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Research Article

The "four Ds" and support for Local Smart Grids: analysis from national surveys in the UK and Canada

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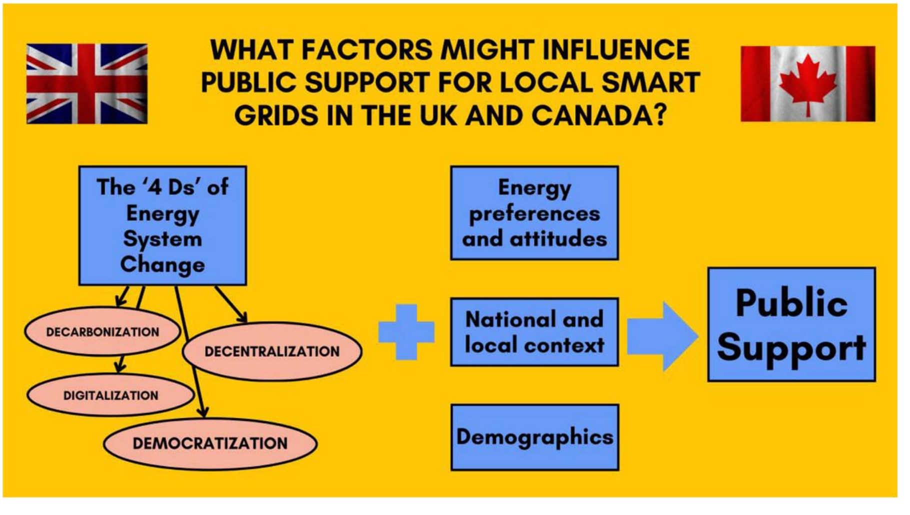
Abstract

Local Smart Grids are emerging during the climate crisis, as governments and industry recognize the need to better integrate intermittent renewable energy, storage, transportation, heating, and smart technologies. Such projects can represent profound changes to the status quo of energy and citizen lifestyles. They are also being associated with the "four Ds," whereby Local Smart Grids are decarbonizing, decentralizing, digitalizing, and potentially democratizing energy systems. Yet, due to their recent arrival, there is very little social scientific research that has aimed to better understand public views, expectations, and support for this change. We attempt to fill this important gap in the literature through the analysis of two nationally representative surveys in the UK ($n = 3034$) and Canada ($n = 941$). This analysis highlights within- and between-country trends, including how the variation in responses regarding the "four Ds," demographic factors, and other variables may explain the differences we see in terms of support for energy system change in the UK and Canada. Our analysis also shows that there are common elements, including the importance of the decentralization, and especially the democratization of energy in shaping support. We hope that this study will help governments, industry, community groups, and local residents themselves in both countries come together to advance the kind of Local Smart Grids that address climate change and represent a supported, just energy transition.

Graphical Abstract



Key words: Local Smart Grids; smart local energy systems; public support; energy transitions

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Lay summary

In many countries, the ways in which we generate, manage, and use energy are changing. This includes the UK and Canada, where Local Smart Grids (that combine renewables with storage, electrification, and technology) are decarbonizing, decentralizing, digitalizing, and democratizing energy. These trends are known as the "four Ds"—yet, there is little research looking at the public opinion of these ideas and how they might relate to support for energy system change. We do so via survey analysis in the UK and Canada, finding key differences between countries as well as the importance of democratization in shaping support.

Introduction

To address related issues of global climate change, energy security, fuel poverty, and local air pollution, the rollout of local energy projects—and what some are calling as Local Smart Grids (LSGs) [Another common though mainly UK-based label for these projects is the Smart Local Energy Systems (SLES); [1, 2]). In this paper, we use LSGs to frame our understanding because it represents a degree of compromise between SLES and Smart Grids, which is used mostly commonly in Canada. LSGs is also the preferred label used by the newly formed "International Community for Local Smart Grids"; i.e. LSGs; [3, 4]]. No matter the label chosen, these innovative, often experimental projects seek to combine smart technology with locally produced renewable energy and storage capacity to help "electrify everything" [5] and cover a complete range of energy vectors, including heating, hydrogen production, and transport [6]. Due to this extensive coverage of the energy system enabled through localized balancing (i.e. of supply and demand), LSGs provide considerable strength in the fight against climate change—especially in places that can electrify heating and transport through high levels of low carbon and renewable electricity (e.g. Canada, where 70%–80% of electricity supply is carbon-free). In addition to climate-related benefits, early research also indicates that LSGs "may" provide additional benefits that improve societal well-being, including improved grid resilience [7], and that stress higher levels of justice and equity through this more local energy transition [8, 9].

Though not yet at the speed or scale that is necessary, these innovative local energy projects are showing the potential to create important changes in the energy systems we know today. More specifically, LSGs have the potential to decentralize, decarbonize, digitalize, and democratize energy systems. That is, in moves away from large-scale and distant energy sources, we are decentralizing; transitioning toward low-carbon sources means that we are decarbonizing; increasing low-carbon, intermittent sources require smart technologies and digitalizing; and lastly, creating new energy systems in local communities presents the opportunity for democratizing. While most often thought of individually, together they are known as the "four Ds" and recent research [10, 11] is showing the value of studying these trends concurrently.

Yet, partly because most LSG projects are in their early or demonstration stages, we lack an understanding of the public's hopes, expectations, and willingness to support this new and evolving local energy transition. In particular, we know very little about what role each of the "four Ds" may be having in this respect; that is, the relative power of each part of energy system change in shaping the overall support of energy system change. Without this understanding, and in line with how many renewable energy projects are developed [11], there is a risk that LSGs are built in a way that are not equitable, just, and/or supported by the public [9, 12–14]—by local residents and beyond. Despite some "potential" tradeoffs in terms of getting projects built faster, this is important both because of the need for a just transition [9] and the subsequent political ramifications [12, 15]. That is to say, the major lesson here should be that like renewable energy projects before them, a successful LSG transition will not happen "automatically." Rather, communicating the potential for LSGs to decarbonize and improve the local communities will mean very little if people do not actually experience (or anticipate) a broadly defined "better" energy system. In this respect, engagement and social acceptance are critical and we must better understand the public's perceptions of a move toward local energy systems, including how they arrived at such perceptions.

To address this gap and introduce a comparative element to our understanding, we present a study which centers around the analysis of two nearly identical nationally representative online surveys, in the UK ($n = 3034$) and Canada ($n = 941$). The surveys' shared focus is on developing a better understanding of support and opposition toward smart local energy development, and in particular, the potential of the "four Ds" to shape such outcomes. We look to advance this understanding of support for energy system change both within and between the UK and Canada. In doing so, this study answers multiple calls for future research, including those from Ford *et al.*, [8] who call for research across different geographic contexts.

Literature review

In this section, we outline the literature related to the study presented here. First, we briefly describe LSGs (What are Local Smart Grids?), including the term's relevance to other decentralized energy (DE) projects and contemporary policy support. In The "four Ds" of energy system change, we then define and describe each of the 'four D's. Included here is a summary of published research, and when appliable, its relation to our research. Lastly, in Other influences on support for Local Smart Grids, we write about the range of other possible influences on support for local energy system change. These influences are organized into three groups (energy preferences and attitudes, national and local context, and demographics) wherein we discuss each variable's potential impact on our dependent variable (DV) of support for energy system change.

What are Local Smart Grids?

While the term is still in its infancy, LSGs are innovative projects that combine smart technology with sustainable, local energy production and local management. They are closely aligned with Smart Local Energy Systems (SLES) in which Rae *et al.* [106] acknowledge the following: (i) utilize smart technology; (ii) include on-site low-carbon energy generation; (iii) serve more than a single building, but less than a region; and (iv) combine on-site generation and demand sources. Somewhat in line with both SLES and the broader concept of smart grids, key differences of LSGs include: (i) energy must be sourced from nearby renewable energy and (ii) LSGs cover a complete range of energy vectors, including storage, heating, hydrogen production, and transport. While the components of each LSG will differ between projects, they are most often focused on finding complementarities among electricity, heating, and transport sectors [107]. For example, this may include finding ways to use wind or solar energy to power electric heat pumps and electric vehicles. (For a broader discussion of related terminology and definitions similar to LSGs, see Walker et al. [2].) Of course, there are important challenges and concerns around the deployment of LSGs, some of which may be slowing down their widespread adoption. These challenges include risks around cyber-attacks [16], the possibility of leaving vulnerable households behind [17], and whether or not a growing electricity sector can accommodate moves toward "electrifying everything" [18].

Like the individual components that makeup LSGs, these projects are in line with the idea of a soft energy path and broader moves toward the decentralization of energy. As recently described by Devine-Wright [108], two modes through which decentralization has and is occurring are via community energy (Even within the context of community energy projects, the term community has been proven to a difficult one to define. For example, academics have differentiated between communities of place and communities of interest [109]; and have sometimes focused on a single type of community project, such as cooperatives [19, 20]) and local energy. While often used interchangeably in much of the developed world, nowhere are these two ideas made more distinct than in the UK, where in a dramatic shift, recent policy commitments to community energy have been replaced by increased funding for local energy. This includes the Government's Local Energy Team replacing The Community Energy Unit. As argued by Devine-Wright (2019), this change is important and "signals reduced support for grassroots, citizen-led action in favour of institutional partnerships and company-led investments." (According to Devine-Wright (2019), the government's rationale behind this move appeared to be that they wanted to involve more "local authorities and private-sector businesses, with a focus on growth, job creation, skills and infrastructure improvements" and drive "low-carbon economic growth".) The concern may come from the well-established social benefits of community energy [109–111].

Given this recent shift in the UK—and to a lesser extent, Canada—there is a need for social scientific research focused on new local energy transitions. Ford et al. [1] do not make a value judgment between community and local energy, but they do make clear that not involving the local community through LSGs and similar developments may impact the realized value of projects. Such local energy projects may help with short-term climate change targets by getting projects built and operational in short order. However, whether local energy aligns with existing lifestyles, is supported by the public, and/or achieves much-needed "societal transformation" (Devine-Wright, 2019) in the energy sector is questionable. To this uncertainty, Ford and her team call for more evidence surrounding the value of local energy, and especially how not engaging with locals, can lead to unintended consequences [8]. We begin to answer this call, with a specific focus on public perceptions within both the UK and Canada, two countries where government-funded LSG projects (In the UK, many of these projects were developed under the UKRI Prospering From the Energy Revolution challenge which ran from 2018 to 2023. In Canada, many projects were built under Natural Resources Canada's Smart Grid program in which project implementation ran from 2018 to 2023.) are quickly being developed.

The "four Ds" of energy system change

Centering around the ways in which LSGs are changing energy systems, academics and others are now writing about the "four Ds"; decentralization, decarbonization, digitalization, and democratization [112]. They are often mentioned in relation to transitioning from traditional, centralized, hidden, and mostly fossil fuel-based energy systems to low-carbon, sustainable, participatory, and renewable alternatives. The "four Ds" have been adapted from the more long-standing, established model of the "three Ds," which include only decentralization, decarbonization, and digitalization [21] (Dinther and Madlener, 2022; there is much less agreement on what is the "fourth D." Some are suggesting it should be either the "dominance" of fixed costs or the "degression" of technology costs; see van Dinther and Madlener, 2022). The study presented here seeks to better understand all four—both in terms of public perceptions of these moves and their role in shaping overall support for LSG projects in the UK and Canada. Because of their importance in our study, below, we take the reader through definitions of each of the "four Ds" and share each's relevance to social acceptance research.

