Sustainable transitions in residential energy use: Characteristics and governance of urban-based initiatives across Europe

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ABSTRACT

Reducing domestic energy use in cities has become a key focus in achieving sustainability goals. Recent and on-going efforts to address excessive residential energy use have taken various forms and have been initiated by a range of different actors. This paper presents evidence from the analysis of a database of 249 recent sustainable energy initiatives that have been implemented at various scales in and across urban areas in Europe. The paper examines common trends and characteristics in the type of initiatives that are promoted, including the problem definition, general approach, and implementation method. A second focus of enquiry centers on the governance mechanisms that underpin these initiatives. Here, attention turns to the main actors responsible for driving initiatives, the frequency and various forms of implementing partnerships, and the funding source through which the selected initiatives are financed. Two major themes emerged from reviewing the data, namely stratification and integration. Stratification or integration was evident across five key areas including problem framing, general approach, engagement mechanisms, governance, and evaluation frameworks. A corresponding typology of initiatives is presented under four categories: Enhancing; Directional; Experimental; and Responsive. Applying the typology to the dataset shows that enhancing initiatives aimed at optimizing technology or individual behavior are most prevalent (56%). Experimental initiatives that deliberate with new ways of living (16%) or responsive initiatives that consider contextual-needs (14%) are less prevalent and are more likely to occur at a smaller scale. Overall, we argue that integration across key areas can increase the success of initiatives that aim to achieve long-term sustainable transformation in household energy use.

1. Introduction

Over half of the world's population now live in urban areas, with a further 2.5 billion people expected to reside in cities by 2050 (United Nations, 2014). The demand for goods and services in urban areas places extreme pressure on natural resources and the environment and contributes to myriad social and environmental problems such as climate change, biodiversity loss, air pollution, energy security and depletion of natural resources (O'Neill et al., 2018). Urban populations not only contribute to these interrelated problems, they are also adversely affected by the ensuing outcomes including disruption and damage caused by intense storms, flash flooding, rising sea levels, health problems associated with the

pollution of air and water, and socio-economic issues such as poverty and inequality (Reckien et al., 2014). While some negative impacts are externalized across time (e.g. impacting future generations) and space (e.g. affecting areas beyond the immediate urban environ), the threats and consequences of unsustainable production and consumption patterns are clearly evident in many urban locations (e.g. air pollution in the UK, China and elsewhere), which rely on interdependencies with surrounding regions to support food, transport and energy systems (Vergragt et al., 2016; Long and Rice, 2019). When responding to these challenges, urban areas should be firmly at the forefront of concerted efforts to overcome sustainability concerns, including energy related issues (Schröder et al., 2019).

In this paper, we address these challenges, by focusing on one particular area of social and environmental concern, namely excessive levels of residential energy use and associated GHG emissions (Pablo-Romero et al., 2017; Fahy et al., 2019). Although transitions develop across multiple scales, cities are of particular

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interest owing to their relative importance as sites of local initiatives, as well as centers of global transitions to more sustainable systems (Bedsworth and Hanak, 2013; Broto and Bulkeley, 2013). Cities, therefore, are important sites of social innovation and social change. They provide the conditions to foster the development of new approaches, new systems, and new ways of thinking through social and technical innovations. They also harbor the potential for rapid upscale and spread of socio-technical innovations in and among cities, for example through local and international city networks (Fünfgeld, 2015; Mejía-Dugand et al., 2016). The recognition of energy transitions as highly complex and uncertain processes involving multiple sectors and societal domains signifies the important role of multi-level governance in facilitating sustainable urban transformation (Bauer and Steurer, 2014; Rutherford and Coutard, 2014). We draw on empirical evidence and insights from the rapidly expanding sustainable transitions literature to conceptualize and explain how urban responses to this challenge are unfolding across Europe, particular in relation to household energy use.

Household energy use generates significant levels of GHG emissions, contributing to the acceleration of global climate change (Pablo-Romero et al., 2017). Drawing on empirical evidence from 249 sustainable energy initiatives located in 27 European countries, we undertake a systematic comparison to better understand recent and on-going urban responses to tackling excess domestic energy use through consumption-based approaches. We identify common characteristics and trends that help understand the types of initiatives that are being promoted and the dominant problem framing (e.g. efficiency; behavior change; systemic restructuring). We also examine the specific focus of interventions, the intended target group and the mechanisms by which initiatives are implemented. We enquire into the governance mechanisms that underpin these initiatives, and analyze the data around three key dimensions including the lead parties driving the initiatives, the number and various forms of implementing partnerships, and the funding arrangements through which the initiatives are financed. This is done to substantiate the increasingly important agenda of enabling sustainable urban living.

The central aims of this paper are twofold. First, to explore the characteristics and governance of urban sustainable energy initiatives targeting households in Europe, with a view to identifying key trends in less conspicuous aspects such as problem framing, implementation method and approaches, actor configurations and financing. The way that energy transitions are framed and governed play a crucial role for the type of change that may come about, and is thus important to assess in order to understand the scale, speed and types of change that are currently produced. Second, to produce recommendations that can inform future initiatives aimed at bringing about needed and *long-term systemic change* in energy use. The current pace and scale of change is far from adequate for even a probability of meeting the climate ambitions as per the Paris Agreement (Southerton and Welch, 2018). To address these aims, section 2 grounds the study in the sustainable transitions literature by exploring ways that changes in energy use might come about, and how such transformations might be framed and governed. Methodological considerations are presented in section 3, while section 4 presents the findings by unpacking the diversity in sustainable energy initiatives and identifying two major themes emerging from the analysis, which highlight the key opportunities and challenges with existing initiatives and the pace and scale of change they seem to enable. These are presented in terms of stratification and integration across five key areas including problem framing, general approaches, engagement mechanisms, governance, and evaluation frameworks, all important aspects for understanding the type, pace and scale of change currently being facilitated. A corresponding typology of initiatives is presented to highlight and discuss main similarities and differences in current approaches, and the implications of these results are discussed. Finally, in Section 5, conclusions from the study are drawn.

