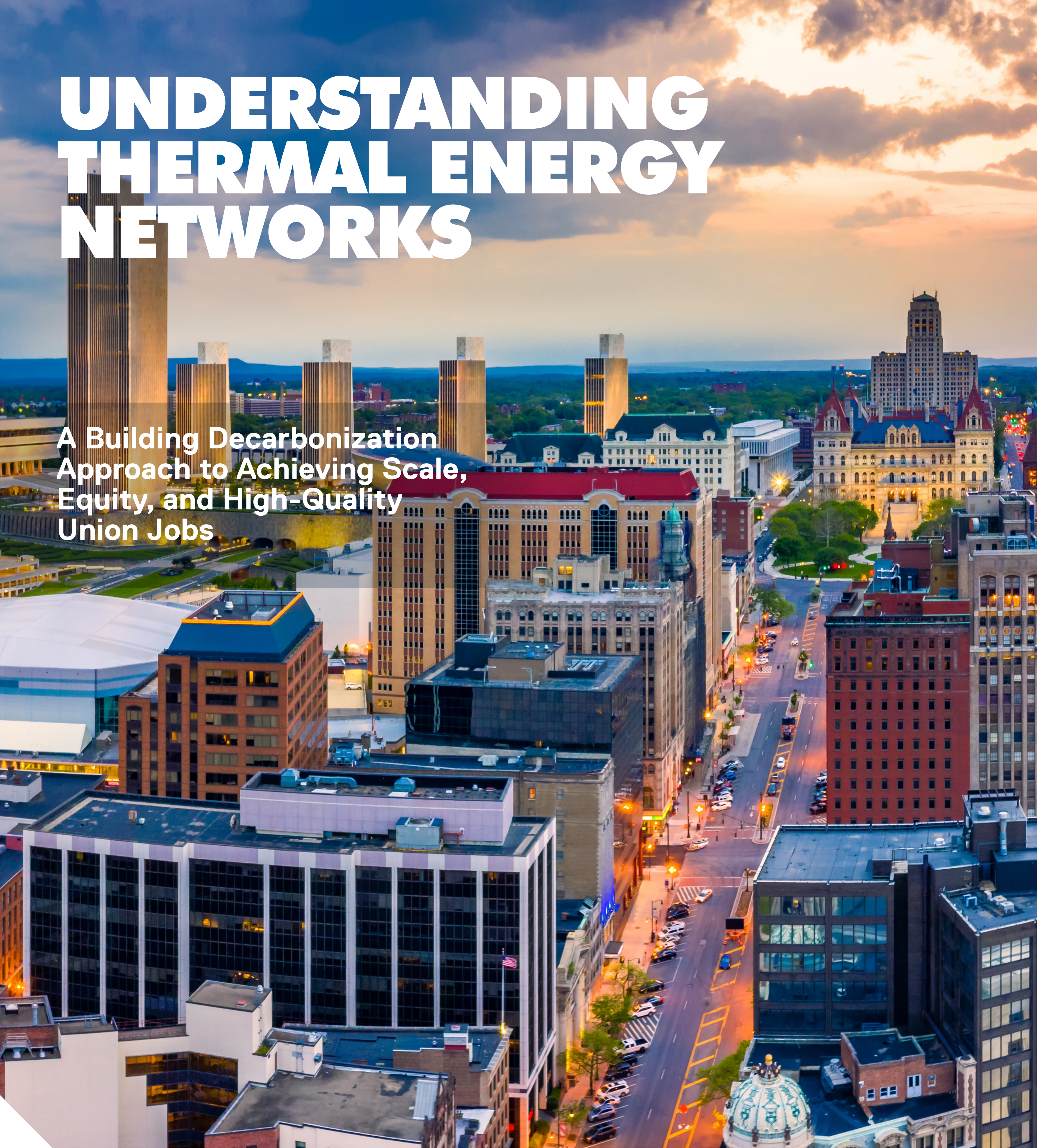
UNDERSTANDING THERMAL ENERGY NETWORKS

A Building Decarbonization Approach to Achieving Scale, Equity, and High-Quality Union Jobs



ILR Climate Jobs Institute

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ILR Climate Jobs Institute

The Climate Jobs Institute (CJI) at Cornell University's ILR School is guiding the nation's transition to a strong, equitable, and resilient clean energy economy by pursuing three aims: to tackle the climate crisis; to create high-quality jobs; and to build a diverse, inclusive workforce.

Through cutting-edge policy studies, deep relationships with on-the-ground partners, and innovative training and education programs, CJI provides information that policymakers, the labor and environmental movements, industry leaders, and others need to navigate this historic transition to a zero-carbon economy.

Core Activities and Objectives

CJI delivers high-quality research, innovative policy solutions, and top-notch educational programming that connects key stakeholders to design and implement climate plans.

The CJI's main areas of work include:

Applied Research and Policy Development for Legislators and Labor, Environmental, and Industry Leaders. CJI crafts equity- and worker-oriented climate policies and analyses indicating how states can address climate change while maximizing high-quality job creation and economic development. The Institute's research and policy efforts result in reports, case studies, policy briefs, and visual tools and maps meant to guide the nation's transition to a clean, equitable economy.

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Technical Assistance. CJI provides rapid response data and policy analysis on the labor, employment, and economic impacts of climate and clean energy issues. The Institute's technical assistance work offers legislators, policymakers, and others real-time support. This work also generates legislative briefings, policy briefs, blog posts, op-eds, and other written materials targeting legislators, local government officials, and leaders in labor, environmental movements, and industry.

Training and Education. CJI organizes a variety of educational convenings that strengthen stakeholders' knowledge, confidence, and motivation to tackle climate change and to build a large, equitable clean energy economy with high-quality jobs. Programs include the Institute's annual Climate Jobs Summit; the design and delivery of member trainings; legislative briefings; educational delegations for legislators, labor leaders, and others; and an online Climate Jobs certificate.

Workforce Development. CJI provides a critical link between the future clean energy workforce we need and workforce development programs that meet these needs. The Institute also provides a pipeline from frontline Black, indigenous, and people of color communities to paid on-the-job training and high-quality careers.

Student Engagement. CJI enriches the ILR and Cornell student experience by engaging undergraduate and graduate students in important aspects of the Institute's core work through fellowships, research assistantships, hands-on clinical experiences, internships, labor-climate undergraduate and graduate courses, and more.

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KEY TAKEAWAYS

Thermal energy networks (TENs) promise to unlock key challenges in building decarbonization and the clean energy transition

Nationally and in New York State, buildings are responsible for the largest proportion of greenhouse gas emissions (U.S. Environmental Protection Agency [EPA], n.d.; New Buildings Institute [NBI] et al., 2022). Due to barriers such as scale, cost, equity impacts, workforce constraints, poor job quality, and impact on the electric grid, building decarbonization also poses some of the biggest challenges to tackling the climate crisis (Walker et al., 2023; Bastian & Cohn, 2022; Liu et al., 2023).

Thermal energy networks, or TENs, heat and cool buildings at the campus, block, or neighborhood scale with non-combusting, non-emitting thermal sources such as geothermal energy or waste heat using a network of interconnected underground pipes (Building Decarbonization Coalition [BDC], n.d.a). Because of their scalability, long-term cost savings and ability to spread costs over a number of buildings, energy and resource efficiency, and ability to load shift and store thermal energy, TENs are essential to overcoming these barriers (Bagdanov et al., 2023; Besic, 2024; Office of Energy Efficiency and Renewable Energy [EERE], 2020).

Installation and maintenance of TENs also require analogous skill sets to those used by unionized trades employed in the construction, maintenance, and operation of the existing gas distribution system; and utility-owned and operated TENs (UTENs) are primed to use the same workforce (Home Energy Efficiency Team [HEET], n.d.c; Bagdanov et al., 2023). In this way, TENs have the potential to transform the building decarbonization workforce landscape into a case study for a labor-led transition into an equitable green energy economy, combatting the race to the bottom with union careers, family-sustaining wages and benefits, and access to lifelong learning.

Thermal energy networks are rapidly gaining momentum, with more and more states adopting legislation to deploy this technology

In the past four years, eight states have passed legislation to accelerate the adoption of thermal energy networks, especially by enabling and mandating UTENs: California, Colorado, Maryland, Massachusetts, Minnesota, New York, Vermont, and Washington (BDC, n.d.a). In addition:

- Two more states—Illinois and Rhode Island—have introduced legislation to enable and/or mandate UTENs (BDC, 2024)
- Eight states have introduced (Connecticut, Maine) or passed (Maryland, Massachusetts, Minnesota, New Jersey, Vermont, Washington) legislation to study the feasibility of TENs in their state (BDC, 2024; HB 1007, 2021; An Act Driving Clean Energy and Offshore Wind, 2022; S4924-4, 2024; S. 305, 2024; E.S.H.B. 2131, 2024)
- Five states have introduced (Minnesota) or passed (Colorado, Massachusetts, New Mexico, Washington) legislation to fund the deployment of TENs (BDC, 2024; HB 22-1381, 2022; An Act Driving Clean Energy and Offshore Wind, 2022 E.S.S.B. 5949, 2024)

TENs represent one of the most promising opportunities for the union workers who build, maintain, and operate the gas system to transition into new green career pathways, but implementers risk leaving workers behind without the appropriate labor standards, incentives, and union engagement

Many of the trades involved in the existing gas system see the enormous potential TENs hold for finding their members a place in the green energy transition (Bagdanov et al., 2023; Ybarra II, 2024; International Union of Operating Engineers Local 150, n.d.; Kim, 2023). The installation, construction, maintenance, and operations of TENs will require drillers, equipment operators, truck drivers, laborers, HVAC technicians, electricians, plumbers, pipefitters, and more (HEET, n.d.c; A. Iliff, personal communication, October 16, 2024). To guarantee that the future of building decarbonization is cost-effective, scalable, and creates a pipeline of high-quality union careers:

- **Legislators** must include robust labor standards in any TENs policy or regulatory measures to ensure union workers are centered in the buildout of TENs;
- **Developers and utilities** must engage unions as both key stakeholders and workforce partners in TENs deployment; and
- **Unions** must continue to lead the fight for TENs and train their members on these new technologies, preparing them for the front lines of the equitable green transition

United Association of Plumbers and Pipefitters Local 104

CHALLENGES IN BUILDING DECARBONIZATION

Reducing greenhouse gas (GHG) emissions from buildings—otherwise known as building decarbonization—is essential to addressing the climate crisis. **When accounting for electricity usage, buildings are responsible for the highest proportion of overall emissions nationally at 31%, and emissions have increased 1.6% since 1990 (U.S. EPA, n.d.). The situation is even more pronounced in New York State, where buildings constitute 43% of statewide emissions, and emissions from the sector have increased 16% since 1990 (NBI et al., 2022; New York State Department of Environmental Conservation, 2022).** In New York City, buildings represent an even higher proportion of emissions at nearly two-thirds or 63% (NYC Mayor's Office of Climate and Environmental Justice, n.d.). Building decarbonization requires a few key elements: (1) reducing buildings' overall energy usage, (2) reducing on-site building emissions from end-uses that currently rely on fossil fuels—such as water or space heating systems and clothes dryers —with non-emitting, zero-carbon alternatives, which today are mostly electric, and (3) transitioning the electric grid to zero-emission sources, thus reducing emissions related to buildings' electricity usage (U.S. DOE, 2024b). In order to reduce building emissions 65% by 2035 and 90% by 2050, in line with federal emissions reduction targets, heat pump deployment must increase 10-fold and retrofit rates must increase 25-fold by 2030 (U.S. DOE, 2024b). **If building decarbonization continues at its current rate, it could take 200 years or more to address certain inefficient or emitting equipment, ultimately threatening the livability of our climate (U.S. DOE, 2024b).**

This centuries-long timeline is due in large part to three key challenges: scale, cost, and workforce. The scale of work needed to decarbonize the entire U.S. building stock is hard to overstate: there are an estimated 5.9 million commercial buildings and 145 million housing units in the country (U.S. Energy Information Administration [EIA], 2020; U.S. Census Bureau, 2024). In New York alone, there are 6.2 million buildings, the majority of which (5.7 million) are residential (NBI et al., 2022). The buildings sector also boasts an impressive number of stakeholders. Per Walker et al. (2023), even the residential sector alone is "uniquely challenging to decarbonize at scale due to the extremely high rate of decision-makers per unit of CO2 compared to any other sector" (p. 23). Moreover, more than 99% of the U.S. housing stock is privately owned (DeGood et al., 2024), hindering the type of broad, collective action necessary to mitigate emissions from the sector at scale by instead

NYC buildings at sunset. CREDIT: Pedro Lastra/Unsplash relying on voluntary action from individual private owners driven largely by market-based incentives (Besbris et al., 2024; Northeast Energy Efficiency Partnerships et al., 2024). The resultant building-by-building approach to decarbonization slows both the pace and scale of emissions reduction (Bagdanov et al., 2023). Lastly, supply chain gaps in both the availability of domestically-manufactured equipment and in distributors' overall stock of equipment further hinders efforts to decarbonize buildings at scale (Walker et al., 2023; Bastian & Cohn, 2022).

