Thermal Energy Networks in the United States

Emerging Opportunities, Challenges, and Needs

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Transformative Strategies

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Transformative Strategies Consulting was created out of a passion for fostering impactful, just, and equitable deep decarbonization solutions. We collaborate with leaders in the climate and sustainability sectors to maximize outcomes and drive lasting, systemic change. We help develop, build consensus around, and implement intentional climate and deep decarbonization policies and programs that drive lasting change, and help leaders translate good ideas into actionable strategies, navigate complex partnerships, and design new initiatives that achieve intended impacts.

Common Spark Consulting works to advance boldly inclusive policymaking as the foundation for a clean energy future for all. We recognize that unjust systems are all around us, and thus uphold a vision of progressive advocacy that takes a reparatory approach to address the intertwined impacts of social, economic, educational, and environmental injustices. Common Spark's client partners include environmental justice organizations and coalitions, environmental and climate advocates and researchers, local and state agencies and regulatory bodies, philanthropic organizations, and utilities and energy service providers.

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Environmental justice and energy democracy interviewees were offered honoraria for their time and expertise, however, we acknowledge that these one-time payments do not sufficiently represent the value of a community's lived experience nor the central role that lived experience can and should play in better policymaking. Long-term investment provided directly to frontline communities and community-based organizations can better support inclusive policymaking and implementation of community-driven solutions.

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Executive Summary

Background

The growing reliance on fossil fuels, rising energy costs, and the need for energy security are significant concerns in the United States. Fossil fuels, especially natural gas,[1] oil, and propane, dominate space heating and cooling and water heating, driving up energy costs and contributing significantly to greenhouse gas (GHG) emissions, which are destabilizing the climate and posing threats to public health. Methane emissions, which account for 20% of global GHGs, and leaks from gas pipelines and other aging fossil fuel infrastructure, cause significant health and safety risks. As energy costs rise and the environmental impacts of fossil fuels become more urgent, the need for solutions that provide affordable, reliable, and sustainable energy becomes critical.

There is a growing opportunity in neighborhood-scale solutions, such as thermal energy networks, which have the potential to advance widescale decarbonization and improve quality of life in our communities. A thermal energy network (TEN) uses a system of water pipes and heat pumps to provide space heating, cooling, and hot water by capturing waste heat from surrounding sources like the ground, water, or air. By leveraging "waste" heat and renewable sources, TENs provide fossil fuel-free heating and cooling with unmatched efficiency.

TENs offer a number of potential benefits over fossil fuel-based heating and cooling systems, including climate benefits; health and safety benefits; facilitating a just transition for oil and gas workers; decreased energy costs; the ability to transition entire neighborhoods off fossil fuels; localized energy sources; resilience from oil and gas supply interruptions; easing strains on the electric grid; water savings; and new business models for utilities to transition from fossil fuels to clean heating and cooling technologies.

Like any emerging solution, TENs face several challenges that must be addressed to ensure thoughtful and intentional deployment in order to avoid the environmental injustices that conventional energy systems have historically caused in low-income and marginalized communities, and enable greater local control and meaningful community participation in energy decision-making.

This report draws on research and 40 interviews with a diverse range of stakeholders — including government agencies, environmental justice organizations, energy democracy groups, TENs advocates, labor organizations, legal advisors, and industry representatives — in order to explore the following questions: 1) What is the scale and breadth of policy action around TENs in the United States; 2) What are the various ownership models we're seeing with TENs development; 3) What are the equity and environmental justice perspectives on TENs; and 4) What is the potential

[1] Many decarbonization advocates have begun using the terms "methane gas" or "fossil gas" instead of "natural gas" in response to the natural gas industry's efforts to rebrand the fuel in a way that makes it more appealing to Americans. However, because these terms have not yet been widely adopted by the general public and for clarity's sake, this paper will use the term "natural gas."

of TENs to advance energy democracy. The goal is to inform stakeholders about strategies for scaling this technology in a way that advances equity, environmental justice, and energy democracy.

Policy Landscape and TENs Ownership Models

An increasing number of states are granting permission for the ownership and operation of TENs by a range of entities, including private developers, investor-owned utilities, municipalities, cooperatives, nonprofit organizations, and community-based organizations. As of March 2025, eight states have passed TENs-specific legislation and four additional states have passed or introduced legislation to study or fund TENs pilot projects. A number of others have passed or introduced complementary policies such as clean heat standards, obligation to serve reform, and methane pollution protections or have begun "future of gas" proceedings to integrate GHG emission targets into gas system planning.

The choice of TEN ownership structure plays a critical role in financing, cost recovery, and eligibility for federal and state incentive programs—often shaping which model is ultimately pursued. This decision is heavily influenced by stakeholder priorities, legal mandates, and the availability of financing options. Ownership—whether private, public, or community-based—determines who bears the financial risks and benefits: a private entity, shareholders, the public, or the community. It also influences how the TEN is funded—through private investment, public financing, ratepayer contributions, or taxpayer dollars—and who oversees the project, whether it be the community, cooperative members, a public utilities commission, or a city council.

This paper explores the ownership structures currently being implemented for TENs (Table 1) and provides case studies of different models from across the country.

Table 1: Types of TENs Ownership Models Discussed in this Paper[2]

Privately Owned	– Private Developers – Investor-Owned Utilities (IOUs)

Publicly Owned	– Publicly Owned Utilities (POUs)
	   ○ Traditional POUs
	   ○ Municipally-Owned Gas Utilities
	   ○ Sustainable Energy Utilities (SEUs)*
	   ○ Public Heating & Cooling Utilities
	   ○ Collaborative Public Ownership Structures
	– Public-Nonprofit Partnerships (PNPs)
	– Untapped Public Ownership Structures
	   ○ Rural Energy Cooperatives (Co-ops)

[2] This paper does not offer a comprehensive analysis of each model, nor are the categorizations based on peer-reviewed, industry-accepted standards, which, to the authors' knowledge, have not yet been established. In the absence of such standards, the authors have made editorial decisions to classify these models as clearly as possible based on our best understanding.

	○ Community Choice Aggregators (CCAs)
Community Owned	– Community Based Organizations (CBOs) – Tribal Nations – Nonprofit Organizations (NGOs)

**SEUs can be established as either publicly sponsored non-profits or municipally owned entities. For this paper, the authors have chosen to categorize SEUs under POUs because the case study presented follows this structure.*

The field remains in its early stages, and new structures are likely to emerge as interest in TENs grows and regulatory frameworks evolve.

Equity and Environmental Justice Perspectives on TENs

Energy infrastructure has historically harmed marginalized communities, exposing them to pollution, safety risks, and economic disinvestment, while clean energy advancements often benefit wealthier populations. The transition to clean energy must prioritize environmental justice (EJ) communities, ensuring that solutions like TENs address inequities and create opportunities for sustainable progress. This includes ensuring community input, addressing concerns like displacement and affordability, and implementing inclusive policies that offer job training for workers in fossil fuel industries. Achieving an equitable transition requires deep collaboration between utilities, policymakers, and EJ advocates, emphasizing community leadership and shared decision-making to ensure that TENs provide long-term social, economic, and environmental benefits.

Interviewees highlighted several challenges in realizing the potential of TENs, including exclusion of meaningful community input due to complex processes and rigid engagement structures, as well as misrepresentation of rural communities in official EJ maps. Technical challenges like spatial constraints, labor shortages, and high retrofit costs also pose obstacles, alongside workforce limitations that require collaboration with unions and diverse hiring practices to ensure EJ communities access clean energy jobs. Additionally, community distrust and cost issues remain significant barriers, as EJ communities have historically been burdened by energy infrastructure with little benefit. Overcoming these challenges requires transparent, community-centered decision-making, strong policy design, and financial mechanisms to ensure equitable access to TENs.

Energy Democracy Perspectives on TENs

There is increasing momentum toward advancing locally controlled, community-driven energy systems, shifting power from private ownership to more localized, community-led models. While local governments and community groups are pioneering innovative ownership models for TENs, they often encounter significant obstacles. TENs present a unique opportunity to transform the energy landscape by empowering communities to control, govern, and benefit from their energy systems, but realizing this potential requires overcoming substantial policy, financial, and governance challenges.

Interviewees identified several challenges to developing and implementing TENs, including policy and regulatory barriers that favor IOUs and restrict community or municipal ownership models. Financial obstacles, such as high upfront costs, limited financing for community-driven projects, and distorted energy pricing due to outdated rate structures, hinder adoption. Additionally, reforms are needed in utilities' "obligation to serve" and thermal energy decarbonization planning. Local governments face resource gaps in staffing and political power, while trusted entities often lack the resources to navigate the complexities of TENs. Legacy gas infrastructure also complicates the transition to non-IOU-owned systems. Successful TENs development requires robust policy, community-driven decision-making, and financial strategies to support inclusive implementation.

Summary of Recommendations

Based on these identified opportunities and barriers, the authors recommend the following actions for effectively deploying TENs as an equitable and democratic decarbonization strategy.

Advancing TENs that Prioritize Equity and Environmental Justice

1. Support Communities in Determining their Own Energy Future — TENs should only proceed with clear community support, especially in Environmental Justice (EJ) communities, ensuring local input through advisory boards and transparent processes.
2. Include and Resource Equitable Processes in Policy Design — Legislation should guarantee inclusive participation, supporting marginalized groups with technical, legal, and financial resources, while ensuring EJ communities can make decisions to avoid displacement and burdens.
3. Build Community Trust through Meaningful Engagement — Building trust in EJ communities requires sustained engagement, early involvement, and addressing concerns like displacement and affordability through informed dialogue.
4. Expand Workforce Training and Development for Local Jobs — Strong labor standards in the TENs industry should prioritize local workforce development through training programs, partnerships with unions, and career pathways for EJ communities.
5. Reduce Consumer Costs with Public and Innovative Financing — To reduce consumer costs, TENs should utilize public-private partnerships and community-led funding to lower upfront costs and promote affordability and collective ownership.
6. Remove Risk to Communities in Project Design and Implementation — TENs projects should be well-researched, cost-effective, and considerate of EJ communities' needs, minimizing disruptions and ensuring energy access during development.
7. Pursue Comprehensive Energy Upgrades — TENs should be integrated with energy efficiency upgrades, weatherization, and energy storage to enhance resilience, sustainability, and overall community benefits.

Advancing TENs that Prioritize Energy Democracy

8. Implement Policy Reforms and Clarify Regulatory Frameworks — Legislative and regulatory reforms should create pathways for local ownership of TENs, empowering communities and municipalities to lead the transition to sustainable energy.
9. Support the Development of Locally Owned Pilot Projects — Financial and technical support for locally-owned pilot projects will help communities test and refine ownership models and establish best practices for TENs.
10. Expand Funding and Financing Support — Increase access to grants and financial mechanisms to support the early stages of locally-owned TENs, including feasibility studies and planning efforts.
11. Resource Deep Community Engagement — Strengthen CBOs by providing resources to engage local communities in inclusive decision-making for TENs development.
12. Support or Mandate Thermal Energy Planning and Waste Heat Mapping — Policies should encourage or require thermal energy planning and waste heat mapping to reduce fossil fuel use and support holistic energy planning.
13. Mandate Safe Decommissioning of Legacy Gas Pipelines — Policies should mandate the safe decommissioning of legacy gas pipelines when installing new non-IOU TEN systems, with incentives or cost-sharing to support this process.
14. Evaluate Fossil Fuel Infrastructure Maintenance Costs When Doing TEN Financial Assessments — Financial evaluations of TENs should account for the full costs of maintaining aging fossil fuel infrastructure to provide a clearer long-term financial picture.
15. Reform Electric Rates — Electric rates should be reformed to reflect the true costs of fossil fuel use, supporting the transition to clean thermal energy and reducing emissions.
16. Reform Utilities' "Obligation to Serve" — Update utilities' "obligation to serve" to include clean thermal energy options, enabling the transition to more efficient and sustainable energy sources.
17. Deploy a Suite of Technical, Financial, Legal, and Governance Resources — Provide local governments and communities with comprehensive technical, financial, legal, and governance resources to support TENs development, fostering collaboration and innovation

Unlocking TENs' Full Potential

TENs offer a transformative opportunity to advance clean energy, equity, and environmental justice by decarbonizing buildings and promoting local ownership and decision-making. They can democratize energy, support local economies, and address disparities in access to clean energy. However, as a relatively new concept, TENs require continuous learning and adaptation for effective design, scalability, and long-term success. Diverse ownership models and community-led engagement are essential, and by resourcing communities to shape their own energy future, enacting reforms that prioritize energy democracy, and ensuring transparency and accountability in project development, TENs can become a cornerstone of a clean, resilient, and community-centered energy future.

Chapter 1: Introduction

The Need to Rethink Heating and Cooling

The reliance on fossil fuels, rising cost of energy, and the urgent need for energy security have become pressing concerns in communities across the United States. Fossil fuel use, particularly in heating, cooling, and hot water, continues to dominate, with natural gas, oil, and propane being the primary sources of energy in most regions. These systems not only drive up energy costs but also contribute significantly to greenhouse gas (GHG) emissions, which are destabilizing the climate and posing threats to public health.

One of the most potent GHGs—methane—accounts for nearly 20% of global GHG emissions. Of this, 60% comes from fossil fuels and other anthropogenic sources.[3] In the U.S., more than one-third of all methane emissions come from gas leaks from oil and natural gas wells, storage tanks, pipelines, and processing plants. Methane is 86 times more potent than carbon dioxide (CO2) at trapping heat in the atmosphere.[4] Because methane is both a powerful GHG and is short-lived compared to CO2, achieving significant reductions would have a rapid and significant effect on atmospheric warming potential. Additionally, aging oil and gas pipeline infrastructure poses a growing threat to safety, with a quarter of pipelines over 50 years old and nearing the end of their service life. Leaks are documented not only in oil and gas wells, storage tanks, and processing plants, but also throughout fossil fuel distribution systems—including inside homes—compromising indoor air quality and sometimes causing explosions.[5]

Yet, the transition away from fossil fuels as our primary thermal energy resource presents a major challenge. Over 60% of U.S. households are connected to gas infrastructure, with 52% relying on it for space heating, 48% for water heating, and 38% for cooking.[6] Another 13% rely on fuel oil[7] or propane.[8] Fossil fuel companies, which made over $12.4 billion from natural gas and fuel oil in 2021,[9] have heavily lobbied against decarbonization, enlisting labor groups, chefs, and influencers to speak in favor of natural gas. Many fossil fuel companies and the workforces employed by them have viewed decarbonization as a threat to their business models and jobs. Instead, they have promoted fuel-for-fuel alternatives like hydrogen or biogas—unproven and potentially unsafe options that continue to raise environmental justice concerns.[10]

As energy costs rise and the environmental impacts of fossil fuels become more urgent, the need for solutions that provide affordable, reliable, and sustainable energy becomes critical.

[3] Greenhouse Gas concentrations hit record high. Again.
[4] https://www.science.org/doi/pdf/10.1126/science.aar7204
[5] Pipeline Replacement Background | PHMSA
[6] The majority of U.S. households used natural gas in 2020 - U.S. Energy Information Administration (EIA)
[7] https://www.eia.gov/energyexplained/heating-oil/use-of-heating-oil.php
[8] https://www.npga.org/wp-content/uploads/2022/05/Todays-Propane-546268.pdf
[9] U.S. oil and gas companies by revenue 2024 | Statista
[10] Refer to Joint Environmental Justice Low Carbon Fuel Standard Letter (March 15, 2023) and Coalition Comments on LCFS Community Workshops (June 14, 2023) submitted regarding the Low Carbon Fuel Standard.

To-date, conventional approaches have struggled to meet these needs. Yet, there is a growing opportunity in neighborhood-scale solutions, such as thermal energy networks (TENs), which have the potential to advance widescale decarbonization and improve quality of life in our communities. TENs offer a unique approach by utilizing localized, efficient, and renewable sources of thermal energy to meet the heating and cooling needs of communities without relying on fossil fuels.

The potential and momentum around TENs is tangible. Yet, TENs are still early in their development and there is much to study as we begin to deploy pilot systems across the country.

What are Thermal Energy Networks?

A thermal energy network (TEN) uses a network of water pipes to interconnect buildings and thermal energy sources to provide space heating, cooling and domestic hot water. TENs utilize heat pumps connected to an “ambient temperature loop,” in which a pump circulates water through an uninsulated pipe network that captures “waste” heat from the surrounding ground, water, or air. As water moves through the pipe, it warms or cools toward the temperature of the source.[11] This ambient temperature loop is connected to many buildings with their own heat exchangers, as well as any number of sources or sinks, including a geothermal borehole field.[12]

The network can harness otherwise wasted thermal energy from buildings, sewage systems and or/underground transit stations. Additional baseload thermal sources can include shallow geothermal boreholes, bodies of water, and data centers.[13] When installed, these networks can provide efficient, fossil fuel-free heating and cooling to commercial and residential buildings.

As described below, TENs take different forms, but this report focuses on those that share three key characteristics:

- They connect multiple buildings with different owners within a shared heating and cooling network.
- They are “bidirectional,” meaning they both supply and receive thermal energy from connected buildings. This enables the management of heating or cooling energy distribution to ensure that demand is met efficiently across all connected buildings or systems, a process known as "load balancing."
- They transfer renewable, passive, or waste heat from sources to sinks, rather than generating new heat or cooling.

For this report, we exclude campus-based TENs such as those in universities and hospitals—of which there are hundreds across the country[14]—where all buildings are under single ownership.

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[11] Buildings consume lots of energy – here's how to design whole communities that give back as much as they take - Green Technology.
[12] Geothermal Heating and Cooling - Pathways to Commercial Liftoff.
[13] A Definitional Taxonomy for (Geo)Thermal Energy Networks
[14] Colorado Mesa University is a notable example.

There is a growing number of district energy systems using geothermal, bodies of water, waste heat, or other sources to heat water and supply heat to buildings (like this one in Boise, Idaho; this one in Seward, Alaska; and this one in). However, we exclude these from our analysis because they are not bidirectional.

Additionally, while neighborhood decarbonization efforts using air-source heat pumps (ASHPs) and other electric heating/cooling systems may be the most cost-effective approach to neighborhood or "zonal" electrification in many parts of the country, these lack bidirectional thermal energy exchange. Consequently, they are not covered in this report.

Lastly, we do not include fossil fuel-based district energy systems, such as those powered by natural gas, steam, or combined heat and power (CHP), as they do not align with the renewable and waste heat transfer principles of TENs.

Types of TENs

TENs utilize waste heat from various sources to provide heating and cooling across a network. Key types include:[15]

- Geothermal Heat Recovery Systems (typically known as networked geothermal or *geothermal energy networks*) use relatively shallow geothermal boreholes and a system of networked ground source heat pumps to deliver heating and cooling to connected buildings.[16]
- Wastewater or Sewer Heat Recovery Systems harness anthropogenic heat from wastewater or sewer pipes to supply space and water heating in surrounding buildings.[17]
- Waterbody Thermal Energy-Based Systems capture the renewable thermal energy of oceans, seas, lakes, or rivers to extract heating and/or cooling.[18]
- Waste Heat Networks (without geothermal boreholes) draw heat/cooling from other sources such as data centers, subway systems, and ice rinks, using heat exchangers to share heating and cooling between buildings with complimentary heating and cooling needs.[19]

TENs can combine two or more of the above thermal energy resources. For example, a TEN can draw heat/cooling from shallow geothermal boreholes, from waste heat coming from a connected data center, and/or from waste heat being released by a nearby subway system to create a highly efficient thermal energy network.

