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Beneath your feet and in your place: Multi-scalar imaginaries of energy, place, and local geothermal development

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ABSTRACT

Research on responses to renewable energy has investigated both sociotechnical imaginaries and place imaginaries; however, interactions between competing visions of energy and place have received limited attention. This study investigates how multi-scalar imaginaries of energy and place interact within local context to shape negotiations of acceptability. In a case study of a campus Enhanced Geothermal Systems (EGS) project, document analysis of media coverage, PR materials, and policy documents are used 1. To identify imaginaries of place and energy present in public discourse across scales; and 2. To determine how multi-scalar imaginaries interact, align, and compete. Rhetoric links the EGS project with a national narrative of geothermal energy as limitless in potential, close at hand, and capable of ensuring national energy security. This geothermal imaginary is reinterpreted at different scales: regional decarbonization of heating in the Northeast, and campus climate leadership through scientific discovery. However, a local counter-narrative draws on place identity as a progressive college town and on local history with energy and extraction. A local vision of an urgent transition using a mix of tested technologies conflicts with the priorities of scientific exploration and intellectual leadership in the campus vision, which motivated the choice of a less mature technology. Multi-scalar imaginaries are embedded throughout public discourse on the EGS project, with misalignment between scales driving local perspectives toward the technology.

1. Introduction

Public attitudes toward new technologies have long been a matter of study, as has the problem of opposition to renewable energy development, but the question of what drives these reactions remains a massive challenge to overcome in addressing climate change. The contextual dimensions that impact public negotiations of acceptability have in particular received increasing attention in recent energy research. Two approaches that attempt to address the influence of context on energy transition pathways include the concept of sociotechnical imaginaries, drawn from science and technology studies, and place theory, particularly imaginaries of place and symbolic interpretations of place-technology fit [1,2]. While sociotechnical imaginaries – collectively-held visions of desirable futures and the desired role of technology [3] – have been applied as an explanation for differing trajectories of energy development at regional and national levels, place theory has most often been used to interpret local differences in acceptance or opposition.

Addressing how visions of energy futures are intertwined with ideas about place and scale is a critical step for understanding dynamics of energy transitions [4]. Multiple imaginaries of energy and place may be deployed by different actors to influence public attitudes and reactions to specific energy projects, and conflicting visions of energy and place may be strong drivers of opposition. This study uses the concepts of sociotechnical imaginaries and place imaginaries, expanded on below in Section 2, to investigate dynamics across scales in a case study of an Enhanced Geothermal System (EGS) project. Studying EGS allows us to capture the role of place and energy imaginaries via an examination of an emerging technology with the potential for unique intersections with place-based identities, imaginaries, and local and regional legacies of energy production and extraction.

EGS is a form of renewable energy that uses heat from within the Earth to provide electricity and heating. While conventional geothermal systems rely on existing reservoirs of hot water or steam in permeable rock layers, EGS creates "enhanced" reservoirs in deep rock through hydraulic fracturing techniques that artificially increase permeability [5]. Providing heat and power that is largely emissions-free, it has been lauded as one of the most benign and low-impact options for renewable energy solutions [6], though risks include possible impacts to water use, traffic, noise, and induced earthquakes [7,8]. EGS allows geothermal heat to be used anywhere that sufficient rock temperatures can be

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reached through drilling, in contrast to conventional geothermal which is limited to tectonically favorable locations.

While the technology itself is new, the indigenous nature of the resource and the similarity of the processes involved to those of extractive industries may mean that differing visions of place and energy at a range of scales are of particular importance in public responses to EGS. Current research on EGS acceptance has shown that concerns include seismic risk [9–12] and similarities with fracking [13], while others have investigated how the uncertainties and potential of EGS parallel imagined narratives of underground exploration and discovery [14,15]. Prior research has also shown that conventional geothermal is bound up in energy imaginaries related to renewable transitions and national energy security and has been linked with discourses around territorial sovereignty, socio-cultural institutions, and energy independence [16–18]. The indigenous nature of EGS, particularly when used in district heating schemes, allows an examination of energy-in-place. Rather than being transmitted to distant communities for use, such projects are by necessity located within the communities that they serve. EGS also carries connotations associated with traditional extractive industries like mining and fossil fuels production, which have been shown to exert significant influence on place identities and imaginaries of future energy development [19–24].

In essence, EGS, as a renewable energy technology that is promoted as a climate change solution, but that also uses the same physical processes as fossil fuel production – drilling and hydraulic fracturing – exists at the intersection of multiple dimensions of energy systems. Interpretations of EGS and its role in visions of energy futures may differ considerably based on context and scale, providing an ideal case study subject to investigate the role of conflicting imaginaries of energy and place. Drawing on the areas of literature discussed below, this case study investigates the following research questions to capture the role of intertwined imaginaries of place and energy at different scales of discourse surrounding an EGS project:

RQ1: What imaginaries of place and geothermal energy are present in public discourse about the project and EGS technology, and how do they differ across geographic scales?
RQ2: How do these multi-scalar imaginaries interact, align, or contradict each other within discussion of the project?