National Residential and Commercial Emissions by End Use

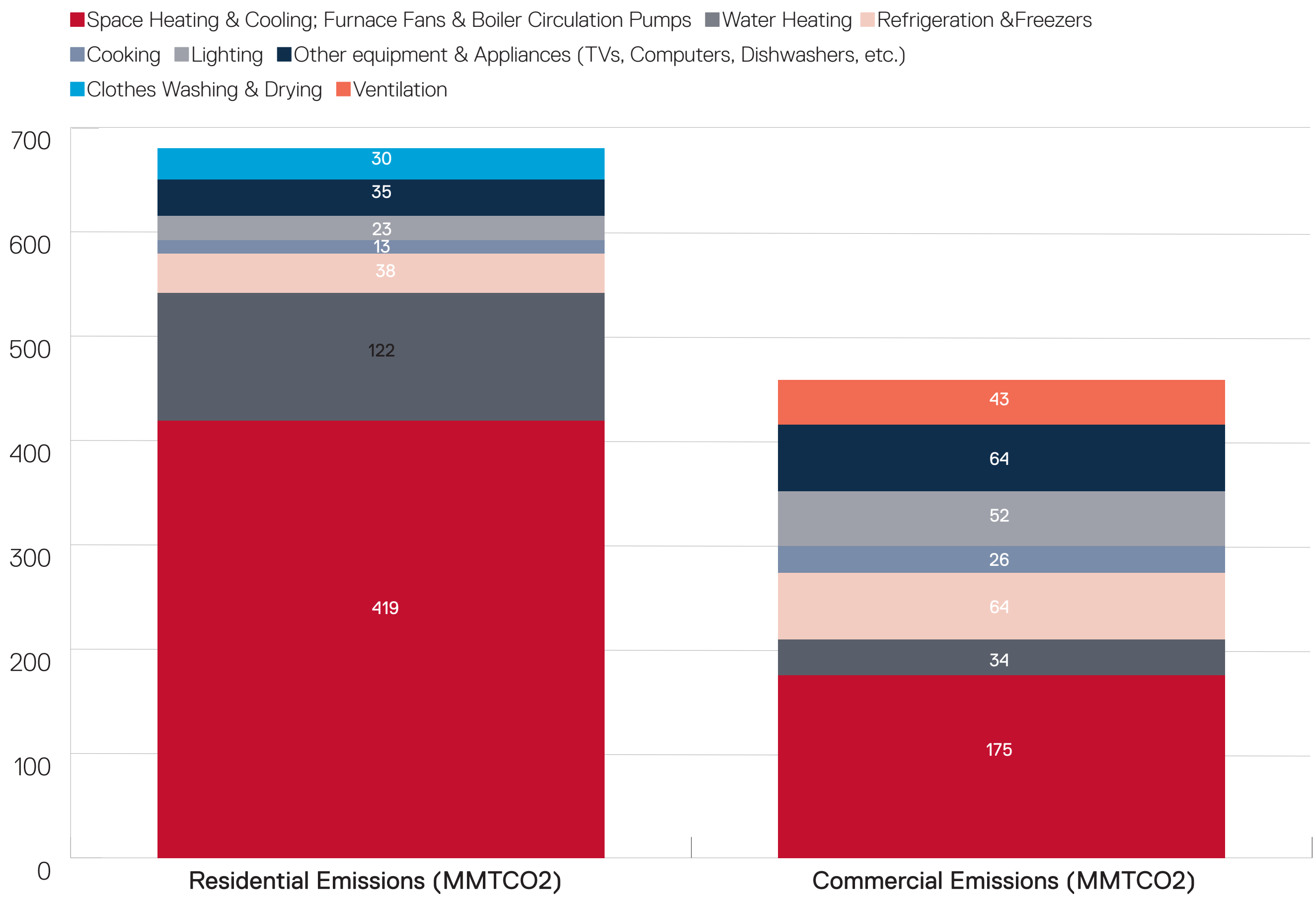


Chart: Dylan Correll Smith, M.S., Research Support Specialist, Cornell ILR Climate Jobs Institute, dcsmith@cornell.edu •
Source: U.S. Energy Information Administration (2023a)

Cost is another substantial barrier to building decarbonization, especially because the large majority of homes are heated with fossil fuels (U.S. EIA, 2023b). For homeowners and building owners, the total cost of decarbonization includes not only the cost of new equipment such as air-source or ground-source heat pumps, but may also include the cost of ductwork sealing, installation, or replacement; rewiring; upgrading electric panels; increased utility service; remediation of structural, health, and/or safety issues; and buoying the profits of home performance contractors (Walker et al., 2023; Bastian & Cohn, 2022). The upfront cost of decarbonization varies widely with building age, type, climate, the number of decarbonization measures implemented, and available incentives (Walker et al., 2022). Nationally, recent cost estimates for home deep energy retrofits (50% energy savings or more) put the price at $23 per square foot or $40,000-50,000 per household before incentives (Walker et al., 2022). Across the 1,769 projects used to calculate this estimate, median project cost was much lower—about $8,740 total or $4.95 per square foot, with projected median energy savings of 28-33% (Walker et al., 2022)—showing just how widely costs can range for building decarbonization. Robust incentive programs can help dramatically shift these upfront costs (Walker et al., 2022), yet even with incentives, the costs remain out of reach for many. Many low- and moderate-income (LMI) households cannot afford to decarbonize and lack access to financing options (Walker et al., 2023). These same households are disproportionately affected by poor air quality and higher energy burdens (Walker et al., 2023; Bagdanov et al., 2023; Drehobl et al., 2020), and thus may see greater benefits from home decarbonization. High upfront costs ultimately create an inequitable decarbonization landscape, limiting the ability to scale maximum emissions reduction and job creation while also failing to reach those who would benefit most. In addition, renters—who are more likely to be low-income or people of color (DeSilver, 2021)—are subject to the split incentive faced by their building owners who may not want to pay for decarbonization without personally benefiting from the long-term energy or cost savings (Walker et al., 2023). If a building owner does choose to decarbonize, renters could be on the hook for utility costs that were once included in the cost of rent, or they may be displaced due to rent increases used to subsidize the cost of decarbonization (Walker et al., 2023). This can in turn entrench existing structures of racial and class inequality in the U.S. housing market (Besbris et al., 2024).

Residential Home Heating by Main Fuel Type Nationally and in New York State

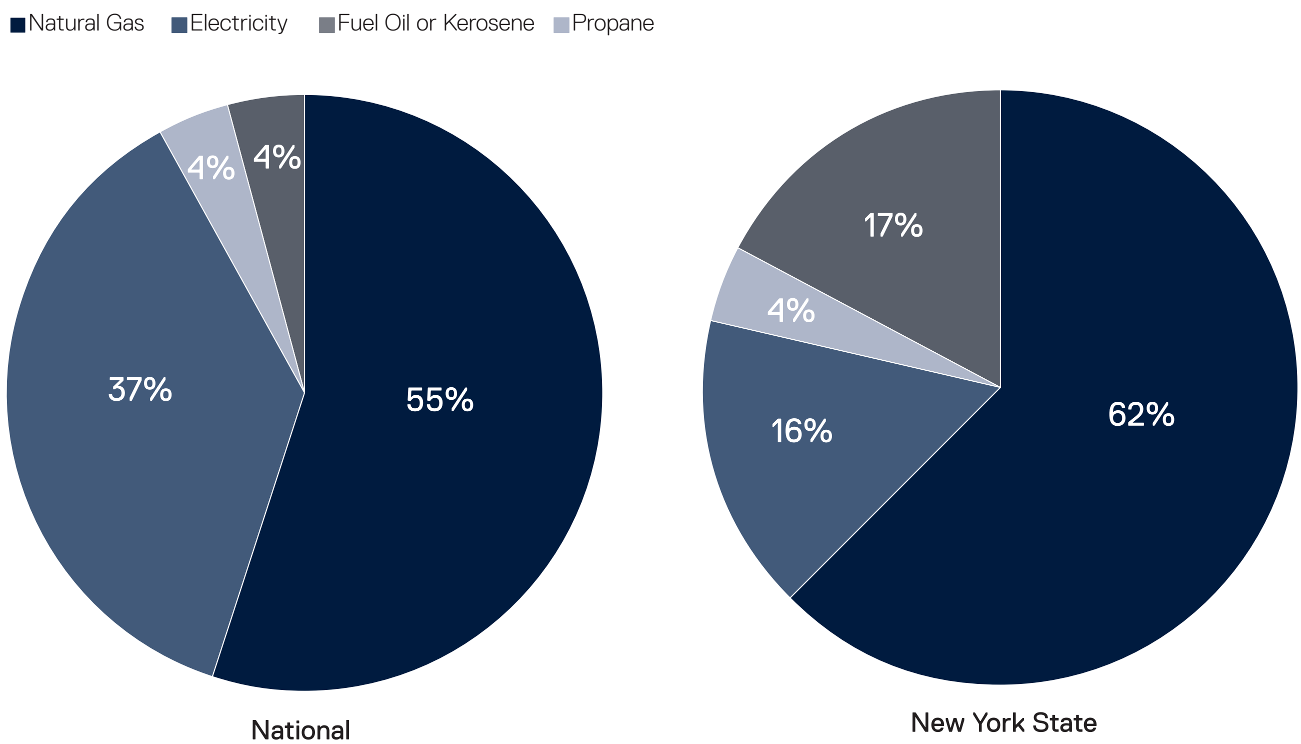


Chart: Reyna Cohen, MSc, Research and Policy Development Associate, Cornell ILR Climate Jobs Institute, rsc265@cornell.edu •
Source: U.S. EIA (2023b)

Confronted with the possibility of stranded gas infrastructure assets and associated expenses, utilities face their own set of costs associated with building decarbonization (Bagdanov et al., 2023). This further exacerbates the inequities of the existing decarbonization model by creating a negative feedback loop: as those who can afford to decarbonize exit the gas system, utility rates will increase for those who remain—the LMI households and renters who are least likely to be able to afford or access building decarbonization measures (Bagdanov et al., 2023).

Lastly, there are considerable labor challenges to the current building decarbonization model, particularly in the residential market. Here, the lack of an available, sufficiently-trained and qualified workforce goes hand in hand with low-quality jobs (Walker et al., 2023; Bastian & Cohn, 2022). Research consistently cites labor gaps as one of the key barriers to residential decarbonization (Walker et al., 2023; Bastian & Cohn, 2022). This shortage is driven partly by lack of demand for decarbonization work and partly by the rate at which contractors are retiring versus entering the market (Bastian & Cohn, 2022). However, another key driver that is often overlooked is job quality. According to Walker et al. (2023), "[r]esidential building workers are paid less than their counterparts in commercial construction and have much poorer benefits packages, making recruitment and staff retention difficult" (p.66). This may be due in part to lower rates of unionization in residential construction—true of both New York State and the United States at large (Milkman & Van Der Naald, 2022)—as unionization is associated with higher wages and better fringe benefits, including retirement and healthcare (U.S. Department of the Treasury, 2023). **Continuing the existing model of building by-building decarbonization threatens to lock union contractors out of the sector, compounding issues of job quality and labor gaps already plaguing the landscape.** The result is an ecosystem of low-road jobs taking the place of highly-skilled, well-trained, fairly-compensated union electricians, plumbers, pipefitters, steamfitters, sheet metal workers, laborers, and more.

Construction workers install new energy-efficient windows

To address these challenges, cities and states are increasingly embracing a new approach to building decarbonization: neighborhood-scale decarbonization using thermal energy networks. This report will provide a deep dive into how thermal energy networks address the key challenges outlined above by:

- Providing an overview of thermal energy networks, including their benefits, the types of technologies considered thermal energy networks, their use case, and where this technology exists today in the United States;
- Summarizing existing federal and state policy creating the conditions to scale up the deployment of thermal energy networks across the country; and
- Outlining a brief case study of the nation's first and only completed utility-scale thermal energy network in Framingham, Massachusetts (Eversource, 2023).

THERMAL ENERGY NETWORKS: THE BASICS

In a thermal energy network (TEN), buildings are connected to a network of underground pipes that utilize zero-carbon, non-emitting, non-combusting thermal resources to provide heating and cooling (BDC, n.d.c). TENs can extract thermal energy from a range of readily available sources, which can include traditional ground-source energy from boreholes, bodies of water, and/or underutilized sources like wastewater systems or waste heat from data centers (BDC, n.d.a). At scale, these networks can serve an entire neighborhood's heating and cooling needs without the use of fossil fuels (Cohen et al., 2024; HEET & Buro Happold Engineering, 2023). TENs are primed to be an essential piece of the building decarbonization puzzle for three key reasons: 1) their scalability; 2) their energy and water efficiency; and 3) their cost-effectiveness. **Importantly, TENs also promise to deliver essential career transition pathways for the existing fossil fuel and utility workforce (HEET, n.d.c; Bagdanov et al., 2023), providing unionized, family-sustaining, long-term careers for these workers through the clean energy transformation.**

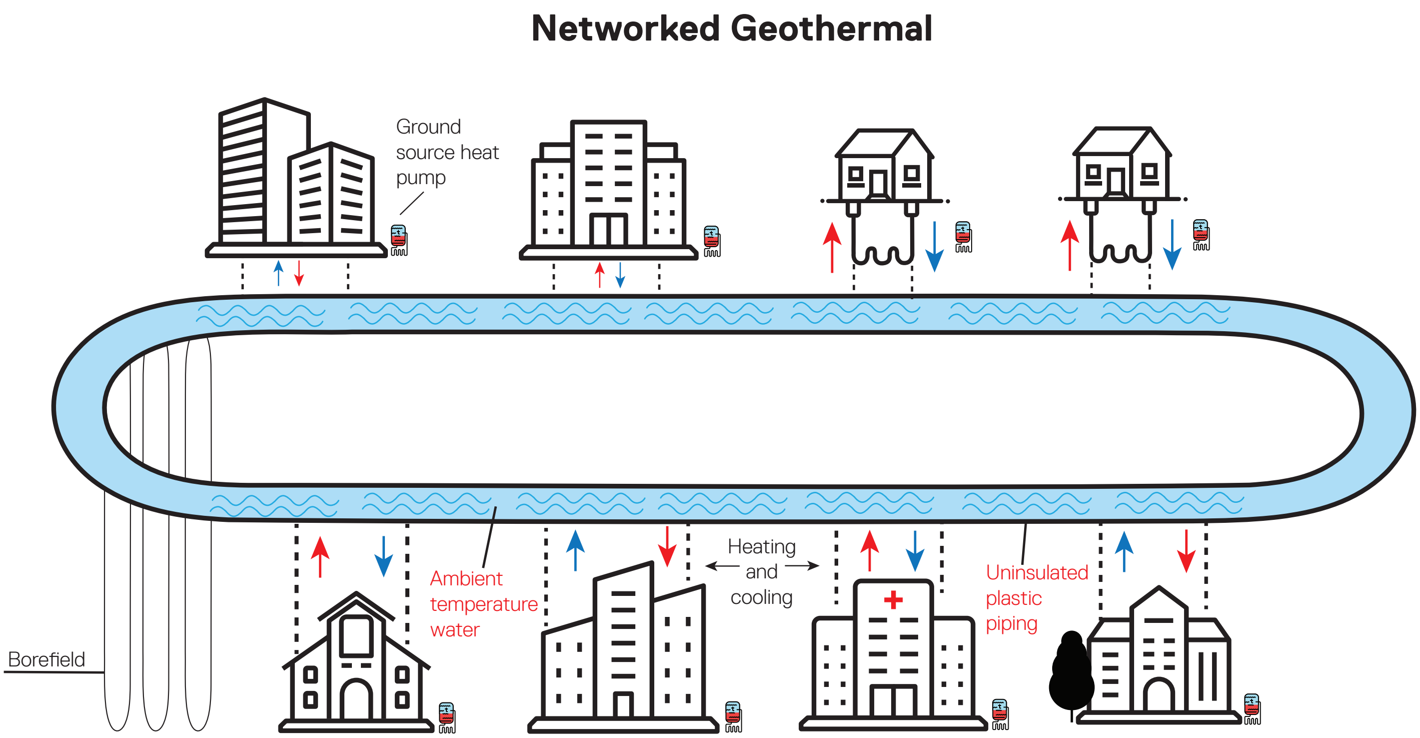
CREATING JOB TRANSITION PATHWAYS FOR UNION GAS WORKERS

Members of United Association of Plumbers and Steamfitters Local 7 pose with a TENs model at the October 2024 NY-GEO conference.