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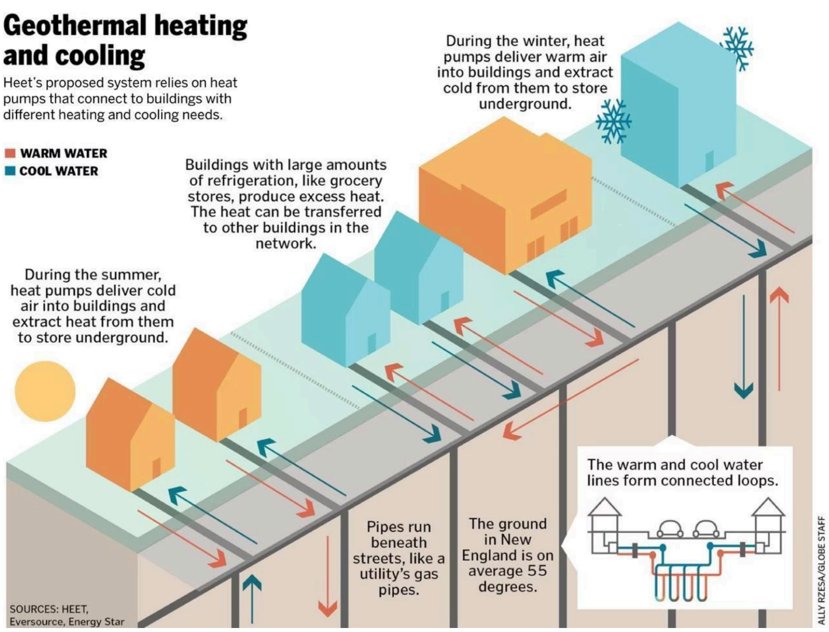
[15] The Building Decarbonization Coalition's TENs resource library contains examples of different types of thermal energy networks.
[16] A Definitional Taxonomy for (Geo)Thermal Energy Networks
[17] Sewer Thermal Energy Network
[18] Waterbodies thermal energy based systems interactions with marine environment — A review - ScienceDirect.
[19] Thermal Energy Networks (Sites) - BDC

One type of TEN that has started receiving tremendous attention in the U.S. in recent years is *networked geothermal*. Thus, it is worth discussing it in more detail here. Geothermal heating and cooling carries incredible efficiency. Because the ground remains a relatively constant temperature throughout the year—about 55 degrees fahrenheit—a geothermal network can achieve upwards of 500-600% efficiency.[20] Geothermal resources exist everywhere, from rural to urban communities, and can work in both hot and cold weather climates, but a geothermal network is most energy-efficient in medium-density, mixed-use neighborhoods when the heating and cooling loads are relatively balanced.

Figure 1 provides an illustration of a typical networked geothermal project.

Figure 1. A Networked Geothermal System



Source: HEET, Eversource Energy, Energy Star

For example, a Massachusetts study found that converting 25% of buildings to TENs could reduce winter peak electricity demand by 25% compared to a high-electrification scenario using air-source heat pumps.[21] Another study by the Oak Ridge National Laboratory estimated that widespread adoption of geothermal heating could significantly reduce peak electricity demand, generation capacity and transmission needs, and electrification costs.[22]

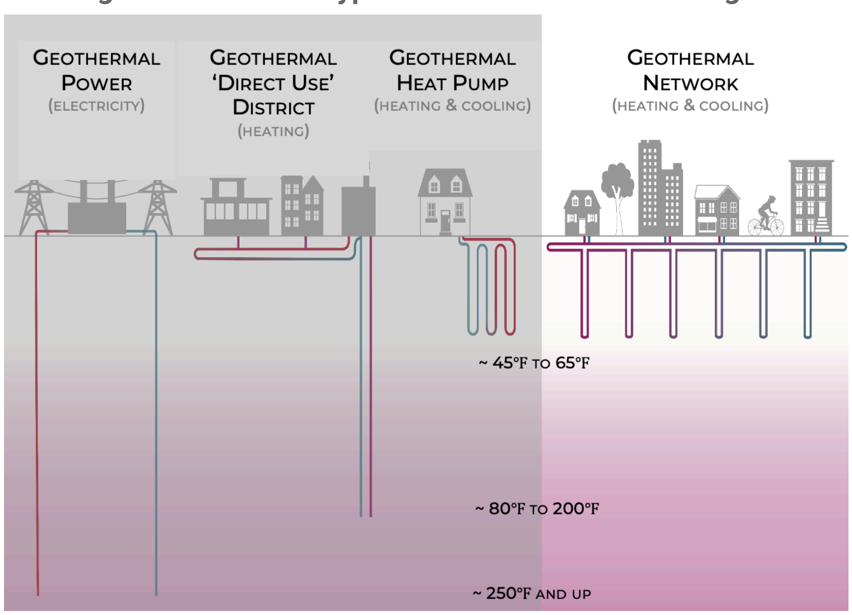
Networked geothermal can easily be confused with other types of geothermal technologies. The difference between networked geothermal and other types of geothermal energy is described below for clarity:

[20] What's up with networked geothermal? - Fresh Energy
[21] Energy and Environmental Economics (2022), The Role of Gas Distribution Companies in Achieving the Commonwealth's Climate Goals.
[22] Oak Ridge National Laboratory (2023), Grid Cost and Total Emissions Reductions Through Mass Deployment of Geothermal Heat Pumps for Building Heating and Cooling Electrification in the United States.

- **Utility-Scale Geothermal Electricity** – Geothermal power plants use superheated fluids from the Earth's geothermal resources to generate electricity. Typically, boreholes are installed to a depth of 2,000-10,000 feet.
- **District Heating** – A system for distributing heat generated from one centralized location through a system of pipes. Traditionally, these systems rely on centralized gas boilers, combined heat and power (CHP) plants, or waste-to-energy facilities to produce high-temperature steam, but many modern district heating networks operate with hot water at lower temperatures from geothermal, waste heat, or other sources, which improves efficiency and reduces energy losses. Typically, boreholes are installed to a depth of 400-500 feet.
- **Individual Building-Scale Geothermal Systems** – A geothermal heat pump in an individual home or building circulates water through pipes buried in the ground, or submerged in a water body, to either provide primary heating and cooling or "pre-heat" and cool a building's HVAC system. Typically, boreholes are installed to a depth of 150-300 feet, depending on site geologic conditions and available space.
- **Networked Geothermal** – Networked geothermal is a system of networked ground source heat pumps that delivers heating and cooling to connected buildings. Typically, boreholes are installed to a depth of 200-700 feet.

Figure 2 illustrates these various types of geothermal technologies.

Figure 2. Different Types of Geothermal Technologies



Source: HEET

TENs represent an emerging and innovative approach to district-scale heating and cooling: Unlike conventional heating and cooling systems that rely on centralized medium and high-temperature sources, many proposed TEN designs—including the most innovative—utilize ultra-low or ambient-temperature loops. This approach enables bidirectional energy flow or energy-sharing between buildings with diverse energy use patterns, reducing energy demands of the system and requiring less energy infrastructure to fulfil the baseload. Additionally, by leveraging ultra-low or ambient temperature distribution, these networks facilitate decentralized energy sourcing, making them highly adaptable to available waste heat and renewable thermal resources.

Costs

Due to the emerging nature of the TENs market, the limited number of projects currently being implemented or under development, and the lack of access to data from privately-owned TENs, there is insufficient data on the costs of implementing TENs. During the course of our interviews, the authors encountered estimated total installed costs ranging from $2 million for a relatively small project to $80 million for much larger projects. In many locations, this cost can be significantly less than the cost of installing new gas pipelines. While not exhaustive, the following key cost categories highlight the many factors influencing overall expenses:

- **Feasibility Study:** Each TEN project requires an assessment of financial, technical, and legal feasibility, given variations in layout, assets, interconnection, billing, and ownership models. The U.S. Department of Energy (U.S. DOE) has funded several such studies nationwide through its Community Geothermal Heating and Cooling Initiative.
- **Community Engagement and Partnerships:** As a relatively new energy approach, TENs require extensive outreach efforts due to the involvement of multiple decision-makers. Funding for community-based organizations involved in outreach will be essential, particularly for locally driven projects.
- **Access and Right of Way:** Depending on ownership, projects may need to purchase or negotiate access to land or right of way for pipeline infrastructure.
- **Energy Source Infrastructure:** If using geothermal, boreholes and equipment must be installed. If integrating waste heat or another existing source, infrastructure modifications will be necessary.
- **Piping Network:** While new pipelines may follow existing gas pipeline rights of way, they will almost always need to be newly constructed to meet TEN-specific requirements.
- **Inside-the-Building Equipment:** Buildings must upgrade to ground-source heat pumps (also known as *water-source heat pumps* or *geothermal heat pumps*) in order to connect to the TEN. Depending on the building's existing heating and cooling distribution system (HVAC), some buildings can use existing ducts and others may need to install new ductwork, while others might replace hot water or steam heating systems with a ductless system.[23] There is currently a federal Residential Clean Energy Credit (25D), which covers

[23] What happens when a Thermal Energy Network is installed?

30% of ground-source heat pump installation costs with no cap. Many states and utilities offer additional incentives for heat pump installations.[24]

The all-in cost of a TENs project is highly dependent on local conditions and requirements and remains an important question to understand more fully as more projects are developed and implemented. HEET is developing an open-source database of geothermal energy network projects in the U.S. to provide cost and other data.[25]

Overview of Potential Benefits of TENs

Thermal energy networks, while not new, are now gaining significant traction as communities and governments seek cost-effective and energy-efficient ways to decarbonize buildings. While not appropriate or economically viable everywhere, early indications are that they offer a wide range of benefits. TENs offer a potentially transformative solution to reducing methane emissions by replacing gas- and delivered fuel-dependent heating and cooling systems with clean, shared, underground water-loop systems that transfer heat efficiently between buildings.

TENs offer an alternative to extractive fossil fuel technologies and hold the potential to not only curb methane emissions but also enhance energy resilience, improve public safety, and accelerate the transition to a cleaner energy future. In particular, TENs offer benefits that promote local, clean sources of energy, bring new stakeholders to the table, and help unlock novel and needed pathways toward building decarbonization. These benefits include:

- **Health and Safety** – Burning natural gas and delivered fuels has significant impacts on indoor air quality and health, as the pollutants released—including particulate matter (PM), sulfur dioxide (SO2), nitrogen oxides (NOx), carbon dioxide (COs), carbon monoxide (CO), and methane—can accumulate inside, especially in poorly ventilated buildings. Increasing the adoption of TENs can significantly enhance indoor air quality by eliminating these harmful pollutants.[26] TENs also enhance safety by eliminating the need for new gas pipelines—as well as the use of fuel oil and propane— reducing the risk of gas leaks, explosions, and carbon monoxide exposure, and the need to fix or replace aging, leak-prone pipes. By using water or other non-combustible fluids to transfer heat, TENs also minimize fire hazards and improve overall system reliability. Replacing aging fossil fuel infrastructure with TENs can significantly lower maintenance risks and enhance community safety.

- **Just Transition for Fossil Fuel Workers** – Drilling the geothermal boreholes for TENs requires similar skillsets as oil and gas drilling. Installing and maintaining thermal energy network pipes requires virtually identical skills as installing gas pipes, securing a place for pipelayers, drillers, utility workers, network operators, and other skilled labor in a clean energy future. This is also true for the plumbers and pipefitters who install and maintain fuel oil and propane heating systems. Expanding work for existing fossil fuel workers will

[24] DSIRE
[25] The First Open-Source Database for Geothermal Networks
[26] https://www.epa.gov/air-quality-management-process/air-quality-and-health

also support the maintenance of the safety of fossil fuel infrastructure as it is being phased out. TENs not only secure a place for skilled labor, but specifically create an opportunity for union clean energy job creation and retention in sectors that already have very high union density in many parts of the country. When compared to many other electrification strategies, TENs not only have the benefit of high-levels of skill-transferability, but specifically the potential to create and retain high-quality jobs with family-sustaining wages and benefits.

– **Energy Affordability** – Electricity rates have increased almost 30% over the last decade and many low- and moderate-income (LMI) households are struggling to pay their utility bills. In 2020, 34 million U.S. households (27% of all households) reported difficulty paying their energy bills or kept their homes at an unsafe temperature because of energy cost concerns.[27] Because they harness "waste" heat, TENs have very low and consistent operating costs, which can translate into lower and more stable energy bills throughout the year.[28] TENs can dramatically reduce (and in some climates, eliminate) fossil fuel and electric demand for heating and cooling, and thus create system-wide savings from avoiding new demand.

– **Equitable Access to Clean Energy** – "Conventional" building-by-building electrification approaches means that customers with the means to decarbonize are likely to leave the gas system, leaving behind a dwindling customer base primarily of those without the means to decarbonize. These remaining customers could be left carrying the significant costs of fossil fuel delivery systems built for many but paid for by fewer. Thermal energy networks work best when all of the buildings within a particular neighborhood or community are connected, allowing entire neighborhoods to transition off fossil fuel infrastructure at the same time. This spreads the costs of decarbonization across the entire system, reduces upfront costs for the customer, and reduces the risk of leaving lower income customers to bear the increasing costs of remaining on the legacy system.

– **Local Energy Resilience** – Gas and oil travel hundreds or thousands of miles from wellhead to end user, making them vulnerable to single point failures. By contrast, thermal energy networks rely on decentralized and local sources of energy and function like microgrids, allowing them to "island," shielding communities from surrounding power outages. For example, during the record-breaking heat experienced across Texas during the summer of 2023, the neighborhood of Whisper Valley, which had connected all of its residents to a community-wide network of ground source heat pumps, solar PV, and energy storage, was the only neighborhood that reported zero power interruptions.[29]

– **Reducing Electric Demand** – Space and water heating and cooling account for about half of the country's total energy consumption.[30] Shifting all of this demand to electrification

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[27] As Utility Bills Rise, Low-Income Americans Struggle for Access to Clean Energy - The New York Times
[28] Note that, as described in the Costs section above, costs to consumers are not solely based on operating costs. They also include the costs of front-end capital investments in the generation and distribution system, the costs of purchasing the in-building equipment, how rates are structured, and other factors.
[29] Own a Geothermal Home Powered by EcoSmart near Austin, TX : WhisperValleyAustin.com
[30] Power to heat and cooling: Status.

would put a tremendous burden on the electric grid. Shifting to TENs where feasible will help "flatten the demand curve" by significantly lowering electricity consumption for heating and cooling, reducing strain on distribution and transmission systems, and minimizing the need for additional peaking power plants. Additionally, this shift frees up electricity for other essential uses, such as transportation and cooking electrification, as well as air-source heat pumps in milder climates where TENs may be less economically viable.

- **Water Savings** – Recent studies have shown that TENs can provide significant water-savings compared to conventional heating and evaporative cooling systems, which are used by fossil fuel plants and some large-scale battery energy storage systems to manage heat dissipation. The water-saving benefits of TENs make them particularly valuable in drought-prone regions where water conservation is a critical concern.[31]

- **New Utility Revenue Models** – Instead of viewing the coming clean energy economy as a "death spiral" that must be fought in order to stay in business, fossil fuel utilities can reinvent themselves as thermal energy utilities that offer sustainable heating while expanding into cooling services—an increasingly critical provision as the climate warms.

Overview of Challenges

As with any emerging technology, there are several challenges that TENs must overcome to advance their adoption. Here we list a few broad challenges that apply to TENs universally:

- **Costs** – Like any emerging industry, TENs are not yet cost-competitive. Key cost challenges include the complexity of installing connecting pipes in areas with existing underground infrastructure, a shortage of qualified drillers, the expense of deferred maintenance, and other factors. However, as the industry scales, costs are expected to decrease, following a trajectory similar to that of other renewable energy technologies like solar and wind. As we discuss in Chapter 4, this early-stage cost challenge is especially important to consider to avoid placing the financial burden of energy systems on communities before their cost-competitiveness has been established.

- **Zonal and Community-Wide Adoption** – For TENs to be most economical, a whole zone or portion of a community will likely need to participate. This will require the agreement of many building owners to participate in the TENs. Achieving this level of cooperation is already showing challenges for early zonal decarbonization pilots in different parts of the nation and might be no different for TENs depending on their respective legislative and regulatory conditions.

- **Navigating Overlapping Jurisdictions, Legally and Physically** – TENs challenge traditional ownership and governance models, making it applicable at state, regional, multi-jurisdictional, and local levels. The enabling policy, which may vary by state, could require authorization at multiple levels. Additionally, TENs physically span across utilities,

[31] Building Decarbonization Meets Water Conservation - BDC

state and local rights-of-way, and private property, creating both opportunities and complexities for any project.

– **Industry and Workforce Limitations** – There is a shortage of qualified engineering and design firms, as well as trained workers, in the design, installation, and maintenance of TENs systems, particularly in geothermal drilling. Only a few U.S. firms specialize in shallow geothermal borefield drilling—particularly in dense urban areas—and have the necessary technology to build networked geothermal systems. In addition to high labor costs and a lack of contractors with expertise in geothermal heat pumps and other TENs equipment, cities across the country have reported significant shortages of skilled electricians, plumbers, and other skilled labor.

– **Retrofit Challenges** – As with any technology, installing systems in new construction is much easier than managing retrofits in older buildings or retrofitting existing infrastructure. This includes difficulties in upgrading aging centralized infrastructure, such as downtown steam systems or water treatment plants, as well as retrofitting older residential buildings, which often have asbestos and ducting problems that add complexity and raise costs.

Outstanding Questions Regarding TENs

As the authors embarked on this research, there were four areas of outstanding research questions:

1. **What is the scale and breadth of policy action around TENs in the United States?** To date, there has not been a landscape assessment of TENs legislation, policy, and project development in the United States. With federal funding supporting some initial projects, oil and gas companies exploring alternative business models, and the push by advocates and state and federal policy to accelerate decarbonization of the energy system, it is valuable to capture this moment in time and elevate the breadth, diversity, and status of policy efforts to advance TENs. *How are legislatures looking at TENs? What authorizations are required to promote TENs? What kinds of pilots and projects are being promoted or required?*

2. **What are the various ownership models we're seeing with TENs development?** The local and zonal nature of TENs technology invites exploration of new and emerging ownership models. While private developers investor-owned utilities certainly can support TENs development, they also open up opportunities for local government, municipal and cooperative utility, and nonprofit entity ownership over TENs. *What lessons can we learn from different ownership models? What are the conditions required for some ownership models over others? What are the pros and cons of these different ownership models?*

3. **What are the equity and environmental justice perspectives on TENs?** Like any new clean energy technology, its implementation requires thoughtful and intentional deployment to avoid the same environmental injustices that other technologies (fossil and clean energy)

have inflicted upon low-income and communities of color. At this early stage of TENs development, there is an opportunity to build upon past lessons learned with environmental justice advocates and engage with their perspectives early on. *What are the greatest concerns by environmental justice communities? What impacts are of greatest priority? Environment and climate? Health and safety? Workforce development and economic resiliency?*

4. **What is the potential of TENs to advance energy democracy?** TENs' potential to develop under community and local ownership invites a unique opportunity for communities to more meaningfully participate in energy decision making and determine the distribution of benefits. *What have energy democracy efforts taught us about how TENs could support more community ownership, decision making, and local resilience? What stands in the way of expanding energy democracy efforts with and through TENs development?*

About this Report

Purpose and Scope of Analysis

Transformative Strategies Consulting, in partnership with Common Spark Consulting, conducted research and interviews with environmental and energy justice organizations, energy democracy organizations, CBOs actively pursuing or considering TENs, TENs practitioners, and local government representatives from across the U.S., and analyzed findings in order to:

- Understand the landscape of existing TENs policy and implementation efforts across the country, with a specific focus on their approach (or lack thereof) to centering equity, empowering community decision-making authority, and creating opportunities for local governments to decarbonize their thermal energy systems.
- Compile existing best practice guidelines and/or language for addressing concerns from an environmental justice standpoint.
- Analyze the various ownership models being pursued, explore their potential to advance energy democracy, and identify existing gaps.
- Identify opportunities for local governments to play a more active role in decarbonizing thermal energy in their jurisdictions.
- Identify where additional investments and resources are needed and well-positioned to shape the trajectory of equitable, locally driven TENs in the coming years based on our findings.

