February 29, 2024

The Honorable Brian Feldman
Senate Committee on Education, Energy, and the Environment
Senate Office Building
Annapolis, Maryland 21401

Chair Feldman, Vice Chair Kagan, and Members of the Education, Energy, and the Environment Committee:

On behalf of the Maryland Geothermal Association (MGA) I write in support of Senate Bill 570, Public Utilities – Thermal Energy Netwok Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act. The Maryland Geothermal Association MGA is a non-profit trade organization that was formed in 2013 in order to promote the development and installation of highly efficient geothermal heating and cooling systems for both residential and commercial applications.

Our association members believe that expanding the use of geothermal energy can assist the state in meeting its renewable energy goals as well as lead to significant job creation. Geothermal systems can provide constant baseline power. The earth's interior heat is consistent, allowing plants and systems to operate consistently regardless of weather or time of day. In addition, geothermal systems have lower emissions and are more efficient when compared to fossil fuels and other recognized forms of renewable energy because of the reliability and consistency the energy source utilized.

From an economic development perspective, increased geothermal capacity could support thousands of installation and construction jobs in Maryland. It is estimated that 4,300 direct geothermal industry jobs would be created per 500 Mega Watts of installed capacity. The ancillary benefits are also profound. Should Maryland invest in an enhanced geothermal industry, there is a potential for manufacturing and supply chain businesses to locate to the State. It is estimated that 2.5 indirect jobs may be created for each direct geothermal job.

Our association membership urges a favorable report.

Sincerely,

Adam Santry, President
Maryland Geothermal Association

Testimony - SB 570 - WARMTH - Favorable - UULM-MD-
Uploaded by: Ashley Egan
Position: FAV

Unitarian Universalist Legislative Ministry of Maryland

Testimony in Support
SB 570 - Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)

To: Chair Feldman and members of the
Education, Energy and the Environment Committee
From: Phil Webster, PhD
Lead Advocate on Climate Change
Unitarian Universalist Legislative Ministry of Maryland.
Date: February 29, 2024

The Unitarian Universalist Legislative Ministry of Maryland (UULM-MD) strongly supports **SB 570 - Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)** and urges a FAVORABLE report by the committee.

The UULM-MD is a statewide faith-based advocacy organization, with over 1,200 members, based on the Principles of Unitarian Universalism. Unitarian Universalists believe in *"justice and equity in human relations"* and "*respect for the interconnected web of all existence of which we are a part."*

This legislation would require each gas company to develop a plan for a pilot Thermal Energy Network System (TENS) in disadvantaged communities. TENS provides efficient, affordable and reliable clean energy heating and cooling to entire neighborhoods through a shared network of water pipes that transfer heat in and out of buildings. These distributed energy heating and cooling systems are one of the most promising climate solutions available to ensure a safe, equitable and just transition away from fossil fuels in buildings.

TENS, solves a wide array of community energy challenges, from lowering and stabilizing energy bills, to providing jobs for local utility workers, improving air quality, and increasing community safety and resilience.

TENS also creates, and maintains, local jobs by providing a pathway for utility fossil fuel workers to transition to clean energy using the skills they already have to install the networks.

TENS are based on electricity, not fossil fuels, providing a path to decarbonization of buildings as solar and wind generation comes on line. TENS systems provide 3-4 times the heat than combusting methane gas.

All Marylanders need bold and urgent action! Please keep us on the right and moral path towards a livable climate and a sustainable world. We owe it to our children.

We support this bill and urge a FAVORABLE report in committee.

Phil Webster, PhD

Lead Advocate, Climate Change UULM-MD

IBEW 410 Written Testimony SB 570.pdf
Uploaded by: Brian Terwilliger
Position: FAV

Local Union 410
International Brotherhood of Electrical Workers

February 28, 2024

Committee: Education, Energy, and the Environment

Testimony on SB 570 Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)

Position: In Support

Hearing Date: February 29, 2024 at 1:00PM

Good afternoon, Chairman Feldman and members of the Education, Energy, and the Environment Committee:

I would like to begin my written testimony by introducing myself and Local Union 410 of the International Brotherhood of Electrical Workers ("IBEW Local 410" or "the Union"). My name is Woodrow ("Woody") Jacobs, and I am the Business Manager and President for IBEW Local 410. I was appointed Business Manager/President/Financial Secretary on July 20, 2022.

IBEW Local 410 is a labor organization representing non-managerial utility workers at Baltimore Gas & Electric Company ("BGE"). The Union is the duly elected and recognized exclusive bargaining representative for approximately one-thousand four hundred (1,400) non-managerial employees of BGE, including its non-managerial employees in its five largest departments. Two of these departments are the Gas–Construction Maintenance & Repair department and the Gas–Emergency Response department.

As of November 27, 2023, six-hundred thirty-nine (639) workers were designated under BGE's Natural Gas department seniority roster. Of those workers, three-hundred and sixty-nine (369) had an occupation seniority date of or after January 1, 2014. Currently BGE's retirement age is sixty-two years (62) old with thirty-five (35) years of service. What this means is that these three-hundred sixty-nine (369) workers need to have an additional thirty-five years (35) of service at BGE in order to retire.

These one-thousand-four hundred (1,400) workers, also called bargaining unit employees ("BUEs"), are among those who contribute daily, directly, and significantly to BGE's efforts to provide safe and reliable service to its customers.

These workers are also fellow members of our community. Unlike contracted laborers who are typically part of a transitory workforce who travel from job to job, these workers are those who live in Maryland, own or aspire to own homes here, and raise their families in our community.

These workers are covered by a current collective bargaining agreement between IBEW Local 410 and BGE which was ratified on March 1, 2023, and will remain in effect for the following six (6) years.

IBEW Local 410 supports SB 570 as an adherence to federal policy supporting and encouraging collective bargaining. Specifically, federal policy is expressly articulated in 29 U.S.C. § 151, which provides as follows:

> The denial by some employers of the right of employees to organize and the refusal by some employers to accept the procedure of collective bargaining lead to strikes and other forms of industrial strife or unrest, which have the intent or the necessary effect of burdening or obstructing commerce by (a) impairing the efficiency, safety, or operation of the instrumentalities of commerce; (b) occurring in the current of commerce; (c) materially affecting, restraining, or controlling the flow of raw materials or manufactured or processed goods from or into the channels of commerce, or the prices of such materials or goods in commerce; or (d) causing diminution of employment and wages in such volume as substantially to impair or disrupt the market for goods flowing from or into the channels of commerce.
>
> The inequality of bargaining power between employees who do not possess full freedom of association or actual liberty of contract, and employers who are organized in the corporate or other forms of ownership association substantially burdens and affects the flow of commerce, and tends to aggravate recurrent business depressions, by depressing wage rates and the purchasing power of wage earners in industry and by preventing the stabilization of competitive wage rates and working conditions within and between industries.
>
> Experience has proved that protection by law of the right of employees to organize and bargain collectively safeguards commerce from injury, impairment, or interruption, and promotes the flow of commerce by

> removing certain recognized sources of industrial strife and unrest, by encouraging practices fundamental to the friendly adjustment of industrial disputes arising out of differences as to wages, hours, or other working conditions, and by restoring equality of bargaining power between employers and employees.
>
> Experience has further demonstrated that certain practices by some labor organizations, their officers, and members have the intent or the necessary effect of burdening or obstructing commerce by preventing the free flow of goods in such commerce through strikes and other forms of industrial unrest or through concerted activities which impair the interest of the public in the free flow of such commerce. The elimination of such practices is a necessary condition to the assurance of the rights herein guaranteed.
>
> It is hereby declared to be the policy of the United States to eliminate the causes of certain substantial obstructions to the free flow of commerce and to mitigate and eliminate these obstructions when they have occurred by encouraging the practice and procedure of collective bargaining and by protecting the exercise by workers of full freedom of association, self-organization, and designation of representatives of their own choosing, for the purpose of negotiating the terms and conditions of their employment or other mutual aid or protection.

The plain language of this statute provides that it is federal policy to encourage the practice and procedure of collective bargaining and it enumerates the multiple benefits of this recognized practice to the free flow of commerce.

Here, SB 570 furthers this policy by (1) mandating a community benefit agreements that promotes a labor relations approach that ensures workers are free to organize and collectively bargain, *see* SB 570 § 7-1001(D), (2) requiring the implementation plan include explanation of how the gas company met with certified representatives of BUEs, *see* SB 570 § 7-1002, and (3) instructing electric, gas, and/or water companies to work with its existing BUE units to complete the front-of-meter projects relating to the construction of the thermal energy network system, and to the extent work is outsourced to a contractor, *see* SB 570 § 7-1004.

IBEW Local 410 and BGE's working relationship is itself a testament to the benefits of collective bargaining. While by no means perfect, the relationship between Local 410 and BGE is mature and stable. When disputes pertaining to the parties' contracts do arise between Local 410 and BGE, such disputes are generally resolved through the parties' grievance and arbitration procedures, and such resolutions are final and binding on the parties. When a collective bargaining agreement is set to expire, rather than ultimately engaging in a show of economic force and counterforce, the parties have sat down and negotiated a new agreement in a constructive manner. Such an agreement, once reached, is the product of good-faith bargaining, characterized by give-and-take exchanges, proposals, and counter proposals between the parties; that is the hallmark of collective bargaining under the National Labor Relations Act.

These benefits are also captured in 29 U.S.C. § 151 and sought by SB 570 in § 7-1001(D)(III)(1)–(6). In IBEW Local 410's estimation, the importance of strong and stable relationships between public service corporations and their employees and contracted labor cannot be overstated. IBEW Local 410 is happy to see that SB 570 further supports these sorts of relationships.

SB 570 will ensure a transition to thermal energy system(s) and accompanying residential electrification that protects worker rights by promoting stable labor relations. Protecting the local workforce who contribute daily, directly, and significantly to safe and reliable gas service to customers is paramount to Maryland's infrastructure. For these reasons, IBEW Local 410 supports the passage of SB 570.

Sincerely,

Woodrow Jacobs
IBEW Local 410
Business Manager/President/Financial Sec'y

SB 570 Public Utilities – Thermal Energy Network S

Uploaded by: Cait Kerr

Position: FAV

The Nature Conservancy
Protecting nature. Preserving life.

The Nature Conservancy
Maryland/DC Chapter
425 Barlow Pl., Ste 100
Bethesda, MD 20814

tel (301) 897-8570
fax (301) 897-0858
nature.org

Thursday, February 29, 2024

TO: Brian Feldman, Chair of the Senate Education, Energy, and the Environment Committee; and Committee Members
FROM: Mariana Rosales, The Nature Conservancy, Director of Climate; Cait Kerr, The Nature Conservancy, State Policy Manager
POSITION: Support SB 570 Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)

The Nature Conservancy (TNC) supports SB 570 offered by Senator Hester. This bill is a strategic investment in Maryland's future, particularly in our commitment to promoting equitable access to renewable energy and addressing climate change.

The WARMTH Act provides a unique opportunity to pilot networked geothermal heating and cooling systems, also known as ground-source heat pumps (GHPs), in Maryland. These systems use the ground's temperature to heat or cool buildings, making them highly efficient and reliable. By promoting GHPs' use, the WARMTH Act will contribute to reducing greenhouse gas emissions and help Maryland achieve our climate action goals.

This legislation is designed to ensure that renewable energy benefits are accessible to all Maryland residents, especially those in underserved and low- to moderate-income communities. The bill requires gas companies to work with community organizations, municipalities, and county governments to identify and propose pilot projects to the Public Services Commission (PSC). These pilot projects will prioritize neighborhoods with 80% low- and moderate-income residents, contributing to equitable and just electrification. Networked geothermal creates opportunities for whole communities to benefit from electrification through a single geothermal system, which would connect to heat pumps in individual homes.

The WARMTH Act aligns with Maryland's statutory requirements to reduce greenhouse gas emissions and transition to a net-zero status. Maryland has a statutory requirement under the Climate Solutions Now Act of 2022 to reduce gas emissions to 60% of 2006 levels by 2031 and the state is further required to transition to a net-zero status by 2045. By promoting the use of GHPs, this bill supports Maryland's ambitious climate action plan and helps the state move towards a more sustainable and resilient future.

TNC commends Senator Hester for introducing SB 570, which is a critical step towards achieving Maryland's climate and energy goals, while focusing on equity and access to renewable energy sources for all residents.

Therefore, we urge a favorable report on SB 570.

SB0570_WARMTH_Act_MLC_FAV.pdf
Uploaded by: Cecilia Plante
Position: FAV

MARYLAND LEGISLATIVE COALITION

TESTIMONY FOR SB0570
Public Utilities - Thermal Energy Network Systems - Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)

Bill Sponsor: Senator Hester
Committee: Education, Energy and Environment
Organization Submitting: Maryland Legislative Coalition
Person Submitting: Aileen Alex, co-chair
Position: FAVORABLE

I am submitting this testimony in favor of SB0570 on behalf of the Maryland Legislative Coalition. The Maryland Legislative Coalition is an association of activists - individuals and grassroots groups in every district in the state. We are unpaid citizen lobbyists, and our Coalition supports well over 30,000 members.

Maryland needs a variety of energy sources to achieve its ambitious statutory requirement to reduce greenhouse gas emissions to 60% of 2006 levels by 2031. Geothermal systems offer a super-efficient, inflation resistant, reliable way to heat and cool buildings. These systems can be constructed today. They are a proven, carbon-free technology that can minimize additional electric demand on the grid.

However, individual geothermal heat pumps are significantly more expensive than other choices, with a 5 to 10 years payback. By networking a neighborhood, savings result from sharing the costs of the boreholes and also sharing the waste heat generated in local businesses. SB0570 would create pilot projects and gather experience and data to assess how well networked geothermal systems will work in different areas in Maryland.

Our members strongly support clean, renewable energy and we believe that putting geothermal in the energy mix is a positive step in reducing Maryland's reliance on dirty energy.

We support this bill and recommend a **FAVORABLE** report in committee.

Takoma Park 2024 - SB 570 FAV - WARMTH Act - Senat

Uploaded by: Cindy Dyballa

Position: FAV

CITY TAKOMA OF PARK
MARYLAND

<u>Support Senate Bill 570</u>
Public Utilities – Thermal Energy Network Systems – Authorization and Establishment – WARMTH Act
Senate Education, Energy, and the Environment Committee
February 29, 2024

The City of Takoma Park supports and urges favorable consideration of this bill. This bill will pilot networked geothermal systems in Maryland, through gas companies working in partnership with community groups and local governments to identify and propose pilot projects to the Public Services Commission (PSC).

The City of Takoma Park is a densely developed, largely residential municipality of almost 18,000 people living within 2.4 square miles in Montgomery County. About half our residents are homeowners and half renters, with a wide range of incomes and a significant number of energy cost-burdened homeowners and renters.

Like communities across Maryland, Takoma Park is keenly aware that we must move ahead rapidly, and on many fronts, to meet our local, county and state greenhouse gas emissions goals. Many of our residents, especially lower income homeowners and small multifamily building owners, simply do not have the resources to consider geothermal on their own.

To that end, this bill provides a way to identify and pilot the installation of networked geothermal systems where they can be most effective. New York and Massachusetts have already started similar programs.

This bill will help us meet our city, county and state greenhouse gas emissions goals, as well as city climate, housing, and equity goals and priorities. By focusing on neighborhoods within underserved and overburdened communities, and on networked rather than individual geothermal systems, this bill supports the city's equity goals and allows a wider range of residents to receive the benefits of efficient, electrified heating.

In sum, the City of Takoma Park supports SB 570 and encourages a favorable committee vote.

City Contact: Talisha Searcy, Mayor
talishas@takomaparkmd.gov

Testimony SB570 Geothermal Networked Systems Final

Uploaded by: Debbie Cohn

Position: FAV

Committee: **Education, Energy and the Environment**
Testimony on: **SB570 –Public Utilities – Thermal Energy Network Systems – Authorization and Establishment -Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act**
Submitting: **Deborah A. Cohn**
Position: **Favorable**
Hearing Date: **February 29, 2024**

Dear Chair and Committee Members:

Thank you for allowing my testimony today in support of SB570.

Maryland has committed to reducing greenhouse gas emissions (GHGs) to 60% of 2006 levels by 2031 and transitioning to a net-zero economy by 2045. Doing so will require major reductions in emissions arising from heating and cooling buildings.

Geothermal heating and cooling systems (ground source heat pumps or GHPs) generate significantly less GHGs than gas or electric resistance equipment and even less than air-source heat pumps. The U.S. Department of Energy estimates that GHPs "can reduce energy consumption and emissions up to 44% compared to air-source heat pumps and 72% compared to standard air-conditioning equipment." GHPs require less energy than air-source heat pumps because, for both heating (including in water heaters) and cooling, GHPs use heat extracted from boreholes 300-500 feet below ground (50-60^{o} F, year-round) rather than from the ambient air (typically, in Maryland, midwinter lows in the low- to mid-20s and mid-summer highs in the mid-to-upper 80s). The difference between geothermal and desired building temperatures is much smaller than the difference between ambient air and desired building temperatures.

Problem: While geothermal heat pumps are a well-tested technology,[1] and their use in districts, such as universities, is spreading,[2] their use in networked systems to heat small neighborhoods is more recent.[3] Pilot projects can be useful to demonstrate proof of concept and identify program design improvements.

Solution: SB570 would create pilot projects and gather information to assess how well networked geothermal systems will work in different areas in Maryland.

Each natural gas utility would be required to develop one or two pilot thermal energy projects to replace gas infrastructure with a thermal energy network system. The gas companies would work with community organizations and local governments to identify projects and would build and manage the

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[1]https://www.montgomeryschoolsmd.org/siteassets/district/departments/facilities/sustainability/geothermal_green-features.pdf

[2] https://www.nytimes.com/2024/01/23/climate/geoexchange-climate-colleges-heat.html?searchResultPosition=2;

[3] Maryland would not be the first state to pilot thermal energy networked systems using geothermal heat pumps. Colorado, Massachusetts, Minnesota and New York have passed laws that allow or mandate gas utilities to undertake thermal energy network pilot projects. Illinois, Maine, Vermont and Washington are exploring similar laws. https://energynews.us/2024/01/18/new-york-will-replace-gas-pipelines-to-pump-clean-heat-into-buildings/

projects approved by the state Public Service Commission (PSC). The pilot projects would have to be in neighborhoods with at least 80% low- and moderate-income residents, with priority given to overburdened and underserved communities. The gas companies would need to seek federal funding for their pilots and propose a rate structure ensuring that participating customers do not pay more for utilities than if they had not participated. The gas companies would also need to collect data to help the state evaluate the pilot program.

Because SB570 enables low- and moderate-income residents to replace gas appliances with GHPs and other efficient electric appliances at no cost to themselves, it protects them from bearing the increasing costs of stranded assets, *i.e.*, gas infrastructure that would serve fewer users as more consumers shift from gas to electricity and the economy becomes decarbonized.[4] SB570 would also protect the jobs, wages and benefits of gas company workers who could use their skills to install and service the pipelines needed by the geothermal heat pump system and would promote use of workers and small businesses in the impacted area to implement some of the changes required within buildings. And, to the extent that behind-the-meter energy conservation upgrades and substitution of highly efficient electric appliances reduce the demand for electricity, SB570 would reduce the need for costly upgrades to the electric grid.[5]

Because of the promise of significant reductions in the use of natural gas and electricity, an equitable transition for gas companies and their workers, provisions to support impacted residents and businesses, and the potential to reduce the need for investments in the electric grid, I urge a **FAVORABLE** report for SB570 in committee.

Thank you.

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[4] Decarbonizing the economy implies significantly reducing use of methane gas. By 2045, *i.e.*, in 21 years, most existing gas pipeline infrastructure becomes a stranded asset.

[5] US Department of Energy research has found that installing geothermal heat pumps in nearly 80 percent of U.S. homes could reduce the costs of decarbonizing the grid by 30 percent and avoid the need for 24,500 miles of new transmission lines by 2050.

Nature Forward -SB570 - FAV.pdf
Uploaded by: Denisse Guitarra
Position: FAV

February 28, 2024,

Written testimony for SB570 – Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)[1]

nature forward
Connecting people and nature in the Capital Region
natureforward.org

Position: Favorable

Submitted by: Denisse Guitarra, MD Conservation Advocate, Nature Forward

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Dear Members of the House Economic Matters Committee,

Nature Forward is the oldest independent environmental organization in the DC metropolitan region. For 126 years, Nature Forward has inspired residents of the greater Washington, DC, area to appreciate, understand, and protect their natural environment through environmental education, advocacy, and outdoor experiences. In our conservation advocacy we prioritize human health & access to nature, biodiversity & habitats, fighting the climate crisis, and sustainable land use. We strongly support passage of **SB570 (WARMTH) Act**.

The recently published "Maryland's Climate Pollution Reduction Report" states that the buildings sector is the largest consumer of electricity in the state of Maryland.[2] By enacting SB570, Maryland will tackle and reduce one of its largest sectors currently producing the largest number of greenhouse gas emissions. This bill will also be aligned and with and help Maryland reach its climate reduction goal of reducing greenhouse gases by 60% of its 2006

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[1] Available at: https://mgaleg.maryland.gov/mgawebsite/Legislation/Details/SB0570?ys=2024RS
[2] Maryland's Climate Pollution Reduction Report. Dec 2023. Page 34. Available at: https://mde.maryland.gov/programs/air/ClimateChange/Maryland%20Climate%20Reduction%20Plan/Maryland%27s%20Climate%20Pollution%20Reduction%20Plan%20-%20Final%20-%20Dec%2028%202023.pdf

levels by 2031 and 100% by 2035.[3] By increasing geothermal energy, we would also be electrifying the grid, Maryland will lead the way towards relying the use of fossil fuels and instead focus on using clean renewable energy.

Furthermore, SB570 if enacted, will designate money from the Inflation Reduction Act to install running, networked geothermal systems to heat and cool buildings and homes in target low- and moderate-income homes and under-resourced communities. This will then mean that we will be able to fill the climate gap and make clean energy sources like geothermal energy more available to more people especially those that cannot afford the expensive clean energy transition. Additionally, this bill will help start a pilot to electrify low-income homes so that they are no longer reliant on gas.

SB570 merits support because it makes use of the now available IRA funds to ensure and establish greater access to geothermal energy which is a renewable source of energy. On behalf of Nature Forward and our 28,000 members and supporters, we recommend that the Committee **SUPPORTS SB570.** Thank you for your time and consideration.

Sincerely,

Denisse Guitarra

MD Conservation Advocate

Nature Forward

[3] Maryland's Climate Change Program. Available at: https://mde.maryland.gov/programs/air/ClimateChange/Pages/index.aspx

CLPP_testimony_SB570_FAV.pdf
Uploaded by: Donald M. Goldberg
Position: FAV

Climate Law & Policy Project

3405 Shepherd St. Chevy Chase, MD 20815
202-390-3050
www.clpproject.org
Contact: donald@clpproject.org

Committees: Economic Matters
Testimony on: SB0570 Public Utilities – Thermal Energy Network Systems – Authorization and Establishment – (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)
Organization: Climate Law & Policy Project
Submitted by: Donald M. Goldberg, Executive Director
Position: Favorable
Hearing Date: February 29, 2024

Climate Law & Policy Project strongly supports SB0570.

Decarbonization of Maryland's building stock is a vital part of the state's climate efforts, and networked geothermal systems provide an exciting and promising opportunity to help accomplish that task. Networked geothermal systems can provide 24/7/365 renewable, non-emitting heating and cooling to buildings. They also provide an avenue for natural gas utilities' workforce to apply much of their existing skill sets and expertise in ways that accelerate decarbonization. Requiring each gas company in the state to undertake one or two pilot projects is a good way to ensure these companies gain the knowledge and experience needed to potentially expand deployment of this promising technology.

Another important aspect of this bill is its requirement that gas company pilot proposals ensure that 80% of the customers are from low- or moderate-income (LMI) housing. As more buildings electrify, there will be fewer remaining on gas heat, and those who remain will be responsible for bearing the cost of maintaining the gas system infrastructure. Without concerted efforts, it will likely be the more well-off homes and buildings that make the investments to switch to non-emitting heating options, leaving those with the greatest energy burdens and least financial ability with the escalating costs of the gas system. Focusing the networked geothermal pilot projects on LMI customers can be one important part of helping them avoid bearing the burdensome costs of gas infrastructure.

CLPP urges this Committee to issue a favorable report on SB0570.

SB 570 - Public Utilities – Thermal Energy Network
Uploaded by: Donna Edwards
Position: FAV

MARYLAND STATE & D.C. AFL-CIO
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Secretary-Treasurer
Gerald W. Jackson

SB 570 - Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)
Senate Education, Energy, and the Environment Committee
February 29, 2024

SUPPORT

Donna S. Edwards
President
Maryland State and DC AFL-CIO

Chairman and members of the Committee, thank you for the opportunity to provide testimony in support of SB 570. My name is Donna S. Edwards, and I am the President of the Maryland State and DC AFL-CIO. On behalf of the 300,000 union members in the state of Maryland, I offer the following comments.

SB 570 creates a pilot program for rolling out networked geothermal heating and cooling systems in Maryland while structuring the program in a way to provide maximum economic benefits to the state, ratepayers, and workers. SB 570 requires gas companies operating in Maryland to begin plans on at least one pilot project, by October 1, 2024, for networked geothermal in partnership with local governments and community organizations. SB 570 includes labor standards that maximize opportunities for receiving federal tax credits under the Clean Energy Financing Program and Greenhouse Gas Reduction Fund from the Inflation Reduction Act of 2022. SB 570 takes tangible steps towards experimenting with new opportunities for clean energy while utilizing the state's existing skilled workforce and a pipeline of new skilled tradespeople through apprenticeship opportunities.

Networked geothermal projects use the benefits of geothermal heating and cooling systems, where ground source heat pumps and boreholes transfer thermal energy into or out of buildings, and the cost savings from economies of scale. This means that networked geothermal energy projects benefit dozens of families or whole neighborhoods instead of requiring a piecemeal house by house rollout. Eversource, an energy and gas utility in New England, began constructing their 37 building pilot program in Framingham, Massachusetts last year.[1]

Through community benefit agreements for qualified contractors and work done with the Maryland Environmental Service, Maryland can gain the full advantages of these projects, with jobs going to local residents, apprenticeship training opportunities, and timely completion of projects. New pilot projects will create magnitudes more good paying, high quality climate jobs. Ratepayers will be investing directly into Maryland's economy.

[1] Nicole Garcia. "A new geothermal project in Framingham may be the future of home heating." WGBH. July 26, 2023.

Maryland’s fragile grid needs geothermal energy. By using geothermal energy and heat pumps, it prevents the full electrical load of heating and cooling from falling directly onto the grid. Our state’s approach to transitioning away from fossil fuels should be building abundant clean and renewable energy sources, not to continuously subsidize the high energy bills of a larger and larger share of Maryland’s residents. Maryland Matters reported that, “A study on SEIF funds for FY 21 showed that 52% of the proceeds went to energy bill assistance programs in Maryland, whereas for the RGGI states overall just 15% of the funding went to bill assistance. In Maryland, 20.5% of the funds went to energy efficiency programs, compared to 54% of funding going to energy efficiency in all the RGGI states collectively.” With SB 570 we have an opportunity to directly incentivize new energy creation and decrease the number of workers that need energy subsidies by requiring quality job standards.

We urge a favorable report on SB 570.

SB0570_Favorable_PSC..pdf
Uploaded by: Frederick Hoover
Position: FAV

STATE OF MARYLAND

PUBLIC SERVICE COMMISSION

February 27, 2024

Chair Brian J. Feldman
Education, Energy, and the Environment Committee
2 West, Miller Office Building
Annapolis, MD 21401

RE: **SB 570 – Favorable - Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)**

Dear Chair Feldman and Committee Members:

SB570 proposes to establish a program in Maryland which explores whether heat pump technology could be used in combination with a utility-owned network of heat exchange pipes to provide a cost-effective alternative to natural gas service or an alternative form of electrification. As proposed, each gas company, using community input, would propose to the PSC, one or more demonstration projects to examine whether this technology could achieve environmental, social, and economic goals as a substitute for natural gas distribution systems. The purpose of the pilot program would examine if such a utility-owned system is in the public interest. There are numerous areas of investigation, including the applicability of geothermal systems to distinct types of housing, e.g., single family, or multi-family buildings, and a series of required community benefits.

If the legislation is enacted, the Public Service Commission anticipates the need for consulting services, as envisioned in the proposed legislation at PUA§7-1006, and will require two additional employees. These needs are driven by timelines within the legislation and to establish in-house expertise for the pilots and the permanent programs, if approved.

Section 7-1002(b)(6)(v) requires that the gas companies determine how the pilot system avoids costs for electric distribution and transmission systems that would otherwise occur with electrification using air-source heat pumps. Gas companies may not have access to the data needed to estimate avoided costs. Electric companies may have data that would enable estimates to be developed, but making use of that data would require gas companies to coordinate with

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electric companies in a new manner. Participating gas companies must be prepared to coordinate with their electric utility counterparts to ensure a successful pilot program.

As has been demonstrated in other energy pilot programs coordinated by the Public Service Commission, community engagement is a critical component of a successful pilot program. In Massachusetts, community groups were the genesis for the development of that State's programs. Because the installation of a thermal energy network system will require the coordination and cooperation of many citizens, a strong community commitment will be vital to the success of a pilot program. The language of SB 570 emphasizes that importance.

The thermal energy network systems to be developed after the enactment of SB 570 have the potential to make great progress towards the attainment of the State's climate goals. The State will be able to look to other jurisdictions already standing up these projects and gain critical knowledge. The Public Service Commission will have an important role in determining the viability and prudency of these projects and the impacts of them on the ratepayers of Maryland. I request a favorable report on SB 570. Please direct any questions to Christina Ochoa, Director of Legislative Affairs, at christina.ochoa1@maryland.gov

Sincerely,

Frederick H. Hoover, Chair
Maryland Public Service Commission

SB 570 - MoCo DEP - Fitzgerald_FAV (GA 24).pdf
Uploaded by: Garrett Fitzgerald
Position: FAV

Montgomery County
Office of Intergovernmental Relations

ROCKVILLE: 240-777-6550 **ANNAPOLIS: 240-777-8270**

SB 570 **DATE: February 28, 2024**

SPONSOR: Senator Hester

ASSIGNED TO: Education, Energy, and the Environment Committee

CONTACT PERSON: Garrett Fitzgerald (garrett.fitzgerald@montgomerycountymd.gov)

POSITION: Favorable (Department of Environmental Protection)

Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)

This legislation meets a critical need in the State's efforts to reduce climate pollution in a manner that is safe, healthy, and cost-effective for Maryland residents.

This bill would require each gas utility company to develop and submit to the Maryland Public Service Commission (PSC) a plan to pilot an alternative approach to provide heating services to customers without burning natural gas. The PSC will review these plans for cost-effectiveness and authorize appropriate pilots. The bill establishes requirements to ensure that projects are constructed with fair labor standards and primarily benefit low-to-moderate income residents.

Networked geothermal heating systems may represent a critical opportunity for gas utilities to maintain their status as providers of heating services while playing a key role in Maryland's clean energy transition away from fossil fuel combustion. The pilot project planning and implementation envisioned by this bill would offer a valuable learning opportunity for the utilities, PSC, and other stakeholders about the potential for networked geothermal projects to play a major role in that transition. Importantly, while aspects of these networked energy systems will require some learning by the gas utilities, the technology involved is well-established, and participating pilot neighborhoods will benefit.

Montgomery County appreciates that the bill authorizes counties and community organizations to suggest pilot areas, and that funding would be provided to enable community organizations to support project planning. Participants would not be on the hook to pay for the equipment and would not experience an increase in utility rates. The bill would allow community members the option to opt out of participating in the pilot.

We support this innovative concept, and respectfully request that the Education, Energy, and the Environment Committee issue a favorable report for Senate Bill 570.

SB570 WARMTH ACT-L. Charkoudian.pdf
Uploaded by: Gerald Jackson
Position: FAV

PLUMBERS AND STEAMFITTERS
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Founded 1889

Education, Energy, and the Environment Committee
To: Chairman Feldman, Vice Chair Cheryl Kagan and Committee Members
Position: Support SB570

My name is Gerald Jackson. I am the Assistant Business Manager for Plumbers & Steamfitter's Local union 486 representing **2500** members, I am also the Secretary- Treasurer for the Maryland State and D.C. AFLCIO representing **300,000** workers and I am a board member for the Maryland Climate Change Commission.
I strongly support **SB570.**

As a Steamfitter who has worker in the construction industry for 43 years, I have seen the decimation of the fossil fuel energy sector. A large portion of our work has transitioned to "Clean Energy" and we are ready to accept the challenge. Geo-Thermal Energy is a sensible option for heating and cooling that eliminates Carbon Emissions. With a mandate to attain full electrification by 2041, which I personally believe is un-attainable, Geothermal Energy is needed to achieve the goals set by the state of Maryland. **SB570** provides a detail plan that Includes language for safe installation, labor peace, MBE participation and Labor Standards which help to facilitate the good paying jobs lost as a result of the emergence of the "Green Energy Sector". We need legislation that promotes good paying jobs, apprenticeship training and a pathway to the middle class.

This is common sense legislation that I believe we all can agree with.
For these reasons I'm asking for a favorable report for SB570.

Respectfully Submitted

Gerald W. Jackson
Assistant Business Manager Plumbers & Steamfitter's Local 486
Secretary- Treasurer Md. State & D.C. AFL-CIO

WARMTH Act Senate Testimony_Rewiring America.pdf
Uploaded by: Jamal Lewis
Position: FAV

February 29, 2024

Honorable Brian Feldman, Chair
Education, Energy, and Environment Committee
2 West
Miller Senate Office Building
Annapolis, Maryland 21401

Re: SB 0570, Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act

Dear Chair Feldman and Members of the Education, Energy, and Environment Committee:

Good afternoon Chair Feldman and committee members, for the record, my name is Jamal Lewis, and I am a Director of Implementation Learning and Integration for Rewiring America, the leading electrification nonprofit working to help families and communities achieve energy efficiency, improve health, and save money while tackling nationwide emission goals. I'm also writing to you today as a member of the Maryland Commission on Climate Change's (MCCC) Mitigation Working Group (MWG). Thank you for the opportunity to provide testimony. Today, we urge a favorable report on SB 0570, which would promote better buildings in Maryland.

Thanks to the efforts of the General Assembly, we have a nation-leading requirement to reduce greenhouse gas emissions by 60% by 2031 and net-zero by 2045. According to Maryland's Climate Pathway Report, electrification is essential to achieving these climate goals and the path includes a zero-emission appliance standard that would cover space and water heating, zero-emissions construction standard covering all new residential and commercial buildings, and strengthened energy efficiency standards. This translates to the rapid electrification of both the residential and commercial building sectors so that by 2045 electricity accounts for 83% and 94% of the energy consumption in residential and commercial buildings, respectively.

The good news is that there are currently clean, electric versions of these machines available on the market today. When it comes to heating and cooling, heat pumps are the gold standard. Heat pumps are 2-4x more efficient than gas furnaces and do not emit- health-harming pollutants. In particular, geothermal heat pumps, especially when connected to a networked system, are the most efficient, produce the least amount of GHG emissions, generate the most energy savings, and reduce energy usage and peak demand the most. Though the benefits are immense, these technologies can be more difficult to access given the high upfront costs. Still, these technologies are well worth the investment. Residential energy use can be cut in half, investments in expensive energy generation can be prevented by minimizing peak demands, and energy bill savings can be maximized due to efficiency, lower utility investments, and peak demand costs.

As we push to electrify everything in Maryland, it is critical that we are maximizing GHG emissions reduction while also minimizing energy bills, especially for low-and-moderate income households in the state. The right mix of geothermal heat pumps connected to networked systems can enable these benefits. In passing SB 0570, this body recognizes that reality and would be taking necessary action. We urge a favorable report on SB 0570 and help Maryland communities move closer to a more resilient, healthier, and cleaner future. I am available for any questions.

Thank you,

Jamal Lewis
Director of Implementation Learning & Integration
Rewiring America

IPL-DMV Testimony for SB 570 FAVORABLE (1).pdf
Uploaded by: Joelle Novey
Position: FAV

Testimony Supporting SB 570
Senate Education, Energy, and the Environment Committee
February 29, 2024

Position: Favorable

Dear Chair Feldman, Vice Chair Kagan, and Members of the Committee,

Interfaith Power & Light (DC.MD.NoVa) is a grassroots organization working directly with religious communities of many faiths as we respond to the climate crisis. In Maryland, our organization has relationships with over 900 congregations across the state. We are called by our different faith traditions to use our voice in protection of our common home.