TENs can help generate ongoing demand and job security for existing gas workers while addressing emissions reduction and energy efficiency in the building sector. The large-scale, systematic approach offered by TENs centers the needs of workers and harnesses the power of unionized labor. According to Bagdanov et al. (2023), "scaling building decarbonization requires engagement from labor unions, who are particularly suited to long-term infrastructure projects and who can ensure that work is of the highest quality due to intensive training requirements, oversight, and depth of experience" (p.8). Further, the skill sets required to do this work are similar to the skills union workers are already trained in (Bagdanov et al., 2023). For instance, TENs use the same piping material as that of gas infrastructure, giving union members experienced in this work a baseline familiarity with key components (HEET, n.d.c). Unions also have a place in the maintenance and operation of TENs. **As the demand for TENs increase across the country, so too will the demand for highly skilled workers, especially drillers, pipelayers and loopers, electricians, and HVAC installers and service technicians (HEET, n.d.c)**. Unions have also begun to adapt their expertise in these fields to new apprenticeship and skill improvement programs (International Union of Operating Engineers Local 150, n.d.). This means that TENs can establish a clear, long-term job retention and creation solution for existing unionized fossil fuel workers, as well as new union members in these trades, as more states, municipalities, utilities, and institutions adopt TENs (HEET, n.d.c). Per John Murphy, International Representative for the United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada, "'This [thermal energy networks] is the closest thing to a true transition or a just transition that we've seen in the energy transformation so far"' (Kim, 2023).

Types of Thermal Energy Networks

Networked Geothermal Systems



Based on HEET (2023); HEET & Buro Happold Engineering (2023); BDC (n.d.a)

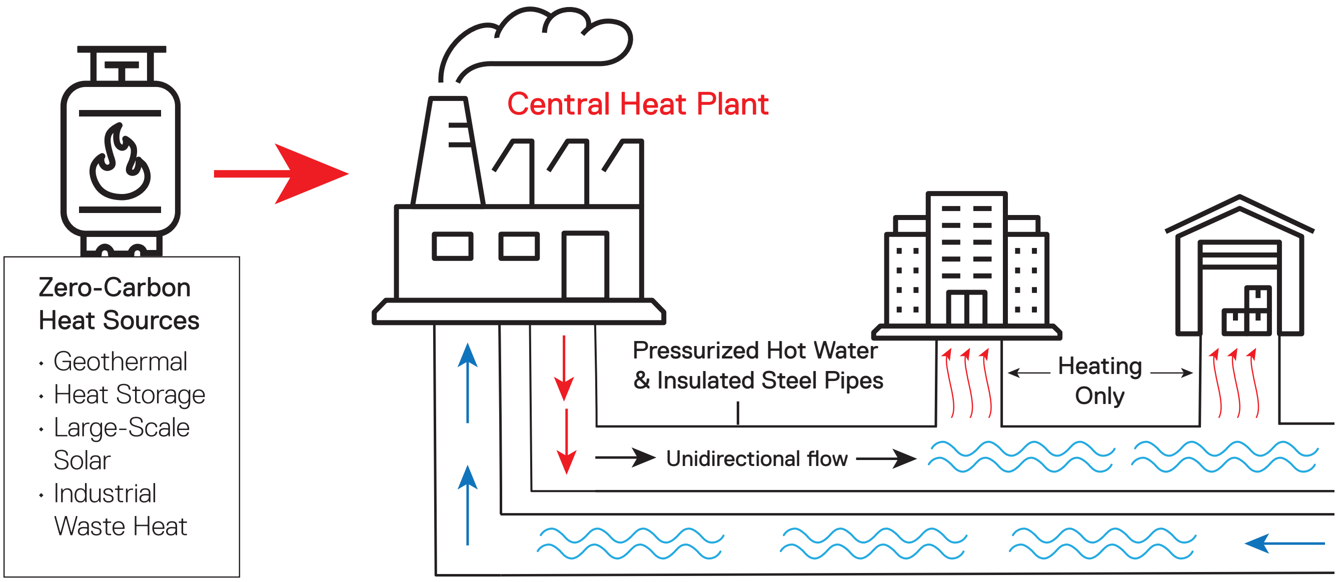
Networked geothermal systems are made up of a single, ambient temperature closed loop filled with water (or other liquid solutions), underground shafts, and heat pumps in each connected building (BDC, n.d.c; HEET, 2023). This system captures and delivers thermal energy through the pipe network to heat and cool buildings (BDC, n.d.a). **Networked geothermal systems become even more efficient when there is an increased diversity of buildings that are connected to the network—the more buildings that get integrated into the network, the more efficient the network becomes (HEET, 2023).** This diversity in energy demand allows for load canceling and waste heat reuse (HEET & Buro Happold Engineering, 2023). For example, a data center's waste heat can be used to meet a residential building's heating demands when interconnected through a networked geothermal system (HEET & Buro Happold Engineering, 2023). This cyclical use of thermal energy allows properly managed TENs to leverage a wide variety of local thermal resources like waste heat that would otherwise go unused (Vermont Community Thermal Network [VCTN], 2024).

District Energy Systems

District energy systems, often referred to as district heating, are a longstanding technology historically used to heat buildings (EERE, n.d.c). **Note that not all district energy systems are TENs; only select systems that meet the definition of zero-carbon, non-combusting, and non-emitting fall within this scope (BDC, n.d.c), and many existing district energy systems rely on fossil fuels to heat their heat-exchanging fluids (EERE, n.d.c).** Conversely, district energy systems that do qualify as TENs may use a variety of zero-carbon sources to heat their heat-exchanging fluids, including but not limited to geothermal energy, bodies of water, wastewater systems, and waste heat (BDC, n.d.a.). Notably, of the 660 district energy systems in the United States, only 1% are electric and thus meet the definition of TENs (EERE, 2020).

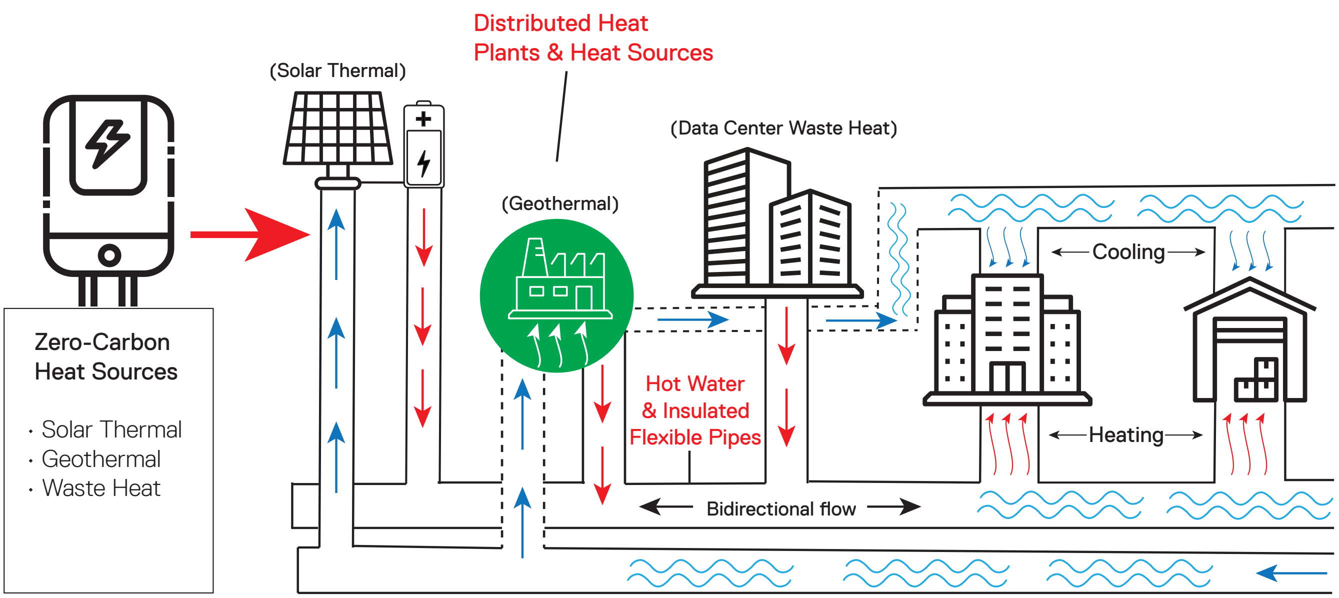
District energy systems have advanced to accommodate new technology, varying mainly in their operating temperature, distribution piping, and type of heat exchanging fluid (BDC, n.d.c). Older generations (I through III) operate at high temperatures and use steam, pressurized hot water over 100°C, and pressurized hot water between 70°C and 100°C, respectively, as their heat-exchanging fluids (Lund et al., 2014). Newer, more efficient generations (IV and V) are able to operate at lower temperatures and use lower temperature water as the means of heat exchange (BDC, n.d.c; Lund et al., 2014; Wirtz et al., 2020). The use of district energy systems frees up building space that would have otherwise been used for boilers, chillers, water towers, and/or water heaters (Pace, 2023). Fifth generation district energy systems are similar to networked geothermal systems in that every connected building has a heat pump (BDC, n.d.c; Lund et al., 2021).

3rd Generation District Energy



Based on Lund et al. (2014); Lund et al. (2021); Sulzer et al. (2021

4th Generation District Energy



Based on Lund et al. (2014); Lund et al. (2021); Sulzer et al. (2021)

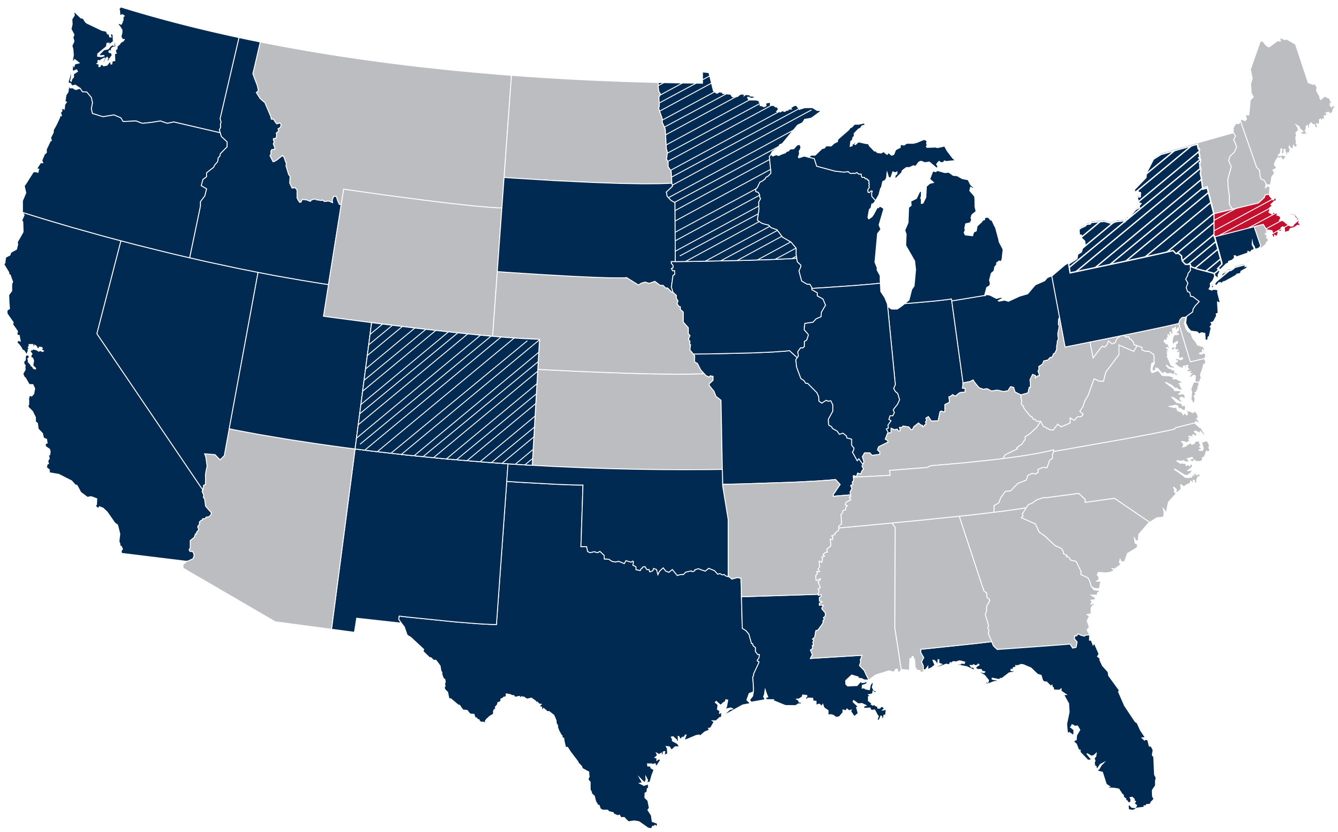
Fossil fuel-based district energy systems—systems which are common in cities, college and hospital campuses, government facilities, and airports across the country—can be retrofitted to become zero-carbon, highlighting the technology's ability to achieve decarbonization and create high-quality union jobs at scale (EERE, n.d.c; Vicinity, 2024).

Existing Thermal Energy Networks in the U.S.

Thermal energy networks, particularly in the form of older generations of geothermal district energy systems, have been in use in the United States for over a century (EERE, n.d.b). The below map demonstrates how this technology has proliferated across the country, as well as showcasing states working at the cutting edge of UTENs.

Existing TENs, Proposed UTENs, and Operational UTENs in the U.S.

Existing TENs | Operational UTEN | Proposed UTEN Pilot(s)



Map: Dylan Correll Smith, M.S., Research Support Specialist, Cornell ILR Climate Jobs Institute, dcsmith@cornell.edu • Source: BDC (n.d.b); Braulick et al. (2020); HEET (n.d.a); Lund (2015); Oh et al. (2024); Robins et al. (2021)

Thermal Energy Networks: Addressing Key Challenges in Building Decarbonization

Scaling Building Decarbonization with Thermal Energy Networks

TENs have the potential to decarbonize entire neighborhoods, college campuses, and city blocks, far outpacing the traditional building-by-building decarbonization approach (Bagdanov et al., 2023). In fact, BDC named TENs as one of just two viable technological pathways to achieving neighborhood-scale decarbonization (Bagdanov et al., 2023). In a TEN, the shared piping connecting multiple buildings allows the system to reuse excess and rejected thermal energy from one building to heat and cool others, helping the system efficiently scale (BDC, n.d.c; HEET, 2023). The 2016 Whisper Valley housing development outside of Austin, Texas, showcases just how scalable these systems can be: the development started with 237 homes connected to its community-wide TEN in 2016, but anticipates eventually connecting all 7,500 homes in the development (Oh & Beckers, 2023; Olick, 2022). States and cities are also exploring utility-scale TENs (UTENs), a novel approach which would allow utilities to own, operate, and maintain TENs (BDC, n.d.c). UTENs are well-suited to address scaled building decarbonization, leveraging both utilities' right of way and their existing highly-skilled in-house union workforce to construct, operate, and maintain these systems (HEET, n.d.c). Moreover, public institutions such as schools and libraries could be used as anchors for neighborhood-scale decarbonization using TENs, as is already being explored in different states such as Massachusetts and New York (Eversource, 2023; 2023-R1952, 2023).

