### Thesis Prospectus 2023-24

**Name:** Emma C. Wright **ID Number:** A00436836

**Email:** csw4@evergreen.edu

**Student Final Submission (date):** 13 December 2023

**Faculty Reader Approval (date):**

**MES Director Approval (date):**

1. Working title of your thesis[[1]](#endnote-1).

**Renewable Heating on United States College Campuses: Mapping Viability According to Place-Based Factors**

1. In 250 words or less, summarize the key background information needed to understand your research problem and question.

Reducing climate change-driving greenhouse gas emissions must be balanced with the human need for everyday heating, which has historically been produced largely through combusting fossil fuels such as coal and natural gas (Gaur et al., 2021; Tester et al., 2021). Renewable, low- or zero-emission forms of heating are already used in some municipalities in Europe (Buffa et al., 2019; Jodeiri et al., 2022), but remain rare in the United States (Han et al., 2021). Where renewable heating does exist in the United States, college campuses are leading its adoption and research (Han et al., 2021), with institutions such as Cornell University (Beckers et al., 2020; Tester et al., 2023) and Ball State University (Im et al., 2016) having either heavily researched or already implemented renewable heating on their campuses.

However, renewable heating can take multiple forms, and these “case-study colleges” even differ in the forms of renewable heating they have pursued. Some colleges have pursued *heat pumps,* which consume electrical power to concentrate ambient thermal energy where it is desired inside buildings and hot-water systems (Gaur et al., 2021); others have pursued *geothermal direct heating*, which extracts heat directly from deep wells drilled into the Earth (Mock et al., 1997; Snyder et al., 2017; Tester et al., 2021). Different forms of renewable heating may become more or less viable for a college to implement, according to its location and local environment; but to fully understand this, it is necessary to first define “viability” in the context of implementing renewable heating, and to then build an understanding of how factors relating to place may positively or negatively affect viability.

1. State your research question(s).

For the renewable heating forms of **air-source heat pumps**, **ground-source heat pumps**,and **geothermal direct heating**:

**Question 1.)** What key criteria must be met to make implementing (constructing and commissioning) these forms of renewable heating *optimal* or *viable*?

**Question 2.)** How do *place-based factors* such as location, climate, and human geography positively or negatively affect the viability of implementing these forms of renewable heating in a given location?

**Question 3.)** According to these place-based factors, where within the contiguous (lower 48) United States are these forms of renewable heating *most viable* for a college campus to implement?

1. Situate your research problem within the relevant literature. What is the theoretical and/or practical framework of your research problem?

The guiding principle of my thesis – fitting solutions to places according to the unique challenges and opportunities that places carry – is inspired by Hester (2010), who introduced me to this idea in a book exemplifying many urban renewal and environmental restoration projects that the author worked on. From this declarative statement – that solutions to challenges, including the challenge of renewable heating, should fit to the places where they are implemented – comes the question, *How do we determine what best “fits” to a place?*

While few, if any, of the case-studies I have read have addressed this question in ways as explicit as Hester (2010), the idea of fitting solutions to places is implicitly present in this literature. For example, addressing the undergoing research of geothermal direct heating at Cornell University, Kassem et al. (2020) recommend constructing a biogas boiler that will be fueled by digested manure sourced from dairy farms surrounding the campus. Although these authors do not refer to “place-based solutions” by this name or in any synonymous terms, this concept is inherent in their article. A major part of my Literature Review will be taking all the case-studies such as Cornell, and *explicitly calling out* the ways in which they each demonstrate both unique challenges and unique solutions resulting from their places.

Regarding renewable heating, most of the current literature focuses on district heating grids primarily in Europe; for recent reviews, see Jodeiri et al. (2022), H. Lund et al. (2021), and Buffa et al. (2019). Recent review articles on the forms of renewable heating themselves include Gaur et al. (2021) and Staffell (2012) for heat pumps; and Tester et al. (2021) and J. Lund and Toth (2021) for geothermal direct heating. These review articles draw from several field and in-situ studies of their respective renewable heating forms, many of which I have sourced directly for my own research.

1. Explain the significance of this research problem. Why is this research important? What are the potential contributions of your work? How might your work advance scholarship?