Decentralization

Decentralization involves shifting away from centralized energy generation and transmission systems, such as large-scale power plants, and associated infrastructure. Simply, it has been described as the move toward "energy generated close to the point of use" ([22]). The original model for modern energy services dates to the 19th century when societies began to move the generation of electricity away from dense populations to achieve economies of scale and improve health and safety [23]. Conversely, DE can be achieved through the integration of renewable energy sources, like solar panels, wind turbines, and especially as is the focus here, LSGs. DE offers numerous advantages, including reduced transmission costs and improved efficiency (via shorter transmission). However, rather than marking a shift in physical infrastructure, decentralization may also imply localization of social structures, e.g. in the planning, ownership, and management of assets and wider systems [24].

In the literature, we can find little research which directly looks at the relationship between decentralization and overall support for energy system change. More often, it is assumed that DE projects have higher levels of support through their tendency for increased citizen participation [2]. Yet, while assumed to be more local in nature [25], DE projects do not require such attributes to be present. Indeed, Cuppen [26] and Pesch et al. [27] describe how conflicts and opposition are likely to emerge through decentralization, as such changes bring forth significant spatial impacts and imbalances of risks and benefits. Relatedly, there are concerns raised from Solman et al. [28] that the technical nature of DE often excludes everyday citizens from taking part—and that this may create opposition. While not focused on public or citizens' views, there is also research from Brisbois [29] that describes the reluctance toward decentralization by incumbent industries and governments responsible for current energy systems in the UK, Canada, and the Netherlands. It is possible that the powerful influence of these actors—who Brondi et al. [30] call "epistemic authorities"—may impact the people of each country (i.e. the people we are interested in studying). Still, Brisbois [29] writes that, even for these powerful groups, there is a "growing *acceptance of decentralisation as* an inevitable future state." Thus, while the literature as a whole points to a trend that decentralization brings about opposition, this research from Brisbois suggests possible, indirect changes in these attitudes among the public.

Decarbonization

Decarbonization entails replacing fossil fuel-based energy generation and sources (e.g. coal, oil, and natural gas) with low or zero-carbon alternatives/solutions, such as efficiency, solar, wind, hydro, geothermal, nuclear, electric vehicles, heat pumps, and/or carbon capture. Carbon-intensive fossil fuels are currently the main source of power generation worldwide [31]. In 2021, the 26th United Nations Climate Change Conference (UN COP26) officially mandated all countries to phase down coal power and accelerate renewable energy—a crucial step toward reaching the 1.5°C target [31]. In 2023, the UN COP28 went even further with almost 200 countries recognizing the need to transition away from all kinds of fossil fuels [32].

There is much research looking at the relationship between support for/social acceptance of decarbonization projects and support for overall energy system change, especially studies centered around renewable energy projects such as wind farms [33, 34]. Summarizing the importance of public support over techno-economic considerations, Papadis and Tsatsaronis [35] write that, especially when done “wrong” (i.e. top-down and/or ignoring local input), some decarbonized energy systems may not be viable due to social opposition. Indeed, we can see examples of this in both the UK and Ontario, Canada, where onshore wind farms became so opposed at a local level that newly elected conservative governments have moved to stop virtually all new development. (In Ontario, public opposition this can be shown through the fact that as of 2015, over 90 townships and municipalities in the province of Ontario had declared themselves “unwilling hosts” for wind farms [36, 37]. Three years later, the Ontario government under Doug Ford canceled 758 renewable energy project contracts. In late 2023, the province announced plans to develop more nonemitting sources of electricity generation including wind and solar.) Outside of renewables, there is also research devoted to understanding support for decarbonized infrastructure, notably transmission lines, where researchers have noted that a lack of public support can threaten their development [113]; see also [38]).

More broadly, opposition/support to new decarbonized projects is shaped by a range of factors depending on the technology, but these can include odors, health concerns, noise, landscape changes, and distributive and procedural injustice; see [13, 39]. Recent literature in this space has moved away from the so-called Not-In-My-Backyard (NIMBY) hypothesis (i.e. that local, selfish motivations are driving anti-renewables sentiment; see [114]) and toward highlighting the importance of elements of energy justice, and especially local procedural justice [14, 115]. Central to these discussions have been considerations of scale. Most notably, differences in terms of support at local versus national levels have been noticed by researchers, including Bell and colleagues [116]. Still, sometimes closely tied with NIMBY attitudes, these researchers labeled the difference between the high levels of general (or national) support for wind energy and low levels for wind energy in their community as the “individual gap.” It is much more difficult to find published research related to LSGs, decarbonization, and public support. More often, recent research is writing about the importance of support [2, 9, 40] or presenting hypotheses, including one from Peters *et al.* [117] who suggest that, in British Columbia, Canada, the social acceptance of Smart Grids may be increased if projects are: (i) centered around pro-environmental frames and (ii) better engage with citizens. Together, this literature focused on decarbonization projects and local support suggests that a range of factors are responsible for shaping public support but that those related to justice and local engagement/participation may be the most salient.

Digitalization

Third, digitalization has emerged as a key trend with the potential to change norms in system operation, consumer behavior, and energy governance [10]. The idea involves the integration of advanced digital technologies and data analytics into energy systems. This includes incorporating Internet of Things devices, real-time monitoring, predictive analytics, artificial intelligence, and blockchain. The greatest transformational potential for digitalization is its ability to breakdown boundaries between sectors, increasing flexibility, and enabling grid integration [41, 42]. Accurate forecasting is crucial for the integration of renewables [43], and as a specific example, smart meters have emerged as a great tool for managing demand-side response.

The study of support for new smart technologies and digitalization, in general, is nothing new. Established research has shown that the opposition is driven by a range of factors, including insufficient education, NIMBY attitudes, fixed behavioral patterns, and the perception that only “elite” of society may benefit; see [44, 45]. Especially when these fears are amplified through social networks, these factors can “make it harder to accept new ideas” ([46]). There is much less research looking at digitalization within energy systems, and we can find none focused on its relative influence on the overall support for energy system change. In their study of smart energy communities, and much like the trends we see above, Savelli and Morstyn [47] argue that the acceptance of these new systems increases when they are bottom-up and citizen-led, “where local members … can determine operating principles and shared objectives.” Meanwhile, Ford *et al.* [8] state that important questions remain regarding how more digital or smart technologies in energy systems can help support a “socially equitable, acceptable, net zero transition.” This point is echoed by Judson *et al.* [118] who write, “these issues remain under-explored in relation to the digitalization of…energy.”

Democratization

The democratization of energy systems is about seeking to reclaim public control over the energy sector, restructuring the relationship between the state, market, and civil society to support democratic processes, promote social justice, and ensure environmental sustainability [48]. While encompassing a plurality of interpretations, in short, it means where the power and control over energy production and consumption are distributed more evenly among individuals and local communities. It also emphasizes the involvement of diverse stakeholders, including local communities, consumers, and prosumers, in an inclusive and transparent decision-making process relating to energy [10]. The development of renewable energy technologies, such as wind and solar, has been particularly influential in shaping energy democracy pathways [49], which has led to new income streams, access to affordable and clean energy, and increased security. Democratization has also sparked localized energy activism and the creation of new democratic imaginaries associating energy politics with community ownership of energy assets [49].

Like the concept of digitalization above, there is a wealth of literature on democratization outside of energy system studies; e.g. [50, 51]. Yet, there is also a fast-growing literature focused specifically on the idea of the democratization of energy systems [14, 52, 119, 120]. Included here is the well-established idea that public engagement in energy system change is essential in increasing acceptance ([53, 54, 99]). As described by Szulecki and Overland (2020), the term energy democracy first originated as a slogan used by activists and has since been used in impactful policy documents and programs related to energy transitions. It has been done so in part because the democratization of energy combines normative and pragmatic benefits, including increasing social acceptance or support for energy systems, especially renewable and/or community energy projects [55–57]. Specific to LSGs, again there is much less research, especially in the context of the relative influence of democratization on the overall support for energy system change.

Other influences on support for Local Smart Grids

While research is showing how powerful the "four Ds" might be in shaping responses to LSG development, there is a wide range of other factors that also play important roles. Informed by tangential literatures associated with renewable, community, and smart energy projects, we outline three other groups of factors considered within this study: energy preferences and attitudes, national and local context, and demographics. We do so by including them as 17 IVs within our regression models predicting overall support for LSG development in the UK and Canada (see Regression analysis: influences on support section). Each set of factors is briefly described below.

Energy preferences and attitudes

There are a range of factors associated with energy preferences and attitudes that are important in shaping public responses. Intuitively, the overall satisfaction with current energy systems, including the cost of energy [58–61], has been shown to impact views toward new energy projects. This trend includes findings in a study from Koirala *et al.* [62] that showed that 16% of citizens in the Netherlands were hesitant to participate in a new community energy system because they were happy with their current energy system. The presence of a reliable energy system has also been shown to be important, including through studies of public support for renewable energy in the USA [121] and grid-scale energy storage technologies in Canada and the UK [63].

Especially as LSGs require digitalization and thus more sharing of energy data at the household level, data privacy concerns have also emerged as a key factor [58]. Research has shown that people sometimes have comfort in sharing data with their energy provider, but they hold a strong aversion for third-party sharing [64]. Indeed, third-party access was found to be a central determinant of households' aversion to time-of-use pricing and the adoption of smart meters [64]. Relatedly, excitement about new technologies has been found to be a strong predictor of intentions to install technologies associated with LSGs, including smart meters [64]. Another controlling factor is environmental concerns. Across multiple studies, support for solar energy, heat pumps, and smart meters have been linked with concerns related to environmental pollution and climate change [65–67].

National and local contexts

Research has also shown that differences in what we label as national and local contexts can impact public support. Still, studies that examine public support for energy transitions across multiple countries are difficult to find. The importance of national context can be seen with reference to the study from Jones *et al.* [122] that examined the differences in public attitudes toward energy storage technologies in the same two countries studied here; Canada and the UK. In their work, it was shown that respondents from Canada were generally more favorable.

The type of community in which a person lives—whether than be urban, remote, or somewhere in between—may also be an important factor is shaping public responses to new energy systems. Koiarala *et al.* [98] found in their review of integrated community energy systems that "community composition differs a lot … between urban and rural areas." We suggest that these compositional differences may result in differing perceptions of new energy system projects. Still, findings related to the community type and support for new energy projects are mixed. Research from Germany has shown that willingness to participate in local energy initiatives increased in rural and suburban areas compared with urban centers [123]. This contrasts with research from Ontario, Canada, that found that the opposition to wind energy in rural communities appeared to be driven by the "lack of representation in regional political processes" [68].