Main Photo: City of Boise, CREDIT: Pinpals. Inset (right): Boise Geothermal Plaque, CREDIT: Kenneth Freeman.

Thermal Energy Networks, Energy Efficiency, and Water Efficiency

Research shows certain types of TENs can be six times more energy efficient than even the most efficient gas furnaces on the market (Lopez, 2024). Newer generations of TENs, such as fifth generation district energy and networked geothermal, typically incorporate ground source heat pumps (GSHPs) into their system design (BDC, n.d.b). GSHPs use the ground as a heat source and heat sink, unlike air-source heat pumps—another popular building decarbonization technology—which utilize ambient air temperature to provide heating and cooling and function similar to air conditioners

Installation of a TEN at Saratoga County Airport. CREDIT: United Association of Plumbers and Steamfitters Local 7

but allow the refrigerant flow to be changed for heating or cooling (BlocPower, 2023). GSHPs are an extremely energy efficient technology that provides reliable and cost-effective heating and cooling, largely because they require less electricity to convert ground heat into energy (Massachusetts Department of Energy, n.d.; EERE, 2011; McDevitt, 2024). **GSHPs can generate up to 65% in energy savings compared to traditional fossil-based heating and cooling systems, and are up to 50% more efficient than air source heat pumps (ASHPs). GSHPs are especially effective in colder temperatures (Massachusetts Department of Energy, n.d.; E.ON Next, n.d.; Woodward, 2021).**

The efficiency of TENs systems offers strong benefits to overall grid resiliency. Across the country, energy load and demand will increase as more buildings are electrified (Moulton, 2024). In New York City alone, researchers estimate that the city will see a 97% increase in its end-use energy demand between 2025 and 2050 (Gagnon et al., 2023, 2024). Research suggests deploying GSHPs alone could mean saving 429 billion kilowatt-hours each year (Liu et al., 2022). GSHPs can also take advantage of load shifting, or moving the network's electricity consumption from peak high-use periods to non-peak hours (Exro, n.d.; Kensa Heat Pumps, n.d.; Liu et al., 2023). Doing so would alleviate stress on the grid and balance out demand throughout the day.

Lastly, TENs' efficient use of water allows them to further conserve resources and save on costs. (Camargo & Rusteika, 2023; Buonocore et al., 2023; HEET & Buro Happold Engineering, 2023). Large buildings like hospitals, schools, and offices use cooling towers and chillers for cooling, both of which require a continuous supply of water to remove heat from the building's system (Besic, 2024). TENs can potentially replace these water-intensive cooling towers and chillers to act as a building's main cooling system, reducing water needs (Besic, 2024).

Cost Savings with Thermal Energy Networks

TENs can result in significant cost savings for both program implementers and customers, in part by reducing costly investments into aging and inefficient transmission infrastructure (Bagdanov et al., 2023; Castigliego et al., 2021; HEET & Buro Happold Engineering, 2023). The country's outdated electrical grid infrastructure has led to transmission congestion costs that have already ballooned to $21 billion in 2022 (Gordon, 2023). Building more transmission lines to both maintain the existing grid and keep up with new demand will require significant investments (Clifford, 2023). TENs can help reduce the scale and cost of these repairs because of their energy efficiency and reduced electricity demand (VCTN, 2024; Camargo & Rusteika, 2023; Liu et al., 2023). Analysis from the Oak Ridge National Laboratory (ORNL) and the National Renewable Energy Laboratory (NREL) indicates that GSHPs can help avoid the buildout of 24,500 miles of new long distance transmission lines, which equates to roughly $557 billion in avoided costs (Lopez, 2024; Liu et al., 2023).

In addition to transmission savings, scaled decarbonization through TENs adoption will also require stakeholders to coordinate long-term resource and system planning in a way that incorporates both electric and gas infrastructure upgrades (Bagdanov et al., 2023). This process maximizes project cost savings, allowing stakeholders to prioritize where and how they invest to generate a larger impact (Bagdanov et al., 2023). Prioritizing TENs deployment in areas where aging gas infrastructure needs replacement can allow for the systematic integration of TENs (Bagdanov et al., 2023). This approach can also avoid investments into infrastructure that risks being quickly phased out (Bagdanov et al., 2023).

Union TENs installation at Smith College, Massachusetts

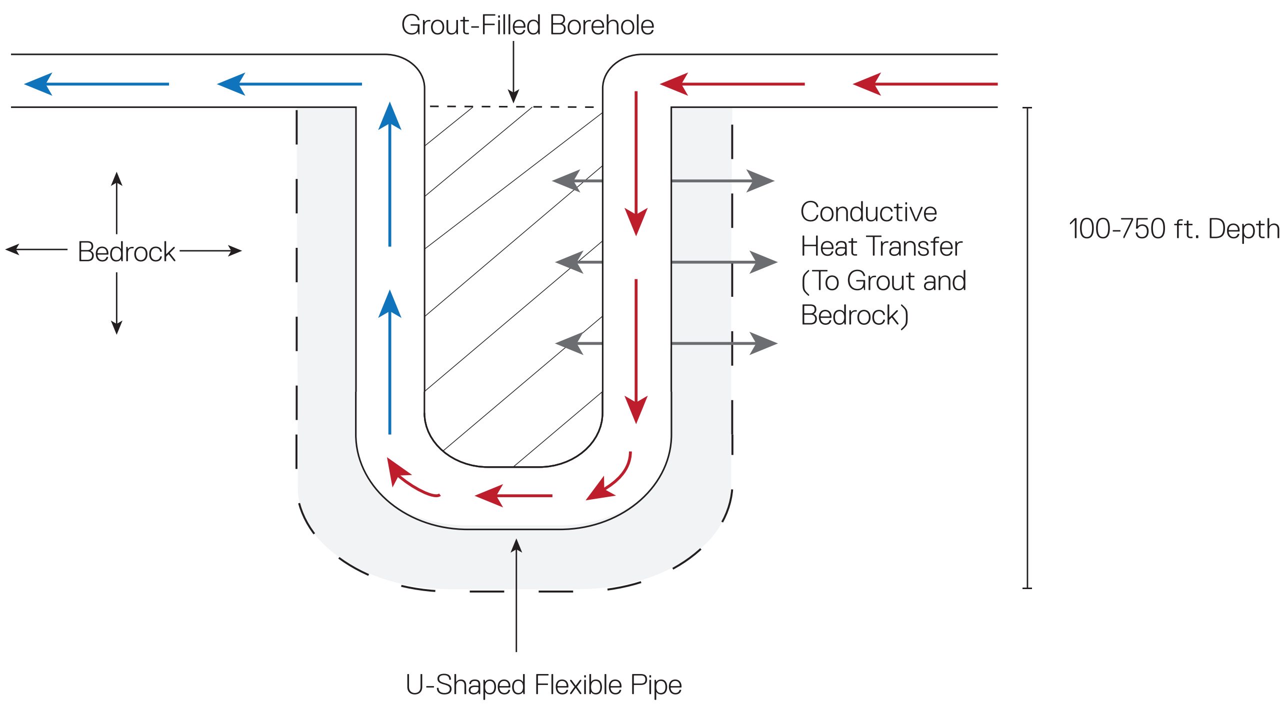
Finally, aggregating buildings for scaled decarbonization through TENs allows stakeholders to bundle procurement, demolition, and installation, which can improve project economics, reduce financial risk, and expand decarbonization to buildings once deemed financially infeasible (Bagdanov et al., 2023). TENs have already generated 30% cost savings at Ball State University and 65% cost savings at Miami University (Oh & Beckers, 2023). For homeowners, GSHPs on their own can help lower electricity bills by up to 60% before factoring in the added benefits of thermal sharing between buildings in a TEN (Aireserv, n.d.). While geothermal heat pumps have higher upfront installation costs compared to other technologies on the market, energy savings and longer life spans help cancel out these initial costs after five to ten years (EERE, 2011). Research shows that the benefits from GSHP adoption are "significant even at lower market penetration rates" (Liu, 2010), can reduce energy consumption by 45.1%, and save up to 48.2% in energy costs in single-family homes (Liu, 2010). Load shifting with GSHPs would also allow the system to buy electricity at a cheaper rate (Exro, n.d.), which will be especially meaningful for lower-income households. Lastly, with UTENs, utilities would be able to help their customers make the transition away from fossil fuels, a transition that is financially out of reach for many LMI households in the current building decarbonization model (BDC, n.d.a).

The Use Case for Thermal Energy Networks: Beyond Neighborhood-Scale Decarbonization

Energy and Thermal Storage

Boreholes used in geothermal TENs can seasonally store large quantities of excess thermal energy to heat and cool buildings, referred to as borehole thermal energy storage (BTES) (Bagdanov et al., 2023; Drake Landing Solar Community [DLSC], n.d.; Skarphagen et al., 2019). During summer months, buildings reject heat through the TEN's heat-exchanging fluid (DLSC, n.d.). That heated water is sent down the system's boreholes, dissipating its heat into the surrounding bedrock (DLSC, n.d.). After this heat transfer, water flows back up from the boreholes at a cooler temperature (DLSC, n.d.). This process would be reversed during winter months to heat buildings: water would enter a borehole at a cooler temperature and return at a higher temperature after being naturally heated by thermal energy stored in the surrounding bedrock (DLSC, n.d.; Sadeghi et al., 2024). The ability of boreholes to seasonally supply and store heat makes them an attractive addition to TENs because they add to the system's overall efficiency. Importantly, heat loss will occur naturally within the BTES system due to factors like system design, the surrounding bedrock and ground temperatures, the ambient ground temperature, and the thermal conductivity of the ground where the boreholes are drilled (Skarphagen et al., 2019).

Borehole Thermal Energy Storage (BTES)

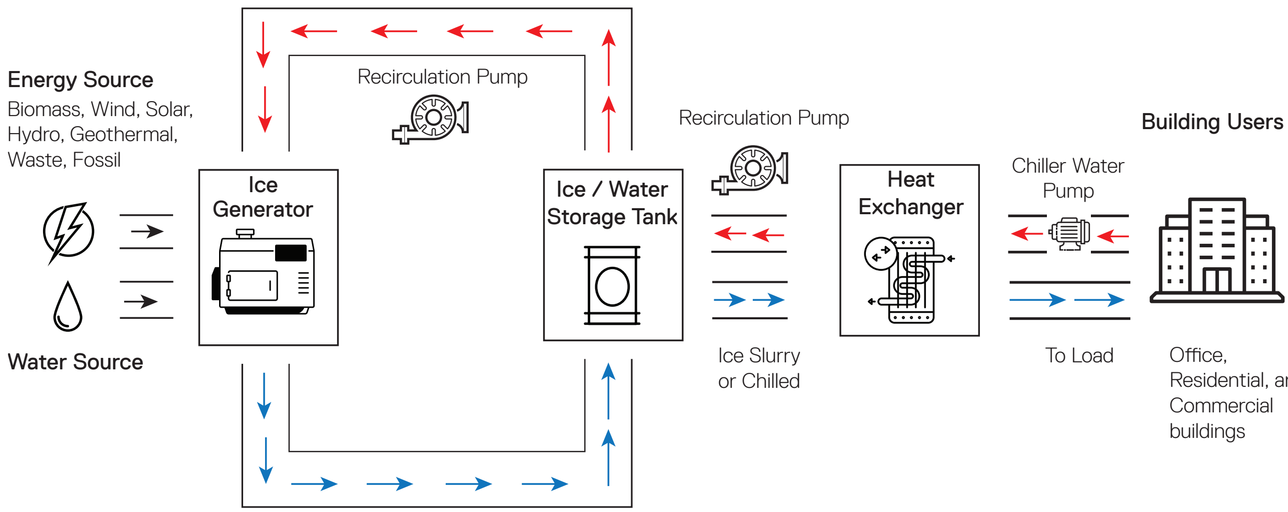


Based on Skarphagen et al. (2019); Sadeghi et al. (2024)

TENs can also incorporate ice systems for energy storage to cool buildings (Kaur et al., 2020). Here, the system uses excess electricity to create ice as a form of energy storage (Sharifi et al., 2023; Saaby Hedegaard, 2023; Na et al., 2017). The stored energy is later deployed to cool buildings during peak demand (Sharifi et al., 2023; Saaby Hedegaard, 2023; Luo et al., 2017). Ice storage systems can generate and thaw ice on a daily or seasonal cycle (Allan et al., 2022). This offers TENs more strategic flexibility with how much and how often they store thermal energy (Goetzler et al., 2019; Song et al., 2018). Locations with large day-night temperature variation may benefit from a daily cycle, whereas locations with extremely cold winters and hot summers may benefit from a seasonal cycle (Allan et al., 2022). The United States already has 100 megawatts of this technology deployed across the country, with the greatest capacity located in New York and Pennsylvania (U.S, DOE, 2020).

Ice thermal energy storage has the potential to provide efficient and climate-friendly cooling while also balancing the grid (Willige, 2021). It may be incorporated into residential buildings, commercial buildings, district cooling systems, or for refrigeration, with varying degrees of feasibility and effectiveness. While installation costs, flood risk, and space requirements can be high, these systems can have lower operational costs and a life cycle that is more sustainable and less energy-intensive than batteries (Nemtzow et al., 2020).

Ice Thermal Storage in District Cooling Systems



Based on Zhang et al. (2022); Calderoni et al. (2019); Snoek (1993)

Renewable Portfolio Standards and Clean Energy Standards

TENs have a place in some of the nation's most powerful clean energy transition policy models: renewable portfolio standards (RPS). RPS aim to reshape the energy landscape from fossil-based to renewable by setting increasingly stringent regulatory mandates on the sale of renewable energy within a state (NREL, n.d.). Clean energy standards (CES) and alternative energy portfolio standards (AEPS) are similar to RPS, but may include a wider slate of no- or low-carbon technologies (Resources for the Future, 2019). These policies work in tandem with a system of renewable energy certificates or credits (RECs). RECs, which represent the benefits associated with one MWh of renewable electricity generated, are tradable credits that can be bought and sold in green power markets separate from the selling of the electricity itself, making them an important tool in financing new renewable, clean, or alternative energy resources (Resources for the Future, 2019). **The inclusion of TENs as an eligible renewable energy, clean energy, or alternative energy source both expands the suite of technologies accessible to utilities to achieve RPS while also providing another powerful tool to incentivize the deployment of TENs.** The section "State Legislative Landscapes" (pg. 23) provides a summary of existing RPS, CES, and AEPS that include TENs or their components.

THE THERMAL ENERGY NETWORK POLICY LANDSCAPE IN THE U.S.