Given the nascence of TENs, perspectives are expected to evolve as more experience is gained with TENs research, policies, and pilots. As such, this document represents a point-in-time synthesis of perspectives captured through the generous time and knowledge sharing of experienced organizations and individuals.

Intended Audience

This report is intended for TENs advocates, local governments, community-based organizations, equity and environmental justice organizations, energy democracy organizations, policymakers, and funders interested in advancing TENs as a community-driven clean energy solution for decarbonizing heating and cooling. It provides a broad landscape analysis of existing efforts, key players, and emerging initiatives, while identifying important considerations for scaling TENs equitably and democratically nationwide. Based on interviews with energy justice, energy democracy, and TENs advocacy organizations, as well as local governments and community-based organizations across the country, this report aims to inform and support stakeholders working to advance community-centered approaches to TENs deployment.

Methodology

Literature Review

The authors conducted a robust literature review from secondary sources in order to establish a foundation for research. The review helped authors identify gaps in the literature to refine interview questions and justify the chosen methodology of in-depth interviews.

Interviews

The authors conducted 40 interviews with:

- 14 government agencies
- 10 environmental justice, equity, and/or community-based organizations
- 6 TENs advocates
- 3 energy democracy organizations
- 2 labor organizations
- 2 private developers
- 1 rural electric co-op
- 1 legal advisor
- 1 investor -owned utility

Each interview was conducted virtually and lasted approximately one hour. Authors selected interviewees based on their relevant experience, research, advocacy, or other work with or around TENs.

For interviewees not directly involved in developing TENs projects, the authors began the session with a short presentation to provide context on the technology and policy landscape to-date. The primer included much of the information provided in Chapters 1 and 2 of this report. Interviews consisted of a set of six to eight questions tailored to the type of organization being interviewed. All 11 environmental justice, equity, and/or community-based organizations and the detailed reviewers were offered honoraria for their time and expertise.

Some of the interviews pertaining to TENs ownership structures were conducted in conjunction with Jessica Silber-Byrne from the Building Decarbonization Coalition, who is developing a web-based overview of different TENs ownership models and their advantages and disadvantages, as well as multiple in-depth case studies, that will be published in the coming months.

How this Report is Organized

This report presents findings and recommendations from our research and interviews, organized as follows:

Chapter 1: Introduction (this chapter) defines TENs and describes the current state-of-play in the policy landscape, providing a tour of the growing body of policies authorizing communities, utilities, and private companies to actively explore TENs development.

Chapter 2: TENs Policy Landscape provides an overview of legislation that is requiring, authorizing, and enabling TENs projects. This section also includes legislation from states that are studying and considering TENs (perhaps for future legislation) and relevant policies that promote projects like TENs. This section demonstrates the scale and breadth of policy action around TENs in the United States.

Chapter 3: TENs Ownership Models summarizes the current landscape of TENs ownership models being pursued and explored and examines how TENs development can be shaped by different business, governance, regulatory, and organizing models.

Chapter 4: Equity and Environmental Justice Perspectives on TENs discusses what is necessary for TENs to fulfill their potential to be an equitable clean energy and decarbonizing solution. Our research uncovered critical questions on the minds of EJ community representatives, and the responsibilities that any developer should consider when exploring TENs in EJ communities. This section provides a lens to consider equity in TENs development and shares key opportunities, challenges, and recommendations, as learned from experienced environmental justice advocates.

Chapter 5: Energy Democracy Perspectives on TENs discusses opportunities to shift control over energy infrastructure to communities and the public and foster more democratic control over energy systems. This section examines energy democracy in TENs development, highlighting key opportunities, challenges, and recommendations drawn from insights shared by experienced energy democracy advocates.

Chapter 6: Conclusion provides critical reminders about what is necessary to see TENs fulfill its potential as a clean energy technology that can advance equity and environmental justice, support greater democratization of energy decisionmaking and ownership.

Chapter 2: TENs Policy Landscape

Over the last several years,TENs have gained significant attention. As of March 2025, eight states—Colorado, Massachusetts, Minnesota, New York, Washington, Maryland, Vermont, and California—have passed TENs legislation authorizing or expanding TENs projects.[32]

This legislation is in large part due to the efforts of environmental, equity, and energy democracy advocacy organizations, labor groups, and local governments working to pass and implement TENs policies in their states. A number of coalitions and working groups have sprung up across the country to support those efforts, including a national network of NGO advocates and practitioners co-facilitated by HEET and the Building Decarbonization Coalition that meets monthly to share knowledge and support state efforts.

This chapter provides summaries and references to policies that have been adopted by states to promote or initiate TENs development.

Legislation "Greenlighting" TENs

An overview of states' TENs legislation passed to-date is provided below. We have ordered them from oldest to most recently adopted legislation:

- **Massachusetts (2019)**-Policy permitting TENs first appeared in Massachusetts in 2019 through regulatory proceedings, leading to the nation's first pilot project approved in 2020.[33] In 2021, MA passed the Next Generation Roadmap for Massachusetts Climate Policy (S2995), which permitted gas utilities to pilot "utility-scale renewable thermal energy" projects. The 2022 Act Driving Clean Energy and Offshore Wind further defined geothermal energy as part of clean energy initiatives, allowing projects to be funded through gas pipe replacement programs. In 2024 the state passed its Act Promoting a Clean Energy Grid, Advancing Equity and Protecting Ratepayers (S2967), a comprehensive climate bill that includes reforms to the gas distribution system. Key provisions enable gas utilities to transition into thermal utilities by expanding the definition of a gas company to include the sale and distribution of non-emitting thermal energy and increase scrutiny of new gas infrastructure by requiring the Department of Public Utilities to assess its public interest, alignment with climate goals, and potential non-gas alternatives. MassDEP also recently allocated $5M to support wastewater energy recovery pilot projects in the state.
- **Minnesota (2021)**-Minnesota's Natural Gas Innovation Act (216b.2427) required gas utilities to explore alternatives to natural gas, including district energy, hydrogen, and carbon capture. Large gas companies were mandated to include district energy pilots in their plans. In October 2024, the Minnesota Public Utilities Commission (MN PUC)

[32] A legislative heatwave: thermal energy network legislation updates (June 2024) - BDC
[33] Dockets | MA | DPU | 19-120 | NSTAR Gas Company d/b/...

approved CenterPoint's modified NGIA plan, which includes a feasibility study for a new networked geothermal system in a neighborhood to be selected following a feasibility study. In February 2025, the MN PUC approved Xcel's NGIA proposal for a networked ground source heat pump pilot. In 2024, an omnibus agriculture, commerce, energy, utilities, and climate bill (SF4942/HF4975) allocated funding for thermal energy networks (TENs), including funding for a statewide TENs site suitability study, a PUC TENs working group, and grants for local governments to analyze geothermal systems. The bill also requires gas utilities to invest at least 15% of their NGIA "innovation plans" in TENs, up from a previous 10% cap. A separate omnibus environment bill (SF3887/HF3911) passed in 2024 granting the Pollution Control Agency authority to encourage waste heat recovery from wastewater treatment for future TENs.

- **New York (2022)**-New York's Utility Thermal Energy Networks and Jobs Act (UTENJA) (S9422), which passed unanimously and was co-authored by an unprecedented coalition of labor unions, gas utilities, EJ organizations and environmental organizations, requires major utilities to propose TENs pilot projects. New York's legislation is notable for its strong worker protections and labor standards for the construction, operation, and maintenance of TENs. Despite defining TENs as fossil fuel-free, some of the 13 proposed TENs pilot projects in 2023 included fossil-fueled plants and hybrid solutions, leading to subsequent efforts to clarify the term as "clean thermal energy networks." By fall 2024 the Department of Public Service had approved nine of these proposals to proceed from the scoping phase to engineering and design.[34]

- **Colorado (2022)**-The Colorado Energy Office Geothermal Energy Grant Program (HB22-1381) established a grant program for geothermal energy projects, and the Encourage Geothermal Energy Use bill (SB22-118) provided legal parity for thermal energy projects with solar energy. In 2023 the Thermal Energy Act (HB23-1252) included thermal energy networks as "clean heat measures" under the state's clean heat standard, requiring large gas utilities to propose at least one pilot by September 2024 and establishing labor standards for public projects. In 2024 the Reduce Cost of Use of Natural Gas bill (SB24-1370) created a framework for local governments in Xcel Energy's territory to develop neighborhood-scale clean heat projects, reducing reliance on natural gas through alternative heat sources, including TENs.

- **Vermont (2024)**-In 2024 Vermont introduced Act 142 (S305) which made several changes to Vermont's Public Utility Commission and uniquely expanded options for TENs ownership in the state. Under these changes municipalities can establish thermal energy utilities without PUC approval, similar to water and sewer utilities. Existing businesses, developers, and nonprofits can also apply for authorization to operate TENs under PUC oversight, including setting rates and providing service to thermal energy customers. The law also authorized a study of utility-owned TENs but does not yet allow them. The law does not impact owners of campuses, condominiums, cooperatives, or tenant properties;

[34] Nine Utility Thermal Energy Network Pilot Projects Advance, Moving New York Closer To Neighborhood-Scale Clean Heat And Cooling

these owners can provide a TEN to themselves and their members or tenants, as long as they comply with existing zoning and municipal regulations.

- **Washington (2024)**-Washington's Act Supporting Thermal Energy Networks (HB2131) expands the role of electric and gas companies to include ownership and operation of thermal energy infrastructure and requires gas utilities to propose TENs pilot projects by June 2025 and begin construction by 2027. It also allocates $25 million in grant funding for TENs projects. Notably, it also permits gas utilities to meet their "obligation to serve" through TENs. The bill also expressly allows public utility districts to own, operate, and manage TENs under their governing body's oversight.

- **Maryland (2024)**-MD's Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act (HB0397) allows gas, water, and electric utilities to own and manage TENs, with Public Utility Commission (PUC) approval. It mandates gas companies with over 75,000 customers to propose 1-2 pilots, requires at least 80% of pilot customers to be low- or middle-income, funds community outreach to boost participation, and includes strong labor provisions like prevailing wages and apprenticeships. Additionally, it requires gas companies to seek federal and state funding, including the federal investor tax credit (ITC).

- **California (2024)**-California's Priority Neighborhood Decarbonization Act (SB1221) allows gas utilities to pilot up to 30 neighborhood-scale decarbonization projects instead of replacing gas pipelines. Projects can include neighborhood electrification or TENs. The bill allows the California Public Utilities Commission to modify gas service requirements in pilot areas if 67% of customers consent and a viable alternative energy source is provided, and pilots must prioritize disadvantaged and low-income communities, include tenant protections, and support prevailing wages and "high-road" job programs.

Legislation to Study, Consider or Fund TENs

Three other states—Pennsylvania, New Jersey, and New Mexico—have passed legislation to study geothermal energy as a potential pathway to TENs, and one—Connecticut—recently introduced similar legislation:[35]

- **Pennsylvania (2023)**-Pennsylvania's House Resolution 185 directs a feasibility study on using abandoned coal mines for geothermal energy and the development of thermal utilities. A report is due by May 2025.

- **New Jersey (2024)**-New Jersey's A1491 orders a statewide study on large-scale geothermal heat pump systems, including costs, feasibility, and marketability. The Board of Public Utilities must consult with other states and recommend a pilot program design.

- **New Mexico (2024)**-New Mexico's Act Relating to Geothermal Resources (HB91) establishes a grant fund for geothermal feasibility studies and a revolving loan fund that

[35] Thermal Energy Networks (TENs) State Legislation

provides low-interest financing for geothermal development across public and private entities.

- **Connecticut**-In February 2025 HB6929 was introduced, proposing a grant and loan program to support the development of TENs projects, including funding for community planning, feasibility studies, design, engineering, infrastructure, and nonfederal cost-sharing.

Other Relevant Policies

These other policies have proven to also provide venues for discussion about TENs:

- **Clean Heat Standards**-One state (Colorado) has passed a Clean Heat Standard bill mandating gas distribution utilities to develop "Clean Heat Plans" aimed at significantly reducing greenhouse gas emissions from residential and commercial gas usage.[36] Another three (Illinois, New Jersey and Rhode Island) have introduced similar bills.

- **Future of Gas Proceedings**-Three states (Colorado, Massachusetts, and Washington) have passed legislation aiming to integrate GHG emission targets into gas system planning. Seven others (California, Connecticut, Illinois, Maryland, Maine, Minnesota, and New York) have proposed similar legislation.[37]

- **Obligation to Serve Reform**-One state (Washington) has passed statewide legislation reforming gas utilities' "obligation to serve" requirements to allow gas utilities to meet their obligation to serve through TENs. Three other states (California, Minnesota, and New York) have passed similar legislation allowing gas service to be substituted with clean energy alternatives in Commission-approved pilots.[38]

- **Methane Pollution Protections**-Four states (California, Illinois, Maine, and Virginia) have passed consumer protection legislation to address methane pollution and energy reliability during extreme weather events. Seven others (Arizona, Indianapolis, Kentucky, Maryland, Missouri, New York, and Washington) have proposed similar legislation.[39]

- **Federal Legislation**-At the federal level, while no direct TENs legislation has been passed, in August 2024 Senator Markey introduced the Pipeline Accountability, Safety, and Environmental Standards (PASES) Act (HR9323), which aims to strengthen pipeline safety regulations, enhance environmental protections, and increase accountability for pipeline operators to prevent accidents and ensure compliance with federal standards, and references the "promotion or encouragement of non-emitting alternatives" like networked geothermal systems.

[36] Vermont also passed the Affordable Heat Act in 2023 to spur the state's transition away from fossil fueled heating, but in 2024 released draft rules that would allow fossil fuel companies to meet their standards by purchasing clean heat credits to installing biofuels, biomass, "renewable natural gas" and hydrogen to quality as clean heat measures, drawing heavy criticism.
[37] 2024 Legislative Roundup - BDC
[38] Mapping Decarb Momentum: which states passed building decarbonization legislation in 2024 - BDC
[39] Mapping Decarb Momentum: which states passed building decarbonization legislation in 2024 - BDC

TENs Regulatory Oversight

Regulatory oversight of the TEN systems themselves varies widely. Some states classify them as utilities, subjecting them to public utility/service commission (PUC/PSC) oversight, while others regulate them more like private infrastructure. Emerging policies in states like New York and Colorado are clarifying how different types of TENs fit within existing regulatory frameworks.

Chapter 3: TENs Ownership Models

In many states, private developers, investor-owned utilities, and certain municipalities and co-ops can legally own and operate TENs, offering some distinct advantages. However, the local and zonal nature of TENs also invites exploration of new and emerging public and community ownership models which bring their own advantages.

The choice of ownership structure plays a critical role in financing, cost recovery, and eligibility for federal and state incentive programs—often shaping which model is ultimately pursued. This decision is heavily influenced by stakeholder priorities, legal mandates (including authorized structures), and the availability of financing options. Ownership—whether private, public, or community-based—determines who bears the financial risks and benefits: a private entity, shareholders, the public, or the community. It also influences how the TEN is funded—through private investment, public financing, ratepayer contributions, or taxpayer dollars—and who oversees the project, whether it be the community, cooperative members, a public utilities commission, or a city council.

This section explores the ownership structures currently being implemented for TENs (Table 1) and provides case studies from across the country. It does not offer a comprehensive analysis of each model, nor are the categorizations based on peer-reviewed, industry-accepted standards, which, to the authors' knowledge, have not yet been established.[40] In the absence of such standards, the authors have made editorial decisions to classify these models as clearly as possible based on our best understanding. This report focuses on TENs ownership models within the U.S., but many other approaches are being explored globally.[41]

At this early stage of TENs development, various ownership structures are being tested. As understanding of TENs deepens, interest expands, and regulatory frameworks evolve, these models will continue to adapt, and new structures will likely emerge. This section aims to document the current landscape of ownership models as they stand today. A more detailed analysis of TENs ownership structures falls outside the scope of this study but remains a critical area for future research.

Table 1: Types of TENs Ownership Models Discussed in this Chapter

Privately Owned	– Private Developers – Investor-Owned Utilities (IOUs)

[40] For a deeper dive into TENs ownership models, consider the following resources:
- Craig Hart and Emma Lagle of the Pace Energy and Climate Center created a comprehensive slide deck on *Community Thermal Energy Network Business Models for New York State Municipalities* for the New York State Energy Research and Development Authority (NYSERDA). While it provides in-depth insights, it was not publicly available at the time of this report.
- The Building Decarbonization Coalition is developing a web-based overview of different TENs ownership models and their advantages and disadvantages, as well as multiple in-depth case studies, that will be published in the coming months.
- The *How to Develop a Thermal Energy Network* toolkit by Vermont Community Thermal Networks (detailed further in Chapter 5) offers an overview of various ownership models, outlining their respective pros and cons.

[41] Canada, Europe, and other regions have developed diverse ownership models that offer valuable insights and alternative frameworks. NYSERDA's *District Heating System Ownership Guide* provides an in-depth analysis of various ownership structures for district heating systems, including those implemented in Central and Eastern Europe as well as Western European countries.

Publicly Owned	– Publicly Owned Utilities (POUs) ○ Traditional POUs ○ Municipally-Owned Gas Utilities ○ Sustainable Energy Utilities (SEUs)* ○ Public Heating & Cooling Utilities ○ Collaborative Public Ownership Structures – Public-Nonprofit Partnerships (PNPs) – Untapped Public Ownership Structures ○ Rural Energy Cooperatives (Co-ops) ○ Community Choice Aggregators (CCAs)
Community Owned	– Community Based Organizations (CBOs) – Tribal Nations – Nonprofit Organizations (NGOs)

**SEUs can be established as either publicly sponsored non-profits or municipally owned entities. For this chapter, the authors have chosen to categorize SEUs under POUs because the case study presented follows this structure.*

Privately-Owned Models

Private Developers

A private developer can own and operate a TEN to provide (sell) space heating and cooling, and/or water heating services to the buildings that are connected to the system. The developer takes on the upfront costs of construction and maintenance while the customer benefits from clean energy at a fixed price.

In some cases, the heating/cooling is sold to customers through a fixed monthly fee, power purchase agreement (PPA), or similar arrangement. The end customer does not own the central thermal energy loop, but sometimes owns (and purchases) the indoor equipment (the water source heat pump) required to access the thermal network. In other cases, the TENs is initiated and owned by an institutional client and the heating/cooling services benefit a single customer, such as an educational campus or hospital system, that networks its buildings for thermal services.

Case Studies

Whisper Valley, Austin, TX

EcoSmart Solution (ESS), a private company that designs and builds geothermal and distributed energy infrastructure for new real estate developments, partnered with global real estate investment firm Taurus Investment Holdings, and Shell New Energies to implement a large-scale TEN in Whisper Valley, near Austin, Texas.