Sense of community or place, described as one's place meanings and attachment, has shown to help us better understand the public responses to energy system change. (It is believed that this opposition is often due to feelings of alienation, local identity loss, and perceived threats to residents' connections with their surroundings because of the new energy infrastructure.) Most notably, this includes the idea of place attachment as a significant driver to the resistance against wind farms [69, 70]. While place attachment as a factor influencing public support/opposition is mostly found in studies of large-scale, rural development, Walker *et al.* [2] have recently suggested that "there is some indication that similar trends might also be seen in smaller, often urban-based energy systems" such as LSGs; see also [71].

The concept of citizenship holds broader implications for various aspects of civic identity, such as sense of belonging, which can impact the energy behavior and views. Devine-Wright and Batel [124] found that strong global attachments were associated with support for DE, while those with strong local attachments were most likely to protest a nearby new power line. For the UK survey question related to feelings of citizenship, we included categories of UK, Europe, and global. For the Canada survey, we included Canada, North America, and global.

We hypothesized that the presence/ownership of at least one LSG element described in our study (e.g. solar panels, electric vehicle, and heat pump) would increase the support for energy system change. This is partly intuitive as those participating in the energy system change would seem to be supporting such change. Though there is also some research that reinforces this idea, including from Cantoni *et al.* [72], who showed that the presence of renewable projects, like solar farms, was the primary reason for both on-grid and off-grid households to prefer solar energy over fossil-based fuels as an additional source of energy.

Demographics

Demographic factors, including age, education, income, gender, home ownership status, and political affiliation, have also been shown to play a role in shaping public support for energy system change. Still, published research has shown inconsistent findings with relation to many of these factors [73, 74]. Research looking at the adoption of heat pumps has shown that younger age groups, those with higher incomes, and those with higher levels of education were all more likely to indicate interest [66]. Yet, other research has shown that despite younger people being more concerned about environmental issues and the impact of climate change, they can display lesser pro-environmental behaviors, including energy usage [75].

Higher levels of education also appear to have a positive impact on energy-saving actions. Individuals with higher education levels have the tendency to be more environmentally conscious and support renewables [75]. Also, women have been found to have higher levels of support for renewable energyprojects [74].

On home ownership, the preference and adoption of new technologies like electric vehicles were higher among people who owned a home or had a housing stability, which indicates that home ownership can affect behaviors and attitudes associated with energy [76].

Regarding partisanship, liberals generally exhibit a higher level of environmental awareness, display greater support for renewable energy sources, and demonstrate more willingness to financially contribute through carbon taxes and investments in clean energy [77]. Research from Canada also has shown that support for the incumbent party responsible for wind energy policy powerfully shaped the local support/opposition ([15]. In the UK, climate change and associated actions have become politicized, and this has resulted in "clear partisan divisions . . . amongst the public" [78].

Research questions and methodology

In this section, we first outline and briefly discuss our three main research questions. We then present the reader with a detailed description of our study's methodology. Here, we take the reader through the data collection, treatment, and analysis stages. We also present a summary of each sample's demographic characteristics and outline how concerns around collinearity and endogeneity were addressed.

Research questions

From the literature review described above, we developed three main research questions:

1) To what degree do people from the UK and Canada support the development of new Local Energy systems—both at the national level and in their local area?
2) To what degree do people from the UK and Canada support elements of the "four Ds" of energy system change?
3) Which of the "four Ds" best explain citizens' support/opposition toward new Local Energy systems in both the UK and Canada?

Thus, Research Questions 1 and 2 look to examine the similarities and differences between UK and Canada. Based on our reading of the literature, it was very difficult to formulate a hypothesis regarding any potential differences between the two countries. The most relevant research in this regard is a study from Jones *et al.* (2018), which looked at the responses to energy storage projects in the UK and Canada and found slightly higher levels of support in Canada. While not found in the literature prior to our data collection, we determined that it could be possible that the overall support could be higher in Canada, given Russia's invasion of Ukraine in Winter 2022—in between data collection phases in the UK and Canada (see more in Methodology below). Research Question 3 is focused on the analysis within each country, whereby we are interested to better understand the relative influence of a range of factors on the overall support for energy system change. Here, given the lack of research in this area, the literature is even less helpful in generating any targeted hypotheses. Still, having Canada data collection take place after and during Russia's invasion may have indirectly changed the dynamics of the items that impact overall support (i.e. the DV).

Methodology

This study was based upon two nearly identical (The UK survey was written first and most questions were directly input into the Canada survey. Some questions needed to be adapted to: (i) make sense to people in Canada; i.e. using "time-of-use pricing" rather than "time-of-use tariffs" or (ii) when categories of demographic responses needed to be changed; i.e. educational levels, income groups, and political affiliation by party.) quantitative, online surveys rolled-out across the UK and Canada. We first collected responses ($n = 3034$) in the UK in April 2021. This was followed by data collection in Canada ($n = 941$) in April 2022. We note this gap as a potential limitation, especially given how the global views of the need to transition away from a fossil fuel-based and DE system may have changed, considering Russia's invasion of Ukraine and the subsequent dramatic rise in the geopolitical and economic cost of energy use associated with the status quo. That is, it is possible that support for energy system change may have increased in both countries from 2021 to 2022.

In the UK, we hired the company Accent to collect our sample data. The UK sample was fully representative of the UK population along demographic and geographic dimensions, including socioeconomic group, age, gender, education, income, political affiliation, and nation of residence. We hired Dynata to collect the Canada data. (Both Accent (UK) and Dynata (Canada) are highly regarded companies in research. Each collected samples using their diverse panel of participants.) The Canada sample was representative along gender, language, age, income, and province of residence. Education (higher levels of education) and political affiliation (less conservative) all slightly differ from population-level statistics. Full descriptions of each sample can be found in the Appendix 2.

Both datasets were cleaned (This process included looking for irregularities in the data and treating incomplete and "don't know" responses as missing.) and then combined. To answer the three research questions identified above, we chose a combination of descriptive statistics (RQ1 and RQ2), *t*-tests of means (RQ1 and RQ2), and multivariate regression modeling (RQ3). The *t*-tests of means (see Tables 3 and 4) related to a comparison of responses between the UK and Canada datasets along levels of support for local energy development, as well as levels of support for each of the "four Ds," to see if significant differences could be seen across countries ([79]; Jones *et al.*, 2018). As Stockemer [102] writes, regression analysis (see Tables 5 and 6) allowed us to "absolutely and comparatively gauge the influence" of our set of independent variables (including "the four Ds") on the DV of combined support for local energy development. This combined support DV was calculated by adding individual responses to questions of local and national support (Table 2). That is, based on their individual five-point scales (1–5), scores ranged from 2 (Strongly supportive) to 10 (Strongly opposed). We combined these variables and created the new DV because we were interested in both concepts and found that they were measuring nearly the same thing (Cronbach's alpha = 0.930 for the entire sample; .930 in UK, .910 in Canada). (We note these values are well above the threshold of 70 [80].) Most questions included in the survey were written to gather five-point Likert-scale responses (i.e. Strongly supportive to Strongly opposed). For both the *t*-tests and regression models, our threshold for statistical significance was set at the accepted level of $P = .05$ [81]. The full Canada survey can be found in the Appendix 1 and the UK survey, which is nearly identical can be accessed upon request. In each, our focus was on a better understanding of the "four Ds," so we included many questions covering these ideas. Other items, including those related to

Table 1. The survey questions representing the "four Ds" (i.e. independent variables).

The "four Ds"—survey independent variables	
Decarbonization	Overall, to what extent do you support or oppose reducing greenhouse gas emissions from electricity, heating, and transport in (the UK/Canada)? Please select one.
Decentralization	To what extent would you support or oppose a change from a mostly large-scale and distant energy system to a smaller scale and more local energy system? Please select one.
Digitalization	When thinking about (the UK/Canada) as a whole, to what extent would you support or oppose a change to using digital or "smart" technologies in energy systems?
Democratization	To what extent would you support or oppose a change to more local control of energy systems in (the UK/Canada)?

Table 2. The survey questions that were combined to create "overall support" (i.e. an indexed DV used in regression analyses; bolded text provided to give emphasis to the reader).

Survey dependent variables used to create "overall support"	
National support	When thinking about **Canada/the UK in general**, to what extent do you support or oppose the development of new Local Energy systems across the country?
Local support	When thinking about **your local area** in particular, to what extent would you support or oppose the development of a new Local Energy system for your area?

energy preferences and attitudes, national and local context, and demographics, were often made up of single questions. In Table 1, we share the individual questions we used to represent each of the "four Ds" (i.e. the key independent variables).

Throughout the analysis presented here, we recognized the possibility of both collinearity (i.e. correlated independent variables) and endogeneity [or common method variance (CMV); i.e. correlated measurements in the dependent and independent variables]. Regarding collinearity, we ran tests among these groups of variables, including the "four Ds," where we found bivariate correlations between .366 and .614 (in both the UK and Canada). Similarly, we were concerned of collinearity between both: (i) support for decarbonization and concern for climate change and (ii) support for digitalization and comfort/concern for sharing data. These correlations were .642 and .395, respectively. For the entire set of variables in our regression analysis, variance inflation factors were between 1.007 (Canada) and 2.235 (UK). Altogether, these values were well below established thresholds and thus showed no evidence of collinearity; see [82, 83].

On endogeneity/CMV, we were concerned that, given the reference to "local energy" in two of the "four D" independent variables (decentralization and democratization) and the questions that made up the DV of overall support, it would result in very similar responses. We tested for endogeneity through Harmon's single factor test, which showed a total variance percentage of 18.822. This means that <19% of the variance in the outcome variable can be predicted based on a single independent variable. This is well below the threshold for endogeneity of 50%; see [84, 85]. (One reason this might be the case is that we created "physiological distance"; see [84]; between each of the key independent variables; i.e. the "four Ds"; and the DV questions of national and local support.)

Results

Findings which are associated with our three research questions are shared below. Together, our results show: (i) differing levels of support between the UK and Canada (see Support for local energy systems and Support for the "four Ds") and (ii) Similarities in terms of the influences of other variables on support in each country (see Regession analysis).

Support for local energy systems

As seen in Fig. 1 and Table 3, while support was high within both samples, overall support for new LSG systems was significantly higher within the Canadian sample (using mean responses; $P = <.001$). This was true at both national (i.e. across the UK/Canada) and local levels (i.e. "in my local area"). When looking at categories of responses, we see that 75.8% of the Canadian sample supported development at national scales, while 76.3% supported development in their local area. These measures were 8.2% and 9.8% higher compared with the UK sample. The factors that predict these differences can be found in Regression analysis: influences on support section.

Support for the "four Ds"

In Fig. 2 and Table 4, we can see that patterns emerge from survey responses associated with support for the "four Ds" in both the UK and Canada. Support for moves toward decarbonization ($P = .052$) and decentralization ($P = .181$) was only slightly higher in the UK compared with Canada, though not statistically significantly so. Meanwhile, in the latter of the "four Ds," we see significantly higher levels of support for both democratization ($P = <.001$) and digitalization ($P = <.001$) in the Canadian sample (2.13) compared with the UK sample (2.33). When looking at categories of responses, we see that 68.4% and 68.2% of the Canadian sample supported moves toward democratizing and digitalizing energy systems, respectively. These measures were 8.8% and 5.4% higher compared with the UK sample.