Federal Funding Opportunities

Legacy federal programs such as the Weatherization Assistance Program have long helped decarbonize the U.S. building stock, particularly by targeting low-income households (EERE, 2021). With the passage of the Infrastructure Investment and Jobs Act (2021) and the Inflation Reduction Act (2022), the federal government has unlocked billions more dollars in clean energy investments, including investments that can be used to fund components of TENs such as heat pumps, or entire systems themselves. One notable program is the Community Geothermal Heating and Cooling Design and Deployment opportunity (EERE, n.d.a). **In 2023, 11 proposals were selected to receive funding to design community-scale geothermal heating and cooling systems in the following locations: Ann Arbor, Michigan; Carbondale, Colorado; Chicago, Illinois; Duluth, Minnesota; Framingham, Massachusetts; Middlebury, Vermont; New York City, New York; Nome, Alaska; Seward, Alaska; Shawnee, Oklahoma; and Wallingford, Connecticut (U.S. DOE, 2023)**. The next phase of funding will support the deployment of these systems (EERE, n.d.a). The sections below summarize additional federal funding opportunities by eligible recipients. More in-depth information on these funding opportunities can also be found in Table 5 in the Appendix (pg. 32).

U.S. DOE Community Geothermal Heating and Cooling Design and Deployment Project Locations

Map: Dylan Correll Smith, M.S., Research Support Specialist, Cornell ILR Climate Jobs Institute, dcsmith@cornell.edu • Source: U.S. DOE (2023)

Funding Opportunities for Homeowners, Renters, and Households

The federal government has a suite of incentives directed at homeowners and renters that can apply to specific components of TENs. This funding can help lower the costs of TENs deployment overall by lowering component costs for individual households connected to a given system, rather than being used for the system in its entirety. These incentives include:

- The **Energy Efficient Home Improvement and Residential Clean Energy tax credits**, for which homeowners and renters are eligible to apply (Internal Revenue Service [IRS], 2024b; IRS, 2024c). Both credits apply to heat pumps. The Energy Efficient Home Improvement tax credit can also be used for water heaters and for home energy audits which may be conducted as part of TENs design and installation (IRS, 2024c).
- The **Home Efficiency Rebates and the Home Electrification and Appliance Rebates**, which are rebates for households (and, in the case of the Home Efficiency Rebates, multifamily building owners) administered at the state level (Office of State and Community Energy Programs [SCEP], 2024). Eligible technologies vary state by state, but according to federal guidelines, these can include ENERGY-star certified heating, cooling, and water heating appliances (or DOE-approved appliances for multifamily buildings) for the Home Efficiency Rebates and heat pumps for heating, cooling, water heating, and clothes drying for the Home Electrification and Appliance Rebates (SCEP, 2024).
- The **Weatherization Assistance Program**—administered by states, Tribes, territories, or contracted organizations—which provides grants to low-income households and can be used to fund TENs components such as heating and cooling systems, water heaters, and duct and heating pipe insulation (EERE, 2021).

While these incentives can help make decarbonized homes more affordable, they mostly lack labor standards such as prevailing wage and apprenticeship utilization requirements that are needed to generate high-quality union jobs. However, both the Home Efficiency Rebates and the Home Electrification and Appliance Rebates programs require states to create Community Benefits Plans for these programs with explicit engagement from labor, including labor unions and contractors (SCEP, 2024); and the Weatherization Assistance Program requires Davis Bacon prevailing wage for buildings with 5 or more units (U.S. DOE, 2024a).

Louisville Ground Source Heat Pump.
CREDIT: U.S. Army Corps of Engineers

Funding Opportunities for Community-Based Organizations, Agricultural Producers, and Rural Small Businesses

Community-based organizations, agricultural producers, and small businesses are all eligible to receive federal funding for TENs or their components. Community-based organizations are eligible to receive grants for microgrids, building energy efficiency, and improved indoor air quality and community health through Track I of the Environmental and Climate Justice Community Change Grants Program, which has nearly $2 billion in funding (Office of Environmental Justice and External Civil Rights [OEJECR], 2024). Agricultural producers and small rural businesses can receive grant funding or loan guarantees for direct-use geothermal or energy efficiency equipment through the Rural Energy for America Program (U.S. Department of Agriculture, n.d.).

Like many of the funding opportunities above, the Rural Energy for America Program lacks labor standards. The Community Change Grants Program requires Davis Bacon prevailing wage for construction jobs (OEJECR, 2024).

Other Funding Opportunities

There are several other miscellaneous incentives and financial instruments that can be used to fund TENs or their components. These include:

- The **Investment Tax Credit for Energy Property (ITC)** for clean energy system owners, which may apply to geothermal heat pumps, thermal energy storage, and TENs themselves depending on final rulemaking from the IRS and the U.S. Department of the Treasury (The White House, 2023).
- The **New Energy Efficient Homes Tax Credit** for homebuilders who construct new homes that meet ENERGY STAR standards or are zero-energy ready (The White House, 2023).
- The **Energy Efficient Commercial Buildings Deduction** for commercial buildings owners or lessees and designers of energy efficient buildings, which can apply to heating, cooling, and hot water equipment (IRS, 2024a).
- The **Energy Efficiency and Conservation Block Grant** administered by states, local governments, and Tribes, which can be used for energy efficiency retrofits, building electrification, and district heating and cooling systems (Li, 2023). Eligible recipients vary by program (Li, 2023).
- The **National Clean Investment Fund** and the **Clean Communities Investment Accelerator** under the Greenhouse Gas Reduction Fund, through which newly-established national clean financing institutions and regional technical assistance and funding hubs respectively can provide a suite of financial tools that can be applied toward net-zero building technologies (U.S. EPA, 2024b; U.S. EPA, 2024a)

The New Energy Efficiency Homes Tax Credit, Energy Efficiency Commercial Buildings Deduction, and ITC offer the most robust labor standards incentives of all the TENs-eligible federal funding listed here (The White House, 2023). The New Energy Efficiency Homes Tax Credit provides five times the base tax credit for multifamily homes that pay prevailing wage, while both the ITC and the Energy Efficient Commercial Buildings Deduction provides five times the base credit for projects that pay prevailing wage and use qualified apprentices (The White House, 2023). In addition, monies under the Greenhouse Gas Reduction Fund must comply with Davis Bacon prevailing wage (U.S. EPA, 2023).

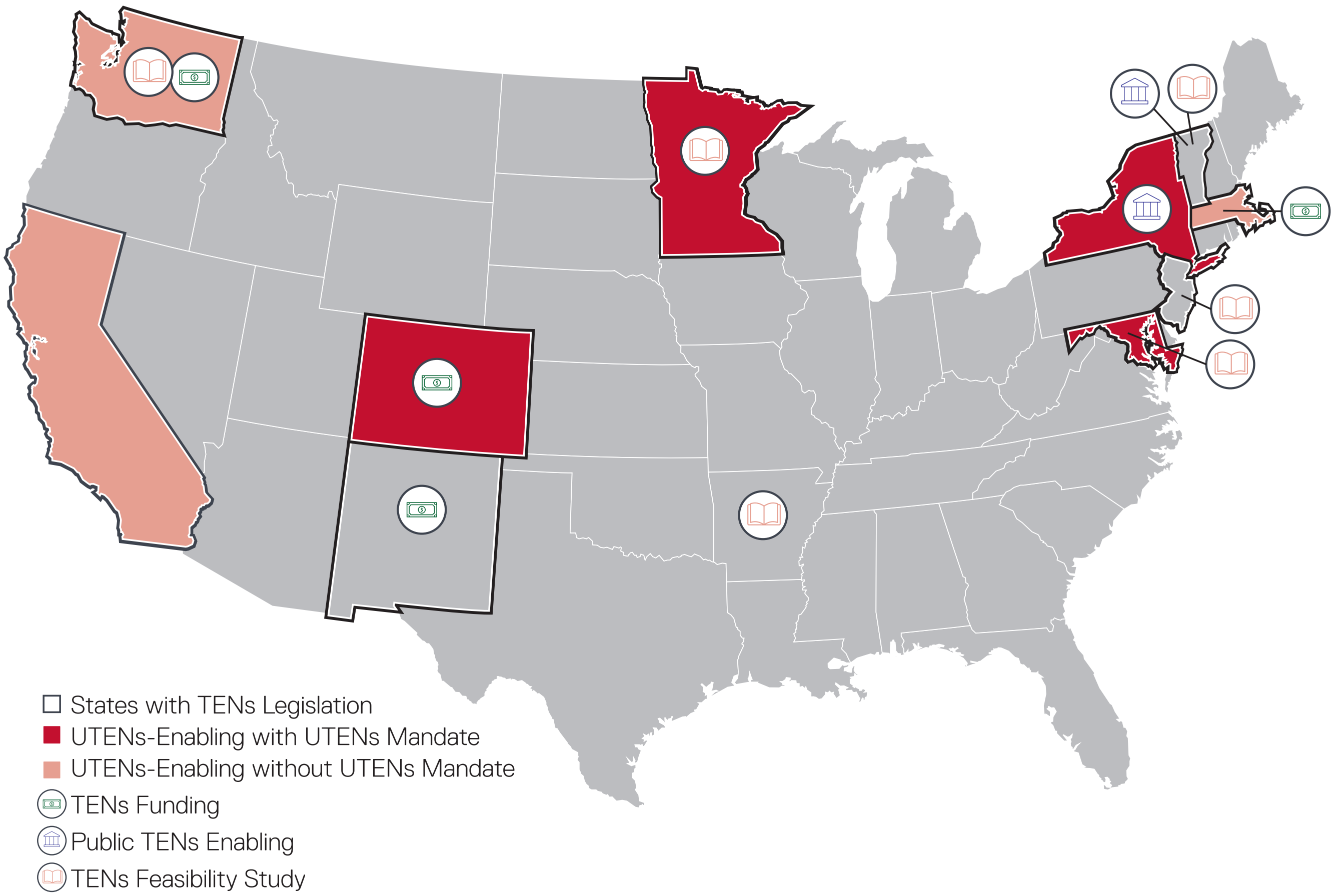
While the wide range of federal financing opportunities for TENs and their components is critical to fast-tracking building decarbonization across the country, the relative dearth of robust labor standards that are required or incentivized by said funding opportunities—paired with the continued reliance on voluntary, incentive-driven individual building-by-building action—misses the chance to jumpstart the creation of a unionized building decarbonization workforce. The inclusion of prevailing wage, apprenticeship requirements, and community benefits agreements on some building decarbonization finance mechanisms is a good start, but future rounds of federal funding as well as any other local or state public monies geared toward TENs should consider more ambitious

Members of United Association of Plumbers and Steamfitters Local 7 install a TEN at Saratoga County Airport. CREDIT: United Association of Plumbers and Steamfitters Local 7 labor standards such as requiring project labor agreements and labor peace agreements, preserving existing collective bargaining agreements, and even entering into memorandum of understanding with existing utility workers to continue operations and maintenance on decarbonized systems to ensure the creation of family-sustaining union careers.

State Legislative Landscapes

State TENs Legislative Landscape

(Excluding Renewable Portfolio Standards and Clean Heat Standards)



Map Author: Hassan Ragy, Research Support Specialist, Cornell ILR Climate Jobs Institute, hr382@cornell.edu
(CA) SB-1221, 2024; (CO) HB 22-1381, 2022; HB 23-1252, 2023; C.R.S. §40-3.3-101 et seq.; Colorado Energy Sector Public Works Project Craft Labor Requirements Act, 2023; (MD) An Act Concerning Renewable Energy Portfolio Standard and Geothermal Heating and Cooling Systems, 2021; WARMTH Act, 2024; (MA) S.9, 2021; An Act Driving Clean Energy and Offshore Wind, 2022; (MN) Minn. Stat. §216B.2427; S. 4924-4, 2024; (NJ) A. 1491, 2024; (NM) HB 91, 2024; (NY) UTENJA, 2022; N.Y. Lab. Law §224-D; S. 4006-C / A. 3006-C, 2023; (VT) S. 305, 2024; (WA) E.S.H.B. 2131, 2024; E.S.S.B. 5949, 2024

Since 2021, states across the country have begun to design and implement legislation to encourage the implementation of TENs projects to meet their climate goals. The map above provides an overview of which states have passed TENS-specific legislation (minus RPS and clean heat standards), and the following sections detail key features of said legislation. More in-depth information is provided in Table 6 (pg. 35), Table 7 (pg. 39), and Table 8 (pg. 40) in the appendix.

UTENs Enabling Legislation and UTENs Mandates

One of the most powerful legislative tools currently deployed by states is legislation to enable utilities to construct, own, maintain, and operate TENs; sell thermal energy; and engage in ratemaking around thermal energy. Such legislation is key to unlocking UTENs as a new business model for gas and other utilities. California, Colorado, Maryland, Massachusetts, Minnesota, New York, and Washington have all enacted UTENs-enabling legislation for: gas utilities (all aforementioned states), electric utilities (Maryland, New York, Washington), dual-fuel utilities (Colorado, New York), water utilities (Maryland), and public utility districts (Washington) (HB 23-1252, 2023; C.R.S. §40-3.3-101 et seq; WARMTH Act, 2024; S.9, 2021; An Act Driving Clean Energy and Offshore Wind, 2022; Minn. Stat. §216B.2427; Utility Thermal Energy Network and Jobs Act [UTENJA], 2022; E.S.H.B. 2131, 2024).

Buildings in Rockefeller Center.Rockefeller Center is part of a proposed project by Con Edison under the Utility Thermal Energy Network and Jobs Act (2022).
CREDIT: David Shankbone.

Some states have included additional provisions in their UTENs-enabling legislation to incentivize the deployment of UTENs. Massachusetts allows gas companies to replace aging or leaking gas infrastructure with TENs as part of their infrastructure replacements plans (An Act Driving Clean Energy and Offshore Wind, 2022). Washington has taken a particularly innovative approach to incentivizing UTENs. The state has amended its regulatory framework for gas companies' obligation to serve, permitting them to meet this obligation through thermal energy and thus unlocking one of the biggest barriers to building decarbonization (E.S.H.B. 2131, 2024). California has taken a similar, but more conservative path, exempting gas utilities from meeting their obligation to provide gas in neighborhoods where they are pursuing neighborhood decarbonization pilot projects (S.B. 1221, 2024). These three states also allow utilities to propose pilot UTENs projects (S.9, 2021; E.S.H.B. 2131, 2024; S.B. 1221, 2024).

States have also built in mandates for demonstrating or deploying UTENs in their enabling legislation. Colorado, Maryland, Minnesota, and New York all require gas and/or dual-fuel utilities over a certain size to pursue pilot UTEN projects ((HB 23-1252, 2023; C.R.S. §40-3.3-101 et seq; WARMTH Act, 2024; Minn. Stat. §216B.2427; UTENJA, 2022). The size trigger for the mandates varies state by state. In addition to its pilot project mandate, Minnesota also requires utilities who submit natural gas innovation plans to spend at least 15% of their proposed costs on UTENs (S. 4924-4, 2024).

Importantly, only three of the seven states that have passed UTENs-enabling legislation and UTENs mandates have included labor standards on this work. Table 1 below summarizes these labor standards.