If I could summarise the motive of my research in one sentence, it would be that “no one has ever done something quite like this before” (that I am aware of; and if I turn out to be wrong about this, I will likely have to adjust something so that it becomes true again). I see myself as taking many different pieces that already exist in clear forms – from reviews of district heating to renewable heating field studies to case-study college implementations to Hester (2010)’s fitting solutions to place – and then *putting together* these pieces in a novel way. In doing so, I intend to create a framework or model that will be useful at a wide range of different scales; both as a guideline for individual U.S. colleges to use for determining which renewable heating solutions may work best for them, and at a much broader level, as a model *for building viability models* in of itself. In other words, the process through which I create the viability models of my thesis should be able to work in a very similar way for creating models covering other forms of renewable heating, renewable heating in other contexts such as municipal grids, or even outside of renewable heating entirely (for example renewable electricity).

1. Summarize your study design[[2]](#endnote-2). If applicable, identify the key variables in your study. What is their relationship to each other? For example, which variables are you considering as independent (explanatory) and dependent (response)?

My study will have three parts, one to address each of the three research questions.

* Part 1: Build a framework to define *what is “viability”*, through assembling, sorting, and prioritising **viability factors** (listed below) to build my own rubric of what a “viable” renewable heating implementation looks like.
* Part 2: Build a framework of *what affects “viability”*, through assembling a large quantity of **place-based factors** and determining (through referring to existing field studies) how they may positively or negatively affect the above viability factors for different renewable heating forms.
* Part 3: Visualise how the place-based factors from Part 2 may affect the viability factors from Part 1 for each studied renewable heating form, across the spatial context of the contiguous (lower 48) United States.

Key elements of my study are:

* The **viability factors** that I will use to define what “viable” means in the context of renewable heating. These include *effectiveness* (producing a desired level of heat), *efficiency* (consuming a minimum amount of electricity and/or material resources to function), *operational affordability* (costing reasonably low in maintenance/operational expenses), *implementation affordability* (costing reasonably low in construction expenses), and so on.
* The **place-based factors**that increase/decrease viability of implementing a form of renewable heating in a particular location. These include *environmental factors* (climate-related such as annual rainfall and temperature patterns), *human-geography factors* (such as local laws, incentives, and economic infrastructure), and so on.
* The *spatial viability distribution* across the contiguous United States for each studied renewable heating form, obtained by mapping the aforementioned place-based factors across the contiguous United States and seeing how they overlap.

1. Describe the data that will be the foundation of your thesis. Will you use existing data, or gather new data (or both)? Describe the process of acquiring or collecting data[[3]](#endnote-3).

I will build the first part of my data (defining “viability”) through a combination of existing data and literature on the “real-world” performance of renewable heating systems, and my own decisions on how to prioritise and sort the viability factors. I am currently considering having only a single viability model against which to test all renewable heating forms in all cases, for the purpose of avoiding over-complication – but I am open to revising this should it become necessary for accuracy purposes.s

For the second part of my data (the “place-based factors”), I will mainly perform **archival research** of existing and previous in-situ/field studies of the relevant renewable heating forms throughout the world. I will glean any findings from these studies on how environmental, physical, economic, or other factors are reported to affect the performance and/or cost of the relevant renewable heating forms. This will enable me to build *relationships* between each place-based factor and how each renewable heating form’s viability relates to it. I will also obtain data for each place-based factor that covers the expanse of the contiguous United States – this will enable me to construct heat maps using this data in the final step of my methods.

1. Summarize your methods of data analysis. If applicable, discuss any specific techniques, tests, or approaches that you will use to answer your research question.

My data analysis will be entirely qualitative. Rather than conducting statistical tests on the data, I will look more generally for trends in the viability of each renewable heating form across the contiguous United States, and will call to attention anything I perceive to be interesting or an anomaly. In the process of working through the place-based factors themselves, I will also call to attention any contradictions or complications I find between different pieces of literature – for example, contradictory results obtained by different field studies. After the main content of my results, I will also return to see how the “case-study colleges” referenced in my Literature Review “match” to their locations on the heat maps for their chosen renewable heating forms. As before, rather than performing a rigorous statistical analysis, I will instead look for and note trends or anomalies – reporting how much or little colleges match up to heat map “hot spots”, adding additional contextual information about certain colleges if necessary. This will also allow me to evaluate my own model after-the-fact, and potentially help me recognise areas for future improvement, and/or recommendations for future research.