2. Literature review

A transition toward renewable and sustainable energy use requires not only technological solutions, but also changes in consumer energy-related practices (Geels et al., 2015). These practices are shaped and reinforced by myriad factors including a wide range of socio-demographic, psychological, contextual and structural considerations (Frederiks et al., 2015). The multiple influences on decision-making patterns have given rise to numerous integrated approaches and models that aim to understand human behavior and alter consumption patterns toward more sustainable pathways (Šćepanović et al., 2017). Yet, despite increased recognition that energy use is shaped by individual, social, and material opportunities and constraints, this rarely translates into policy and planning. Most policy efforts to reduce energy demand focus on optimization through technological advances and incremental social change (Labanca and Bertoldi, 2018). The focus remains largely on the individual (Frederiks et al., 2015) and critics argue that these perspectives largely neglect structural (e.g. institutions, organizations) and collective (e.g. social and cultural contexts) factors that shape and underpin behavior, thereby limiting their transformative capacity (Geels et al., 2018; Goggins, 2018; Sahakian and Dobigny, 2019). Solutions grounded in transition theory and social practice theory have been posited as alternatives to these dominant individualistic approaches (Hargreaves, 2011; Gram-Hanssen, 2014).

2.1. Framing energy demand as a socio-technical issue

A social practices perspective shifts the central focus from the individual to the social organization of society by investigating the competencies, meanings, and materials involved in everyday energy related practices such as heating, showering, cooking, etc. (Shove, 2010). From this perspective, energy demand arises as a result of engaging services to carry out what are often routinized activities such as lighting, mobility and eating (Gram-Hanssen, 2014; Maréchal and Holzemer, 2015). As interventions occur within the processes that are the target of change, a practice theoretical approach enables the identification of similarities and variances in how practices are played out within different cultural and socio-material contexts (Moloney et al., 2010). This systemic approach questions existing lifestyles and ways of living, and seeks to elicit shared meanings and understandings of societal needs and wants, and the material configurations necessary to deliver them (Shove, 2010; McMeekin and Southerton, 2012).

A social practices approach, therefore, targets a change in the underlying conditions that support more or less sustainable practices and encourages reflection about the status and legitimacy of energy related practices and related implications of resource intensive everyday lifestyles (Jensen, 2017; Shove, 2018; Sahakian et al., 2019). The ensuing argument suggests that in questioning the fundamental use of energy and its associated outcomes, a social practices approach can lead to more radical changes in energy related behaviors (McMeekin and Southerton, 2012). These more complex and nuanced understandings of what a sustainable transition is and how it might come about coincide with calls for new ways of framing the problem of unsustainable energy use (e.g. Foulds and Christensen, 2016; Labanca and Bertoldi, 2018).

Moving beyond traditional problem framing approaches that focus on the implementation of new technology or individual behavior change, Spurling et al. (2013) demonstrate three different

yet complementary ways that a social practices approach can by applied to inform sustainable energy initiatives and policies. They show how initiatives can aim to re-craft existing practices (i.e. changing their constituting elements of competencies, meanings and materials), substitute practices (i.e. by replacing unsustainable practices with more sustainable alternatives such as replacing car driving with cycling), or change how practices interlock (i.e. changing interactions between interdependent practices such as washing, drying and ironing clothes). Building on this work, Jensen et al. (2019, forthcoming) identify four different categories of problem framing including two that correspond to dominant behavioral and technocratic approaches (i.e. changes in technology; changes in individuals behavior) and two that offer alternative imaginaries that challenge existing systems of production and consumption (i.e. changes in everyday life situations; changes in complex interactions). These problem framings, in turn, have implications for sustainable production and consumption policy priorities (e.g. efficiency gains; restructuring patterns of consumption) (Rau et al., 2018) and their implementation across different scales and divergent internal and external conditions.

In their report on communicating about sustainable consumption for municipal leaders, Pike and O'Sullivan (2019) suggest that issues should be framed in a way that presents an opportunity (benefit of action), challenge (imperative for action) and choice (what can be done). Applying this framework to the problem of unsustainable energy use, Table 1 demonstrates how energy use might be understood as a socio-technical issue.

2.2. The resulting role of governance and new partnership approaches

A focus on governance brings into question how, and by whom, sustainable energy challenges are addressed, the type of change that comes about as a result, and the ensuing long-term impact on wider society (Matschoss and Heiskanen, 2017; Hölscher et al., 2019). Sustainable energy initiatives face significant social and technical challenges if they are to destabilize and ultimately transform or replace dominant (unsustainable) infrastructures,

technologies, and user practices (Geels et al., 2015). Of immediate concern is the continuing dominance of short-term, techno-centric and individualistic policy and planning practices that fail to address the structural causes of unsustainable energy use (Hölscher et al., 2019). Nonetheless, the emergence of new forms of governance manifested through new networks and partnerships are altering the relationship between state and non-state actors including businesses, research institutions, non-governmental organizations and community groups (Bulkeley and Broto, 2013; McGuirk et al., 2014). These new networks give rise to alternative governance arrangements that empower a wide range of actors with the capacity and agency to develop solutions that are more appropriate for the local cultural and socio-material context (Bauer and Steurer, 2014). Additionally, this multiplicity of actors bring financial, technical and other capacity building supports as well as a diverse range of ideas, visions and networks, which are critical for bringing about broad social and economic transformations (Fünfgeld, 2015), or deliver what Sahakian and Dobigny (2019) refer to as transformative and socially embedded change.