Table 1: Labor Standards for UTENs Enabling Legislation and UTENs Mandates

	Apprenticeship Utilization Requirements	Benefits Requirements	Existing Utility Workforce Utilization/ Priority Hire for Utility Workers	Labor Peace Agreements	Local/ Targeted Hire	Prevailing Wage or Project Labor Agreements
Colorado (1,2, 3)	X		X			X
Maryland (4)	X	X	X	X	X	
New York (5,6)	X		X			X

Table: Reyna Cohen, MSc, Research and Policy Development Associate, Cornell ILR Climate Jobs Institute, rsc265@cornell.eduSource: (1) HB 23-1252, 2023; (2) C.R.S. §40-3.3-101 et seq; (3) Colorado Energy Sector Public Works Project Craft Labor Requirements Act, 2023; (4) HB 1007, 2021; (5) Utility Thermal Energy Network and Jobs Act, 2022; (6) N.Y. Lab. Law § 224-D

Public TENs Enabling Legislation

States are also pushing for the deployment of public TENs through legislation. New York requires the completion of TENs feasibility studies at the 15 highest-emitting state facilities as part of broader decarbonization action plans for these sites (S. 4006-C / A. 3006-C, 2023). Vermont has adopted legislation enabling municipalities to bypass the Public Utility Commission to construct, operate, and set rates for TENs. Public TENs offer an innovative model, lowering the cost of TENs by bypassing the need for such systems to create profit as with utilities while still opening up a potential new avenue of employment for existing union members employed in oil and gas industries with the possibility of even higher labor standards. For instance, New York's S. 4006-C / A. 3006-C (2023) expands on the labor standards required for public TENs to include Buy American provisions as well as provisions to protect workers from displacement due to decarbonization projects at state facilities and to protect their existing collective bargaining agreements.

TENs Funding Legislation

Colorado, Massachusetts, New Mexico, and Washington have passed legislation to help fund TENs (HB 22-1381, 2022; An Act Driving Clean Energy and Offshore Wind, 2022; HB 91, 2024; E.S.S.B. 5949, 2024). Colorado created a new Geothermal Energy Grant Program under the Colorado Energy Office with a 25% carveout targeting funding the design and installation of TENs (HB 22-1381, 2022). Massachusetts expanded the eligible technologies for its Renewable Energy Trust Fund and Green Jobs Initiative for Public Schools to include networked geothermal (An Act Driving Clean Energy and Offshore Wind, 2022). New Mexico established both a grant program and a revolving loan fund to support the development of geothermal projects including TENs (HB 91, 2024). Finally, Washington established a Thermal Energy Network Pilot Project Grant with $25,000,000 in funding to support pilot UTENs, contingent on the continuation of the state's Cap-and-Invest Program (E.S.H.B. 2131, 2024; E.S.S.B. 5949, 2024).

TENs Feasibility Studies

Maryland, Massachusetts, Minnesota, New Jersey, Vermont, and Washington all include some form of TENs feasibility study as part of their TENs legislation (An Act Concerning Renewable Energy Portfolio Standard and Geothermal Heating and Cooling Systems, 2021; An Act Driving Clean Energy and Offshore Wind, 2022; S. 4924-4, 2024; BDC, 2024; S. 305, 2024; E.S.H.B. 2131, 2024).

RPS, CES, and AEPS

Outside of TENs-specific legislation like the above, many states already include TENs, their component technologies, or direct-use thermal energy sources in their RPS, CES, or AEPS. The table below summarizes eligible thermal technologies by state.

Table 2: RPS, AEPS, and CES-Eligible Thermal Energy Sources & Technologies by Statees

	TENs	GSHPs	Useful Thermal Energy	Waste Heat	Other TENS-related Thermal Resources
Connecticut (1)				X	
Maryland (2)	X	X			X
Massachusetts (3)		X	X		X
Michigan (4)		X			
New Hampshire (5)			X		
New Mexico (6, 7)			X		
North Carolina (8)			X	X	
Ohio (9)			X	X	X
Vermont (10)		X			
Virginia (11)	X				

Table: Reyna Cohen, MSc, Research and Policy Development Associate, Cornell ILR Climate Jobs Institute, rsc265@cornell.eduSource: (1) Public Utilities Regulatory Authority, 2023; (2) Md. Code. Pub. Util. Comm'n. §7-701 et seq; (3) C.M.R. §16.01 et seq; (4) Clean and Renewable Energy and Energy Waste Reduction Act, 2023; (5) R.S.A. §362-F:2-362-F:3; (6) N.M.S.A. §62-16-1 et seq; (7) N.M.S.A. §§62-15-34, 62-15-37; (8)N .C.G.S. §62-133.8; (9) Ohio Rev. Code §4928.64; (10) V.S.A. tit. 30 §§8002-8006; (11) Va. Code §56-585.5Get the data

More comprehensive information on RPS, AEPS, CES, and TENs can be found in Table 7 in the appendix (pg. 39).

Clean Heat Standards

Lastly, states have also begun to adopt clean heat standards, policies which may incentivize the adoption of TENs. Much like an RPS, a clean heat standard (CHS) gradually requires thermal energy suppliers such as gas companies to decarbonize their heating supply by setting increasingly stringent benchmarks for what percentage of a supplier's sales must be derived from "clean" heating sources (Environmental Defense Fund, 2024). Such policies create an analogous system to RECs called clean heat credits to incentivize utilities' adoption of clean heating sources (Environmental Defense Fund, 2024). Because they create mandate and incentive structures for clean heat, CHS could become powerful legislative tools for advancing TENs deployment.

Thus far, four states are in different stages of developing and implementing clean heat standards: Colorado, Massachusetts, Maryland, and Vermont (Environmental Defense Fund, 2024). Only Colorado has fully implemented its clean heat standard, while Massachusetts, Maryland, and Vermont are in the process of developing the relevant rules and regulations. Table 8 in the appendix provides detailed information on Colorado's CHS (pg. 40x).

FRAMINGHAM, MA: A FIRST LOOK AT UTILITY THERMAL ENERGY NETWORKS IN THE U.S.

Eversource, a New England-based utility company, is piloting utility-owned and operated networked geothermal in Framingham, Massachusetts—a city of just over 70,000 people in the Greater Boston area (U.S. Census Bureau, 2023; Metropolitan Area Planning Council, n.d.)—to prove the viability of UTENs (Eversource, n.d.a). This first-in-the-nation UTEN, which is set to replace the oil, propane, and natural gas that previously heated the connected buildings (Eversource, n.d.b), will act as a case study for the integration of TENs into the utility model. It will also provide lessons on how to ensure that unionized workers are not left behind as TENs and UTENs gain momentum.

A photo of Framingham City Hall. Framingham is the location of a pilot utility-scale thermal energy network by Eversource. CREDIT: Christopher Ryan.

The Framingham Pilot UTEN at a Glance

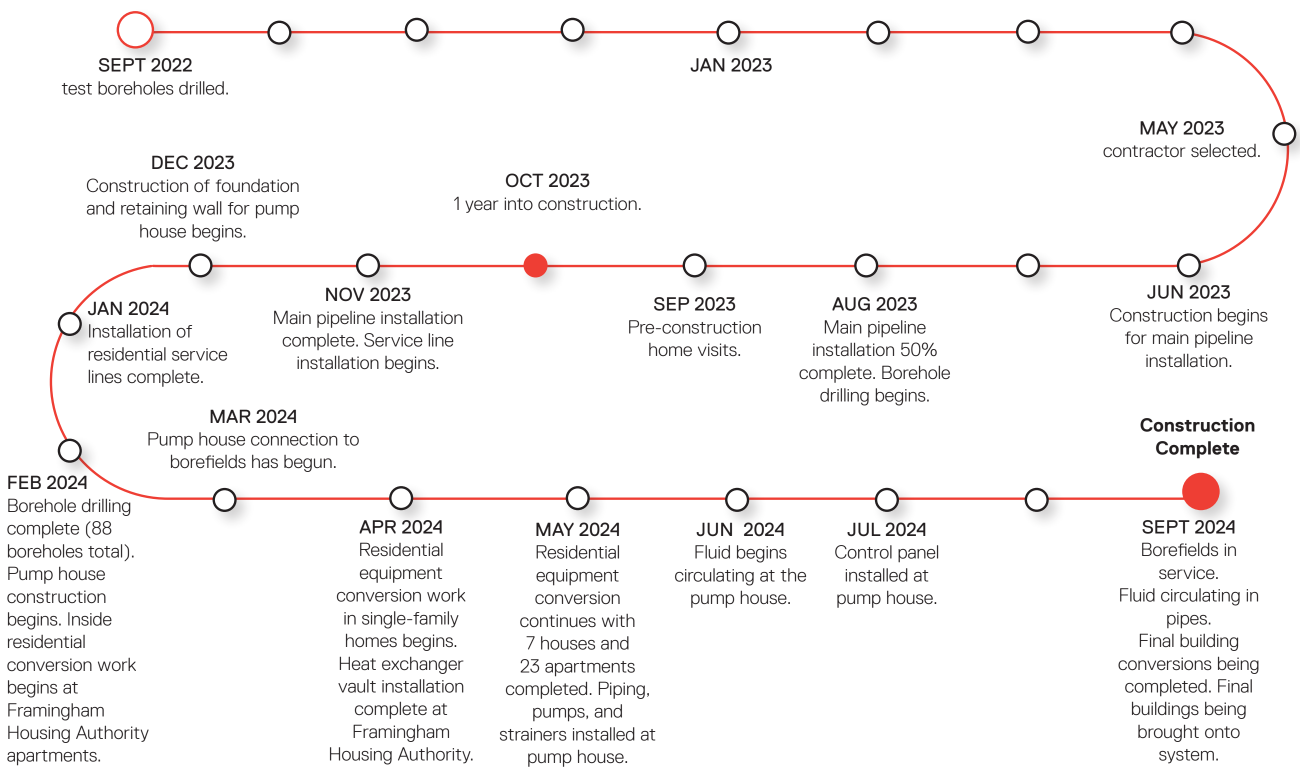
Table 3: Framingham, MA Eversource UTEN Pilot Network Specs at a Glance

	Number of Buildings Connected	Number of Customers	Heating and Cooling Capacity	Number of Boreholes	Estimated Volume of Conditioned Space	Mileage of Main Pipe
Framingham, MA (1,2)	37 total 5 commercial 32 residential	140	375 tons	90	1,778,147 cubic feet	1 mile

Table: Reyna Cohen, MSc, Research and Policy Development Associate, Cornell ILR Climate Jobs Institute, rsc265@cornell.eduSource: (1) Eversource, n.d.; (2) Graf & Dumas, 2023

The Framingham UTEN was constructed in a moderately dense, mixed-use neighborhood (Eversource, n.d.b). It connects 37 buildings—including 20 single-family homes, 2 two-family homes, 2 public buildings, and 5 commercial buildings—each with varying energy demands (Graf & Dumas, 2023; Benoit, 2024; Eversource, n.d.b; Camargo & Rusteika, 2024). This diversity will help the system efficiently balance the thermal energy it uses across the connected buildings throughout the year (HEET & Buro Happold Engineering, 2023). The Framingham UTEN has a heating and cooling capacity of 375 tons and includes 90 boreholes across three locations to service 140 residential and commercial customers (Eversource, n.d.b). Its boreholes were drilled using both vertical drilling and incline drilling (C. Kilmer, personal communication, October 23, 2024). The pilot took a year to construct and will run for two years, or two heating and cooling seasons, with the hope to extend operation depending on performance and cost (Eversource, 2023; Kempe, 2024).

EVERSOURCE FRAMINGHAM TENS PROJECT CONSTRUCTION TIMELINE
SOURCE: EVERSOURCE, N.D.-B



Cost

The Eversource pilot cost $15 million, which included the construction and installation of the UTEN itself along with all residential and commercial geothermal conversions, energy efficiency upgrades, GSHP and ductwork installations, and removal of old fossil fuel equipment (Eversource, n.d.b). As a result, customers could connect to the UTEN at no cost. During the pilot phase of the UTEN, customers will pay a flat monthly service fee based on their average energy usage during the two years prior to the pilot launch, with discounted rates for low-income customers (Eversource, n.d.b). Monthly rates are anticipated to be as follows: $10 for residential customers, $20 for commercial customers, and $8 for low-income customers (Eversource, n.d.b). Customers may save money on their energy bills in part by no longer paying for natural gas or other home heating fuels during the winter months (Eversource, n.d.b).

Community Engagement and Building Buy-In

Successful UTEN construction demanded collaboration with Framingham residents and customers (Eversource, n.d.a). Eversource first started building community relationships by educating prospective participants about networked geothermal and their UTEN proposal (Eversource, n.d.a). From there, the utility pursued a wide variety of strategies to keep Framingham residents engaged, including: hosting regular informational sessions to provide key updates like upcoming home visits and events, project timelines, and mitigation strategies to reduce impact on local wildlife; partnering with local schools to highlight STEM career opportunities for girls and participate in science fairs; creating a robust public engagement campaign; and hiring a dedicated community partner for the project (CDM Smith, n.d.; Eversource, n.d.a). These efforts highlight how community engagement can build buy-in to secure the zoning, permitting, and overall planning needed to break ground (Eversource, n.d.b).

Engaging a Unionized Workforce in UTENs: Lessons Learned from Framingham

While the Framingham pilot holds promise for showcasing new models of decarbonizing the gas system through existing utility structures, it also represents a cautionary tale by failing to deliver on the promise of a just transition for the union workers who helped build and maintain that same system. The large majority of the construction, installation, and conversion work on the project was done by non-union workers; for instance, the estimated 41 workers employed in borehole drilling, installation of the ground loop, commercial conversions, and electrical work were all non-union (C. Kilmer, personal communication, October 23, 2024). Importantly, these estimates exclude residential conversions, which constituted the bulk of the retrofits. This resulted in the exclusion of union drillers, pipefitters, machinists, laborers, truck drivers, plumbers, equipment operators, and HVAC technicians from a variety of trades. For the pipefitting alone, Dan Coady of the Boston Pipefitters Local 537 estimates the work could have employed up to 10 of his members for a year, far beyond the two or three part-time members he estimates were ultimately involved in the project (personal communication, October 21, 2024).

The lack of union involvement in the Framingham pilot is a missed opportunity on many fronts. Firstly, union members are key stakeholders in both the community and the fossil fuel workforce, and failing to engage them can threaten the viability of a project just as failing to engage any key community members would. Secondly, union construction sites are correlated with fewer fatalities and Occupational Safety and Health Administration violations while also being correlated with higher productivity (Manzo et al., 2021; Doucouliagos et al., 2017). Contracting with unionized labor—especially through a Project Labor Agreement—can also help companies such as Eversource meet the prevailing wage and apprenticeship utilization criteria to maximize tax credits through the Inflation Reduction Act (U.S. Department of Labor, n.d.). Unions are also equipped with lifelong learning apparatus through their apprenticeship centers, which are well-equipped to train members in new technologies such as those involved in TENs (Helper et al., 2016). Perhaps most importantly, as mentioned in this report's introduction, transitioning the union members who helped to build and maintain the existing fossil fuel system to analogous career pathways in green technologies helps guarantee a just transition for these workers, delivering high-quality careers with family-sustaining wages and benefits (HEET, n.d.c; Bagdanov et al., 2023). Without engaging unions in the transition to TENs and other green technologies—especially those for whom the transition away from the gas system threatens job displacement—a green energy transition threatens to repeat the mistakes of deindustrialization.