In Section 2, I review the literature on sociotechnical imaginaries of energy, place imaginaries, and the role of scale, and further motivate the research questions of this study.

2. Literature review

2.1. Sociotechnical imaginaries of energy transitions

One element of achieving low-carbon energy transitions is understanding and overcoming the social and cultural barriers to energy systems change, including how visions of desirable energy futures are defined and contested. Imagined futures drive scientific and technical activity, mobilize support and investments, and fuel rhetorical strategies and communication used by proponents of a technology in support of their cause [25]. The concept of sociotechnical imaginaries [3] provides a useful framework for understanding how visions of energy futures can shape trajectories of transition. Sociotechnical imaginaries are "collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared under-standings of forms of social life and social order attainable through, and supportive of, advances in science and technology" [6,p.4]; they encode what is viewed as both achievable and societally desirable through technology. The term "imaginaries" refers to systems of meaning that are communally shared, are expressed through images, language, and stories, and generate common understandings and shared senses of legitimacy [27,28]. Sociotechnical imaginaries can explain divergences in energy policies, research and development investments, and preferences for different forms of technology; underlying energy imaginaries shape weighting of risks and benefits, priorities, and visions of decarbonization, leadership, and innovation [3,29]. Imaginaries also provide cultural resources for proponents to use in strategies to gain funding and policy commitments [30], such as narratives of energy security that promise independence, affordability, and availability.

While early research on sociotechnical imaginaries focused on dominant national-scale visions, energy imaginaries form at other levels as well, reflecting both dominant power structures and alternative, emergent imaginaries. Energy representations are integrated into future-oriented agendas at levels that range from the home and the local to the region and nation [31]. National imaginaries have been shown to prioritize national-level narratives and benefits while downplaying local risks and impacts [23,32,33]. Contested imaginaries of energy transitions emerge from evolving power dynamics and value systems, reflecting tensions like those between continuity and transformation [34], or the prioritization of economic growth versus poverty reduction [35]. Such tensions can reflect differences in imaginaries between scales, as dominant imaginaries of top-down, large-scale policy implementations are challenged by emergent narratives of locally grounded social change [36]. With the urgent need to transition away from fossil fuels, top-down visions of transition have been increasingly criticized, opening the field to alternative imaginaries that emerge from civil society and invoke different models of progress, social change, and the role of the public [37].

Imaginaries at the local or regional scale both compete with and reproduce national energy imaginaries. Visions from state actors are reimagined in ways that draw on local and regional histories, particularly legacies of energy and extractive industries, to produce geographically-bounded visions of energy futures [23,24,38–41]. For example, Levenda et al. [40] found that national imaginaries centering on themes of modernization and security "'refract' differently through the lens of local concerns and relationships among publics, the state, and science and technology" (p. 189), leading to regional imaginaries shaped by historical perspectives and experiences with related industries. Similarly, Eames et al. [42] detail how the great interpretive flexibility of visions of the "hydrogen economy" results in a set of broad themes that are "raided, drawn upon and rejected" (p. 371) by a variety of actors at different scales to develop place-specific visions of hydrogen. In many of these cases, national and regional imaginaries present diverging priorities, leading to contestation and opposition. For instance, bioenergy in the American South was promoted via a national imaginary that presented it as a solution to rural poverty and lost wood product markets; however, a history of boom and bust cycles in wood products and the failure of bioenergy projects led to opposition and distrust [38,39].

Alignment across scales is also possible; Trencher and van der Heijen [43] found that a national hydrogen imaginary in Japan generated local contestations but led to eventual convergence with an imaginary encountered among stakeholder communities. In some cases, stakeholders have been shown to engage with actors at different scales as a deliberate strategy for promoting energy interests and achieving alignment across scales [31,44]; examining the role of "guiding visions," Späth and Rohracher [45] detail how local actors link up with regional-level discourses to establish and institutionalize a particular vision of the "energy region." Reviewing research on the geography of sustainability transitions, Hansen and Coenen [44] suggest that urban and regional visions and policies tend to run ahead of national responses to climate change, leading to a need for greater attention to the dynamics and processes between levels.

In summary, while energy imaginaries aid in materializing desirable energy futures, understanding how they interact across scales is important for teasing out their impact in shaping actual progress and implementations in context. National imaginaries tend to privilege national scales and actors and to obscure risks and local impacts in favor of benefits [23,32,33]; these visions are reimagined, reproduced, and contested in local context, drawing on both visions of the future, past experiences, and local and regional identities. In order to fully understand the role of place and local context in coproducing multi-scalar levels of energy imaginaries, I now turn to the concept of place.