Our breath connects us to each other and to life. Our faith communities understand that our breath is for singing praise — not for breathing soot and pollution. This session we are using our breath to speak out for a safer, cleaner, and more efficient future. **We respectfully request a favorable report on SB 570, the Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act.**

The WARMTH Act would create pilot projects of super-efficient and reliable neighborhood geothermal systems, leveraging incoming federal funds and existing infrastructure. Network geothermal unlocks dramatic energy efficiency improvements by having multiple homes and buildings working together. The rights of way already have conduits for gas pipes that are ready and available for network geothermal pipes.

The pilot projects created by this bill will be aimed at equitable and just electrification by requiring they be in neighborhoods with 80% low- and moderate-income residents. As we work towards the state's climate goals to reduce climate pollution, we must prioritize overburdened and underserved communities by removing cost barriers to healthier homes. The technology behind neighborhood geothermal heating is efficient, reliable, and can be constructed today. This is an already proven technology that will moderate additional electric demand on the grid.

This bill will preserve family-sustaining jobs for gas workers. Labor standards in this bill prioritize maintaining work for those who work on gas infrastructure and ensure prevailing wages for construction on the projects. Underground pipes are similar regardless of what they are carrying; skilled workers who lay gas pipe can also lay geothermal pipe. We welcome the several unions supporting this bill, and affirm the need to ensure job security for gas system workers in a new clean energy future.

The WARMTH Act aligns with the state's aggressive climate action plans. Maryland has a statutory requirement to reduce climate pollution to 60% of 2006 levels by 2031 and the state is further required to transition to net-zero status by 2045. Meeting these targets is imperative to sustaining our common home and caring for our neighbors. Our faith communities across the state are already working together to care for our common home and neighbors, for this reason **Interfaith Power & Light (D.C.MD.NoVa) respectfully requests a favorable report on SB 570, the Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act.**

We are documenting the harms of burning gas in our homes.

In the low and moderate income communities where Interfaith Power & Light (DC.MD.NoVA) and Action in Montgomery (AIM) are working, there is a groundswell of families eager to get their homes off gas.

They understand the harms of gas-burning because they're measuring the pollution themselves.

For well over a year, Adama Harouna and colleagues have measured NO2 in over three hundred kitchens at Cider Mill Apartments in Gaithersburg, Enclave high rises in White Oak, and in Northwest Park's garden-style apartments.

Over and over again, we find that when their stoves are on, these Marylanders are routinely exposed to levels of nitrogen oxide indoors exceed the EPA's outdoor standard, raising concerns about asthma and the many other respiratory problems exacerbated by gas stove pollution.

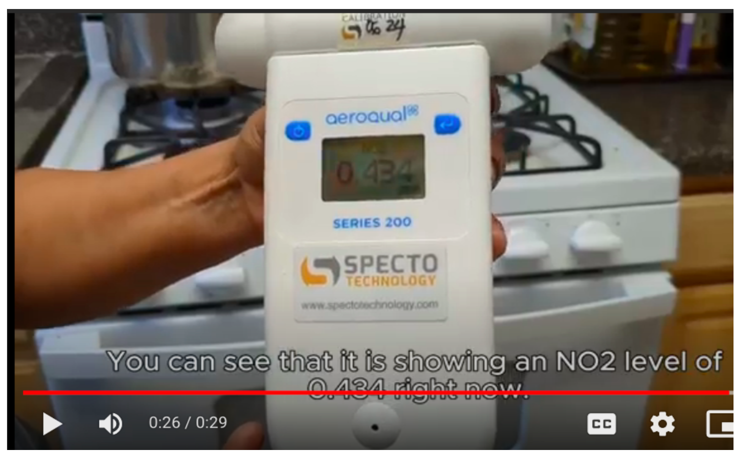
These communities want to provide healthy homes for their loved ones, and they see the gas-burning appliances they're stuck with as an obstacle to that goal. If the WARMTH Act pilot offers these families a chance to shift to healthier, more efficient, all-electric equipment, they would sign up! Let's get this done.

On December 5th, Lorena Joya and Ana Argueta delivered the following remarks (in Spanish) at Good Hope United Methodist Church in Silver Spring before a gathering of nearly 400 Marylanders convened by Action in Montgomery, People Acting Together in Howard, Interfaith Power & Light (DC.MD.NoVA), and Maryland Sierra Club:

Good evening. I am Ana Argueta. I am a mom to three children and I have been organizing other parents and renters to improve our schools and our community.
Good evening. I am Lorena Joya. I am a mother, part of the South Lake PTA, and Safe Places.

We are here for three reasons:
I have learned that using a gas stove I am poisoning my home and my lungs with NO2.
Using a gas stove and gas-powered HVAC, I am also contaminating the environment.
Not using methane gas will avoid the risk of both explosions and pollution.

We took a video of doing the NO2 testing at Ana's apartment. Let's watch: "Hello, I am Ana Argueta. I live in Silver Spring. This is my stove, which I turned on 20 minutes ago. This is an NO2 meter. You can see that it is showing an NO2 level of 434 parts per billion."



The U.S. Environmental Protection Agency says that outdoor levels of NOx above 100 parts per billion are dangerous for our health. And what we measured inside my home was more than four times what the EPA says is healthy.

The NO2 in my home is not unique. We have measured NO2 levels in over 200 apartments and homes,and we have measured very high levels. I invite our guests to raise the papers with the NO2 tests. The red papers are measurements we took [in homes in Montgomery County, Maryland] that were higher than what the EPA recommends for outdoors.

Many children who live in older apartment buildings have asthma. NO2 causes asthma and makes it worse and affects brain development. Other toxins from burning methane, or natural gas, cause cancer. We have other problems in our apartments like toxic mold, dirty AC filters, and a lack of ventilation. **Changing from gas appliances to appliances like electric induction stoves or electric heat pumps- could improve our health and the conditions of our apartments while also reducing greenhouse gasses and other pollutants.**

Testimony SB570 Geothermal Networked Systtems.pdf

Uploaded by: Karl Held

Position: FAV

CLIMATE COALITION
Montgomery County, MD

Committee: **Education, Energy and the Environment**
Testimony on: **SB570 –Public Utilities – Thermal Energy Network Systems – Authorization and Establishment -Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act**
Organization: **Climate Coalition Montgomery County**
Submitting: **Karl Held**
Position: **Favorable**
Hearing Date: **February 29, 2024**

Dear Chair and Committee Members:

Thank you for allowing our testimony today in support of SB570. The Climate Coalition Montgomery County, a coalition of over 20 grassroots organizations focused on climate and environment urges you to vote favorably on SB570.

Maryland has committed to reducing greenhouse gas emissions (GHGs) to 60% of 2006 levels by 2031 and transitioning to a net-zero economy by 2045. Doing so will require major reductions in emissions arising from heating and cooling buildings.

Geothermal heating and cooling systems (ground source heat pumps or GHPs) generate significantly less GHGs than gas or electric resistance equipment and even less than air-source heat pumps. The U.S. Department of Energy estimates that GHPs "can reduce energy consumption and emissions up to 44% compared to air-source heat pumps and 72% compared to standard air-conditioning equipment." GHPs require less energy than air-source heat pumps because, for both heating (including in water heaters) and cooling, GHPs use heat extracted from boreholes 300-500 feet below ground (50-60^{o} F, year-round) rather than from the ambient air (typically, in Maryland, midwinter lows in the low- to mid-20s and mid-summer highs in the mid-to-upper 80s). The difference between geothermal and desired building temperatures is much smaller than the difference between ambient air and desired building temperatures.

Problem: While geothermal heat pumps are a well-tested technology,[1] and their use in districts, such as universities, is spreading,[2] their use in networked systems to heat small neighborhoods is more recent.[3]

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[1]https://www.montgomeryschoolsmd.org/siteassets/district/departments/facilities/sustainability/geothermal_green-features.pdf

[2] https://www.nytimes.com/2024/01/23/climate/geoexchange-climate-colleges-heat.html?searchResultPosition=2;

[3] Maryland would not be the first state to pilot thermal energy networked systems using geothermal heat pumps. Colorado, Massachusetts, Minnesota and New York have passed laws that allow or mandate gas utilities to undertake thermal energy network pilot projects. Illinois, Maine, Vermont and Washington are exploring similar laws. https://energynews.us/2024/01/18/new-york-will-replace-gas-pipelines-to-pump-clean-heat-into-buildings/

Pilot projects can be useful to demonstrate proof of concept and identify program design improvements.

Solution: SB570 would create pilot projects and gather information to assess how well networked geothermal systems will work in different areas in Maryland.

Each natural gas utility would be required to develop one or two pilot thermal energy projects to replace gas infrastructure with a thermal energy network system. The gas companies would work with community organizations and local governments to identify projects and would build and manage the projects approved by the state Public Service Commission (PSC). The pilot projects would have to be in neighborhoods with at least 80% low- and moderate-income residents, with priority given to overburdened and underserved communities. The gas companies would need to seek federal funding for their pilots and propose a rate structure ensuring that participating customers do not pay more for utilities than if they had not participated. The gas companies would also need to collect data to help the state evaluate the pilot program.

Because SB570 enables low- and moderate-income residents to replace gas appliances with GHPs and other efficient electric appliances at no cost to themselves, it protects them from bearing the increasing costs of stranded assets, *i.e.*, gas infrastructure that would serve fewer users as more consumers shift from gas to electricity and the economy becomes decarbonized.[4] SB570 would also protect the jobs, wages and benefits of gas company workers who could use their skills to install and service the pipelines needed by the geothermal heat pump system and would promote use of workers and small businesses in the impacted area to implement some of the changes required within buildings. And, to the extent that behind-the-meter energy conservation upgrades and substitution of highly efficient electric appliances reduce the demand for electricity, SB570 would reduce the need for costly upgrades to the electric grid.[5]

Because of the promise of significant reductions in the use of natural gas and electricity, an equitable transition for gas companies and their workers, provisions to support impacted residents and businesses, and the potential to reduce the need for investments in the electric grid, we recommend a **FAVORABLE** report for SB570 in committee.

The Climate Coalition Montgomery County

350 Montgomery County
ACQ Climate (Ask the Climate Question)
Bethesda Green
Biodiversity for a Livable Climate
Chesapeake Climate Action Network (CCAN)
Elders Climate Action
Environmental Justice Ministry Cedar Lane Unitarian Universalist Church
Friends of Sligo Creek (FoSC)

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[4] Decarbonizing the economy implies significantly reducing use of methane gas. By 2045, *i.e.*, in 21 years, most existing gas pipeline infrastructure becomes a stranded asset.

[5] US Department of Energy research has found that installing geothermal heat pumps in nearly 80 percent of U.S. homes could reduce the costs of decarbonizing the grid by 30 percent and avoid the need for 24,500 miles of new transmission lines by 2050.

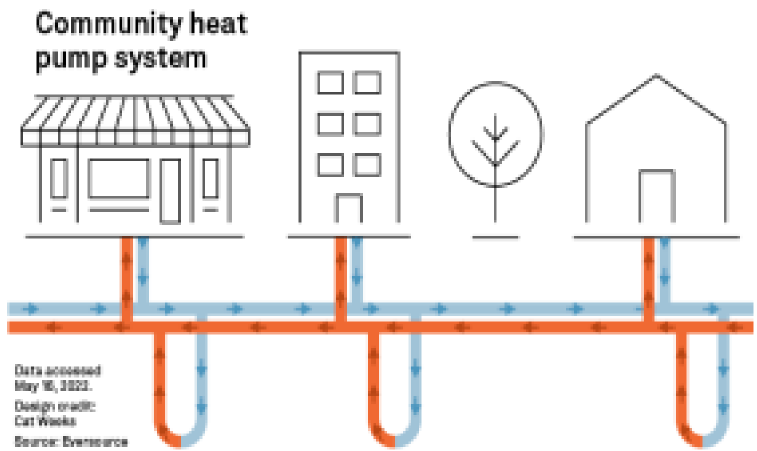
Green Sanctuary Committee of the Unitarian-Universalist Church of Silver Spring
Montgomery County Faith Alliance for Climate Solutions (MC-FACS)
Montgomery Countryside Alliance
One Montgomery Green
Poolesville Green
Transit Alternatives to Mid-County Highway Extended/M-83 (TAME)
The Climate Mobilization Montgomery County (TCM-MoCo)
Takoma Park Mobilization Environment Committee (TPMEC)
Zero Waste Montgomery County

Networked Geothermal Factsheet.docx (1).pdf
Uploaded by: Katie Fry Hester
Position: FAV

SB 570
Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act
Neighborhood Geothermal

Maryland has a statutory requirement to reduce greenhouse gas emissions to 60% of 2006 levels by 2031. Once this milestone is achieved, we are further required to transition to a net-zero economy by 2045. Meeting these targets is urgent and imperative. The transition to a carbon-free economy provides benefits to public health and opportunities to invest in Maryland's overburdened and underserved communities.

Networked geothermal systems are a super efficient, inflation resistant, reliable way to heat and cool buildings. These systems can be constructed today. They are an already proven, carbon-free technology. They minimize additional electric demand on the grid.



How Networked Geothermal Works

Geothermal heating and cooling systems, also called ground source heat pumps(GHPs), moderate the temperature of buildings using heat energy from the ground instead of the air. The entire system is made of a network of horizontal and vertical pipes, a water-based solution that transfers heat energy within the pipes, and heat pumps that warm and cool individual houses and buildings. The ground keeps the water based solution at a constant temperature as it circulates through the pipes. The heat pumps pull the heat energy from the solution to warm buildings. Similarly, these systems disperse heat energy via the solution to cool buildings. In a networked geothermal system, geothermal heating and cooling systems are connected and can benefit multiple buildings- using waste heat from one building to heat another building nearby.

The WARMTH Act provides an opportunity to pilot networked geothermal systems in Maryland. This legislation is a strategic investment in the future of Maryland and has several benefits:

Strategic Use of IRA Funds

The Inflation Reduction Act provides an opportunity for historic investment in Maryland's energy infrastructure. However, these IRA funds give us an opportunity to fully electrify many low- and moderate-income homes, but not all. We need to invest these funds as efficiently as possible and we must invest them so that we can gather data and learn for future electrification from fund sources we have not yet identified.

Directing a portion of IRA funds to be used as part of a network geothermal system will allow for full electrification and weatherization of an entire neighborhood, with funds coordinated by MEA and construction coordinated by MES. This can create a model for future electrification.

Electrify Everything as Efficiently as Possible

Decarbonizing to meet Maryland's greenhouse gas reduction goals requires greater electrification of buildings and transportation. As Maryland electrifies, we need to maximize efficiency to limit upgrades needed to the electric grid. Specifically, we need to flatten the projected winter peak energy usage. A Maryland Energy Administration (MEA) study found that 1kW of electricity grid demand reduction can be achieved for each ton of ground source heat pump technology installed compared to electrification with air source heat pumps (citation forthcoming).

Ground Source Heat Pumps Efficiency Avoids Costs to Upgrade the Grid

A US Department of Energy study finds the "mass deployment of GHPs can electrify the building sector without overburdening the US electric power system. In all GHP deployment scenarios considered, significant reductions are realized in the needed power generation and capacity, energy storage capacity, transmission build-outs, seasonal capacity that can contribute toward resource adequacy, CO_2 emissions, and marginal and cumulative system costs of electricity across the United States. Although this study was for the contiguous United States only, the findings are applicable to all 50 states and US territories."[1]

Utility Implementation

This legislation offers a new business model for gas utilities that relies on 100% clean energy and utilizes existing pipeline workforce skills. In Massachusetts, both Eversource and National Grid have pilot projects through which they will own the networked geothermal system and it will be rate-based in the same way their gas and electric assets are currently rate-based.[2] These projects have broken ground and will come on line in the next year. In states such as New York, legislation has been passed in order to remove barriers preventing utility providers from operating networked geothermal systems.[3]

Proven, community-scale change

Networked geothermal systems are the best opportunity for neighborhood scale shifts to fully electric heating and cooling. By operating on the neighborhood level, the state has the opportunity to implement projects that will move the needle toward our 2031 and 2045 goals. These systems are already operating in areas across the country and providing savings for institutions[4] and residents[5].

This bill…

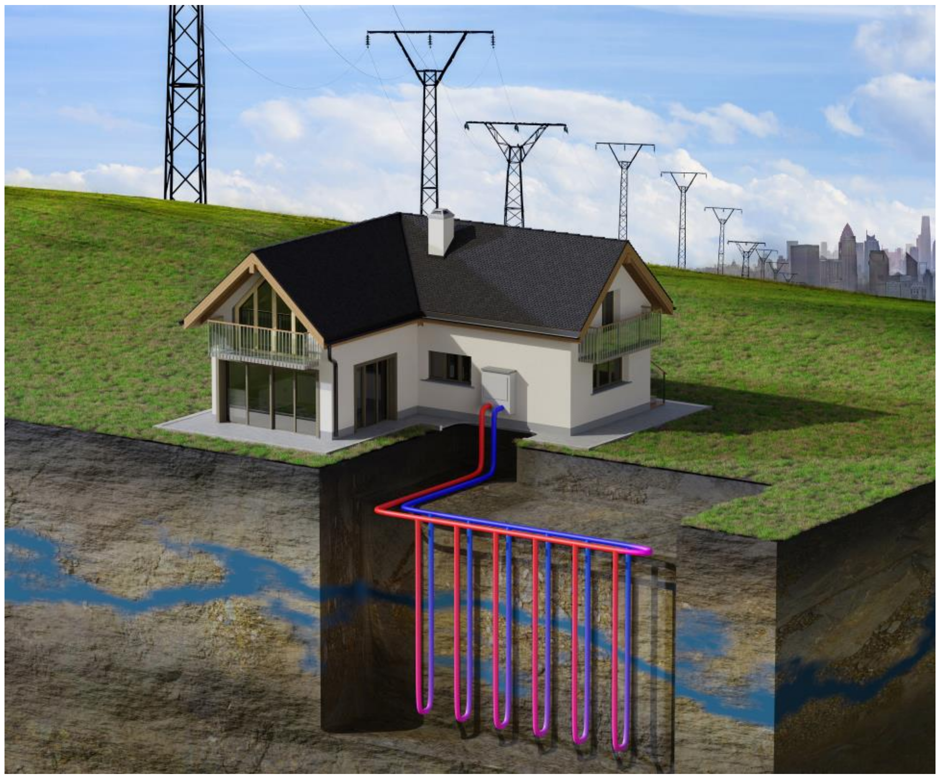
- ✔ requires each gas company in the state to work with community organizations, municipal, and county governments to identify and propose one or two pilot projects to the Public Services Commission (PSC). Based on the cost benefit analysis, the PSC can approve pilots. The utilities will build and manage the boreholes and pipes in their current right of way, which will connect to ground source heat pumps in people's homes which will be owned by the property owner. Utilities will recover the cost of the networked system, and IRA funds will cover the costs of the electric appliances which pilot properties will receive.
- ✔ Requires significant data collection once pilot projects are operational. This data will be key to developing the models for the mix of technology that will be needed for full electrification of buildings in Maryland.
- ✔ The pilots will be in neighborhoods with 80% low- and moderate-income residents and will prioritize overburdened and underserved communities.
- ✔ Labor standards in the bill prioritize maintaining work for those who work on gas infrastructure and ensure prevailing wages for construction on the projects. Because GHP work is similar to gas distribution work, minimal additional training ensures job security. Workers on our gas system have kept us safe and warm for decades. We need to ensure their job security in a new clean thermal energy system.

[1] page xxiv, https://www.osti.gov/biblio/2224191
[2] https://www.eversource.com/content/residential/about/transmission-distribution/projects/massachusetts-projects/geothermal-pilot-project
[3] https://www.nysenate.gov/legislation/bills/2021/S9422
[4] https://www.coloradomesa.edu/facilities/sustainability/geo-systems.html
[5] https://www.cnbc.com/2022/09/01/geothermal-powered-housing-development-saves-homeowners-big-bucks.html

Pub196793.pdf
Uploaded by: Katie Fry Hester
Position: FAV

ORNL/TM-2023/2966

Grid Cost and Total Emissions Reductions Through Mass Deployment of Geothermal Heat Pumps for Building Heating and Cooling Electrification in the United States



Xiaobing Liu
Jonathan Ho
Jeff Winick
Sean Porse
Jamie Lian
Xiaofei Wang
et al.

November 2023

Oak Ridge National Laboratory

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ORNL/TM-2023/2966

Energy Science and Technology Directorate

GRID COST AND TOTAL EMISSIONS REDUCTIONS THROUGH MASS DEPLOYMENT OF GEOTHERMAL HEAT PUMPS FOR BUILDING HEATING AND COOLING ELECTRIFICATION IN THE UNITED STATES

Xiaobing Liu
Jonathan Ho*
Jeff Winick♦
Sean Porse♦
Jamie Lian
Xiaofei Wang†
Weijia Liu*
Mini Malhotra
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Jyothis Anand

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* National Renewable Energy Laboratory
♦ US Department of Energy
† Joint position at Oak Ridge National Laboratory and the University of Tennessee, Knoxville

November 2023

Prepared by
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UT-BATTELLE LLC
for the
US DEPARTMENT OF ENERGY
under contract DE-AC05-00OR2272

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LIST OF FIGURES

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ABBREVIATIONS

AEO	Annual Energy Outlook
AHRI	Air-Conditioning, Heating, and Refrigeration Institute
ANSI	American National Standards Institute
ASHP	air source heat pump
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BA	balancing area
CEM	capacity expansion modeling
CO_2e	CO_2 equivalent
COP	coefficient of performance
CSP	concentrating solar power
CZ	climate zone
DOAS	dedicated outdoor air system
DOE	US Department of Energy
DX	direct expansion
EER	energy efficiency ratio
EFS	*Electrification Futures Study*
ERCOT	Electric Reliability Council of Texas
EULP	end-use load profile
GHE	ground heat exchanger
GHG	greenhouse gas
GHP	geothermal heat pump
H_2-CT	hydrogen combustion turbine
HVAC	heating, ventilation, and air-conditioning
IECC	International Energy Conservation Code
ISO	International Organization for Standardization
LMP	locational marginal price
MLP	multilayer perceptron
MMT	million metric tons
NERC	North American Electric Reliability Corporation
NG-CC	natural gas combined cycle
NG-CT	natural gas combustion turbine
NPCC	Northeast Power Coordinating Council
NREL	National Renewable Energy Laboratory
O&M	operation and maintenance
OA	outdoor air
ORNL	Oak Ridge National Laboratory
PCM	production cost modeling
PSH	pumped storage hydropower
PTAC	packaged terminal air-conditioner
PV	photovoltaic
RAZ	reliability assessment zone
ReEDS	Regional Energy Deployment System Model
SEER	seasonal energy efficiency ratio
SERC	SERC Reliability Corporation
SFH	single-family home
TMY3	third edition of typical meteorological year data
VBGHE	vertical bore ground heat exchanger
VRE	variable renewable energy

NOMENCLATURE

Item	Definition and explanation
Annual load (TWh)	Total electrical energy consumption at the point of use, including end-use demand and storage charging but not including losses between the points of generation and the points of use
Annual generation (TWh)	Total electrical energy generation, which is the sum of the loads at the points of use (including storage charging) plus the losses in delivering energy from the point of generation to the loads
Annual generation cost ($ billion)	Total electricity generation operational costs, including fuel and variable operation and maintenance cost
Annual generator revenue ($ billion)	Total payment for electrical energy in the wholesale market; equivalent to the sum of the product of locational marginal price and demand at each region
Average wholesale electricity price ($/MWh)	Average wholesale price that utilities paid for electricity to serve the annual load
Annual operating reserve provision (TWh)	Total hourly reserve capacity throughout the year
Annual unserved load (GWh)	Total unserved load, possibly because of maintenance, congestion, and so on
Annual peak demand (GW)	Peak demand throughout the year
RA eligible capacity (GW)	The portion of a generator or storage capacity that can be reliably counted on during a period of need ensuring resource adequacy
Generation capacity (GW)	The summation of all power plant nameplate capacities. The capacity of all plants is not always available (e.g., solar capacity at night, or when a power plant is in maintenance or shutdown). In this study, *generation capacity* also includes battery power capacity.
Battery capacity (GW)	The summation of the maximum amount of power that can be delivered by the batteries
Battery energy storage (GWh)	Total energy that can be stored in the battery
Emissions (MT or MMT)	Emissions of CH_4, CO_2, NO_x, and/or SO_2 that are released as the products of the combustion of fossil fuels at power plants or in buildings for space heating. Emissions from water heating for use in buildings were not evaluated in this study.
Annual fuel cost ($ billion)	Total generation cost associated with fuel consumption
Annual fuel offtake (TJ)	Total fuel energy (i.e., heat value) consumed for generation
Net demand (TW)	Electric demand minus renewable power generation
EULP	End-use load profile, which includes hourly electric and fuel consumption in an individual building or a cluster of buildings

ACKNOWLEDGMENTS

This study was funded by the US Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy, Geothermal Technologies Office. This study used resources at the Building Technologies Research and Integration Center and the Compute and Data Environment for Science (CADES) at the Oak Ridge National Laboratory, which is supported by the Office of Science of the DOE under Contract No. DE-AC05-00OR22725. The authors would like to acknowledge the technology managers at DOE's Geothermal Technologies Office for their input and guidance in this project. We also appreciate the valuable support from the following individuals:

- Jennifer Livermore, Boston Government Services LLC
- Kevin Kitz, Boston Government Services LLC, and Kitzworks LLC
- Professor Fangxing (Fran) Li, University of Tennessee
- Yarom Polsky, Oak Ridge National Laboratory
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EXECUTIVE SUMMARY

This report presents the results of a study on the potential grid impacts of national-scale mass deployment of geothermal heat pumps (GHPs) coupled with weatherization in single-family homes (SFHs) from 2022 to 2050. GHPs are a technology readiness level 10, commercially available technology across the United States. This study is an impact analysis only; installed costs and available land areas for installing GHPs are not accounted for in determining their estimated deployment. The three scenarios studied were (1) continuing to operate the grid as it is today (the *Base scenario*), (2) a scenario to reach 95% grid emissions reductions by 2035 and 100% clean electricity by 2050 (the *Grid Decarbonization scenario*), and (3) a scenario in which the Grid Decarbonization scenario is expanded to include the electrification of wide portions of the economy, including building heating (the *Electrification Futures Study* or *EFS scenario*). The analysis team modeled each of these three scenarios with and without GHP deployment to a large percentage of US building floor space.[1] In all cases, deployment of approximately 5 million GHPs per year demonstrated system cost savings on the grid, consumer fuel cost savings through eliminated fuel combustion for space heating, and CO_2 emission reductions from avoided on-site fuel combustion—and, in the case of the Base scenario, CO_2 emissions reductions from the electric power sector.[2]

GHPs have traditionally been viewed as a building energy technology. The most notable result of this study, however, is the demonstration that GHPs coupled with weatherization in SFHs are primarily a grid-cost reduction tool and technology that, when deployed at a national scale, also substantially reduces CO_2 emissions, even in the absence of any other decarbonization policy.

Key Findings

GHPs widely deployed across the United States could result in the following key benefits.

1. Wholesale payments for electric grid services are reduced by at least $300 billion through 2050. This study evaluated the all-in electricity costs that are avoided by GHP deployment. Savings are 10% ($316 billion) in the Base scenario, 13% ($557 billion) in the Grid Decarbonization scenario, and 11% ($607 billion) in the EFS scenario. These reported numbers are the present-day value of future savings (at a 5% discount rate).
    a. For the Grid Decarbonization scenario, the undiscounted cumulative savings through 2050 are more than $1 trillion. This scenario has the effect of reducing the wholesale price of electricity by 12% (a $10/MWh price reduction).
    b. GHPs reduce the cost of meeting the Grid Decarbonization objective by 47% (a $632 billion undiscounted cost reduction) and by 27% including electrification (a $810 billion undiscounted cost reduction).
    c. Because GHPs reduce the cost of power on the grid, as well as the marginal system cost of electricity, which, combined with reduced fuel consumption, reduces consumer energy payments, GHPs are valuable for potentially achieving economic and environmental justice in underserved communities. Because less grid infrastructure investment is required with the large-scale deployment of GHPs, they could reduce the cost of power for *all* grid consumers—even those who do not have the technology installed.

[1] The modeling considered deployment across 68% of total building floor space in the contiguous US, which includes deployment to 43% of commercial and 78% of residential building floor space.
[2] In the Decarbonization and EFS scenarios, electric-power sector emissions are still avoided but are attributable to CO_2 policy drivers as opposed to the deployment of GHPs.

2. Consumer payments for heating fuels are reduced, resulting in a savings of $19 billion per year by 2050.[3]

3. CO_2 emissions are reduced cumulatively by 7,351 million metric tons (MMT) from 2022 to 2050 compared with the Base scenario, where 3,033 MMT reduction comes from the electric sector, and 4,318 MMT comes from the building sector (a 26% reduction in building sector emissions).

4. By the year 2050, 593 TWh/year[4] less generation is required in the Grid Decarbonization scenario, and 937 TWh/year less generation is required in the EFS scenario. These results represent reductions in overall generation requirements of 11% and 13%, respectively.

5. Even though building heating is electrified with GHP deployment—increasing winter electricity use for homes and businesses that otherwise are heated with fossil fuels—the increase is more than offset by the electricity savings from the high-efficiency performance of GHPs for summer cooling and reduced thermal loads owing to weatherization in single-family homes, resulting in substantial net reductions in grid generation, capacity, and transmission (see Figure ES-1).

6. The mass GHP deployment reduces transmission expansion requirements by 33% under the Grid Decarbonization scenario and by 38% under the EFS scenario. This amount equates to roughly 24,500 mi of transmission that can be avoided under the Grid Decarbonization scenario and nearly twice as much (43,500 mi) under the EFS scenario, which is enough to cross the average contiguous US coast-to-coast distance 9 and 16 times, respectively.[5]

7. Although outside the scope of the analysis described herein, key findings could lead to significant workforce and human health effects. The widespread GHP deployment modeled in this analysis would likely incentivize local job creation in the drilling and HVAC sectors across the US. The large emissions (e.g., CO_2, SO_x, and NO_x) reductions attributable to avoided on-site fuel combustion will similarly produce substantial local health benefits that would be realized across the country. Future work is planned to further quantify the magnitude of these benefits.

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[3] This category covers all fuels purchased for use in building heating but does not include reductions in consumer payments for heating from electric resistance heaters (e.g., baseboard heaters). The fuel cost savings are calculated as all avoided on-site fuel combustion (natural gas, propane, and fuel oil) and using the forecasted price of natural gas of $3.26/MMBtu, conservatively ignoring higher costs for propane and fuel oil for heating. For comparison, the average trading price of natural gas for the last 5 years (including the disruptions caused by the COVID-19 pandemic and the war in Ukraine) has been over $3.50/MMBtu (NYMEX natural gas data 06/14/18 to 06/14/23).

[4] For comparison, 580 TWh/year is equivalent to the output of 66 1,000-MW nuclear power plants running 24/7, 365 days a year. The EFS scenario generation reduction is equivalent to 106 1,000-MW nuclear power plants running 24/7, 365 days a year.

[5] Transmission distances were determined based on a 36.7 TW·mi and 65.3 TW·mi reduction under the Grid Decarbonization and EFS scenarios, respectively, assuming a representative 1,500-MW line capacity and an average distance from the west to the east coast of 2,800 mi for the contiguous United States.

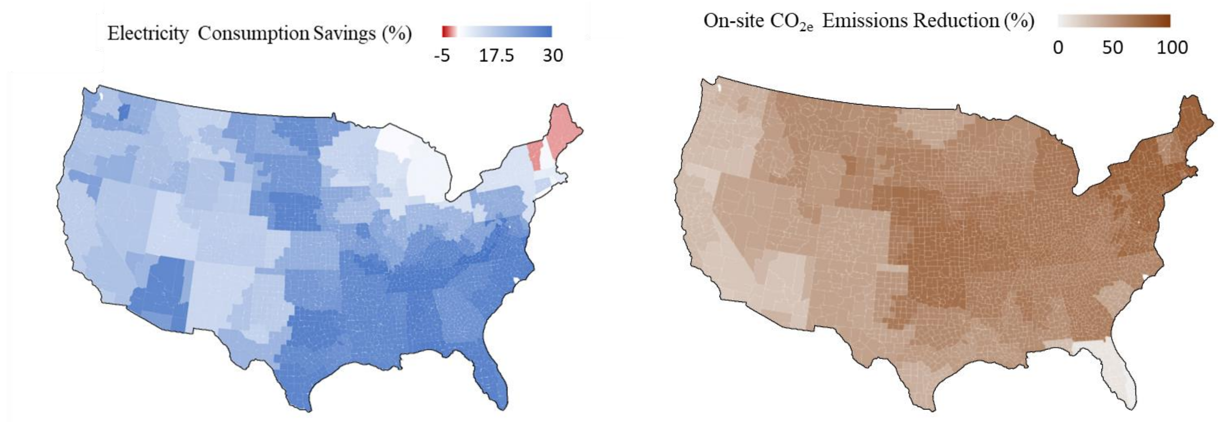

Figure ES-1. Geospatial representation of the percentage changes in (left) building annual electricity consumption and (right) carbon emissions (from on-site combustion in buildings) resulting from deploying GHPs into 68% of existing and new residential and commercial buildings in the United States, coupled with weatherization in single-family homes.

Background

Geothermal heat pumps (GHPs; also called ground source heat pumps) transfer heat to and from the ground by circulating water (or antifreeze solution in regions with cold climates) through underground piping. GHPs are well-understood to be beneficial for lowering building energy costs because of their high efficiency and ability to supply heat without fuel purchases. As a result, GHPs have zero on-site emissions. However, few studies have investigated the impacts on the electric grid of the large-scale deployment of GHPs.

This first-of-its-kind study simulates the energy use impacts of deploying GHPs into 68% of existing and new building floor space in the United States (78% of residential floor space and 43% of commercial floor space) in 14 climate zones[6] across the contiguous United States by 2050. Because this study is an impact analysis only, it does not examine the costs of and available land areas for installing GHPs in existing buildings or new constructions. Further analysis is needed to assess installation costs and needed land areas of the deployment scenarios presented in this study.

The results of this impact analysis demonstrate that savings in grid costs, CO_2 emissions, and building energy consumption are all significant. These results also demonstrate that when achieving mass deployment levels, GHPs coupled with weatherization in SFHs are primarily an electric grid cost-reduction tool and technology.

Modeling Scenarios

This study analyzed the impacts of mass GHP deployment on the electric grid through capacity expansion modeling and production cost modeling of the US electric power sector. The analysis includes a simplifying assumption that GHP deployments in this study were for individual buildings (not district-scale and/or networked systems). The building modeling accounted for weatherization in SFHs by reducing outdoor air ventilation to the minimum required by ASHRAE Standard 62.2 (ASHRAE 2007, 2016) and by eliminating air leakage from the ductwork of HVAC systems through air-sealing, which are commonly recommended practices in heat pump retrofits. According to previous studies, air-sealing can

[6] ANSI/ASHRAE Standard 169-2021 entitled *Climatic Data for Building Design Standards* (ASHRAE 2021) defines climate zones 1 through 8 as very hot, hot, warm, mixed, cool, cold, very cold, and subarctic/arctic, respectively, and sub climate zones A, B, and C as moist, dry, and marine, respectively, in several climate zones.

reduce heating energy consumption by 30%–50% (Chan 2013, Hassouneh et al. 2012, Jokisalo et al. 2009, Lozinsky and Touchie 2018, Pasos et al. 2020, Sawyer 2014). Deployment rates were fixed at 3.6% per year of existing and new building floor space that is considered applicable[7] for GHP in this study for 28 years until 2050. This study used four core scenarios.

- **Base scenario:** No GHP deployment occurs, energy consumption in new buildings between 2020 and 2050 is consistent with *Annual Energy Outlook 2021* projections (US Energy Information Administration 2021), and CO_2 emissions policies remain the same as existing state policies, including renewable portfolio standards, clean energy standards, and CO_2 emissions policies.

- **Base + GHP scenario:** The GHP deployment rate increases linearly from 0% in 2021 to 100% of all applicable buildings in 2050, which would amount to approximately 5 million GHP units installed per year. GHPs are included in new buildings starting in 2022, assuming the same energy savings as those for existing buildings.