Framingham: Looking Forward

HEET, a Massachusetts-based non-profit focused on decarbonizing thermal energy (HEET, n.d.b), is partnering with Eversource to pursue federal funding through the Community Geothermal Heating and Cooling Design and Deployment program to expand the Framingham UTEN with a second loop (Varela Gutierrez, 2024), the details of which can be found in Table 4 below.

Table 4: Framingham, MA HEET & Eversource Prospective UTEN Expansion Specs at a Glance

	Number of Buildings Connected	Heating and Cooling Capacity	Number of Boreholes	Mileage of Main Pipe
Framingham, MA (1)	44 total 1 public building (school) 29 single family homes 13 multi-family buildings 1 other residential	217 tons	80	0.61 mile

Table: Reyna Cohen, MSc, Research and Policy Development Associate, Cornell ILR Climate Jobs Institute, rsc265@cornell.edu • Source: (1) Varela Gutierrez, 2024

The construction phase of this project is anticipated to require 4 full-time and 38 part-time roles across the aforementioned trades that could go to union members and apprentices (A. Iliff, personal communication, October 16, 2024). Moreover, Eversource is expected to assume responsibility for the system and thus its operations and maintenance, opening the opportunity to retrain their existing union employees with the Utility Workers Union of America and the United Steel Workers Union in this new technology (United Steel Workers Local 12004, n.d.; Utility Workers Union of America Local 369, n.d.). The expansion of the Framingham loop is a chance to learn from the lessons of the pilot, providing the nation with a case study in a just transition for the gas system and its workers instead of a cautionary tale. This momentum could lead to sustained demand and job security for gas workers across the New England region.

CONCLUSION

TENs, a zero-carbon, non-combusting, non-emitting take on a technology that has been used in the United States for over a century, offer the United States a new paradigm of building decarbonization: decarbonization at the neighborhood scale (EERE, n.d.b.; Bagdanov et al., 2023; BDC, n.d.c). Such a paradigm promises to unstick some of the most challenging problems in this sector even beyond building decarbonization at scale. This includes: lowering the costs of building decarbonization for all different stakeholders (homeowners, building owners, renters, utilities, ratepayers, and taxpayers), decreasing both the energy demands of building decarbonization and the costs of the resultant grid buildout, and transforming the ecosystem of low-quality decarbonization jobs by providing one of the most viable pathways for creating an equitable, union green workforce (Liu, 2010; VCTN, 2024; Camargo & Rusteika, 2023; Liu et al., 2023; HEET, n.d.c; Bagdanov et al., 2023).

To harness the enormous potential of TENs, more and more states have adopted legislation to hasten their deployment (BDC, n.d.a; BDC, 2024); and the federal government has included funding in its signature climate and infrastructure laws (Infrastructure Investment and Jobs Act, 2021; Inflation Reduction Act, 2022). Yet, key stakeholders should learn from the nation's first UTEN in Framingham, Massachusetts and take note: the promise of an equitable green union transition for the buildings sector rests on continued union involvement and engagement alongside robust and even creative enforceable labor standards attached to legislation and funding. Without these, such a promise threatens to fade away.

APPENDIX

Table 5: Federal Funding Opportunities for TENs and TENs Components

Type	Title	Funding Amount	TENs-applicable Eligible Technologies	Eligible Recipient	Key Agency	Direct Pay?	Prevailing Wage Requirement or Incentive?	Apprenticeship Utilization Requirement or Incentive?	Other Equity & Labor Standards
Tax Deduction	**Energy Efficient Commercial Buildings Deduction (1)**	$0.50/square foot for buildings with 25% energy savings, plus $0.02/square foot for each additional percentage of energy savings up to $1.00 or 50% energy savings	• Heating, cooling, and hot water equipment	Commercial building owners and lessees, designer of energy efficient building properties	IRS	No	5x base credit	5x base credit	No
Tax Credit	**Energy Efficient Home Improvement Credit (2)**	• $150/year for home energy audits • $2,000/year for qualified heat pumps and water heaters	• Heat pumps • Water heaters • Home energy audits	Homeowner or renter	IRS	No	No	No	No
Tax Credit	**Investment Tax Credit for Energy Property (3)**	6% of qualifying investment	Eligebility technology depenent on final rules, but may include: • Geothermal heating including geothermal heat pumps • Thermal Storage • Microgrid controllers	System owners	IRS	Yes	5x base credit	5x base credit	• 10% credit increase for meeting domestic content requirements • 10% credit increase if project is located in an energy community
Tax Credit	**New Energy Efficient Homes Tax Credit (4)**	• For homes meeting Energy Star: $2,500 for single family, $500/unit for multifamily • For zero-energy ready homes: $5,000 for single family, $1,000/unit for multifamily	• N/A	Homebuilders	IRS	No	5x base credit for multifamily homes	No	No
Tax Credit	**Residential Clean Energy Credit (5)**	30% equipment cost through 2032, 26% in 2033, 22% in 2034	• Geothermal heat pumps	Homeowners and renters	IRS	No	No	No	No
Program-dependent (block grants awarded to states, local governments, and Tribes)	**Energy Efficiency and Conservation Block Grant (6)**	$550,000,000 in overall grant funding	• Energy efficiency retrofit and building electrification measures • District heating and cooling systems	Program-dependent	U.S. EPA	N/A	No	No	Justice40 goal of 40% of overall benefits go to disadvantaged communities

Grants	**Environmental and Climate Justice Community Change Grants Program (7)**	$1.96 billion total funding for Track I Community-Driven Investments for Change	• Microgrids • Energy-efficient buildings • Indoor air quality and community health	based Organization and partners (local government, federally-recognized tribes, institutes of higher education)	U.S. EPA	N/A	Required for construction jobs	No	• Projects must benefit disadvantaged communities
Grants (state-administered)	**Home Efficiency Rebates (8)**	Modeled Energy Savings: • Single-Family: 20%-34% energy savings: 80% project costs up to $4,000 for households below 80% of area median income (AMI), 50% project costs up to $2,000 for households 80% AMI or greater OR 35%+ energy savings: 80% project costs up to $8,000 for households below 80% AMI, 50% project costs up to $4,000 for households 80% AMI or greater • Multifamily: 20%-34% energy savings: 80% project costs up to $4,000/unit for buildings with 50% or more households below 80% AMI, for all other buildings $2,000/unit up to $200,000/building OR 35%+ energy savings: 80% project costs up to $8,000/unit for buildings with 50% or more households below 80% AMI, for all other buildings $4,000/unit up to $400,000/building Measured Energy Savings: • Single-Family: 15%+ energy savings: 80% project costs up to $4,000 for households below 80% of area median income (AMI), 50% project costs up to $2,000 for households 80% AMI or greater • Multifamily: 15% energy savings: 80% project costs up to $4,000/unit for buildings with 50% or more households below 80% AMI, for all other buildings $2,000/unit	• ENEGRY STAR-certfied heating, cooling, and water heating appliances. Systems for multifamily homes subject to DOE approval. Specific technologies variable by state	Household or multifamily building owner	U.S. DOE	N/A	No	No	• Double the maximum rebate for retrofits for low- and moderate-income homes • Requires states to create a Community Benefits Plan from their program, including engagement with labor
Grants (state-administered)	**Home Electrification and Appliance Rebates (9)**	Up to $14,000/home	Heat pump for water heating, heating and cooling, and/or clothes drying. Specific technologies variable by state	Household	U.S. DOE	N/A	No	No	• Double the maximum rebate for retrofits for low- and moderate-income homes • Requires states to create a Community Benefits Plan from their program, including engagement with labor

Grants (administered by organizations contracted through states, Tribes, and territories)	**Weatherization Assistance Program (10, 11)**	N/A	• Heat and cooling systems • Water heaters • Duct and heating pipe insulation	Household	U.S. DOE	N/A	Yes (for multi-family buildings)	No	• Funding targets low-income households
Grants, Loan Guarantees	**Rural Energy for America Program (12)**	• Grants: up to 50% of project costs if the project is (a) zero GHG, (b) located in an energy community, (c) is an energy efficiency improvement, or (d) proposed by an eligible Tribal Corporation of business. $2,500-$1,000,000 for renewable energy systems including geothermal heating and cooling; $1,500-$500,000 for energy efficiency projects • Loan Guarantees: up to 75% total eligible project costs	• Direct-use geothermal • Energy efficiency equipment	Agricultural producers, rural small businesses	United States Department of Agriculture	N/A	No	No	No
Financial Products	**Greenhouse Gas Reduction Fund (13, 14, 15)**	• $14,000,000,000 for the National Clean Investment Fund program overall • $6,000,000,000 for the Clean Communities Investment Accelerator overall	Net-zero buildings technologies	Program-dependent	U.S. EPA	N/A	Yes	No	• National Clean Investment Fund: 40% of capital to low-income and disadvantaged communities • Clean Communities Investment Accelerator: 100% of capital to low-income and disadvantaged communities

Table: Reyna Cohen, MSc, Research and Policy Development Associate, Cornell ILR Climate Jobs Institute, rsc265@cornell.edu • Source: (1) IRS, 2024a; (2) IRS, 2024b; (3) The White House, 2023; (4) The White House, 2023; (5) IRS, 2024c; (6) Li, 2023; (7) OEJECR, 2024; (8) SCEP, 2024; (9) SCEP, 2024; (10) EERE, 2021; (11) U.S. DOE, 2024a; (12) U.S. Department of Agriculture, n.d; (13) U.S. EPA, 2024b; (14) U.S. EPA, 2024a; (15) BlueGreen Alliance, n.d • Created with Datawrapper

Table 6: Overview of State TENs Legislation (Excluding RPS, AEPS, and CHS)

State	Type	Year Passed	Description	Key Agencies	Funding	Labor Standards?	Pilots required?
California (1)	• UTENs-enabling	2024	• Requires gas corporations to submit a map of all gas line replacement projects and any foreseeable distribution pipeline replacement by July 1, 2025 and annually therafter • Requires the Public Service Copmmission to establish "priority neighborhood decarbonization zones" based on the presence of disadvantaged or low-income that disproportionately lack cooling or heating; the presence of Environmental or social justice communities, based on the Environmental and Social Justice Action Plan; availability of support from local government and community partners; and concentration of gas line replacement projects identified. • Creates a voluntary program for gas corportations to pursue up to 30 neighborhood decarbonization pilot projects in priority neighborhood decarbonization zones, including but not limited to TENs, necessitating that at least 67% of property owners in an identified neighborhood consent to the project (if 100% consent,the project will not count towards the 30). No pilot projects from this law after January 1, 2030 • Requires an annual report to the legislature reviewing the efficacy of all pilot projects, including the costs and benefits of TENs and any implementation barriers • Allows gas service providers to stop gas service in a pilot project area	• Public Utilities Commission	None	• Preference for pilot projects that provide prevailing wages and use high road job programs when choosing pilot projects	Not required but permitted
Colorado (2)	• Funding	2022	• Creates a Geothermal Energy Grant Program under the Colorado Energy Office, up to 25% of the total funds of which may be allocated to community district heating systems using ground-source, water-source, or multi-source thermal energy	• Colorado Energy Office	Yes, grants of up to: • $100,000/project to conduct a scoping study • $500,000/project for a detailed design study • $500,000 for project installation	None	No
Colorado (3)	• UTENs-enabling with mandate	2023	• Requires gas utilities with over 500,000 customers to propose at least one pilot thermal energy network program by September 2024, with additional proposals allowed for review until September 2026. A utility's proposal may be part of its clean heat plan. Each proposal much incorporate funding sources, including proposed rate structures for thermal energy • Enables gas utilities to include thermal energy networks as a clean heat resource in their clean heat plans • Establishes labor standards for any TEN and thermal energy system project that: (a) is considered a public project and (b) is procured by government agencies or state higher education institutions	• Public Utilities Commission	None	• Apprenticeship requirements for public projects $1 million or more • Prevailing wage for public projects $500,000 or more • Must be performed by licensed plumbers, electricians, or supervised apprentices (3 apprentices per each master or journeyman) • Requires utility TENs (UTENs) to use utility employees or qualified contractors with access to apprenticeship programs for any construction trade work	Yes, at least one per gas utility that serves more than 500,000 customers

Colorado (4, 5)	• UTENs-enabling with mandate	2024	• Allows local governments whose residents are served by dual-fuel utilities to become "gas planning pilot communities," five of which will be prioritized for neighborhood-scale low- or zero-carbon gas alternative projects including TENs • Allows utilities to fund gas appliance/equipment conversions for customers for non-emitting thermal resources • Allows utilities to establish rate structures for TENs • Requires utilities to report on project progress each year	• Public Utilities Commission	None	• Must meet apprenticeship utilization requirements • If a project qualifies as an energy sector public works project, requires prevailing wage or project labor agreements	Yes, five
Maryland (6)	• TENs feasibility study	2021	• Requires the Maryland Energy Administration to conduct a technical study on (a) existing geothermal heating and cooling systems in the state, and (b) the impact of expanding and incentivizing the use of such systems • Creates a Geothermal Energy Workgroup to study the impacts of increasing geothermal heating and cooling in the state,especially in environmental justice communities. This study must include including the potential for high-quality job creation, enforcement methods for labor standards compliance and apprenticeship utilization, and opportunities for minorities, women, local residents, veterans, and their businesses. This group requires representation from the Baltimore-D.C. Metro Building and Construction Trades Council and the Maryland State and District of Columbia AFL-CIO	• Public Service Commission • Department of Labor • Maryland Energy Administration	RECs	See Table 3	No
Maryland (7)	• UTENs-enabling with mandate	2024	• Enables gas, electric, and water companies to own, manage, and recover costs from TENs, including TENs pilots • Permits gas, electric, and water companies to drill geothermal boreholes in the public right-of-way where feasible • Directs gas companies with at least 75,000 customers to develop at least one and up to two pilot TEN system proposals and allows gas companies with fewer than 75,000 customers to do the same • Requires gas companies to obtain federal funding for each pilot • Requires pilot proposals to include rate structures not exceeding customer payment for existing utilities and allows companies to recover the costs no covered by other funding sources • Requires companies with pilot TENs to comply with Maryland's Minority Business Enterprise Program, and requires gas companies in particular to develop plans for minority business enterprise participation in the pilots • Directs the Maryland Energy Administration to coordinate funding sources including federal funding to assist electric, gas, and water companies in covering the costs of behind-the-meter projects associated with TENs • Establishes labor standards for front-of-meter and behind-the-meter TENs construction, operations, and maintenance	• Public Service Commission • Maryland Energy Administration • Governor's Office of Small, Minority, and Women Business Affairs	Yes, grant funding for community-based organizations to support outreach for consumer connection to a TENs pilot, up to $1,000,000 per organization	• In the construction of TENS (including front-of-meter and behind-the-meter projects), requires companies to work with their existing contracted employee workforce or use qualified contractors under a community benefit agreement • Give employee bargaining units and opportunity to work on the construction, maintenance, and operation of the project • Requires all contractors or subcontractors engaged by companies to pay prevailing wage rate including fringe benefits; offer health care and retirement benefits to project employees; participate in a registered apprenticeship; and have a plan for outreach, recruitment, and retention of Maryland residents to reach a goal of 25% of work hours being performed by state residents; and have been in compliance with wage and hour laws for the past 3 years	Yes, at least one per gas utility that serves more than 75,000 customers
Massachusetts (8)	• UTENs-enabling	2021	• Enables gas utilities to pilot utility-scale renewable thermal energy projects that reduce GHG emissions • Permits utilities pursuing a pilot to bill for thermal energy	Department of Public Utilities	None	None	Not required but permitted