2.2. A place-based perspective on energy

The importance of place in shaping responses to energy has received increasing attention in energy infrastructure acceptance research, particularly as an alternative to the reliance on NIMBY ("Not In My Backyard") language. A place-based perspective on energy acknowledges the importance of people's relationships with place, involving both the physical landscape and the identities, relationships, events, experiences, and history that are embedded there. Emotional bonds with place can provide a spatial explanation for differences in responses to risky technologies [46], particularly energy projects, where land-use changes and new risks may disrupt place attachment, leading to loss of identity and stability for individuals [47]. Symbolic meanings of place serve as foundations for the emotional bonds people develop with a place; when a threat is posed to important meanings, such as an area being a place of natural, untouched beauty, people are more likely to take protective action [48]. The perceived, rather than actual, threat of disruption to the future of a place can also drive oppositional attitudes [49]; Kim and Chung [50], for example, found that in response to proposed wind farms, residents in South Korea imagined the negative future place that would result, drawing on past experiences of traumatic place disruption to fuel opposition to the new projects.

The concept of place-technology fit provides one framework for the interaction of place meanings with the interpretation of a technology; contradictions between the interpretations of place and technology lead to opposition, as the contradiction is seen as a threat to place identity [1,2]. However, perceptions of the fit between interpretations of place and energy may also be influenced by different scales of place. Attachments to different scales have been shown to vary in relative strength and importance for levels of support for different energy systems; Devine-Wright and Batel [51] found for example that strong attachment to nation over local and global scales was associated with low levels of climate change concern and low support for a European-wide grid.

In considering perceptions of lack of fit or misalignment, therefore, it is necessary to consider how these perceptions may differ depending on the scale of place being considered; in addition, we consider collective visions rather than only individual-level meanings of and attachment to place. Addressing the role of collective imaginaries of place at different scales draws on a robust area of literature in place and spatial imaginaries. Place imaginaries encompass collective understandings of a distinct place, drawing on both narratives of the past and visions of what the future should look like for the place [4,52]. Place imaginaries can be thought of as one aspect of the broader concept of spatial imaginaries, which also include idealized generic spaces like "the global city" and imaginaries of spatial transformation like globalization and modernization [52]; "spatial imaginaries," overlapping with the concepts of "imaginary geographies," "geographic imaginaries," and "sociospatial imaginaries," can be thought of as socially held stories that are collective representations of places and spaces [52]. This study, as a case study of a particular EGS project that is embedded within a particular place and community, focuses on the concept of place imaginaries.

Collective imaginaries of place are also co-produced with energy systems in a setting, which contribute significantly to relationships with place [31]. As discussed above, place identities that are rooted in legacies of past energy industries provide an interpretive lens that shapes perceptions of new energy technologies [19] and can result in the formation of alternative regional energy imaginaries [23,40]. In order to understand how energy imaginaries emerge and interact across scales, it is necessary to recognize that imaginaries of energy and of place are co-produced, rather than as two separate sets of interpretations. This study conceptualizes new energy projects as being developed within the context of multi-scalar imaginaries of place and energy futures: overlapping and interacting visions of what kind of place one lives in, what kind of energy future is seen as desirable, and what kind of future would result for one's place in consequence of energy decisions.

The study aims to incorporate these multi-scalar energy imaginaries into a broader approach to understanding how place-based concerns affect public reactions to energy infrastructure. To do so, I examine first how imaginaries of geothermal development are structured around place imaginaries, including incorporation of place-based meanings and identities. Secondly, I examine differences in these imaginaries between scales that may impact perceptions of alignment between "place" and energy projects. This study sets out to identify the coproduced imaginaries of place and energy that are present at different scales of discourse surrounding a single energy project developing an emerging technology and to identify how these multi-scalar imaginaries interact, align, or contradict each other within discussion of the project.

In the context of EGS, intertwined narratives and associations with extraction, legacies of prior energy industries, and energy futures make an ideal object of study to explore the concepts of interacting place and energy imaginaries. Examining the role of imaginaries is also particularly important in considering the forces shaping EGS development; while a number of pilot-scale projects have been realized in Europe and the US, the technology has yet to be widely deployed and remains largely within the imaginations of proponents and developers. Due to the technological uncertainties and high capital costs involved in such projects, the visions and imaginaries used discursively to rally resources, funding, and support are central. Analysis of public discourse, as an ensemble of ideas, concepts, and categorizations that embody social realities and relationships [53,54] allows us to capture the shared meanings emerging about EGS development. In addition, evaluating discourse by different groups at different scales allows an assessment of what narratives and imaginaries are present that actors in specific contexts could draw on. This study investigates both discourses about a specific EGS project and about EGS technology in general, in order to capture the full breadth of narratives and visions relevant for efforts to develop an EGS site.

3. Methods

To address the research questions of this study, I take a case study approach following Yin [55], which, with its applicability for situations involving contemporary phenomenon in real-life contexts, is an appropriate research design for understanding a modern EGS project and its context. To capture the rich detail and contextual elements that are of interest in my research questions, I use qualitative methods to evoke the subjective meanings, narratives, and visions associated with the key concepts related to place and energy. I draw on multiple data sources: local and nonlocal news media coverage, public relations materials, and policy and planning documents. Below, I motivate the case site selection before expanding on the research design.