In a longitudinal review of 178 urban energy initiatives, Rydin and Turcu (2019) found three broad types of projects: *policy-related initiatives*, which are government-led and that address specific policy frameworks through grants, subsidies or other incentivizing measures; *investment dependent projects*, largely short-term initiatives concerned with installing new technology including decentralized energy generation and distribution and energy retrofits; and a range of *community-based initiatives* characterized as small-scale initiatives developed by community and civil society groups to address local and global issues. From these, the authors concluded that community-based urban energy initiatives offered the best scope for ongoing localized movement. These are typically bottom-up initiatives driven by wider sustainability concerns (including social, environmental and economic issues) and involving formal and informal networks of local actors.

Community-based projects are generally small-scale, localized, and responsive to local contexts and conditions. Their success often relies on dynamic social interaction, strong community leadership, and the involvement of committed individuals who share a

Table 1
Sustainable energy use problem framing narrative.

Sustainable energy use as a(n) …	Socio-technical issue
Opportunity	- Combining social and technical considerations can lead to new systems of production and consumption or reconfiguration of existing systems. - Multiple individual and social benefits including financial savings, reducing carbon emissions, building social capital, increasing access to services (e.g. technical supports; new mobility options). - Contribute to a strong, resilient and connected community that shares common concerns related to energy use (e.g. concerns around the environment; access to services; poverty; etc.); enhanced well-being; greater social equity. - Technological improvements and changes in the material context can reduce carbon emissions, improve standards of living (e.g. enable greater comfort), create new economic opportunities and reduce vulnerability and risks to uncertain economic (e.g. fossil fuel prices) and environmental (e.g. climate change) processes.
Challenge	- Understanding what energy is used for and why. - Developing, testing and pioneering new socio-technical innovations. - Increase social acceptance and uptake of new technologies and new ways of doing. - Challenging collective conventions around energy use. - High costs of energy use, unsustainable resource use and social pressure to consume (often non-essential) products and services place a strain on household budgets. - Inefficiency of outdated materials and technologies and the need to implement new technologies to reduce emissions
Choice	- Combining social and technical elements to experiment with more sustainable ways of living. - Promoting sufficiency standards such as setting absolute limits to consumption (e.g. promoting smaller homes; maximum levels of energy use), and challenging collective conventions around consumption (e.g. question the need to own particular material goods and status associated with consumption). - Households can make fundamental consumption choices that deliver multiple benefits and foster new forms of social organization. - Develop new skills and competencies that can reduce resource use (e.g. through initiatives that promote sharing and repairing of goods and services). - Choosing to purchase greener products and services (e.g. more efficient appliances, lighting, etc.) to reduce energy use. - Choosing to undertake retrofitting and / infrastructural improvements to improve energy efficiency.

common vision. Moloney et al. (2010) also found that community-based projects were most likely to adopt a combination of approaches that target both social and technical dimensions of change, thus increasing their transforming capacity. Diffusion and maintaining such initiatives can be challenging as they often rely on a small core group to ensure their survival and they are difficult to replicate in new contexts (Schröder et al., 2019). Many community-based projects rely on institutional support from established government bodies that can provide assistance through a range of technical, financial and capacity building supports (Rydin and Turcu, 2019). Government support, particularly in relation to enabling policy and regulatory frameworks, is also needed if community-based projects are to be a catalyst for wider systemic change.

In their study examining the governance of sustainable energy programs in Australia, McGuirk et al. (2014) found almost 900 urban initiatives aimed at reducing carbon-based energy or developing alternative energy sources, primarily targeting households but also businesses and public sector organizations. They identified four distinctive governmental programs: Behaviour change, Demonstration, Transition, and Advocacy. The majority of initiatives were described as *behaviour change* programs, which were primarily initiated by local government, targeted individuals with responsibility to reduce their energy demand, and operated within existing infrastructure and systems of production and consumption. In other words, their characteristics are consistent with traditional or dominant problem framings and approaches (Labanca and Bertoldi, 2018). A predominance of initiatives aimed at 'governing behavior' was also found by Sahakian and Dobigny (2019) in their review determining representations of change in 50 Swiss-based sustainable energy initiatives.[1] *Demonstration programs* were mostly state-led, involve multiple partners, and aim to bring new technologies to a wider audience through socialization of experience and learning. Public-private partnerships were a common feature of demonstration programs, however community groups and NGOs were not centrally involved and their participation was largely limited to a passive or receptive role. *Transition programs* consisted of two types of projects. Small-scale community-based initiatives aimed at transforming everyday life — which correspond with what Jensen et al. (2019, forthcoming) categorized as changes in complex situations or Rydin and Turcu (2019) broadly labeled community-based initiatives — and large-scale government-led initiatives that aim to restructure energy systems through the development of new business models, new demand management services and new economic structures. A commonality in transition-orientated programs is the importance of partnerships, their multi-dimensional nature and socio-technical perspective on change. Of course, such initiatives are not without criticism. In particular, they raise questions as to whose visions and voices are included (or excluded) to what extent, and what socio-material and institutional arrangements are promoted to facilitate sustainable transformation (Smith et al., 2016). Diffusion and mainstreaming of good practice is also an ongoing concern for many small-scale, grassroots or community-based programs (Heiskanen et al., 2018), although it should also be noted that not all initiatives might have a desire to bring about widespread social change and they may be firmly embedded in the local context. Also adopting a socio-technical perspective, McGuirk et al. (2014) identified a number of *advocacy programs*, which attempted to influence social and political representations of low carbon transitions and leverage policy changes to support carbon reduction. These initiatives were generally driven by community groups and NGOs, and aimed at

securing widespread support for sustainable transformation through mobilization of collective action.

Overall, the audit undertaken by McGuirk et al. (2014) demonstrates the diversity in traditional and emergent governance approaches. As found by Moloney et al. (2010), also in Australia, the majority of initiatives were initiated by local government, but other actors such as businesses, NGOs and community groups were also found to play a significant role in setting up various initiatives. Public bodies were instrumental in funding initiatives, with local and state government providing financial support for over 80% of projects. Interestingly, over half of all the initiatives did not involve partners despite the benefits of partnership approaches (Bedsworth and Hanak, 2013).