Massachusetts (9)	• Funding • TENs feasibility study • UTENs-enabling	2022	• Permits gas companies to replace existing infrastructure with utility-scale non-emitting thermal energy infrastructure and recover the costs of the replacement through ratemaking • Establishes a stakeholder working group responsible for developing recommendations regarding gas system enhancement planning, including evaluating the ability to scale utility-scale thermal energy through gas system planning. This group requires representation from a unionized gas distribution worker • Expands grants through the green jobs initiative for public schools (including vocational schools and public higher education) to include networked geothermal • Makes networked geothermal eligible for grants and expenditures from the Massachusetts Renewable Energy Trust Fund • Updates reporting requirements for gas utilities participating in TENs pilots, including data on job creation and retention • Permits the Department of Public Utilities to require gas utilities participating in TENs pilots to develop plans to transition gas infrastructure to non-emitting infrastructure including thermal projects • Directs the Department of Public Utilities to deliver a recommendation on whether gas companies can generate, distribute, and sell renewable thermal energy	• Department of Public Utilities • Massachusetts Clean Energy Center • Department of Energy Resources	Yes, grants	None	No
Minnesota (10)	• UTENs-enabling with mandate	2021	• Allows natural gas utilities to submit innovation plans to meet the state's GHG reduction and renewable energy generation goals. Utilities with more than 800,000 customers that choose to file a plan must include a pilot program to develop, expand, or modify a district energy system • Requires utilities to include an estimate of projected local job impacts from the implementation of their innovation plans	• Public Utilities Commission	None	None	Yes, 1 per utility with over 800,00 customers that submits a natural gas innovation plan
Minnesota (11)	• TENs feasibility study • UTENs-enabling with mandate	2024	• Requires utilities with over 800,000 customers who submit a natural gas innovation plan to spend 15% of their proposed costs on TENs. This 15% may be inclusive of any TENs projects in development outside of submitted plans • Establishes a Thermal Energy Network Deployment Work Group responsible for providing recommendations on deploying TENs in the state, including regulatory opportunities for utilities and analyzing potential barriers. The Work Group includes representation from labor organizations • Requires the Department of Commerce to conduct a Thermal Energy Network Site Suitability Study to identify potential areas for deployment and potential barriers	• Public Utilities Commission • Department of Commerce	$500,000 for the Thermal Energy Network Site Suitability Study	None	No
New Jersey (12)	• TENs feasibility study	2024	• Requires the Board of Public Utilites to conduct a feasibility study on the benefits of large-scale geothermal systems in the state, including: barriers, marketability, energy efficiency, costs versus savings, and a potential incentive system	• Board of Public Utilities	None	None	No
New Mexico (13)	• Funding	2024	• Establishes a Geothermal Projects Development Fund to distribute grants to study and finance geothermal projects including TENs • Establishes a Geothermal Projects Revolving Loan Fund to provide loans for geothermal projects including TENs	• Energy, Minerals, and Natural Resources Department • State Treasury	Yes	None	No

New York (14, 15)	• UTENs-enabling with mandate	2022	• Allows gas, electric, and combined gas and electric utilities to own, operate, and manage TENs • Instructs the Public Service Commission to create a regulatory structure for TENs • Requires the 7 largest gas, electric or combined utilities to pilot up to 5 TENs project, with at least one in disadvantaged communities • Establishes labor standards for UTENs	• Department of Public Service • Public Service Commission • Department of Labor	None	• Establishes TENs as a covered renewable energy project under §224-d of New York State Labor Law, requiring prevailing wage for TENs absent a project labor agreement and support for the participation of minority and women-owned business • Contractors and subcontractors must use apprenticeship agreements with direct entry agreements from pre-apprenticeship • Requires labor peace agreements • Priority hire for displaced or potentially soon-to-be displaced utility workers	Yes, at least one and up to five for the seven largest gas, electric, or combined utilities in the state
New York (16)	• Public TENs	2023	• Establishes Article 4-D Decarbonization of State-Owned Facilities under public buildings law • Requires the New York Power Authority to create decarbonization action plans for the state's 15 highest-emitting facilities. These plans must include the feasibility of using TENs at each facility	• New York Power Authority	None	• For any project funded due to decarbonization action plans: classifies such projects as public works and thus subject to article 8 of labor law, requires project labor agreements and prevailing wage, and protects workers from displacement due to decarbonization projects, and protects workers' existing collective bargaining agreements • Includes Buy American requirements for component parts of geothermal heating and cooling systems	No
Vermont (17)	• Public TENs • TENs feasibility study	2024	• Grants municipalities the authority to construct, operate, set rates for, finance, and use eminent domain to create a thermal energy exchange utility without approval by the Public Utility Commission • Requires the Public Utility Commission to issue a report on how to support the development, permitting, construction, operation, and rate-setting of TENs	• Public Utility Commission	None	None	No
Washington (18, 19)	• Funding • TENs feasibility study • UTENs-enabling	2024	• Allows electric and gas companies as well as public utility districts to own, control, operate, or manage TENs • Permits gas companies to meet their obligation to serve by providing thermal energy upon approval by the Utilities and Transportation Commission • Establishes a thermal energy network pilot project grant program under the Department of Commerce to help gas companies fund TENs pilot project • Establishes a TENs pilot project program which: (a) gives gas companies priority for developing TENs, and (b) requires the utilities and transportation commission to consider certain labor standards when reviewing pilot project proposals • Requires the Joint Legislative Audit and Review Committee to evaluate the TENs pilot project program by June 2027	• Utilities and Transportation Commission • Department of Commerce	Yes, grants ($25,000,000 in overall funding available	• None required, the utilities and transportation commission must consider the following standards when reviewing pilot projects for approval: usage of existing natural gas workforce, training, job creation and retention, payment of prevailing wage, and use state-registered apprenticeship programs	Not required but permitted

Table: Reyna Cohen, MSc, Research and Policy Development Associate, Cornell ILR Climate Jobs Institute, rsc265@cornell.edu • Source: (1) SB-1221, 2024; (2) HB 22-1381, 2022; (3) HB 23-1252, 2023; (4) C.R.S. §40-3.3-101 et seq.; (5) Colorado Energy Sector Public Works Project Craft Labor Requirements Act, 2023; (6) An Act Concerning Renewable Energy Portfolio Standard and Geothermal Heating and Cooling Systems, 2021; (7) WARMTH Act, 2024; (8) S.9, 2021; (9) An Act Driving Clean Energy and Offshore Wind, 2022; (10) Minn. Stat. §216B.2427; (11) S. 4924-4, 2024; (12) A. 1491, 2024; (13) HB 91, 2024; (14) UTENJA, 2022; (15) N.Y. Lab. Law §224-D; (16) S. 4006-C / A. 3006-C, 2023; (17) S. 305, 2024; (18) E.S.H.B. 2131, 2024; (19) E.S.S.B. 5949, 2024 • Created with Datawrapper

*NOTE: More information on the RPS portions of Maryland's (7) An Act Concerning Renewable Energy Portfolio Standard and Geothermal Heating and Cooling Systems (2024) law are provided in Table 7 below

Table 7: States with RPS, CES, or AEPS Inclusive of TENs Technologies

State	Type	Description	Key Agencies	Funding	Labor Standards?
Connecticut (1)	RPS	• Includes waste heat recovery systems that generate thermal energy from captured waste heat installed on or after April 1, 2007 under Class III renewable energy sources • Requires 4% of electric providers portfolios come from Class III sources	• Public Utilities Regulatory Authority	RECs	None
Maryland (2)	RPS	• Expands the RPS to include geothermal heating and cooling, heat from wastewater in Tier I renewable sources • Requires 50% of sales from Tier I renewable resources by 2030, with at least 1% from geothermal systems	• Public Service Commission • Department of Labor • Maryland Energy Administration	RECs	Requires companies installing geothermal systems with 360,000 British Thermal Unit capacity to provide the following to be eligible for meeting the RPS: family sustaining wages, employer-provided affordable healthcare, career advancement training, fair scheduling, employer-paid workers' compensation and unemployment insurance, a retirement plan, paid time off, and the right to collectively bargain. Additionally requires that a minimum of 10% of employees on the proejct are enrolled in a registered apprenticeship program
Massachusetts (3)	AEPS	• Includes "useful thermal energy" (direct heat, steam, hot water, or hot air for end usage), ground source heat pumps, deep geothermal heat exchange systems, and compost heat exchange as qualifying sources under the state's Alternative Energy Portfolio Standard. Note that ground source heat pumps are only eligible for APS Alterantive Energy Attributes when operating in heat mode. • Requires 5% of electrical energy sales to be from qualitifying alternative energy sources by 2020, with a 0.25% annual increase thereafter	• Massahcusetts Department of Energy Resources	Alternative Energy Certificates	None
Michigan (4)	RPS	• Includes thermal energy prodcued by geothermal heat pumps in definition of renewable energy resource. Note that such resources will only generate credits if they produce steam • Requires electric providers to achieve 15% renewable energy credit portfolios through 2029, 60% by 2035 and thereafter	• Public Service Commission	RECs	None
New Hampshire (5)	RPS	• Includes useful thermal energy "in the form of direct heat, steam, hot water, or other thermal form that is used for heating, cooling, humidity control, process use, or other valid thermal end use" in its definition of Class I renewable energy sources • Requires 15% of electricity providers' portfolios to be derived from Class I sources by 2025 and thereafter	• Department of Energy	RECs	None
New Mexico (6, 7)	RPS	• Includes "useful thermal energy" (direct heat, steam, hot water, or other thermal form for end usage) as a renewable energy resource for rural electric cooperatives • Requires 40% of a distribution cooperative's sales to be from renewable energy sources by 2025, 50% by 2030, and 80% by 2050	• Public Regulation Commission	RECs	None
North Carolina (8)	Clean Energy and Energy Efficiency Portfolio Standard	• Includes waste heat and geothermal in "Renewable Energy Resource" and "Combined heat and power system" definitions. Waste heat should be derived from renewable energy sources used to produce electricity or "useful" thermal energy as a renewable energy resource. • Requires 10% of retail sales to be from renewable energy resources for electric membership corportation or muncipalities that sell electric power by 2018 and 12.5% of retail sales to be from renewable energy resources for electric public utilites by 2021. However, portfolio standard requirements can only be met through electricity generation, reduced energy consumption, or electricity demand reduction. • Electric membership corporations or municipalities will need to meet 10% renewable energy retail sales threshold by 2018 abd threafter. This will need to be met through electricity generation, reduced energy consumption, or electricity demand reduction.	• North Carolina Utilities Commission	RECs	None

Ohio (9)	RPS	• Includes waste heat or other thermal resources under its definition of a qualitfying renewable energy resource • Requires 8.5% of electric distribution utilities' portfolios to be generated from renewable energy resources	• Public Utilities Commission	RECs	None
Vermont (10)	Renewable Energy Standard	• Establishes a Tier III "energy transformation" provision inclusive of additional distributed renewable generation or a net reduction of fossil fuel consumption and susbequent GHG emissions for utility customers, which can be applicable to heat pumps (Renewable Energy Vermont, n.d.) • Requires 12% of electricity providers' sales to consit of Tier III resources by 2032, unless the provider is a municipal electric utility for which the standard is 10.7% by 2032	• Public Utility Commission	RECs	None
Virginia (11)	RPS	• Establishes geothermal heating and cooling systems as an eligible renewable energy source under the RPS and to qualify for RECs • Requires 45% of electric energy sold from Phase I utilities to be from renewable energy sources by 2031 and 100% by 2045 • Requires 45% of electric energy sold from Phase I utilities to be from renewable energy sources by 2035 and 100% by 2050	• State Corporation Commission	RECs	None

Table: Reyna Cohen, MSc, Research and Policy Development Associate, Cornell ILR Climate Jobs Institute, rsc265@cornell.edu • Source: (1) Public Utilities Regulatory Authority, 2023; (2) Md. Code. Pub. Util. Comm'n. §7-701 et seq; (3) C.M.R. §16.01 et seq; (4) Clean and Renewable Energy and Energy Waste Reduction Act, 2023; (5) R.S.A. §§ 362-F:2-362-F:3; (6) N.M.S.A. §62-16-1 et seq; (7) N.M.S.A.§§62-15-34, 62-15-37; (8) N.C.G.S. §62-133.8; (9) Ohio Rev. Code §4928.64; (10) V.S.A. tit 30. §§8001-8006 ; (11) Va. Code §56-585.5 • Created with Datawrapper

Table 8: Implemented State Clean Heat Standards

State	Year Adopted	Description	Key Agencies	Funding	Labor Standards?
Colorado (1)	2021	• Requires all gas distribution utilities to submit clean heat plans to meet clean heat standards by January 1, 2024 • Requires a 4% emissions reduction compared to a 2015 baseline by 2025,22% by 2030. The Public Utilities Commission will be responsible for developping rules for clean heat standards after 2030	Public Utilities Commission	Clean Heat Credits	• Directs utilities to use their own employees to complete clean heat projects where practiciable • Requires that utility projects part of competitive solicitations and costing more thant $1,000,000 to provide information about the use of in-state versus out-of-state labor • Subjects any gas demand-side management projects and beneficial electrification projects to existing gas demand-side management and beneficial electrification labor standards, which: require residential customers to use licensed contractors when receiving rebates, require commericla or industrial customers in buildings 20,000 square feet or more to use contractors from a certified contractor list that participate in registered apprenticeship programs unless the work is done by utility employees when receiving rebates

Table: Reyna Cohen, MSc, Research and Policy Development Associate, Cornell ILR Climate Jobs Institute, rsc265@cornell.edu • Source: (1) C.R.S. §40-3.2-10 • Created with Datawrapper

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