3.1. Case selection

The site selected for this case study is an EGS project in progress on the campus of Cornell University, a research university located in rural New York State. The project aims to provide district heating to the university campus, replacing a combined power and heating system fueled by natural gas. Formally proposed in 2009, the project forms a major component of the university's Climate Action Plan, which aims to achieve a carbon-neutral campus by 2035. Public townhalls discussing the project with the local community were held in March 2017, May 2018, and January 2021. The project is currently in the preparation stage; the Department of Energy awarded the project $7.2 million in funding in 2020 for the drilling of an exploratory borehole to better characterize the underlying geology. Drilling of an exploratory borehole (the Cornell University Borehole Observatory, or CUBO) began in June

2022; the completion of the CUBO well was planned for August 2022, to be followed by testing to determine heat flow and reservoir characteristics. Pending testing, an injection/production well pair will then be drilled to produce heat for the campus.

The geothermal project is located in the town of Ithaca, a college town known for its generally liberal nature and scenic surroundings, within Tompkins County. The region is largely agricultural, with vineyards, dairy, and specialty agriculture; eco- and culinary tourism center around the many wineries and breweries along with the lakefronts and narrow gorges surrounding the region's numerous deep glacial lakes. Recent significant experiences with energy and extractive industries in the area include controversy and local conflict during the debate over hydraulic fracturing in New York State. While a regional leader in such forms of renewable energy as photovoltaic solar, the county has also experienced local controversies over proposed wind and solar projects in recent years.

3.2. Data sample

In order to analyze EGS discourse and emerging imaginaries across scales, the data sample for the document analysis focused on local and non-local news coverage, public relations materials such as press releases from the university, and policy and planning documents related to energy and climate policies. These materials were targeted in order to capture themes and narratives in how the EGS project was depicted at a range of scales, as well as to provide triangulation through the analysis of multiple data sources. While the news coverage and PR materials pertained directly to the project itself, policy and planning documents from institutions at multiple levels were also selected that pertained to climate and energy policies generally; these documents were first analyzed to assess whether they referred to the EGS project or to EGS technology before undergoing full analysis. Documents such as energy roadmaps and climate action plans are deliberate articulations of desired energy futures and as such are included to capture visions of how EGS may be incorporated into these futures.

The full sample consisted of: 1. articles from U.S. national publications, containing the key words “enhanced geothermal” or “deep geothermal” and the university name or the project title in the body of the article, that were listed in the Nexis Uni database ($n = 6$), 2. Articles from local newspapers within the target county, identified through observation of the news sources available locally, containing the keywords “enhanced geothermal,” “deep geothermal,” or the project title ($n = 33$), 3. Press releases retrieved from the university press page, containing the keywords “enhanced geothermal,” “deep geothermal,” or the project title ($n = 31$) as well as public-facing materials such as websites and videos [56,57], 4. Policy and planning documents related to energy and climate planning for the institutions and governing bodies relevant for the project, ($n = 32$). Documents in this fourth category were identified through a review of websites and public archives for the university ($n = 5$), surrounding municipalities ($n = 7$), county ($n = 6$), state ($n = 10$), and national offices and agencies ($n = 4$). The total document sample consisted of 102 texts. The timespan included in the document search was 2007–2021 to cover the lifespan of the EGS project. The document sample is designed to capture a broad range of perspectives on EGS development in public discourse at different scales; however, document analysis is limited in its findings to the perspectives and biases of those who produced the documents [58]. As such, the scope of the document search, which did not include such sources as those in languages other than English or those available only in print, may exclude some perspectives less prominent in public discourse.

3.3. Data analysis

The document sample was imported into Atlas.ti [59] for coding and theme identification. Analysis followed Brennan [60], with themes allowed to emerge from an immersive reading of the material and from consideration of how each text is related to ongoing dialogue about the project. An initial round of coding was used to identify key themes, allowing themes and categories to emerge through close reading while also drawing on the theoretical concepts discussed above as sensitizing concepts. These included place and energy imaginaries; the concept of imaginaries was operationalized here as representations of idealized, future-oriented visions for the role of technology in society [26], with particular attention to whether the representation of the future was structured around references to place, including place-based identities and meanings.

Imaginaries were also coded based on the geographic scale that the vision encompassed: campus, local, regional, or national. Discussions of “scale” below therefore refer to the geographic scale of the vision being invoked, rather than that of the actor or institution expressing the vision; as such, an individual document may contain references to multiple scales. In addition, analysis of the multi-scalar visions also includes examination of which actors most commonly invoked the different visions, such as representatives of the university linking the project to both campus and regional climate goals. The “scale” categories emerged during the analysis and were defined as followed: “campus” refers to the university and its campus; “local” to scales ranging from the town to the county, and “regional” to subnational units including both New York State and the Northeast Region of the US.

Following initial coding, a round of focused coding was used to combine and sort categories across the full document sample, drawing on memos generated throughout the coding process and peer-debriefing. To further enhance the trustworthiness of the findings, the themes generated by this process are described below with representative quotations and accompanying context to capture rich descriptions, in keeping with recommendations from Lincoln and Guba [61] for enhancing credibility and transferability within the qualitative research paradigm.

4. Findings

Below, I present the findings from the document analysis: firstly, in Section 4.1, with a description of the geothermal-specific imaginaries that emerge at different scales and how they incorporate place characteristics and imaginaries. Secondly, in Section 4.2, I examine how these visions of geothermal energy interact and conflict across scales.

