Background

A renewable energy transition is underway across the globe and in the U.S. The transition away from fossil fuels and towards clean or renewable energy is motivated by multiple factors. A significant catalyst is the need to reduce greenhouse gas emissions in order to limit the extent of anthropogenic climate change (Calvin et al., 2023). Additional motives are improved air quality and subsequent health benefits, increased energy security, and cheaper and more stable energy costs (Fershee, 2008; Griffith, 2021). To fully transition energy generation to renewable sources, multiple forms of renewable energy technologies will need to be adopted at higher rates and on a rapid timeline. The 2023 National Climate Assessment states "limiting global temperature change to well below 2 degrees Celsius requires reaching net-zero carbon emissions globally by 2050…to reach net zero targets, the U.S. will need to add new electricity generating capacity, mostly wind and solar, faster than ever before" (Jay et al., 2023, pp. 40-42). One technology with potential to play a growing role in replacing fossil fuels is distributed solar photovoltaics (PV), also referred to as small scale solar. This term constitutes solar arrays smaller than 1 MW, and includes residential, commercial and community solar projects of this size. Currently, distributed solar constitutes 1.5 percent of U.S. energy generation, though there is technical potential for it to expand to 45 percent of our energy (Dutzik et al., 2024).

Distributed solar has seen significant reductions in cost (Feldman et al., 2021), offers financial benefits to the households that adopt it (Griffith & Calisch, 2020), allows for a more decentralized energy system (Shapsugova, 2023), decreases the need for land devoted to electricity generation (Zahran et al., 2008) and holds potential to benefit to the grid overall, as it reduces the amount of additional transmission and distribution infrastructure needed (Roberts, 2024). The technology also comes with challenges. A primary obstacle is the high upfront investment required to install solar panels (Kwan, 2012). Empirical evidence finds that this leads to distribution skewed by income level, with low and middle income populations or renters unable to afford or access solar and therefore to receive the subsequent benefits (Lukanov & Krieger, 2019; Reames, 2020). Another equity concern is that as more individuals adopt solar, utility companies may increase electricity prices for remaining customers. This further places strain on already overburdened communities (Gao & Zhou, 2022). Finally, exists technical challenges with integrating this form of dispersed energy generation into the electrical grid, the systems for which are currently accustomed to managing electricity from centralized and large-scale fossil fuel power plants (Jones-Albertrus, 2017; Valova & Brown, 2022).

Purpose

In order to fully transition our energy system, we need to scale up renewable energy technology on a rapid timeline, yet also ensure equitable processes and outcomes (García-Muros et al., 2022; McCauley & Heffron, 2018). To achieve both goals, better understanding of the barriers and pathways to increased and equitable adoption of potential technologies is necessary. My research seeks to further this understanding for residential solar as a subset of distributed solar to illuminate implications for what role this technology stands to play in the future of the energy transition.

Adoption rates for distributed solar vary across the U.S, not necessarily due to varying amounts of sun light. Washington and Vermont provide an example of this disparity. Washington, with a population of 7.78 million people, has installed capacity for 518,000 megawatt hours (MWh) of distributed solar, or 67 Watts per capita (EIA, 2023). Vermont, with a population of 600,000, has installed capacity for 239,000 MWh, or 369 Watts per capita. This disparity is despite the fact that the states have relatively similar climates, and the cost of purchasing and installing solar is less in Washington, at $2.66 per Watt, than Vermont, at $3.01 per Watt (NREL, 2023). To further underline the point, in 2018 Burlington, Vermont had more solar per capita than Phoenix, Arizona (Bradford et al., 2019).

It is understood in the academic literature that state level policy plays a role in influencing adoption rates, particularly net metering policies. These set standards for how people are compensated for the distributed energy they generate and therefore how financially advantageous it is for individuals to adopt. Net metering policies vary widely in design state by state (Gregoire-Zawilski & Siddiki, 2023; Ros & Sai, 2023). Also emerging in the literature is the impact that local policies such as building and permitting codes can have (Burkhardt et al., 2015; Dong & Wiser, 2013; O'Shaughnessy et al., 2019). However, the majority of this research around distributed solar is focused on quantitative data (Burkhardt et al., 2015; Dong & Wiser, 2013; Griffith & Calisch, 2020; Kahsar, 2021; Kaufmann & Vaid, 2016; Kwan, 2012; Lemay et al., 2023; Muaafa et al., 2017; Phillips et al., 2019) and the impacts of a single policy (Cayton, 2022; Gregoire-Zawilski & Siddiki, 2023; Ros & Sai, 2023; Smith et al., 2021; Sunar & Swaminathan, 2021), while local contexts for distributed solar are influenced by multiple different policies across scales of government, as well as factors beyond policy.