The project features a community-wide geothermal loop that provides efficient heating and cooling to connected homes. The TEN was installed during the new development's construction phase and integrated alongside water, sewer, and electric utilities. Each home is connected to the system via a geothermal heat pump, reducing energy consumption by up to 70%. Homes in the planned community are also equipped with solar PV panels, electric battery storage, and smart home technology.

ESS owns, operates, and maintains the main distribution loop and service lines to the buildings, while homeowners own the remaining system components. ESS will maintain ownership of the TEN as the development expands. Four phases are completed, with six to eight more planned, ultimately serving 7,500 market-rate housing units. The system uses high-density polyethylene piping with a 50-year warranty against breakage, ensuring long-term durability.

During the Texas 2021 Winter Storm Uri, Whisper Valley's geothermal system proved its resilience; homes with electric battery backups maintained heat throughout the storm, and homes without came back online quickly when power was restored.

Center for Life Science, Seattle, WA
Built by Alexandria Real Estate Equities and SHARC Energy, the Alexandria Center for Life Science Sewer Heat Recovery (SHR) project is part of a five-building, 1.6 million-square-foot mixed-use life-science campus. The SHR system is designed to provide approximately 70% of the campus's heating needs by extracting heat from a county sewer pipe and distributing it through a heat pump system and network of pipes to the buildings. The system is expected to be operational in 2025.

The project is the first of three pilot projects supported by King County, Washington's SHR Program, which the County created to harness thermal energy from wastewater flowing through its sewer pipes. This innovative approach allows private commercial property owners and developers to utilize the consistent temperatures of wastewater for heating and cooling their buildings. As part of this program, King County developed a Sewer Heat Recovery Interceptor Map to identify locations within King County's wastewater infrastructure where sewer heat recovery could be implemented. This map helps developers, utilities, and policymakers assess opportunities to capture waste heat from sewer lines for their development projects.

In exchange for accessing the energy from the system, developers reimburse King County's Wastewater Treatment Division for costs to review designs and pay an annual fee based on the amount of energy transferred between their system and the sewer. However, for the 3-year pilot phase of the program, the project's annual fee is waived for the first three years of the contract in return for usage data.[42]

Investor-Owned Utilities (IOUs)

Investor-Owned Utilities (IOU) are private, for-profit companies that provide electricity, natural gas, or water services to customers. Unlike publicly owned utilities, which are operated by municipalities or cooperatives, IOUs are owned by shareholders and traded on stock exchanges. Most IOUs operate in regulated markets, where Public Utility Commissions (PUCs) or Public

[42] Potential users - King County, Washington

Service Commissions (PSCs) set rates that allow the utility to recover costs and earn a guaranteed rate of return on their investments (ROI). In deregulated markets, IOUs may compete to sell electricity or gas directly to consumers. They profit from the difference between generation costs and market prices. IOUs earn a return on capital expenditures, such as building power plants or upgrading transmission lines. Regulators allow them to recover these costs through customer rates, often with a guaranteed profit margin. IOUs sometimes receive subsidies, tax credits, or incentives for investing in renewable energy, grid modernization, or energy efficiency programs.

IOUs are starting to demonstrate increased interest in TENs. At the time of this report, IOUs are developing or implementing TENs pilots in at least eight states, and a group of nearly 30 investor- and municipally-owned gas utilities—including National Grid, Xcel Energy, Southern Company Gas, ConEdison, NW Natural, PGW, Eversource Energy, Vermont Gas, and others—have formed a working group to explore and collaborate on transitioning into thermal utilities that provide heating and cooling through these systems.[43]

For IOUs, particularly gas-only utilities, TENs have been identified as a cost-effective solution for meeting state-mandated GHG reduction goals. If gas utilities redirect investments from traditional gas infrastructure upgrades to TENs development, they can achieve significant cost savings. These savings can lead to more affordable rates for customers, potential incentives to encourage the transition to TENs, and lower costs associated with maintaining and expanding both gas pipelines and electric grid infrastructure.

Utilities often also have the benefit of ownership and control over pipeline infrastructure. For investor-owned utilities, a substantial portion of return on investment is tied to the capital expenditures related to building out and upgrading gas distribution infrastructure. This includes pipelines, storage facilities, and meters. Utilities can also recover the cost of constructing and maintaining the infrastructure through the rates charged to customers, which are set by regulatory commissions.

Lastly, utilities have a strong obligation to support their significant workforces. Advancing TENs mitigates potential job losses that could be part of other decarbonizing solutions. Drilling shallow geothermal wells requires similar skill sets to those of the existing oil and gas workforce upstream. TENs could provide significant just transition benefits for existing drillers, pipelayers, utility workers, network operators, and other skilled labor.

Below, we summarize several examples from across the nation ranging from projects in development to proposed projects by IOUs.

[43] https://www.theguardian.com/environment/article/2024/aug/09/every-building-sits-on-a-thermal-asset-how-networked-geothermal-power-could-change-cities

Case Studies

Eversource Energy, Framingham, MA
Eversource Energy and HEET launched the first U.S. geothermal energy network in Framingham, MA, breaking ground in June 2023 and going live in June 2024. The system serves 36 buildings—24 residential (including affordable housing units), a school district facility, a fire station, and other commercial properties—providing heating and cooling to 135 customers in a medium-density neighborhood. It includes 90 boreholes and a one-mile shared geothermal loop.

Originally proposed in 2019 as part of a natural gas rate case, the project was approved by the Massachusetts Department of Public Utilities in 2020. Eversource covered both the installation of the shared geothermal infrastructure and the indoor ground-source heat pumps (GSHPs) in each unit. The system will operate as a two-year demonstration, with the natural gas system maintained as a backup. If customers are dissatisfied after the pilot phase, Eversource will pay to remove the GSHPs and either reinstall gas units or install other agreed upon equipment, such as an air source heat pump (ASHP).

The project received a $7.8 million grant from the U.S. DOE Geothermal Technologies Office's Community Geothermal Heating and Cooling Design and Deployment initiative for its expansion, following a $700,000 grant in 2023 for feasibility studies. A research team coordinated by HEET, called Learning from the Ground Up (LeGUp), includes project partners, national labs, and leading academic institutions. They will collect real-world data beyond standard regulatory procedures, supplementing utility measurements with independent research. Non-proprietary findings will be shared through an open-access database maintained by HEET.[44]

National Grid, Boston, MA
National Grid recently announced that it will abandon plans for a previously announced TEN project in Lowell, MA, citing higher-than-expected costs. However, a TEN project in Boston was announced by Mayor Michelle Wu in January 2024. A collaborative initiative between the Boston Housing Authority (BHA) and National Grid, the geothermal networked project will serve 129 units in Dorchester's Franklin Field affordable housing community. BHA secured state funding to pay for the replacement of gas stoves in a subset of the units in an effort to eliminate combustion completely and increase indoor air quality in these small urban units. The project is currently in the design phase, with construction expected to begin in late 2025.[45]

[44] The First Open-Source Database for Geothermal Networks
[45] Boston Housing Authority, National Grid Agree to Develop Networked Geothermal Heating at Franklin Field Apartments

IOUs in New York State

In April 2024, the New York Department of Public Service (DPS) advanced nine of the original 12 proposed Utility Thermal Energy Network (UTEN) pilot projects from feasibility to engineering under the Utility Thermal Energy Network and Jobs Act (UTENJA),[46] including:

- ConEdison-Three pilots in New York City and Mount Vernon. One will use waste heat from a data center to heat and cool public and private multifamily housing projects in Chelsea.[47] Another will integrate multiple waste heat sources to serve 3.6 million square feet of commercial space in Rockefeller Center. The third, in Mount Vernon, will use geothermal energy to serve up to 76 buildings—including 241 residential customers, churches, a fire station, and a recreation center—while aiming to retire 500 feet of leak-prone natural gas pipeline. ConEd has reported delays in finalizing engineering designs due to unforeseen challenges with the unique project sites.[48]

- National Grid-Three pilots in Brooklyn, Troy, and Syracuse. One will use geothermal energy to serve a public housing authority property and commercial buildings in Brooklyn. Another will support a downtown business and arts district in Troy in partnership with the City of Troy, which is providing the parcels for the geothermal well fields. The third will capture waste heat from a wastewater treatment plant's outfall to supply a mixed-use neighborhood in Syracuse.

- NY State Electric & Gas (NYSEG)-A pilot in Ithaca exploring multiple heat exchange methods, including wastewater, shallow geothermal borefields, and surface water from a canal.

- Orange & Rockland (O&R)-A geothermal borefield project in Haverstraw designed to serve municipal, residential, and commercial properties.

IOUs in Minnesota

Under Minnesota's Natural Gas Innovation Act (NGIA)[49], both CenterPoint Energy and Xcel Energy have proposed networked geothermal pilot projects to the Minnesota Public Utilities Commission (MN PUC).

- CenterPoint Energy-In October 2024, the MN PUC approved CenterPoint Energy's innovation plan, which includes 17 pilot projects and seven research initiatives.[50] Among these is a project aimed at providing geothermal heating and cooling to a neighborhood currently served by the company. The pilot will begin with a study phase to determine the optimal location, technologies, and business model for the system.

[46] Nine Utility Thermal Energy Network Pilot Projects Advance, Moving New York Closer To Neighborhood-Scale Clean Heat And Cooling
[47] Many local EJ groups see this as a controversial project because it will take public housing land to develop private housing.
[48] Case 22-M-0429
[49] 216b.2427 natural gas utility innovation plans
[50] State approves first natural gas innovation plan and advances clean energy goals

- Xcel Energy. In February 2025, the MN PUC approved Xcel Energy's plan under the NGIA that features a networked geothermal pilot project.[51] Specific details about Xcel's proposal are limited.

Vermont Gas Systems, Hinesburg, VT

The Coalition for Community-Supported Affordable Geothermal Energy Systems project in Hinesburg, Vermont, is a collaborative effort between Vermont Gas Systems and GTI Energy, in partnership with the National Renewable Energy Laboratory, and other partners. In December 2024 the project was awarded a $3M grant from the U.S. DOE Community Geothermal Heating and Cooling Initiative for its implementation phase.[52] The project aims to design a community geothermal system to meet 100% of the heating, cooling, and domestic hot water needs for a new affordable housing development in Hinesburg.[53]

Publicly-Owned Models

A number of local jurisdictions are exploring and actively testing the model of publicly-owned TENs. Local governments have unique advantages when seeking to develop TENs. Often, they own the right-of-way across their communities to lay utilities, such as water pipes. They usually have critical connections with business districts, main streets, or other dense urban areas. They are trusted sources in their community for information and projects. From a financial standpoint, they have the ability to raise capital through public bonds and to access relatively low cost and significant resources for infrastructure projects.

Lastly, while federal climate policy and leadership is critical to macro-level progress on climate change, action at the state and local level ultimately adds up impactful carbon reductions. Local jurisdictions have shown leadership in climate policy and efforts to reduce carbon. That political will provides important motivation for public investment in TENs.

Publicly-Owned Utilities (POUs)

A publicly-owned utility (POU) is a not-for-profit public agency that supplies and delivers energy to its community. POUs are governed by locally elected officials, such as city council members or regionally elected directors, who set rates, approve budgets, and establish policies and regulations. Many POUs are municipally-owned (typically called a "muni") and operated by a local government, such as a city, town, or county. In many states, POUs are exempt from some or almost all direct oversight by state regulatory commissions since they are non-profit entities. Some state and federal regulations still apply, namely compliance with the federal Natural Gas Pipeline Safety Act of 1968, the Pipeline Safety Improvement Act of 2002, U.S. Environmental Protection Agency (EPA) emissions and environmental impact requirements, and Federal Energy Regulatory Commission (FERC) interstate natural gas transmission and transportation rules.

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[51] Minnesota regulators advance energy efficiency and electrification in Xcel Energy's gas innovation plan
[52] Community Geothermal Heating and Cooling Initiative | Department of Energy
[53] Coalition For Community-Supported Affordable Geothermal Energy Systems (C2SAGES)

According to the American Public Gas Association, there are roughly 1,000 publicly-owned gas utilities in the U.S. The highest concentration of publicly-owned gas utilities is found in the states of Alabama, Georgia, Indiana, Kentucky, Minnesota, Tennessee, and Texas.[54]

POUs present strategic advantages when pursuing TENs and other clean energy initiatives. Local and regional jurisdictions typically have more influence over publicly governed utilities than IOUs, allowing for stronger control over sustainability, affordability priorities, and more direct action on policy and operational decisions. This may mean that cities with POUs and aggressive climate policies can decide to increase investments in such programs, drawing from both POU revenues and municipal budgets. On the other hand, POUs often provide a crucial revenue stream for the jurisdiction(s) they serve, meaning any effort that reduces their gas customer base could have an outsized impact on that jurisdiction's revenues, unless they find alternatives—like TENs—that both ensure a stable and reliable revenue stream and meet their clean energy goals.

The following examples highlight projects, feasibility studies, and other efforts by publicly-owned utilities actively pursuing TENs.

Case Studies

Rochester Public Utility, Rochester, MN

As part of its goal to achieve 100% renewable energy by 2030, Rochester Public Utility (RPU)—which provides water and electricity to the city—successfully transitioned a failing downtown steam loop to a geothermal-based system. Rochester City Hall is already fully geothermal, and expansion plans are underway to extend the system to the Civic Center, public library, several private buildings, and a Section 8 housing facility.[55] While the current project plans focus on providing heat, the potential for bi-directional energy flow could be incorporated as the system expands, especially if future plans involve integrating energy storage or further technological upgrades that allow buildings to both send and receive energy from the grid or the geothermal system.

The project's $30 million expansion will be partially funded through $10 million in grants—$5 million from the federal Inflation Reduction Act and $5 million from the Destination Medical Center (DMC), a public-private initiative designed to drive infrastructure and economic growth around the Mayo Clinic. The city is currently exploring various ownership models for the expanded system, including the possibility of a public-nonprofit partnership, similar to the District Energy St. Paul model.

Philadelphia Gas Works (PGW), Philadelphia, PA

In 2021, Philadelphia Gas Works (PGW) and the City of Philadelphia commissioned a study to explore how the utility could address climate change and leak-prone pipes. The study recommended several strategies including implementing TENs. In 2022, PGW allocated $500,000 for a "networked geothermal district heating system" feasibility study, Specifically, the study

[54] Natural Gas State Profiles
[55] City of Rochester - News & Announcements | Rochester, MN

highlighted the potential of networked geothermal systems to retrain PGW's existing workforce to build and maintain them given the similarities between the infrastructure required for networked geothermal systems and natural gas.

PGW's December 2022 report detailed initial steps, including a market survey and site identification, with a decision point set for July 2023. That deadline passed, and a 2024 report showed no further progress until March 17, 2025, when PGW released a much anticipated RFP to assess the feasibility of implementing a TEN in conjunction with the School District of Philadelphia.[56]

Sustainable Energy Utility (SEU), Ann Arbor, MI

A Sustainable Energy Utility (SEU) is either a publicly-sponsored non-profit or a municipally-owned entity that is solely focused on renewable energy production and energy conservation and efficiency.[57] While most models use the term "utility" (as they provide an energy service like a utility), they are distinct in that they do not own transmission and distribution infrastructure and are not regulated by state utility commissions. An SEU operates alongside the existing publicly- or investor-owned utility, allowing residents to receive services from the SEU while still having the option to remain connected to the existing grid. Some examples include Energize Delaware and the District of Columbia SEU.

In November 2024, Ann Arbor residents voted to create a municipally-owned SEU to supplement the city's energy system with locally produced clean power. The idea emerged in 2021 as a way to achieve the city's 2030 carbon neutrality goal despite legal constraints on utility options.[58] Ann Arbor's Office of Sustainability and Innovations (OSI) studied SEUs in Delaware and Washington, D.C., and developed a Michigan-specific model.

A key SEU innovation is its ability to interconnect properties, allowing excess energy to be shared—typically restricted by utility monopoly regulations. The city leveraged a legal precedent (Michigan Constitution, Article VII, Section 25) to form its own energy-sharing networks.

In December 2024, Ann Arbor secured a $10M U.S. Department of Energy grant to implement a community geothermal heating and cooling network in the Bryant Neighborhood. The SEU will own the TEN, following a model similar to the city's water utilities. Private companies will handle installation and maintenance, while the city will manage billing and customer service, potentially partnering with regional municipal utilities. The SEU can issue municipal bonds and offer on-bill financing, unlike the incumbent utility, DTE Energy.

The project, led by engineering firm IMEG, will install 334 geothermal boreholes—232 under Arbor Oaks Park and 102 beneath a playground—plus a six- to eight-inch diameter pipe network to serve 262 homes, an elementary school, a community center, and an industrial park, with a larger

[56] PGW explores heating, cooling a Philly school and city rec center with geothermal energy
[57] SEUs can be established as either publicly sponsored non-profits or municipally owned entities. For this chapter, the authors have chosen to categorize SEUs under POUs because the case study presented follows this structure.
[58] Ann Arbor Sustainable Energy Utility

10- to 12-inch pipe to transfer water between sites. The system, expected to be operational by 2028, will support 758 heating tons of demand. The Washtenaw Community Action Network (CAN) is leading outreach, with over 30 households having signed letters of commitment reflecting their interest.

Public Heating and Cooling Utility, Hayden, CO

Hayden, Colorado, is developing the tentatively-named Hayden Heating and Cooling Utility to support its new 58-acre Northwest Colorado Business Park near Yampa Valley Regional Airport. In 2024, the town received $2.2 million in state grants to study and design an ambient temperature loop geothermal system for the park, which began construction in April. The city will own the system, including boreholes, and charge customers for heating and cooling similar to a water utility.

Initially, Hayden considered having its water or wastewater utility manage the system but opted to create a new utility to mitigate risk and ensure long-term control. The effort began after Xcel Energy announced the closure of the coal-fired Hayden Generating Station, which provided 55% of the town's tax revenue. Seeking economic diversification, Hayden pursued industrial development and, after community input, decided to act as a private developer for the business park.

While committed to clean energy, the primary motivation for the project is economic. The city evaluated extending gas lines or using air-source heat pumps but found networked geothermal more cost-effective, especially for industrial loads. The $2.5M system will be funded through state grants, municipal tax-exempt financing, and tax credits. The proposal to establish the new utility will go before the Town Council in early 2025.

New Haven Union Square Project, New Haven, CT

New Haven, CT, is advancing a bidirectional TEN project centered around its Union Station and the adjacent Union Square development. The TEN will serve Union Station and a new housing development being built by the Elm City Communities, New Haven's Housing Authority. A number of city agencies are collaborating to develop and manage the system, including the Housing Authority; the New Haven Parking Authority, which manages Union Station; and the city's Office of Climate & Sustainability.

Up to a thousand mixed income apartments are expected to be connected.[59] The system will consist of approximately 285 boreholes, each reaching depths of 800 to 900 feet.[60] In winter, it will extract heat from the ground to warm buildings, and in summer, it will transfer excess heat from buildings back into the ground, effectively cooling them. The geothermal system is projected to reduce GHGs from Union Station and the Union Square development by 76% and to lower heating bills for residents by 50%.

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[59] Church Street South Futures Floated | New Haven Independent

[60] Geothermal Energy Sought For "Union Square" | New Haven Independent

In 2024, the U.S. EPA awarded New Haven a $9.47 million Climate Pollution Reduction Grant to support the TEN project. The total project cost is estimated at $16.5 million, with the city planning to cover the remaining expenses through municipal funds, state rebates, and federal reimbursements available under the Inflation Reduction Act.[61]

Public-Nonprofit Partnerships (PNPs)

A public-nonprofit partnership (PNP) is a formal collaboration between a government entity and a nonprofit organization to deliver public services, programs, or infrastructure. Similar to public-private partnerships (PPPs), PNPs involve mission-driven nonprofits rather than for-profit businesses.