- **Grid Decarbonization (or *Decarbonization*) scenario:** CO_2 emissions from the US electric power grid are reduced by 95% in 2035 and 100% in 2050 compared with 2005 emissions from the electric power sector.[8] This scenario indicates that all the power generation will use clean energy by 2050.

- **Grid Decarbonization + GHP scenario:** The impact of GHP deployment is incorporated into the Grid Decarbonization scenario using the same GHP deployment assumptions as the Base + GHP scenario. Both the grid decarbonization goal and the GHP deployment goal (i.e., deploying GHPs in all applicable new and existing buildings in the US) will be achieved in 2050.

Two additional scenarios were assessed in this study based on the EFS (Sun et al. 2020). These two scenarios use the same power system decarbonization pathways as the previous Grid Decarbonization scenarios.

- **EFS scenario:** No GHP deployment occurs, and economy-wide electrification of end uses—including partial building electrification through air source heat pumps (ASHPs), including the cold climate heat pumps, and other electrified devices for water heating and cooking—occurs, consistent with the values used in the high-electrification scenario from the EFS.[9] Weatherization in SFHs was not included in EFS.

- **EFS + GHP scenario:** An economy-wide electrification of end uses occurs, along with 100% GHP deployment in applicable existing and new buildings coupled with weatherization in SFHs.[10] Electrification of other end uses (not for heating and cooling) is consistent with the values used in the high-electrification scenario from the EFS.

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[7] It covers all buildings included in the original end-use load profile (EULP) data set published by the National Renewable Energy Laboratory (NREL; NREL 2021), except for buildings that use district heating/cooling, mobile homes, buildings without heating or cooling, and buildings that already use GHP.

[8] The electric-sector CO_2 emissions cap is based on the decarbonization scenario in the US Department of Energy's (DOE's) *Solar Futures Study* (DOE 2021) and is consistent with the goals in *The Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050* (White House 2021).

[9] In the EFS scenario, ASHPs were assumed to be used in 68% of residential buildings and 46% of commercial space in the United States. It is also assumed that residential ASHP efficiency will increase by 116% from 2015 to 2050 in the rapid technology development case.

[10] ASHPs in the EFS scenario are replaced with GHPs.

Impacts of Widespread GHP Deployment

The modeled scenarios described previously revealed major impacts resulting from the mass deployment of GHP systems (i.e., deploying GHPs into 68% of residential and commercial buildings in the United States, coupled with weatherization in SFHs) by 2050 in the contiguous United States.

1. **Net reduction in annual electricity consumption and greenhouse gas (GHG) emissions:** The greatest electricity savings occur in the southeastern United States, and the greatest in-building emissions reductions occur in the northern United States, as shown in Figure ES-1.

   The deployment of GHP systems has different impacts in different geographic areas (Figure ES-1). Large reductions in annual electricity consumption in the southern United States occur, for example, because energy-efficient GHPs replace widely used conventional air-conditioning systems, which dominate total annual energy use in the region.

   In the northern United States, GHP deployment results in dramatic reductions in on-site carbon emissions because GHPs replace existing combustion-based heating sources (gas, propane, and fuel oil), which emit substantial GHG emissions and other pollutants. In many regions, the gain in efficiency from GHPs during the summer cooling season more than offsets the increase in electrified winter heating load. Furthermore, weatherization in SFHs also reduces thermal loads for heating and cooling, especially in cold climates. In aggregate, this combined solution (GHP and weatherization in SFHs) results in full building electrification with reductions in total annual electricity use in most parts of the United States.

2. **Reduced need for annual power generation:** Mass GHP deployment could reduce the required annual electricity generation in the contiguous United States[11] by **585 TWh** for the Base scenario, **593 TWh** for the Grid Decarbonization scenario, and **937 TWh** for the EFS scenario, as shown in Figure ES-2.

   The major difference between the impacts of GHP deployment in these scenarios is related to the types of generation being reduced. In the Base + GHP scenario, generation is reduced across all technology types with both thermal generation and renewable technologies. In contrast, in the Grid Decarbonization + GHP scenario, the net reduction is primarily attributable to reductions in variable renewable energy (VRE) generation, such as wind and solar, and hydrogen combustion turbines (H_2-CTs), with small increases in output from nuclear power plants. The EFS + GHP scenario sees the same reductions in H_2-CTs with an increased magnitude of VRE reductions. The shift in onshore wind generation in the EFS + GHP scenario is related to reductions in winter electricity consumption under EFS as a result of replacing ASHPs (including cold climate heat pumps) with GHPs coupled with weatherization in SFHs. More details are provided in Section 4.2.1.1 of this report.

[11] This excludes Alaska, Hawaii, and US territories because of limited data for conducting a detailed analysis.

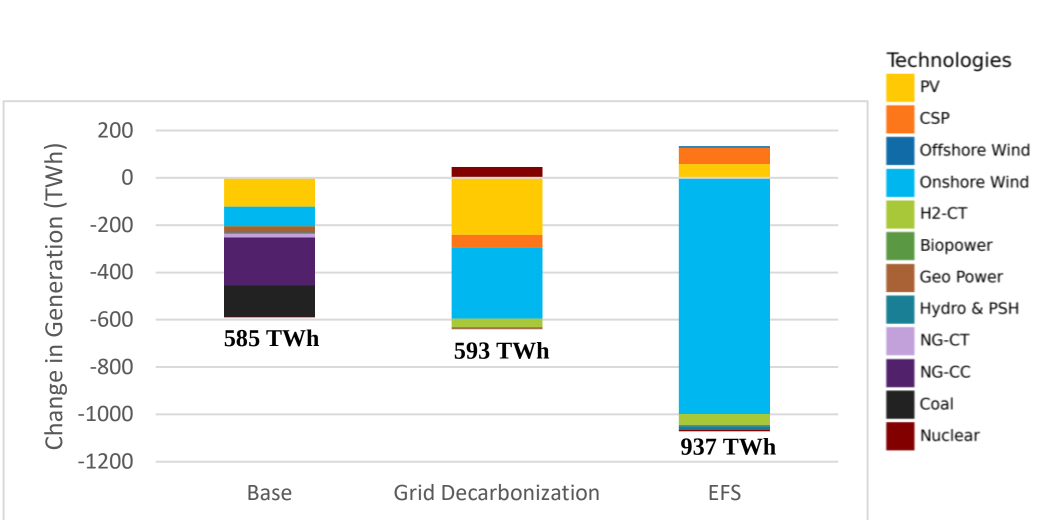


Figure ES-2. Changes in US annual electricity generation (TWh) in 2050 for Base, Grid Decarbonization, and EFS scenarios resulting from deploying GHPs into 68% of buildings in the United States, coupled with weatherization in single-family homes. (CSP: concentrating solar power; H2-CT: hydrogen combustion turbine; NG-CC: natural gas combined cycle; NG-CT: natural gas combustion turbine; PV: solar photovoltaic; PSH: pumped storage hydropower.)

3. **Reduced need for power generation capacity and storage capacity:** Mass GHP deployment in the Grid Decarbonization scenario could double the reduction in installed generation and storage capacity achieved in the Base scenario (173 GW reduction in the Base + GHP scenario versus 345 GW reduction in the Grid Decarbonization + GHP scenario), as shown in Figure ES-3. In the EFS + GHP scenario, the installed generation and storage capacity was reduced by 410 GW.

   In the Grid Decarbonization scenario, more of the US generation mix is made up of VREs (74%–77% in the Grid Decarbonization scenario, compared with 43%–44% in the Base scenario). The Grid Decarbonization scenario also includes more battery storage than the Base scenario to improve the capacity factor of VREs. Therefore, the reduction in electricity demand resulting from GHP deployment has a greater impact on the Grid Decarbonization scenario. More details are provided in Section 4.2.1.1 of this report.

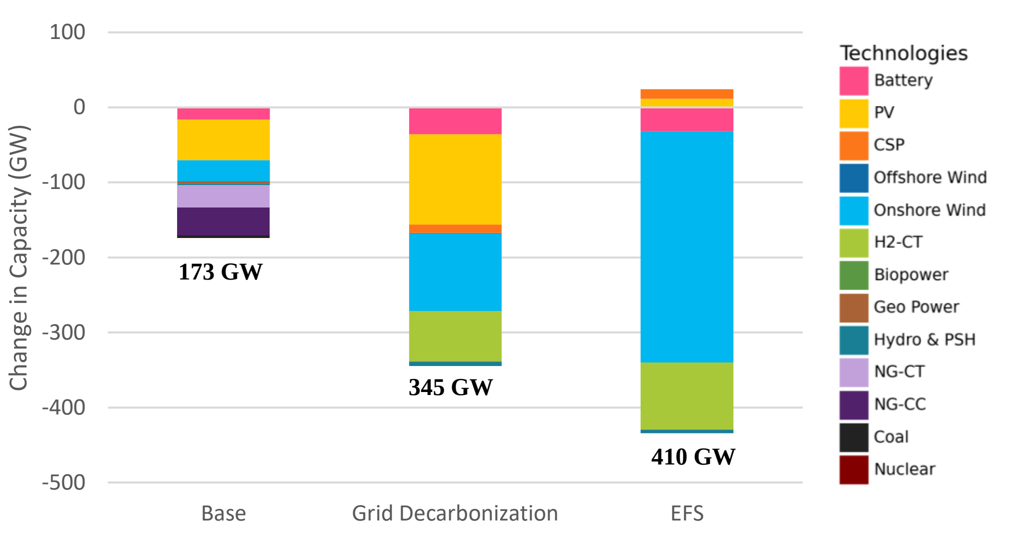


Figure ES-3. Changes in US installed power generation and storage capacity (GW) in 2050 for Base, Grid Decarbonization, and EFS scenarios resulting from deploying GHPs into 68% of buildings in the United States, coupled with weatherization in single-family homes.

Mass GHP deployment coupled with weatherization in SFHs reduces the need for generation capacity compared with electrifying the building sector using ASHPs: Compared with electrification using ASHPs assumed in the EFS scenario, the mass GHP deployment could reduce the required electric power system capacity by 410 GW (from 3,568 GW to 3,158 GW) by 2050, as indicated in **Error! Reference source not found.**1.[12] Electrifying buildings using GHPs also reduces resource adequacy requirements compared with using ASHPs, especially in cold climate regions. More details are provided in Section 4.2.1.6 of this report.

Table ES-1. US electric power system capacity comparison in 2050

Scenario		Total generation capacity in 2050 (GW)	
No GHP deployment	Base	1,829	
	Grid Decarbonization	2,482	
	EFS	3,568	
			Difference
With GHP deployment	Base	1,656	173
	Grid Decarbonization	2,137	345
	EFS	3,158	410

4. **Alleviating transmission build-out requirements:** Because of the efficiency of GHPs and reduced thermal loads owing to weatherization in SFHs, less electricity generation will be needed to cool and heat buildings. Therefore, under the Base scenario, GHP deployment avoids **3.3 TW·mi**[13] transmission additions (a 17.4% reduction relative to the Base scenario without GHP), and in the Grid Decarbonization scenario, GHP deployment avoids **36.7 TW·mi** (a 33.4% reduction relative to the Grid Decarbonization scenario without GHP). Under the EFS scenario, GHP deployment avoids

[12] The total installed capacity in the EFS scenarios is much larger than in the Base and the Grid Decarbonization scenarios because of the increased demand in other sectors of the economy, including transportation and industry.
[13] Transmission deployment is measured as an increase in the capacity (terawatts) of modeled transmission lines multiplied by the length (miles) of the lines. The terawatt-mile is a common unit of measurement for transmission expansion in capacity expansion models.

65.3 TW·mi (a 37.6% reduction relative to the EFS scenario without GHP). **Assuming transmission lines have 1,500 MW capacity, a 65.3 TW·mi reduction is equivalent to 43,500 mi of transmission lines that do not need to be built—enough to cross the average contiguous US coast-to-coast distance 16 times.**

The larger reductions in the Grid Decarbonization and EFS scenarios are due to the longer transmission additions required to connect VRE resources to load centers and an increased need to flexibly move power generated with VREs over long distances. The total capital cost savings in present value in the long-distance transmission system resulting from the mass GHP deployment is $2.7 billion in the Base scenario, $29.9 billion in the Grid Decarbonization scenario, and $39.5 billion in the EFS scenario (dollar amounts in present value using a 5% discount rate). Recently, it has been more challenging to permit and construct new transmission systems; avoiding new transmission build-out through GHP deployment may have benefits beyond cost by reducing the uncertainty and delays of getting new transmission constructed to serve the needs of a decarbonized grid. More details are provided in Section 4.2.1.2 of this report.

5. **Reduced summer and winter resource adequacy requirement:**[14] Another advantage of mass GHP deployment is its impact on *capacity that can contribute toward resource adequacy*—reliable generation that is deployed in the summer and winter when demand peaks. In the Base scenario, mass deployment of GHPs means that the grid no longer needs 102 GW (summer) and 95 GW (winter) of capacity that can contribute toward resource adequacy, mostly from power plants using fossil fuels. In the Grid Decarbonization scenario, 103 GW (summer) and 101 GW (winter) of capacity that can contribute toward resource adequacy would no longer be needed. In the EFS scenario, the substitution of ASHPs with GHPs reduces the resource adequacy requirement by 127 GW in summer and 185 GW in winter.

   In the Base + GHP scenario, natural gas combustion turbines (NG-CTs) and natural gas combined cycle (NG-CC) plants are largely reduced, with the next-largest reduction being in battery storage. In the Grid Decarbonization + GHP scenario, all CO_2-emitting power plants were modeled to be retired by 2050, so the largest source of the summer capacity that can contribute toward resource adequacy reduction would come from hydrogen combustion turbines (H_2-CTs). More details are provided in Section 4.2.1.3 of this report.

[14] Capacity that can contribute toward resource adequacy differs from the installed capacity discussed previously in that it represents the portion of a generator or storage capacity that can be reliably counted on during a period of need.

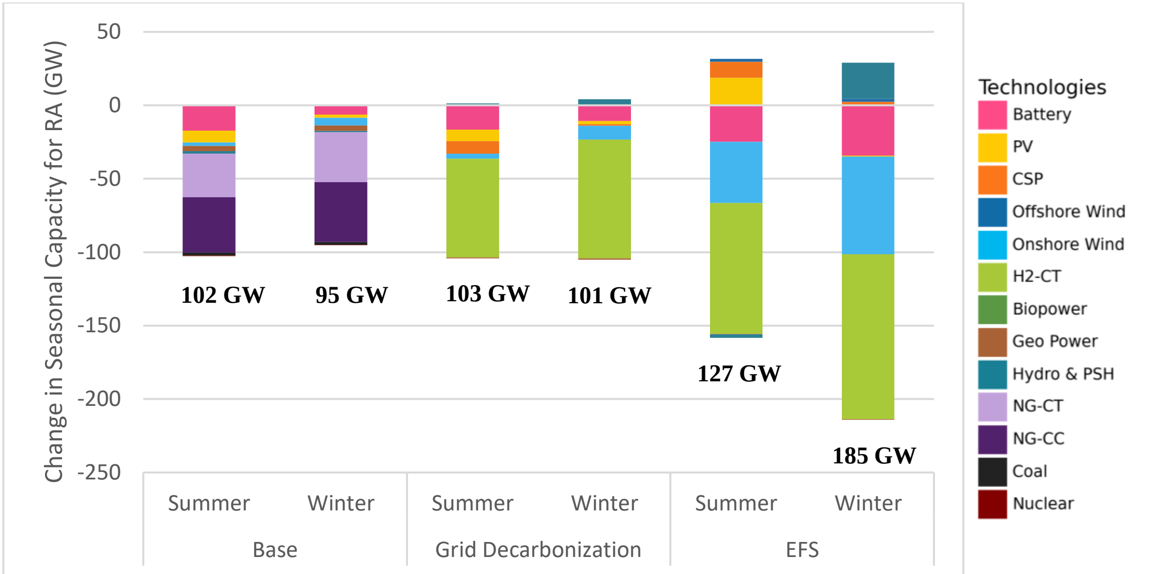


Figure ES-4. Changes in summer and winter capacity contributing to resource adequacy in 2050 for Base, Grid Decarbonization, and EFS scenarios resulting from deploying GHPs into 68% of buildings in the United States, coupled with weatherization in single-family homes. (CSP: concentrating solar power; H2-CT: hydrogen combustion turbine; NG-CC: natural gas combined cycle; NG-CT: natural gas combustion turbine; PV: photovoltaic; PSH: pumped storage hydropower.)

6. **Reduced CO_2 emissions in the electric power system and building sector:** Compared with the Base scenario, GHP deployment will eliminate 217 MMT of CO_2 emissions each year from the US electric power system by 2050 because of the reduced total electric demand and peak load. However, in the Grid Decarbonization scenario, GHP deployment does not affect carbon emissions from the electric power system. This lack of effect is because, in the Grid Decarbonization scenario, carbon emissions reductions are built into the scenario, with the rapid 95% power system decarbonization target in 2035 and complete decarbonization in 2050. Therefore, GHP deployment rates modeled in this study do not alter the emissions from the electric power system. However, if the emissions that are avoided from the building sector through the avoided on-site fuel combustion are applied as a decarbonization credit to the grid, the net effect of GHP deployment is to achieve the emissions reduction goal of decarbonizing the grid by the year 2035. This observation is explored in greater detail in Section 4.2.1.4 of this report.

   GHP deployment could also avoid CO_2 combustion emissions related to end-use heating in the building sector. The emissions reductions in the electric power system and the building sector are counted toward the economy-wide impacts. As shown in Figure ES-5, the deployment of GHPs leads to a 7,351 MMT cumulative emissions reduction from 2022 to 2050 compared with the Base scenario, where the 3,033 MMT reduction comes from the electric sector, and 4,318 MMT comes from the building sector (a 26% reduction in building sector emissions). Compared with the EFS scenario, the mass deployment of GHPs reduces 2,178 MMT cumulative emissions from 2022 to 2050, which is from the building sector (a 16% reduction in building sector emissions).[15] More details are provided in Section 4.2.1.4 of this report.

[15] The EFS scenario had a higher share of commercial building electrification using ASHPs than the GHP retrofit scenario, contributing to the small increase in commercial building emissions.

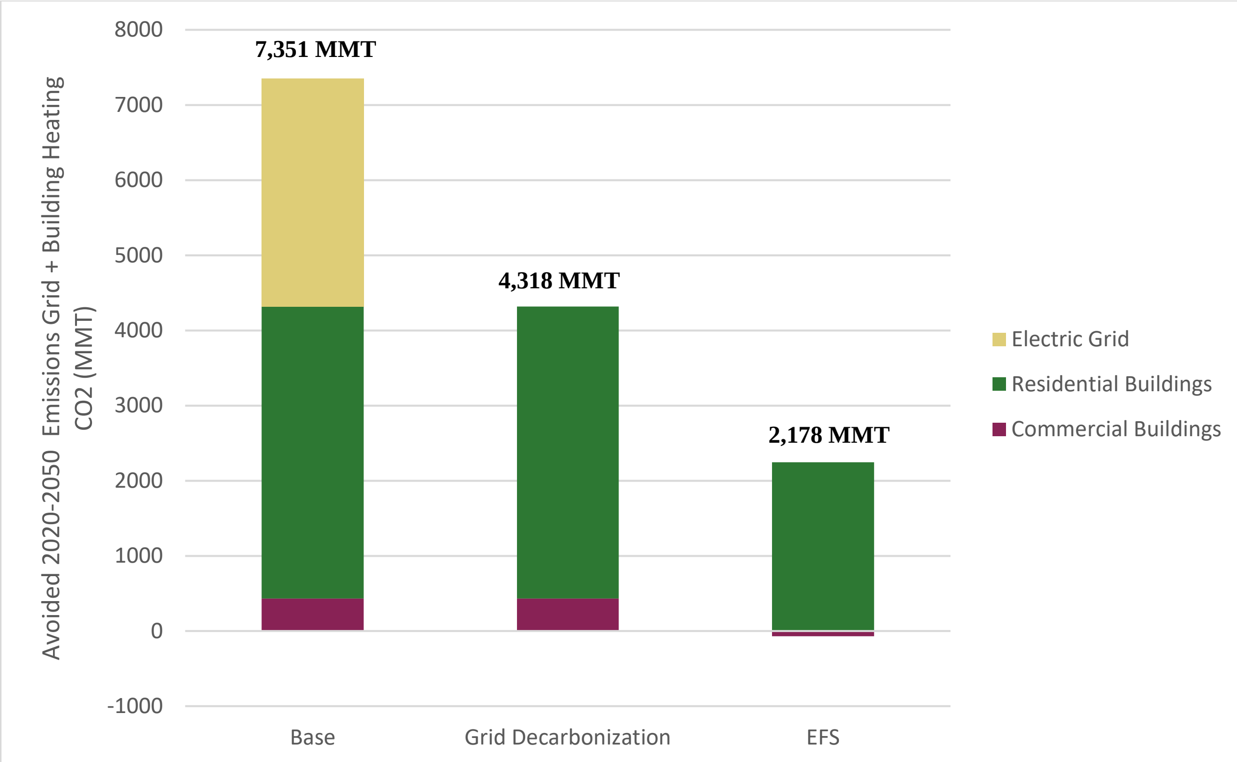


Figure ES-5. Cumulative economy-wide emissions reductions from 2022 to 2050 resulting from deploying GHPs into 68% of buildings in the United States, coupled with weatherization in single-family homes, in the Base, Grid Decarbonization, and EFS scenarios.

7. **Reduced marginal system cost of electricity for consumers:** The marginal system cost is the wholesale cost for electricity that wholesale buyers pay to generators and grid operators. The marginal system cost ultimately affects what consumers pay to electricity providers.[16] GHP deployment reduces peak energy demand and flattens annual energy use, which lowers the marginal system cost to wholesale buyers in the Base, Grid Decarbonization, and EFS scenarios.

   As shown in Figure ES-6, the reduction in marginal system costs in the Base + GHP scenario is relatively small (6% in 2050) because many of the currently operating natural gas and coal plants have already recovered their initial investment costs. However, with GHP deployment, the increase in marginal system cost resulting from transitioning the existing grid (Base) to a decarbonized grid can be cut by nearly a third.

   GHP deployment in the Grid Decarbonization scenario reduces the new investment required to meet capacity and generation needs, yielding greater savings (a 12% reduction in 2050) in the marginal system cost than in the Base scenario. From 2022 to 2050, the reduced marginal system cost decreases wholesale electricity payments from consumers by $316 billion in the Base scenario, $557 billion in the Grid Decarbonization scenario, and $606 billion in the EFS scenario (all present values considering a 5% discount rate). More details are provided in Section 4.2.1.5 of this report.

[16] The marginal system cost comprises the locational marginal price of electricity, the marginal price of capacity for resource adequacy for the planning reserves, the marginal price of operating reserves, and the marginal credit price of renewable portfolio standards.

	Scenario	Marginal system cost in 2050 ($/MWh)		Annual payments in 2050 ($B)		Present value of cumulative electricity payments from 2022 to 2050 ($B)	
No GHP deployment	Base	49		257		3,163	
	Grid Decarbonization	83		436		4,361	
	EFS	90		636		5,460	
			Savings ($Mwh)		Savings ($B)		Savings ($B)
With GHP deployment	Base	46	3	217	39	2,848	316
	Grid Decarbonization	73	10	341	95	3,805	557
	EFS	83	7	504	132	4,854	606

Figure ES-6. Marginal system costs and payments of electricity in various scenarios.

8. **Reduced cumulative system cost of electricity:** The cumulative system cost captures the capital costs of generators and transmission systems, as well as the costs for operating the generators and the grid. As shown in Figure ES-7, GHP deployment could reduce the cumulative system cost by $147 billion (a 5.0% reduction) in the Base scenario, $246 billion (a 7.1% reduction) in the Grid Decarbonization scenario, and $306 billion (a 7.4% reduction) in the EFS scenario. The greater cost reduction in the Grid Decarbonization and EFS scenarios is mostly due to greater savings in capital costs and transmission investments compared with the changes seen in the Base scenario. More details are provided in Section 4.2.1.6 of this report.

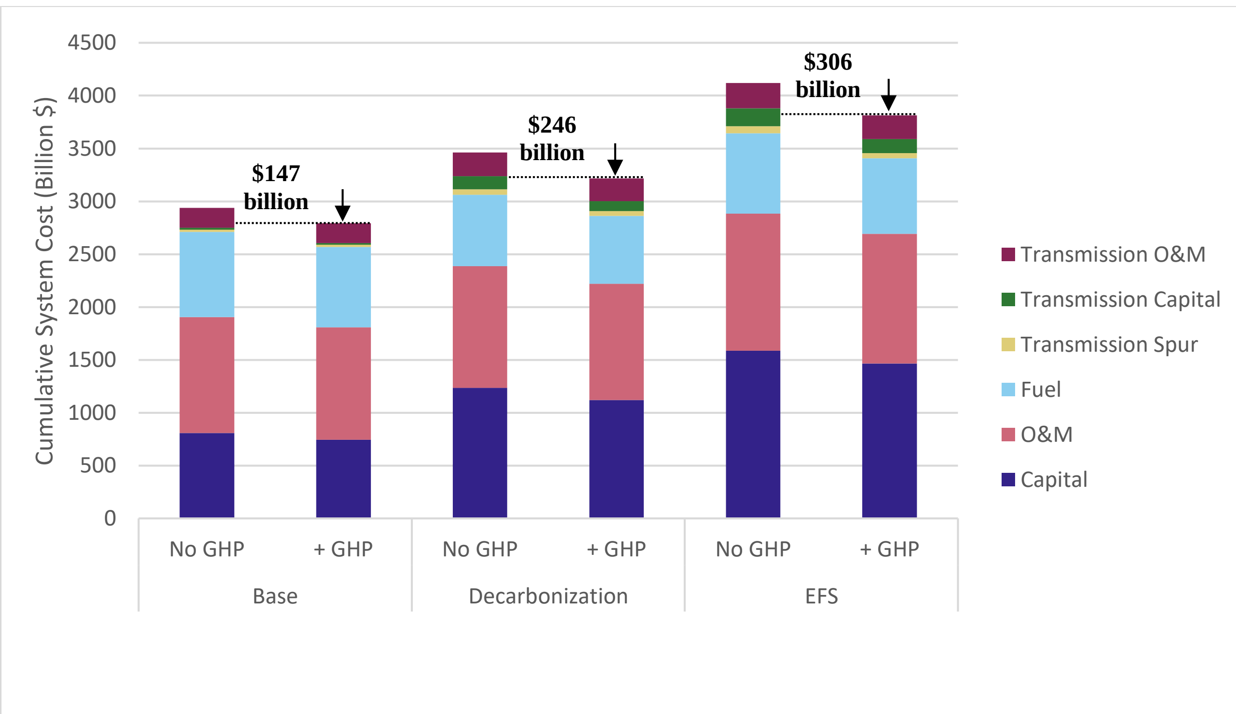
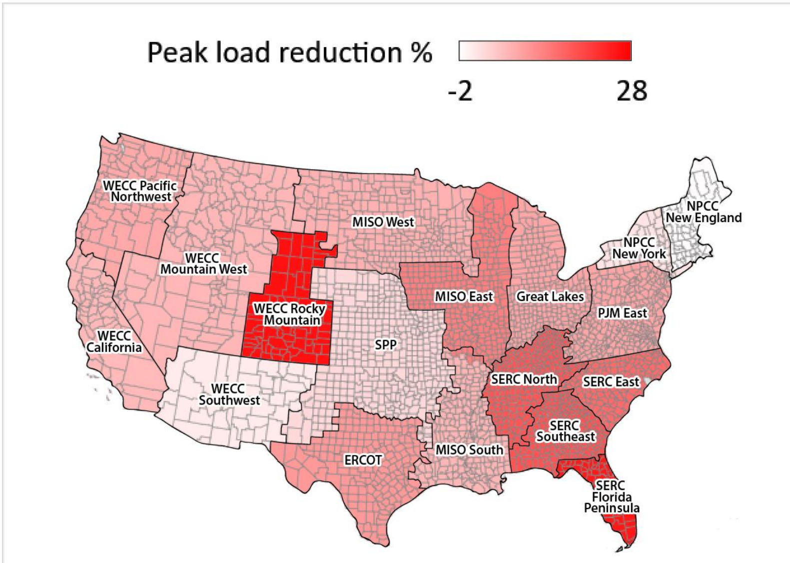


Figure ES-7. Cumulative discounted electric power system cost (present values considering a 5% discount rate) from 2022 through 2050 in various scenarios.

9. **Reduced regional peak load of electricity:** As shown in Figure ES-8, the mass GHP deployment can reduce the peak load in the summer in all reliability assessment zones (RAZs)[17] by 3%–28%. This reduction is because GHPs have a higher cooling efficiency than conventional HVAC systems. This reduction also contributes to the annual electricity consumption savings observable in Figure ES-1. The South and Southeast have higher peak load reductions than other areas because of higher cooling demand in the summer. In the winter, GHPs can also reduce the peak load for most areas; in the Southeast, where electric heating (e.g., ASHPs and electric resistance heaters) is widely used, the peak load reduction ratio can be up to 28%. Notably, the peak load is less reduced in areas where fossil fuel–based heating is used. More details are provided in Section 4.2.2.3 of this report.



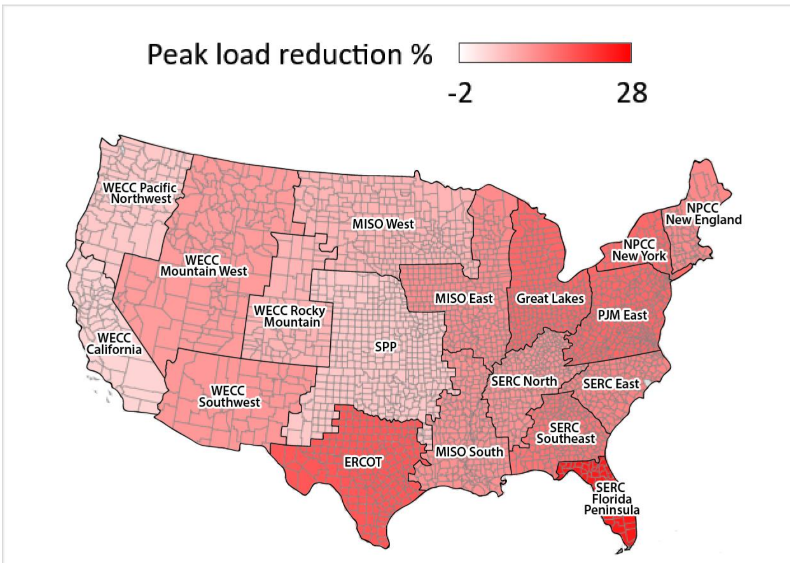


Figure ES-8. Peak load reduction ratio of the Base scenario in (top) winter and (bottom) summer resulting from deploying GHPs into 68% of buildings in the United States, coupled with weatherization in single-family homes.

[17] The RAZs are used by the modeling program to determine regional factors beyond serving the required electric loads, such as reliability.

10. **Improved reliability of regional electric power supply:** A preliminary analysis reveals that GHP deployment can improve the operational reliability of power grids in extreme weather events. As an example, during the 2021 winter storm in Texas, approximately 28 GW (38%) of the anticipated electricity demand was left unmet during the most severe outage periods. However, if all the applicable buildings in Texas had been retrofitted with GHPs, the unserved electricity demand ratio would have been reduced to approximately 18% (10 GW). GHP deployment could thus reduce rolling blackouts, which affected many consumers and resulted in high economic losses. More details are provided in Section 5 of this report.

Study Implications

As demonstrated through this study, **the mass deployment of GHPs can electrify the building sector without overburdening the US electric power system**. In all GHP deployment scenarios considered, significant reductions are realized in the needed power generation and capacity, energy storage capacity, transmission buildouts, a seasonal capacity that can contribute toward resource adequacy, CO_2 emissions, and marginal and cumulative system costs of electricity across the United States. Although this study was for the contiguous United States only, the findings are applicable to all 50 states and US territories.

Impacts on annual electricity consumption varied geographically, with greater reductions in the southern part of the country. Meanwhile, in the northern United States, carbon emissions related to on-site heating were reduced. GHP deployment can reduce the peak load of electricity in all RAZs in the summer by 3%–28%. A similar reduction can be achieved in winter in all RAZs except in the Northeast because GHPs displace natural gas heating rather than electrified heating (e.g., ASHPs) in this region. The reduced need for electricity generation results in significant reductions in CO_2 and other emissions. This study also found that using GHPs to electrify space heating in buildings requires less electricity generation capacity than using ASHPs.

In all analyzed scenarios, deploying GHPs significantly reduces the national peak electricity demand in 2050. With the mass deployment of GHPs, less new generation capacity will be needed to meet the electricity needs of the country, reducing the required investment to expand the grid, including generators and transmission lines. Mass GHP deployment can be a key strategy to achieve decarbonization—not just for homes and communities, but for the entire grid and the broader US economy.

Moreover, the beneficial impacts of GHP deployment presented in this study may be conservative. For example, the analysis used only existing GHP technology; it did not consider GHP technology improvements over the study period. However, mass deployment of GHPs would be expected to spur in technology improvements (e.g., higher efficiency and lower cost). Because this was an impact analysis only, there is a simplifying assumption that all the GHP systems are for individual buildings. The study did not analyze the district geothermal energy networks, which have the potential for large capital expenditure reductions and improved performance. Water heating was not considered as part of this analysis but is a need that could be addressed by GHPs. The study also did not attempt to estimate domestic job creation resulting from GHP mass deployment, which is expected to be significant.

To deploy GHPs into 68% of residential and commercial buildings in the United States between 2022 and 2050, it is estimated that 5 million GHP units need to be installed each year. However, currently, only about 70,000 GHP units are installed in the US each year (Malhotra et al. 2023). This significant gap for GHP deployment needs to be addressed through technology development, supporting policies, innovative business models, and substantial investments from both the building and electric sectors.

1. INTRODUCTION

The Biden-Harris administration has set aggressive goals to reduce economy-wide emissions and achieve a 100% carbon pollution–free electric power sector by 2035 (i.e., supply-side decarbonization targets) and a net-zero emissions economy by 2050 (i.e., demand-side decarbonization targets). According to the *Annual Energy Outlook 2022* published by the US Energy Information Agency (Nalley and LaRose 2022), building heating and cooling currently represent 13% of total primary energy use, 15% of total electricity use, and 12% of total CO_2 emissions (including those from the electric power sector) in the United States. Technologies to increase building energy use efficiency and reduce emissions are critical to meeting decarbonization goals.

Electrifying space heating and water heating in buildings using electric heat pumps is a method to reduce carbon emissions. Air source heat pumps (ASHPs) are the most common type of electric heat pumps in the marketplace. ASHPs extract heat from the ambient air to warm buildings or move heat to the ambient to cool buildings. The heating and cooling capacity and efficiency of ASHPs thus depend on and are limited by the ambient air conditions. The heating capacity and efficiency of ASHPs typically drop when the ambient temperature is low, and the heating demand is high. Therefore, ASHPs are usually equipped with electric resistance heaters to provide supplemental heating, which could result in high power draws when they are turned on. Mai et al. (2018), Tarroja et al. (2018), and White and Rhodes (2019) indicated that replacing gas-fired furnaces with ASHPs in the residential sector would result in higher annual electricity consumption and a shift in electric peak demand from summer to winter in regions with cold climate. Such a change could substantially affect how the power grid operates and would require substantial new investments in the electric power infrastructure.

Geothermal heat pumps (GHPs, i.e., ground source heat pumps) are another type of electric heat pump. GHPs use the ground (or sometimes water bodies such as lakes) as their heat sink/source instead of the ambient air, and they use water or a mixture of water and antifreeze as the heat transfer medium, which can transfer heat much more effectively than the air. Because of the relatively stable temperature of the ground, GHPs are more energy-efficient than ASHPs in providing heating and cooling to buildings. GHPs have been used in residential and commercial buildings in all 50 US states (Liu et al. 2019). Previous studies (e.g., Bayer et al. 2012, Liu et al. 2017, Yuan et al. 2012, You et al. 2021) reported that GHPs are typically 20%–50% more energy-efficient than conventional heating and cooling systems. Furthermore, GHPs offer a promising path to reduce economy-wide CO_2 emissions by reducing the power needed for providing space cooling and electrifying space heating, which is currently provided in many buildings by furnaces/boilers consuming natural gas, heating oil, propane, or other fossil fuels. Lim et al. (2016) reported that retrofitting residential buildings in the United States with GHPs could lead to maximum annual savings of 1.3 EJ (1.3 quad Btu) in energy, $7.1 billion in energy costs, and 64.8 million metric tons (MMT) in CO_2 emissions. Liu et al. (2019) reported that if all the existing HVAC systems in the residential and commercial sectors were retrofitted with GHPs, annual primary energy consumption could be reduced by 5.9 EJ (5.7 quad Btu), annual CO_2 emissions could be reduced by 356.3 MMT, and annual energy costs could be reduced by $49.8 billion. The 5.7 quad Btu of primary energy savings from GHP retrofits could reduce the US primary energy consumption for heating and cooling by 46%. However, these studies only assessed the impacts of GHP retrofitting on buildings. The effects of large-scale GHP deployment on the electric power sector have not been examined in previous studies.