Partnerships create an opportunity where different levels of government, business and civil society can come together in pursuit of common interests or goals by sharing resources and knowledge transfer, and, in doing so, overcome some of the financial, technical and administrative challenges facing public sector authorities (Bedsworth and Hanak, 2013). This facilitates greater opportunities for local actors to increasingly take the lead in supporting a societal shift toward greater sustainability. Yet while some urban areas have mature networks of interested actors and significant capacity to address sustainability concerns, other areas are less engaged in dealing with these issues (Araos et al., 2016). It is also important to note that there is no guarantee that more participatory forms of governance and decision-making will deliver more inclusive, socially just or environmentally sound results (Bulkeley et al., 2016).

2.3. Summary

In summary, this paper takes the position that addressing the problem of unsustainable energy use requires complex shifts in socio-technical systems and practices (Geels et al., 2018). We acknowledge that energy use is socially and culturally embedded in a series of interwoven social, political, economic and technological relationships (Hodson and Marvin, 2010), and that these interactions are underpinned by habits and routines that are built around socially shared and institutionalized norms and are notoriously difficult to change in the long-term (Shove, 2010). We also recognize that energy systems are spatially embedded in particular settings, and give rise to distinct networks, connections and dependencies across time and space (Bridge et al., 2013; Hui and Walker, 2018). Overall, our analytical framework focuses on transitions in socio-technical systems and routinized social practices, whereby socio-technical systems and social practices are conceptualized as configurations of heterogeneous elements, whose reconfiguration can deliver more sustainable lifestyles (Geels et al., 2015).

3. Methodology

This study is part of ENERGISE, a three-year European H2020 project that focuses on the social and cultural influences on household energy use and examines ways of reducing energy use through an experimental approach. One of the objectives of the project is to systematically identify, classify, and examine sustainable energy initiatives across European countries. Europe is an interesting case study location given its high levels of urbanization, advanced environmental policies, and technologically developed economy (Bulkeley and Betsill, 2013; Araos et al., 2016). In addition, residential energy use across Europe remains stubbornly high, with many efficiency gains offset by increases in overall demand (Pablo-Romero et al., 2017; Shove, 2018). Hence, there is significant potential to reduce household energy use in Europe through consumption and demand-oriented approaches.

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[1] 14 of these initiatives are also included in the sample used in this paper.

Over a six month period in 2017, 30 researchers working on the ENERGISE project compiled a database of 1067 existing and recent European based initiatives that aim to reduce residential energy use or lower GHG emissions (Jensen et al., 2018). To meet the criteria for inclusion in the database, initiatives must target household energy use, either by reducing direct energy use and/or by reducing associated emissions related to energy use at the household level. Initiatives recorded in the database must also have an active involvement of households, although this may take several forms including householders as consumers, prosumers, innovators or investors. Initiatives that are strictly focusing on energy production are not included, and therefore not represented in the database. It is important to note that the database from which the selected initiatives are drawn is not intended to be comprehensive, but rather it provides an overview of key trends and characteristics in sustainable energy initiatives that specifically target households. While the data collection methodology makes it possible to systematically analyze a broad range of sustainable energy initiatives that represent a variety of methods, types and approaches, the sample is not representative as researchers were primarily looking for initiatives that include socio-technical or practice-based elements (i.e. initiatives that are not purely technology focused). Therefore the number of sustainable energy initiatives that have a strong technological focus is presumably much greater than what is represented here.

Information on sustainable energy initiatives were primarily collected through desktop searches and consultation with experts based in various European countries. The data collection team had a broad range of language skills covering several major European languages. Additional assistance was sought for some languages (e.g. Greek, Norwegian) where the expertise was not available within the core research group. Each of the 1067 database entries were recorded in a template under more than 30 analytical categories that were informed by a practice-based approach and refined based on extensive discussions and feedback cycles between several researchers. Documenting each of initiatives under 30 defined categories provides a nuanced description of each initiative and facilitates empirical investigation and cross-analysis between a range of aspects including description, objective, target group, scale, lead initiator, lead funder, involvement of other actors, medium of intervention and outputs (see Jensen et al., 2018 for a comprehensive list). The initiatives were also categorized according to their location relating to one of rural, urban, peri-urban, non-specific, mix or other. The material, social and discursive conditions under which urban-based initiatives are implemented are somewhat different than initiatives implemented in other contexts (e.g. rural), for example due to the significant role of municipal authorities, differences in population density, building type, etc. The specific location and start date of each initiative was recorded, thus providing further context in which the initiative occurs. The broad range of analytical categories reflects an understanding of a sustainable energy transition as a complex multidimensional and multi-actor process, as summarized in section 2. Categories were defined to capture difference in forms of governance as well as to assess whether initiatives focus on social practices as a target for intervention.

Initially drawing on the complete database, this paper specifically focuses on initiatives that were identified as taking place in an urban setting only, resulting in a selection of 249 urban-based sustainable energy initiatives located in 27 different countries across Europe (Table 2).

Considerable practical and conceptual challenges exist in conducting large-scale data collection involving multiple researchers (Jensen et al., 2018), including maintaining consistency in the data collection process and ensuring that researchers have shared

Table 2
Country location and frequency of urban initiatives in the ENERGISE database.