4.1. Geothermal imaginaries and interactions with place and scale

Across the document sample, the EGS project was centered within four levels of place-related narratives detailing specific visions of energy futures relying on EGS development: national, regional, local, and campus. At the national level, the project was depicted as contributing to a national transition to an independent and renewable energy supply, with demonstration of the technology at the campus level ideally leading to adoption of the technology at broader levels. At each of these smaller scales, however, different aspects of EGS technology, of the project, and of place interact to fuel different visions of what the project will accomplish, which I summarize in Table 1. The use of EGS for heating, rather than electricity production, generates a regional vision of clean heat for the cold winters of the Northeast, while the emerging nature of the technology supports a campus vision of innovation and knowledge generation as well as carbon-neutrality. In contrast, at the local level, EGS as emerging technology results in conflict with a local vision of an urgent, pragmatic response to climate action.

4.1.1. National imaginaries: our energy, beneath our feet

A distinct vision of geothermal energy emerges from the texts, coalescing around specific characteristics of geothermal energy: an unlimited resource, simultaneously bottomless yet accessible “right beneath our feet,” invisible from the surface but capable of providing clean baseload heating and power. As summed up in the Department of

Table 1
Summary of findings.

Scale	Characteristics of EGS Imaginary
National	Limitless heat "beneath our feet" for reliable heat and power
	National energy security and independence
	Clean energy jobs, economic growth, and revitalization
Regional	Regionally-appropriate clean heat for Northeast winters
	Clean energy jobs, economic growth, and revitalization
Local	Local leadership as a climate-forward, sustainable community
	"Sustainable but practical" energy transition relying on a mix of proven technologies
	Maintaining rural place character
	Opposing fracking
	Clean energy jobs, economic growth, and revitalization
Campus	Campus carbon neutrality
	Leadership as a "living laboratory" site of innovation and knowledge
	Clean energy jobs, economic growth, and revitalization

Energy's GeoVision Report [62], evaluating the potential for geothermal energy to contribute to America's energy future:

> The Earth beneath our feet contains vast energy potential, enough to power the global electric grid many times over. This natural geothermal heat radiating from the Earth's mantle—a byproduct of our solar system's formation billions of years ago—is virtually limitless in supply…Geothermal is an increasingly valuable contributor to energy diversity—and for good reason: it's an "always-on," renewable, 50-state solution that can provide flexible electricity and heating and cooling solutions to all Americans.

This "geo-vision" is associated with national priorities including energy security and independence from imports, technological leadership, and a clean energy economy. The GeoVision report continues on to state that "Harnessing the full potential of U.S. geothermal resources will strengthen domestic energy security and allow the United States to continue its leadership in energy innovation." EGS, and geothermal energy more generally, is depicted as a potential foundation for a clean energy economy featuring new jobs, development, and revitalization in locales not previously conducive to geothermal development. A vision of a national geothermal economy was invoked in news coverage as well; as one national publication put it, "A large investment of time, money, and policy attention in geothermal heat could help create jobs in almost every US zip code…That number of geothermal systems [predicted by the DOE] would require over 50 times the number of wells dug by the entire US oil and gas industry — a bonanza of skilled trade jobs" [63].

4.1.2. *Regional imaginaries: decarbonized heat for northeast winters*

A regional narrative of using EGS to decarbonize heat in New York State and in the American Northeast takes shape over time, with emphasis on the issue of heating as an overlooked component of greenhouse gas emissions compared to electricity generation. At the state level, geothermal energy has emerged slowly; increased attention to the potential role of geothermal did not come about until 2019's Climate Leadership and Community Protection Act (CLCPA). A university spokesperson makes a point of associating the EGS project and other aspects of campus climate efforts with efforts to help the state meet its climate goals, as quoted in one news article: "I think [the university's] pledge to go carbon neutral by 2035 is part of momentum which has helped lead the state to this CLCPA and has set the stage for the Green New Deal" [64]. The regional setting is also invoked in order to emphasize the innovative nature of the technology and the cutting-edge nature of the project itself, which aims to be "a new model for enhanced geothermal energy that can be applied…in areas long thought unsuitable, like the northeastern United States" [65]. University planning also emphasizes the potential for a regional industry with associated jobs and economic benefits: "a new source of heat that could potentially give birth to a new industry right here in upstate New York" [66].

Rather than a general focus on regional climate goals, however, the focus is specifically on the regional suitability of the technology based on its applications for heating purposes, which is moved to the fore in public-facing materials from the university: the website for the project, for instance, proclaims it "a scalable solution for renewable heating in New York" [56]. In a weekly update about the progress of the project, a university expert describes the regional implications: "We're taking one huge step for Cornell, which ultimately I hope will be an even bigger step for the state of New York and for the Northeast because this kind of technology is really needed" [67] for reducing heating emissions. This is directly linked to the regional climate, with repeated references to "the Northeast's cold winters and dense population centers" juxtaposed against the imagery of warm heated buildings. The snowy climate, the endurance of which is a point of regional and local pride, is used to motivate the specific design of the EGS project: a combination of EGS with a district heating system. Discussing the project design at a town-hall, one university speaker noted with amusement, "as many of you know - you live in this region like I do - there are some really cold days that we have" in a year, before going on to describe how the system would handle periods of peak load in "frigid Ithaca" [68].