1. Address the ethical issues[[4]](#endnote-4) raised by your thesis work. Include issues such as risks to anyone involved in the research, as well as specific people or groups that might benefit from or be harmed by your thesis work, perhaps depending on your results. List any specific reviews you must complete first (e.g., Human Subjects Review or Animal Use Protocol Form).

My research does not require me to complete any of the above reviews (I am no longer considering human-subject interviews as part of my data collection). While the “case-study colleges” are not the primary focus of my research, discussion of their chosen renewable heating implementations/research will form a non-trivial component of my thesis. Especially when reviewing how well I perceive these colleges to “match up” to the heat maps I produce, I acknowledge that I must be careful to not inject my own opinion into the data – for example, by being mindful of my language and not referring to colleges as matching “well” or “poorly”, but instead as having “higher” or “lower” levels of agreement with the results displayed on my heat maps. (This will also allow me to be more curious and critical of my own results – if a college does not match up well, I will examine the implications for my own methodology as much as for that college’s situation.)

1. List specific research permits[[5]](#endnote-5) or permissions you need to obtain before you begin collecting data (e.g. landowner permissions, agency permits).

I am not conducting “physical” research either in the field or in the lab, so I will not require any permits for location or physical-material access. However, during the “place-based factors” part of my research, it is possible that I may need to access data locked behind a private database – for example, to obtain data that spans the expanse of the contiguous United States as I will need it to. I will have to address this on a case-by-case basis, but I will mitigate its potential to hamper my research by obtaining all my place-based-factor data (or knowing where to locate it) as early as possible in my thesis timeline (see question 14 below).

1. Reflect on how your positionality as a researcher could affect your results and how you will account for this in the research process[[6]](#endnote-6).

I am a white, English-native-speaking, college-educated individual, born and raised entirely within the United States, who has never experienced major poverty or hardship. There are numerous perspectives that I am certain I overlook because of these demographics, and this oversight could manifest in a number of ways. For example, in building my “viability factors” model, I may implicitly assume that there is only one way to design a “best” or “correct” viability model, and in doing so overlook equally valid other perspectives of defining what viability is. I also hold my own subjective beliefs and opinions (like everyone does) about pertinent topics such as energy, the environment, climate change, and politics. It is possible for example that when assessing the influence of jurisdictional place-based factors on viability, I may subconsciously assign lower viability scores within “red” states without fully critically evaluating state-level legislation/incentives, based on my own pre-held beliefs. I will account for this as best I can by being fully transparent through the entire process of assigning viability relationships to place-based factors, and wherever I can, letting the findings of existing research fully determine how I build these relationships (rather than injecting my own opinions).

I am also transgender, queer, neurodiverse, and a person with disabilities. I am very aware that many people in the world will not treat me kindly because of who I am; and while the chance of these people being in key contact positions at other universities (if I decide to reach out directly to some universities for further information) is hopefully low, it remains a possibility that I am vigilant of. I am aware that I may “shy away” from contacting college representatives directly for information if I am afraid of how they might view or treat me. To address this, I may plan to communicate primarily or entirely by email with other colleges if I choose to do so, ideally lessening the potential “judgmental aspect” on both sides; and I may also draft ahead of time template emails to use with slight modifications when reaching out to other colleges, therefore lessening the stress of writing them each time.

1. Provide at least a rough estimate of the costs associated with conducting your research, if any.  Provide details about each budget item so that the breakdown of the final cost is clear.

Right now, there are no definite or certain costs for my research – fieldwork, lab equipment, travel, and similar expenses are non-applicable. However, I may still have to pay for access to information in databases for the “place-based factors” component of my research, if I should come across anything critical that is “paywalled”. Unfortunately, there is a high degree of uncertainty here and I cannot currently say for sure that I will encounter this situation; hence, I did not apply for the MES thesis fund because I had no clear and certain expenses to state. If I do find myself in need of funds for database access, I will submit an application to the Clean Energy Committee (CEC) and make a case for the advancement of renewable energy understanding that will come from the completion of my thesis.

1. Provide a detailed working outline of your thesis.

I have consciously decided to style my thesis like a story – both from reading Schimel (2011), and from having many years of personal experience/interest in creative writing and story-structuring. The division of my thesis content into “acts”, and many of the terms used in this outline, reflect this structure.