Cities and jurisdictions often seek to ensure projects serve the public while transferring decision-making, fiscal responsibility, and daily operations to an independent community benefits entity. To achieve this, they are developing new models of local ownership that remain distinct from direct government control. One increasingly prevalent model is where a locality (or a joint powers authority made up of several local jurisdictions) establishes a nonprofit entity with a mission to provide public services, such as energy distribution. These nonprofit entities are established with an enforceable public-purpose charter—in the case of TENs, energy-efficient heating and cooling for communities or public infrastructure—but with the agency and power of an independent entity.

They often have independent governing boards, with representation dictated by the establishing legislation, and the ability to raise and finance their own capital. As a result, they typically fall outside the regulation of utility commissions and often function outside of the governmental bureaucracy.

Various models—such as those described in the section below—have proven effective in advancing community-wide energy projects. As non-governmental entities, they can secure innovative financing and swiftly procure contractors. Yet, as publicly aligned organizations, they may access public rights-of-way, funding, and the trust associated with government agencies. Collectively, these approaches create promising opportunities for developing TENs.

Several cities are actively exploring or implementing TENs through such innovative structures. Minneapolis, MN, is assessing the feasibility of a municipal geothermal utility for public buildings and large developments. Boulder and Denver, CO, are considering municipally-owned geothermal networks for future redevelopment projects. Other jurisdictions have progressed even further, as detailed below.

[61] City of New Haven (Connecticut) | US EPA

Case Studies

The Heights Community Energy NGO, St. Paul, MN

District Energy St. Paul is a nonprofit utility that provides district heating and cooling services to downtown St. Paul, Minnesota. It operates one of the largest hot water district energy systems in North America. In 2024, District Energy St. Paul partnered with the St. Paul Port Authority, the owner and master developer of The Heights—a 112-acre redevelopment project transforming a former industrial site into a mixed-use, sustainable community. They collaborated with Ever-Green Energy, a for-profit subsidiary of District Energy St. Paul that specializes in district energy and networked geothermal, to supply clean heating and cooling to this brownfield development.

Ever-Green Energy has introduced an innovative nonprofit ownership model involving establishing a new nonprofit organization (NGO) to own and operate the TEN, named The Heights Community Energy. The NGO's board of directors is in the process of being formed, with plans to include local community members and representatives from community-based organizations (CBOs) serving the neighborhood, as well as possibly members from the Saint Paul Port Authority and District Energy St. Paul. While Ever-Green Energy will manage and operate the system initially, the NGO has the flexibility to choose a different system operator in the future.

The system will be one of the first aquifer thermal energy storage systems in Minnesota, providing sustainable heating and cooling to approximately 1,000 housing units and several light industrial buildings. To help fund the construction, the Minnesota Climate Innovation Finance Authority, the state's green bank, provided a $4.7 million bridge loan.[62]

West Union District Energy LLC, West Union, IA

The city of West Union, Iowa's TENs project is unique, in that it is owned by the city, but leased to the West Union District Energy User Group, a nonprofit LLC formed by users who manage operations and cover costs through monthly fees based on heating capacity and usage. West Union, Iowa, developed its shared geothermal system in 2006 as part of a downtown revitalization initiative. The total cost of the project was approximately $10 million, with federal and state grants, including an Iowa Green Streets grant, funding $7.5 million of the project, and the city investing $2.7 million. The project includes bioswales, LED streetlights, permeable streets and sidewalks, a Civic Plaza, and a geothermal TEN. Currently, the system serves 12 users, including the Fayette County Courthouse, a library, a historical center, banks, and retail businesses, with 58 additional connection points available for expansion. A study by the Winneshiek Energy District found annual savings ranging from $535 for a bank to $6,772 for the Courthouse compared to traditional natural gas heating.[63]

The city is currently exploring ownership/operations restructuring to improve efficiency and expand access. Options include city ownership and operation, which could integrate the system

[62] The Heights Awarded $4.7 Million for Geothermal Energy System | Saint Paul Minnesota
[63] WED Wraps Up West Union Geothermal Project

with municipal resources but raises taxpayer concerns, or third-party ownership, which may enhance efficiency but could shift priorities toward profit over affordability.

Lincoln Park Wastewater Heat Recovery Project, Duluth, MN

In April 2023, the City of Duluth, MN, received a $700,000 grant from USDOE's Community Geothermal program to design a networked geothermal system in partnership with local CBO Ecolibrium3 (Eco3). The project created designs for creating a new geo-exchange system in the city's Lincoln Park neighborhood and connecting it to Duluth's existing district energy system, Duluth Energy Systems (DES). A unique feature of the project is the use of wastewater effluent from the local treatment plant as a heat source. Ever-Green Energy, leading the design of this system, considered two primary business models for implementation: either incorporating into the existing municipally-owned DES or establishing a new NGO ownership similar to District Energy St. Paul.

In April 2024, the City and Eco3 applied for additional implementation funding through the EPA's Carbon Pollution Reduction Grant, but were not awarded the funding, which would have been required to pursue round two funding from the DOE. At this time, it is unclear whether the project will go forward due to these significant funding constraints.

Untapped Public Ownership Structures

Rural Energy Cooperatives (Co-ops)

Whereas IOUs are for-profit companies owned by shareholders, and POUs are governed by a public agency, rural energy cooperatives, or co-ops, are member-owned, nonprofit utilities that prioritize affordable service and reinvest profits into the community. About 13% of U.S. electricity customers get their power from rural electric cooperative utilities (co-ops).[64] There are also a small handful of gas cooperatives, but due to their scarcity, there is limited comprehensive data.[65] At the time of this study, no known co-ops were actively exploring TENs.

Community Choice Aggregators (CCAs)

Community Choice Aggregators (CCAs) are structured as a local nonprofit entity that is empowered to purchase and manage energy sources on behalf of their residents and businesses. Ten states—California, Illinois, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Ohio, Rhode Island, and Virginia—have enacted CCA legislation that empowers local governments to aggregate the electricity loads of residents, businesses, or municipal facilities. Approximately 7% of residential customers in the U.S. are served by a CCA.[66] CCA energy procurement is, in part, regulated by public utility commissions, but their overall activities, including clean energy and energy efficiency and other energy programming, are governed by an independent board.

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[64] Electric Co-op Facts & Figures - America's Electric Cooperatives

[65] For example, The Energy Cooperative in East Central Ohio, Union Rural Electric Cooperative (URE) in Maysville, Ohio, and Utility Pipeline, Ltd., which serves areas in Ohio, Pennsylvania, West Virginia, Virginia and Indianapolis.

[66] LEAN Energy US

CCA programs primarily focus on electricity procurement, but there are a small number of CCAs that also offer natural gas services.[67] However, at the time of this study, no known CCAs were actively exploring TENs.

Community-Owned Models

For the purposes of this paper, community-owned models are considered distinct from privately- or publicly-owned models based on their non-governmental, independent nature, and their mission to prioritize the needs of the local community through community governance structures, benefit-sharing agreements, and other agreements.

For community-owned systems, TENs would typically be owned and operated by a non-profit entity or through another type of community partnership agreement, perhaps like a (non-utility) cooperative or other charter-driven model, like some community solar projects. The system might be managed by a special-purpose entity, such as an energy services company (ESCO) or a community energy cooperative, which can also maintain the infrastructure and manage billing and other operations, but the governance and fiscal management would be held by community members on behalf of a community.

Community ownership models are largely untested, though, in emerging neighborhood-scale clean energy approaches like TENs, but innovative approaches are starting to emerge, as described below.

Case Studies

Sustainable Chicago Geothermal Project, Chicago, IL
Blacks in Green (BIG), a Chicago-based nonprofit focused on environmental justice and economic development, is leading the development of a shared community geothermal project in West Woodlawn on Chicago's South Side. Spanning four city blocks and over 100 residential buildings, the initiative will provide clean, affordable thermal energy to more than 200 households by installing a geothermal network beneath alleyways to minimize property disruption.[68]

BIG received a $750,000 U.S. DOE grant in 2023 for feasibility studies and design, followed by a $10 million U.S. DOE grant in December 2024 for implementation.[69] The project brings together a coalition of partners, including the City of Chicago, University of Illinois, The Accelerate Group, Citizens Utility Board, Climate Jobs Illinois, GeoExchange, and Illinois AFL-CIO. An additional $10 million U.S. EPA grant supports collaboration with other Midwest environmental justice communities to replicate similar projects.[70]

[67] For example, Northeast Ohio Public Energy Council (NOPEC) serves approximately 500,000 electric customers and 400,000 natural gas customers across 112 cities and towns in Ohio; and Sustainable Westchester includes both electricity and natural gas supply services for customers in participating municipalities in Westchester County, NY.
[68] Geothermal energy could soon heat, cool up to 180 homes in Chicago's Woodlawn neighborhood - ABC7 New York
[69] Department of Energy funding to boost community-led geothermal projects
[70] Biden-Harris Administration Selects Blacks in Green to Serve as New Technical Assistance Center to Help Communities Across Region 5 Access Historic Investments and Advance Environmental Justice

Currently in the design and community engagement phase, the project will soon begin installation. BIG aims for full community ownership of the system, reinforcing its commitment to energy justice and community wealth-building.

Citizen Potawatomi Nation, Shawnee, OK

The Citizen Potawatomi Nation (CPN) in Shawnee, Oklahoma, received a U.S. DOE Community Geothermal Phase 1 grant to build a hybrid solar and geothermal networked system. Since 2005, CPN has utilized geothermal energy, initially converting its 30,000-square-foot Cultural Heritage Center from natural gas, aligning with the tribe's long-standing commitment to environmental stewardship. CPN's new networked solar/geothermal system will provide 100% of the heating and cooling needs for 37 tribal residential units and three major commercial buildings: a health clinic, a recreation center, and an after-school learning center.[71] In 2024, the Nation, in collaboration with the University of Oklahoma, and other partners, secured a second round of U.S. DOE Community Geothermal funding (a $7 million grant), to advance to the implementation stage.

Third Street Center NGO, Carbondale, CO

Clean Energy Economy for the Region (CLEER), a regional NGO, in partnership with NREL, received Round 1 funding from the DOE Community Geothermal program to conduct a feasibility and design study for a TEN project in the rural town of Carbondale, Colorado. The $21M project built on previous design work to create a net-zero energy district, and includes community buildings such as a library, high school, and the Third Street Center (TSC) nonprofit office building and event venue. The TSC was the proposed initial system owner and operator, with the intention to transfer ownership to a local utility (the town or other entity) once the TENs grew to expand to a larger service area. Project partners have approached the local electric co-op Holy Cross Energy to create a thermal franchise for the entire town.

The project did not receive Round 2 implementation funding from DOE. While fundraising for the exact system design at TSC is on hold, the feasibility study spurred a high level of interest with the community and local elected officials. At the time of this report the town of Carbondale, CLEER, and others are beginning a thermal asset evaluation and modeling study to determine the viability of a town-wide TENs.

[71] $13 Million in DOE Funding Heats Up Geothermal Energy Projects in Justice40 Communities

Chapter 4: Equity and Environmental Justice Perspectives on TENs

Background

For any clean energy development, new technology, or approaches to reduce carbon emissions and slow the progression of climate change, it is critical that it is coupled closely with a deep understanding of the environmental injustice context that surrounds it. It is no different for TENs: the potential and vision for TENs remains true, but only to the extent TENs development learns from and responds to past environmental injustices, can it provide an equitable clean energy and decarbonizing solution.

This chapter seeks to provide that context; provide a lens for assessing TENs as an equitable decarbonization strategy; provide a state of play of equity-oriented policy for TENs; and share key opportunities, challenges, and recommendations as learned by this project team through the generous time and knowledge sharing of experienced environmental justice advocates.

For the purposes of this report, we use the following definition of environmental justice: **Environmental justice** means that everyone—regardless of race, color, national origin, or income—has the right to the same environmental protections and benefits, as well as meaningful involvement in the policies that shape their communities.[72] The current inequitable distribution of energy services and cost burden is due to imbalanced dynamics between stakeholders in the energy sector and society.[73] Environmental Justice communities include, but are not limited to, low-income communities, communities of color, frontline communities, and Indigenous communities.

The Legacy of Energy and Environmental Injustice

Energy infrastructure is disproportionately located near neighborhoods with higher concentrations of marginalized communities, low-income populations, and people of color, who experience a higher risk of exposure to pollution and negative health effects. For the purposes of this paper, we refer to these neighborhoods as environmental justice (EJ) communities. Fossil fuel infrastructure like processing facilities, storage wells, compressor stations, and transmission pipelines expose communities to poor air quality, safety risks, water and soil contamination, and economic disinvestment.[74] [75] [76] At the same time, electric power plants (often fossil-fueled) are frequently sited in low-income communities, communities of color, and communities affected by structural inequities, either due to their initial placement in these areas or because such

[72] Natural Resources Defense Council, (2023), Explainer: The Environmental Justice Movement, accessed March 17, 2025.
[73] Edem Lawrencia Anku, N., University of Energy and Natural Resources, Sunyani, Ghana, (2023), The Power of Procedural Justice in the Planning of Energy Projects, The Power of Energy Justice & the Social Contract, Just Transitions.
[74] The Impacts of Natural Gas on Public Health and the Environment
[75] Environmental Injustices of Leaks from Urban Natural Gas Distribution Systems: Patterns among and within 13 U.S. Metro Areas
[76] Natural Gas Gathering and Transmission Pipelines and Social Vulnerability in the United States - Emanuel - 2021 - GeoHealth - Wiley Online Library

communities have grown around them over time.[77] These harms coincide with inequitable access to clean energy technology and advancements, as development thus far has favored more affluent and historically privileged communities.

Though the power sector has reduced many pollutants in recent years, EJ communities continue to bear a disproportionate burden of environmental harms and adverse health outcomes, including the development of heart or lung diseases, greater numbers of emergency room visits and hospital admissions, and premature deaths.[78]

Further, due to their proximity to power plants, a disproportionate number of residents from EJ communities work in and are overrepresented in this industrial sector.[79] For these workers, the clean energy transition requires an intentional and managed plan to ensure that jobs, training, and benefits remain accessible. The effects of clean energy technologies on labor demand and income inequality vary significantly depending on the sector in which the transition takes place.[80] The concept of a just transition from fossil fuels to clean energy demands that the labor force is transitioned to and applicable to new, sustainable energy production, as opposed to being replaced and made irrelevant.[81]

Further, the cost of energy is growing increasingly unaffordable, as measured by energy burden, which is defined as the percentage of gross household income spent on energy costs.[82] Recent research finds that a quarter of low-income U.S. households spend over 15% of their income on energy bills.[83] EJ communities experience higher energy burdens than other households. High energy burdens are associated with greater risk of respiratory illnesses, low birth weights, increased stress, and economic insecurity and immobility.[84]

As the country transitions to cleaner energy, it is crucial to prioritize environmental justice (EJ) communities to ensure a just shift away from fossil fuels while creating equitable economic opportunities through local renewable energy jobs. Poorly executed initiatives risk reinforcing the harms of the fossil fuel industry, deepening distrust in energy policies. While clean energy can alleviate these burdens, there is always potential for worsening inequities. For instance, the California Public Utilities Commission recognizes that while distributed energy resources like solar reduce emissions, their high upfront costs make them accessible primarily to wealthier households, shifting costs of the electric rate base onto now fewer lower-income customers, thus exacerbating energy burdens.[85] Without a strong focus on equity, the energy transition will be less effective and could create compounding negative effects.[86]

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[77] Research brief Natural gas power plants in California's disadvantaged communities
[78] Power Plants and Neighboring Communities | US EPA
[79] Racial disparities in pollution exposure and employment at US industrial facilities | PNAS
[80] https://marenhedne.com/wp-content/uploads/2024/11/hedne_jmp-1.pdf
[81] Just Transition - Climate Justice Alliance
[82] https://www.energy.gov/scep/low-income-energy-affordability-data-lead-tool#:~:text=Energy%20burden%20is%20defined%20as,a%20high%20energy%20burden%20household%20.
[83] Energy Burden Research | ACEEE.
[84] https://www.aceee.org/energy-burden#:~:text=ACEEE's%20research%20has%20found%20that,bills%E2%80%94than%20the%20average%20household.
[85] UTILITY COSTS AND AFFORDABILITY OF THE GRID OF THE FUTURE
[86] https://justsolutionscollective.org/will-clean-energy-impoverish-the-poor-or-help-create-a-path-to-energy-justice-part-i/

Key Equity Concepts

The inequitable distribution of energy services and cost burden is due to imbalanced dynamics between stakeholders in the energy sector and society.[87] Environmental and energy injustices should be addressed from a lens of procedural justice and distributive justice. Applying these lenses in the exploration of any new technology, including TENs, can highlight critical risks to address and opportunities to ensure TENs development is not adding to inequities and can promote just outcomes. We discuss each of these in more detail below.

Procedural Justice

Procedural justice is about the fairness of the decision-making process.[88] In the clean energy context, procedural justice calls for meaningful community engagement in policy-making, legislative, and regulatory processes at local, regional, and state governments and regulatory agencies, ensuring that EJ communities have a voice in shaping the future of energy infrastructure in their neighborhoods. Meaningful engagement includes complete transparency of energy and environmental information, unbiased sharing of technical context, and deeply inclusive and accessible participation from stakeholders at every level.[89]

Many utility-scale renewable energy projects face local opposition. Procedural complexities deepen conflicts and create procedural injustice. A 2022 MIT study that reviewed 53 U.S. utility-scale wind, solar, and geothermal projects that were delayed or blocked found that public participation process conflicts occurred in 28 percent of cases.[90] When government bodies and project developers fail to properly find, address, and respond to community concerns, it can lead to delays and even cancellations of projects. Local communities are local experts; they have deep knowledge of their communities and area. Residents are directly impacted by both the benefits and consequences of renewable energy project development, so it is crucial that there are accessible and inclusive processes for them to provide input and influence decision-making.

TENs development holds potential to avoid past injustices for how energy resources and technologies have been developed in the past. TENs are not a novel technology–geothermal energy networks have existed for some time–thus, some familiarity with the technology allows stakeholders to better account for potential applications. TENs are differentiated from other geothermal technologies in that networked buildings circulate and efficiently distribute energy. With more stakeholders involved and technology being implemented on a larger scale as compared to building-by-building electrification approaches, it is crucial that TENs are designed with a robust community input process.

87 The Power of Procedural Justice in the Planning of Energy Projects | SpringerLink
88 Three types of environmental justice
89 "ENERGY JUSTICE AND U.S. ENERGY POLICY: CASE STUDY APPLICATIONS EXPLORI" by Emily Prehoda
90 Sources of opposition to renewable energy projects in the United States - ScienceDirect

Distributive Justice

Distributive justice relates to distribution according to needs, based on the principle that every human being has the right to fulfill basic needs.[91] Distributive justice demands equitable access to the benefits of clean energy, such as affordable solar power or energy efficiency programs, and equitable distribution of costs and harms. Distributive justice also requires addressing the historical inequities that have excluded these communities from such opportunities. The clean energy industry is not immune from the distributive justice issues that plague the energy industry as a whole. TENs have the opportunity to learn from these examples.