The electric power sector represents a substantial portion of the US energy system. In 2021, the electric power sector used 38.2 EJ (36.9 quad Btu), or 38%, of the total primary energy consumption and resulted in 1,559 MMT, or 32%, of CO_2 emissions in the United States. Depending on the efficiency of the electrified heating and cooling technology deployed, implications for grid decarbonization and costs could vary significantly. Therefore, when considering the effects of heating electrification via electric heat pumps, the system-level coupling of the electric power sector with the building sector must be evaluated.

Liu et al. (2015) reported that by 2012, the cumulative capacity of GHPs installed in the United States reached 3.9 million refrigeration tons (approximately equivalent to serving 1.4 million households). Approximately 1% of the 126 million existing buildings in the United States currently use GHP systems. Major barriers that prevent the adoption of GHPs are high initial costs and spatial requirements for installing ground heat exchangers (GHEs). The US Department of Energy's (DOE's) *GeoVision* analysis (2019) predicted that the "equivalent of more than 28 million households [would be] using geothermal heat pumps by 2050." These numbers were based on market potential (i.e., only including GHP systems with a simple payback of less than 10 years), whereas economic potential (i.e., including GHP systems with a life cycle cost savings over 20 years) was far higher and would equate to 60 million households.

GHP applications have no resource limitations. The thermal storage capacity of the Earth is essentially inexhaustible from the standpoint of using GHPs in every building in the United States. Therefore, the main limiting factor is the economics. Economics is only limiting when considered at the building level instead of the system level, which accounts for both the building sector and the electric power sector. Considering the potential impacts of GHPs on the electric power sector, the economic potential at the system level could be greater than that projected in the *GeoVision* analysis (2019).

A recent report from the American Council for an Energy-Efficient Economy indicated that energy efficiency measures that reduce building thermal loads for heating and cooling, including building envelope improvements and HVAC system upgrades, are likely to contribute the most to energy savings and avoided electricity system costs. These energy efficiency improvements can also help mitigate many of the challenges associated with high levels of renewable energy deployment, including critical materials mining, land acquisition, transmission siting, and long renewable energy interconnection queues. Therefore, an aggregated set of energy efficiency measures should be part of any deep decarbonization or high renewable energy pathway study (Specian and Bell-Pasht 2023).

In this study, the effects of heating and cooling electrification via GHP deployment across the contiguous US,[1] which includes weatherization in single-family homes, are comprehensively analyzed for the first time. Specifically, this study investigates the national-scale benefits that GHP deployment could provide for, including

- reducing energy consumption and the associated carbon emissions,
- shedding peak electricity demand,
- lowering grid infrastructure costs, and
- improving grid operational reliability.

To facilitate the modeling and analytical work, a workflow was developed and used to effectively manage substantial project scales and underlying complexities. In this workflow, commercial and residential building GHP retrofits were first modeled individually and then aggregated to quantify the associated impacts on each balancing area (BA) of the electric energy system. Then, these building-related impacts were considered via grid modeling to evaluate the effects of GHP retrofits on the electric power sector.

The remainder of this report is organized as follows. Section 2 introduces the methodology and data sources used to evaluate the impacts on energy consumption and carbon emissions that would result from

[1] This excludes Alaska, Hawaii, and US territories because of limited data for conducting a detailed analysis. Although this study was for the conterminous United States only, the findings are generally applicable to all 50 states and U.S. territories.

a mass deployment of GHPs in the United States. Section 3 presents the building sector analysis results, and Section 4 describes the electric power sector analysis results. Section 5 presents a preliminary regional grid reliability analysis. Finally, Section 6 provides conclusions and a discussion on future work.

2. ANALYSIS METHODOLOGY

The procedure for analyzing the effects of mass GHP deployment on the US electric grid includes two stages, as depicted in Figure 2-1. In the first stage, the impacts of GHP retrofits on the energy consumption and electricity demand of residential and commercial building stocks were quantified for each county in the United States and aggregated across the contiguous United States. In the second stage, the difference in hourly electricity use that resulted from the GHP retrofits was used as an input in the grid modeling tools to evaluate the impacts of GHP retrofits on the electric power sector.

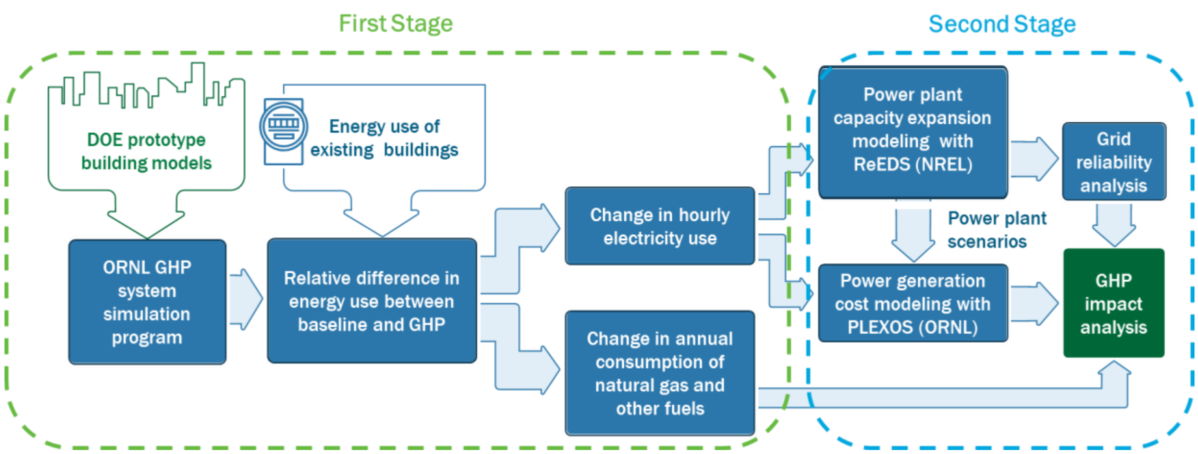


Figure 2-1. Flowchart of the combined building and grid modeling approach.

2.1 BUILDING SECTOR MODELING

2.1.1 New End-Use Load Profiles of Existing Buildings Resulting from GHP Retrofits

Existing buildings have diverse characteristics and operation schedules that must be considered when calculating their end-use load profile (EULP), which is the pattern of building energy use at each hour of the year. This study used the EULP data set published by the National Renewable Energy Laboratory (NREL; NREL 2021) for the existing US building stock in 2018[2] (does not include any new buildings after 2018) as the baseline energy use for assessing the impacts of GHP retrofits. Approximately 1 million EULPs are included in the data set, representing all major end uses (e.g., space cooling, space heating, fan, pump, lighting, equipment, water heating) in various building types and climate regions in the US commercial and residential building stocks. These EULPs are generated with sub-hourly simulations of millions of different buildings across all US counties using the ResStock and ComStock programs, which are physics-based building stock modeling tools. These models have been informed by and validated against the best-available ground-truth data (NREL 2021).

New EULPs that result from retrofitting all applicable residential and commercial buildings in the United States with new GHP systems were calculated in this study. Only HVAC-related end uses (i.e., space cooling, space heating, fan, and pump) were adjusted in the new EULPs. Air sealing (e.g.,

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[2] NREL's EULP data covers 57% and 98% of the floor space of the commercial and residential buildings, respectively, that exist in 2018.

weatherstripping of windows and doors, blocking air leakage through ductwork and ceiling) was also accounted for when calculating new EULPs for single-family homes because it is a typical practice associated with GHP retrofits. Although GHPs can also contribute to water heating for part or all of the year depending on the design, using GHPs for water heating was not included in the new EULP. Figure 2-2 illustrates the following steps for calculating the new EULPs:

- Calculate energy consumption after replacing existing HVAC systems in DOE's prototype models for existing buildings (DOE 2022) with new distributed GHP systems using the GHP simulation program developed at DOE's Oak Ridge National Laboratory (ORNL) (Liu et al. 2022).

- Calculate hourly relative differences (i.e., fraction factors) in the HVAC-related site energy consumption between the existing HVAC system and the new GHP system for each prototype building in 14 US climate zones (CZs).[3]

- Identify valid candidates for GHP retrofits by using the metadata summary of the residential and commercial building stock characteristics in the original EULP data set. In this study, all buildings included in the EULP data set were considered valid for GHP retrofits except for buildings that use district heating and cooling (i.e., no energy consumption for heating and cooling at the building), mobile homes, buildings without heating or cooling, and buildings that already use GHPs.

- Apply the fraction factors to the original EULPs that are applicable candidates for GHP retrofits to determine the new EULPs that result from the GHP retrofits.

The original and new EULPs were aggregated for each BA, and the differences between the aggregated original and new EULPs were calculated to determine the changes in hourly electricity consumption and fossil fuel use in each BA. Additionally, the resulting carbon emission reductions from reduced fossil fuel consumption on the building sites in each BA were calculated using carbon emission factors of various fossil fuels (American Society of Heating, Refrigerating and Air-Conditioning Engineers [ASHRAE] 2022). The carbon emission reductions related to changes in electricity use are reported in Section 4.

[3] Based on heating and cooling degree-days, (ASHRAE 2021) defines CZs 1 through 8 as very hot, hot, warm, mixed, cool, cold, very cold, and subarctic/arctic, respectively, and sub-CZs A, B, and C as moist, dry, and marine, respectively.

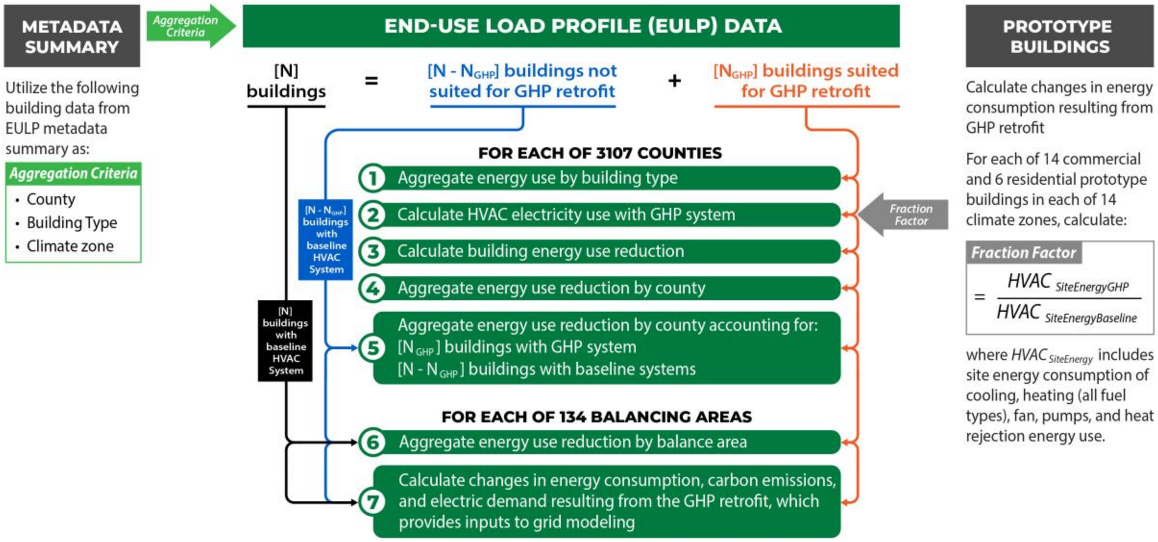

Figure 2-2. Procedures for calculating energy savings and carbon emission reductions in existing buildings resulting from GHP retrofits.

2.1.2 GHP Simulation Tool

ORNL's GHP simulation program (Liu et al. 2022) was developed to establish a fully automated process for (1) replacing an existing HVAC system submodule in a building energy simulation model with a distributed GHP system; (2) sizing each component of the GHP system, including heat pumps and vertical bore GHEs (VBGHEs); and (3) simulating the performance of the existing HVAC system and the GHP system to compare the differences. The data flow of the automated process is shown in Figure 2-3. A web interface was also developed to take user inputs and display simulation results.

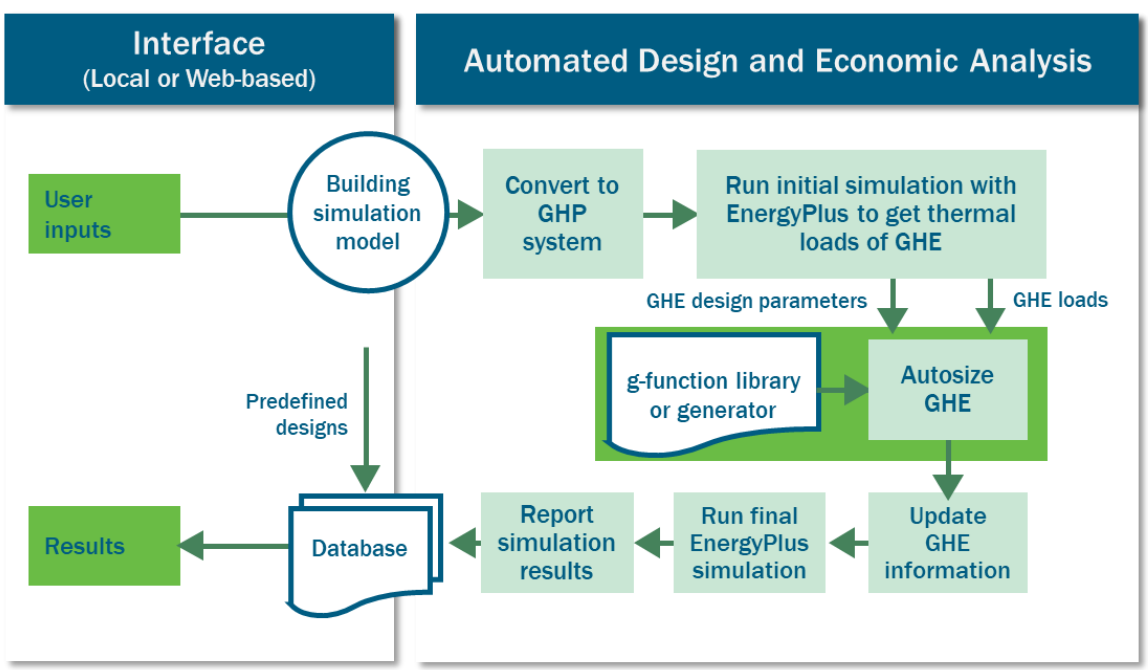

Figure 2-3. Flowchart of ORNL's GHP simulation program.

2.1.3 Prototype Building Models

DOE's prototype building models (DOE 2022) of 16 types of commercial buildings and 4 types of single-family homes (SFHs) in 14 US CZs were used in this study. Each prototype building model has a submodule for an HVAC system that is commonly used in buildings represented by the prototype model. The third edition (the latest) of typical meteorological year (TMY3) weather data (Wilcox and Marion 2008) of representative cities of these CZs were used in the energy simulation with these prototype models. To represent average existing buildings, this study used the prototype commercial building models created following the 2007 edition of ANSI/ASHRAE/IES Standard 90.1 (ASHRAE 2007) and the prototype SFH models created following the 2006 edition of the International Energy Conservation Code (IECC) (ICC 2006). Characteristics of the prototype building models used in this study and the representative cities of the 14 US CZs are listed in Appendix A.

2.2 ELECTRIC POWER SYSTEM MODELING

The electric power system in the 48 contiguous US states is divided into 134 BAs, as indicated by the boundary lines and numbered in white circles in Figure 2-4, consistent with other NREL grid modeling studies. The boundary lines generally follow the lines of real BAs but are adjusted in some instances to follow county lines instead of actual BA territory lines and to absorb small BAs into single larger regional BAs (for example, BA 10 in California encompasses several smaller BAs). Although counties are the spatial resolution of the building sector modeling, BAs are the spatial resolution at which generation, load, and transmission are balanced in the grid modeling. The map also shows the reliability assessment zones (RAZs), which are indicated with various colors on the map, to which each BA is assigned. The RAZs are used by the modeling program to determine regional factors beyond serving the required electric loads, such as reliability. The colors on the map simply indicate that each RAZ comprises multiple BAs.

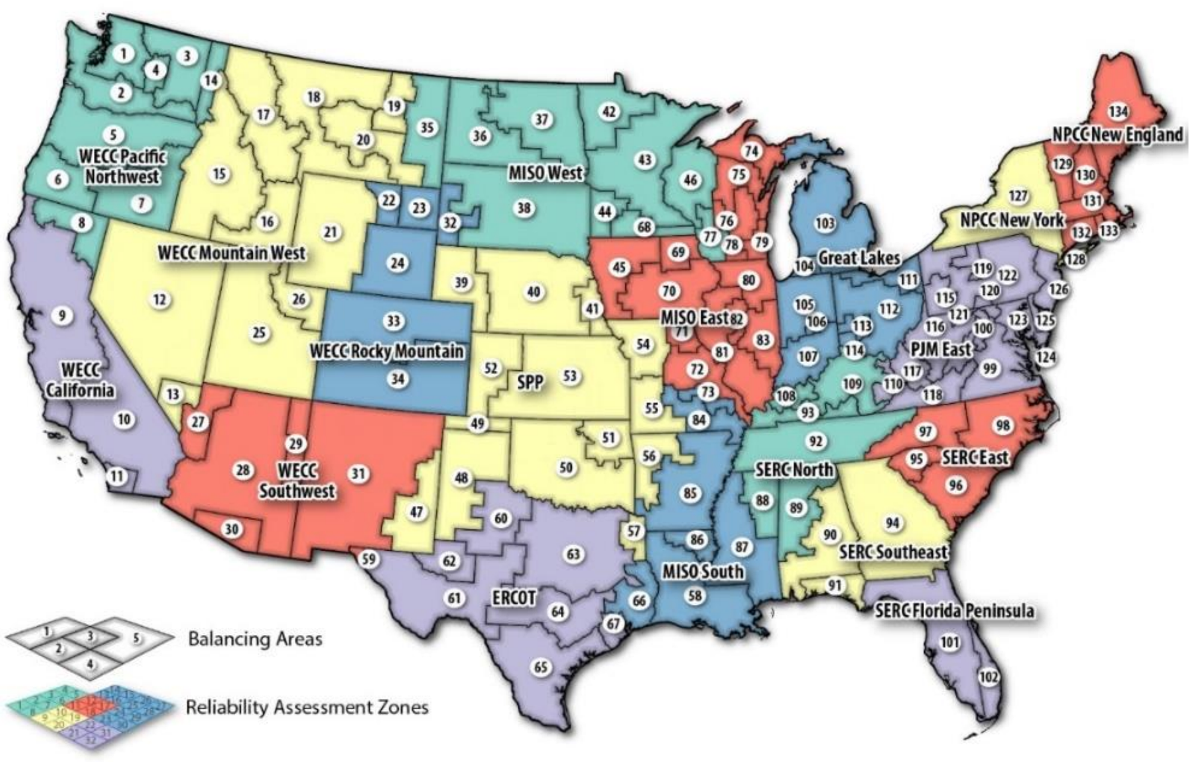

Figure 2-4. BAs of the contiguous US electric power system modeled in this study.

Two grid modeling methodologies—capacity expansion modeling (CEM) and production cost modeling (PCM)—were performed sequentially to analyze the effects of mass GHP deployment on the electric power sector. CEM is used to identify the least expensive mix of power generation in each BA over multiple decades. It takes into consideration factors such as new policies, technological advancements, changing fuel prices, and electricity demand projections. CEM is not suited to detailed, hour-by-hour simulation of power plants and grid operations. Other analyses, such as PCM, are needed alongside CEM to capture the full spectrum of the planning and operations of the electric power sector and to predict the cost and emission impacts of mass GHP deployment. PCM seeks to minimize the total cost of operating a fleet of generators to satisfy electricity demand and requirements for ancillary services. The minimization is achieved by controlling the commitment and dispatch of generators while adhering to system-level constraints on transmission capacity and generators' physical or operational limitations.

Regional Energy Deployment System Model (ReEDS), a publicly available CEM tool developed at NREL, is used to predict power system planning. It forecasts the time, location, and quantity to install new generation resources (e.g., renewable energies, fossil fuel–based units, storage systems, nuclear units) and transmission lines, accounting for the load growth and retirement of aging infrastructure in the future. The outputs of ReEDS include generation capacity, generator builds and retirements, high-level results on carbon emissions and fuel consumption, and so on.

PLEXOS, a commercial software for PCM, is used to simulate power systems' operation at hourly or finer resolution. For a given power system infrastructure, PLEXOS can optimize the operating schedule for power systems to minimize operational costs. The PLEXOS simulation outputs are in fine time resolutions, such as the online/offline status of a generator in several days, the hourly power output of a generator, and the hourly electricity prices. It can also analyze reliability indexes, such as total unserved load, power interruption, outage duration, and outage frequency.

The flowchart of the grid sector analysis is shown in Figure 2-5. The changes in hourly electricity use in the building sector of each BA resulting from the mass GHP deployment are added to the electric load profile of the BA to obtain a new BA load profile, which is used as the input of ReEDS. ReEDS simulation is performed using a representative set of time slices for multiple specific years to predict the needed generator build/retirement, generation capacity, and renewable energy penetration that are required to meet the new load profile. The time slices are composed of overnight, morning, afternoon, and evening average hours for each season, and a 17^{th} time slice selected from the 40 top summer peaking hours is included to capture higher peak operations. A translation process is employed to translate the generation, storage, and transmission network topology results from ReEDS into inputs of PLEXOS to perform the hourly modeling of grid operations and predict hourly power generation, carbon emissions, fuel consumption, and annual peak demand of the electric power sector. Thus, PLEXOS can capture more details of electric power systems' operations and associated costs compared with the 17 time slices of operations used during ReEDS optimization.

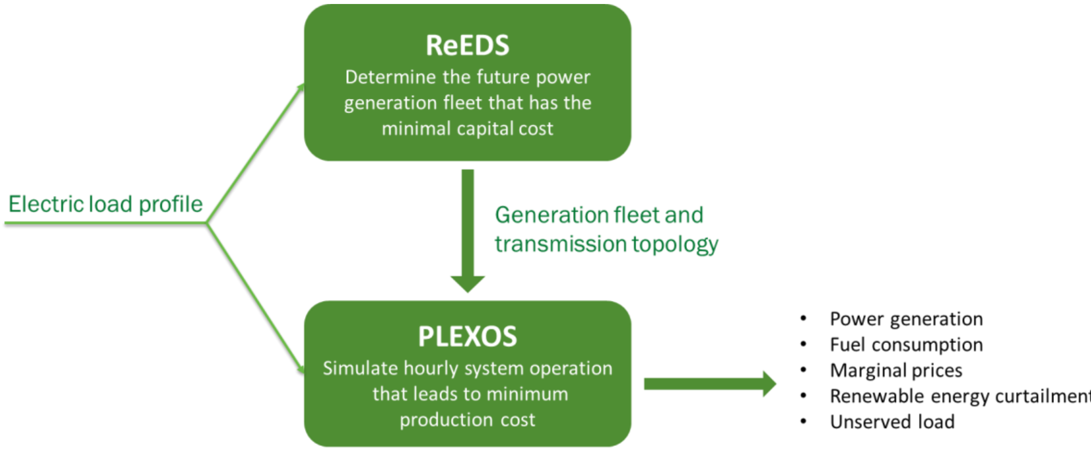

Figure 2-5. Flowchart of the electric power sector analysis.

3. BUILDING SECTOR ANALYSIS

The impacts of the mass deployment of GHP systems in commercial and residential buildings were evaluated by comparing the original EULPs of the existing building stock and the new EULPs resulting from retrofitting all buildings included in the original EULPs with GHPs, except for buildings that use district heating/cooling (i.e., no energy consumption for heating and cooling at the building), mobile homes, buildings without heating or cooling, and buildings that already use GHPs. The scenarios and assumptions used in the building modeling and the results are presented here, along with discussions of the limitations of this study.

3.1 SCENARIOS AND ASSUMPTIONS

In this study, distributed GHP systems were modeled for retrofitting existing HVAC systems in commercial and residential buildings. The distributed GHP system is typically coupled with a dedicated outdoor air system (DOAS) (Kavanaugh and Rafferty 2015), as shown in Figure 3-1. This system configuration separates outdoor air (OA) ventilation from the temperature control in each zone so that it can maintain the indoor air temperature at a user-specified set point while ensuring that only the needed OA is delivered to each zone of the building. The following assumptions were used in the simulations:

- The GHP system is sized to meet 100% heating and cooling demands in each thermal zone without using any supplemental heating or cooling.
- The heating coefficient of performance (COP) of the GHP is 4.0 and the cooling COP is 6.5 at the rating conditions specified in the ANSI/AHRI/ASHRAE/ISO Standard 13256-1 (2012). These COPs are 10%–30% higher than the minimum requirements specified by ENERGY STAR.[4] The operational efficiency of each GHP during each hour of its annual operation is modeled using the performance curves of a typical GHP, which correlate the operational heating and cooling capacity and efficiency of the GHP with the simulation-predicted supply fluid temperature of the VBGHE in response to the heating and cooling loads of the GHP.[5] The performance curves of GHPs are listed in Appendix B.

[4] https://www.energystar.gov/products/heating_cooling/heat_pumps_geothermal/key_product_criteria
[5] Some GHPs can use the condensing heat during cooling mode operation to preheat domestic hot water so that the heat rejection load to the VBGHE is reduced. However, this feature was not accounted for owing to the limitations of the simulation program used in this study.

- Each building has its own VBGHE, which comprises boreholes laid out in a square or near-square array and with uniform spacing between boreholes.[6] The design parameters of the VBGHE are listed in Table 3-1. The required number of boreholes and borehole depth of each VBGHE are autosized with ORNL's GHP simulation program (Liu et al. 2022, Spitler et al. 2022) based on the thermal loads and the VBGHE's design parameters. Each VBGHE is sized to maintain its supply fluid temperature between 1°C and 35°C year-round.[7]

- For commercial buildings, the DOAS delivers unconditioned OA to the return air of the GHP in each thermal zone. For SFHs, an energy recovery ventilator is used in the DOAS to preheat or cool the OA before it enters the building.

- Air sealing[8] is applied to SFHs as a part of GHP retrofits to reduce outdoor air ventilation to the minimum required by ASHRAE Standard 62.2 (ASHRAE 2007, 2016)[9] and to eliminate air leakage from the ductwork of the HVAC system. Air sealing can reduce the heating and cooling load, especially in cold and hot climates. Air sealing can make GHP retrofits more cost-effective because it reduces the required capacity of a GHP and the size of ground heat exchangers, which may offset the cost of air sealing and save more energy. The impact of OA infiltration and ductwork leakage on the annual heating and cooling energy consumption of SFHs at each CZ is presented in Appendix C.

- Fans used in the new GHPs are more energy-efficient than the fans used in the existing HVAC systems. Fan efficiencies and pressure rise of the existing residential HVAC system and the new GHP are listed in Appendix B.[10]

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[6] We don't have information on the available land area for installing boreholes at each applicable building. We assume that, with the development of drilling technologies, such as compact drill rigs and tilted angle drilling, as well as the wide adoption of district GHP systems, there could be solutions to drill needed boreholes.
[7] Recent work has identified that in areas with mixed building types, the use of a shared VBGHE can greatly reduce the number of vertical boreholes that must be drilled (Spitler et al. 2022).
[8] Air sealing is usually done by applying weather strips at windows and walls, spraying foams in the attic, filling the cracks in the foundation and walls, and sealing the ductwork of the HVAC system.
[9] According to ASHRAE Standard 62.2 (ASHRAE 2007, 2016), the minimum OA ventilation requirement for acceptable indoor air quality in low-rise residential buildings is 0.35 air change per hour. However, the OA ventilation rate (including mechanical ventilation and infiltration) of the prototype SFH models developed based on the 2006 edition of IECC is 0.84 air change per hour, which is typical for old existing SFHs (Yamamoto et al. 2010).
[10] Most commercial HVAC systems use central air distribution systems, which typically use large, variable-speed fans to supply air throughout the building via central ductwork. These fans are quite different from the fans of GHPs, which only circulate a small amount of air within a thermal zone.

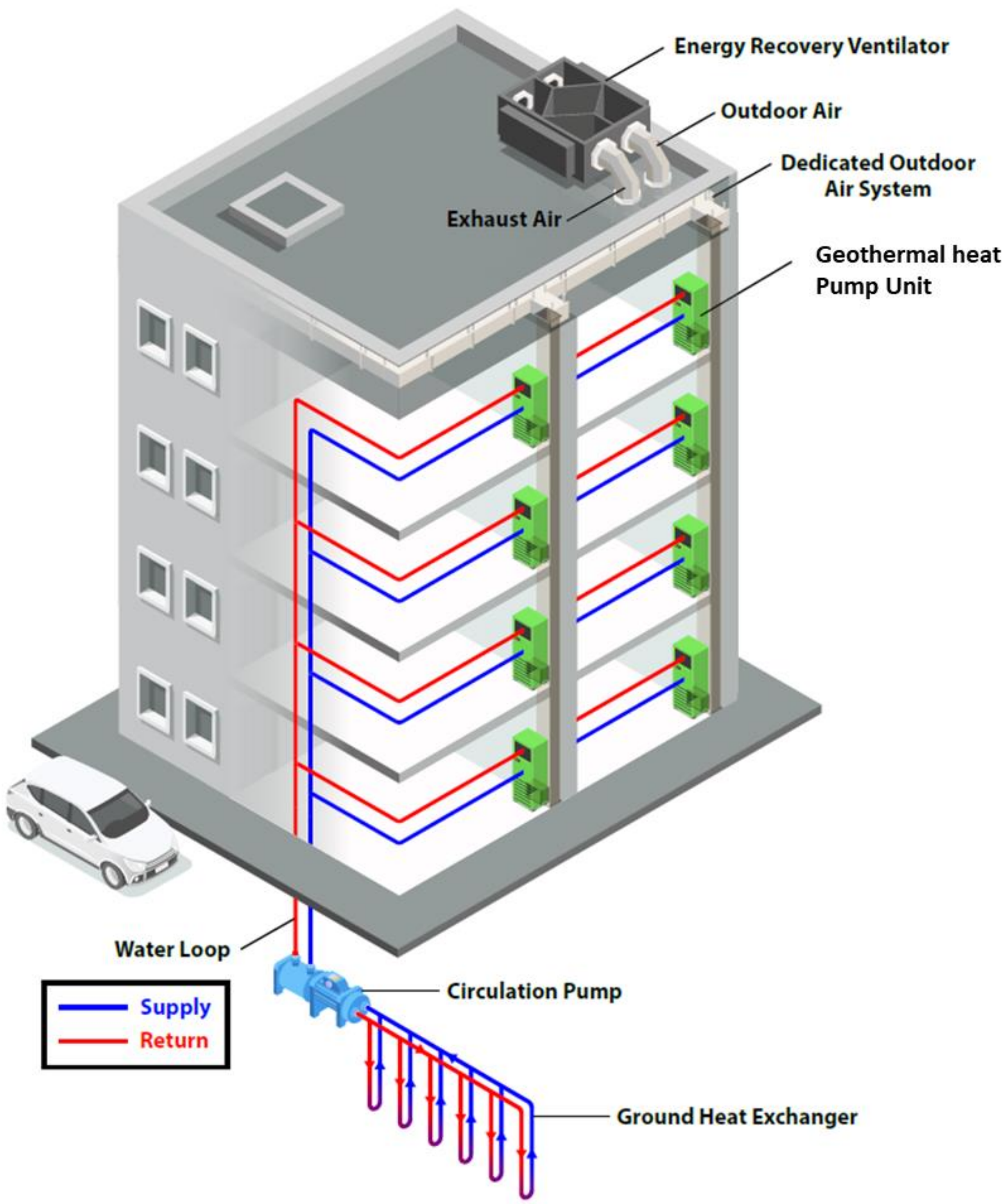


Figure 3-1. Illustration of a distributed GHP system coupled with a DOAS.

Table 3-1. Default values of VBGHE design parameters

Parameter	Default value	Parameter	Default value
Borehole radius (m)	0.0762	Grout heat capacity (kJ/[m^3·K])	3,901
U-tube pipe thickness (m)	0.002	Ground conductivity (W/[m·K])	1.29
U-tube pipe outer diameter (m)	0.027	Ground heat capacity (kJ/[m^3·K])	2,347
U-tube leg spacing (m)	0.025	Undisturbed ground temp. (°C)	Site-specific and calculated with the method by Xing et al. (2016)
Pipe conductivity (W/[m·K])	0.39	Bore spacing (m)	6.1
Pipe heat capacity (kJ/[m^3·K])	1,542	Maximum GHE supply temp. (°C)	35
Grout conductivity (W/[m·K])	1.29	Minimum GHE supply temp. (°C)	1

To represent existing commercial buildings, the DOE commercial prototype models (Pacific Northwest National Laboratory 2018) created following the 2007 edition of ANSI/ASHRAE/IES Standard 90.1 were used in this study. The 2007 edition was selected because buildings built or retrofitted around 2007 likely followed the 2007 edition of the building energy standard, and the HVAC systems in these buildings have reached their lifetime at the time of this study (2023) and need to be replaced with a new system. Similarly, the DOE residential prototype building models (Mendon et al. 2012) created following the 2006 edition of the IECC standard were used in this study to represent the existing residential buildings.[11]

3.2 HEATING ENERGY SOURCES OF EXISTING BUILDINGS

The energy sources for space heating in residential and commercial buildings were analyzed using the metadata of NREL's EULP data set. Figure 3-2 shows the percentages of total existing building floor space heated with various energy sources. This figure only shows the heating energy sources of the buildings that are considered applicable for GHP retrofits (i.e., excluding buildings with district heating and cooling, mobile homes, buildings without heating or cooling, and buildings that already use GHPs), which accounts for 78% of the total conditioned space of all existing residential buildings and 43% of the total conditioned space of all existing commercial buildings. In total, 241 billion ft^2 of floor space in the residential and commercial buildings are included in this study for GHP retrofits. As shown in Figure 3-2, although natural gas is the predominant heating energy source, a significant number of buildings are heated with electricity using electric resistance heaters or heat pumps (mostly ASHPs).

[11] Future buildings were not modeled explicitly in this study. The same energy savings percentages in the existing buildings are approximately applied to the future buildings in the grid analysis. This limitation is discussed in Section 3.4.

