and behavior, migration and demographic challenges, and employment-related social structure issues, encompassing social and economic inclusion aspects. Problems related to political inclusion were recognized as well – i.e., inadequate political participation and ineffective communication by the local governments, albeit to a lower extent.

Problems related to environmental inclusion with local government aim to address future generations' needs in terms of use and access to environmental resources. An inclusive city perspective focuses on cities enhancing their inclusive performance by local government coordinating increasing efforts to assure stakeholder participation, allowing each to contribute to and partake in inclusive urban prosperity in its own unique way (Espino, 2015; Liang et al., 2021; Makushkin et al., 2016). This suggests that inclusion should be at the core of inclusive smart city development, shifting from a technology-centric environment accessible only to the knowledgeable towards a human-centric approach that accommodates those who may need additional support to actively engage with technological innovations (Shtjefni et al., 2024). However, the results also show that in practice, coordinating the participation with local stakeholders remains challenging due to different stakeholders adhering to a different set of values. Moreover, results indicate that technology takes center stage in smart energy projects, primarily because these projects are technology-driven, with inclusion often considered as an afterthought.

The results confirm that inter-stakeholder collaboration is fundamental, with the stakeholder analysis distinguishing primary groups as

Table 2
Results on key themes and stakeholder perspectives on inclusion in smart energy projects.

Main theme	Sub-theme	Description	Illustration
Concept of Inclusion	Equitable Participation	Inclusion as the equal engagement of all societal groups	"Inclusion involves engaging all stakeholders and addressing inequality" (AMS Institute)
	Inequality and Displacement	Inclusion relates to mitigating inequality and preventing displacement, particularly through gentrification.	"Urbanization attracts higher-income individuals, leading to displacement." (ATELIER)
Dimensions of Inclusion	Social Inclusion	Importance of social inclusivity, ensuring representation and participation of marginalized groups in smart energy projects.	"Social inclusion is sidelined in SEC projects" (Amsterdam Smart City)
	Economic Inclusion	Financial accessibility, focusing on cost allocation of energy solutions while ensuring affordability	"Who bears the financial burden in each project?" (Various interviewees)
	Environmental Inclusion	Ensuring that smart energy policies meet the needs of both present and future generations, preventing environmental inequalities	"Providing equal opportunities to improve the living environment." (University of Utrecht)
	Political Inclusion	Emphasis on public decision-making on behalf of a democratic representation of groups in society, governance, and information sharing within smart energy initiatives	"Political inclusion is key for cost-sharing and governance." (Amsterdam Smart City)
	Spatial Inclusion	Equal physical access to smart energy technology and infrastructure, with no location-based discrimination	"Everyone in the area is entitled to equal access." (Municipality of Amsterdam)
Technology and Inclusion	Technology Accessibility	Emphasizing the role of technology in ensuring that smart energy systems are inclusive and accessible for all	"Accessible smart grids promote community involvement." (University of Utrecht)
	Cost of Technology	Financial considerations for deploying and maintaining smart technology solutions	"Higher-income residents can afford technology, leading to disparities." (City of Amsterdam)
	The role of ICT and fair information sharing	Importance of accurate information distribution to avoid exclusion	"Importance of accurate information to prevent exclusion." (AMS Institute)
Strategies for Inclusion	Involvement of the municipality Involvement	Active role of local government in promoting Inclusion through subsidized initiatives and public engagement.	"The municipality focuses on affordability, sustainability, and adequacy." (Municipality of Amsterdam)

(continued on next page)

Table 2 (*continued*)

Main theme	Sub-theme	Description	Illustration
	Community-Based Approaches	Emphasis on bottom-up energy transition strategies, starting from community involvement and local needs	"Community involvement is key to the bottom-up energy transition." (Stichting CoForce)
	Personal Engagement	Value of direct engagement with citizens to simplify complex smart energy information and promote inclusivity	"Personal engagement is vital for explaining benefits." (AMS Institute)
	Education and Awareness	Promoting inclusion by raising awareness, especially through early education and interactive workshops.	"Workshops, games, and education build awareness." (AMS Institute)
	Value Proposition	Need for clear value propositions in smart energy projects that outline benefits, problems, solutions, and alternatives	"Clear incentives encourage participation." (Stichting CoForce)
Challenges to Inclusion	Technology-Society Gap	Disparities arise from prioritizing on technological innovation over social inclusivity	"Smart energy projects often prioritize technology over social aspects." (Spectral)
	Regulatory Constraints	Restrictions that follow from implementing regulations that limit inclusivity efforts, especially in EU-funded projects	"The Lighthouse project faces constraints balancing affordability and livability." (ATELIER)
	Inequality in Investment	Economic disparities arise between those who can and cannot invest in smart energy solutions, leading to unequal opportunities	"Investments like solar panels lead to unequal opportunities." (Energy Lab Zuidoost)
	Language and Cultural Barriers	Language limitations and cultural differences in smart energy communication hinder inclusivity, particularly for non-native speakers and less educated groups	"Language barriers impede inclusiveness efforts." (Municipality of Amsterdam)