In this context, the EGS district heating project on campus provides a model for a technological configuration depicted as a missing piece in current efforts to reduce natural gas use for heating purposes. This vision of regional decarbonized heating is invoked in state-level policy documents, local news coverage, and by university representatives discussing the project; it is particularly predominant in press releases from the university.

4.1.3. *Local imaginaries: a place to be sustainable but practical*

For the municipalities and county surrounding the campus, EGS emerges over time as part of local visions of renewable energy futures as well. Local energy goals include the aim to become "most climate forward city in New York State," and while geothermal energy receives few mentions prior to 2010, documents released in 2010 and 2011 include geothermal as a technology to be investigated for local retrofitting efforts. A "fresh look" at geothermal energy is taken in the county's Energy Roadmap 2016 [69], where EGS is included as an option for the first time. Directly citing the proposed campus EGS project, the document states that the project would provide the needed demonstration in order to consider implementing EGS elsewhere in the county. Similarly, a Sustainability Plan [70] for a consortium of eight counties surrounding the project location includes a reference to the EGS project as a potential springboard for local and regional energy advancement. For the consortium, the vision of the future centers on revitalization of an economically depressed area, with energy development in service of such goals as creating livable communities and protecting the landscape.

Local identity as a place of sustainability and progressive values was also invoked in discussions of EGS, emphasizing the opportunity for climate leadership: as a resident quoted in a local news article stated, "If New York State is going to [decarbonize], Tompkins County should really be in a leadership position to show how it's done" [71]. However, while the EGS project is incorporated into visions of sustainable futures at the local level, it is also subject to a more nuanced set of attitudes that emerge from local sustainable identity alongside past experiences and local history. Two themes make up a vision of what can be termed a "sustainable but practical" transition: firstly, a robust history of fighting fracking in the region combined with concerns about governance and impacts to local character led to skepticism about EGS. Secondly, a commitment to urgent climate action led to a focus on finding available, locally appropriate energy technologies and a wariness of putting time and resources into one riskier, less-proven technology.

The similarity of EGS to fracking techniques and the potential for earthquakes were discussed as sources of concern at the local level, particularly among local environmental activists [72,73]. At town hall meetings held with the public [74], questions often focused on whether there would be comparable risks to water and the environment as with fracking; university representatives stressed the differences between

EGS and fracking operations, particularly the difference in surface impacts compared to those of the fracking boom in Pennsylvania: "Under no circumstances would we ever be doing anything close to what's being done to our neighbors in the south of Pennsylvania right now" [75].

Prior experiences with solar and wind projects in the area also led to concerns about lack of proper governance of energy projects and impacts to the county's rural character through loss of agricultural land. A local news article about area renewable energy development sets the scene thusly, before going on to describe pushback against proposed solar projects in the area: "An overwhelming majority of Tompkins County residents view renewable energy favorably, as demonstrated by the support residents share in public meetings. Regardless, projects are often met with intense scrutiny before municipalities agree to proposals by developers" [76]. Residents quoted about the EGS project note the potential threat to the area's attractiveness as a place of scenic beauty: "What about disruption to campus?...We have such a naturally beautiful campus, what impacts would the drilling have on the physical beauty?" [77]. Others raised concerns about disturbances to residences and property values [73].

At the same time, concerns about threats to place were also associated with a sense of urgency about addressing climate change, with quotes from others noting "There's no preserving the rural character of our county if we don't act now and we don't act fast" [76]. Rather than outright opposition to the EGS project, local news coverage of town halls and editorials captured a sense of urgency and frustration with the opportunity cost of the university's reliance on EGS as the cornerstone of its climate actions, particularly while the university continues to expand while relying on natural gas in the interim: "Members of the public urged the [university] team to embrace higher energy standards now, with one commenter calling plans for geothermal energy by 2035 "extremely speculative"" [78]. Questions at townhalls held in 2018 and 2021 [74] included numerous questions about Cornell's choice of EGS as a pillar of its climate planning and why alternatives such as heat pumps and biomass were not being pursued; meanwhile, an op-ed in a local newspaper lays out a blunt case for wind, solar, and hydropower: "all are on hand today, well in advance of Cornell's deep geothermal initiative on the horizon in thirty years" [79]. University leadership at times acknowledges this: "While extraordinarily promising, this approach has not been pursued in our region and remains one of uncertain costs and ultimate feasibility. If we are to achieve the goal of carbon neutrality by 2035, we need a plan that does not rely on a single, unproven technology, but rather incorporates multiple strategies" [80].

4.1.4. Campus imaginaries: a carbon-neutral campus through knowledge creation

Finally, at the campus level, the EGS project is intricately connected with climate action planning for the university; the vision of a carbon-neutral campus is one of the driving narratives behind the project. The EGS project was a part of the university's climate action plan (CAP) beginning in 2009, where it was one of 19 original strategies proposed for reaching a carbon-neutral campus, with emphasis placed on EGS' reliability and ability to deliver baseload power and heat. As priorities for climate action were refined, the EGS project took a more central role; a 2014 update declared the project the "single largest emissions reduction in our CAP" [81].