Country	Initiatives	Country	Initiatives	Country	Initiatives
Austria	6	Germany	15	Poland	8
Belgium	5	Greece	4	Portugal	2
Bulgaria	18	Hungary	8	Romania	7
Croatia	2	Ireland	23	Slovakia	1
Cypress	5	Italy	5	Slovenia	6
Denmark	10	Latvia	12	Spain	5
Estonia	2	Lithuania	1	Sweden	2
Finland	19	Malta	1	Switzerland	14
France	14	Netherlands	29	United Kingdom	25

theoretical and ontological understandings. While considerable efforts were taken to mitigate any divergence in this regard (see Jensen et al., 2018), nonetheless, the lead author analyzed each of the 249 initiatives in order to ensure consistency in data collection and processing for the particular analytical interest of this paper. In addition, websites and other links providing more information on the selected initiatives were recorded in the database and perused by the lead author to further validate and verify database entries. Here, online translation tools were used to translate material from non-native languages.

The methodology used to construct the database resulted in a large sample size covering a variety of urban contexts across much of Europe. The inclusion of 30 analytical categories provided a rich source of data in terms of both breath and depth of information. However, not all categories could be filled for each initiative and in these cases individual categories were left blank or were considered to be non-specific. Results should also be understood in relation to the significance of the timeframe in which the selected projects are undertaken, particularly in light of the rapidly evolving social and political sustainable energy landscape (Rydin and Turcu, 2019). Here, researchers were instructed to primarily concentrate on projects occurring over the last 20 years. Accordingly, over 70% of the selected initiatives commenced in the period 2010−2017, 27% started from 2000 to 2009, with the remaining 2% of initiatives commencing before the turn of the century.

Hence, the vast majority of selected projects began in what Bulkeley and Betsill (2013) describe as an era of new governance and partnership approaches, which would predict that many of these initiatives involve multiple actors in diverse roles. The database also contains a significant number of on-going initiatives at the time of data collection, with one-third of the overall number of projects continuing into 2018 or beyond, and two-thirds finished by the end of 2017.

4. Results and discussion

Results of analyses center around two key areas including: 1) characteristics, trends, and approaches in the type of sustainable energy initiatives being promoted, and 2) governance mechanisms that underpin these initiatives.

4.1. Characteristics, trends, and approaches of urban sustainable energy initiatives

Findings reveal that there is significant capacity to tailor projects to suit local conditions, with almost 70% of initiatives undertaken at the sub-national level. A further 10% of initiatives were implemented at the national level, with the remaining 21% of initiatives cross-national, indicating the involvement of geographically broad networks of actor configurations. There are a number of variables that influence the scale (i.e. number of participants) at which urban

sustainable energy initiatives can be administered, including the aims, scope and complexity of the project, and the range and roles of actors involved. Across the sample presented in this study, there was no clear predominance in the scale of initiatives, although the majority (34%) were large-scale projects defined as targeting more than 1000 households. Medium-sized projects, defined as targeting between 100 and 999 households were almost equally as prevalent (32%), with smaller scale initiatives that target less than 100 households accounting for a further quarter of all initiatives. This data was not available for the remaining 10% of initiatives. Cross analysis of the data shows that large-scale projects are less prevalent in initiatives administered at the sub-national level (24%) than in national and cross-national cases (46%), while the majority of small-scale initiatives occur at the sub-national level.

4.1.1. Targeting specific dynamics of energy demand — a missed opportunity?

The majority of initiatives did not target a specific group aside from households that are located in an urban area. In initiatives where specific groups were targeted, households were defined as a community of place (e.g. residents of a particular apartment block) or by socio-demographic indicators (e.g. low-income). Almost one in eight initiatives targeted low-income households, while high-income households were the specific primary focus of just 1% of initiatives. Other less frequently target groups included families, students, and children. Small-scale projects were more likely to target specific groups such as low or high-income households.

As well as focusing on household characteristics, sustainable energy initiatives can be tailored to everyday practices that are dependent on energy use, such as heating, washing and cooking. By addressing the different elements of practices (i.e. meanings, materials, competencies), initiatives can promote less energy-intensive ways of living and encourage the adoption of more sustainable practices (Hargreaves, 2011). Nonetheless, the dominant approach found in this study was to target energy use more generally and focus on optimizing behaviors and technologies, which may be more limited in articulating a nuanced understanding of everyday social practices and how they relate to sustainable lifestyles. An alternative approach is to understand how and to what effect these resource intensive practices are undertaken, as well as identifying how they might be restructured to become more sustainable, as different social and material arrangements can differ in importance for changing practices (Shove, 2018).

4.1.2. Beyond energy efficiency — sufficiency and collective approaches

Over 40% of initiatives promoted the use of greener more energy efficient products, yet many of these initiatives also articulated an aim to achieve absolute reductions in overall energy use and carbon emissions. Few initiatives went a step further by questioning the level of energy use required to live a 'good life' as well as considering the source of energy, evoking notions of energy sufficiency (Lorek and Spangenberg, 2014; Sahakian et al., 2019).

Collective approaches were also evident in a significant number of initiatives, with one quarter of projects promoting the repairing or sharing of products. Many of these initiatives aim to develop alternative approaches to reducing household energy use, achieved through a reconfiguration of daily practices. Sharing of products manifested in a number of different ways, including donating, lending, swapping, co-ownership or renting. Similarly, repairing products took many forms including fixing broken or damaged goods or up-cycling (re-using) of materials to make new products. Sharing and repairing products can reduce material consumption and therefore reduce the energy needed to produce or store goods.

These approaches also encourage 'alternative' actor-configurations and new social networks and take place in various locations including at the home (e.g. organized home visit from handyman to fix appliances) or out-of-home such as at a designated 'repair café'.

4.1.3. From information to interaction — methods of engagement in sustainable energy initiatives

Despite increased recognition of the limitations of information-based campaigns as a means of changing behavior, almost one-fifth of initiatives were characterized as solely information-based. The majority of initiatives in this cohort involved providing householders with information on *how* to save energy, with a minority focusing primarily on *why* people should save energy. While information on its own is often criticized as a poor method of engagement, information can be a powerful tool when provided in conjunction with supplementary approaches (Goggins, 2018). In this respect, over half of the initiatives combined information with some form of interaction. Common mediums of intervention evident across the selected cases included peer-to-peer learning, training, competitions and experimentation (e.g. Living Labs) (Heiskanen et al., 2018).