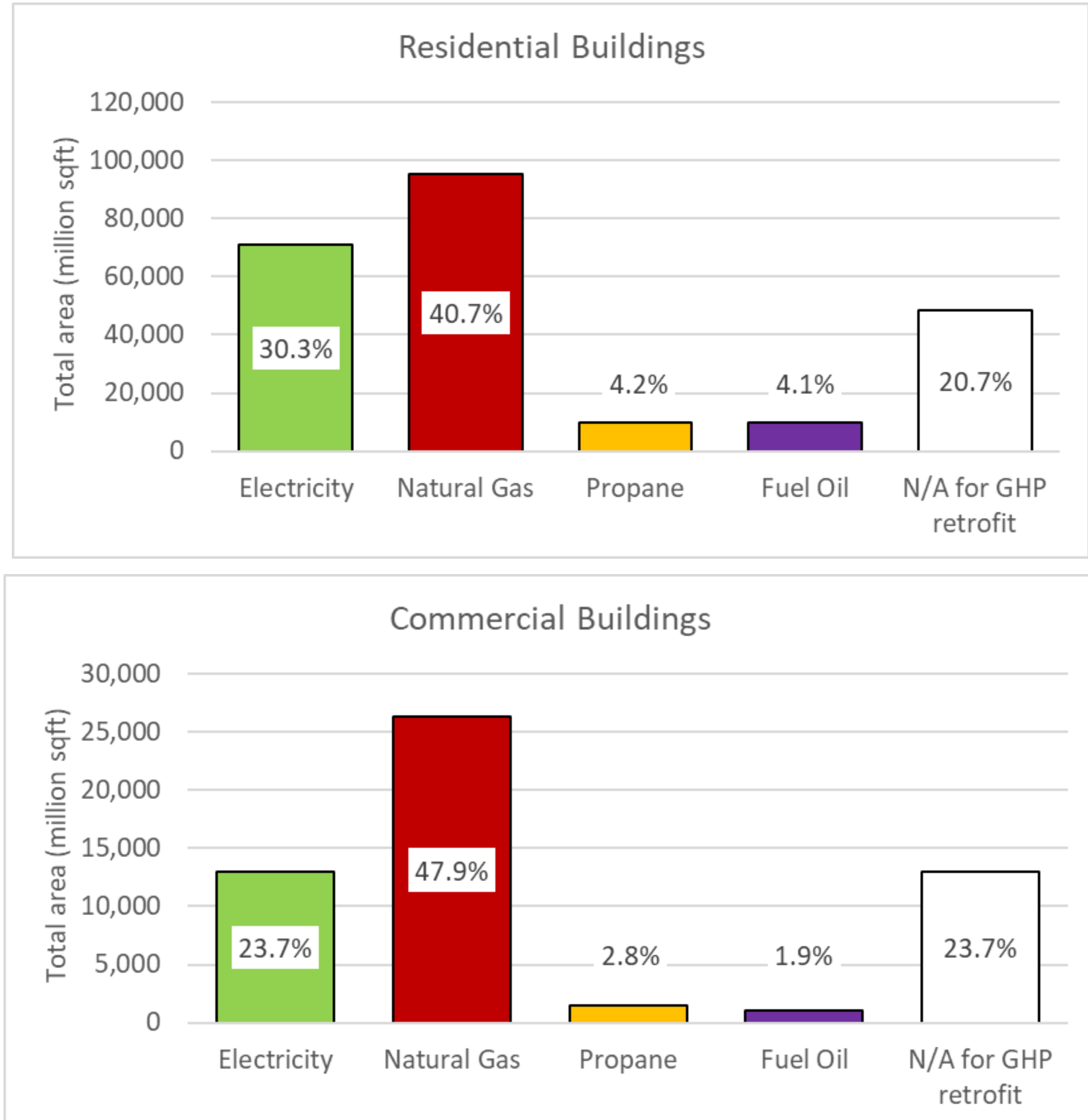


Figure 3-2. Existing residential and commercial building floor space heated by different sources. The white columns represent the amount of existing floor space that is not considered for GHP retrofits in this study.

The two stacked bar charts in Figure 3-3 show the space heating energy use in residential and commercial buildings, respectively, in each BA. Each stacked bar represents the contribution of various heating energy sources to the total space heating energy of all the buildings that are applicable for GHP retrofits in each BA. A BA map is shown in Figure 2-5. The percentages of heating energy sources vary widely across BAs. In some BAs in the Northwest region, such as BA 2 in Washington State, the share of electric heating was greater than 60%. However, the share of electric heating was less than 10% in most BAs in the Northeast region, such as BA 128 in New York state.

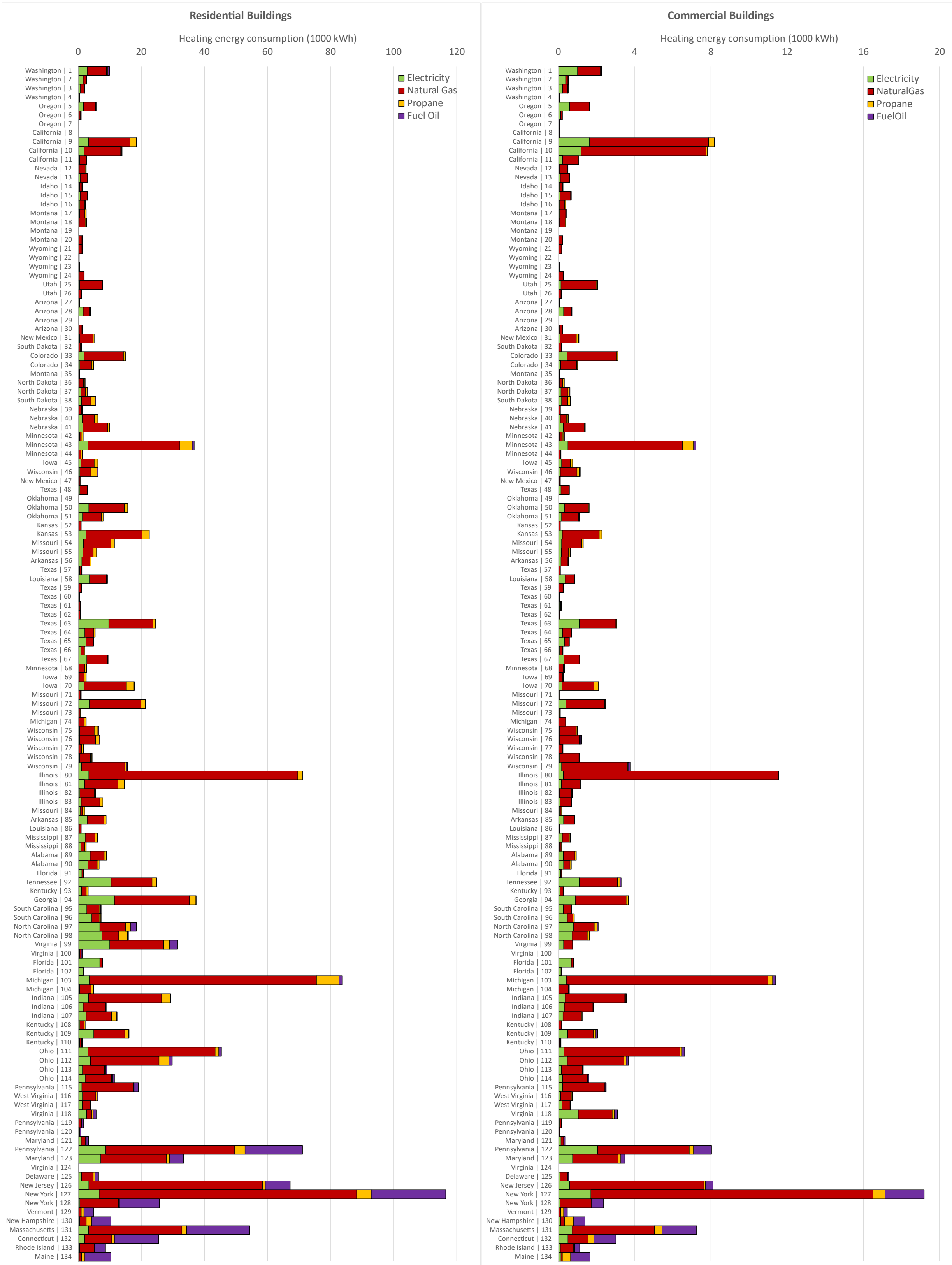


Figure 3-3. Percentages of various energy sources used for space heating in each BA for existing buildings that are applicable for GHP retrofits.

3.3 ANALYSIS RESULTS

The results of building sector analysis indicate that mass GHP retrofits (including weatherization in SFHs) have significant potential to reduce energy consumption and carbon emissions. If all applicable buildings in the contiguous United States were retrofitted with GHPs at once, electricity usage would be reduced by 401 TWh, which is an 18% reduction from the baseline EULP each year. Furthermore, 5,138 billion MJ of annual fossil fuel (e.g., natural gas, heating oil, propane) consumption (approximately 4,747 billion ft^3 of natural gas equivalent) would be eliminated. The reduced on-site fossil fuel consumption at buildings would avoid 342 MMT of equivalent carbon emissions each year. The emissions reduction resulting from the reduced electricity consumption are discussed in Section 4. The geospatial characterization of the impacts of GHP retrofits in each BA is presented here.

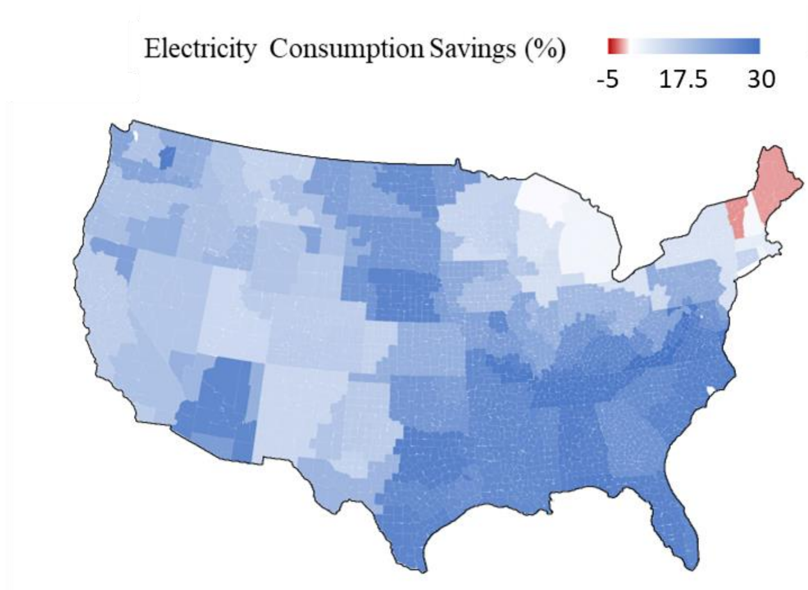
3.3.1 Geospatial Characterization of the Impacts

Because of the different heating and cooling demands in each BA and the various energy sources used for providing space heating in the existing HVAC systems, regional differences exist in the effects of GHP retrofitting. According to the US Energy Information Agency (EIA; EIA 2021), more than 99% of existing HVAC systems consume electricity to provide space cooling. GHPs reduce electricity consumption for space cooling because they are more efficient than all other commonly used existing space cooling systems. Existing space heating systems use electricity or fossil fuels. If a GHP replaces an electric heating system (e.g., electric resistance heater or ASHP), it will reduce electricity consumption for space heating. However, if it replaces fuel-burning heating equipment, it will eliminate fuel consumption and use electricity for space heating. Therefore, in southern BAs, where the cooling demand is high and more than 40% of space heating is provided with electricity, GHP retrofitting will result in significant savings in electricity. In contrast, because most space heating in northern BAs is provided by fossil fuels, the GHP retrofits will result in increased electricity consumption in the heating season, which will offset part of the electricity savings obtained during the cooling season; in limited examples (VT and ME), this offset may even slightly increase annual electricity consumption. Therefore, electricity savings gained from GHP retrofits in northern BAs are not as significant as in southern BAs. However, compared with the electricity consumption increase that would result from electrified heating with ASHPs, as demonstrated in this report and documented in previous analyses such as the *Rhode Island Strategic Electrification Study* (Erickson et al. 2020), GHP deployment (including weatherization in SFHs) achieves electrified heating with lower electricity consumption than the alternative, resulting in significant avoided costs and carbon emissions. Furthermore, the difference in energy efficiency between GHPs and conventional HVAC systems for cooling (e.g., a GHP with a cooling COP of 6.5 vs. a chiller with a cooling COP of 5.0) is smaller than that for heating (e.g., a GHP with a heating COP of 4.0 vs. a natural gas furnace with a burner efficiency of 0.8). Therefore, the site energy reduction would be higher in northern BAs, where buildings have greater heating demands.

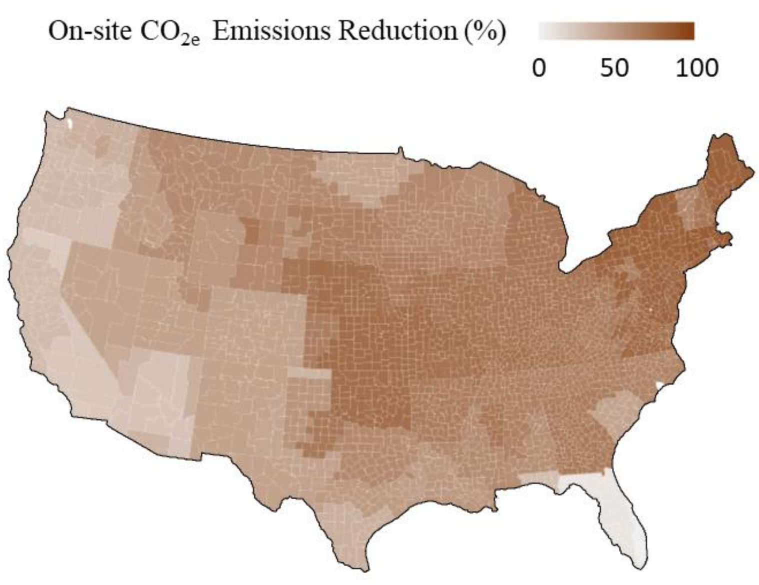
Figure 3-4 shows a geospatial representation of the percent changes in annual electricity consumption, site energy consumption, and on-site carbon emissions that result from the mass deployment of GHPs in each BA. Figure 3-4(a) shows that retrofitting the existing HVAC systems with GHPs and weatherization in SFHs will reduce electricity consumption in most parts of the United States, except in a few BAs in the Northeast. More significant reductions in annual electricity consumption will be achieved in southern BAs. On the other hand, Figure 3-4(b) shows that GHP retrofits result in higher percentages of carbon emission reductions (counted with CO_2 equivalent [CO_2e] of various emissions from combustion of fossil fuels[12]) in northern BAs (colder climates) than in southern BAs. Buildings in northern BAs have a higher burden for electrification of heat because of a higher heating load (in total energy and peak demand), so

[12] The CO_2-equivalent means the number of metric tons of CO_2 emissions with the same global warming potential as 1 metric ton of another GHG.

on average for the year, the electricity savings are not as significant and in some cases are negative. However, GHP retrofits eliminate high–CO_2 emitting, low-efficiency fossil fuel consumption for heating. Therefore, the overall site energy savings (including changes in electricity and fossil fuel consumption) on average are higher in northern BAs. Furthermore, as discussed in Section 4, to electrify all buildings' heating and cooling, the GHP retrofits investigated in this study would use less electricity compared with replacing existing HVAC systems with ASHPs.



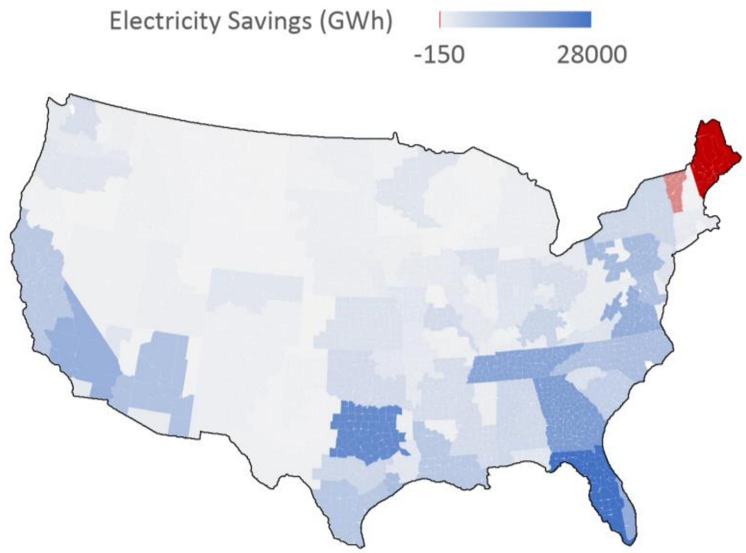
(a)



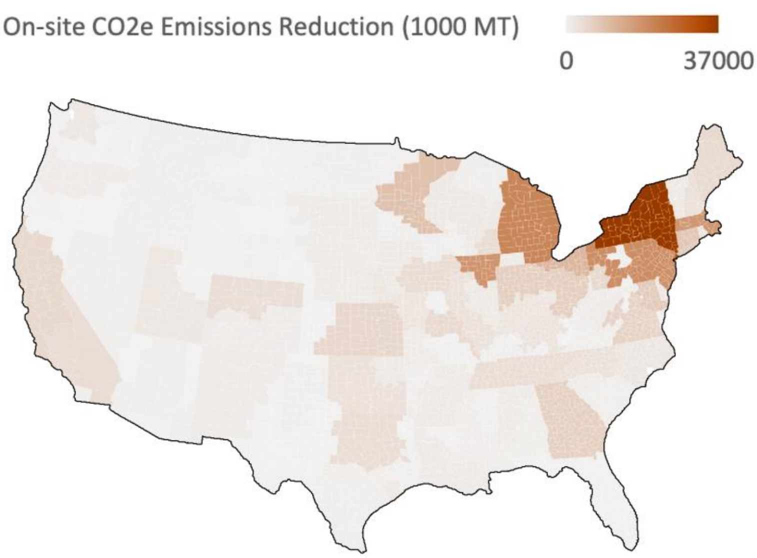
(b)

Figure 3-4. Geospatial representation of the percent changes in (a) building annual electricity consumption and (b) annual on-site carbon emissions (from combustion of fossil fuels for space heating) that would result from retrofitting all appliable existing buildings in 2018 with GHPs (including weatherization in SFHs) in each BA.

Figure 3-5 shows the absolute values of the changes in annual electricity consumption and on-site carbon emissions that would result from the mass deployment of GHPs in each BA. The absolute values of electricity savings are high in the densely populated areas in the southern and western United States, including Florida, Texas, and California. In Figure 3-5, BAs in Maine and Vermont are colored red, indicating an increase in electricity consumption. The increase is caused by the current low percentages of electric heating and low cooling demands in the existing buildings in these BAs. In terms of on-site carbon emissions reduction and site energy savings, BAs in New York and Michigan show the highest values because of the high populations and heating demands in these areas.



(a)



(b)

Figure 3-5. Geospatial representation of the absolute values of changes in (a) annual electricity consumption and (b) annual on-site carbon emissions (from combustion of fossil fuels for space heating) that would result from retrofitting all appliable existing buildings in 2018 with GHPs (including weatherization in SFHs) in each BA.

3.3.2 GHP Impacts in Each BA

Table 3-2 lists the minimum, maximum, and average values of the changes (the absolute values and the percentages) in electricity and fossil fuel consumption, as well as the on-site carbon emissions that result from the GHP retrofits in the 134 BAs. These values represent the maximum energy savings that can be achieved each year compared with the baseline energy consumption of the existing US building stock in 2018, assuming all the applicable existing buildings are retrofitted with GHPs at once. Positive values indicate energy savings or carbon emission reductions compared with the baseline, and negative values indicate increased energy use or carbon emissions.

Table 3-2. Statistics of changes in building energy consumption and on-site emissions resulting from retrofitting all applicable existing buildings in 2018 with GHPs and weatherization in SFHs in each BA

Building energy consumption parameters		Minimum	Maximum	Mean
Building electricity savings	GWh/year	−150.2	27,958	2,992
	%	−2.1	29	17
Natural gas savings	10^6 MMBtu/year	0.02	384	29
	%	1.4	77	62
Heating oil savings	10^6 gal/year	0	758	31
	%	0	100	54
Propane savings	10^6 gal/year	0.15	274	29
	%	1.6	85	56
On-site carbon emissions reduction	10^3 MT/year	16.18	36,560	2,549
	%	1.4	82	57

On-site fossil fuel consumption and associated carbon emissions are reduced in all BAs. Although GHP retrofits result in electricity savings in most BAs, they lead to increased electricity consumption in a few BAs in the Northeast because most space heating in these BAs is provided by furnaces or boilers that consume fossil fuels, and the heating requirements are very large. Replacing these furnaces and boilers with GHPs will increase electricity consumption but will eliminate fossil fuel consumption for space heating. More electricity would be consumed in these BAs if the gas furnaces were replaced with ASHPs because of their lower heating efficiency than GHPs and the usage of supplemental electric resistance heating. In BAs without propane or heating oil consumption, the change in propane or heating oil consumption is zero.

All the graphs and tables in this section come from modeling the changes if all applicable existing buildings in 2018 were retrofitted at once. However, retrofitting all the applicable existing buildings will take many years, so the energy savings and carbon emission reductions that can be achieved each year would be smaller than those presented above.

If GHP deployment increases linearly from 0% in 2021 until reaching its maximum by 2050,[13] cumulatively, $1,020 billion[14] in fuel costs will be saved, and 5,290 MMT equivalent carbon emissions will be avoided by replacing the on-site consumption of fossil fuels for space heating with GHPs and weatherization in SFHs. These numbers are strictly the on-site cost savings and carbon emission reductions that are achieved in the building sector and do not include the fuel cost savings and emission reductions in the electric power sector, which is assessed in Section 4.

[13] This calculation does not account for any new construction between 2021 and 2050.
[14] The cumulative fuel cost is calculated based on AEO-projected fuel prices (USD [2021]) at various regions in the United States. Data source: EIA. 2022. "Table 3. Energy Prices by Sector and Source, Reference Case." *Annual Energy Outlook 2022*, Interactive Table Viewer. https://www.eia.gov/outlooks/aeo/data/browser/.

3.4 DISCUSSION AND LIMITATIONS OF THE CURRENT STUDY

Energy savings from the GHP retrofits result from several causes. First, the higher operational efficiency of the new GHP system is a result of more favorable ground source temperatures than ambient air for the heating and cooling operation of the heat pump. Second, distributed GHP systems modeled in this study avoid the common issue of simultaneous heating and cooling in commercial buildings conditioned with conventional variable air volume systems. Third, fan power is reduced by using fans with higher efficiency and separately controlling the airflow for climate control and OA ventilation (i.e., using a small fan in the DOAS to deliver OA and allowing fans of the GHPs to be turned on and off with the compressor based on the thermal demands). Finally, heating and cooling loads are lowered by reducing air infiltration and ductwork leakage in SFHs.

The limitations in the building energy simulation performed in this study are as follows.

- The prototype building models are based on the 2007 edition of ANSI/ASHRAE/IES Standard 90.1 for commercial buildings and the 2006 edition of IECC for residential buildings. These models are used to represent the average performance of existing buildings.[15] Newer/remodeled buildings may be more efficient, so the energy savings from retrofitting newer buildings may be lower than those calculated in this study. On the other hand, more energy savings may be obtained by retrofitting older buildings. More extensive modeling that accounts for the variances in building energy efficiency is recommended for future studies.

- Newer/remodeled SFHs may have a lower OA infiltration rate than that in the 2006 prototype SFHs, and the energy savings resulting from weatherization may be lower than what is calculated in this study. On the other hand, the energy savings may be higher by weatherizing older (leakier) buildings. More extensive modeling that accounts for the variances in air tightness in SFHs is recommended for future studies.

- TMY3 weather data were used instead of historical weather data in all the simulations of the prototype buildings and the building stock modeling used for generating the original EULPs. The typical weather year represents average weather over the past 30 years, which might not include extreme weather conditions. Therefore, the calculated peak electricity demands in this study are likely lower than in actual years in the future given the continuous climate change. It is thus recommended to consider future year weather data in future studies.

- Fraction factors for HVAC-related site energy consumption resulting from GHP retrofits and weatherization in SFHs were generated using DOE's prototype building models, which have a set of operation schedules for each prototype building. These schedules do not always align with the operation schedule of the building stock models used for generating the original EULPs, which used a series of different operation schedules for each type of the modeled buildings to reflect the diversity of building operation. It may introduce some errors in the calculated energy savings, especially during the shoulder seasons. More extensive modeling that accounts for the variances in operation schedules of different buildings is recommended for future studies.

[15] Less than 17% of existing buildings in 2018 were built after 2007, which are likely more energy efficient than the modeled buildings. On the other hand, many existing buildings built before 2007 may be less efficient than the modeled buildings.

3.5 SUMMARY

The building sector analysis results indicate that retrofitting all applicable buildings existing in 2018 with GHPs and weatherization in SFHs can save 401 TWh of electricity and eliminate 5,138 billion MJ of fossil fuel (e.g., natural gas, heating oil, propane) consumption (approximately 4,747 billion ft^3 of natural gas equivalent) each year compared with the electricity and fuel consumption of the existing building stock in 2018. The reduced on-site fossil fuel consumption at these buildings would avoid 342 MMT of equivalent carbon emissions each year. These benefits result from higher operational efficiency of GHP systems, avoided simultaneous heating and cooling in commercial buildings, reduced fan power due to improved fan efficiency and ventilation control, as well as lowered thermal loads by reducing air infiltration and ductwork leakage in SFHs.

Retrofitting existing HVAC systems with new GHPs and weatherization in SFHs will reduce electricity consumption in most parts of the United States, except in a few regions in the Northeast. Electricity savings are larger in densely populated areas in the southern and western United States. If the retrofits increase linearly from 0% in 2021 to 100% of all applicable buildings in 2050, $1,020 billion in fuel costs will be saved, and 5,290 MMT equivalent carbon emissions will be avoided by replacing the on-site consumptions of fossil fuels for space heating with GHPs and reducing air infiltration and ductwork leakage in SFHs. This estimate does not include the carbon and cost savings realized at the grid level, which are explored in the following sections.

4. ELECTRIC POWER SECTOR ANALYSIS

This section reviews ReEDS and PLEXOS modeling results to analyze the impacts of mass GHP deployment, which includes weatherization in SFHs, on the energy and capacity mix of the contiguous US electric power system. These results also show how the timing and quantity of electric power demand reduction reduces (1) the required transmission expansion for supporting grid decarbonization, (2) costs to the power system as a whole and electricity prices to consumers, and (3) the summer and winter resource adequacy requirement.

This study focuses on identifying the types and magnitudes of benefits resulting from the mass GHP deployment and weatherization in SFHs. The costs of GHP installation and weatherization, which depend on the maturity and size of the industry supporting it, were not considered as part of this study and will be accounted for in a future analysis.

This section first presents the four core scenarios and two sensitivities incorporated into the modeling analysis (Section 4.1) and then discusses the ReEDS and PLEXOS results (Section 4.2), limitations of the study (Section 4.3), and a summary of results (Section 4.4).

4.1 SCENARIOS AND ASSUMPTIONS

4.1.1 Core Scenarios

Four core scenarios were formulated for this study:

- **Base:** In this scenario, there is no GHP deployment, building sector energy consumption is consistent with Annual Energy Outlook (AEO) 2022 projections, and the CO_2 emission policy remains the same as existing state policies, including renewable portfolio standards, clean energy standards, and CO_2 emissions policies.

- **Base + GHP:** In this scenario, the GHP deployment rate increases linearly from 0% in 2021 to 100% in 2050. GHPs are included in new constructions starting in 2022, with the same assumptions as the existing buildings regarding the percentage of buildings applicable for GHPs and the energy savings compared with conventional HVAC systems.[16] The total floor space of new constructions is based on residential and commercial building stock changes[17] predicted by the EIA (AEO 2022).

- **Grid Decarbonization:** In this scenario, the national electric power grid's CO_2 emissions will be reduced by 95% in 2035 and 100% in 2050 as compared with the 2005 level.[18] This reduction indicates that all power generation will use clean energy by 2050.

- **Grid Decarbonization + GHP:** This scenario incorporates the effects of GHP deployment into the decarbonization scenario using the same GHP assumptions as the Base + GHP scenario. Both the grid decarbonization goal and the GHP deployment goal will be achieved in 2050. Avoided end-use emissions from GHP deployment do not count toward the grid decarbonization goal but are accounted for separately in the quantification of economy-wide emission effects.

4.1.2 Electrification Scenarios

In addition to the core scenarios, two electrification scenarios are formulated in this study based on values derived from the *Electrification Futures Study* (EFS, Sun et al. 2020). Both electrification scenarios use the power system decarbonization pathways used by the decarbonization scenarios among the core scenarios.

- **EFS:** No GHP deployment occurs, and economy-wide electrification of end uses—including partial building electrification through air source heat pumps (ASHPs), including the cold climate heat pumps, and other electrified devices for water heating and cooking—occurs, consistent with the values used in the high-electrification scenario from the EFS.[19] Weatherization in SFHs was not included in EFS.

- **EFS + GHP:** An economy-wide electrification of end uses occurs, along with 100% GHP deployment in applicable existing and new buildings coupled with weatherization in SFHs.[20] Electrification of other end uses (not for heating and cooling) is consistent with the values used in the high-electrification scenario from the EFS.

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[16] Energy savings in new constructions are approximately calculated by multiplying the total floor space of applicable new constructions and the normalized energy savings per unit of floor space, which are calculated based on energy savings achieved by GHPs (including weatherization in SFHs) in existing buildings as presented in Section 3.

[17] Building stock changes are modeled using the residential and commercial demand modules of the National Energy Modeling System, with residential building stock measuring the total number of units and commercial building stock measured in terms of total floor space, each broken down into US census regions.

[18] The electric sector CO_2 emission cap is based on the Decarbonization scenario in the Solar Futures Study and is consistent with goals presented in *The Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050* (White House 2021).

[19] In the EFS scenario, ASHPs were assumed to be used in 68% of residential buildings and 46% of commercial space in the United States. It is also assumed that residential ASHP efficiency will increase by 116% from 2015 to 2050 in the rapid technology development case.

[20] ASHPs in the EFS scenario are replaced with GHPs.

4.2 ANALYSIS RESULTS

4.2.1 ReEDS Capacity Expansion Modeling Scenario Results

As discussed in Section 2, ReEDS is an open-source capacity expansion modeling tool developed by NREL.[21] It simulates the evolution of the US power system by providing forecasts of new generation resources and transmission lines, as well as accounting for the load growth and retirement of aging infrastructure. This subsection describes ReEDS results of generation portfolios that capture the benefits of deploying GHPs (including weatherization in SFHs) in residential and commercial buildings. The impacts with and without fully decarbonizing the grid are compared. The analysis was completed using a version of the main ReEDS model from the spring of 2022.

4.2.1.1 Generation and Capacity Portfolios

Figure 4-1 shows that in 2050, if there is complete GHP deployment for all applicable residential and commercial buildings—representing 68% of the building stock in 2050—the electric power generation requirement will be reduced by 585 TWh and 593 TWh each year compared with the Base and the Grid Decarbonization scenarios, respectively. The major difference between the Base and the Grid Decarbonization scenarios lies in the types of generation being reduced. In the Base + GHP scenario, energy generation is reduced across all technology types, including fossil and renewable technologies. In contrast, the Grid Decarbonization + GHP scenario shows reductions primarily in variable renewable generation using wind, solar, or other variable renewable energy (VRE) and hydrogen combustion turbines (H_2-CTs), with small increases in output from nuclear power plants and solar photovoltaic (PV) battery hybrid storage plants.

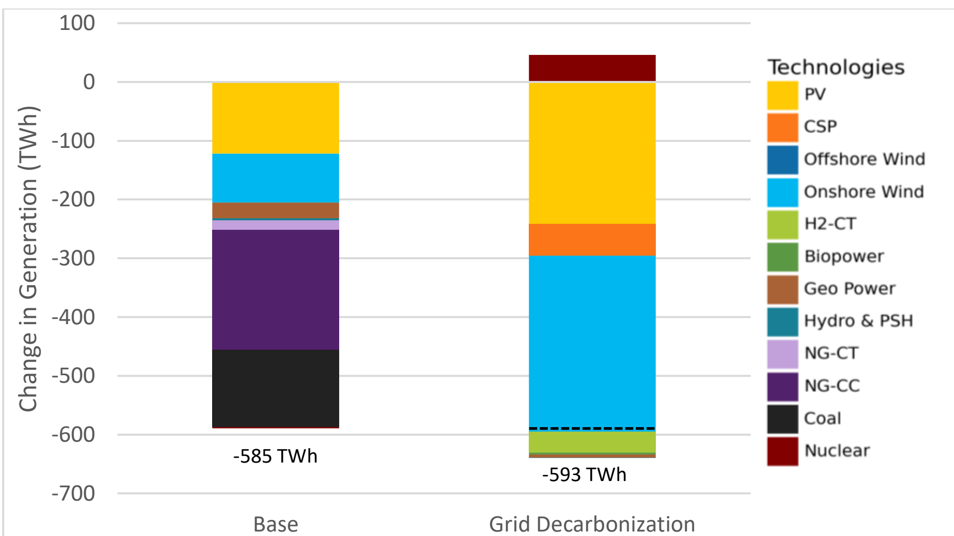


Figure 4-1. Changes in annual national generation (TWh) in 2050 resulting from deploying GHPs into 68% of buildings in the United States, coupled with weatherization in single-family homes, in the Base and Grid Decarbonization scenarios.

Figure 4-2 shows that with GHP deployment in all applicable commercial and residential buildings, a sizeable reduction exists in installed capacity in 2050 compared with the Base and the Grid Decarbonization scenarios. GHP deployment in the Grid Decarbonization scenario doubles the reduction in installed generation and storage capacity compared with that in the Base + GHP scenario (345 GW vs.

[21] For more information, see https://www.nrel.gov/analysis/reeds/.

173 GW). In the Grid Decarbonization scenario, a large fraction (74%–77%) of the generation mix is made up of VRE sources, which typically have lower capacity factors than natural gas which is heavily used in the Base scenario. Therefore, the Grid Decarbonization scenario contains a large fraction of battery storage. These results indicate that GHP deployment will have a greater effect on electric power systems with higher VRE and energy storage deployment.

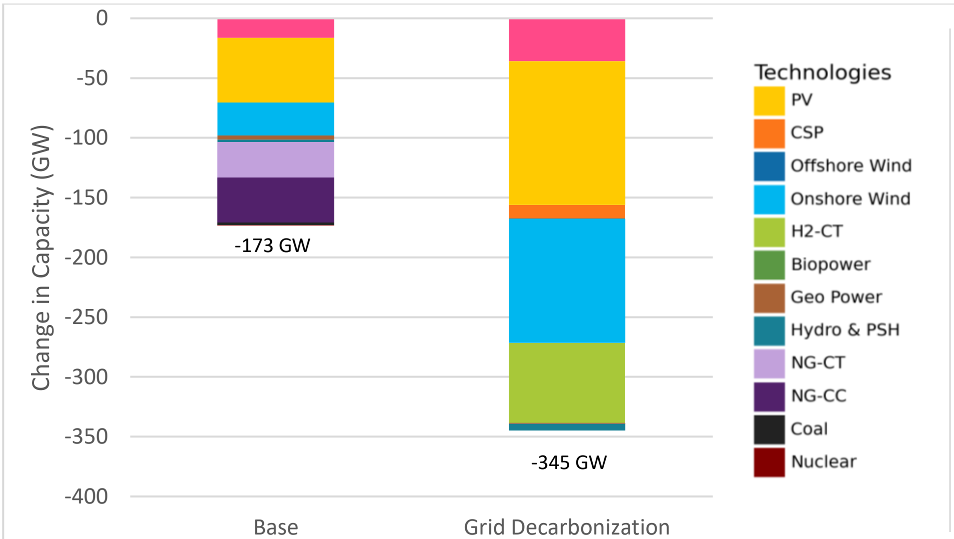


Figure 4-2. Changes in national installed capacity in 2050 (GW) resulting from deploying GHPs into 68% of buildings in the United States, coupled with weatherization in single-family homes, in the Base and Grid Decarbonization scenarios.

4.2.1.2 Interregional Transmission Expansion Requirement

The interregional transmission expansion results are shown in Figure 4-3. The mass GHP deployment in the Base and the Grid Decarbonization scenarios reduces the need for transmission additions. Similar to the generation capacity changes, a greater benefit of avoided transmission additions can be achieved by deploying GHPs in the Grid Decarbonization scenario than in the Base scenario. In the Grid Decarbonization scenario, the electric power system transitions to a high-VRE system, which benefits from increased transmission additions to connect load centers and to provide geographic diversity of generation and load. The mass GHP deployment can reduce the new transmission requirement by 3.3 TW·mi, or a 17.4% reduction, in the Base scenario and 36.7 TW·mi, or 33.4% reduction, in the Grid Decarbonization scenario. With a representative transmission expansion of 1,500 MW capacity per transmission line, the 36.7 TW·mi reduction could represent on the order of 24,500 mi of avoided transmission construction.