Achieving reduced carbon emissions is only one goal of the project; the vision of a carbon-neutral campus is closely linked with the university's identity as a research institution, land-grant university, and "living laboratory": "We consider this part of our land grant mission…If we're able to eliminate the use of fossil fuels on campus, we're demonstrating a pathway for many other communities to be able to do the same" [82]. Visions of energy leadership are transformed into a model of the campus as a place of knowledge creation. Public relations materials and outreach messaging from the university strongly relies on narratives of knowledge creation, innovation, and climate action, particularly when discussing the exploratory "borehole observatory" stage of the project, which is presented as a "data mine" that will generate the knowledge needed to fully demonstrate the technology. The potential for secondary applications of geothermal heating was also linked to the university's identity as an agricultural school: making use of "Cornell's links to agriculture through greenhouse agriculture [for] supplying regionally our own food in geothermal greenhouses" [75].

This sense of identity is also linked to a historical legacy; at community townhalls about the EGS project, multiple speakers representing the university emphasized a tradition of innovative energy projects in Cornell's history, such as the Lake Source Cooling project of the late 1990s and a hydroelectric plant built in the 1880s. The opening speaker of the 2018 townhall noted that "Cornell was really renewable before that was even a term…We're going to try to return to that lofty goal" [68]. Press releases emphasize this continuity as well, with phrases like "Cornell has been a leader in sustainability since the early 1880s" [83] and "a long history of commitment to sustainability" [84]. In pursuing EGS as a solution to decarbonizing heating during the campus' notorious winters, the university presents a vision of a self-contained, locally-embedded energy system that taps into resources directly below campus, in continuity with an idealized imaginary of the university campus as a place of energy innovation and knowledge generation.

4.2. Interactions, alignment, and tension between scales

The vision of a carbon-neutral campus through EGS knowledge creation is in alignment with the regional imaginary of decarbonized heat and the national imaginary of energy security through heat beneath our feet; all three are structured around pursuit of leadership in developing a new, innovative technology. These three imaginaries are often invoked together in public-facing materials and communication efforts from the university, which position the multi-scalar impacts of the project as the key benefits of the project, second only to the reduction in campus emissions. Asked at a townhall whether there would be "all this intrusion just to benefit Cornell University?", a moderator countered with: "If we can demonstrate that the technology works, it could be used to benefit municipalities and businesses across the region" [75]. These benefits were stated in more concrete terms in the one aspect of an envisioned geothermal future that was shared across all four levels: EGS as the foundation for a clean energy industry fueling job creation, economic growth, and local and regional revitalization.

The priorities of knowledge generation and innovation that are embedded in the choice of an emerging technology like EGS are made explicit in the campus imaginary and linked to the pursuit of funding opportunities. Both Climate Action Plan documents and PR documents link the novelty of EGS and its ability to generate new knowledge with the ability to attract external funding; for instance, "The experimental nature of this technology creates the opportunity to attract research and development funding through a consortium of public and private partners" [66]. While an emphasis on discovery and innovation does resonate at a surface level between the campus imaginary and local visions of renewable energy leadership, there is also a tension with the local imaginary of a pragmatic, urgent energy transition that relies on a mix of available energy technologies. Local news coverage suggests a feeling of frustration among community members, who feel that the university is prioritizing the development of a new technology over solutions that can be implemented now [78]. In addition, the campus, regional, and national narratives predominate in non-local news coverage, policy documents, and PR materials; as a result, discussion of specific risks and impacts tended to only emerge in local news coverage and in instances when the public were asking questions at townhall events.

Another source of tension and misalignment is the aspect of local identity rooted in anti-fracking activism, which leads to skepticism about EGS development. Here, however, the local and campus levels interact in a way which attempts to resolve the tension by highlighting the innovation and knowledge generation aspects of the project. Communications from the university emphasize the distinctions between

EGS and fracking, underscoring the new nature of EGS technology as well as the technical differences in the processes being carried out. One university representative, in response to the question of what the difference was between the drilling and well-casing practices of the EGS project and those in the oil-gas industry, was blunt: “The ‘best’ [practice] isn't used in the oil and gas industry. That's the simple answer. In [industry], the idea is to put the least amount of money down the hole in order to get the most oil and gas out. What we've designed here…is the best available way of doing it. This well, a data mine, is designed so that the only thing that ever comes out of the well is information” [75].