While all initiatives included the active involvement of households, the most common form was initiatives that required ongoing participation from households for a significant duration (41%), with the remaining initiatives requiring either periodic active participation (28%) or once-off participation (29%). Unsurprisingly, on-going participation of households is more common in initiatives that include interaction-based elements such as competitions and games. It is interesting to note that some initiatives primarily based around retrofitting of buildings involved once-off participation of households (e.g. conducting a building survey), while others took a more integrated approach where householders were guided through the design and implementation of retrofitting measures combined with information and training on how they might adopt more sustainable practices accordingly. While evaluation of the outcomes of these different approaches is beyond the scope of this paper, previous research suggest that initiatives are more successful when they take an integrated approach across different stages of the retrofitting process (e.g. identifying measures; contracting works; coordinating financing and services; etc.), and consider building type and occupant behavior (Maréchal and Holzemer, 2015).

4.2. Governance mechanisms: initiators, partnerships and funding

Urban centers can play an integral role in responding to sustainability challenges, but efforts need to be coordinated across multiple dimensions and multiple actors, and different relationships, perspectives and interests need to be considered, included or challenged. Results from this study suggest that there is a plurality of public and private sector actors taking the lead in tackling residential energy use (Fig. 1). The leading initiator was municipal government (28%), followed by 'other' government (e.g. national or European government) (27%), including a large number of projects initiative through various European Union frameworks. Non-profit and community groups (e.g. householders; community activists; resident groups), often referred to as the third sector, were also found to be influential in developing sustainable energy initiatives, accounting for over 30% of initiatives. Additionally, private sector business instigated a further 10% of initiatives, bringing the total of initiatives instigated by non-state actors to 40%.

The emergence of cooperative approaches as key to addressing complex societal issues is reflected in the large number of partnerships evident in the cases described in this study (75%). Findings also reveal significant diversity in the form of partnership, with a
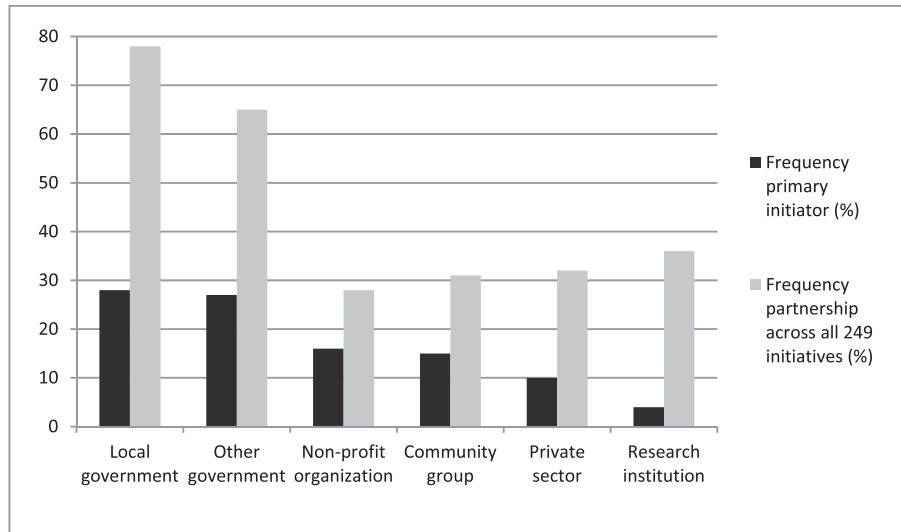
Fig. 1. Frequency of partnerships and involvement of various actors.

range of actors involved across a large number of initiatives (Fig. 1). Regional authorities continue to be key actors in sustainable energy initiatives. Although they were the principal initiator in less than 30% of cases, the unique position of municipal and regional governments as key intermediaries between national and community-based actors is exemplified by their involvement in almost 80% of the initiatives identified in the study. While other government were the main initiator in just over a quarter of cases, they were involved in 65% of projects, primarily through the provision of financial and capacity-building supports. Community groups were found to play a partnering role in 30% of initiatives, a similar number to other non-state actors private sector businesses (32%) and non-profit organizations (28%) — reflecting what has been described as a new governance approach involving public-private partnerships.

While new forms of governance and social partnerships have facilitated the formation of bottom-up niche innovations involving local non-state actors, public sector entities including local and regional government, national government and international entities such as the European Commission continue to play a key role in providing financial support. This trend is reflected in over 70% of initiatives financed primarily through public funds, with 13% funded by private business and the remaining 16% funded through non-profit organizations and civil society. The dominance of public sector funding in supporting sustainable energy initiatives raises questions regarding the autonomy of decision-makers to pursue their own aims, vis-à-vis satisfying funder requirements and demands (cf. Genus et al., 2018). For example, funders may look for quantitative reductions in energy use or carbon emissions as a prerequisite for supporting projects, which may neglect important qualitative issues such as addressing the underlying conditions that give rise to energy demand or the gendered dimension of energy use.

4.2.1. Evaluation of sustainable energy initiatives

While a broad overview of the selected cases in this study shows that approximately 40% of initiatives underwent some form of evaluation, more detailed analysis is required to determine the detailed outcomes of these exercises. Preliminary analysis suggests that the majority of evaluations undertaken were short-term focused and based on a narrow set of quantitative indicators such as measuring direct energy use or emissions. The most commonly used qualitative methods were participant feedback and surveys. Feedback mechanisms were also used in conjunction with measuring changes in energy use. Longitudinal, or in-depth qualitative evaluations that address pertinent sociological questions such as how practices become entrenched and how they change over time were rarely pursued (Sahakian et al., 2019).