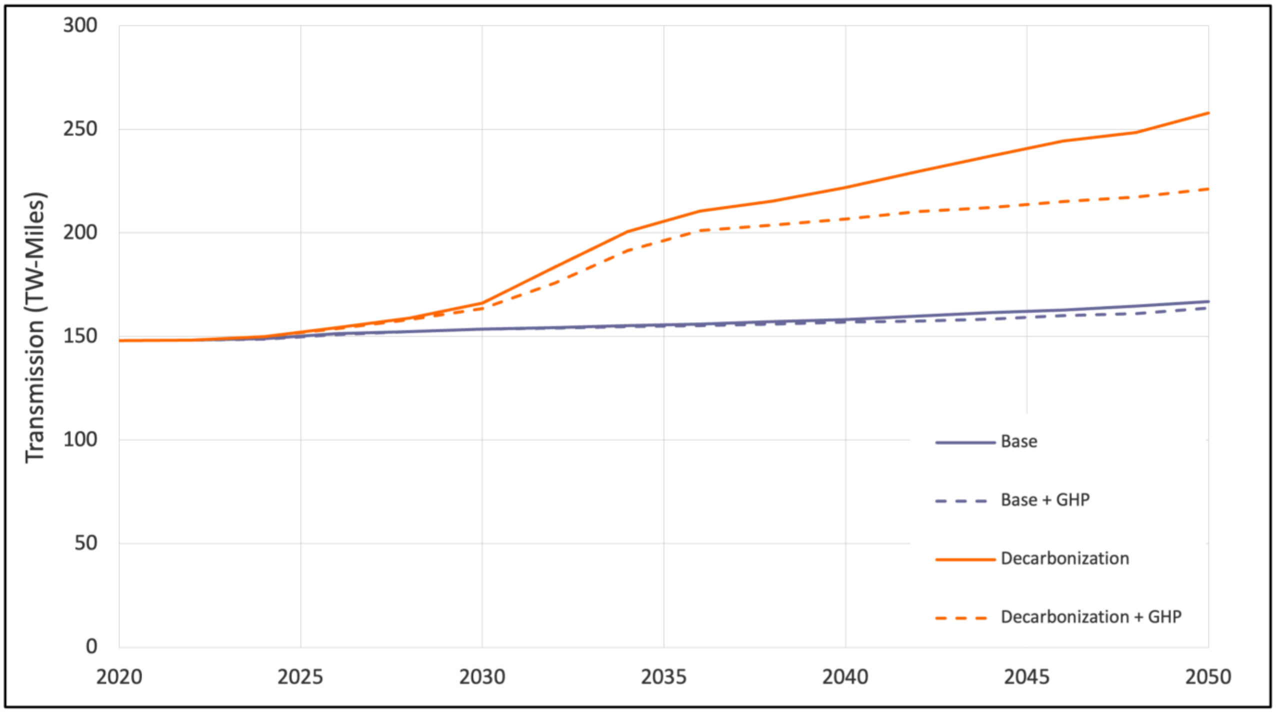


Figure 4-3. Interregional transmission expansion requirements in the Base and Grid Decarbonization scenarios with and without deploying GHPs into residential and commercial buildings in the United States (including weatherization in single-family homes) from 2022 to 2050.

Table 4-1. Interregional transmission expansion results comparison

Scenario		New + existing transmission in 2050 (TW·mi)	New transmission in 2050 (TW·mi)	Reduction (TW·mi)	Reduction (%)	Present value of transmission capital cost savings from 2022 to 2050 ($ billions)
Base	No GHP	167.0	19.0	—	—	—
	With GHP	163.7	15.7	3.3	17.4	2.7
Grid Decarbonization	No GHP	257.9	109.9	—	—	—
	With GHP	221.2	73.2	36.7	33.4	29.9

Reduced transmission has two effects: cost savings and ease of implementation. The total system cost savings in terms of the present value (5% discount rate) in the long-distance transmission system from the deployment of GHPs is $2.7 billion in the Base scenario and $29.9 billion in the Grid Decarbonization scenario. Transmission costs, including capital and operation and maintenance (O&M), account for 10% of total grid costs. Although GHP deployment reduces the requirement for new transmission construction and the associated costs, the transmission cost savings represent only approximately 1% of the total electricity payment reduction between 2022 and 2050. In recent years, there has been greater difficulty in permitting and constructing new transmissions. Therefore, reducing the amount of high-voltage transmissions may have benefits beyond cost savings by reducing the uncertainty and delays of getting new transmissions constructed to serve the needs of a decarbonized grid. It also reduces land use impacted by the transmission expansion.

4.2.1.3 Resource Adequacy

Resource adequacy (RA) is an important criterion for planning and operating electric power systems. Sufficient RA is required to meet the supply- and demand-side electric demands without a shortfall. Consumption and generation must be precisely balanced at all times; shortfalls in energy can result in blackouts. North American Electric Reliability Corporation (NERC) guidance sets a standard that power systems should procure sufficient eligible capacity such that there should be less than 1 day of shortfall in 10 years. The capacity that contributes to RA differs from the installed capacity discussed in the previous subsection in that it represents the portion of a generator or storage resources capacity that can be used during a reliability event. The amount of capacity that can contribute toward RA varies depending on the type of supply and the timing of reliability events. Although most regions currently experience peak and net peak demands in the summer, electrification (especially in buildings) can create more winter-peaking regions. The 100% Clean Electricity by 2035 Study (Denholm et al. 2022) contained electrification scenarios assuming completely electrified residential and commercial space heating without using GHPs (assumed electrification with ASHPs supplemented with electric resistance heaters) and observed winter peaks 35% higher than summer peaks. This transition from summer peak to winter peak is not included in the Base and Grid Decarbonization scenarios (with and without GHPs), but it is partially modeled in this study's EFS scenario (see Section 4.2.1.7).

ReEDS models RA and ensures that planning reserve margins comply with published NERC values for the peak demand and available capacity that can contribute toward RA in each season. Technologies are assigned a capacity credit, which represents the availability of a technology to produce power during a reliability event. For example, conventional nonvariable generation resources have a capacity credit of one. For VRE, a seasonal capacity credit is calculated by using the net hourly load duration curve to approximate the expected load-carrying capacity. This method captures the variability in weather, as well as the geographic correlation in resources that affect a VRE's ability to contribute capacity toward RA. Storage capacity credit is calculated by simulating hourly storage dispatch for each region and storage configuration. Further details on the calculation of capacity credit are available in ReEDS documentation (Ho et al. 2021). In the modeled core scenarios, only the summer season was a binding requirement for RA, and the other seasons' resources were in excess of the established planning reserve margin. This section focuses on changes occurring during the summer season because it is the driving factor in system investment decisions.

Figure 4-4 demonstrates the annual difference in 2050 summer RA eligible capacity resulting from the mass GHP deployment in the Base and the Grid Decarbonization scenarios. The summer RA eligible capacity requirement is reduced by 102 GW after deploying GHPs in the Base or the Grid Decarbonization scenario. However, the makeup of the reductions differs substantially between the two scenarios, reflecting the types of resources built primarily for satisfying RA rather than energy. In the Base scenario, most reductions come from natural gas combustion turbines and combined cycle plants, with the next-largest fraction coming from battery storage. In the Grid Decarbonization scenario, with all CO_2-emitting power plants retired by 2050, the largest contributor to the summer RA eligible capacity requirement reduction comes from H_2-CT. There is a similar reduction in battery storage capacity in the Base and Grid Decarbonization scenarios, with both seeing reductions in 6 and 8 h duration batteries. The Grid Decarbonization + GHP scenario has a greater reduction in solar RA eligible capacity, primarily because of the larger share of PV battery hybrid plants, which maintain a higher capacity credit under high-VRE scenarios compared with traditional PV plants.

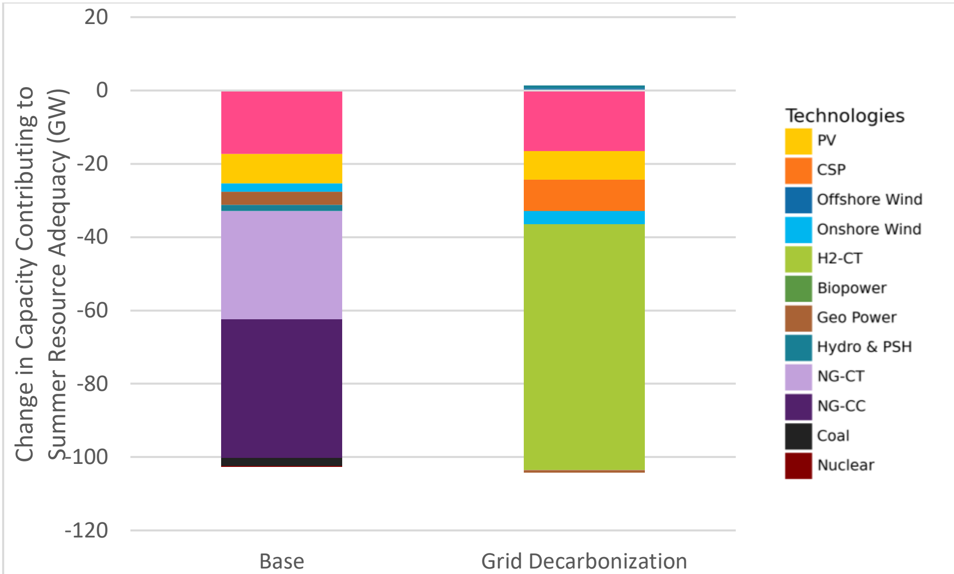


Figure 4-4. Changes in 2050 summer RA eligible capacity in the Base and the Grid Decarbonization scenarios resulting from deploying GHPs into 68% of buildings in the United States, coupled with weatherization in single-family homes.

The noncoincident peak demands of the studied four core scenarios are listed in Table 4-2. To ensure sufficient capacity for RA, a planning reserve margin applied to each region, the summation of the regional seasonal peak demand, or noncoincident peak, is closely related to this requirement. Although spatially correlated, the exact day and hour on which peak demand occurs in each region varies, and a noncoincident peak will exceed the national coincident peak, which is the maximum demand nationally occurring at a specific day and hour. The total noncoincident peak demand in 2022 is 650 GW and will be used as a reference to analyze the peak demand growth. As shown in Table 4-2, in both the Base and the Grid Decarbonization scenarios, the mass deployment of GHPs (including weatherization in SFHs) will significantly reduce the national noncoincident peak demand in 2050. This result means by adopting the GHP technology, much less new generation capacity is needed to meet the electricity demand and to address RA needs. In other words, the expansion investment of both generating units and transmission lines can be relieved with the mass GHP deployment, which has already been validated in the capacity mix analysis and transmission expansion requirement analysis. Of note in the Grid Decarbonization + GHP scenario, reductions in H_2-CT would also reduce the investments in pipelines, storage, and hydrogen production facilities that are needed to support green hydrogen.

Table 4-2. Noncoincident peak demand comparison between 2022 and 2050 for four core scenarios

Year and case		Noncoincident peak demand (GW)	Increase from 2022 (%)
2022		650	—
2050	Base	839	29.0
	Base + GHP	697	7.2
	Grid Decarbonization	841	29.3
	Grid Decarbonization + GHP	700	7.7

4.2.1.4 CO_2 Emissions

The CO_2 emissions in this section are reported in million metric tons (MMT) of emitted CO_2 instead of the CO_2e used in Section 3. The CO_2 measures the total combustion emissions, and CO_2e includes additional GHG effects associated with a specific fuel (e.g., pipeline leakage in natural gas distribution). The CO_2 emissions were focused on in this section because the implemented decarbonization policy is a cap on those emissions and not CO_2e, mirroring the scope of CO_2 policies such as the Regional Greenhouse Gas Initiative.

The electric sector CO_2 emissions are shown in Figure 4-5. In the Base + GHP scenario (dashed-blue line), the deployment of GHP will lead to a reduction in CO_2 emissions, relative to a no-deployment Base scenario (solid blue line), because the total electric load (TWh) and peak demand (GW) are both smaller with GHP deployment by 2050, resulting in a 217 MMT/year reduction by 2050. However, the emission of the Grid Decarbonization scenario (solid orange line) is identical to that of the Grid Decarbonization + GHP scenario (dashed orange line). This result is because in the Grid Decarbonization scenario, the carbon emission constraint is always binding because of the rapid 95% electric power system decarbonization target in 2035 and complete decarbonization in 2050. GHP deployment rates assumed in this study are not aggressive enough to alter the power generation emissions.

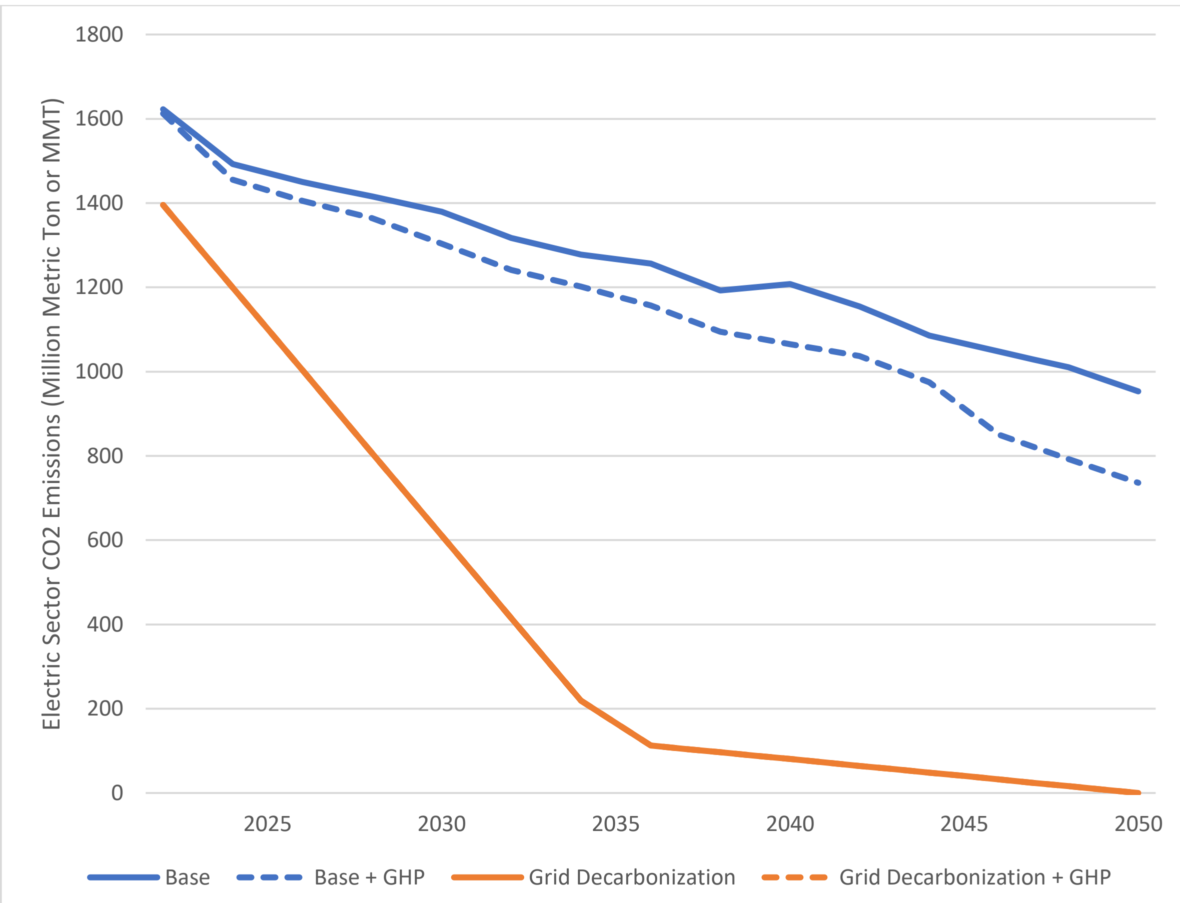


Figure 4-5. Electric sector CO_2 emissions in four core scenarios from 2022 to 2050. Note that the Grid Decarbonization + GHP scenario has identical emissions as the Grid Decarbonization scenario.

In addition to reducing electric power systems' emissions as shown in Figure 4-5, GHPs also displace end-use heating fuels such as natural gas and heating oil. Combined electric and building sector emissions are analyzed in this subsection. Figure 4-6 illustrates the combined electric and building sectors emissions for the four core scenarios from 2022 to 2050. In contrast to the electric sector–only emission scenarios, GHP deployment measurably diverges from the no-deployment counterparts. The increase in the combined electric and building sectors emissions following 2035 in the Grid Decarbonization scenario is a result of the decarbonization policy being applied solely to electric power emissions. The remaining 5% of electric power emission reductions are offset by increases in emissions in buildings. The amount of avoided end-use emissions from deployment of GHPs (including weatherization in SFHs) is sufficient, if credited, to help achieve the net-zero emissions goal of the electric power system by 2035.

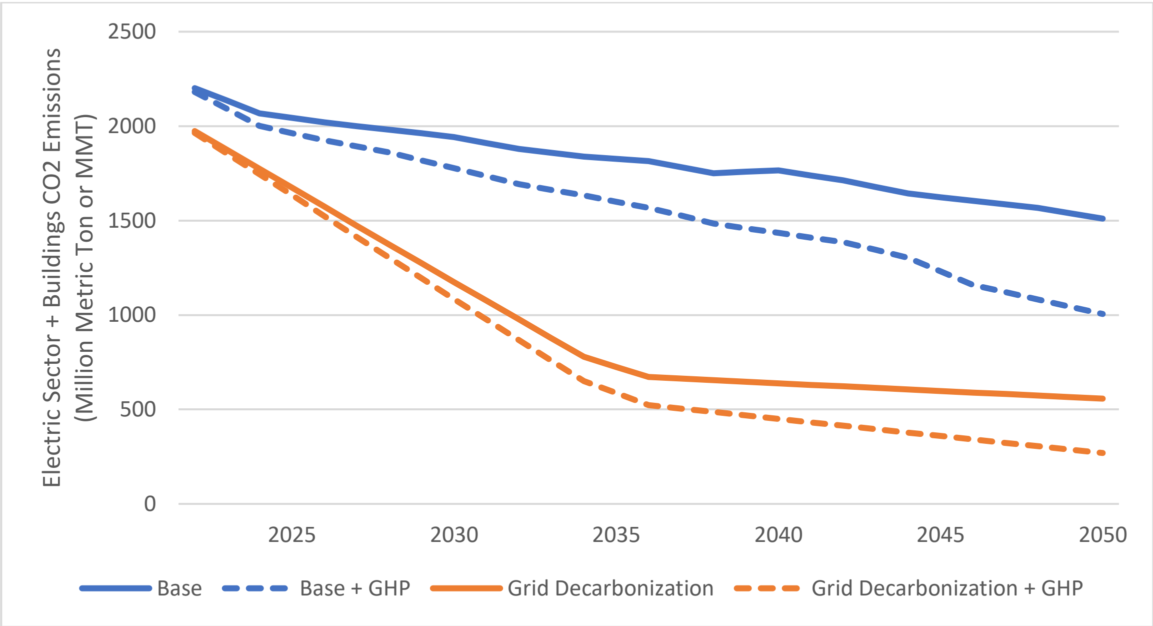


Figure 4-6. Combined electric and building sectors CO_2 emissions with and without GHP deployment (including weatherization in SFHs) in the Base and the Grid Decarbonization scenarios from 2022 to 2050.

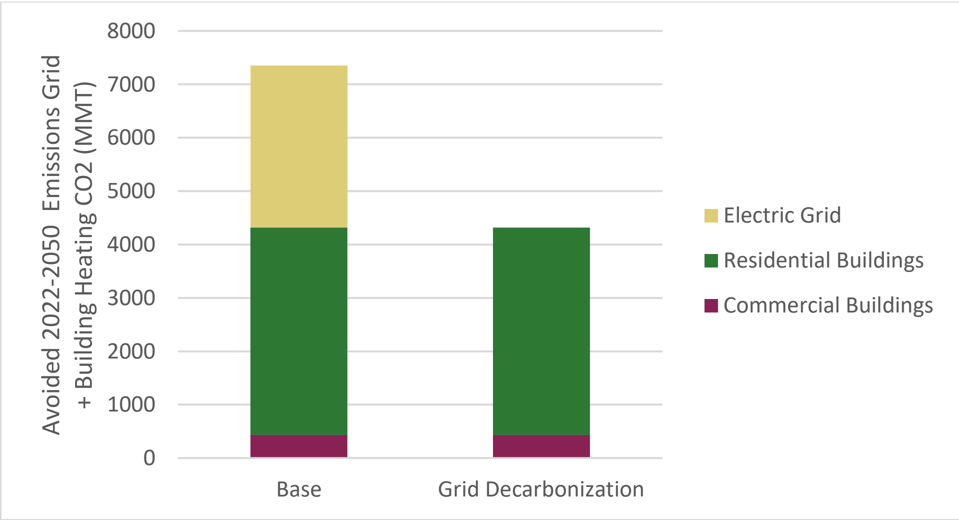


Figure 4-7 shows the cumulative CO_2 emission reductions in the combined electric and building sectors from 2022 to 2050 resulting from 100% GHP deployment in all applicable buildings for the Base and the

Grid Decarbonization scenarios. The avoided end-use heating CO_2 emission from GHPs are still counted toward the combined electric and building sectors CO_2 emission. In the Base scenario, the deployment of GHP will contribute 7,351 MMT CO_2 emission reduction in total, where 3,033 MMT comes from electric sector, and the balance of 4,318 MMT comes from the reduction of on-site fossil fuel combustion for space heating in the building sector. In the Grid Decarbonization scenario, the deployment of GHPs primarily reduces the end-use CO_2 emission at buildings by 4,320 MMT from 2022 to 2050, with small and unreported CO_2 emission reduction from the electric sector.

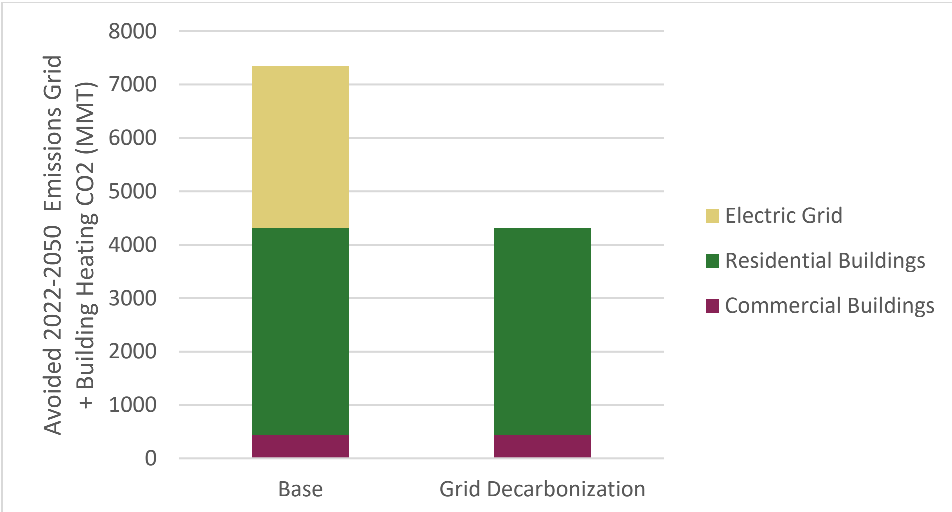


Figure 4-7. Cumulative combined electric and building sectors CO_2 emission reduction from 2022 to 2050 resulting from deploying GHPs into 68% of buildings in the United States, coupled with weatherization in single-family homes, in the Base and the Grid Decarbonization scenarios.

4.2.1.5 Marginal System Cost of Electricity

The national-average marginal system cost of electricity from 2022 to 2050 is shown in Figure 4-8 for the Base and the Grid Decarbonization scenarios with and without GHP deployment. The marginal system cost is composed of the locational marginal price of electricity, the marginal price of capacity for the planning reserves, the marginal price of operating reserves, and the marginal credit price of renewable portfolio standards.[22] The national-average marginal system cost of electricity in 2050 is listed in Table 4-3 along with the predicted total savings in electricity payments by consumers resulting from the mass GHP deployment in the two scenarios for 2050 and the cumulative savings from 2022 to 2050.

As expected, the marginal system cost of electricity is much higher for the Grid Decarbonization scenarios than the Base scenarios because of the replacement of existing fossil-fired power plants with zero-CO_2 power plants to achieve 100% grid decarbonization. Investment in VRE substantially increases with grid decarbonization, as does long-distance transmission construction to support the geographic diversity of the VRE resources. The ability for VRE to contribute to resource adequacy declines; therefore, energy storage and expensive power plants (i.e., H_2-CTs) are needed to ensure resource adequacy. New capital expenditures, even for resources with zero operational costs, increase the system

[22] The locational marginal price of electricity, or *energy price*, is most analogous to the PLEXOS electricity price discussed in Section 4.3 but will differ because PLEXOS can capture more extreme prices in its hourly representation compared with the 17 time-slice representation used in ReEDS. The additional temporal granularity and inclusion of generator unit commitment that are accounted for in PLEXOS reflects a greater degree of operational inflexibility, which can result in higher electric power prices compared with that predicted with ReEDS, which is a capacity expansion model.

cost of electricity, which must be recovered through electric rate payers or, in the case of tax incentives, the government.

The reduction in peak demand and flattening of annual energy use resulting from the mass GHP deployment (including weatherization in SFHs) lowers the marginal system cost in both the Base and the Grid Decarbonization scenarios relative to the non-GHP scenarios. The Base scenario makes use of the existing natural gas and coal plants, many of which have already recovered their initial investment cost, resulting in comparatively small cost savings. The reductions in capacity investment, fuel, and O&M costs create a consistent but small change (a 6% decrease) in the marginal system cost of electricity in the Base + GHP scenario in 2050.

With Grid Decarbonization, the marginal system cost of electricity attains a $10/MWh differential by 2036. By 2050, the GHP deployment has reduced the cost for transitioning the existing grid to a decarbonized grid by approximately 30%. This greater reduction in the marginal system cost is explained by the types of capacity and generation changes that occur in the Grid Decarbonization scenarios. To meet 100% grid decarbonization, there is a greater investment in new carbon-free generation and storage, which displaces existing CO_2-emitting generation that has been paid for. The deployment of GHPs reduces the new investment required to meet capacity and energy needs, yielding a greater savings in marginal system cost than in the Base + GHP scenario. The calculated annual (2050) and cumulative (from 2022 to 2050) savings in electricity payments by consumers are presented in Table 4-3.

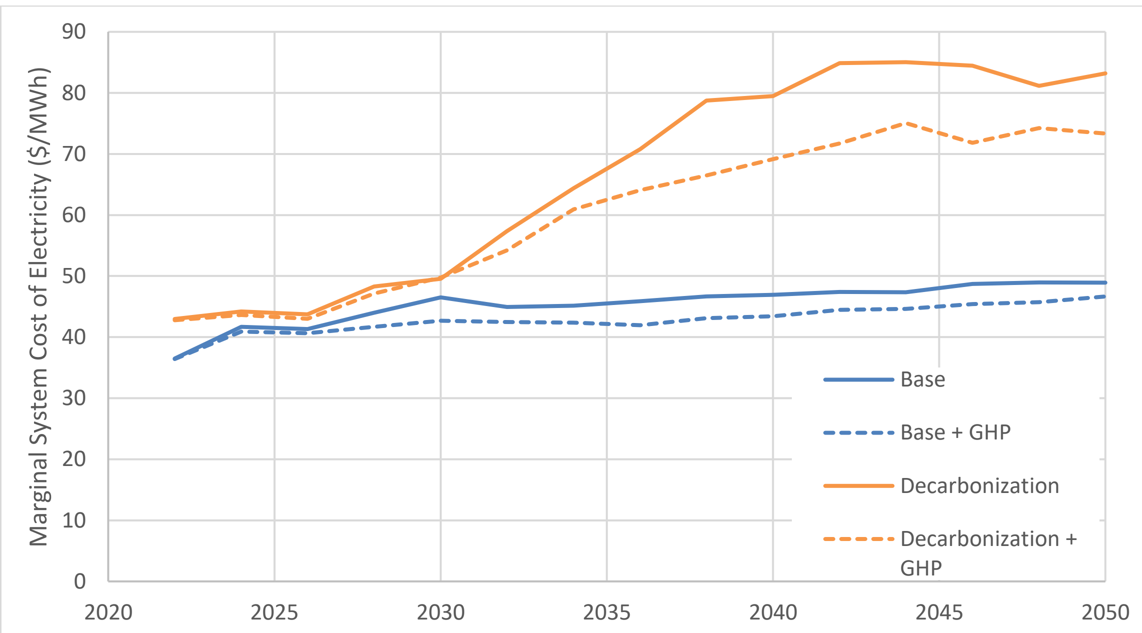


Figure 4-8. National-average marginal system cost of electricity from 2022 to 2050 with and without GHP deployment (including weatherization in SFHs) in the Base and the Grid Decarbonization scenarios.

Table 4-3. Comparison of marginal system cost of electricity and electricity payments by consumers in 2050 and from 2022 to 2050 with and without GHP deployment (including weatherization in SFHs) in the Base and the Grid Decarbonization scenarios

Scenario	Marginal cost ($/MWh)	2050 values of annual electricity payments ($ billions)	Present value of cumulative electricity payments from 2022 to 2050 ($ billions)

No GHP	Base	49	—	257	—	3,206	—
	Grid Decarbonization	83	—	437	—	4,444	—
With GHP	—	—	**Savings ($/MWh)**	—	**Savings ($ billions)**	—	**Savings ($ billions)**
	Base	46	**3**	218	**39**	2,877	**329**
	Grid Decarbonization	73	**10**	342	**95**	3,862	**582**

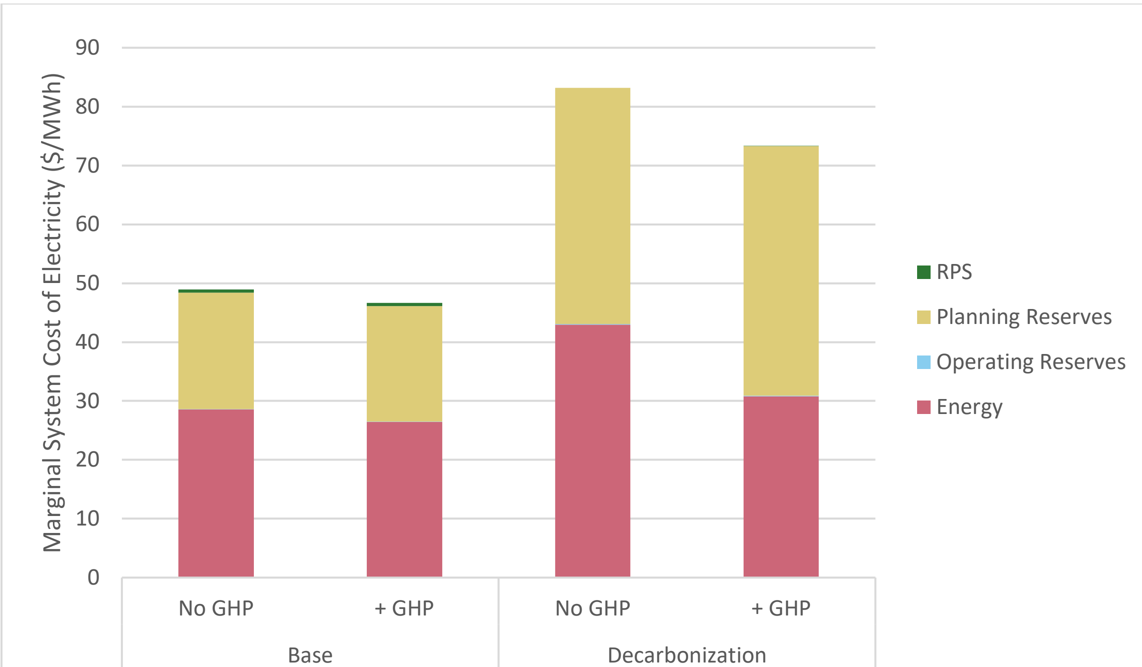


Figure 4-9 shows the breakdown of the marginal system cost of electricity in the four core scenarios in 2050. As shown in this figure, the electricity price mainly consists of the energy price (red bar) and planning reserve price (yellow bar). In the Grid Decarbonization scenarios with and without GHP, the planning reserve price has a larger share because more firm generation capacity needs to be developed to support a high-VRE system while retiring existing natural gas and coal power plants.

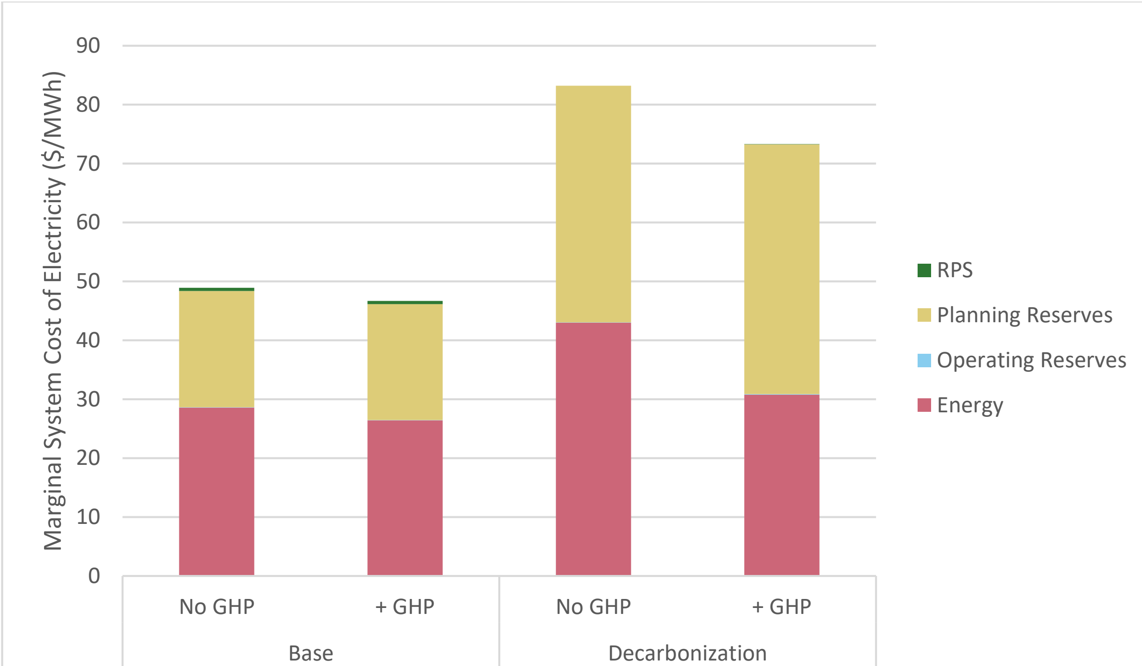


Figure 4-9. Breakdown of the marginal system cost of electricity in 2050 with and without GHP deployment (including weatherization in SFHs) in the Base and the Grid Decarbonization scenarios.

4.2.1.6 System Costs and Benefits

The total cumulative discounted system costs of the four core scenarios are shown in Figure 4-10. The values shown are the present value of the cumulative power system costs (from 2022 to 2050 with 5% discount rate). The metric is related to the marginal system cost of electricity described in the prior section, which characterized the types of services and prices that consumers of electricity would pay to generators and grid operators; the cumulative system cost captures the total costs of investment and operations to electric power generators and grid operators. The system cost is a holistic measure to assess effects of the mass GHP deployment on the electric power system and can be broken down by distinct categories of expense, including capital costs for generation, storage, and transmission, as well as operational costs, including fuel and O&M. Avoided costs outside of the electric power system are not included in this calculation, including changes in building fuel costs.

In the Base and the Grid Decarbonization scenarios, the deployment of GHP technology reduces the total system cost. The total system cost savings are $145 billion and $241 billion in the Base + GHP scenario and the Grid Decarbonization + GHP scenario, respectively. As a percentage, these savings are a 5.1% reduction in the Base + GHP scenario and a 7.2% reduction in the Grid Decarbonization + GHP scenario. The higher cost reduction with GHP in the Grid Decarbonization + GHP scenario is primarily due to greater savings in generation capital costs and transmission investment compared with the changes seen in the Base + GHP scenario.