**“ACT I”: Introduction through Lit. Review**

* Introduction: Setting the stage with background information on climate change and the contributions to it of heating
* The “Non-Dramatic Question”: *How do we reconcile our need for heating with our need to reduce greenhouse gas emissions?*
* Literature Review: Looking at the relevant forms of renewable heating and what U.S. college campuses and other “campus-like” places have done with them so far; making sure to highlight the unique factors of each place relating to its “place”
  + Renewable forms of Heating: Briefly describing the ones I will not cover in-depth; describing in further detail the ones that will be a focal point of my research
  + Case-Study College Campuses: Briefly summarising the work of each U.S. college campus that has either implemented or heavily researched one of the renewable heating forms I am covering, with an emphasis on *why* each college chose the form that it did
* Hester (2010)’s “sense-of-place": Making explicit this concept as a core guiding principle of my thesis
* Naming the Research Gap: Arguing that the case-study literature implicitly contains the above concept, but no one has explicitly put it together into a full framework
* “First Plot Point”: Stating my **Research Questions**

**“ACT II”: Methods, Results, “meat of the data”**

* Overview of Methods: Explain what I will be doing to answer each of the research questions
* “Meat” of Methods: Here I will go into detail about the step-by-step process I take to build each part of my data; for example, explaining my process of sorting different aspects of “viability criteria”, and explaining how I judge each place-based factor to relate to viability based on relevant studies.
* The “MIDPOINT”: This serves only as an invisible divider between the so-called “before experiment” and “after experiment” (used metaphorically, since I am not doing an experimental study). Everything in the thesis before here (minus the abstract) is written as if I have not yet gone through with the methods; everything after here has to do with the results of, interpretation of, and further recommendations stemming from my methods.
* Results: Display the results of each Research Question in the same order, with appropriate diagrams:
  + Question 1 (Viability Criteria): Display a “funnel” / “pyramid” or similar chart detailing the breakdown of factors that go into my ultimate definition of renewable heating “viability”, from most encompassing/influential to finest detail
  + Question 2 (Place-Based Factors): Display a chart or list of *all* factors included, sorted by broad categories such as climate-related, physical geography-related, human geography-related, etc.
  + Question 3: Display my constructed *heat maps* for each renewable heating form showing where across the contiguous United States they are most and least “viable” according to my data

**“ACT III”: Discussion; Implications; Limitations and Recommendations for Further Research**

* Discussion: Relate the “case-study colleges” to my heat maps; note patterns, anomalies, and curiosities
* “Self-Evaluation”: Evaluate my own model and process to the degree that I can in post-analysis; note its limitations (potential or observed)
* Recommendations: Suggest how my work could be expanded on or applied to sectors other than renewable heating (or in places other than U.S. college campuses)
* Conclusion: Return to the “Non-Dramatic Question” posed at the very beginning; give final thoughts on how my thesis work might have helped us get ever so slightly closer to answering this question

1. Provide a specific work plan and a timeline for each of the major tasks in the work plan. Be as realistic and specific as you can at this point, including the deadlines for Spring quarter.