Regression analysis: influences on support

Next, we can look at Tables 5 (UK) and 6 (Canada), and the multivariate regression models that were done with the indexed variable of "combined support" (i.e. combining national and local support) as the DV. (The reader should note that apart from the DV, all other variables were single questions from the survey.) We decided to run these separately as in-country analyses to better understand the potentially distinct set of influences within the UK and Canada. Reflecting their importance to our understanding of support, Model 1 began with the inclusion of only the "four Ds." Model 2 added six independent variables labeled under "energy preferences and attitudes." Finally, Models 3 and 4 added a total of

Table 3. Overall support for new Local Energy systems in the UK and Canada.

	Strongly support	Tend to support	No feelings either way	Tend to oppose	Strongly oppose	Mean response	Std. Dev.
National-level support for new Local Energy systems (across country)							
UK (*n* = 3034)	26.1	41.5	26.7	4.1	1.6	2.14	.905
Canada (*n* = 941)	30.7	45.1	20.0	3.1	1.2	1.99[a]	.858
Local support for new Local Energy systems							
UK (*n* = 3034)	25.8	40.7	26.7	4.8	2.0	2.16	.932
Canada (*n* = 941)	33.8	42.5	19.6	2.7	1.5	1.96[a]	.879

[a](P = <.001).

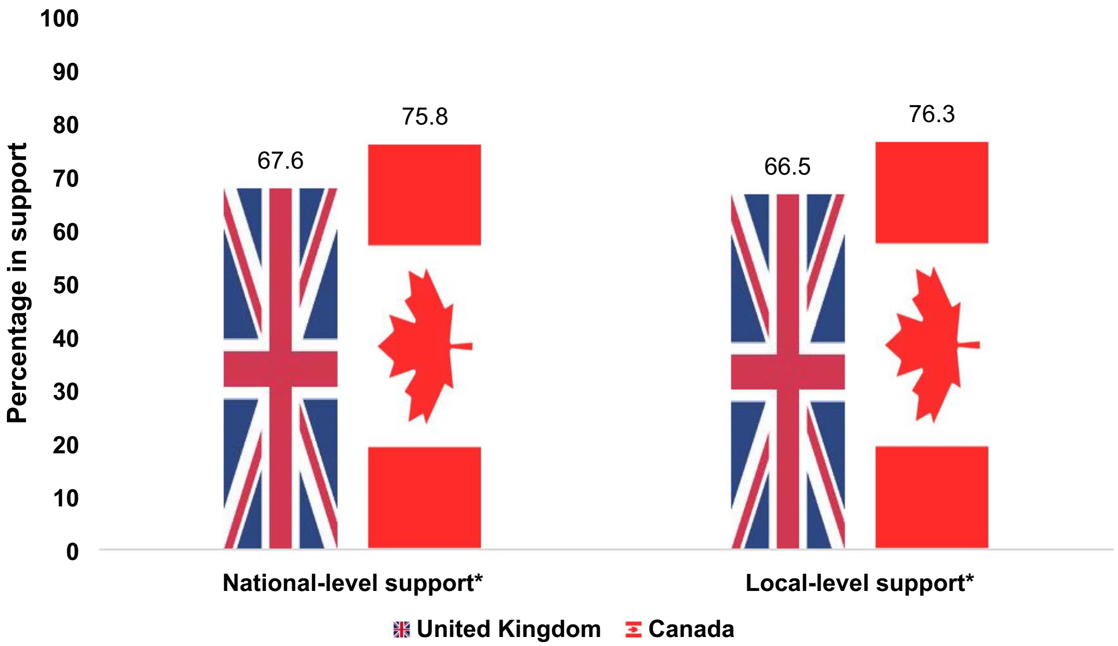

Figure 1. Overall support for new Local Energy systems in the UK and Canada (∗statistically significant difference based on *t*-tests of means; $P < .05$).

10 independent variables under "national and local context" ($n = 4$) and "demographics" ($n = 6$), respectively. All variables were chosen for inclusion in the original survey, and the analysis here, because of their potential to influence the support for local energy system development.

Focusing on the UK data in Table 5, all "four Ds" are significant in Model 1. In Model 2, these remain significant, as do the new variables of: comfort in sharing data, concern about climate change, and excitement about new technology. In Model 3, results remain the same as in Model 2, as none of the "national and local context" variables introduced show statistical significance. In the final model (4), all "four Ds" remain significant and a newly introduced demographic variable of household income is shown to be significant. In summary, the independent variables of decarbonization, decentralization, digitalization, democratization, comfort in sharing data, concern about climate change, excitement about new technology, and household income were all associated with the DV of combined support. In the final model, all these measures are significant at the $P = .01$ level.

When looking at Table 6 and the Canada sample, all four of the "four Ds" are significant in Model 1. In Model 2, decentralization and democratization retain their significance, while four of the six "energy preferences and attitudes" variables (satisfaction, comfort in sharing data, concern about climate change, and excitement about new technology) show statistical significance. In Models 3 and 4, the addition of the "national and local context" and demographic variables makes little difference, with decentralization, democratization, comfort in sharing data, and concern about climate change remaining significant throughout both iterations. Only excitement about a new technology becomes insignificant. In the final model, decentralization, democratization, comfort in sharing data, and concern about climate change are significant at the $P = .01$ level, while the other two (decarbonization and satisfaction) are significant at the $P = .05$ level.

Discussion

To mitigate a range of problems, including climate change, energy systems around the world are changing quickly. These changes can be seen through the simultaneous decentralizing, decarbonizing, digitalizing, and democratizing of our energy systems ([10]; van Dinther and Madlener, 2022). Collectively, these ideas are known as the "four Ds," and they are especially apparent in the development of LSGs in places like the UK and Canada. These projects use advances in smart technology and storage to grow local renewable energy capacity and "electrify everything" (Bacekovic and Ostergaard, 2018; [5]).

It is within the context of these new energy systems, and a growing interest in "the four Ds," that we conducted a study which assessed the importance of these ideas in two countries that

Table 4. Support for each of the "four Ds" in the UK and Canada.

	Strongly support	Tend to support	No feelings either way	Tend to oppose	Strongly oppose	Mean response	Std. Dev.
Decarbonization							
UK ($n = 2976$)	42.1	36.0	18.5	2.3	1.1	1.84	.878
Canada ($n = 913$)	40.9	36.8	16.4	3.5	2.4	1.90 ($P = .052$)	.959
Decentralization							
UK ($n = 2919$)	27.3	41.2	27.1	3.0	1.3	2.10	.878
Canada ($n = 899$)	28.0	39.3	26.3	4.8	1.7	2.13 ($P = .181$)	.932
Democratization							
UK ($n = 2870$)	20.3	39.3	30.7	7.0	2.7	2.33	.964
Canada ($n = 880$)	26.9	41.5	25.2	4.7	1.7	2.13A[a]	.920
Digitalization							
UK ($n = 2910$)	27	35.8	25	8.3	3.9	2.26	1.07
Canada ($n = 893$)	29.7	38.5	23.2	5.8	2.8	2.14[a]	.998

[a] ($P = <.001$).

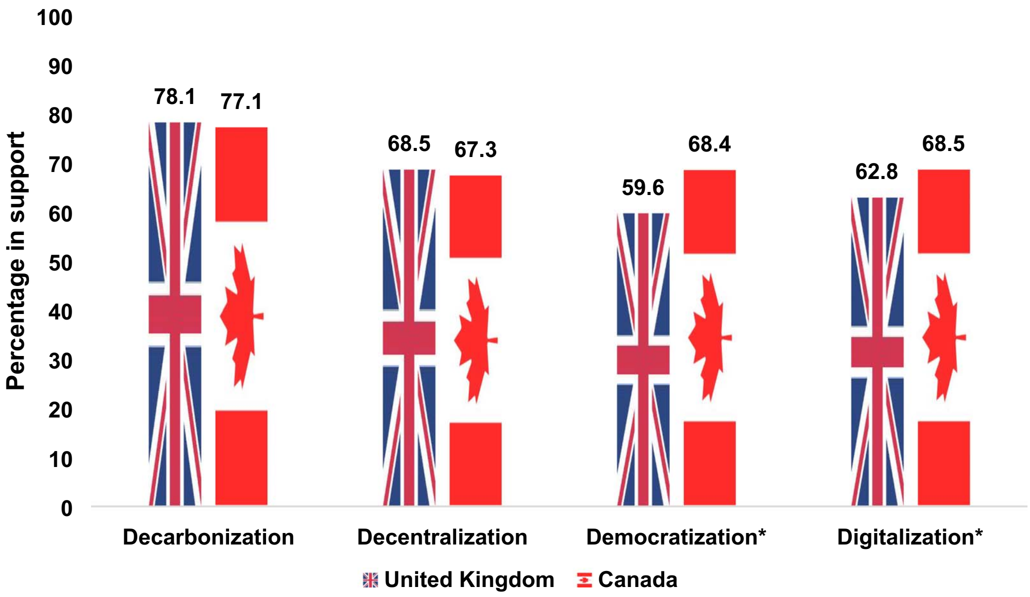

Figure 2. Support for each of the "four Ds" of energy system change in the UK and Canada (*statistically significant difference based on *t*-tests of means; $P < .05$).

are moving forward with government-supported, innovative LSG projects: the UK and Canada. In line with our three research questions, we aimed to: (i) determine levels of support for LSG projects; (ii) determine levels of support for each of the "four Ds"; and (iii) with a focus on the "four Ds," explore what factors best explain support for these new local energy systems. We answered these questions via the analysis of two nearly identical online national surveys from the UK ($n = 3034$) and Canada ($n = 941$). In doing so, we answer a few different calls for future research, including from Devine-Wright (2019) who questions about whether moves toward the local energy will be supported by the public, and from Ford *et al.* [1] who call for more evidence focused on better understanding of the public perceptions of local energy system projects.

Our findings highlight the overall high support for new local energy systems (i.e. between 66.5% and 76.3%)—with significantly higher levels of support at both local and national levels in Canada. This suggests that people are generally keen to accept or more actively support LSG projects and associated energy system change. Especially, when looking at the similar regression results in both countries, why this was the case is a difficult question to answer. The difference could be attributed to the timing of the surveys (i.e. 2021 in the UK, 2022 in Canada; see more below), or more cultural or political factors [86] such as electricity being of subnational jurisdiction in Canada [29]. An interesting element of the overall support responses in both countries was the high number of people who indicated "no feelings either way" (~27% in the UK and 20% in Canada) regarding support at the local and national levels. Whether this suggests true ambivalence or uncertainly is an interesting question in and of itself, and with a focus on the Canada sample, is explored in a companion paper [125]. What exactly public engagement in complex energy projects (like LSGs) might look like in the context of potentially high levels of ambiguity should be a point of focus for researchers moving forward.

Table 5. UK dataset: four-stage regression model with "combined support" as the DV.