The dominance of quantitative approaches in project evaluations reflects prominent sustainability debates and policy initiatives that prioritize 'solid' data that are directly measurable (e.g. reductions in greenhouse gas emissions). However, such approaches fail to capture less tangible outcomes that can have a significant societal impact such as shifts in (public) opinion and changing practices among policy makers and civil society actors (Rau et al., 2018). Furthermore, context needs to be a central consideration in any evaluation scheme as initiatives have different goals at the outset as well as different starting points. Therefore direct comparison as to the effectiveness of different types of interventions is extremely difficult, if not impossible to achieve. For example, initiatives that seek to address energy poverty might aim to *increase* rather than decrease energy use among participants in order to deliver better health and wellbeing. Further exploration into the scope and framing of project evaluations could provide important insights into the problem definition and impact on outcomes (Hobson et al., 2016), however this is beyond the scope of this paper and would require further in-depth research.

4.3. Towards integrated approaches in sustainable energy initiatives

It is well documented that the problem of excess energy use is both multidimensional and multiscalar, and achieving sustainable transformations requires concerted action involving diverse actors operating within the context of different relationships, perspectives and interests (Hodson and Marvin, 2010; Geels et al., 2015). This plurality of public and private sector actors and approaches suggests that transitions cannot be governed from a top-down perspective, rather they must accommodate a variety of views and be flexible to deal with uncertainty and change as societal problems evolve and new opportunities and capacities for transformative governance are created (Hölscher et al., 2019). This evidence points towards the need for integrated approaches towards sustainable transformation. Emerging from our review of sustainable energy initiatives, we identified 5 key areas where there was

evidence of integration or stratification in the design, implementation and assessment (Table 3).

Relating the data on 249 initiatives to the findings presented in Table 3, four distinct types of initiatives emerged: enhancing, directional, experimental, and responsive (Table 4). The first two correspond with the category stratification, while the latter two correspond with integration. The typology should be considered as a broad classification of initiatives that acts as a heuristic device for positioning of initiatives according to dominant characteristics, rather than seeking to silo or reduce initiatives to a single common denominator. Indeed, some initiatives display characteristics of integration or stratification across different elements and may lie in a somewhat ambiguous position between categories (e.g. some responsive initiatives may also be experimental).

Application of the typology to the database of initiatives highlights what actors are driving what type of initiative, revealing some interesting insights (Table 5). It is not surprising that government-led initiatives are primarily enhancement-orientated, although it is interesting to note that this is also the most prevalent type initiated by non-profit and community groups, who are often associated with more radical responses (Seyfang and Haxeltine, 2012). At the same time, this cohort largely drives initiatives that are responsive to contextual-needs. The EU was the main driver of experimental initiatives, most frequently in partnership with research institutions, but also with municipalities.

As noted by Fahy and Rau (2013), striking the balance between the requirements to produce scientific knowledge with the increasing demands for evidence-based policy reveals major challenges and also opportunities for those engaged in sustainability research, specifically in relation to how results are formulated and distributed. Complementing previous studies, such as that by McGuirk et al. (2014), the cross-national empirical data presented in Table 5 provides strong and timely evidence to support calls for new approaches to addressing pressing sustainability concerns as well as identifying trends and the potential challenges to improved measurement capabilities and evaluation of policy effectiveness. These are key priorities set out in the European Commission's publication *Communicating research for evidence-based policy-making* (European Commission, 2010).

5. Conclusion

This paper demonstrates the diversity in approaches to address unsustainable energy use. Urban areas are at the forefront of these efforts, and have the ability to engage a significant cohort of the population. We identify 5 areas where we find evidence of either stratification or integration in the way that the energy challenge is addressed through sustainable energy initiatives, and argue that greater integration across these dimensions can lead to more promising interventions for long-term transformation.

Policy efforts need to move beyond relatively simple efficiency-based approaches, such as promoting the replacement of old appliances or fittings, which were found here to be dominant in urban sustainable energy initiatives. An alternative more integrated approach, orientated to practices and context, is to consider how such technological changes could simultaneously bring about sustainable changes in everyday lifestyles by challenging existing norms, routines and ways of doing, as well as focusing on the actor-configurations that underpin sustainable energy initiatives. A practice approach therefore provides an opportunity to look beyond optimization of existing behavior, to create space to experiment with new more sustainable ways of addressing householder needs and concerns, as well as reshaping collective conventions around energy use.

For this to happen, sustainable energy initiatives, and the policies that drive them, require a multi-dimensional approach that integrates a variety of perspectives, which recognizes that the needs and behaviors of households, including individuals within households, differ greatly. Therefore, we call for a greater emphasis on co-creation of knowledge and related policy with the involvement of citizens at all stages of decision-making. While partnerships have the potential to bring about significant change, the potential role of community groups as key actors remains underutilized. Including householders in the design, implementation and evaluation of sustainable energy initiatives can empower citizens to effect change, and provide policy-makers with insights into what groups should be targeted and using what energy saving policies and supports. Such exchange of knowledge can build consensus, spawn new ideas, new ways of thinking and new approaches to foster and mainstream more sustainable lifestyles that

Table 3
Sustainable energy initiatives characteristics and governance matrix.