The most prevalent clean energy program model, supported by market transformation theories (positing that if we increase adoption quickly, the price will fall and more consumers can access the technology), provides incentives to encourage early adopters in energy efficiency, electric vehicles, and solar installation. These incentives are usually funded across all ratepayers (sometimes excluding low-income ratepayers), and are usually only accessible if the consumer can pay for the technology upfront and wait for a rebate or tax credit. This has resulted in wealthier homeowners reaping the benefits of clean energy technologies. While there are certainly systemwide benefits to any participant, the predominance of this model for the last 50 years has created a deep inequity between what populations can access the health and cost benefits of clean energy, and which cannot.

Furthermore, depending on the rate structure, as wealthier homeowners reduce their reliance on the grid, the cost of maintaining shared energy infrastructure is spread across fewer remaining customers. Since these remaining customers are more likely to be lower income, they end up bearing a disproportionate share of rising energy costs. California, for example, has historically not had a fixed charge, but recently adopted income-graduated fixed charges, in part to ensure that higher-income households pay a fairer share of transmission and distribution costs.[92] This case underscores the importance of making clean energy technology accessible to all—an inequitable rollout can add to structural distributional inequities that are difficult to correct.

Of course, technological developments, including the emerging interest and development of TENs, do not occur in a silo. All energy stakeholders are subject to local, state, and federal policies; these policies inform how EJ and equity are prioritized. The next section overviews the current policy "state of play" in which TENs are being developed.

Policy State of Play

This section briefly examines the requirements of existing and planned policies related to EJ, consumer protections, and energy equity within the context of TENs policy. Below we highlight equity-specific language in adopted policies (from Chapter 2), showcasing their equity elements and noting certain gaps in their approaches.

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[91] Three types of environmental justice
[92] https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M531/K686/531686019.PDF

- **Washington** – HB2131 prescribes that the commission must consider "whether the pilot project creates benefits to customers, communities, and society at large including, but not limited to, public health benefits such as improved air quality in areas with disproportionate environmental or public health burdens and disadvantaged communities as identified by the environmental health disparities map described in RCW 43.70.815, and increased affordability of thermal energy options." The legislation does not specify how the definitions of benefits will be defined, nor who will be involved in the process. The Washington Environmental Health Disparities Map includes pollution measures, poverty rates, and cardiovascular disease incidence to compare communities across the state for environmental health disparities.

- **Colorado** – SB24-1370 requires that local governments include information on disproportionately impacted communities near proposed development sites for potential neighborhood-scale alternatives projects. The legislation does not specify how perspectives of disproportionately impacted communities near proposed development sites will be collected or included in evaluation. The legislation does not mandate community engagement, nor specify how local governments or the utility must perform community engagement and outreach. Colorado hosts an Office of Just Transition to assist communities and workers transitioning away from the mining and burning of coal as an energy source, but this work was not mentioned in the legislation.[93]

- **Minnesota** – The Natural Gas Innovation Act (NGIA) requires the Commission to consider whether a pilot thermal energy network project creates economic and social benefits, including impacts on public health, especially in environmental justice areas, defined as an area where 40% or more of the area's total population is nonwhite; 35% or more of households in the area have an income that is at or below 200% of the federal poverty level; 40% or more of the area's residents over the age of five have limited English proficiency; or the area is located within Indian country, as defined in United State Code, title 18, section 1151.[94] The legislation does not identify how environmental justice areas and communities will be involved in these pilot development processes, but the TENs Siting Suitability Study includes a requirement to consider an area's status as an EJ area when recommending its suitability for a TEN, and that representatives from low-income communities be included in the TENs Working Group, along with other groups.

- **New York** – S9422 mandates that at least one of each IOU's required pilot project proposals must be proposed in a disadvantaged community as defined in subdivision five of section 75-0101[95] of the environmental conservation law, and if a utility proposes four or more pilot projects, at least two shall be proposed in disadvantaged communities.[96] S9422 additionally requests that pilot projects account for public health benefits in areas with disproportionate environmental or public health burdens, job creation, and

[93] The Office of Just Transition | Department of Labor & Employment
[94] Sec. 216B.1691 MN Statutes
[95] section 75-0101 - NYSenate.gov
[96] section 75-0101 - NYSenate.gov

affordability considerations, and includes strong worker protections and labor standards for the construction, operation, and maintenance of TENs.

- **Vermont** – S.305 does not explicitly include language surrounding equity or environmental justice considerations.

- **California** – SB 1221 acknowledges that without active planning, reduced demand for natural gas will place a disproportionate burden on vulnerable customers and directs the California Public Utilities Commission to designate priority neighborhood decarbonization zones, "accounting for the presence of environmental and social justice communities" as defined in the CPUC's Environmental and Social Justice (ESJ) Action Plan.[97] The CPUC's ESJ Action Plan defines environmental and social justice communities as "those where residents are predominantly communities of color or low-income, underrepresented in the policy setting or decision-making process, subject to a disproportionate impact from one or more environmental hazards, and likely to experience disparate implementation of environmental regulations and socio-economic investments in their communities."[98] The legislation's language of "accounting for the presence of environmental and social justice communities" does not indicate a plan to consult or uplift the communities' perspectives and preferences.

- **Maryland** – HB397 requires gas companies piloting TENs to submit an annual report on "minority-owned enterprise" participation to the commission. Pilot proposals must include a proposal to ensure that at least 80% of customers are from low or moderate income housing. Proposals must also identify the extent to which it prioritizes underserved or overburdened communities as defined as any census tract in which, according to the most recent U.S. Census Bureau Survey, at least 25% of the residents qualify as low–income, at least 50% of the residents identify as nonwhite; or at least 15% of the residents have limited English proficiency.[99] The legislation does not mandate community engagement processes through pilot proposal development. However it does require that a utility either use their existing workforce or utilize contractors that abide by a Community Benefit Agreement (CBA) for the construction of pilots. These CBAs must include strong labor standards and benefits to local communities, including measures to ensure career training opportunities, local hiring, and hiring of historically disadvantaged groups.

- **Massachusetts** – S.2995 requires pilot project proposals to disclose costs for both participating and non-participating customers, factoring in the social value of reduced greenhouse gas emissions. The Department of Public Utilities must assess whether the project's size, scope, and budget are reasonable and if its benefits justify the costs for all customers. Additionally, an environmental impact report is required for projects that may cause significant environmental harm and are within one mile of an environmental justice population—or within 5 miles if the project affects air quality. However, the bill does not

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97 https://www.cpuc.ca.gov/news-and-updates/newsroom/environmental-and-social-justice-action-plan
98 Environmental and Social Justice Action Plan
99 https://mgaleg.maryland.gov/mgawebsite/Laws/StatuteText?article=gen&section=1-701&enactments=false

explicitly address community engagement or equity practices in the development of TENs.

Other Relevant Policies

- **Justice40** – Under the Biden administration, Executive Order 14008 established the Justice40 Initiative, which aimed to address historical inequities by requiring that 40% of the overall benefits of certain federal climate, clean energy, affordable and sustainable housing, and other investments flow to disadvantaged communities that are marginalized by underinvestment and overburdened by pollution.[100] However, in January 2025 the Trump administration announced the rescission of various Executive Orders,[101] including the Justice40 initiative. As of February 2025, it is unclear to what extent the U.S. DOE initiatives will be impacted. It is clear that this regressive action will have significant negative impacts on EJ communities, and in particular, those pursuing TENs feasibility studies or project planning and implementation.
- **U.S. DOE Community Geothermal** – The U.S. DOE Community Geothermal Heating and Cooling Design and Deployment Initiative (Community Geo) was structured as a first-of-its-kind funding opportunity focused on empowering communities to make decisions about their energy futures, with input from those affected by those decisions. One of the five original goals of the initiative was to "identify solutions for environmental justice conditions, such as cumulative environmental pollution and other hazards, underserved and disadvantaged communities, and community members who have historically experienced vulnerability due to climate change impacts." By prioritizing community voice and environmental justice considerations, this initiative initially illustrated a strong commitment to addressing energy system inequities. It is unclear whether or how these priorities may shift under the Trump administration.

Key Findings

Pursuing energy justice requires localized, community-driven solutions that prioritize input from the affected populations. When considering the equitable development of TENs in EJ communities, the initial primary question should be: *Does the community want a TEN?*

The answer to that central question, for many EJ communities that have unfortunately become experts in how clean energy projects may not serve but can exacerbate harms in their communities, often leads to a much longer list of questions. The following is an illustrative list of questions the authors heard in interviews with EJ community and equity representatives. They demonstrate the critical nuance and complexity of ensuring a project like TENs genuinely benefits communities and doesn't sacrifice other areas of well-being for the sake of clean energy and efficiency.

[100] https://www.whitehouse.gov/environmentaljustice/justice40/
[101] Initial Rescissions Of Harmful Executive Orders And Actions

- *How can we measure and ensure social and economic impacts of thermal energy on frontline and EJ communities?*
- *How can we ensure that thermal energy does not exacerbate issues of displacement or gentrification in areas? How do we ensure that this doesn't happen when implementing new technologies?*
- *What are financial mechanisms that can support equitable access to clean energy? How are we going to make clean energy technologies accessible for low-income and rural communities?*
- *How can existing energy policies be adjusted to make thermal energy and existing tech more equitable? How can we ensure that policies are inclusive in the sense of language when we are implementing these policies? How might this line of questioning intersect with the question above on financial mechanisms; how can policy incentivize a developer to provide to EJ customers that will otherwise follow free market dynamics?*
- *How can we responsibly approach the conversation of cost? How can communities lead on TENs development and bear the risk of unknown costs? How can we protect consumers from bearing that risk?*
- *What are the documented (if any) economic benefits or impacts of TENs in a community? Are their numbers around job development and the types of jobs TENs would support? Is it actually economically and technically feasible to retrofit existing pipelines? Replacing the lines could be costly, but it does offer opportunities for workers – how would this work?*
- *How does TENs impact the local environment?*
- *How long does the infrastructure last, what is the lifespan?*

Utilities, public utilities commissions, and advocates must ensure that development is community-centered rather than imposed through top-down decision-making. This requires extraordinary thought partnership with EJ community leaders. A project done well by EJ community standards will stand to provide broader and more enduring benefits, showcasing the fullest potential of TENs.

This section discusses opportunities and challenges to advancing equity and energy justice in the deployment of TENs.

Opportunities

- **Centering Community Priorities in Policy Development** – Effective policy development for TENs must be co-created with EJ communities or their designated representatives to ensure equitable outcomes. Frameworks such as the Green Justice Coalition's analytical proposal review questionnaire provide tools for mitigating and eliminating disproportionate burdens on vulnerable populations; protecting and preserving public land, resources and services; promoting racial and gender equity; and advancing a more sustainable, equitable economy.

Policies should include clear mechanisms for community involvement at every stage of the development process (from site selection to construction), with accessible decision-making opportunities and fair compensation structures. Other tools like community-developed "scorecards"[102] can be used to evaluate the equity and environmental justice aspects of proposed projects. Such scorecards have generally been well-received by developers who were open to adjusting their processes based on community feedback.

– **Economic and Technical Advantages** – While TENs have the potential to offer long-term cost savings and environmental benefits, TENs development requires high initial capital investment. While costs can be distributed across multiple users at a neighborhood scale, potentially reducing energy expenses for households, government grants and financing, and philanthropic resources can help overcome the initial cost barrier.

  A consideration in TENs investment is that TENs enables broader-scale electrification, which can provide cost efficiencies by achieving higher economies of scale when compared to building-by-building electrification.

– **Local Workforce and Job Creation** – While there are certainly unique aspects to TENs infrastructure development, operations, and maintenance, the skillsets of TENs and conventional pipeline workforce overlap substantially. As many EJ community members are also employed in fossil fuel infrastructure, TENs present a unique opportunity to enhance local economic development and keep and create local, family-sustaining jobs in EJ communities. Due to the likely operational and maintenance required of any pipeline infrastructure, TENs jobs could be more enduring than those created for other clean energy technologies.

  TENs development should collaborate with local workforce development and labor unions to design training, support transfer of skills, and secure project labor agreements (PLAs) and permanent local jobs. While labor unions have often expressed a disconnect with clean energy initiatives, and want to be included in design conversations, TENs provide a welcome opportunity for unions to expand their training to accommodate TENs-specific skills and create longevity for their members.

– **Health and Environmental Benefits** – EJ communities face cumulative disproportionate health risks from fossil fuel reliance, including increased respiratory and cardiovascular illnesses due to harmful emissions. TENs can mitigate these risks by reducing exposure to harmful pollutants caused by burning natural gas, fuel oil, and propane, and transitioning communities away from fossil fuel dependence, both in the home and

[102] Environmental Justice and Geothermal Energy Networks

broader energy system. TENs can enhance resilience by providing a stable, localized combustion-free heating and cooling source, decreasing reliance on centralized fossil fuel infrastructure prone to failures such as pipeline explosions.[103]

- **Resiliency Benefits** – TENs can help address energy unreliability in many EJ communities. Because they consume less energy than fossil fuel-based or conventional all-electric heating and cooling systems, renewable energy-powered battery backups can keep TENs operational during outages, as demonstrated in the Whisper Valley, TX, case study. However, since TENs rely on a small amount of electricity to run heat pumps, they can still go offline without backup power. To maximize their resiliency benefits, integrating backup power should be a priority in the early design phase.

Challenges

- **Policy and Regulatory Barriers** – The policy landscape for TENs remains emergent and underdeveloped, with limited equity protections for EJ communities. While state legislatures have authorized utility-led pilot programs, municipal sustainability offices often lack the capacity to advance TENs, and rulemaking processes can exclude community input through technical language and rigid procedures. Current frameworks frequently place equity impact assessments in the hands of utilities or regulators, reducing EJ communities' role in shaping projects. Top-down policy development fails to recognize all EJ community nuances or capture the full diversity and complexity of their issues, making it inadequate for ensuring equitable decarbonization. Barriers such as technical jargon, limited language translation services, and rigid engagement structures hinder meaningful community participation. For example, public utility commissions are often reluctant to provide guidance without established rulemakings, and once those rulemakings are in place, they typically only accept community input in specific formats, disregarding verbal testimonies or lived experiences.

  Some interviewees also noted that official state and federal EJ maps frequently misrepresent on-the-ground realities, so tying funding to eligibility maps can sometimes hinder rather than support effective community-driven solutions, especially in rural communities. A more flexible and locally informed approach is needed to ensure resources reach the communities that need them most.

- **Technical Challenges** – Like any new energy technology, TENs development requires careful spatial planning, especially when replacing existing infrastructure. Factors such as density constraints, the placement of buildings and infrastructure, and proximity to networked users can influence feasibility and cost effectiveness. Further, the limited availability of specialized labor and geothermal drilling expertise further complicates deployment. There can be substantial risk in introducing TENs to EJ communities before the necessary technologies are fully developed and cost effective.

[103] Deadly South Philadelphia house explosion in 2019 leads to new safety measures in Philly

As with many existing building retrofits, integrating TENs with existing heating, ventilation, and cooling (HVAC) systems can present significant technical and cost challenges, particularly when extensive retrofitting is required. For instance, buildings with incompatible HVAC systems may need entirely new indoor equipment, ventilation, and other upgrades. To address this barrier, Eversource's TENs pilot in Framingham, MA, is covering the cost of weatherization, asbestos and mold abatement, HVAC upgrades, electric upgrades, replacing furnaces, and installing heat pumps.[104] While this approach effectively supports impacted communities, it is funded through utility rates and grants and may not be sustainable for broader implementation. Buildings in EJ communities often require such essential "healthy building" upgrades, including insulation, asbestos and lead abatement, and other weatherization improvements. Enhancing energy efficiency is crucial to maximizing the effectiveness of TENs; without sealing the building envelope to reduce thermal energy waste and providing these other upgrades, investments in TENs may not yield their full benefits.

Further, as noted above, while TENs use significantly less energy than conventional systems, they remain vulnerable to power outages if backup systems are not in place. Without intentional planning, TENs risk losing functionality when the grid goes down. To fully realize their resilience potential, backup power must be incorporated into system design from the outset.

- **Workforce Challenges and Barriers to Local Hiring** – Many of those interviewed cited a shortage of skilled labor with expertise in the design, installation, and maintenance of TENs, particularly in specialized areas such as geothermal drilling.[105] This gap in workforce knowledge poses a challenge that will need to be addressed in close collaboration with labor unions to ensure successful deployment and operation. At the same time, labor unions must actively create pathways for people from local communities to join their workforce, ensuring that the benefits of clean energy projects, like TENs, are accessible to those who live and work in the areas where these projects are being developed.

  Additionally, building trades unions have traditionally been composed primarily of white males, with aging memberships. This demographic shift presents both a challenge and an opportunity to cultivate more inclusive pathways for young workers from EJ communities to access family-sustaining careers. Successfully addressing this requires targeted training programs—not only to equip a diverse incoming workforce with the necessary skills, but also to support incumbent leadership in fostering a more inclusive and welcoming workplace culture.

[104] Decarbonized Heating and Geothermal Energy | Eversource
[105] Though it was noted by some interviewees that in many cases, perceived skilled workforce shortages are actually a result and reflection of poor job quality in a sector, underscoring the importance of strong labor standards in order to attract a skilled workforce.

- **Community Distrust and Inadequate Outreach and Engagement** – A barrier to equitable TENs adoption is the mistrust that has developed over many experiences between EJ communities and utilities and energy developers. EJ communities have so often shouldered the burdens of technological experimentation while receiving minimal benefits. Effective TENs implementation requires prioritizing trust-building through transparent, sustained engagement that respects community agency. EJ communities seek the integration of procedural and distributive justice in TENs development. Establishing meaningful, equitable partnerships must be a core priority in TENs community engagement to ensure fair and inclusive decision-making. If this is the foundation, TENs have the potential to correct for past mistakes, and set a new standard for equitable decarbonization.

  TENs ownership models can play a critical role in the degree to which community needs are prioritized. Too often, EJ communities have seen utilities make symbolic gestures toward clean energy goals and community priorities without delivering meaningful benefits to the communities hosting energy infrastructure, and in many cases still, further harming those communities. Thus, there is justified skepticism among many EJ organizations that IOU or other privately-owned TENs will truly serve the public interest, given their responsibility to generate returns for their shareholders.[106]

- **Costs** – As discussed in Chapter 1, TENs are an emerging industry and not yet cost-competitive. As the industry scales, costs are expected to decline, mirroring the cost reduction trends observed in solar and wind energy. This early-stage cost challenge is especially important to consider to avoid placing the financial burden of energy systems on communities before their ost-competitiveness has been established. Community solar models are successful today because solar energy has reached a stage where it is economically viable—somethingthat was not true in its early market development; the industry needed time to leverage cost reductions driven by technological advancements. When examining the lifecycle of new technology adoption, the early stages are not necessarily the ideal time for widespread community ownership due to the high risks involved. Instead, government and private sector investment should absorb these risks in this early stage, ensuring the technology matures and becomes a stable, cost-effective option before transitioning to widespread community ownership.

- **The Split Incentive Challenge** – The "split incentive" problem for renters refers to the misalignment of costs and benefits between landlords and tenants when it comes to energy efficiency and renewable energy improvements. Because landlords typically own the property but renters pay the utility bills, landlords have little financial motivation to invest in clean energy upgrades since they do not directly benefit from the resulting lower energy costs. Conversely, tenants who would benefit from lower utility bills often

[106] Keynote Address from Naomi Davis (Blacks in Green) - Midwest BDC Justice40 Leadership Bootcamp

lack the ability or incentive to invest in long-term improvements to a property they do not own.