	Model 1	Model 2	Model 3	Model 4
The "four Ds" of energy transitions				
Decarbonization	.163[a]	.120[a]	.121[a]	.119[a]
Decentralization	.240[a]	.231[a]	.230[a]	.228[a]
Digitalization	.151[a]	.108[a]	.105[a]	.110[a]
Democratization	.402[a]	.377[a]	.374[a]	.370[a]
Model 1: r^2 = .618 (adj. = .617)				
Energy preferences and attitudes				
Satisfaction with current energy		−.006	−0.015	−.016
Price (energy bills as low as possible)		.031	.032	.031
Reliability (reliable energy without blackouts)		−.038	−.040	−.040
Comfort in sharing data (with anyone)		.047[a]	.045[a]	.046[a]
Concern about climate change		.090[a]	.086[a]	.086[a]
Excitement about new technology		.065[a]	.058[a]	.073[a]
Model 2: r^2 = .630 (adj. = .628)				
National and local context				
Community type (urban–remote)			−.001	.005
Presence of at least one LSG element (e.g. solar panels)			−.020	−.027
Sense of community (index)			−.026	−.025
Feeling like a citizen of the UK			.019	.014
Model 3: r^2 = .632 (adj. = .629)				
Demographics				
Age				−.026
Gender (binary)				−.005
Home ownership status (binary)				.004
Education (highest educational level)				.006
Household income				.045[a]
Political affiliation (Conservative/UKIP/Reform/Brexit/DUP, Lib Dem, Labor)				.001
Model 4: r^2 = .635 (adj. = .630)				

[a]Statistically significant at the $P < .01$ level. [b]Statistically significant at the $P < .05$ level.

On levels of support for each of the "four Ds," again support is high in both countries. In the UK, support is highest for decarbonization (78.1%), followed by decentralization (68.5%), digitalization (62.8%), and democratization (59.3%)—where nearly 31% responded about "no feelings either way." Support for decarbonization was similarly the highest of the "four Ds" in Canada (77.7%), while the other three, democratization (68.4%), digitalization (68.2%), and decentralization (67.3%), were much closer together. That support for decarbonization and democratization were the two most supported of the "four Ds" in Canada aligns with the suggestions from Peters *et al.* (2018) who wrote that in order to increase acceptance, smart grid projects should be framed around environmental- and engagement-related goals. Compared with the UK sample, mean responses of support for democratization ($P = <.001$) and digitalization ($P = <.001$) were significantly higher in the Canada sample. Therefore, it is in Canada where these two newest energy trends appear to have gathered the highest level of support to date. As was not the goal here, it is again difficult to tease out answers to the "why," though this might be related to the practical and political factors described above.

Looking at the results from each of the "four Ds" and their connections to the established literature, we see some alignment and some divergence with existing trends. On decentralization, survey results showcased a supportive public in both the UK and Canada as well as strong associations with combined support in both regression analyses. These results are difficult to connect with existing studies as little research directly looks at decentralization and support for energy system change. More often, it is the characteristics that are assumed to come alongside DE projects (i.e. more democratized, or citizen-led development patterns) that are studied with relation to support. The best alignment between our findings and the literature can be seen through a recent paper from Brisbois [29], whose work in the UK, Canada, and the Netherlands showed that among industry and governments, there is increasing acceptance of DE projects as "an inevitable future state." This acceptance and support for energy system change—in the way we described it to survey respondents—may be slowly and indirectly trickling down to everyday citizens in the UK and Canada. It might be that as people become more familiar with DE projects seen in their communities, support increases as well [87]. If so, this bodes well for the future of public support for these new energy systems and their individual components.

Findings related to decarbonization showed the highest levels of support of any of the "four Ds" (77.7%+) and no statistically significant differences between Canada and the UK. Canada had 5.9% of respondents opposed to decarbonization, which was higher than the 3.4% in the UK. These results are important though once again difficult to connect with existing research that took the approach we did here. Indeed, like the research literature focused specifically on decentralization, there is very little research we can find that looks to see the impact of support for decarbonization on support for local energy system change. More often, studies look at decarbonized energy projects

Table 6. Canada dataset: Four-stage regression model with "combined support" as the DV.

	Model 1	Model 2	Model 3	Model 4
The "four Ds" of energy transitions				
Decarbonization	.171[a]	.094[b]	.095[a]	.094[b]
Decentralization	.268[a]	.237[a]	.237[a]	.234[a]
Digitalization	.124[a]	.061	.061	.066
Democratization	.337[a]	.315[a]	.311[a]	.308[a]
Model 1: $r^2 = .505$ (adj. = .502)				
Energy preferences and attitudes				
Satisfaction with current energy		.075[a]	.060[b]	.062[b]
Price (energy bills as low as possible)		.004	.001	−.002
Reliability (reliable energy without blackouts)		.039	.033	.041
Comfort in sharing data (with anyone)		.083[a]	.081[a]	.081[a]
Concern about climate change		.125[a]	.111[a]	.112[a]
Excitement about new technology		.070[b]	.056	.051
Model 2: $r^2 = .535$ (adj. = .528)				
National and local context				
Community type (urban–remote)			−.005	−.004
Presence of at least one LSG element (e.g. solar panels)			−.017	−.017
Sense of community (index)			−.043	−.045
Feeling like a citizen of Canada			.032	.035
Model 3: $r^2 = .537$ (adj. = .528)				
Demographics				
Age				.021
Gender (binary)				.012
Home ownership status (binary)				−.004
Education (highest educational level)				.033
Household income				.017
Political affiliation (Conservative/PPC, Liberal, NDP)				−.012
Model 4: $r^2 = .540$ (adj. = .525)				

[a]Statistically significant at the $P < .01$ level.
[b]Statistically significant at the $P < .05$ level.

(i.e. wind farms) and local support, but with factors like odors, health concerns, noise, landscape changes, and distributive and procedural injustice being most responsible for such responses [13, 39].

On digitalization, while displaying some of the highest mean responses of all the "four Ds" (2.26 in UK; 2.14 in Canada), the support was still high—at between 62.8% (UK) and 68.2% (Canada). In the regression models, digitalization was a significant variable in the much larger UK sample, but not the Canada sample. These results are, in part, difficult to contextualize, given the lack of research looking at support for digitalization and its effect on support for an overall energy system change. However, we do know that opposition to such new and smart technologies can often be seen and is driven by things like a lack of education, fixed lifestyles, and the idea that they will only benefit the "elite" [46]. What recent research does show us is that these new technologies are more likely to be accepted if they are led by local citizens who have decision-making power [47]. Our research here is novel in a sense that it shows that digitalization may have a modest effect on the overall support for energy system change.

Finally, on democratization [10, 49], we once again see strong support (59.6%+) among both countries alongside elevated levels of either ambivalence or indecision ("no feelings either way"). With a mean difference of 0.20, this variable represented the largest difference between the survey results from the UK (2.33) and Canada (2.13). That is, those in Canada were much more likely to indicate support for more local control of energy systems—a topic further explored in a companion paper [125]. (In that paper, we focus on the Canadian sample to better understand the dynamics of energy democracy in the context of LSG development, including the kinds of actions people are interested in.) How much this is due to citizens' perceptions of local and how that may interact with the size of Canada versus the UK (i.e. ∼40× larger) are interesting questions for future qualitative research in this area. This difference also may be due to a range of other factors, including local or community cohesion.

Within the regression analyses focused on each country, we created an indexed DV which combined responses to questions of local and national support for new LSG projects (see Table 2). When looking at the analysis from each of the two samples, we see some common trends, including the importance of decentralization and democratization in shaping support. For the UK regression, all four of the "four Ds," as well as comfort in sharing data, concern about climate change, and excitement about new technology, are statistically significant through the second, third, and fourth models. Therefore in the end, decarbonization ($P = <.001$), decentralization ($P = <.001$), digitalization ($P = <.001$), democratization ($P = <.001$; largest Beta at 0.370), comfort in sharing data ($P = <.001$), concern about climate change ($P = <.001$), excitement about new technology ($P = <.001$), and income

(P = <.001) were significant in shaping the overall support in the UK. Of special note, none of the four variables related to national and local contexts and only one of the six demographic variables (income) were significant in the final model.

For the Canada sample, decarbonization, decentralization, democratization, satisfaction, comfort in sharing data, and concern about climate change were shown to be significant predictors of combined support through the second, third, and fourth regression models. Though the Beta was small, satisfaction with current energy systems was positively associated with support for local energy system change—a key and surprising difference in comparison with the UK data. Not a single variable associated with national and local contexts or demographics was shown to be significant through any model.

Across both countries, the democratization variable was the most significant predictor of combined support throughout all eight regression models. With Betas between .402 and .337, we can confidently say that this variable had the strongest influence of any of the "four Ds"—and indeed any variable included in our models. This is not surprising at all, as through our reading of the literature, we learned of the power of energy democracy (Szulecki and Overland, 2020; [14]), democratic decision-making (Van Veelan and Van Der Horst, 2018; [52]), and elements of what some researchers are labeling as procedural justice [11, 13]. As mentioned above, even in research about the other "three Ds," researchers would often cite how important democratic ways of developing decarbonized, decentralized, and/or digitalized energy systems are [13, 47]. Just how important this idea of democratic decision-making might be toward the overall support for energy system change is something we hope the reader takes away from this study.

In terms of our study's major contributions, we have identified several contributions which add to our existing knowledge base around new, local, and innovative energy systems and public opinion. On the most general level, our study has added important social scientific insights in the study of LSGs, SLES, and synonymous projects [3, 4]. Apart from our companion study [125], we can find no peer-reviewed published research focused on nationally representative, public views toward this kind of smart and local energy transition. That we do so across two countries with distinct cultural, geographic, demographic, political, and energy system differences helps us to better contextualize the findings from each. Early evidence from the social scientific LSG literature (i.e. [2, 54, 126]) suggests that projects are not being developed in line with what might be expected, given the label of local- or place-based names that are given to most projects. That is, they are not being developed as locally driven or community-based projects—as some locals may hope or even demand. Not doing so incurs risks of the mistakes of energy projects of the past, most notably renewable energy projects like wind farms that have created significant waves of opposition and threatened the future of important climate policies [11, 13]. The right kind of local engagement, participation, and opportunities for ownership (i.e. the kind that are bottom-up, inclusive, and accessible) is key for ensuring projects like the ones studied here are supported over the long term. We believe an important first step is about listening to the public and determining their overall views toward the (energy) changes that may soon be coming.

While our work was not focused on themes of energy justice and equity (as in [9]), our analysis that showed an overwhelming overall support for energy system change and all "four Ds"—including more democratization of energy. Additionally, of all possible justice or equity-related variables, only the variable of income, in the UK sample, was a significant predictor of combined support for energy system change. This suggests significantly more support for energy system change at lower levels of income (beta = .045). However especially as this was not our focus, more work is needed in the area, including analysis that draws from this large and crossnational dataset.

Regarding our regression analysis, it was interesting that both decentralization and democratization were significant in our model of combined support as a DV. This suggests that these two "Ds"—plus digitalization in the UK—are important factors shaping the support for local energy system change in both countries studied here. Indeed, if we dig deeper into the data, we can see, for example, much stronger correlations between democratization and combined support (r = .684; P = .000) than decarbonization and combined support (r = 527; P = <.001) in an overall sample of UK and Canada responses (n = 3975). Another way to look at these relationships is through looking at the small number of responses that indicated opposition toward each of the "four Ds" and combined opposition toward new local energy projects. Thus, while the support for decarbonization is associated with support for an overall energy system change, the relative influence of the other three "Ds"—and democratization and decentralization in particular—is much more important.