|  |  |  |
| --- | --- | --- |
|  | **(HOLIDAY BREAK)** |  |
|  | Begin brainstorming **place-based viability factors** | Fully write out **Lit. Review** |
|  | Continue reading **renewable heating in-situ field studies** and taking notes(already doing for work) | Start writing **Introduction –** think of as extension to Lit. Review (for getting-ball-rolling purposes) |
|  |  |  |
| **Week** | **Research** | **Writing** |
|  | **~Winter Quarter~** |  |
| **W-01** | Discuss with Mike plans for **Special Topics in GIS** (put together a plan to learn to build the **Heat Maps**, and discuss a final project that can relate to my thesis work) | WD **Introduction** |
| **W-02** |  | Submit to Reader **Introduction** |
| **W-03** |  | WD **Methods** |
| **W-04** | Goal: Have ALL **place-based viability factors** (and where to get / how to make their ArcGIS Pro layers spanning the contiguous U.S.) documented.  \*Know how much, if anything, it will cost to access any “paywalled” data.\* | Submit to Reader **Methods** |
| **W-05** | If necessary, **submit small funding application to CEC** to cover any unavoidable paywall costs  Work on Question 1 results (building the **viability factors** theoretical model for renewable heating forms)  ST GIS: Will have opportunity to learn Python in choice of weekly lab assignment (unsure of applicability to heat-map-model-building, but will probably take regardless) | FINAL DRAFT **Lit. Review** |
| **W-06** | Roughly finish Question 1 results | Submit to Reader **Lit. Review** |
| **W-07** | Work on Question 2 results (building “viability relationships” between the **place-based factors** and the viability factors – this is expected to take longer than the first part) | “Storyboard” **Results** |
| **W-08** | Continue working on Question 2 results |  |
| **W-09** | Roughly finish or continue working on Question 2 results | WD **Results** |
| **W-10** | Should have Question 2 results done at the absolute latest  ST GIS: Present final project – uncertain yet what it will be | Submit to Reader **Results** |
| **W-11 (Eval)** | Have everything assembled & ready to begin building the Heat Maps (i.e., have ALL the ArcGIS Pro layers I need ALREADY on hand) – ACTUALLY DOING SO WILL TAKE A NON-TRIVIAL AMOUNT OF TIME. |  |
| **Week** | **Research** | **Writing** |
|  | **~Spring Quarter~** |  |
| **S-01** | Begin building the Heat Maps – start with **one** renewable heating form, then once I have the hang of the process do the others. | WD **Results/Discussion** |
| **S-02** | Heat Maps should be finished by now. Allow myself time for writing interpretation of the results. ***Everything from this point forward should be solely focused on writing / polishing!!*** | Submit to Reader **Results/Discussion** |
| **S-03** |  | WD **Conclusion** |
| **S-04** |  | Submit to Reader **Conclusion** |
| **S-05** |  | Submit **REQUEST TO PRESENT RESEARCH** |
| **S-06** |  |  |
| **S-07** |  | Submit to Reader **FULL-LENGTH DRAFT THESIS** |
| **S-08** |  |  |
| **S-09** |  | Submit to Reader **FINAL THESIS DRAFT** |
| **S-10** | **FINAL THESIS DUE!!!** |  |
| **S-11 (Eval)** |  |  |

1. Who (if anyone), beyond your MES thesis reader, will support your thesis (in or outside of Evergreen)? Be specific about who they are and in what capacity they will support your thesis. If you are working with an outside agency or expert, be specific about their expectations for your data analysis or publication of results.

Scott Morgan (Evergreen Office of Sustainability)

While not directly involved in my thesis, Scott has helped me find work to perform for the Office of Sustainability that parallels and complements my thesis research. Additionally, Scott has contact with a large network of people in sustainability-related positions with colleges and universities throughout Washington state. I may reach out to some of these people for informal data-collection (not formalised interviews) as part of my research process, for example to learn more about Washington state laws/incentives that I may want to include in my research of place-based factors.

Mike Ruth (Evergreen GIS Professor)

I am taking the full GIS-certification sequence at Evergreen under Mike’s instruction, including *Special Topics in GIS* this Winter quarter. I will work with Mike in this course to develop a model for creating my desired heat maps in ArcGIS Pro once I have all the data for them collected (it is possible that collecting all this data will take longer than Winter quarter). I may also ask Mike for ideas on where to locate GIS layers or other spatial data that span the contiguous United States and contain factor-data I need for building the heat maps.

1. Provide the 5 most important references you have used to identify the specific questions and context of your topic, help with issues of research design and analysis, and/or provide a basis for interpretation. Annotate these references with notes on how they relate to/will be helpful for your thesis. For any other sources cited in your prospectus in other answers, provide a complete bibliographic citation here as well.

**Gaur, A. S., Fitiwi, D. Z., & Curtis, J. (2021). Heat pumps and our low-carbon future: A comprehensive review. *Energy Research & Social Science, 71,* 101764. https://doi.org/10.1016/j.erss.2020.101764**

This is a recent review article covering heat pumps and their role (both existing and potential) in renewable heating systems. Because I am heavily covering heat pumps in my thesis research, this article provides important background and contextual information as well as potential leads to referenced in-situ field studies (which I am relying on for much of my research).

**Han, A. T., Laurian, L., & Brinkley, C. (2021). Thermal planning: What can campuses teach us about expanding district energy? *Journal of Environmental Planning and Management, 64*(11), 2066–2088.** [**https://doi.org/10.1080/09640568.2020.1855577**](https://doi.org/10.1080/09640568.2020.1855577)

This article covers district energy systems within college campuses in the United States and Canada, and their potential to lead further adoption of district energy in these nations. Because of how closely these topics align with my own, this article is one of the earliest and most important sources to have shaped the direction of my thesis.It is most useful to me in setting background and context; however, it also contains some discussion of barriers that university decision-makers have reported when considering renewable energy on their campuses.