To generate a more holistic understanding of the factors influencing solar adoption, I will conduct a qualitative, comparative case study of Bellingham, WA and Burlington, VT to answer the following questions: **What have adoption rates and patterns for residential solar looked like in each case study? What factors influence adoption rates and how have they come about? How has equity and accessibility been considered in policies and action related to distributed solar at the local level?**

Methods

My research will utilize qualitative methods, including semi-structured interviews, policy analysis and causal process tracing to create a local history of residential solar for the case studies of Bellingham, Washington and Burlington, Vermont. Qualitative methods are useful in this research, as I am hoping to gain nuanced detail rather than wide angle scope, and study people, opinions, and context (Bierbaum et al., 2013; Ray & Grannis, 2015; Stults & Woodruff, 2017). Similarly, a case study approach allows me to focus on deeply understanding the "dynamics present within a single setting" (Huberman & Miles, 2022, p.8). This research will be longitudinal, tracing each case study over the past 10 years, as a timeframe in which the cost of solar is reduced enough to become more widely accessible.

Semi-structured interviews are chosen due to the ability for me as the researcher to ask a consistent set of questions to each interviewee, but also allow room for the interview to adapt and follow threads brought up by different individuals. This results in more detailed and "textured" results than if sticking to a ridged script (Berg & Lune, 2012, p. 114). Policy analysis will entail reviewing all relevant state and local policies impacting the context created for distributed solar. I also hope to gather data that reflects the narrative history of each case study in numbers such as the total amount of solar installations in each city, the cost of solar installations in each location, the timeline for a return on investment, and if possible, data on the distribution of solar broken down by demographics like income and race.

Research Design

I will begin my research by conducing 8-10 semi-structured interviews in each case study. Interviews will be non-random, as I am looking to speak with individuals holding knowledge of distributed solar specifically (Kanazawa, 2017). This will include state and local government officials, solar installers, and renewable energy advocates that have knowledge of the history and factors influencing solar. It will also include representatives from low- and middle-income housing advocacy organizations that can offer perspective on efforts to address equity and accessibility related to residential solar. To thank people for their time, I will offer $50 visa gift cards to each interviewee.

After my interviews, I will gather all policy documents that I identify as relevant to residential solar for each state and city. I will analyze the documents to understand the different policy contexts for solar in each case study. I will also gather the numerical data for each case study relevant to solar adoption rates over the last 10 years. Finally, I will analyze my interview transcripts, policy analysis and solar adoption numerical data using causal process tracing. This data analysis method is similar to historical analysis (George & Bennett, 2005; King, 1994). It will ideally result in my being able to create a historical narrative for each case study, including the factors that impacted solar adoption rates and the causal mechanisms, or that which "exists between cause and effect" (King, 1994, p. 85). This method leaves room for other elements and relationships to emerge in my analysis that may be missed when focused on quantitative analysis or impacts of a singular policy.

Anticipated Results

The overall goal of this research is to understand how the local context for residential solar has emerged in Bellingham and Burlington through an approach that may allow new insights or elements to be revealed. Additionally, by comparing across case studies, patterns may emerge that can shed light on the future of residential solar as a piece of the larger just energy transition. The results of this research will be relevant to academics working to further develop theory around how our current transition is playing out, to policymakers across cities in the U.S. wanting to understand how they can support an equitable energy transition, and to individuals in each city curious about how they can contribute to and benefit from new energy technologies.

Schedule for Completion

Spring 2024:

- Proposal Presentation
- Thesis Topic Approval
- IRB Application
- Apply for Funding

Summer 2024:

- Conduct interviews
- Obtain numerical data
- Policy analysis

Fall 2024:

- Analyze data
- Begin writing thesis

Winter 2024:

- Write thesis
- Submit draft to committee

Spring 2025:

- Thesis Defense
- Graduate

Budget

RSP has granted me funding for some of my research, however, my research plans changed after I applied, and I added the Burlington case study. Therefore, I am hoping to obtain additional funding to travel to Burlington to be able to conduct interviews in person over the summer. If I do not receive the funding, I will conduct interviews over zoom and may be more limited in who I am able to include in my research.

Funding Requested				
Budget Item Description	**Cost of Item**	**Quantity**	**Requested Dollar Amount**	**Justification**
Flight to Burlington, VT	$750	1	$750	Travel to conduct interviews in person. I can stay with a friend and borrow a car so do not need lodging. Current flights on google.flights.com are listed at $720-750 from Seattle to Burlington.
Travel in Burlington, VT	.67/mile	80 miles	$53	Travel throughout Burlington to meet with interview participations in person
Otter AI	$10 / month	10 months	$60	I do not need the $40 of funding I already obtained for Atlas TI so can roll that over to make up $100 for Otter AI subscription
Total requested			$863	

Funding Received from RSP				
Budget Item Description	**Cost of Item**	**Quantity**	**Requested Dollar Amount**	**Justification**
Supplies & Materials				
Atlas TI Software	$10 / month	4 months	$40	Qualitative Data Analysis Software, student monthly rate
Interview Travel – Bellingham	.67/mile	80 miles	$53	Travel throughout Bellingham to meet with interview participants in person
Interview Thank You	$50	15	$750	$50 visa gift cards will be offered to all interview participants to appreciate them for their participation
Total received			$843	