We have identified several limitations of the study presented here, some of which present important opportunities for future research in this area. The first relates to the fact that the UK data was collected in Spring 2021 and the Canada data a year later in 2022. While this difference may not typically be too significant, Russia's invasion of Ukraine and the subsequent rise in the cost of energy (of all kinds) around the world may have influenced peoples' responses. Indeed, research published following our data collection [88, 101] has shown that the conflict may be increasing the public's confidence and support for green/clean energy transitions. For our study, this trend may help partially explain why we saw significantly higher support for new energy systems in Canada. The years 2021 and 2022 also represented the years of the COVID-19 pandemic, which may have influenced respondents' understanding of the climate crisis and support for new kinds of energy systems [89]. We suggest that future quantitative and qualitative research needs to be completed to tease out these ideas in more detail. A second limitation is related to the number of survey responses that indicated "no response either way" (i.e. between ∼16% and 30%). Whether to include and how to treat such neutral responses are questions that have been debated in the methodological literature—with some suggesting its value in avoiding false responses [90, 91] and others writing that its inclusion is more likely to elicit neutral responses when people actually do have an opinion [92, 93, 98]. Our choice to include these responses as "neutral" no doubt influenced the findings presented here.

Conclusion

Our goal in this study was to advance a much-needed understanding of public opinion toward LSG project development—both in their local area and the wider context of the UK and Canada. We were able to do so through two nearly identical online and nationally representative surveys. Data was collected in Spring 2021 (UK) and Spring 2022 (Canada). What we currently know about these projects in terms of a social scientific understanding is limited to mostly qualitative and desktop research that have yet to capture the views of citizens to any great extent. The crossnational nature of our analysis, wherein we saw higher levels of support for energy system change in Canada, further increases the value of this research. Lastly, in terms of take-home messages, our results show the importance of support for two of the "four Ds" (decentralization and democratization) in shaping the overall support for smart and local energy system change—with support for digitalization showing a modest influence in the larger UK sample. Combined with the well-established literature looking at support for clean and renewable energy projects, we suggest that if governments, developers, and other stakeholder want to maximize support for these upcoming changes, democratizing energy is a key part of the solution. This is partially because one could argue that the changes associated with the other "three Ds" are inevitable. We will see energy systems becoming cleaner (decarbonized), closer to local areas (decentralized), and utilizing more smart technology (digitalization). However how much local control, decision-making ability, ownership opportunities, and associated benefits host communities will have is still a great uncertainty. We suggest that multiple groups of people, from academics and community groups to local and national governments, pay due attention to ensuring that local communities playing home to such fundamental and rapid energy system change are empowered and supported to democratize energy as they see fit.

Author contributions

Chad Walker (Conceptualization [Equal], Data curation [Lead], Formal analysis [Lead], Methodology [Lead], Project administration [Equal], Resources [Equal], Software [Lead], Validation [Lead], Visualization [Lead], Writing—original draft [Lead], Writing—review & editing [Lead]), Ian H. Rowlands (Funding acquisition [Equal], Methodology [Lead], Project administration [Supporting], Resources [Equal], Software [Supporting], Supervision [Lead], Validation [Supporting], Writing—review & editing [Supporting]), Patrick Devine-Wright (Conceptualization [Lead], Formal analysis [Supporting], Funding acquisition [Lead], Investigation [Lead], Methodology [Lead], Project administration [Lead], Resources [Equal], Supervision [Lead], Writing—original draft [Supporting], Writing—review & editing [Supporting]), Iain Soutar (Formal analysis [Supporting], Investigation [Supporting], Methodology [Supporting], Project administration [Supporting], Validation [Supporting], Writing—original draft [Supporting], Writing—review & editing [Supporting]), Charlie Wilson (Conceptualization [Supporting], Funding acquisition [Supporting], Investigation [Supporting], Methodology [Supporting], Supervision [Supporting], Validation [Equal], Writing—original draft [Supporting], Writing—review & editing [Supporting]), Rajat Gupta (Conceptualization [Supporting], Funding acquisition [Equal], Investigation [Supporting], Methodology [Supporting], Project administration [Supporting], Validation [Supporting], Writing—original draft [Supporting], Writing—review & editing [Supporting]), Hannah Devine-Wright (Conceptualization [Supporting], Formal analysis [Supporting], Investigation [Supporting], Methodology [Supporting], Validation [Supporting]), Juli Bishwokarma (Investigation [Supporting], Project administration [Supporting], Writing—original draft [Equal], and Rebecca Ford (Conceptualization [Supporting], Funding acquisition [Equal], Investigation [Supporting], Project administration [Equal]).

Conflict of interest statement

None declared.

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Data availability

This study's data are not available to be shared.

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Appendix 1

A Canada-wide survey to better understand public perceptions of smart and local energy systems

Introduction

Welcome to a survey being conducted by Chad Walker and Ian Rowlands of the University of Waterloo. They are members of a research team based out of the (School of Environment, Resources and Sustainability).

For this survey, we would like to explore your opinions on emerging energy systems in Canada. We value your time and hope you will enjoy taking part!

We expect the survey will take ∼15–20 min. It is conducted according to the Tri-Council Policy Statement and has ethics approval from the University of Waterloo..

The questions ask about your views on energy in Canada. There are no right or wrong answers; all views are important to us, so please answer all questions as best you can.

Please review the following before proceeding to the survey (please initial each box If you agree):

(1) I confirm that I have read the information sheet for the above project. I have had the opportunity to consider the information in full.
(2) I understand that my participation is voluntary and that I am free to withdraw at any time before the survey is complete.
(3) I understand that relevant sections of the anonymized data collected during the survey may be looked at by (Names, names, and their colleagues in the UK).
(4) I understand that taking part involves anonymized survey responses to be used for the purposes of data analysis and inclusion in a secure research archive.
(5) I understand that taking part means that the data collected will be used in reports published in academic and other (i.e. media and blog posts) publications.
(6) I understand that taking part means that the data collected may be used in teaching or training materials for use in University activities and/or public engagement activities.
(7) I agree to take part in the above project.

__________________ __________________

Date Virtual

START OF SURVEY.

1. Which of the following describes where you live?

1) Ontario
2) Quebec
3) British Columbia
4) Alberta
5) Manitoba
6) Saskatchewan
7) Nova Scotia
8) New Brunswick
9) Newfoundland and Labrador
10) Prince Edward Island

2. Which of these age groups do you belong to?

1) 18–24
2) 25–34
3) 35–44
4) 45–54
5) 55–64
6) 65–74
7) 75+

3. Which of the following describes how you think of yourself?

1) Male
2) Female
3) In another way ____________

4. Which of these applies to your home? Please select one only.

1) I am the sole owner (either with or without a mortgage)
2) I own it with someone else (either with or without a mortgage)

3) I live in public, subsidized, or government-assisted housing
4) I live in privately rented accommodation
5) I am the sole owner in a shared ownership program or co-op
6) I live in my parents' (or parent's) home
7) I live in my friend's/relative's/partner's home
8) I own it with someone else in a shared ownership program or co-op
9) Other situation

5. How would you describe the type of area you live in? Please select one only.

1) Urban—downtown/city center
2) Urban—not downtown
3) Suburban
4) Rural
5) Remote
6) Other ____________

6. How would you describe the occupation type of the main income earner in your household? Please select one.

Occupation type	(Check here)
Management occupations	
Business, finance, and administration occupations	
Natural and applied sciences and related occupation	
Health occupations	
Occupations in education, law and social, community, and government services	
Occupations in art, culture, recreation, and sport	
Sales and service occupations	
Trades, transport and equipment operators, and related occupations	
Natural resources, agriculture, and related production occupations	
Occupations in manufacturing and utilities	
Unemployed	
Retired	
Student	
Prefer not to say	

7. What is the highest level of education you have reached? Please select one.

1) No formal schooling
2) Elementary school
3) Secondary or high school diploma
4) Apprenticeship or other trade's certificate
5) College diploma
6) University (below bachelor's degree)
7) University (bachelor's degree)
8) University (higher than bachelor's; e.g. masters and doctorate)

8. What is your household's total annual gross income (i.e. before tax)? Please include any pensions and benefits received. Please select one.

1) <$10 000 (including loss)
2) $10 000–$19 999
3) $20 000–$29 999
4) $30 000–$39 999
5) $40 000–$49 999
6) $50 000–$59 999
7) $60 000–$79 999
8) $80 000–$99 999
9) ≥$100 000
10) Don't know
11) Prefer not to say

9. Please could you tell me which of the following statements best applies to you?

1) I have sole responsibility for choosing the electricity/energy supplier in my household
2) I have joint responsibility for choosing the electricity/energy supplier in my household
3) I have no responsibility for choosing the electricity/energy supplier in my household (e.g. someone else in the household makes the decision, or your bills are covered within your service charge or rent)
4) Don't know

10. My political affiliation is most closely associated with the _____ party.

1) Conservative or Progressive Conservative
2) Liberal
3) New Democrat (NDP)
4) Bloc Québécois
5) Green
6) People's Party of Canada
7) Other ____________
8) I do not associate with any party
9) Prefer not to say

11. Before we introduce the full survey, we have an open-ended question for you:
When you see the phrase **Local Energy**, what immediate thoughts or ideas, if any, come to your mind? (write in all areas below).

A) **Introduction to Energy Systems**

Next, we would like to ask you a few questions about your current energy situation and preferences.
A1. How satisfied or dissatisfied are you with the overall service you receive from your current electricity/energy supplier(s)? Please select one.

1) Very satisfied
2) Fairly satisfied
3) Neither satisfied nor dissatisfied
4) Fairly dissatisfied
5) Very dissatisfied

A2. Have you ever switched your electricity/energy supplier(s)?

1) Yes, often
2) Yes, rarely
3) No
4) Not sure

A3. When you think about **the Canadian energy system as a whole**, how important are each of these priorities? Please select one for each statement.

(ROTATE OPTIONS)	Very important	Somewhat important	Neither important nor unimportant	Somewhat unimportant	Very unimportant	Don't know
Keeping energy bills as low as possible						
Tackling climate change by reducing the use of fossil-fuels such as oil and gas						
Ensuring a reliable energy system without blackouts						
Reducing energy imports from outside of Canada						

Introduction to Local Energy
Throughout the survey, you will see the words "Local" and "local area."
Please take these words to mean whatever best fits your own understanding of "local" and "local area." This might be the city, town, or village that you live in.
Currently, Canada has an energy system where electricity is mostly generated in large power stations located far away from where most people live. Electrical grids deliver this electricity to where it is used. The natural gas and oil that we use to meet some energy

demand (e.g. heat buildings) come partly from Western Canada and also from the USA. Finally, the gasoline and diesel that we use to fuel our vehicles are often imported from other Canadian provinces and sometimes from other much more distant countries.