The close alignment between the campus, regional, and national scales results in a dominant narrative that obscures the local counter-imaginary, with the effect of masking discussion of local concerns and impacts. In addition, interactions between the campus and local levels reveal a double-edged blade in efforts to align university communications about the project with visions of energy for the local place. A focus on innovation and scientific endeavor as key aspects of the project is used to distance EGS from fracking and the oil and gas industry, but is also the source of tension and frustration for local residents whose sense of sustainability leadership includes the need to protect local place character through immediate, pragmatic climate action. Multiple dimensions of local place identity – of the county as rural community, as home to innovation and sustainability, and as site of anti-fracking activism – are exposed and made salient in response to the dominant imaginaries of EGS development, leading to different reactions to the EGS project and to different preferences for future energy development in the area. Investigating the role of place within energy imaginaries unveils challenges for communication and engagement efforts that require understanding how place imaginaries combine and are coproduced with energy imaginaries, rather than focusing on place meanings and identities in isolation.

5. Conclusions

Distinct geothermal imaginaries are used to promote EGS development, differing across scales as different aspects of the technology interact with relevant contextual characteristics and priorities. At the national level, EGS development was associated with a vision of energy security focused on economic growth and independence, consistent with Meller et al.'s [16] suggestion of an association between geothermal energy and territorial sovereignty. I find that visions of energy futures related to EGS technology are intertwined with place-based identities at the campus and local levels, with a single demonstration-scale geothermal project serving as a tool to perform imaginaries of renewable energy leadership, innovation, and revitalization. Rhetoric describing EGS potential also connected the project to a vision at the regional level of clean heat in the Northeast, removing the reliance on natural gas heating for battling the region's cold winters.

The findings of this study show that the “fit” between EGS technology and place depends both on the scale of place and on the nuances of place characteristics. The appropriateness of EGS for achieving the envisioned futures at the campus, regional, and national levels is highlighted in public discourse. But while the multi-scalar EGS imaginaries are closely aligned between campus, region, and nation, tension emerges between the campus and local imaginary which is not immediately apparent in much of public discourse. At the local level, the presence of multiple place identities leads to conflicting preferences for the adoption or rejection of EGS technology; higher level imaginaries refract differently through these local identities, shaping conflicts as well as broader concerns for what is desirable for future energy development within the county.

A dominant narrative of innovation is, at the surface, consistent with conceptions of both the campus and the local community as places of innovation, discovery, and sustainability, though inconsistent with the rural place imaginary also present. A “town-gown” conflict between a self-identified rural community, concerned with maintaining local landscapes, and a university, embedded within that community and focused on transition and transformation, is one source of tension exposed by the EGS project. Delving deeper into local conceptions of place, however, also reveals that the facet of local identity linked to sustainability leadership diverges considerably from that of the campus when it comes to visions of concrete climate action. Pride in past resistance to fracking and a sense of urgency in implementing climate solutions to protect place character and local ecosystems combine to create a vision of an urgent local transition relying on a mix of available, tested technologies. This local imaginary provides another source of conflict with the priorities of innovation, scientific exploration, and intellectual leadership embedded in the EGS project, with its deliberate choice of a less mature technology. Despite the shared goal of taking action against climate change, different visions of what climate action should look like, rooted in differing imaginaries of place, leads to, if not outright opposition to the project, a sense of frustration among climate-conscious members of the population who might have been expected by project advocates to embrace the project as a good “fit.”

While future-oriented expectations can serve to bridge across different scales and boundaries [85], nuances in these expectations that emerge at different scales develop into alternative visions, which may in turn complement, contradict, or compete against more dominant visions. In this study, the framing used in promotions of the EGS project often relied on imaginaries that coalesce around regional and national priorities, which obscure or minimize risks and potential impacts. In general, public discourse on the project also lacked concrete information on risks, necessary for providing the public with a well-rounded understanding of EGS, particularly given the importance of induced seismicity for public attitudes demonstrated by other research. Reliance on conveying the broad-scale benefits of renewable energy projects has also been shown elsewhere to be ineffective in garnering public support for energy projects, in comparison to more local concerns [e.g., [86]].

Limitations of this study include methodological issues associated with a single case study, which is illustrative in the context of an emerging area of research, but is limited in generalizability beyond the specific case. In the tradition of naturalistic inquiry, this study has aimed for the standards of credibility and trustworthiness through the use of triangulation with multiple data sources and rich description in order to support comparisons with other settings [61]; future work, however, will aim to explore the transferability of these findings to other contexts via comparison with other cases. In examining only publicly available documents, this study is able to identify the presence of imaginaries in the document sample, but is also limited in its ability to directly assess the implications of these imaginaries; there is room for future studies to apply different methods to investigate the impact of these imaginaries on individual attitudes and levels of support for projects like the EGS site studied here.

To conclude, this study highlights the need to understand how energy imaginaries interact and compete in ways that draw on other visions of place, identities, and histories at different scales. Addressing place as a key force shaping multi-scalar geothermal imaginaries reveals the source of conflict within public debate about an emerging renewable energy technology. Core characteristics of place such as the campus as a site of knowledge creation and the local community as a place of sustainability and climate leadership lead to visions of energy futures that, despite shared elements, still diverge significantly. With alignment between all levels besides the local, a dominant narrative focused on the campus, regional, and national scales obscures local concerns, risks and impacts. It is critical to consider how, for an energy project embedded in many overlapping visions of place and the future, some visions are privileged and others overlooked, potentially driving opposition due to perceptions of misalignment at a local level.

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Data availability

Data will be made available on request.

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