	Stratification	Integration
1. Problem framing	Target individual behaviors; Explore practices in isolation, failing to acknowledge how practices interlock; Techno-centric narrative	Systems perspective targeting reconfiguration of practices; Energy use understood as a key component of sustainable living and aligned with wider lifestyle choices; incubate social and practical learning
2. General approach	Focused on either social or technical approaches, without due consideration for the interdependencies between these approaches	Socio-technical approaches that are culturally sensitive and simultaneously targeting changes in the physical (e.g. targeting infrastructure and appliances) and behavioral (e.g. targeting changes in user practices) environment
3. Engagement mechanisms	Information-based approaches; passive participation of households; limited engagement opportunities	Combining information, education/training and interaction; active participation of households; deliberative approaches; promotes inclusivity
4. Governance	Single actor approaches, or multi-actor approaches that silo actors into prescribed roles (e.g. expert/non-expert); narrow engagement; homogenous network participation; focus on changing individual behaviors; Short-term goals	Multi-actor or heterogeneous network approach, working with diverse actors (e.g. different municipal departments; households and community groups; NGOs; academics; policy-makers) throughout the initiative from goal setting to implementation and evaluation; set and implement long-term goals that address shared concerns and deliver tangible benefits
5. Evaluation frameworks	Narrow evaluative framework; focus on quantitative data only (e.g. emissions or monetary savings); ignores or underrepresents qualitative and social dimensions	Considers quantitative and qualitative evaluative frameworks, interrelationships and potential trade-offs (e.g. saving emissions; saving time; saving money; new networks; build social capital; improved access to services; equality; improved health and well-being; rebound)

Table 4
Typology of sustainable energy initiatives including examples and key issues.

	Category	Example	Key strengths/weaknesses
STRATIFICATION	*ENHANCING:* Initiatives aimed at optimizing technologies and individual behaviors (e.g. promoting more efficient use of appliances)	*Goed voorbeeld doet goed volgen* (NL) was an initiative aiming to optimize and enhance residents energy related behaviors by offering free energy smart meters. In this way, households could measure their energy use and make 'smart' decisions about energy usages.	The use of smart meters can make energy use visible and encourage reflection but do not fundamentally challenge collective conventions such as levels of service expected (e.g. number and size of appliances, frequency of use). Focus on informing individual consumer choice overlooks the social, institutional and material context of consumption and production patterns.
	DIRECTIONAL: Initiatives designed to achieve a specific aim and directed from top-down with prescribed actor roles (e.g. government information campaign; government grant support scheme)	*Energiesparberatung incl. Abwrackprämie für alte Kühlschränke* (DE) was a German initiative run by the local municipality that aimed for energy efficiency in low-income homes in Düsseldorf, with a special focus on replacing inefficient refrigerators with high energy rated appliances (min. A+). The primary goal was to reduce energy bills and lower carbon emissions in low-income households and train long-term unemployed people to become energy advisors.	Conceptual connection of employment promotion, social policy and environmental protection. However spaces for change are narrow, focusing on individual people and individual products and neglecting wider institutionalized dynamics of energy demand practices across systems and domains.
INTEGRATION	*EXPERIMENTAL:* Practice-based initiatives that anticipate how future social and technical changes might alter the way we live, or the way we 'ought' to live and that test new ways of sustainable living (e.g. energy living labs)	*My Climate Plan Middelfart* (DK) brought together various actors to encourage householders to include sustainable energy measures when renovating their homes. Craftsmen were trained in energy renovations, and banks reconfigured lending practices. The municipality worked with a local utility company to develop an experimental framework concerning further monetary incentives for homeowners through a financial reimbursement scheme calculated per kWh of energy saved.	Systems perspective targeting reconfiguration of consumption and production practices through an experimental multi-actor and network approach. However, difficult to operationalize without persuasive or regulative planning instruments to mobilize energy renovations among private homeowners.
	RESPONSIVE: (Bottom-up) context-orientated initiatives designed to address evolving problems through co-creation of ideas and reconfiguration of systems of production and consumption through participatory processes (e.g. eco-communities)	*BedZed* (UK), located in south London, is the UK's best-known eco-village, and claims to be one of the most coherent examples of sustainable living in the UK. BedZED comprises 100 homes, community facilities and enough workspace for 100 people. Residents aim to live low-carbon lifestyles through sustainable production and consumption patterns, including energy, transport, food and waste.	Holistic approach to sustainable energy with energy use understood as an outcome of social and material organization. However, high development costs and context dependency makes the initiative difficult to scale up.

Table 5
Frequency of primary initiator for different types of sustainable energy initiatives.

		Local gov.	Other gov.	Research institution	Non-profit	Community group	Private sector
Enhancing	140 (56%)	39	39	2	21	21	18
Directional	34 (14%)	22	12	–	–	–	–
Experimental	39 (16%)	4	16	6	7	3	3
Responsive	36 (14%)	6	–	1	13	13	3
Total	**249**	**71**	**67**	**9**	**41**	**37**	**24**

respond to current and future societal needs. A reconfiguration of systems of production and consumption should also consider how interlocking practices could provide synergies between residential and other sectors (e.g. services, industry), for example reducing transport emissions by allowing people to work from home or enabling new forms of engagement with (locally generated) renewable energy across different sectors.

Finally, we find that municipal authorities continue to be key actors in different types of sustainability initiatives. Public sector support for achieving reductions in energy use is vital, and it is essential that local and national governments continue to provide appropriate financial, technical and other supports for sustainable energy initiatives. Municipal authorities might also benefit from engaging in more reflexive and inclusive evaluation of initiatives that they support, for example by including narratives and case studies, which can reveal more intangible impacts such as indirect spillover effects. Since public funding is so prevalent in supporting sustainable energy initiatives, government should promote technologies and innovations (both social and technical) that can facilitate sustainable lifestyles and contribute to the protection of the climate. Policy interventions in related areas such as education, building standards, infrastructure, taxation, grants and subsidies should be aligned to enable such efforts.

However, it is also vital to understand the power dynamics that underpin partnership approaches, as well as the problem framings and agenda of different actors (e.g. funders; practitioners; householders) who may not share a common understanding of issues related to sustainable energy. Such an understanding might include an examination of if, and in what ways, sustainable energy initiatives are evaluated (e.g. ex-ante/ex-post, quantitative/qualitative, etc.), as well as exploring the temporal aspects of participation in partnership approaches. These insights could assist in understanding which coalitions are most effective in producing what kind of outcomes, through which mechanisms, where, and for whom. Addressing these concerns would provide fertile ground for future research.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2019.117776.

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