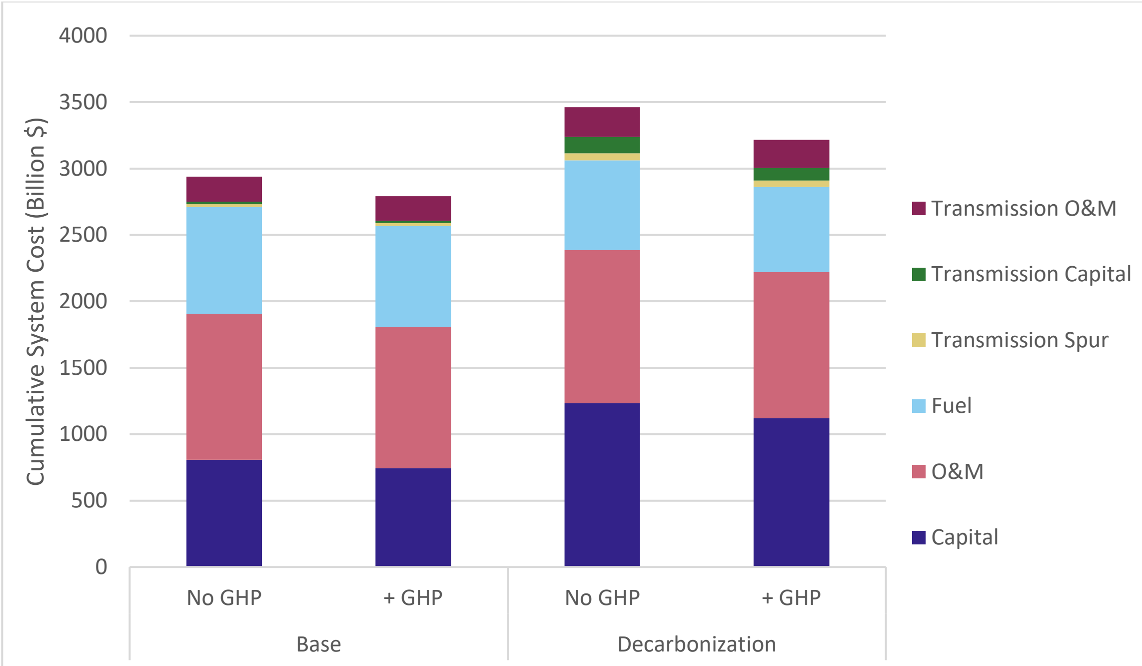


Figure 4-10. Cumulative discounted system cost (2022 to 2050 with 5% discount rate) with and without GHP deployment (including weatherization in SFHs) in the Base and the Grid Decarbonization scenarios.

4.2.1.7 Electrification Sensitivity

The EFS scenario, analyzed in this subsection, considers the electrification of other sectors such as transportation. The EFS scenario also incorporates the Grid Decarbonization assumptions (i.e., reduce emissions by 95% in 2035 and 100% in 2050). Electrification potentials in the original EFS were calculated using the EnergyPATHWAYS model, which is a bottom-up energy sector tool that measures changes to the end-use technology based upon regional stock changes and prescribed assumptions about change to market share of end use technologies. In the EFS high-electrification scenario, ASHPs will be installed in 68% and 46%, respectively, of all residential and commercial buildings existing in 2050. The underlying assumptions achieve only partial electrification of heating and cooling in residential and commercial buildings. Electric demands increase in the EFS scenarios as transportation, industry, residential, and commercial energy uses that were previously met with fuels are electrified. Therefore, the total installed electric power generation capacity in the EFS scenario is much larger than the Grid Decarbonization scenario, with an increase of 1,090 GW in capacity and 1,900 TWh in annual generation.

For this analysis, the high-electrification scenario from EFS was first modified to remove changes in electricity use for heating and cooling in residential and commercial buildings (i.e., without electrification in heating and cooling). Then, GHP deployment in all applicable buildings (78% of residential buildings and 43% of commercial buildings) was applied consistent with the methodology used in the core scenarios. This method created a new electrification scenario that is consistent with the high-electrification scenario of EFS but uses GHP deployment (including weatherization in SFHs) for electrifying residential and commercial heating and cooling. The changes in generation capacity mix and the annual electricity generation in 2050 in the EFS scenario resulting from the mass GHP deployment is presented in Figure 4-11. Electrifying building space heating and cooling with GHPs, along with weatherization in SFHs, reduces electricity capacity and generation requirements by 410 GW and 937 TWh, respectively, compared with the original EFS scenario with high electrification.

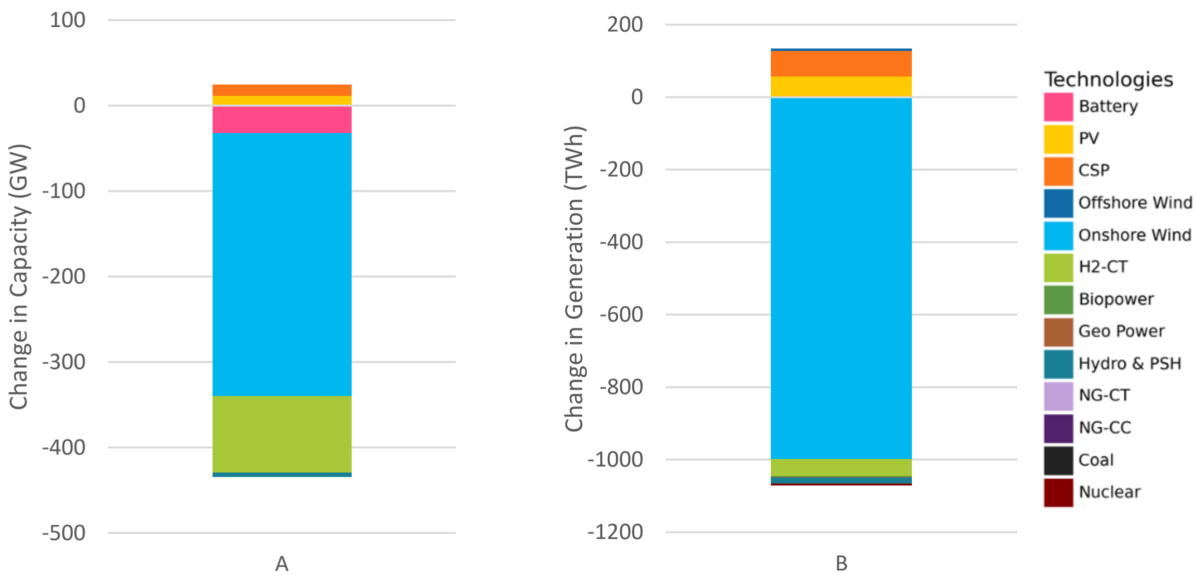


Figure 4-11. Change in (A) national electricity generation capacity and (B) national annual electricity generation in the EFS scenario in 2050 resulting from deploying GHPs into 68% of buildings in the United States, coupled with weatherization in single-family homes.

Compared with the core scenarios, the mass GHP deployment in the EFS has an increased ability to reduce resource adequacy requirements in cold climate regions, which previously relied heavily on natural gas for heating. This effect would be greater if the original EFS had fully electrified heating and cooling, as was studied in *Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035* (Denholm et al. 2022). The change in seasonal RA eligible capacity contributions toward the planning reserve margin is shown in Figure 4-12. In contrast to the capacity changes shown in Figure 4-11, bulk reductions in RA eligible capacity are from H_2-CT and battery storage. It can also be observed that RA eligible capacity from solar (PV and CSP) increases in summer while hydropower (hydropower and PSH) increases in winter, which is thought to be due to the wide geographic coverage of GHP applications so that more renewable energy can be accessed. The GHP deployment in the EFS scenario shows a higher reduction in winter peak resource adequacy requirements than in summer, which has increasing importance in EFS, where electrification of heating with ASHPs results in an increasing number of regions shifting from summer peaking to winter peaking.

Figure 4-12. Change in summer and winter RA eligible capacity contribution by technologies in the EFS scenario resulting from the mass GHP deployment (including weatherization in SFHs) instead of the partial electrification using ASHPs.

Interregional transmission has a greater buildout in the EFS scenario compared with the core scenarios because of the high deployment of VRE. As shown in Table 4-4, with GHP deployment, interregional transmission is reduced by 65.4 TW·mi, representing a 38% reduction (or $39.5 billion less cost in present value) in new investments. The EFS scenarios directly compared two solutions for electrifying building heating and cooling. The higher efficiency of GHPs relative to ASHPs results in a larger impact relative to the Grid Decarbonization scenarios (see Table 4-4), reducing required transmission expansion by a factor of 1.8 and the present value costs by a factor of 1.3. The comparably lesser effect on the present value costs is a result of the timing of EFS transmission investments, which diverges from the Grid Decarbonization scenarios after 2035.

Table 4-5. Comparison of the interregional transmission expansion requirements in the EFS scenario with and without GHP deployment (including weatherization in SFHs)

Scenario	New + existing transmission in 2050 (TW·mi)	New transmission in 2050 (TW·mi)	Reduction (TW·mi)	Reduction (%)	Present value of transmission capital cost savings with 5% discount rate ($ billions)
No GHP	322	174	—	—	—
With GHP	256	108	65.4	37.7	39.5

Table 4-5 lists the economy-wide emissions in all analyzed scenarios from 2022 to 2050 with and without GHP deployment, respectively. The EFS scenarios show a comparably smaller reduction in economy-wide emissions with GHPs. This result is because the EFS scenario has reduced economy-wide emissions compared with the Base and the Grid Decarbonization scenarios through electrification of both the electric and building sectors.

Table 4-5. Comparison of economy-wide CO_2 emissions in the Base, Grid Decarbonization, and EFS scenarios with and without GHP deployment (including weatherization in SFHs)

Scenario		Economy-wide emissions in 2050 (MMT)		Cumulative emissions from 2022 to 2050 (MMT)	
No GHP	Base	4,529		136,063	
	Grid Decarbonization	3,576		111,129	
	EFS	2,284		94,737	
			Difference		Difference
With GHP	Base	4,024	505	128,712	7,351
	Grid Decarbonization	3,288	288	106,811	4,318
	EFS	2,153	131	92,559	2,178

4.2.2 Detailed Scenario Analysis in 2050 with PLEXOS

Hourly simulation of the electric power system in 2050, which was identified with the capacity expansion modeling (CEM) using ReEDS, was performed with PLEXOS to conduct production cost modeling (PCM) for the four core scenarios discussed in the preceding subsections. PLEXOS results provide a more granular understanding of GHP impacts on the electric power system. In contrast to CEM, PCM provides a higher degree of temporal granularity and includes operational constraints such as unit commitment, ramp rates, and up times of electricity generation. PCM results complement CEM analysis by identifying additional details that are otherwise simplified in the CEM and by providing validation of the operability of an electric power system identified by CEM. The PLEXOS results regarding the grid operations are analyzed in this subsection. The terms in this subsection are explained in the nomenclature page at the beginning of this report.

4.2.2.1 Validation of CEM Results of ReEDS

Sufficient resource adequacy should be provided in an electric power system to minimize the unserved demand, which could result in blackouts or brownouts. The electric demand change resulting from the mass GHP deployment is substantial and it merits a validation of the electric power system identified with CEM results of ReEDS. The validation is performed by comparing key results determined with ReEDS and PLEXOS, respectively.

PLEXOS can allow the load to go unserved if the demand required cannot be met with the available generation, storage, and transmission capacity. An unserved load incurs a significant penalty cost and is used by the model as a last resort. Significant quantities of unserved loads would be a key indicator that the capacity expansion solution determined by ReEDS is underbuilt for the simulation year.

In the findings for all four core scenarios, shown in Table 4- and Table 4-, minimal unserved loads were found, indicating that the capacity expansion solution is sufficient. In the Base and the Grid Decarbonization scenarios without GHP deployment, there are 4 and 9 GWh of annual unserved load, respectively. However, no unserved load was observed in these scenarios if GHPs were deployed.

Table 4- and Table 4- summarize the key metrics reported by PLEXOS for the Base scenario and the Grid Decarbonization scenario, respectively, with and without GHP deployment. Some of these metrics, including power generation capacity and battery energy capacity, directly reflect ReEDS results and they were used to confirm that the electric power system modeled with PLEXOS is an accurate translation from the capacity expansion solution determined by ReEDS. Also included in these tables are metrics that capture operational results that are not reported directly by ReEDS.

Table 4-6. PLEXOS results for the Base scenario with and without GHP deployment (including weatherization in SFHs) in 2050

	Base	Base + GHP	Reduction	Reduction ratio (%)
Annual load (TWh)	5,709	5,091	618	10.8
Annual generator revenue ($ billions)	182	125	57	31.5
Annual average wholesale electricity price ($/MWh)	32	24	8	23.2
Annual operating reserve provision (TWh)	457	413	44	9.5
Annual unserved load (GWh)	4	0	4	100.0
Annual peak demand (GW)	963	839	124	12.9
Generation power capacity (GW)	1,855	1,677	178	9.6
Battery energy capacity (GWh)	3,036	2,626	410	13.5

Table 4-7. PLEXOS results for the Grid Decarbonization scenario with and without GHP deployment (including weatherization in SFHs) in 2050

	Grid Decarb	Grid Decarb + GHP	Reduction	Reduction ratio (%)
Annual load (TWh)	5,709	5,092	617	10.8
Annual generator revenue ($ billions)	771	572	199	25.9
Annual average wholesale electricity price ($/MWh)	135	112	23	16.9
Annual operating reserve provision (TWh)	673	584	89	13.3
Annual unserved load (GWh)	9	0	9	100.0
Annual peak demand (GW)	1,062	908	154	14.5
Generation power capacity (GW)	2,532	2,198	334	13.2
Battery energy capacity (GWh)	4,362	3,809	553	12.7

A comparison between the results of PLEXOS and ReEDS indicates that these results are in agreement with differences explainable through the differences in the modeling scope between PLEXOS and ReEDS. Load results of PLEXOS show a 10.8% reduction in the annual load with GHP deployment in the Base and the Grid Decarbonization scenarios. In ReEDS, this reduction was 11.2%, showing similar reductions. The total reported load in terms of terawatt-hours is higher as reported by PLEXOS compared with that predicted by ReEDS because the PLEXOS results included the total energy used to charge battery storage.

Peak demand results of PLEXOS show a 12.9% reduction in the Base + GHP scenario and 14.5% reduction in the Grid Decarbonization + GHP scenario. The reported peak demand reduction in ReEDS is 17%. The small discrepancy between the results of PLEXOS and ReEDS is due to the differences in the reported metrics in the two models. In PLEXOS, the values reported in this section include storage charging and are a measurement of the national concurrent peak demand. In ReEDS, the peak demand is based upon the regional peak demands, which are not temporally concurrent, and does not consider battery charging. Further analysis indicates that the annual peak demand hour used in PLEXOS occurs during a summer daylight hour, which is a period with abundant solar production, incentivizing charging battery storage to meet the net peak demand period during a later time of the day. Therefore, the percentage of peak demand reduction in the PLEXOS results is lower than that predicted with ReEDS.

Another area of contrast with ReEDS is on the reported annual average wholesale electricity price and annual generator revenue (annual consumer payment for electricity). The wholesale electricity price reported by PLEXOS is equivalent to the weighted average of the locational marginal price (LMP) of electricity. LMP is an important price metric used in power markets in the United States and describes, at a specific location and time, the cost of producing the next unit of electricity. LMP is used by power markets to determine the settlement price for the energy sold by a power generator and is directly related to the generator's revenue. ReEDS has an equivalent metric for the energy component of the marginal system cost of electricity as described in Section 4.2.1.5. In the Base + GHP scenario, PLEXOS results showed a relatively larger cost reduction of 23% for LMP compared with a 7.5% reduction predicted by ReEDS. In the Grid Decarbonization + GHP scenario, PLEXOS results showed a reduction of 17% compared with 28% predicted by ReEDS. With the hourly temporal resolution, PLEXOS identified higher prices for energy in the Grid Decarbonization + GHP scenario ($112–$135/MWh) compared with ReEDS ($32–$42/MWh). It highlights a limitation of the available resolution in the ReEDS representation of power system operations.

4.2.2.2 Reliability Assessment Zone Peak Demand Results and Analysis

This section builds upon Section 4.2.1.3; a discussion of resource adequacy and its implementation within the ReEDS can be found there. This section focuses on the temporal granularity and operational detail available in the PLEXOS simulation, which gives more details regarding the operation of the electric power system in different scenarios.

Reliability assessment zones (RAZs) are aggregations of BAs used in ReEDS, within which the bulk power system is assessed to ensure resource adequacy. The RAZs are closely aligned with the regions used by NERC for regional assessments, which subdivide the interconnected power systems of North America based on the characteristics of the electric grid and the entities responsible for its operation. The area coverage of each RAZ is shown in Figure 2-4. In this subsection, the concurrent peak is calculated for each RAZ using PLEXOS. The calculation of the peak load includes the fixed hourly demand (from end uses) and grid demand for charging battery storage.

Figure 4-1 and Figure 4-13 show the PLEXOS results of peak load changes resulting from GHP deployment in each RAZ under the Base and the Grid Decarbonization scenarios in 2050 for the summer and winter, respectively. With Grid Decarbonization in nearly all regions, there is an increase in the peak load because of a higher reliance on battery storage in the electric power systems. Although peak load has historically been the benchmark for periods of the greatest stress to the electrical grid, it is different for systems with significant shares of wind and solar power. Summer afternoon peak demand coincides with high solar availability and be an opportune period for storage systems to charge using inexpensive electricity.

The increase in peak demand in the Grid Decarbonization scenario is indicative of this effect with peak demand increasing because of the charging of battery storage. The peak demand reduction resulting from GHP deployment increases in the Grid Decarbonization + GHP scenario because the hourly load reduced by GHP deployment reduces the reliance on battery storage for both summer and winter periods. This effect is observable in the Northeast Power Coordinating Council (NPCC), where peak demand reductions shown in PLEXOS results are achieved at a higher fraction for both summer and winter in the Grid Decarbonization + GHP scenario.

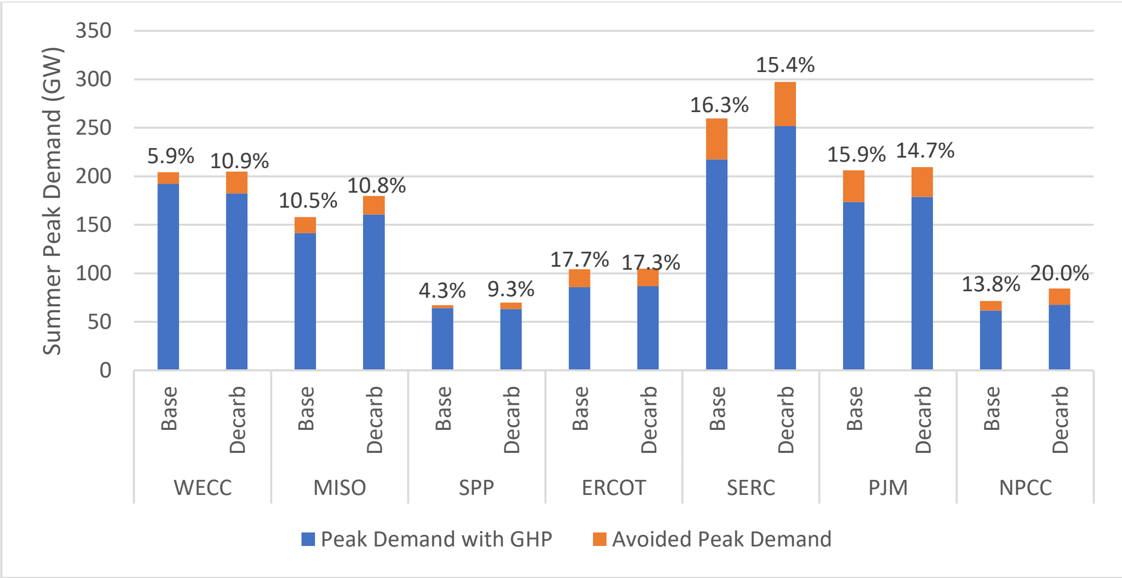


Figure 4-13. Summer peak demand in the Base and Grid Decarbonization scenarios; the blue bars are the peak demand by region, and orange bars are the avoided peak demand owing to demand reductions from deploying GHPs into 68% of buildings in the United States, coupled with weatherization in single-family homes. The percentage of avoided peak demand is shown in the figure's labels.

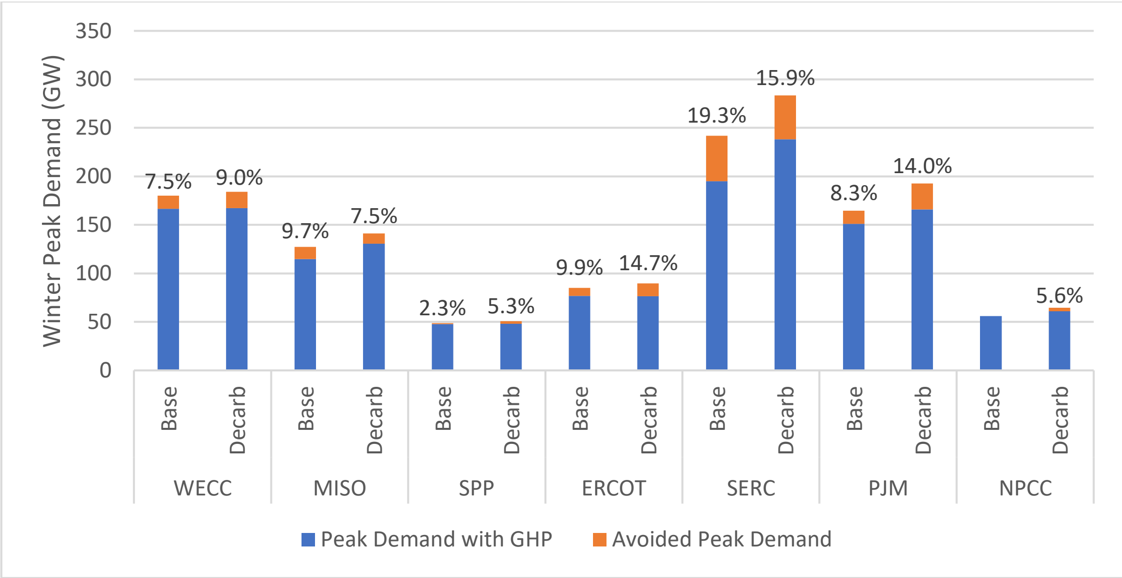


Figure 4-13. Winter peak demand in the Base and Grid Decarbonization scenarios; the blue bars are the peak demand by region, and orange bars are the avoided peak demand owing to demand reductions from deploying GHPs into 68% of buildings in the United States, coupled with weatherization in single-family homes. The percentage of avoided peak demand is shown in the figure's labels.

The seasonality results highlight the differences in effects derived from regional differences in climate and displaced HVAC technologies. Summer peak demand analysis shows reductions across all regions because of the higher cooling efficiency of the GHP system compared with existing conventional air-conditioning systems. This difference is particularly pronounced in the electric power systems managed by Electric Reliability Council of Texas (ERCOT) and SERC Reliability Corporation (SERC), which have a much higher peak demand reduction because these areas have a strong cooling demand in the summer.

In winter, the mass GHP deployment (including weatherization in SFHs) reduces peak demand most strongly in regions where heating is already electrified (e.g., using ASHPs). Here, SERC is most notable; having mild winters and a highly electrified heating system, the regional peak demand reduction ratio was 19%, and in the constituent RAZ, it was as high as 28%. In contrast, peak demand sees lower reductions in regions with high fossil fuel–dominated heating systems. In the region managed by NPCC, with harsher winters, a slight increase in electric consumption occurred in the Base + GHP scenario, with reduced battery charging in the Grid Decarbonization + GHP scenario yielding a reduction in peak demand. In these regions, the electricity consumed by a GHP for space heating is not offset by the avoided electricity for cooling, but there will be other operating costs, health, and decarbonization benefits from retrofitting fossil fuel heating systems in these regions with GHPs that fall outside of the PLEXOS analysis.

Figure 4- and Figure 4- show the percentages of avoided peak demand resulting from the mass GHP deployment for each RAZ for the summer and winter in the Base and Grid Decarbonization scenarios. In summer, the south, southeast, and east usually have a higher peak demand reduction after GHP deployment than other areas. These maps show the overlapping interactions between regional differences in climate and existing installed HVAC systems.

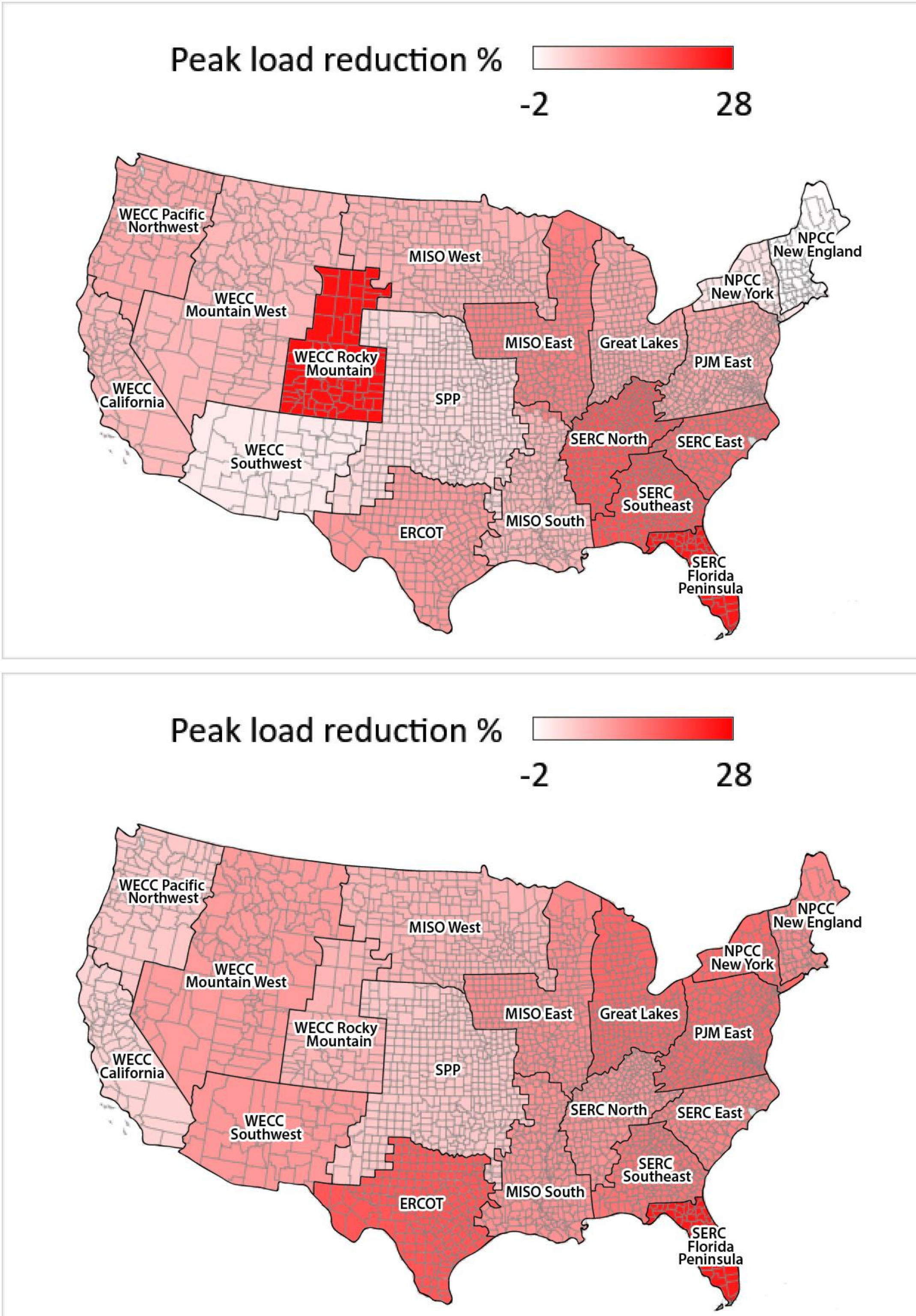


Figure 4-14. Peak electric demand reduction percentage in (top) winter and (bottom) summer at each RAZ resulting from deploying GHPs into 68% of buildings in the United States, coupled with weatherization in single-family homes, in the Base scenario.

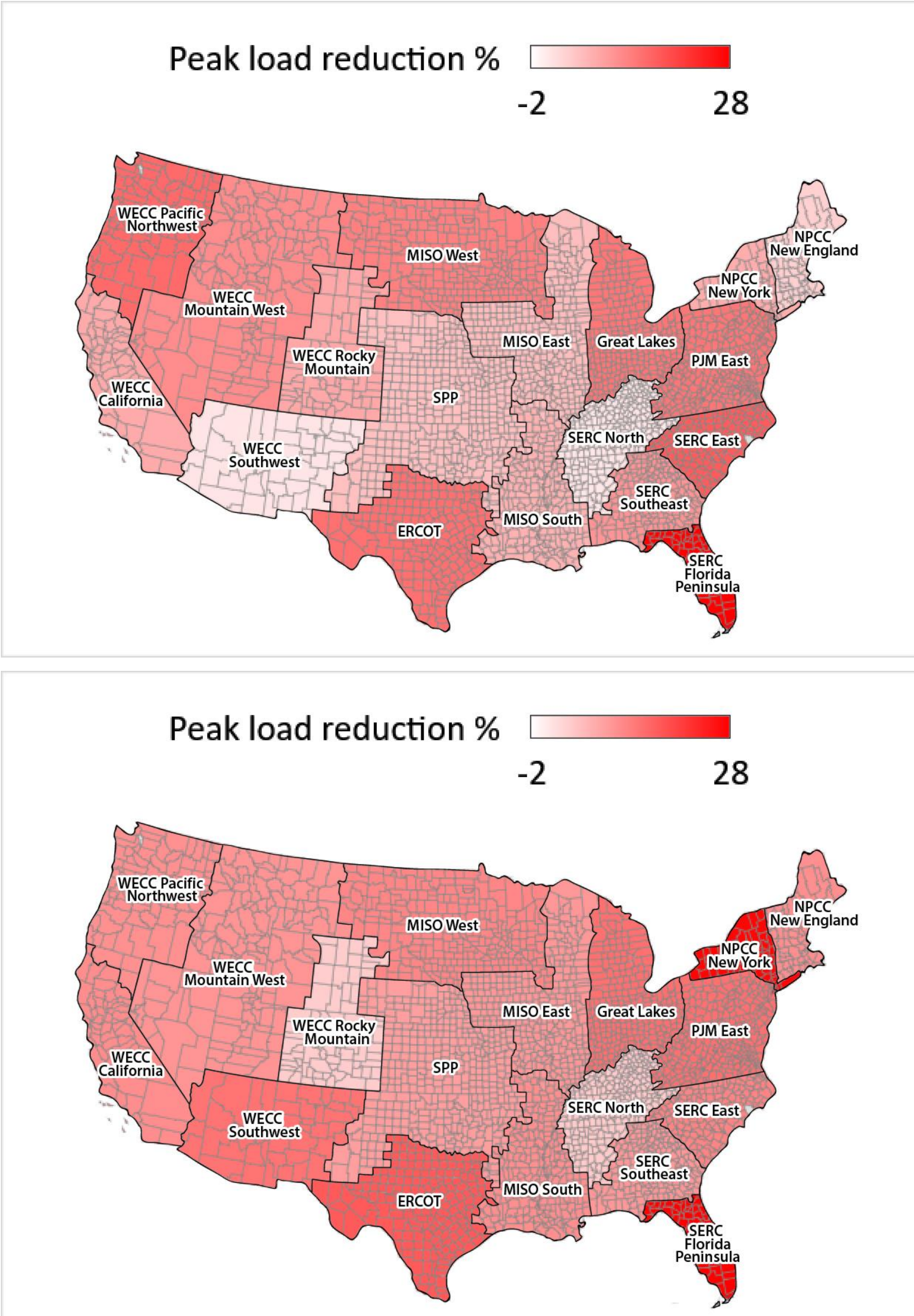


Figure 4-15. Peak electric demand reduction percentage in (top) winter and (bottom) summer at each RAZ resulting from deploying GHPs into 68% of buildings in the United States, coupled with weatherization in single-family homes, in the Grid Decarbonization scenario.

4.2.2.3 Regional (Balancing Area) Results and Analysis

To investigate the effect of GHP deployment at a finer spatial resolution, the peak demand at the BA level is examined in this subsection. Three BAs were selected based on their differences in climates and the currently used heating energy sources, including BA 1 in Western Washington, BA 94 in Georgia, and BA 134 in Maine. Table 4- and

Table 4- show the PLEXOS results of peak demand with and without the mass GHP deployment in the Base and Grid Decarbonization scenarios, respectively. Note that the timing of peak demand differs by BA because of the weather and differences in patterns of electric demand composition.

For BA 1 (Western Washington), the climate is relatively mild, so the energy consumption for heating and cooling is also moderate. It is a winter-peaking region. The GHP deployment (including weatherization in SFHs) can reduce the peak demand by 4.5% in summer in the Base scenario and achieve the same reduction in the Grid Decarbonization scenario. This BA is a highly electrified region, with only 50% of heating demand served by natural gas. GHP deployment in this BA reduces winter peak demand by 5.9% in both the Base and the Grid Decarbonization scenarios.

For BA 94 (Georgia), the summer is hot, and the winter is mild. Currently, grid demands are nearly balanced between summer and winter on the grid. Georgia also has a high degree of electrified heating within, with 60% of the building heating provided by natural gas and propane. GHP deployment reduces the summer peak by 14.1% because of the higher efficiency of the GHP in both the Base and Grid Decarbonization scenarios. In Georgia, the deployment of GHPs (including weatherization in SFHs) reduces the winter peak demand by a similar quantity as the summer peak reduction of 5 GW, or 15.3%, in the Base scenario and by 3 GW, or 9.2%, in the Grid Decarbonization scenario.

For BA 134 (Maine), the summer is warm, and the winter is very cold. Electricity makes up little of Maine's current heating demand in winter, which is mostly served by a mix of oil, propane, firewood, and natural gas. Thus, full electrification of building heating in this area increases electricity consumption. GHP deployment reduces the summer demand by 170 MW, or 7%, in both the Base and Grid Decarbonization scenarios. In contrast to other regions, there is an increase in the winter peak demand by 220 MW, or 8.3%, in the Base scenario and 140 MW, or 5.9%, in the Grid Decarbonization scenario.

Table 4-8. Regional analysis for the Base scenarios in 2050

Location	Season	Base (GW)	Base + GHP (GW)	Reduction (GW)	Reduction (%)
Western Washington	Summer (Aug. 17)	9.52	9.09	0.43	4.5
	Winter (Jan. 18)	12.62	11.87	0.75	5.9
Georgia	Summer (Jun. 30)	39.24	33.69	5.55	14.1
	Winter (Jan. 3)	33.1	28.05	5.05	15.3
Maine	Summer (Jul. 19)	2.40	2.23	0.17	7.1
	Winter (Jan. 20)	2.64	2.86	−0.22	−8.3

Table 4-9. Regional analysis for the Grid Decarbonization scenarios in 2050

Location	Season	Grid Decarbonization (GW)	Grid Decarbonization + GHP (GW)	Reduction (GW)	Reduction ratio (%)
Western Washington	Summer (Aug. 17)	9.52	9.09	0.43	4.5
	Winter (Jan. 18)	12.62	11.87	0.75	5.9
Georgia	Summer (Jun. 30)	39.24	33.69	5.55	14.1
	Winter (Jan. 3)	33.34	30.27	3.07	9.2
Maine	Summer (Jul. 19)	2.40	2.23	0.17	7.1
	Winter (Jan. 20)	2.36	2.50	−0.14	−5.9

4.3 DISCUSSION AND LIMITATIONS

The GHP impacts analysis is subject to the limitations affecting most forward-looking studies that are quantitative and qualitative. This study depends on fundamentally uncertain modeling input assumptions, including load shapes, growth, and future costs. ReEDS, PLEXOS, and the ReEDS-to-PLEXOS model translation have known limitations that were considered when analyzing results. For ReEDS-specific limitations and ReEDS-to-PLEXOS model translation limitations, see Ho et al. (2021). Both ReEDS and PLEXOS are techno-economic models and do not account for specific business structures, market power, or socioeconomic considerations. Qualitative results are limited by literature and an understanding of the conditions that would influence a future power system, which are limited by historical trends and the body of existing literature. These limitations are mitigated by collecting input from the diverse body of expertise among the authors and reviewers when drafting this report.

Changes in the electric load from GHP deployment assume linear deployment rates and no improvements in efficiency of the GHPs during the study period. Although the total deployment is aspirational, the rate of deployment and the fixed assumption around performance may be conservative. This study did not quantify the cost of GHP installation and the available land areas for installing GHP systems because the intention was to quantify the potential benefits to the grid from the GHP deployment. Future analyses accounting for the costs and efficiency improvement of GHPs, as well as constraints of available land areas, could better explore the GHP deployment rates in various markets.