decision-makers, service providers, consumers, and influential groups (Mosannenzadeh et al., 2017). The importance of collaboration among stakeholders is highlighted in the case study, emphasizing clear communication, shared goals, and an understanding of the interests of each party involved. However, the study also discerned differences in perceptions between 'technical' and 'social' stakeholders participating SEC projects, stressing the need to build strong collaboration, especially between these stakeholder groups (Hargreaves et al., 2022; Raimi & Carrico, 2016; Walnum et al., 2019).

The theoretical framework presented in Section 2 highlights that through the use and integration of smart energy solutions and a high degree of inter-stakeholder collaboration, the "hard domain" of SECs can be planned, managed, and realized. Both the LIFE and Lighthouse projects in Amsterdam integrate various smart energy technologies, including solar panels smart meters, V2G, as well as energy storage technology. These projects leverage existing energy assets within the city and employ innovative solutions to address grid capacity challenges and enhance renewable energy production.

However, the case study also revealed that integration of smart energy technologies into the "hard domain" requires interventions in the "soft domain". This involves technology use, collaborative planning, consumer behavior management, and energy and data management. Hence, sound implementation in the "hard domain" depends on and cannot do without proper utilization and implementation in the "soft domain" (i.e., institutions, governance, and management) (Battarra et al., 2016). Results show that simulations and scenario analysis tools are used to achieve this. 'Energy Lab Zuidoost', through experimentation in various 'Living Labs,' actively develops and tests innovative solutions in a real-life context. This practical approach helps to gain insights into effective strategies and how to scale and implement smart energy solutions from both technological and organizational aspects (Walnum et al., 2019).

In the realm of consumer behavior management, the focus is on enhancing information and awareness among stakeholders regarding their energy consumption. It involves educating stakeholders about their options for reducing energy usage and adopting other smart energy solutions. This domain also includes efforts to manage energy demand by encouraging change in consumer behavior.

Smart meters are among the tools used to give consumers insights into their energy consumption patterns. Results show that the (LIFE project) energy management platform's primary focus is addressing grid capacity issues, particularly concerning large-scale assets. Both the 'LIFE' and 'Lighthouse' projects were found to address the development of energy management platforms to resolve grid-related problems. An energy market platform was developed in the latter, enabling peer-to-peer and community-to-community energy trading with wholesale energy markets. Case study results highlight the platform's role, emphasizing its capacity for peak shaving and its utility as a tool for overall energy system optimization. Furthermore, it facilitates data collection, processing, and transformation using algorithms. The platform, often called a smart community platform, includes a visualized dashboard tool for energy communities like "Schoonschip" or business parks, providing insights into energy flows and a clearer understanding of the smart grid.

In the platform's preliminary design, consideration is given to potential future smart energy technology and its impact on users. Collaboration between technology developers, intermediaries, and local business firms is crucial to incorporating these considerations into technology design. However, sufficient attention should also be paid to how to involve citizens, even though direct involvement is often difficult. The intention in the LIFE project to invest financial returns in the platform in a neighborhood fund can serve as an example.

The theoretical framework presented in Section 2 addresses the critical role of governance and policy in smart energy projects. Given the complex components that constitute a SEC, including stakeholder collaboration, smart energy technology implementation, and integrated solutions through new technologies, it is of great importance. Governance and policy are essential for preserving the five dimensions of inclusion and achieving smart energy project objectives (Norouzi et al., 2022, 2023). However, practical challenges persist in achieving increased prosperity due to stakeholders holding different values and interests, as well as related issues having to do with coordination and governance of these (Walnum et al., 2019). This also requires public government to take up different roles in regulating, facilitating, informing and incentivizing local stakeholders. Case study results verify this, indicating that public government can assume various roles in SEC projects. For example, in the Light House project, it acted as a funder and partaking in EU-funded research and innovation, whereas public government served as a regulator, ensuring common standards and regulations. Interviewees often attribute the public government's responsibility to information provision and citizen involvement in decision-making, emphasizing the importance of gaining inputs and insights from citizens. Effective communication between local governments and citizens, providing channels for citizen input, facilitates participatory decision-making and inclusive governance.