**Hester, R. T. (2010). *Design for ecological democracy*. The MIT Press.**

I have included this book as a “sixth source” here because of how much it has influenced my thinking, even being a major reason why I landed on my thesis topic in the first place. Covering many urban renewal and environmental restoration projects spanning multiple decades that its author has worked on, this book is what first introduced me to “sense of place” as a core concept that I have begun to integrate into my own work. It is therefore an important reference source as I begin to conduct my own research, and I intend to dedicate a portion of my literature review to its ideas.

**Jodeiri, A. M., Goldsworthy, M. J., Buffa, S., & Cozzini, M. (2022). Role of sustainable heat sources in transition towards fourth generation district heating – A review. *Renewable and Sustainable Energy Reviews, 158,* 112156.** [**https://doi.org/10.1016/j.rser.2022.112156**](https://doi.org/10.1016/j.rser.2022.112156)

This is a recent review article covering the history and latest developments of renewable district heating. It is useful to me as a reference for recent developments in the field, for its history, and for covering essentially *all* forms of renewable heating currently in use – both those inside and outside the scope of my own research. This is therefore a good reference to enable me to briefly describe solar thermal, biomass/biogas, thermal energy storage, and other renewable heating forms that I am not covering in my thesis, as part of my Literature Review.

**Kassem, N., Hockey, J., Beyers, S., Lopez, C., Goldfarb, J. L., Angenent, L. T., & Tester, J. W. (2020). Sustainable district energy integrating biomass peaking with geothermal baseload heating: A case study of decarbonizing Cornell's energy system. *Journal of Renewable and Sustainable Energy, 12,* 066302.** [**https://doi.org/10.1063/5.0024841**](https://doi.org/10.1063/5.0024841)

This is one of many journal articles covering Cornell University and its on-going research into geothermal direct heating, which has become the most prominent case-study (so far) in my Literature Review. However, this article additionally evaluates the potential for Cornell to supplement its proposed geothermal system with biogas boilers, to be fueled by processed manure sourced from cattle farms surrounding the campus. I highlight this article because it builds upon the research and planning that has already been conducted for renewable heating at Cornell, and *offers an additional supplement to it that is based on the unique factors and characteristics of Cornell’s place*.

**Tester, J. W., Beckers, K. F., Hawkins, A. J., & Lukawski, M. Z. (2021). The evolving role of geothermal energy for decarbonizing the United States. *Energy & Environmental Science, 14*(12), 6211–6241*.*** [**https://doi.org/10.1039/d1ee02309h**](https://doi.org/10.1039/d1ee02309h)

This article is authored by multiple figures heavily involved in Cornell University’s research into geothermal direct heating (Tester and Beckers in particular). However, the focus of this article is broader and analyses the potential for further geothermal implementation in the U.S. in general. As part of their research, the authors have produced several maps showing various physio-geological data pertaining to geothermal implementation – this will be incredibly helpful to me as I develop my viability criteria and begin to consider how different place-based factors may affect them.

References

Beckers, K. F., Galantino, C. R., Jurado, N. R., Kassem, N., Hawkins, A. J., Beyers, S. M., Gustafson, O., Jordan, T. E., Fulton, P. M., & Tester, J. W. (2020). Geothermal district heating using centralized heat pumps and biomass peakers: Case-study at Cornell University. *GRC Transactions, 44*, 217–234.

Buffa, S., Cozzini, M., D’Antoni, M., Baratieri, M., & Fedrizzi, R. (2019). 5th generation district heating and cooling systems: A review of existing cases in Europe. *Renewable and Sustainable Energy Reviews, 104,* 504–522. <https://doi.org/10.1016/j.rser.2018.12.059>

Gaur, A. S., Fitiwi, D. Z., & Curtis, J. (2021). Heat pumps and our low-carbon future: A comprehensive review. *Energy Research & Social Science, 71,* 101764. <https://doi.org/10.1016/j.erss.2020.101764>

Han, A. T., Laurian, L., & Brinkley, C. (2021). Thermal planning: What can campuses teach us about expanding district energy? *Journal of Environmental Planning and Management, 64*(11), 2066–2088. <https://doi.org/10.1080/09640568.2020.1855577>

Hester, R. T. (2010). *Design for ecological democracy.* The MIT Press.