Many renters are interested and excited by the quality of life and cost benefits of clean heating and cooling technologies, and may be interested in accessing TENs, but landlords are often not motivated to install them. A broad challenge is: How can renters be engaged and activated?

Recommendations

Building on these identified opportunities and barriers, we recommend the following actions to effectively and equitably deploy TENs:

1. **Support Communities in Determining their Own Energy Future** – TENs development should only proceed where there is clear community interest. EJ communities wishing to pursue TENs should be funded and supported to do so. Where not originated by the communities themselves, EJ communities should have the agency to accept or decline development projects based on their defined benefits.

   If proceeding, establish community advisory boards and support the participation of trusted community representatives to oversee planning and implementation. Facilitate participatory budgeting processes where community members and representatives can help allocate resources for TENs projects. Ensure that decision-making structures are transparent, inclusive, and representative of diverse community voices.

Blacks In Green's Sustainable Square Mile

A successful case of community-led and -driven design is exemplified by the Blacks In Green (BIG) TENs project in West Woodlawn, Chicago (described in Chapter 3). BIG's Sustainable Square Mile concept integrates community solar and microgrids powered by clean energy, and embodies BIG's Eight Principles of Green Village Building, which include developing affordable community microgrids powered by clean energy, cutting GHGs and unhealthy air pollution, creating jobs, and boosting community resilience to energy rate spikes and blackouts.

This project demonstrates how projects with community priorities meaningfully in the lead can genuinely align with broader community goals of resilience, job creation, and divestment from fossil fuels. The Sustainable Square Mile project offers an opportunity to divest from the fossil fuel system, break away from investor-owned utilities, and promote community ownership, thereby fostering resilient and self-sufficient communities.[107]

BIG's core focus on community values guided their interest in pursuing a networked geothermal project. However, not every EJ community has the same motivations to pursue TENs. Each

[107] Keynote Address from Naomi Davis (Blacks in Green) - Midwest BDC Justice40 Leadership Bootcamp

community has distinct priorities; TENs should only be pursued when they align with specific communities' values and needs.

2. **Include and Resource Equitable Processes in Policy Design** – Legislation should mandate inclusive participation, provide technical, legal, and financial support for community representatives navigating policy frameworks, and require direct collaboration with community members that represent historically marginalized, harmed or burdened, and underserved parts of the community. It is crucial that EJ communities experience genuine relationship-building efforts from external stakeholders, rather than being treated as a mere outreach "check box" by agencies, utilities, and government entities.[108, 109] Resource local CBOs, who are best equipped to lead the design of flexible and locally informed approaches to ensure resources reach the communities that need them most.

   Policies must ensure that EJ communities hold meaningful decision making power, so they can effectively ratify terms, protect against displacement, and avoid undue financial burdens. Tools like the Green Justice Coalition's analytical review questionnaire and community-developed "scorecards" can help guide equitable processes. Finally, as discussed in greater detail in Chapter 5, TENs legislation should enable and encourage local TENs ownership models to ensure that decision-making power, economic benefits, and access to clean energy remain within the communities they serve.

3. **Build Community Trust through Meaningful Engagement** – Building trust through sustained, meaningful engagement is essential for successful TENs development in EJ communities. Partnering with and resourcing local community-based organizations (CBOs) that have built long relationships of trust with the communities they serve can help establish long-term, trust-based relationships with and throughout the community through ongoing dialogue and culturally relevant outreach.

   As mentioned in the first bullet above, EJ communities and their representatives need to be engaged in the earliest stages of considering any clean energy project, including TENs. They should be supported with the tools and a process that builds their power and capacity to be in the driver-seat of projects.[110] Providing educational resources, workshops, and town halls ensures communities stay informed and can confidently participate in any discussions and decisionmaking. Community design charrettes and one-on-one conversations, though slower than mass outreach, are among the most effective strategies for ensuring informed engagement. This outreach is supported by offering materials in locally relevant languages, translation services, transportation, childcare, and honoraria fosters accessibility and participation. Engagement

[108] Acceptance through inclusion? Political and economic participation and the acceptance of local renewable energy projects in Switzerland - ScienceDirect
[109] Community Engagement and Equity in Renewable Energy Projects: A Literature Review
[110] Spectrum of Community Engagement to Ownership by Facilitating Power

opportunities should be inclusive of all community members, regardless of their knowledge of TENs or clean energy, recognizing that not everyone will reach the same awareness due to practical constraints. Developers should ensure flexible, accessible engagement tailored to diverse expertise and experiences.

The Eversource Energy TEN pilot in Framingham, MA, exemplifies how an IOU can prioritize effective community engagement by collaborating with and providing resources to local community-based organizations and working closely with community members. As a result of conversations about community priorities and concerns, the pilot covers the cost of weatherization, asbestos and mold abatement, HVAC and electrical upgrades, furnace replacements, and heat pump installations. If customers are dissatisfied after the pilot phase, Eversource will cover the cost of removing the equipment and will either reinstall gas units or provide alternative agreed-upon equipment, such as air-source heat pumps.

Language barriers within linguistically isolated households can significantly hinder participation in programs and services. Ensuring workforce representation that reflects the communities served is essential to delivering retrofits and other implementation efforts in a manner that upholds dignity and trust. For instance, multi-generational households may feel vulnerable if they fear judgment or repercussions for not reporting the exact number of occupants to authorities. Additionally, certain nationalities may have deep-seated distrust of government entities, further complicating engagement. Addressing these dignity considerations is just as critical as ensuring energy access, as overlooking them may discourage participation among vulnerable and marginalized populations.

Research highlights a strong correlation between community trust, procedurally just engagement, and the social acceptance of renewable energy projects.[111] To achieve equitable outcomes, trust and community engagement must be prioritized from the earliest stages of project development.[112] Engaging local EJ organizations can help dispel misinformation and ensure that community concerns—such as potential displacement, rising property taxes, and affordability—are addressed proactively, potentially leading to smoother and efficient implementation.

4. **Expand Workforce Training and Development for Local Jobs** – Skilled workers, particularly those in drilling, construction, plumbing, and utility sectors, are essential to the design, installation, and maintenance of TENs. By leveraging the expertise of unionized labor, we can ensure that TENs are built to high standards, provide quality job opportunities, and uphold labor protections. Investing in training programs to build a skilled workforce for TENs design, installation, and maintenance can ensure job

[111] Trends in Social Acceptance of Renewable Energy Across Europe—A Literature Review
[112] Community Engagement and Equity in Renewable Energy Projects: A Literature Review

opportunities for local workers, particularly in EJ communities. Develop these programs in collaboration with labor unions, technical schools, and apprenticeship programs to create clear career pathways. Prioritize a just transition for existing utility and oil and gas workers while expanding opportunities for underrepresented groups in the clean energy sector. Support efforts to address the shortage of skilled drillers to meet the growing need as TENs scale, like that of the Geothermal Drillers Association. Ensure that workforce development initiatives and TENs projects prioritize local hiring,attract a diverse workforce that reflects the diversity of the communities they serve, and foster welcoming workplace cultures. Include Project Labor Agreements or Community Benefits Agreements with local hire provisions for TENs construction to ensure job creation within the surrounding community.

Ensuring a Just Transition: The Role of Labor Standards in the Energy Shift

Meaningful engagement in the energy transition must involve labor organizations and workers in policy-making. They bring expertise in system design, construction, maintenance, and workforce development. Without strong labor standards, workforce challenges will persist, as unions need clear demand for skilled apprentices and workers at competitive wages.

With strong labor standards, expanding apprenticeship programs can create pathways for under-represented communities to access high-quality training and union careers. Project Labor Agreements or Community Benefits Agreements for TENs construction can further support local job creation. The right labor standards, along with robust union training, can drive economic opportunities and scale the TENs workforce.

Costs disproportionately borne by frontline workers in transitioning sectors must also be addressed, including publicly-funded retraining, job placement assistance, and wage and pension guarantees for impacted utility workers.

A successful just transition requires intentional policy design with strong labor standards to support the skilled workforce, and inclusive pathways for young workers from EJ communities.

5. **Reduce Consumer Costs with Public and Innovative Financing** – TENs development should not add additional cost burden to communities that have and are already shouldering a disproportionate of costs and fewer of the benefits in the energy system. Avoid placing the financial burden of TENs on communities before their cost-competitiveness has been established. Explore different ownership models that can leverage different financing structures and public-private partnerships to lengthen payback periods and reduce upfront costs of TENs. Explore financial mechanisms such as low-interest loans, grants, and subsidies to enhance affordability for the equipment the end-users are responsible for installing. Explore innovative financing such as renewable energy credits, revolving loan funds, and other structures, and develop community-led funding models to enable collective ownership and investment in TENs

infrastructure. Social investment and other funds could offer flexibility for TENs development initiatives.

6. **Remove Risk to Communities in Project Design and Implementation** – Ensure that the necessary policies and technologies are fully researched, developed, and cost effective before introducing them to EJ communities. When considering the deployment of TENs, respect the energy service needs of EJ communities, ensuring that their utility services remain uninterrupted and their time is not exploited. Maintaining reliable access to energy is essential, and TENs development should be designed so as to disrupt the daily lives of community members as little as possible, if at all.

7. **Pursue Comprehensive Energy Upgrades** – TENs should be implemented in a comprehensive approach with complementary initiatives such as solar energy, microgrids, weatherization, and energy efficiency upgrades to maximize benefits. TEN projects should be implemented alongside energy efficiency retrofits and “healthy building” improvements, such as lead and asbestos abatement, with these upgrades prioritized well before TEN installation. Additionally, to enhance resilience, TENs should incorporate robust energy storage solutions, such as electric battery storage or geothermal borefields for bedrock thermal storage, as part of their design.

Chapter 5: Energy Democracy Perspectives on TENs

Background

Energy democracy promotes locally controlled, equitable, and community-driven energy systems, shifting power away from IOUs toward decentralized, community-led models. It encompasses social ownership of energy infrastructure, decentralized systems, and public participation in energy policymaking.

This chapter seeks to provide a lens for assessing TENs as an energy democratization strategy; provide a state of play of energy democracy-oriented policy for TENs; and share key opportunities, challenges, and recommendations as learned by the authors through the generous time and knowledge sharing of experienced energy democracy advocates and local government representatives.

For the purposes of this report, we use the following definition of energy democracy: **Energy democracy** is the process of democratizing the production and management of energy resources, including the social ownership of energy infrastructure, decentralization of energy systems, and meaningful public participation in energy-related policymaking.

Through the course of this project, we received feedback on this definition and now specify that energy democracy does not necessarily need to emphasize energy, as energy is not the "golden ticket" solution to the climate crisis. Rather, energy democracy relates to the relationships between people and the planet. Further, the "social ownership of energy infrastructure" as used in the initial definition of energy democracy could reference wide distribution of energy generation, and "meaningful public participation" could be specified as democratic and equitable participation. We are grateful for the feedback received on the initial definition of energy democracy.

History of Energy Democracy in the U.S.

Rooted in the rural electrification movement of the 1930s, the concept of energy democracy gained traction during the 1970s energy crisis and environmental movement, with policies like the Public Utility Regulatory Policy Act (PURPA) of 1978 fostering small-scale renewable energy. Growing concerns over climate change, corporate monopolies, and energy affordability in the 1990s–2000s led to grassroots efforts expanding solar, wind, and municipal utilities.[113] Since the 2010s, the movement has gained momentum with racial and economic justice groups advocating for clean energy access in marginalized communities. Groups like the Energy Democracy Project and the Institute for Local Self Reliance (ILSR) and the push for publicly

[113] Vaheesan, Sandep. *Democracy in Power: A History of Electrification in the United States*. The University of Chicago Press, 2024.

owned microgrids, solar cooperatives, and TENs reflect ongoing efforts to decarbonize the grid while empowering communities.

For TENs, energy democracy means ensuring these systems are designed, governed, and operated to prioritize community needs, affordability, and sustainability. As we saw in Chapter 3, there are a number of existing and emerging public and community ownership models for TENs, including publicly owned utilities, Sustainable Energy Utilities, innovative new public ownership models, and community-owned structures. Each model presents unique advantages and challenges in financing, governance, and operational oversight.

Public utilities and municipal governments are exploring ownership structures that allow greater local control and public accountability. Cities like Ann Arbor, Michigan, Hayden, Colorado, and others are pioneering municipally owned TENs, often funded through government grants, tax-exempt bonds, and partnerships. Public ownership models can align with community priorities, ensuring equitable access and reinvestment in local economies, but they also benefit significantly from substantial public funding and governance expertise.

Emerging community-owned models, such as those being explored by Blacks in Green in Chicago, IL, and the Citizen Potawatomi Nation in Shawnee, OK, offer pathways to democratized energy systems. These structures emphasize local decision-making, equitable benefit-sharing, and long-term affordability. However, challenges such as securing financing, navigating regulatory barriers, and building technical capacity must be addressed to scale these efforts.

A number of useful tools and resources have been developed to help local jurisdictions and communities pursue TENs in ways that advance energy democracy, including:

- In March 2024 the NGO Vermont Community Thermal Networks and TENs development firm firm Community Decarbonization Partners created a useful toolkit, called How to Develop a Thermal Energy Network, that examines municipal, cooperative, and third-party ownership structures, detailing how these choices impact financing, cost recovery, and eligibility for federal and state incentive programs.[114]
- The NGO HEET has also developed useful guidelines for communities wishing to explore whether GENs might be right in their neighborhoods. HEET's Networked Geothermal Toolkit guides communities through the stages of planning and implementing geothermal networks, from learning about the technology to selecting sites for installation. It provides resources for understanding geothermal systems, building coalitions with key stakeholders, and gaining support from decision-makers. The toolkit emphasizes community engagement and offers guidance on identifying thermal opportunities and conducting citizen science. It also covers critical steps like scoping sites, considering geological factors, and selecting the best locations for geothermal

[114] New Toolkit: How to Develop a Thermal Energy Network

projects, with a focus on collaboration, funding opportunities, and inclusivity throughout the process.

HEET also organizes community charrettes as collaborative, community-driven workshops to help communities explore and plan networked geothermal systems. These sessions bring together residents, policymakers, utilities, engineers, and environmental justice advocates to assess local energy needs, potential geothermal resources, and system design options for ensuring that proposed TENs align with community priorities, equity considerations, and long-term sustainability goals.

- Sponsored by the New York State Energy Research and Development Authority (NYSRDA), in 2023 the Pace Energy & Climate Center held a series of charettes for municipalities to help them understand the legal and regulatory issues confronting the development of district geothermal energy systems in the State of New York. Monthly sessions covered five key areas: planning, job training, affordable housing challenges, regulatory alignment, and business models. The charette series built on some of the findings from a report authored by Pace in 2022 on the same topic.

Policy State of Play

Of the eight states that have passed legislation enabling TENs, four authorize non-IOU ownership models:

- **Vermont** – S305 decrees that “municipalities shall have the authority to construct, operate, set rates for, finance, and use eminent domain for a thermal energy exchange network utility without a certificate of public good or approval by the Commission,” allowing municipalities to own and operate TENs without requiring approval from the PUC, similar to how they manage water and sewer services. The legislation also requires existing utilities, businesses, developers, and nonprofits to conduct a PUC study before any authorization to operate TENs will be considered. Owners of campuses, condominiums, cooperatives, or tenant properties remain unaffected by this law and are still permitted to operate a TEN for their own use and for their members or tenants, provided they comply with existing zoning and municipal regulations.
- **Colorado** – SB22-118 allows for the creation of “community geothermal gardens,” geothermal energy facilities of 10MW or less that are located in or near a community served by a qualifying retail utility and serving at least 10 subscribers. The facility can be owned by the utility, a for-profit or non-profit entity, or a subscriber organization formed under this legislation.
- **Washington** – HB2131 allows “Public Utility Districts” (PUDs) to own, operate, and manage TENs under their governing body’s oversight. A PUD is a community-owned, nonprofit utility that is owned by a local government created by a local vote to provide

essential services such as electricity, water, and telecommunications. PUDs are similar to POUs, in that they are owned by the public as a special-purpose district and cover a county or multiple jurisdictions. There are 28 PUDs in Washington state.[115]

- **Maryland** – HB0397 allows gas, water, and electric utilities to own thermal energy networks.

Other Relevant Policies

- **Policies Allowing for State-Owned Renewable Energy Projects** – Some states have passed laws allowing for state agencies to directly build and operate renewable energy systems, bypassing traditional private utility companies. For example, New York's Build Public Renewables Act, passed in 2023, authorizes the NY Power Authority (NYPA), the nation's largest state-owned electric utility, to develop and own renewable energy projects and related infrastructure like energy storage systems.[116] Several other states—including California, Nebraska, Colorado, and Washington—have taken steps toward publicly owned renewable energy or expanding state involvement in clean energy development.[117]

- **Home Rule States** - While specific laws and regulations regarding the ownership and operation of renewable energy systems like TENs can vary widely, many "home rule" states provide local governments the authority to make decisions about energy infrastructure, including renewable energy systems, without needing state approval. Each state's home rule laws can differ, and the ability for local governments to engage in energy system projects might also depend on other factors, such as public utility regulations, local government charters, or specific legislative acts.

Key Findings

With their compatibility with a range of ownership models, TENs present a unique opportunity to reshape the energy landscape by empowering public entities and communities to own, govern, and benefit from their energy systems. Beyond their environmental and economic advantages, TENs is a tool in the pathway to energy democracy, enabling local stakeholders to take control of energy infrastructure, make collective decisions, and ensure equitable access to clean and affordable heating and cooling.

However, achieving this vision requires addressing significant policy, financial, governance, and capacity challenges that currently hinder widespread public- and community-owned models. This section explores both the opportunities and obstacles associated with advancing energy democracy through TENs and outlines key recommendations for overcoming these barriers.

[115] Fast Facts about Washington State PUDs
[116] Legislation — Public Power NY
[117] Opposition to Renewable Energy Facilities in the United States: June 2024 Edition | Sabin Center for Climate Change Law

Opportunities

We describe the numerous potential benefits of TENs in Chapter 1. In addition to these benefits, TENs offer further opportunities to promote energy democracy, empowering communities to shape and secure their own energy advantages. Specific energy democracy opportunities include:

- **Local Control and Public Ownership** – TENs can be developed and managed by municipalities, cooperatives, or community-based organizations, reducing dependence on IOUs and shifting decision-making power to local stakeholders. While they bring their own funding and financing challenges, public ownership models are more frequently focused on ensuring energy infrastructure aligns with community priorities, fosters democratic governance, and serves the public interest. TENs offer a critical addition to the toolkit for clean energy that is decentralized, democratized, distributed, and diversified.

- **Economic and Workforce Development** – Community-driven TENs create skilled jobs in engineering, construction, and system operation. Locally owned projects can prioritize hiring from underrepresented groups in the clean energy sector, supporting workforce diversity, and reinvesting revenues in economic development and workforce training programs and other local initiatives supporting local economic development.

- **Resilience and Energy Security** – Locally managed TENs enhance community resilience by reducing reliance on volatile fossil fuel markets and centralized energy grids, which become strained during peak demand periods. These systems offer stable, reliable heating and cooling while safeguarding communities from supply disruptions and fuel price fluctuations. Integrating fossil fuel-free energy storage and backup systems further strengthens resilience, ensuring uninterrupted service during outages.

Challenges

However, as with any energy system, there are several challenges to energy democratization in TENs as well, as we describe below.