According to the theoretical framework presented in Section 2, an ISEC should meet five key objectives. In technology development and smart energy projects, goals like optimized, self-sufficient, sustainable, and resilient energy systems are common (Liang et al., 2021). However, the results show that three key objectives stand out for inclusion: accessibility, affordability, and adequacy. These objectives represent the primary hurdles to achieving inclusion. Accessibility presents challenges due to the gap between technology and society, compounded by issues like language barriers and varying levels of interest and understanding among stakeholders. Affordability plays a pivotal role in technology adoption, directly affecting inclusion efforts. To ensure a balanced population and enable low-income residents to live in the city, the City of Amsterdam has acted by focusing on providing enough affordable and sustainable living (CityofAmsterdam, 2021).

7. Conclusion

This paper started with the research question, "How can inclusion be effectively integrated into a framework on SEC design?" It was answered by developing and illustrating a theoretical framework using the case study of Amsterdam's smart energy domain, including embedded studies of two demonstration projects. The study addresses gaps in the literature regarding inclusion in the smart energy domain. It combines SEC and inclusive city concepts into an integrative theoretical framework, promoting the development of inclusive smart energy cities.

Achieving an ISEC involves placing inclusion at the core of its development. The three principles of a SEC (i.e., energy conservation, energy efficiency, and renewable energy) should align with the four dimensions of an inclusive city. As a theoretical concept, inclusion in the city context encompasses multiple dimensions of social, spatial, economic, environmental, and political inclusion that have to be requisites in developing a SEC. These inclusive city dimensions need to be embedded in three pillars of: 1) collaboration with stakeholders, 2) application of smart energy solutions, and 3) integration of solutions. The impact of technology development on inclusion depends on the approach used to implement smart energy solutions. While technology can enhance inclusion by reducing collective costs, fostering social cohesion, and contributing to environmental sustainability, it can also lead to economic disparities and exclusion when not deployed properly.

As a good practice example of developing ISEC, Amsterdam's smart energy projects prioritize inclusion, driven by the local government's attention to inclusion policies. The objectives of affordability, sustainability, and adequacy guide these projects. Intermediaries and citizen initiatives play a vital role in identifying residents' needs and preferences to promote inclusion.

Challenges related to inclusion arise from misalignment between the technological and social aspects in these projects. Additionally, restrictions, inequality concerns, and varying motivations among stakeholders hinder fair inclusion. Overcoming illiteracy, language barriers, and differences in perspectives further complicates inclusion efforts. To achieve inclusion in Amsterdam's smart energy domain, while becoming an ISEC, stakeholders must carefully consider each of the three pillars. Case study results in Amsterdam, in which the framework was demonstrated, affirm the claim from the academic literature, highlighting that collaboration between societal and industry stakeholders is essential from the start of the project (Mosannenzadeh et al., 2017). Smart energy solutions should prioritize accessibility and affordability (CityofAmsterdam, 2021). Results from our study reveal that government regulations and information provision play crucial roles in ensuring this. The study also supports the claims by scholars that addressing social, economic, and political inclusion through collaborative planning, consumer behavior management, and data and energy management, supported by appropriate tools and technologies, are key to realizing ISECs (Mosannenzadeh et al., 2017; Pérez-Delhoyo et al., 2017).