Im, P., Liu, X., & Henderson, H. (2016). *Case study for the ARRA-funded ground source heat pump demonstration at Ball State University* (ORNL/TM--2016/644, 1337858). Oak Ridge National Laboratory. https://doi.org/10.2172/1337858

Jodeiri, A. M., Goldsworthy, M. J., Buffa, S., & Cozzini, M. (2022). Role of sustainable heat sources in transition towards fourth generation district heating – A review. *Renewable and Sustainable Energy Reviews, 158,* 112156. <https://doi.org/10.1016/j.rser.2022.112156>

Kassem, N., Hockey, J., Beyers, S., Lopez, C., Goldfarb, J. L., Angenent, L. T., & Tester, J. W. (2020). Sustainable district energy integrating biomass peaking with geothermal baseload heating: A case study of decarbonizing Cornell's energy system*. Journal of Renewable and Sustainable Energy, 12*, 066302. <https://doi.org/10.1063/5.0024841>

Lund, H., Østergaard, P. A., Nielsen, T. B., Werner, S., Thorsen, J. E., Gudmundsson, O., Arabkoohsar, A., & Mathiesen, B. V. (2021). Perspectives on fourth and fifth generation district heating. *Energy, 227,* 120520. <https://doi.org/10.1016/j.energy.2021.120520>

Lund, J. W., & Toth, A. N. (2021). Direct utilization of geothermal energy 2020 worldwide review. *Geothermics, 90,* 101915. <https://doi.org/10.1016/j.geothermics.2020.101915>

Mock, J. E., Tester, J. W., & Wright, P. M. (1997). Geothermal energy from the Earth: Its potential impact as an environmentally sustainable resource. *Annual Review of Energy and the Environment, 22,* 305–356.

Schimel, J. (2011). *Writing science: How to write papers that get cited and proposals that get funded*. Oxford University Press.

Snyder, D. M., Beckers, K. F., & Young, K. R. (2017, February 13–15). Update on geothermal direct-use installations in the United States. In *42nd Workshop on Geothermal Reservoir Engineering*, Stanford University, Stanford, CA (USA).

Staffell, I., Brett, D., Brandon, N., & Hawkes, A. (2012). A review of domestic heat pumps. *Energy & Environmental Science, 5,* 9291–9306. <https://doi.org/10.1039/c2ee22653g>

Tester, J. W., Beckers, K. F., Hawkins, A. J., & Lukawski, M. Z. (2021). The evolving role of geothermal energy for decarbonizing the United States. *Energy & Environmental Science, 14*(12), 6211–6241*.* <https://doi.org/10.1039/d1ee02309>

Tester, J. W., Gustafson, J. O., Fulton, P., Jordan, T., Beckers, K., & Beyers, S. (2023, February 6–8). Geothermal direct use for decarbonization—Progress towards demonstrating earth source heat at Cornell. In *48th Workshop on Geothermal Reservoir Engineering,* Stanford University, Stanford, CA (USA).

1. You are not locked into this title; we want you to identify the main point or topic of your thesis. [↑](#endnote-ref-1)
2. You might discuss a selection of case studies, sampling methods, experimental design, and/or specific hypotheses you will test. You should also address any specialized knowledge or skills that are necessary to complete the research. [↑](#endnote-ref-2)
3. If you are planning to use existing data, explain the specific source, contact information, arrangement with collaborating agencies, and expectations about use of data and final products of your research. If you are planning to gather new data, describe specific methods, time, place, and equipment that will be required. [↑](#endnote-ref-3)
4. If you’re not sure where to start, consult a ‘Code of Ethics’ or other similar document from an academic society in an applicable field of study. [↑](#endnote-ref-4)
5. If you are collecting ANY samples or data, even observational data, on public lands (city, county, state and/or federal) it is your responsibility to find out the permit requirements BEFORE you collect data. Conducting research with tribal members/on tribal lands will have different and additional requirements. [↑](#endnote-ref-5)
6. Your *positionality as a researcher* refers to the fact that one’s “…beliefs, values systems, and moral stances are as fundamentally present and inseparable from the research process as [one]’s physical, virtual, or metaphorical presence when facilitating, participating and/or leading the research project…” (The Weingarten Blog 2017). [↑](#endnote-ref-6)