- **Policy and Regulatory Barriers to Different Ownership Models** – Many states have policies favoring IOU-owned models, making it more difficult for municipalities or community groups to develop and operate TENs independently. As noted above, only half of the eight states that have passed TENs-specific legislation authorize non-IOU ownership models.

- **The Need to Reform Utilities' "Obligation to Serve"** – Another key policy barrier is utilities' "obligation to serve," a regulation established during the era of regulated monopolies to ensure that utilities provide access to reliable and affordable energy to all customers, regardless of location or income.[118] The intent was to guarantee universal service, prevent discrimination, and maintain stability in the energy market. However, this obligation has traditionally been interpreted to mean that gas utilities must fulfill their duty by supplying natural gas to their customers. Efforts are now underway to reform this requirement, allowing utilities to meet their obligation through the provision of thermal energy instead. This shift would enable utilities to use TENs to achieve both their service and clean energy goals, but these efforts are complex, challenging, and often face significant resistance from the fossil fuel industry.

- **Financial Barriers and Upfront Costs** – Building TENs requires significant initial investment, which may be a barrier for community-led projects without public funding or private partnerships. As with any energy system, construction costs increase dramatically when retrofitting existing systems, which tends to be far more complex and expensive. Unincorporated entities lack the ability to de-risk projects through grants or zero-interest loans and limited access to long-term financing options. Financial hurdles are compounded by the lack of credit eligibility for multi-ownership systems and community energy projects. While some community-driven projects have been initiated with U.S. DOE grants, the uncertainty around federal funding puts all efforts in jeopardy.

- **The True Costs of Maintaining Aging Fossil Fuel Infrastructure Are Typically Not Considered When Comparing TENs Construction Costs** – When evaluating TEN construction costs, it is important to consider the high cost of maintaining aging fossil fuel infrastructure. The estimated cost of maintaining aging oil and gas infrastructure can vary widely based on location and specific needs, but studies have shown that the costs are significant. For example, in New York State, the Building Decarbonization Coalition estimates that replacing gas mains could cost over $3 million per mile of pipeline, and ongoing repairs, safety upgrades, and leak management add significant expenses.[119] These maintenance costs make relying on outdated fossil fuel systems financially unsustainable. In comparison, TENs often prove more cost-effective in the long term, though these infrastructure costs are frequently overlooked in financial assessments.

- **The Need for Rate Reform** – A major challenge consumers face is the high cost of electricity, yet most utility rates do not reflect the full environmental and social costs of fossil fuel-based energy. The majority of electricity in the U.S. is still generated from fossil fuels, and while current rates may be high, they are actually lower than they would be if the true costs of carbon emissions, environmental degradation, and public health impacts were factored in. This price distortion makes it harder for clean energy solutions like TENs to compete, reinforcing reliance on fossil fuels and delaying the transition to sustainable energy. Pushing for electrification without addressing these artificially low fossil fuel-based rates risks deepening energy inequality, making clean technologies less

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118 https://buildingdecarb.org/wp-content/uploads/FINAL_Decarbonizing-the-Obligation-to-Serve_Oct2024.pdf
119 https://buildingdecarb.org/wp-content/uploads/BDC-The-Future-of-Gas-in-NYS.pdf

accessible and potentially increasing costs without delivering the full environmental and economic benefits needed for a just energy transition.[120]

- **Resourcing a Community-Driven and -Owned Process** – To support a community-driven and locally-owned process, usually a trusted entity must be willing to host and run that process from conception through operation. This entity must be resourced to navigate the technical, political, and financial aspects of a TENs project, alongside managing a community governance process. Considering the length of time it can take to go from conception to feasibility to planning to implementation, this entity must be well-resourced to lead the process, have the capacities to partner with government agencies, developers, and funders. Often such trusted entities are historically and continually underresourced.

- **Capacity and Resource Gaps in Local Governments** – To the extent the local government may partner in hosting a community-driven process, cities and counties often face significant limitations in their staffing capacity to promote and implement TENs and other building decarbonization efforts. Further, cities and counties also usually lack the political power or influence to push for systemic changes that could enable the widespread adoption of TENs or enable and support a community-driven and -owned process.

- **Thermal Energy Decarbonization Planning and Waste Heat Mapping** – Many of the local governments and communities we interviewed mentioned the challenge of not knowing what waste heat resources are available to them. There is a clear need to investigate the waste heat potential in municipalities and develop thermal or waste heat maps, and then use these to aid in holistic planning around existing and anticipated heating and cooling needs. For example, King County, WA's Sewer Heat Recovery Interceptor Map (discussed in Chapter 3) is used to identify and visualize available waste heat sources for use in district heating or other energy recovery applications. Toronto, Canada, has developed a similar tool called the Wastewater Energy Map.

  There is also a need to promote—or require—thermal energy decarbonization plans, similar to Germany's approach. In 2023, Germany passed the Act on Heat Planning and the Decarbonization of Heating Networks, which requires municipalities to create heat plans as part of the country's strategy to decarbonize the heating sector and move away from fossil fuels.

- **Legacy Gas Pipes** – A key challenge of non-IOU-owned TENs models is that they typically do not include the removal of legacy gas pipes, which remain the property of the gas utility. As a result, aging infrastructure is left in place, increasing the risk of methane leaks and safety hazards. Without a coordinated effort to decommission gas pipelines

[120] See, for example, Electricity Rates that Keep Bills Down after Electrification of Home Heating | ACEEE.

alongside TEN installations, communities may continue to face the dangers of gas leaks, explosions, and carbon monoxide exposure.

– **Governance Complexity** – Even if a TEN is locally-owned, it is very likely it will be operated and used by multiple parties. The operation of a TEN requires skilled and dynamic management, transparent governance, long-term planning, and multi-stakeholder engagement. This is significantly more complex than installing energy equipment in a single building.

Recommendations

Building on these identified opportunities and barriers, we recommend the following actions to effectively deploy TENs in a way that advances energy democracy and enables greater local control.

1. **Implement Policy Reforms and Clarify Regulatory Frameworks** – Enact legislative and regulatory changes that enable local TENs ownership pathways to support community-driven and municipally led projects.

2. **Support the Development of Locally Owned Pilot Projects** – Establish financial and technical support and provide guidance on different governance frameworks for communities and local governments to test ownership and operational models, refine best practices for promoting sustainability and expansion, and build confidence in locally owned TENs deployment. Resource cities and counties, both in terms of resources and authority, to advance TENs.

3. **Expand Funding and Financing Support** – Increase the availability of and access to grants, zero-interest loans, and other sources of funding and financing to support feasibility analysis, planning, and pre-development costs for locally-owned TENs. Prioritize grants that de-risk early-stage investment and capacity building. Improve transparency on IRA funding eligibility and remove financial and regulatory barriers to decentralized energy systems. Explore innovative funding and financing mechanisms such as clean air grants, capital assets from housing authorities, urban heat island mitigation funds, resiliency hub funding, and other unconventional funding and financing structures.

4. **Resource Deep Community Engagement** – Support and strengthen staffing and technical capacity and general operating budgets for community-based organizations poised to and interested in leading TENs development, and related community engagement, project management, and partnership development. Prioritize funding for community engagement initiatives, including feasibility studies, technical consultations, and grassroots outreach, ensuring inclusive participation in multi-ownership systems. Require or strongly encourage TENs owners and developers to include this as part of their project budget.

5. **Support or Mandate Thermal Energy Planning and Waste Heat Mapping** – Adopt policies that encourage or mandate thermal energy decarbonization plans to provide clear frameworks for transitioning to sustainable heating systems and reducing reliance on fossil fuels. Prioritize the development of waste heat maps to identify and visualize available energy resources in municipalities.

6. **Mandate Safe Decommissioning of Legacy Gas Pipelines** – Policy and regulations should establish clear guidelines requiring the coordinated removal of legacy gas pipes when non-IOU-owned TENs are installed. This could involve incentivizing gas utilities to decommission aging pipelines through cost-sharing mechanisms, regulatory mandates, or funding support for safe removal. Additionally, collaboration between local governments, utilities, and TEN developers can help streamline the transition, ensuring that communities benefit from modern, low-carbon heating solutions while eliminating the risks associated with outdated gas infrastructure.

7. **Evaluate Fossil Fuel Infrastructure Maintenance Costs When Doing TEN Financial Assessments** – To address the challenge of comparing TEN construction costs with aging fossil fuel infrastructure, it is essential to factor in the full costs of maintaining legacy systems, including replacement, repairs, and safety upgrades. By incorporating these ongoing expenses into the financial evaluation, TENs can be better assessed as a cost-effective alternative, ensuring investments are based on a more accurate long-term financial picture.

8. **Reform Electric Rates** – Electric rates need to be reformed to reflect the true costs of fossil fuel use, including environmental and social impacts. Under current rate structures, consumers bear the financial burden of IOUs' guaranteed rates of return, resulting in continued rate increases even as utilities invest in renewable energy and transition away from fossil fuel infrastructure. These rate structures often simultaneously hinder the adoption of small-scale, distributed renewable energy. A more societally-beneficial rate structure would facilitate the transition to clean thermal energy and emissions reduction while safeguarding vulnerable communities from undue financial strain. Additionally, rate reforms should be accompanied by income-adjusted limits to ensure affordability and prevent perverse economic effects.

9. **Reform Utilities' "Obligation to Serve"** – We need to update utilities' "obligation to serve" requirement to allow utilities to meet their service mandates through the provision of clean thermal energy rather than solely through natural gas. This reform would enable utilities to transition toward cleaner, safer, and more efficient energy solutions while still ensuring reliable and affordable service for all customers.

10. **Deploy a Suite of Technical, Financial, Legal and Governance Resources** – Strengthen the collective knowledge of local governments and communities exploring TENs by providing information on funding and financing options, geothermal and waste energy sources, system design considerations, optimal site selection factors (geology, climate,

and density), ownership models, and legal and regulatory challenges. Support and formalize a “community of practice” to bring together local governments, technical experts, policymakers, and community organizations to share insights on funding, regulatory challenges, ownership models, and implementation strategies, reduce barriers, pursue shared resources, scale successful solutions across different regions, and accelerate innovation.

Several interviewees suggested creating a national or regional entity to serve as a central resource for local governments developing and implementing TENs. This entity would help secure funding and build the technical and administrative capacity needed for these initiatives. By structuring this entity as a B Corp or Shared Services Entity, it would be well-positioned to raise program-related investment (PRI) funding, while also leveraging philanthropic social investment funds, green bank funds, and other public benefit funds to maximize its impact.

Chapter 6: Conclusion

TENs hold great promise as a clean heating and cooling solution that can advance equity and environmental justice, support greater democratization of energy decisionmaking and ownership, while improving health and climate by supporting broad-scale building decarbonization.

As we showed in Chapter 2, there is growing policy activity, inviting communities, utilities, and private companies to actively explore TENs development. While TENs hold great promise as a clean energy approach that can advance equity and environmental justice, support greater democratization of energy decisionmaking and ownership, much remains to be learned in the next several years as pilot projects come to completion.

Chapter 3 showcased the different ownership models that will result in a diversity of different TEN projects and outcomes. From conventional investor-owned utility companies in the driver seat to public and community ownership, it seems no particular model has a monopoly on TENs development, though each ownership model comes with their own advantages and disadvantages.

Chapter 4 discussed the need to address the myriad questions on the minds of EJ community representatives, and the onus that any TENs developer must consider when proposing to support a TEN in an EJ community. Our research uncovered critical questions on the minds of EJ community representatives, and the responsibilities that any developer should consider when proposing TENs in EJ communities. To pursue TENs in a way that advances equity and justice and seeks to prevent any new harms, the community must be the first and final decisionmaker. Only then, can they ensure the benefits flow to their communities and support their workforce, health, and agency, rather than keeping costs and burdens localized while outsourcing the benefits.

Chapter 5 described how TENs present a significant opportunity to advance energy democracy by shifting control over energy infrastructure to communities, ensuring equitable access to clean and affordable energy, and fostering local economic development. By prioritizing local ownership and governance transparency, policymakers and stakeholders can create an energy system that is more resilient, sustainable, and responsive to community needs. As TENs continue to evolve, collaboration between governments, advocacy groups, and local organizations will be essential to building a just and democratic energy future.

Summary of Recommendations

This section summarizes the recommendations in this report for effectively deploying TENs as an equitable and democratic decarbonization strategy.

Advancing TENs that Prioritize Equity and Environmental Justice

1. **Support Communities in Determining their Own Energy Future** – TENs development should only proceed with clear community support, particularly in Environmental Justice (EJ) communities. Communities should have the agency to approve or reject projects. Community advisory boards and participatory budgeting processes should be established to ensure that decisions reflect local needs, with transparent and inclusive structures to guide planning and implementation.

2. **Include and Resource Equitable Processes in Policy Design** – Legislation should mandate inclusive participation and provide technical, legal, and financial support to community representatives, particularly those from marginalized groups. Policies must guarantee that EJ communities hold meaningful decision-making power to protect against displacement and undue financial burdens, with tools like community-developed scorecards and encouragement for local ownership models. Work with local community-based organizations (CBOs) to design a flexible and locally informed approach to ensure resources reach the communities that need them most.

3. **Build Community Trust through Meaningful Engagement** – Trust is essential for TENs success in EJ communities, requiring sustained engagement through local community organizations. Early involvement, educational resources, and culturally relevant outreach help build community capacity, while ensuring that concerns such as displacement and affordability are addressed through dialogue and informed decision-making.

4. **Expand Workforce Training and Development for Local Jobs** – Require strong labor standards in the emerging TENs industry to ensure it capitalizes on the existing skilled workforce and union training infrastructure, to ensure safe and high-quality installations of TENs, and to deliver on its promise of providing a high-quality employment pathway for workers from traditional energy industries. Invest in workforce training programs in partnership with labor unions and technical schools to create career pathways for local workers, prioritize diversity, and ensure high-road job opportunities, particularly for EJ communities and underrepresented groups in the clean energy sector.

5. **Reduce Consumer Costs with Public and Innovative Financing** – TENs development should not increase the financial burden on communities already facing disproportionate costs. Avoid placing the financial burden of TENs on communities before their cost-competitiveness has been established. Leverage public-private partnerships, low-interest loans, grants, and community-led funding models to reduce upfront costs and increase affordability while enabling collective ownership and investment in TENs infrastructure.

6. **Remove Risk to Communities in Project Design and Implementation** – TENs projects should be fully researched, cost-effective, and respectful of the energy needs of EJ communities. The design should minimize disruption to daily life, maintaining

uninterrupted access to energy and ensuring that communities' time and services are not exploited during the development and implementation stages.

7. **Pursue Comprehensive Energy Upgrades** – TENs should be integrated with complementary building and energy upgrades, such as weatherization, energy efficiency upgrades, solar, and backup power, to maximize benefits. Prioritize energy efficiency retrofits and healthy building improvements, while incorporating energy storage solutions into TENs for enhanced resilience and sustainability.

Advancing TENs that Prioritize Energy Democracy

8. **Implement Policy Reforms and Clarify Regulatory Frameworks** – Legislative and regulatory reforms are needed to create pathways for local ownership of TENs, supporting community-driven and municipally led projects. These changes should provide clearer frameworks to facilitate the growth of locally-owned TENs and empower local governments to lead the transition to sustainable energy solutions.

9. **Support the Development of Locally Owned Pilot Projects** – Providing financial and technical support for pilot projects will help communities test and refine ownership and operational models for TENs. This support will build confidence, establish best practices, and equip cities and counties with the resources and authority needed to advance sustainable TENs.

10. **Expand Funding and Financing Support** – Increase access to grants, zero-interest loans, and other financial mechanisms to support the early stages of locally-owned TENs, including feasibility studies and planning. Prioritize funding that de-risks initial investments and capacity-building efforts while improving transparency around funding eligibility under the Inflation Reduction Act (IRA).

11. **Resource Deep Community Engagement** – Strengthen the capacity of CBOs by providing funding, staffing, and technical support to engage local communities in TENs development. This ensures inclusive participation in decision-making, with a focus on feasibility studies, technical consultations, and grassroots outreach for locally-owned systems.

12. **Support or Mandate Thermal Energy Planning and Waste Heat Mapping** – Policies should encourage or mandate the creation of thermal energy decarbonization plans, with a focus on reducing fossil fuel reliance. Developing waste heat maps will help municipalities identify and visualize available thermal energy resources for holistic energy planning.

13. **Mandate Safe Decommissioning of Legacy Gas Pipelines** – Policies should require the safe removal of legacy gas pipelines when IOU-owned TENs are installed. Policies should either require or provide incentives, cost-sharing, or funding to encourage decommissioning of legacy pipelines when non-IOU TENs systems are installed.

Coordination between local governments, utilities, and TEN developers is essential to streamline the transition and eliminate risks associated with outdated infrastructure.

14. **Evaluate Fossil Fuel Infrastructure Maintenance Costs When Doing TEN Financial Assessments** – To accurately assess the cost-effectiveness of TENs, it's crucial to include the full costs of maintaining aging legacy infrastructure in financial evaluations. This includes the ongoing expenses of replacement, repairs, and safety upgrades of maintaining legacy fossil fuel systems, which will provide a clearer long-term financial picture for TEN investments.

15. **Reform Electric Rates** – Electric rates should be reformed to reflect the true environmental, social, and financial costs of fossil fuel use. Aligning rates with the true cost of energy will support the transition to clean thermal energy and reduce emissions without unduly burdening vulnerable communities.

16. **Reform Utilities' "Obligation to Serve"** – Utilities' "obligation to serve" should be updated to include clean thermal energy options, not just oil or gas. This reform would enable utilities to transition to cleaner, more efficient energy solutions while ensuring affordable, reliable service for all customers.

17. **Deploy a Suite of Technical, Financial, Legal, and Governance Resources** – Local governments and communities exploring TENs need access to comprehensive resources covering funding, geothermal and waste energy sources, system design, ownership models, and legal challenges. Establishing a "community of practice" will foster collaboration among governments, experts, and organizations to share knowledge and accelerate innovation in TENs deployment. Creating a national or regional entity to support local TENs development would provide centralized resources for funding, technical assistance, and capacity building to help scale successful TENs solutions.

Unlocking the Potential of TENs

TENs represent a transformative opportunity for advancing clean energy solutions, equity, and environmental justice. As highlighted in this discussion, TENs have the potential to not only decarbonize buildings but also empower communities by promoting local ownership and decision-making. The promise of TENs lies in their ability to foster democratization of energy, supporting both the environment and local economies while addressing long-standing disparities in access to clean energy.

However, it is important to acknowledge that networking buildings together to supply and receive heat and cooling from each other and connecting them to outside "waste" heat sources is still a relatively new concept. There is much to learn as these systems are implemented and refined. The evolving nature of TENs means that there will be a continuous process of experimentation, learning, and adjustment as pilot projects and early adopters provide valuable insights into their effectiveness, challenges, and opportunities. This learning phase will be crucial for improving the design, scalability, and long-term success of TENs, ensuring they meet the needs of both communities and the environment.

It is clear that successful TENs implementation requires a thoughtful approach to policy design and implementation, and project development and rollout, with a focus on deep community involvement, equitable governance, and careful consideration of equity, environmental justice, and the democratization of energy. As we've outlined, the diverse ownership models and community-led engagement are crucial to ensure that TENs work for everyone, particularly those in historically underserved communities. By resourcing communities to shape their own energy future, enacting policy reforms that prioritize energy democracy, and ensuring transparency and accountability in project development, we can create an energy landscape that is more sustainable, equitable, and just. With the right policies and strategies in place, TENs can truly become a cornerstone of a clean, resilient, affordable, and community-centered energy future.