It is advisable to utilize the theoretical framework as a guiding tool to promote inclusion within smart energy projects and to align with the goals of creating an ISEC. This framework can be used by researchers, project developers, stakeholders, and policymakers to enhance the inclusivity of smart energy projects. Before initiating a project, it is crucial to establish a clear understanding of inclusion as a theoretical concept. This ensures that all stakeholders share a common perspective on inclusion. It is important to note that not all stakeholders are active simultaneously during a project. Nonetheless, it is vital to involve all parties, including citizens, right from the project's inception. Transparency regarding objectives, interests, and individual values is essential. The focus should be on fostering collaboration between social and technological stakeholders, avoiding any division between society and technology. Additionally, the use of tools and technologies in the soft domain can greatly support collaboration and facilitate project implementation. It is also recommended that policymakers incorporate the theoretical framework into their decision-making processes. They should integrate the pillars and conditions of an ISEC into their policies. When crafting policies that address exclusion in specific contexts, it is advantageous to demonstrate sensitivity. This approach enhances the understanding of the needs, concerns, preferences, and values of the people affected. By considering these aspects, policies can be positively influenced. This may lead to necessary policy adjustments, ultimately increasing the social acceptance of these policies and projects. Furthermore, policymakers can leverage insights gained from this study to understand the perspectives of various stakeholders involved in smart energy projects concerning inclusion, technology, and project development.

The current study acknowledges certain limitations that impact the findings. The study's examination of only two smart energy projects in one frontrunner city may have implications for representativeness. Diverse interpretations of inclusion and external factors like neighborhood type and residents' backgrounds add complexity, making clear conclusions challenging. Furthermore, the study acknowledges the relatively early stage of the LIFE project and limited access to background information about the Lighthouse project, which hindered a detailed comparison. Interviews and thematic coding, while valuable, have inherent limitations, including potential bias in interview questions and subjective perceptions.

Currently, this study is limited to the analysis of one frontrunner city, with two demonstration projects. Future research could encompass multiple projects situated in diverse socio-economic neighborhoods to obtain a more comprehensive understanding. This expanded research would shed light on the extent to which the theoretical framework is applicable and its dependency on geographical, political, and cultural contexts. Additionally, future research endeavors could explore the applicability of the framework and the findings from this study in other cities. This would contribute to a broader understanding of the topic and its potential impact beyond the scope of the current research.

CRediT authorship contribution statement

Negar Noori: Writing – original draft, Supervision, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Thomas Hoppe:** Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **Isabelle van der Werf:** Investigation, Formal analysis, Conceptualization. **Marijn Janssen:** Writing – original draft, Supervision, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

The interview list.

Name indication	Organization
Interviewee 1	AMS Institute
Interviewee 2	Atelier
Interviewee 3	Amsterdam Smart City
Interviewee 4	University of Amsterdam
Interviewee 5	Municipality of Amsterdam
Interviewee 6	Energy Lab Zuidoost
Interviewee 7	Coforce
Interviewee 8	University of Utrecht
Interviewee 9	Municipality of Amsterdam
Interviewee 10	LIFE
Interviewee 11	Spectral
Interviewee 12	Coforce
Interviewee 13	Municipality of Amsterdam

Interview Guide

Questionnaire Inclusive Smart Energy City

The purpose of this questionnaire is to gain insight into the most important aspects of Inclusion within the smart energy domain of the Smart City concept.

1. Can you briefly describe your position?
2. If applicable, please provide a brief description of the project you are involved in.?
3. What are the different aspects of your inclusion program? What do you understand by the following dimensions of Inclusion:

(a) Social Inclusion
(b) Economic inclusion
(c) Environmental Inclusion
(d) Digital inclusion
(e) Political Inclusion

4. What do you think are the most important aspects of Inclusion related to the smart energy domain?
5. Which dimensions of Inclusion do you think are most important and most applicable within the smart energy domain? And why?
6. Which technological innovations within the smart energy domain (think of smart and renewable energy technology as well as information technology and) contribute in your opinion to the different dimensions of Inclusion and which ones not?
7. Why do/don't these innovations contribute to the different dimension of Inclusion?
8. The energy transition can lead to economic prosperity on the one hand and to energy scarcity and social inequality. This depends, among other things, on the investment should be done in smart efficient energy technology and. How do you think the reach people who do not have the opportunity to make such an investment to do so that they can enjoy the benefits of this technology and?
9. Who do you think are the most important and influential stakeholders within smart energy projects related to Inclusion? And why?
10. What are possible strategies, and which can be used to target potential parties who want to participate in smart energy projects and how can these parties become dented in the first place?
11. How can (civil) actors such as community workers, local communities, sports clubs, involve denominations, local environmental clubs, etc. in smart energy projects?
12. Do you have any suggestions regarding approaching other (practice) experts for more relevant information? Or any relevant documents?

Data availability

Data will be made available on request.

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