Local Energy would involve a change to this system. Electricity and heat would mostly be generated using renewable energy (i.e. solar or wind) in the same city, town, or village that you live in. Cars would be powered by locally generated electricity, and their electric batteries would be used in ways that make the local grid work best, for example, storing electricity when renewable energy is abundant (e.g. on a sunny day) and releasing it into the local grid when it might be scarce (e.g. when dark at night). Energy would be managed by local organizations, for example, electricity would be sold to you by local people and businesses.

The "four Ds" of new Local Energy systems.

We can describe the potential changes in Local Energy systems as the "four Ds"—Decarbonized, Decentralized, Digitalized, and Democratized. The questions below deal with each theme separately.

B. The first D of Local Energy is DECARBONIZATION

This means reducing greenhouse gas emissions from electricity, heat, and transport. The Canadian and provincial/territorial governments have set targets for reducing emissions that contribute to global warming. To meet these targets, they propose the following:

(1) To increase the use of renewable energy sources (i.e. wind, solar, and hydro) to generate electricity.

(2) To reduce the use of natural gas and oil for heating buildings and for industry.

(3) To stop the use of gasoline and diesel for transport and instead switch to electric vehicles or other "green fuels" (e.g. hydrogen).

B4. Which of the following, if any, do you already have . . .

(ROTATE OPTIONS)	Yes	No	Don't know
Renewable energy installed in the building where I live (e.g. solar panel)			
An electric vehicle			
Entire-home electric heating (e.g. air source heat pump)			
Household green energy contract (i.e. sourced from utility company) OR renewable energy certificates			

B5. Overall, to what extent do you support or oppose reducing greenhouse gas emissions from electricity, heating, and transport **in Canada**? Please select one.

1) Strongly support
2) Tend to support
3) No feelings either way
4) Tend to oppose
5) Strongly oppose
6) Don't know

B6. When thinking about **your local area**, to what extent do you support or oppose each of the three ways to reduce greenhouse gas emissions below. Please select one for each statement.

Random order In my local area	Strongly support	Tend to support	No feelings either way	Tend to oppose	Strongly oppose	Don't know
Reducing the use of **NATURAL GAS AND OIL IN** heating and industry						
Stopping the use of **GASOLINE AND DIESEL** in transport						
Increasing **RENEWABLE ENERGY** in electricity generation						

Local Energy systems will use renewable energy much more than our current energy system. This means that they will need to use new technologies to manage energy sources that are variable—sometimes plentiful and sometimes scarce.

One way to do this is to use **large household or neighborhood-scale batteries**. Batteries can help to store electricity when renewable energy is abundant (like a sunny day) and share it locally when there is less available (like at night). This would also help to level the "highs" (lots of people using electricity) and "lows" (fewer people using electricity) of electricity usage, which means less reliance on large, distant, and often polluting backup power stations in Canada.

Another way that Local Energy systems reduce emissions would be to have **heat pumps** installed in houses or buildings. Heat pumps replace gas/oil furnaces and boilers by using local renewable energy to move warmer underground or outside air into your home.

A third way that Local Energy systems reduce emissions would be to introduce more **electric vehicles** to replace gasoline or diesel vehicles. Local Energy systems will not produce electric vehicles, but they may introduce ways to make them easier to use or to own.

This includes leasing programs or car clubs. The batteries in electric vehicles may also serve as a way to store and share local renewable energy when not in use.

B8. When thinking about **Canada**, to what extent do you support or oppose these ways that Local Energy systems might reduce emissions from electricity, heat, and transport? Please select one.

1) Strongly support
2) Tend to support
3) No feelings either way
4) Tend to oppose
5) Strongly oppose
6) Don't know

B9. When thinking about **your local area**, to what extent would you support or oppose each of these ways that Local Energy systems might reduce emissions? Please select one for each statement.

Random order In my local area ...	Strongly support	Tend to support	No feelings either way	Tend to oppose	Strongly oppose	Don't know
New **household or neighborhood BATTERIES** which can store electricity when renewable energy is plentiful and release it when energy is scarce						
New **HEAT PUMPS** which replace gas/oil furnaces and boilers and heat homes using warmer air in the ground or the air						
New programs to help increase the ownership and use of **ELECTRIC VEHICLES** like leasing and electric car clubs						

C. The second D of Local Energy is DECENTRALIZATION

Currently, in Canada, we get our electricity mostly from large, distant power stations that use hydro, nuclear, natural gas, and we often heat our homes via national and regional gas/oil networks, and we power our vehicles using gasoline and diesel from across Canada and around the world. Local Energy systems would make the energy system closer to where we live by using locally available renewable energy to generate electricity or heat and to power vehicles for transport.

C10. To what extent would you support or oppose a change from a mostly large-scale and distant energy system to a smaller scale and more local energy system? Please select one.

1) Strongly support
2) Tend to support
3) No feelings either way
4) Tend to oppose
5) Strongly oppose
6) Don't know

C11. Looking at the **electricity system as a whole in Canada**, which of the following options do you prefer? Please select one.

1) A distant energy system involving a small number of large power stations located far away from where energy is used
2) A local energy system involving a large number of small power stations located close to where energy is used
3) A mix of the two (1 and 2)
4) Don't know

C12. Where would you prefer the electricity that you use **in your home** to come from? Please select one.

1) From my own home or building
2) From my neighborhood or village
3) From other parts of my town or city
4) From somewhere else in my region (e.g. from somewhere else in Southwestern Ontario, and Southern Alberta)
5) From somewhere else in my province or territory
6) From somewhere else in Canada
7) From outside Canada
8) No preference

C13. If energy systems become more local, then electricity, heating, and transport could become more integrated—working WITH each other to balance energy supply and use.

For example, electricity generated from neighborhood solar panels could be stored in a local battery and used when needed for local electric heating and/or electric transport.

If energy systems become more integrated in the future, to what extent would you support or oppose this increased integration in the following areas? Please select one for each area.

	Strongly support	Tend to support	No feelings either way	Tend to oppose	Strongly oppose	Don't know
In my own home						
In my neighborhood or village						
In other parts of my town or city						
In my region (e.g. Southwestern Ontario and Southern Alberta)						

C14. To what extent do you agree or disagree with the following statements? (Please select one for each statement).

I wish my local area was ...	Strongly agree	Tend to agree	Neither agree nor disagree	Tend to disagree	Strongly disagree	Don't know
Less reliant on regional energy networks (e.g. regional gas networks)						
Less reliant on national energy networks (e.g. gasoline produced far away from my home)						
Less reliant on international energy networks (e.g. electricity cables between Canada and the USA)						

D. The third D of Local Energy is DIGITALIZATION

Digitalization means using "smart" technologies in energy systems. You can think of "smart" technologies as those like a smartphone or computer—they are connected to the internet and are able to send and receive information with other people and groups from around the world.

Examples of digital energy technologies include smart meters and smart thermostats. They can help to monitor use of electricity or heat; to predict patterns of use based on past behavior; to control when appliances come on or off during the day; and to control appliances remotely.

D15. Do you have a piece of digital or "smart" energy technology (examples: smart meter, smart thermostat, smart electric vehicle charger, or something similar) installed in your home right now?

1) Yes
2) No
3) Don't know

D16. When thinking about **Canada as a whole**, to what extent would you support or oppose a change to using digital or "smart" technologies in energy systems?

1. Strongly support
2. Tend to support
3. No feelings either way
4. Tend to oppose
5. Strongly oppose
6. Don't know

D17. When thinking about **Canada as a whole**, to what extent would you support or oppose the use of digital energy technology in each of the three areas below? Please select one for each statement.

	Strongly support	Tend to support	No feelings either way	Tend to oppose	Strongly oppose	Don't know
Electricity (e.g. technology that controls appliances remotely)						
Home heating (e.g. smart thermostats that monitor and learn patterns of heat use)						
Transport (e.g. smart electric vehicle chargers that are timed with electricity grid networks)						

D18. When thinking about **your local area**, to what extent would you support or oppose the use of digital energy technology in each of the three areas below? Please select one for each statement.

	Strongly support	Tend to support	No feelings either way	Tend to oppose	Strongly oppose	Don't know
Electricity (e.g. technology that controls appliances remotely)						
Home heating (e.g. smart thermostats that monitor and learn patterns of heat use)						
Transport (e.g. smart electric vehicle chargers that are timed with electricity grid networks)						

D19. To what extent do you agree or disagree with the following potential BENEFITS and RISKS of digital/smart technologies **in the Canadian energy system**? (Randomize order):

	Strongly agree	Tend to agree	Neither agree nor disagree	Tend to disagree	Strongly disagree	Don't know
Enables me to have more control over energy systems						
Keeps benefits of energy systems in my local area						
Helps to lower my energy bills						
Would reduce my privacy						
Would increase community tensions in my local area						
Would increase local use of renewable energy						
Would decrease the chance of a shortage of power in my local area						

D20. One of the most common concerns regarding digital technology (like smart meters) in local areas is that energy usage and personal data may need to be shared with other groups.

Assuming energy usage and some personal data need to be shared in new Local Energy systems, which groups, if any, would you be comfortable to share your energy data with? (Check all that apply)

1) My local municipal council (city or county)
2) A local community energy group
3) Local businesses
4) University researchers
5) Canadian energy businesses or utilities
6) The Canadian (federal) government
7) My Provincial/Territorial government
8) I would not be comfortable sharing my data with any of these groups
9) Others (please specify)______________
10) Don't know

D21. Digital technology can help energy supply and use to be more balanced, especially in a local system that uses a lot of renewable energy.

For example, it may help by turning on your washing machine earlier (or later) to help with energy system balance and emissions.

It may also let you know about **dynamic** Time of Use Prices—different rates for electricity use throughout the day. If the supply was predicted to be low, prices would be high. If supply shifted and became high, prices would be low or even negative (i.e. you would be paid for using energy).

Thinking about these two ideas above, how much do you support or oppose these changes **in Canada**?

ROTATE ORDER	Strongly support	Tend to support	No feelings either way	Tend to oppose	Strongly oppose	Don't know
Digital technology controlling certain appliances when it is best for the local energy system						
Time of Use Pricing where prices could be higher or lower depending on the supply of local renewable energy						

D22. Thinking about these two ideas above, how much do you support or oppose these changes **in your local area**?

ROTATE ORDER	Strongly support	Tend to support	No feelings either way	Tend to oppose	Strongly oppose	Don't know
Digital technology controlling certain appliances when it is best for the local energy system						
Time of Use Pricing where prices could be higher or lower depending on the supply of local renewable energy						

E. The fourth D in Local Energy is DEMOCRATIZATION

What we mean by this is the potential for more local control over energy systems. Right now, most of the energy systems in Canada are owned by a small number of large companies that are not based in people's local areas and most of the system is managed at the national or provincial/territorial levels. Local Energy systems allow for more participation and control by local councils, local businesses, and local community groups over how these systems work.

E22. To what extent would you support or oppose a change to more local control of energy systems **in Canada**?

1) Strongly support
2) Tend to support
3) No feelings either way
4) Tend to oppose
5) Strongly oppose
6) Don't know

E23. If a new Local Energy system was going to be developed **in your local area**, to what extent do you agree or disagree that each of the following groups should be involved?

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree	Don't know
My local municipal council (city or county)						
A local community energy group						
Local businesses						
University researchers						
Canadian businesses or utilities						
My provincial/territorial government						
The Canadian (federal) government						
Other (write in)						

E24. If a new Local Energy system was going to be developed **in your local area**, to what extent would you trust or distrust each of the following groups to effectively manage the energy system?

	Trust a lot	Trust a little	Neither trust or distrust	Distrust a little	Distrust a lot	Don't know
My local council (city or county)						
A local community energy group						
Local businesses						
University researchers						
Canadian businesses or utilities						
My provincial/territorial government						
The Canadian (federal) government						

Local Energy systems could allow local people like you to generate and store your own electricity (like through rooftop solar panels + a storage battery) and then buy and sell this energy with other people in your local area.

Local Energy systems could also promote the use of batteries in electric cars to help the local grid network. It would do this by offering car owners financial incentives to charge their car at a certain time of day when energy was plentiful or to release electricity from their car battery into the grid when energy was scarce.

E25. Thinking about these two ideas above, how much do you support or oppose these changes **in Canada**?

	Strongly support	Tend to support	No feelings either way	Tend to oppose	Strongly oppose	Don't know
Opportunities for people to buy and sell electricity with other people in their local area						
Opportunities for people to use electric car batteries to help manage the local grid network						

E26. Now thinking about **your local area**, how much do you support or oppose these changes?

	Strongly support	Tend to support	No feelings either way	Tend to oppose	Strongly oppose	Don't know
Opportunities for me to buy and sell electricity with other people in my local area						
Opportunities for me to use an electric car battery to help manage the local grid network						

E27. Personally, how interested would you be in taking part in an energy trading program with each of the three groups below?

	Very interested	Moderately interested	Slightly interested	Not at all interested	Don't know
My neighbors					
Other people in my village/city/town					
Other people in my region (e.g. Southwestern Ontario and Southern Alberta					

E28. How important do you think it is that LOCAL RESIDENTS have the chance to meaningfully participate in the development of new Local Energy systems **in Canada**?

1) Extremely important
2) Somewhat important
3) Neither important nor unimportant
4) Somewhat unimportant
5) Extremely unimportant
6) Don't know

E29. If a Local Energy system was being developed **in your local area**, how important is it that **YOU YOURSELF** have the chance to meaningfully participate in the development of the new Local Energy System?

1. Extremely important
2. Somewhat important
3. Neither important nor unimportant
4. Somewhat unimportant
5. Extremely unimportant
6. Don't know

E30. **When thinking about Canada as a whole**, how important is it that the benefits from Local Energy systems stay in **local areas** compared with the **rest of Canada**?

1. All benefits should be kept in local areas only
2. Most benefits should be kept in local areas
3. There should be an even balance in sharing benefits between local areas and the rest of Canada
4. Most benefits should be shared across Canada
5. All benefits should be shared across Canada
6. Don't know

E31. When thinking about **your local area**, how important is it that the benefits from Local Energy systems stay in your **local area** compared with the **rest of Canada**?

1. All benefits should be kept in my local area only
2. Most benefits should be kept in my local area
3. There should be an even balance in sharing benefits between my local area and the rest of Canada
4. Most benefits should be shared across Canada
5. All benefits should be shared across Canada
6. Don't know

E32. If a new Local Energy system was being developed **in your local area**, which of the following actions might you consider doing (check all that apply):

1) Learning more about the project (e.g. by going to meetings or reading a website)
2) Trying to influence or shape the project with my views
3) Offering to be a technology host (e.g. solar panels on roof, battery in home, smart meter, and electric heating)
4) Buying and selling electricity with other local people
5) Using a battery to help manage the local grid network
6) Leasing an electric car for use when I need it
7) Investing my own money in a part of the system
8) Recommending the project to my friends or family
9) None of the above
10) Other (please specify) ___________________________

E33. What are your main motivations behind the action(s) identified in the previous question.

[ROTATE OPTIONS]

1) To support the project in being successful
2) To take part in a local initiative
3) To help strengthen the community
4) To gain a personal financial return on investment
5) To enable the community to gain a financial return
6) To help the environment (e.g. climate change)
7) To reduce the problem of local air pollution
8) Because others I know may have invested as well
9) Other _____________

F. Overall Support for Local Energy.

F34. When thinking about **Canada in general**, to what extent do you support or oppose the development of new Local Energy systems across the country?

1) Strongly support
2) Tend to support
3) No feelings either way
4) Tend to oppose
5) Strongly oppose

F35. When thinking about **your local area** in particular, to what extent would you support or oppose the development of a new Local Energy system for your area?

1) Strongly support
2) Tend to support
3) No feelings either way
4) Tend to oppose
5) Strongly oppose

F36. Imagine **your local area** 10 years from now. What parts of a local energy system would you like to see more of (compared with today)? (Check all that apply)

1) More renewable energy
2) More electric vehicle leasing programs
3) More electric heating systems (like air source heat pumps)
4) More in-home batteries (to store electricity)
5) More neighborhood-scale batteries (to store electricity)
6) More smart technologies (i.e. smart meters)
7) More use of Time of Use Pricing programs during the day and night
8) More opportunities to buy and sell electricity
9) More opportunities for electric cars to help with the local energy network

G. Sense of Community

Please answer the following questions about how you feel about the local area where you live. If you have more than one home, please answer based on where you spend most of your time.

G37. To what extent do you agree or disagree that:

[Randomize statements]	**Strongly agree**	**Moderately agree**	**Neither agree nor disagree**	**Moderately disagree**	**Strongly disagree**
I would regret having to move to another place					
This is my favorite place to live					
This place is a part of me					
This place says a lot about who I am					
This place is the best place for what I like to do					
No other place can compare to this place					

G38. How much do you see each of the following as important or central to your identity?

[Do not randomize statements]	**Extremely important**	**Somewhat important**	**Neither important nor unimportant**	**Somewhat unimportant**	**Extremely unimpor-tant**
Being a citizen of my province or territory					
Being a Canadian citizen					
Being a North American citizen					
Being a global citizen					

H. Final Section.

H40. How much do you **agree or disagree** with the following statements?

	Strongly agree	**Somewhat agree**	**Neither agree not disagree**	**Somewhat disagree**	**Strongly disagree**
I am concerned about climate change					
Individuals have a responsibility to tackle climate change					
Government and authorities have responsibility to tackle climate change					

H41. To what extent would you agree or disagree with the following statement: "I'm the kind of person who looks forward to new technology and gets excited to try them out."

1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

Appendix 2

UK sample characteristics

Gender (*n* = 3034)	**Frequency**	**% of sample**
Male	1516	50%
Female	1511	49.8%
Other	7	0.2%
Age (*n* = 3034)	**Frequency**	**% of sample**
18–24	152	5%
25–34	554	18.3%
35–44	440	14.5%
45–54	669	22.1%
55–64	553	18.2%
65–74	539	17.8%
75+	127	4.2%
Province (*n* = 3034)	**Frequency**	**% of sample**
England	2545	83.9%
Wales	150	4.9%
Scotland	239	7.9%
Northern Ireland	100	3.3%
Education (*n* = 3034)	**Frequency**	**% of sample**
No formal schooling	25	0.8%
Primary School	37	1.2%
Secondary School (e.g. O-Level and GCSE)	840	27.7%
Sixth Form/College (e.g. A-level and NVQ)	919	30.3%
Higher Education (e.g. bachelor’s degree)	892	29.4%
Postgraduate (e.g. masters and doctorate)	321	10.6%
Household income (before tax; *n* = 2793)	**Frequency**	**% of sample**
<£5000	88	3.2%
£5001—£10 000	166	5.9%
£10 001—£15 000	302	10.8%
£15 001—£20 000	304	10.9%
£20 001—£30 000	601	21.5%
£30 001—£50 000	671	24%
£50 001—£75 000	362	13%
£75 001—£100 000	190	6.8%
>£100 000	109	3.9%
Political affiliation (*n* = 3034; all responses)	**Frequency**	**% of sample**
Conservative	990	32.6%
Labor	776	25.6%
Liberal Democrat	181	6%
Scottish National Party of Plaid Cymru	109	3.6%
Green	126	4.2%
Other	68	2.2%
I do not associate with any party	681	22.4%
Prefer not to say	103	3.4%
Political affiliation (*n* = 2182; major five parties)	**Frequency**	**% of sample**
Conservative	990	45.4%
Labor	776	35.6%
Liberal Democrat	181	8.3%
Scottish National Party of Plaid Cymru	109	5%
Green	126	5.8%

Canada sample characteristics

Gender (n = 941)	**Frequency**	**% of sample**
Male	455	48.4%
Female	478	50.8%
Other	8	0.9%
Language (n = 941)	**Frequency**	**% of sample**
English	710	75.5%
French	231	24.5%
Age (n = 941)	**Frequency**	**% of sample**
18–24	104	11.1%
25–34	153	16.3%
35–44	166	17.6%
45–54	142	15.1%
55–64	160	17%
65–74	120	12.3%
75+	96	10.2%
Province (n = 941)	**Frequency**	**% of sample**
Ontario	344	36.6%
Quebec	229	24.3%
British Columbia	124	13.2%
Alberta	111	11.8%
Manitoba	33	3.5%
Saskatchewan	30	3.2%
Nova Scotia	28	3%
New Brunswick	23	2.4%
Newfoundland and Labrador	14	1.5%
Prince Edward Island	5	0.5%
Education (n = 941)	**Frequency**	**% of sample**
No formal schooling	11	1.2%
Elementary school	21	2.2%
No formal + elementary school	32	3.4%
Secondary or high school diploma	222	23.6%
Apprenticeship or other trade's certificate	85	9%
College diploma	188	20%
University (below bachelor's degree)	70	7.4%
University (bachelor's degree)	231	24.6%
University (higher than bachelor's; e.g. masters and doctorate)	113	12%
Household income (before tax; n = 906)	**Frequency**	**% of sample**
<$20 000	76	8.4%
$20 000—$29 999	92	10.2%
$30 000—$39 999	73	8.1%
$40 000—$49 999	90	9.9%
$50 000—$59 999	94	10.4%
$60 000—$79 999	128	14.1%
$80 000—$99 999	137	15.1%
$100 000—$149 999	139	15.3%
$150 000 and over	77	8.5%
Political affiliation (n = 941; all responses)	**Frequency**	**% of sample**
Conservative or Progressive Conservative	183	19.5%
Liberal	270	28.7%
New Democrat (NDP)	124	13.2%
Bloc Québécois	62	6.6%
Green	36	3.8%
People's Party of Canada	21	2.2%
Other	7	0.7%
I do not associate with any party	188	20%
Prefer not to say	50	5.3%

(Continued)

Continued

Gender (n = 941)	Frequency	% of sample
Political affiliation (n = 696; major six parties)	**Frequency**	**% of sample**
Conservative or Progressive Conservative	183	26.3%
Liberal	270	38.8%
New Democrat (NDP)	124	17.8%
Bloc Québécois	62	8.9%
Green	36	5.2%
People’s Party of Canada	21	3%