Although land use is an important consideration for questions of equity and environmental impact, this study did not quantify the relative changes in land use among technologies. Reductions in solar and wind installation from the mass GHP deployment will see reductions in long-term land use. GHP deployment for commercial and residential buildings is known to have minimal long-term land use impacts.

4.4 SUMMARY

In this section, the electric power sector analysis based on ReEDS and PLEXOS simulations revealed various impacts on the electric sector from deploying GHP systems in all applicable buildings (including weatherization in SFHs). First, the mass deployment of GHPs can reduce the generation and capacity needs of the electric power system by up to 11% and 13.2%, respectively, in 2050. The peak demand in some zones can be reduced up to 28%, which will ease grid operations and defer the installation of new generation capacities. Second, the mass GHP deployment reduces the reliance on carbon-emitting power generation in the Base scenario and cuts the transmission expansion need by approximately one-third in the Grid Decarbonization scenario. Third, the deployment of GHPs can help reduce the requirements for summer and winter resource adequacy. In the Base scenario, it reduces the natural gas generation capacity requirements in the summer, whereas in the Grid Decarbonization scenario, all natural gas power plants are retired, so the summer RA eligible capacity reduction is mainly a reflection of reduced capacity requirements from H_2-CTs. In winter, the RA eligible capacity in 2050 with the GHP deployment is less than the 2022 reference, and such a reduction is even more significant in the Grid Decarbonization scenario. It can also reduce the wholesale, system-level electricity price because of the decreased peak demand, the annualized cost savings from reduced fuel use in power plants, and the relaxed reserve requirements. Importantly, these system cost reductions represent savings that could be available as incentives to reduce the cost to consumers for retrofitting buildings with GHPs.

5. PRELIMINARY REGIONAL GRID RELIABILITY ANALYSIS

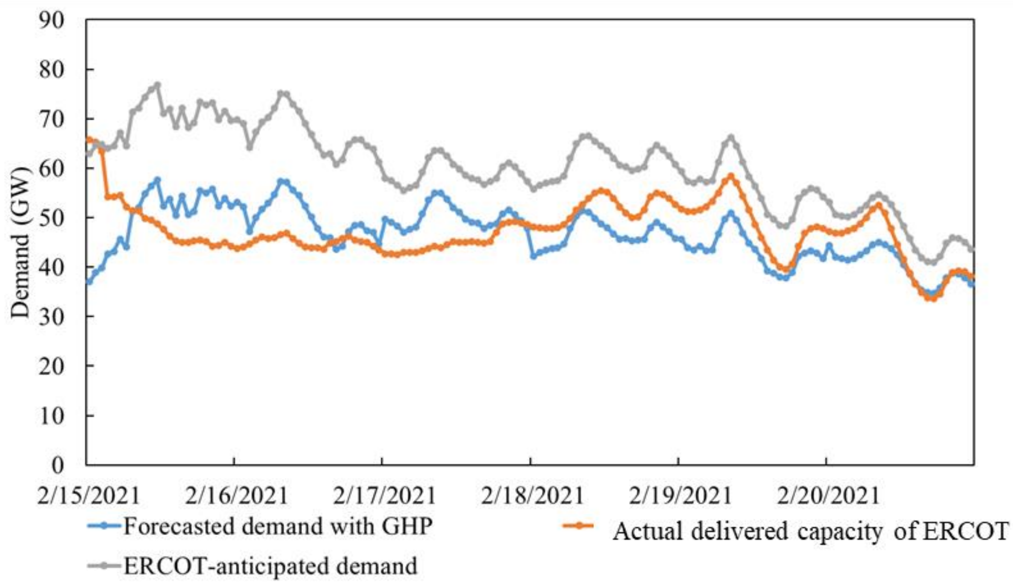
This section presents preliminary simulation results aimed at analyzing the effects of GHP deployment on grid reliability. Instead of conducting a comprehensive nationwide analysis, the focus is narrowed to assess regional grid reliability. Specifically, this section examines a blackout event that occurred during a winter storm in Texas, which commenced on February 15, 2021, and persisted for multiple days. During this severe winter storm, the electricity demand of the ERCOT power grid surged to a peak of 69 GW, surpassing the previous winter record of 66 GW. As a result, more than 4.5 million households (approximately 10 million Texans) were left without electricity at the height of this event. The associated economic losses attributable to this calamity were estimated at $130 billion (Busby et al. 2021).

The blackout event was caused by the frigid conditions brought about by the winter storm. The extreme cold weather led to a sharp decline in gas supply because of various factors such as freezing occurring at natural gas wells and gathering lines, power outages at compressor stations, and other related issues. Furthermore, the demand for gas surged significantly because approximately 40% of households in Texas rely on gas and propane for space heating during cold weather conditions. Consequently, the combination of decreased gas supply and increased consumption resulted in a shortage of approximately 30 GW in generation capacity. However, the electricity demand increased further regardless of the generation capacity shortage because approximately 60% of Texas households employ electricity for space heating. In this case, the deficiencies in the gas system, combined with insufficient generation capacity, led to significant disparity between supply and demand, which created a precarious imbalance that ultimately culminated in the occurrence of the blackout event (Busby et al. 2021).

As illustrated in the preceding sections, GHP retrofitting presents an opportunity to eliminate gas consumption and reduce the electricity demand of buildings. Given these premises, the widespread deployment of GHPs in Texas could offer a means to mitigate blackout events. To evaluate the potential effectiveness of GHP retrofitting in mitigating the 2021 winter storm blackout, a specific scenario was considered. This scenario assumes that all applicable buildings within the ERCOT had already undergone GHP retrofitting before the onset of the storm. To quantify the effects, the resulting electric demand attributable to GHP retrofitting was calculated. This value was then compared with the anticipated electric demand in the absence of GHP retrofitting, which was obtained from the EIA (EIA 2021). The historical demand (i.e., the actual delivered electric power) that was experienced in this event was limited by the capacity of the power plant. Appendix E provides more details of the calculation of the electric demand resulting from GHP retrofitting.

5.1 ANALYSIS RESULTS

Figure 5-1 presents a comparison between the anticipated electricity demand of the ERCOT and the calculated electricity demand resulting from the implementation of mass GHP retrofitting. The anticipated electricity demand was the one forecasted by the ERCOT for 2021. The calculated electricity demand with GHP retrofitting was obtained by first calculating the demand reduction owing to GHP retrofitting and then subtracting it from the anticipated electricity demand. As shown in Figure 5-1, the anticipated electricity demand exhibited a sharp increase during the 2021 winter storm. Conversely, the electricity demand was calculated to be reduced through GHP retrofitting, and the reduction is pronounced during the summer and winter. This comparison demonstrates that if all applicable buildings within the ERCOT had undergone GHP retrofitting, the anticipated electricity demand would have been significantly reduced, which would be vital in mitigating the strain on the grid such as what occurred during the 2021



winter storm.

Figure 5-2. shows three profiles of electricity demand more granularly during the 2021 winter storm. Along with the anticipated and calculated electricity demand, the delivered capacity of ERCOT recorded during the 2021 winter storm is also shown. As shown in Figure 5-2, the delivered capacity was less than the anticipated demand during the winter storm, which implies that there was a power outage. The significance of a system blackout can be measured by the difference between the delivered capacity and the anticipated electricity demand. If mass GHP retrofits were achieved in Texas before the 2021 winter storm, the newly anticipated electricity demand would become the calculated electricity demand, which is significantly smaller than the anticipated demand. Although the calculated electricity demand with GHP retrofitting is still higher than the delivered capacity for certain periods, the severity and duration of the power outage would be much smaller than that before GHP retrofitting.

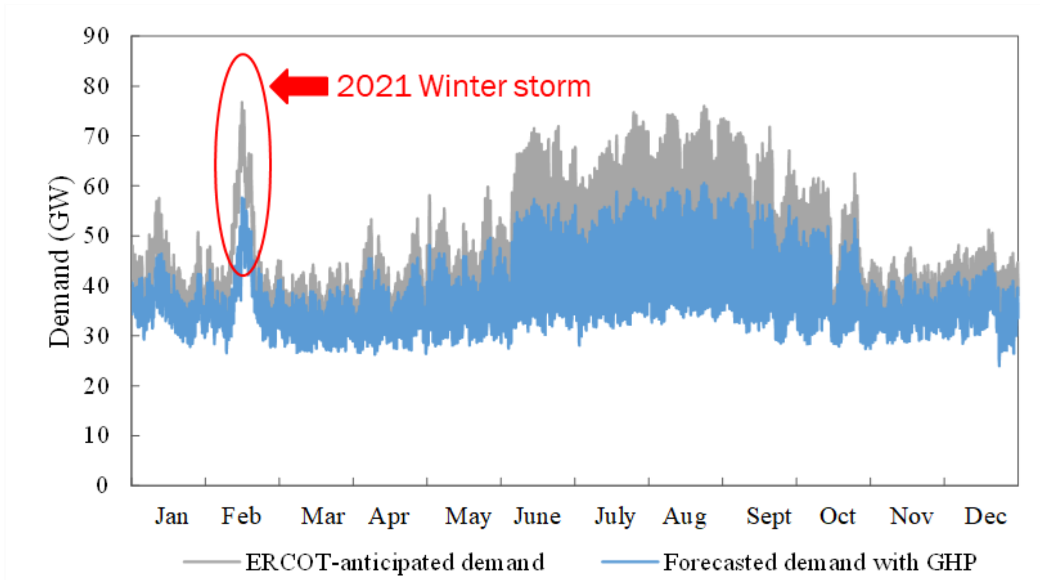


Figure 5-1. Hourly electricity demand profile of ERCOT before and after GHP retrofit in 2021.

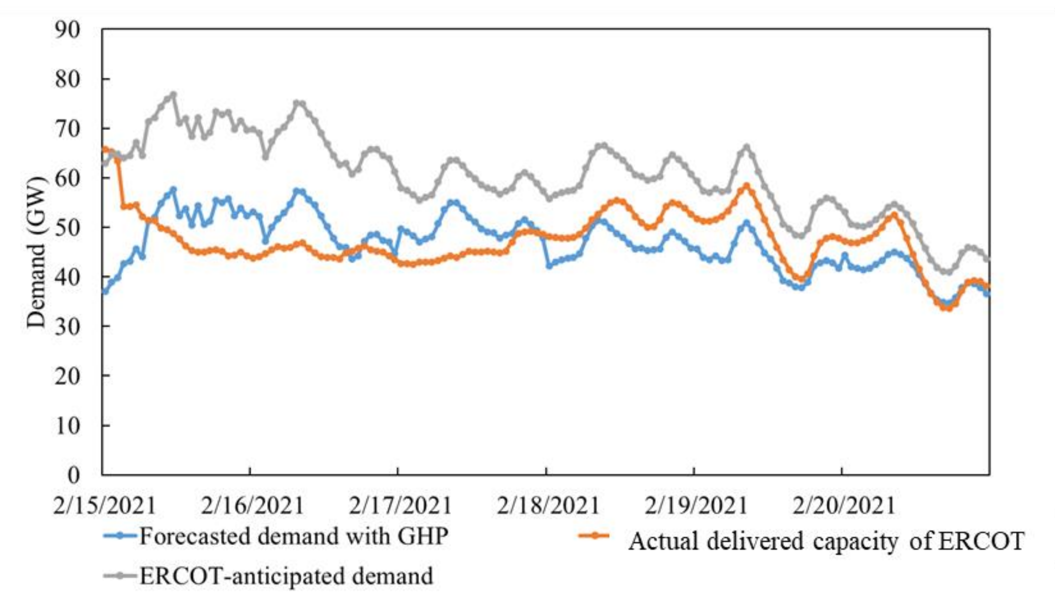


Figure 5-2. Hourly demand profiles of six consecutive days during the 2021 winter storm in Texas.

Table 5-1 provides a comprehensive overview of the most severe outage periods during the 2021 winter storm. It reveals that during these critical periods, 36.5% to 39.5% of the anticipated electricity demand was left unmet. However, when considering GHP retrofitting, the unserved electricity demand ratio would have been notably reduced, ranging from 15.4% to 20.6%. These findings strongly indicate that widespread deployment of GHPs can significantly enhance the reliability of the power system.

Table 5-1. Electricity demand during the most severe outage periods in the 2021 Texas winter storm

Time	Without GHP retrofitting	With GHP retrofitting

	Unserved demand (GW)	Served demand (GW)	Outage ratio (%)	Unserved demand (GW)	Served demand (GW)	Outage ratio (%)
2/15/2021, 11 a.m.	28.04	48.75	36.5	8.88	48.75	15.4
2/15/2021, 3 p.m.	27.10	44.96	37.6	9.43	44.96	17.3
2/15/2021, 6 p.m.	27.86	45.45	38.0	10.00	45.45	18.0
2/15/2021, 7 p.m.	27.67	45.11	38.0	9.95	45.11	18.1
2/15/2021, 8 p.m.	28.89	44.26	39.5	11.49	44.26	20.6
2/16/2021, 7 a.m.	28.51	46.56	38.0	10.82	46.56	18.9
2/16/2021, 8 a.m.	28.15	46.85	37.5	10.36	46.85	18.1
2/16/2021, 9 a.m.	27.12	45.81	37.2	9.72	45.81	17.5

Notably, the analyses presented thus far primarily focus on the reduction of electricity demand, which represents just one of the benefits achievable by GHP retrofitting. Another notable advantage is the concurrent decrease in gas consumption for heating within buildings. The saved gas can be redirected toward electricity power generation, thereby augmenting the overall power supply. Considering the interdependence of gas and electricity systems, an adequate electricity supply can enable gas supply, leading to mutual improvement and reinforcing system stability. Thus, the widespread implementation of GHPs could have potentially prevented the large-scale blackout in Texas during the 2021 winter storm.

5.2 SUMMARY

The preliminary analysis conducted demonstrates that mass GHP retrofitting can effectively enhance the operational reliability of the power grid in Texas, particularly during extreme weather conditions. This improvement stems from the substantial reduction in electricity demand achieved through GHP retrofitting, thereby reducing the strain on the power system.

Considering the ongoing effects of climate change, Texas and other areas will likely encounter a greater frequency and intensity of extreme weather events in the coming years. Notably, events such as the polar vortex experienced in December 2022 are expected to exert significant pressure on the electricity infrastructure. These circumstances are especially challenging for areas reliant on ASHPs and electric heaters for building heating and cooling. Under such circumstances, there is an increased risk of rolling blackouts or uncontrolled blackouts that affect many consumers and result in substantial economic losses. Therefore, more efficient heating and cooling systems such as GHPs must be adopted to alleviate the electricity demand burden, thereby improving the resilience and robustness of the electric power system.

6. CONCLUSIONS AND FUTURE WORK

This study began with a large-scale building stock energy simulation to assess the effects of mass GHP deployment, which is combined with weatherization of SFHs (i.e., reducing air infiltration and ductwork leakage), on electricity usage and on-site carbon emissions in the building sector. The simulation results show that retrofitting 68% of all existing building floor space in the United States (78% of residential floor space and 43% of commercial floor space of the 2018 building stock[23]) with GHP systems, along with measures for reducing OA infiltration and ductwork leakage in SFHs, can save 401 TWh of

[23] In this analysis, GHP retrofits excluded buildings that use district heating/cooling (i.e., no energy consumption for heating/cooling at the building), mobile homes, buildings without heating/cooling, and buildings that already use GHPs.

electricity and eliminate 5,138 billion MJ of fossil fuel consumption (e.g., natural gas, heating oil, propane) (approximately 4,747 billion ft^3 of natural gas equivalent) each year compared with the electricity and fuel consumption of the existing building stock in 2018. The reduced on-site fossil fuel consumption at buildings would avoid carbon emissions equivalent to 342 MMT CO_2 each year. If GHP deployment increases linearly from 2020 until reaching its maximum potential by 2050, fuel costs of US$(2021)1,020 billion would be saved, and 5,290 MMT CO_2e emissions would be avoided over 30 years by replacing the on-site consumptions of fossil fuels with GHPs for space heating.

Retrofitting existing HVAC systems with GHP systems has different effects in different regions. Large reductions in annual electricity consumption occur in the southern United States because of the dominance of air-conditioning in total annual energy use. In the northern United States, GHP retrofits result in high on-site carbon emission reductions because of the dominance of existing combustion-based heating systems (i.e., furnaces or boilers using gas, propane, and fuel oil). In many regions, the gain in efficiency during the cooling season more than offsets the increase in electrified heating load, resulting in a full building electrification with reductions in total annual electricity use. It is noteworthy that roughly 50% of the benefits described in this report (carbon, energy, and system cost reductions) are attributable to the superior efficiencies of GHPs with the remaining benefits attributable to reducing OA infiltration and ductwork leakage in SFHs. Thus, the key to realizing the enormous value proposition is through a combination of both deep efficiency measures, which should be considered for all future retrofits.

The US electric power system were analyzed in several scenarios, including Base, Grid Decarbonization, and economy-wide decarbonization (i.e., the EFS scenario). This analysis revealed various effects on the electric power system resulting from the mass deployment of GHPs (including weatherization in SFHs). The following effects can be expected if the maximum deployment of GHPs is realized by 2050:

- Reduce the requirement for annual electricity generation in the contiguous United States[24] by 585 TWh, 593 TWh, and 937 TWh compared with the Base, Grid Decarbonization, and EFS scenarios, respectively.
- Reduce the needed generation and storage capacity by 173 GW, 345 GW, and 410 GW compared with the Base, Grid Decarbonization, and EFS scenarios, respectively.
- Avoid transmission additions by 3.3 TW·mi (a 17.4% reduction), 36.7 TW·mi (a 33.4% reduction), and 65.3 TW·mi (a 37.6%) compared with the Base, Grid Decarbonization, and EFS scenarios, respectively.
- Reduce the required capacity for resource adequacy, mostly from power plants using fossil fuels, by 102 GW in summer and 95 GW in winter compared with the Base scenario. In the Grid Decarbonization scenario, 103 GW (summer) and 101 GW (winter) of capacity would no longer be needed. In the EFS scenario, substitution of ASHPs with the mass GHP deployment reduces the resource adequacy requirement by 127 GW in summer and 185 GW in winter.
- Eliminate 217 MMT CO_2 emissions each year from the US electric power system by 2050 compared with the Base scenario. However, in the Grid Decarbonization scenario, GHP deployment does not affect carbon emissions from the electric power system because the carbon emission constraint of the electric power system is determined by the predefined grid decarbonization target. GHP deployment could also avoid CO_2 emissions related to end-use heating in the building sector. The deployment of GHPs leads to a 7,351 MMT cumulative CO_2 emissions reduction from 2022 to 2050 in the Base + GHP scenario. In the Grid Decarbonization + GHP scenario, the deployment of GHPs primarily

[24] This excludes Alaska, Hawaii, and US territories because of limited data for conducting a detailed analysis.

reduces carbon emissions in the building sector (4,318 MMT from 2022 to 2050). Compared with the EFS scenario, the mass deployment of GHPs reduces 2,178 MMT cumulative CO_2 emissions from 2022 to 2050.

- Reduce the wholesale cost for electricity. The mass GHP deployment reduces peak electricity demand and flattens annual electricity use. As a result, the wholesale cost for electricity in 2050 can be lowered by 6% in the Base + GHP scenario, 12% in the Grid Decarbonization + GHP scenario, and 8% in the EFS + GHP scenario. From 2022 to 2050, the reduced wholesale cost decreases electricity payments from consumers by $316 billion in the Base + GHP scenario, $557 billion in the Grid Decarbonization + GHP scenario, and $606 billion in the EFS + GHP scenario (all present values considering a 5% discount rate).

- Reduce the cumulative system cost of electricity (including the capital costs of generators and transmission systems, as well as the costs for operating the generators and the grid) by $145 billion (a 5.1% reduction) in the Base + GHP scenario, by $241 billion (a 7.2% reduction) in the Grid Decarbonization + GHP scenario, and by $306 billion (a 7.4% reduction) in the EFS + GHP scenario.

- Reduce the peak load in all RAZs in the summer by 3% to 28%. In the winter, GHPs can also reduce the peak load for most areas; in the Southeast, where electric heating (e.g., ASHPs with supplemental electric resistance heaters) is widely used, the peak load reduction ratio can be up to 28%. Notably, the peak load is less reduced in areas where fossil fuel–based heating is used. A case study indicates that mass deployment of GHPs could improve the operational reliability of Texas electric power system in extreme winter weather events. It thus will reduce rolling blackouts, which could affect many consumers and result in high economic losses.

To address the limitations of the current study and generate more useful information to utility companies and decision-makers, the following actions are recommended:

- Conduct a regional analysis, such as for the service territory of a particular electric grid system or for a specific group of buildings in each county, to investigate the effects and costs of implementing GHPs. This analysis should include (1) CO_2 and energy cost reduction from eliminating natural gas combustion; (2) jobs to retrofit buildings and drill boreholes for implementing GHPs in applicable buildings; (3) water consumption in the electric power system resulting from mass GHP deployment, as well as water use in the cooling towers of commercial buildings; and (4) changes in grid assets (e.g., avoided lithium batteries), infrastructure development, and cost of transmission.

- Expand the building sector analysis to account for improvement in building energy efficiency, including improvement in building envelopes, the energy efficiency of conventional HVAC systems and GHP systems, and outdoor air ventilation controls.

- Develop a web-based interactive national map with built-in analytical tools to present the results of the impact analysis, including building and grid simulation results. The map will support data-driven research that explores the environmental and socioeconomic benefits associated with GHP deployment.

- Investigate the cost reduction potential resulting from the mass manufacturing of GHP units and the scale of economy for GHE installation.

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APPENDIX A. CHARACTERISTICS OF THE PROTOTYPE BUILDING MODELS USED IN THIS STUDY AND THE REPRESENTATIVE CITIES OF THE 14 US CLIMATE ZONES

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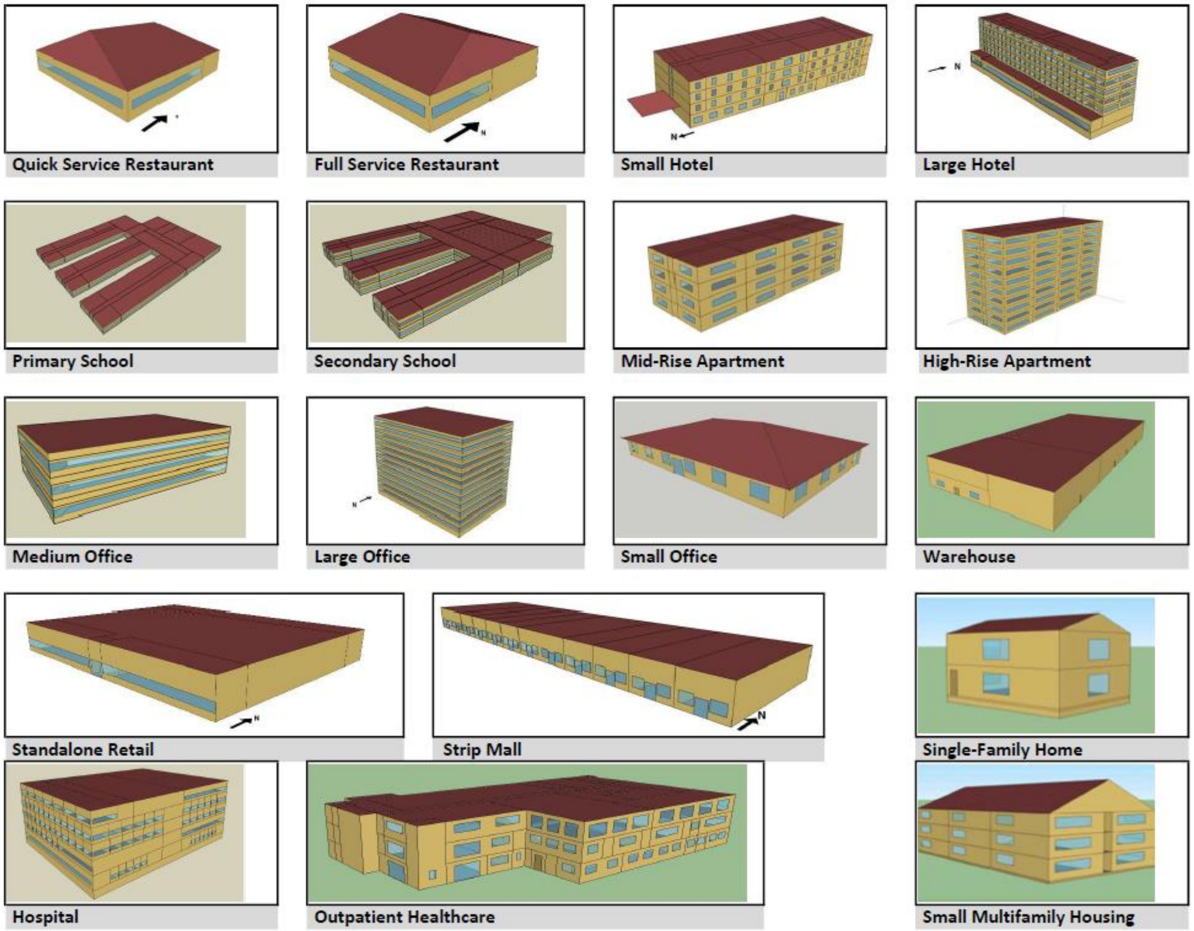

Figure A-1. 3D renderings of the commercial and residential prototype building models used in this study.

Table A-1. Total floor area and existing HVAC equipment of commercial and residential prototype buildings used in this study (designed following the 2007 edition of ANSI/ASHRAE/IES Standard 90.1 for commercial buildings and the 2006 edition of IECC for residential buildings)

Building description	Total floor area (ft^2)	Heating equipment	Cooling equipment
Small office	5,500	Heat pump with a backup gas furnace: 7.7 Heating Seasonal Performance Factor	Heat pump: seasonal energy efficiency ratio (SEER) 13
Medium office	53,600	Gas furnace: 80% burner efficiency	Packaged terminal air-conditioner (PTAC): energy efficiency ratio (EER) 9.3
Large office	498,600	Gas boiler: 80% thermal efficiency; water source heat pump: Heating COP 4.2	Water-cooled centrifugal chillers: 6.2 COP; water-source direct expansion (DX) cooling coil for data center and IT closets: EER 12

Table A-1. Total floor area and existing HVAC equipment of commercial and residential prototype buildings used in this study (designed following the 2007 edition of ANSI/ASHRAE/IES Standard 90.1 for commercial buildings and the 2006 edition of IECC for residential buildings) (continued)

Building description	Total floor area (ft^2)	Heating equipment	Cooling equipment
Standalone retail	24,695	Gas furnace: 80% burner efficiency; standalone gas furnace for entrance: 80% burner efficiency	PTAC: EER 9.3–10.1; no cooling for entrance
Strip mall	22,500	Gas furnace: 80% burner efficiency	PTAC: EER 9.5–10.1; no cooling for entrance
Primary school	73,960	Gas furnace: 80% thermal efficiency; gas boiler: 80% thermal efficiency	PTAC: EER 9.3–10.1
Secondary school	210,900	Gas furnace: 80% thermal efficiency; gas boiler: 80% thermal efficiency	PTAC: EER 9.3; air-cooled chiller: 2.7 COP (1.3 kW/ton)
Outpatient healthcare	40,950	Gas boiler: 80% thermal efficiency	DX cooling: EER 9.3
Hospital	241,410	Gas boiler: 80% thermal efficiency	Water cooled chillers: 6.1 COP (0.6 kW/ton)
Small hotel	43,200	PTAC with electric resistance, gas furnace: 80% burner efficiency; electric cabinet heaters for storage and stairs	PTAC: EER 9.3–11; split system with DX cooling: SEER 13; no cooling for storage and stairs
Large hotel	122,132	Gas boiler: 80% thermal efficiency	Air-cooled chiller: 2.7 COP (1.3 kW/ton)
Warehouse	49,495	Gas furnace: 80% burner efficiency	PTAC: 9.5 EER; SEER 13
Quick service restaurant	2,500	Gas furnace: 80% burner efficiency	PTAC: EER 9.5–10.1
Full service restaurant	5,502	Gas furnace: 80% burner efficiency	PTAC: EER 9.3–10.1
Mid-rise apartment	33,700	Gas furnace: 80% burner efficiency	Split system DX: SEER 13
High-rise apartment	84,360	Water source heat pumps: Heating COP 4.2	Water source heat pumps: EER 11.2–12.0
Single-family home (SFH)	2,376	Gas furnace	Central air conditioner: SEER 13
SFH	2,376	Oil furnace	Split system DX: SEER 13
SFH	2,376	Heat pump	Split system DX: SEER 13
SFH	2,376	Electric resistance	Split system DX: SEER 13
Small multifamily housing	21,600	Gas furnace	Split system DX: SEER 13
Small multifamily housing	21,600	Oil furnace	Split system DX: SEER 13
Small multifamily housing	21,600	Heat pump	Split system DX: SEER 13
Small multifamily housing	21,600	Electric resistance	Split system DX: SEER 13

Table A-2. The 14 US climate zones included in this study, along with representative cities

Climate zone	Representative city
1A	Miami, Florida
2A	Houston, Texas
2B	Phoenix, Arizona
3A	Atlanta, Georgia
3B	Las Vegas, Nevada
3C	San Francisco, California
4A	Baltimore, Maryland
4B	Albuquerque, New Mexico
4C	Seattle, Washington
5A	Chicago, Illinois
5B	Boulder, Colorado
6A	Minneapolis–St. Paul, Minneapolis
6B	Helena, Montana
7A	Duluth, Minneapolis

APPENDIX B. PERFORMANCE CURVES AND FAN EFFICIENCIES OF GEOTHERMAL HEAT PUMPS

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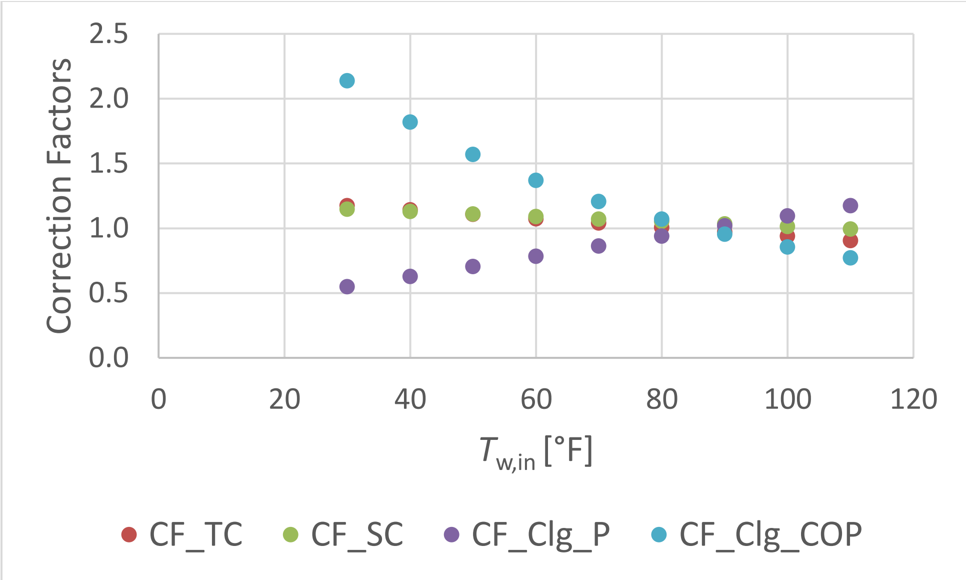


$T_{w,in}$: The temperature of water entering the source side of the geothermal heat pump (GHP)

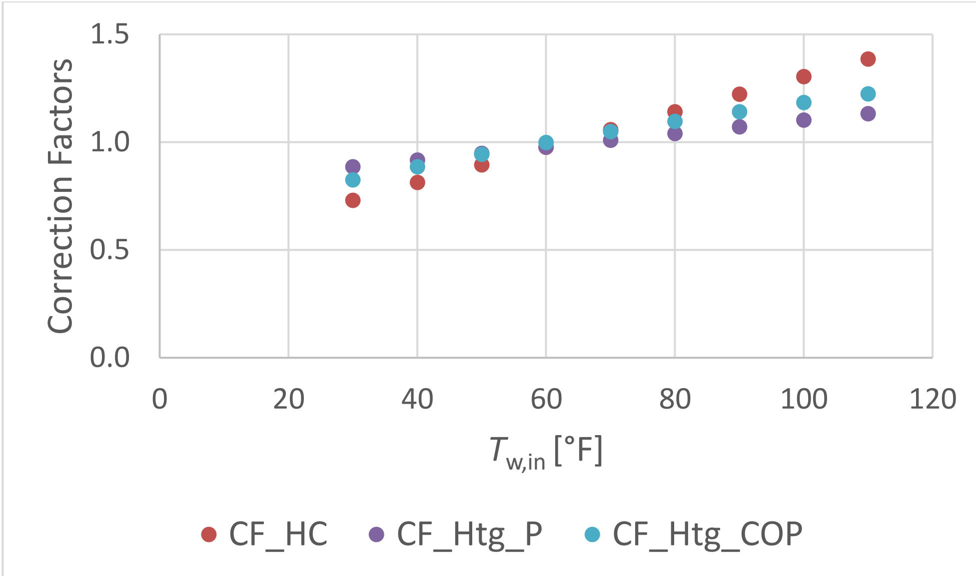
CF_TC: Correction factor for total cooling capacity, which is the ratio of the actual total cooling capacity to the nominal total cooling capacity at the rating condition

CF_SC: Correction factor for sensible cooling capacity, which is the ratio of the actual sensible cooling capacity to the nominal sensible cooling capacity at the rating condition

CF_Clg_P: Correction factor for cooling power consumption, which is the ratio of the actual power consumption to the nominal power consumption at the rating condition in cooling mode

CF_Clg_COP: Correction factor for cooling coefficient of performance (COP), which is the ratio of the actual COP to the nominal COP at the rating condition in cooling mode

Figure B-1. Performance curves of the GHPs in cooling mode.



***$T_{w,in}$*:** The temperature of water entering the source side of the GHP

CF_HC: Correction factor for heating capacity, which is the ratio of the actual heating capacity to the nominal heating capacity at the rating condition

CF_Htg_P: Correction factor for heating power consumption, which is the ratio of the actual power consumption to the nominal power consumption at the rating condition in heating mode

CF_Htg_COP: Correction factor for heating COP, which is the ratio of the actual COP to the nominal COP at the rating condition in heating mode

Figure B-2. Performance curves of the GHPs in heating mode.

Table B-1. Efficiency and pressure rise of fans used in the modeled GHPs and the fans used in the existing HVAC systems of the prototype single-family homes

Variable	GHP fan	Existing fan
Motor efficiency	0.9	0.65
Fan total efficiency	0.7	0.38
Pressure rise (pa)	75	400

APPENDIX C. IMPACT ANALYSIS OF OUTDOOR AIR INFILTRATION ON HEATING AND COOLING LOADS OF SINGLE-FAMILY HOMES

APPENDIX C. IMPACT ANALYSIS OF OUTDOOR AIR INFILTRATION AND DUCTWORK LEAKAGE ON HEATING AND COOLING LOADS OF SINGLE-FAMILY HOMES

Outdoor air (OA) infiltration and ductwork leakage of an HVAC system significantly affects the heating and cooling demands of buildings, especially for single-family homes (SFHs). Depending on the climate and air tightness of a building envelope (e.g., exterior walls, ceilings, roofs, windows, and doors), the OA infiltration rates vary significantly from building to building. For SFHs in the United States, the majority of HVAC ductwork is installed in unconditioned attic space, where the air temperature is close to that of the outdoor ambient. Thus, air leakage and the associated energy loss from the ductwork could significantly increase the energy consumption for keeping the room temperature at desired set points.

To quantify the effects of OA infiltration and ductwork leakage on the heating and cooling energy consumption of SFHs, simulations were performed with the US Department of Energy's prototype SFH models across 16 climate zones (CZs) in the United States (Figure C-1). The prototype SFH models developed following the 2006 edition of the International Energy Conservation Code (IECC) were selected to represent existing SFHs. The 2006 edition of the IECC does not specify the minimum allowed OA infiltration rate and ductwork leakage. An airflow network was used in the prototype model to simulate the OA infiltration and ductwork leakage.[42] Four SFH models are in each CZ, and each has a different heating system, including an electric resistance heater, air-source heat pump, oil furnace, and gas furnace. The first set of 64 cases model OA infiltration and ductwork leakage using the airflow network implemented in the original prototype models. The second set of 64 cases eliminate OA infiltration and ductwork leakage by removing the airflow network.

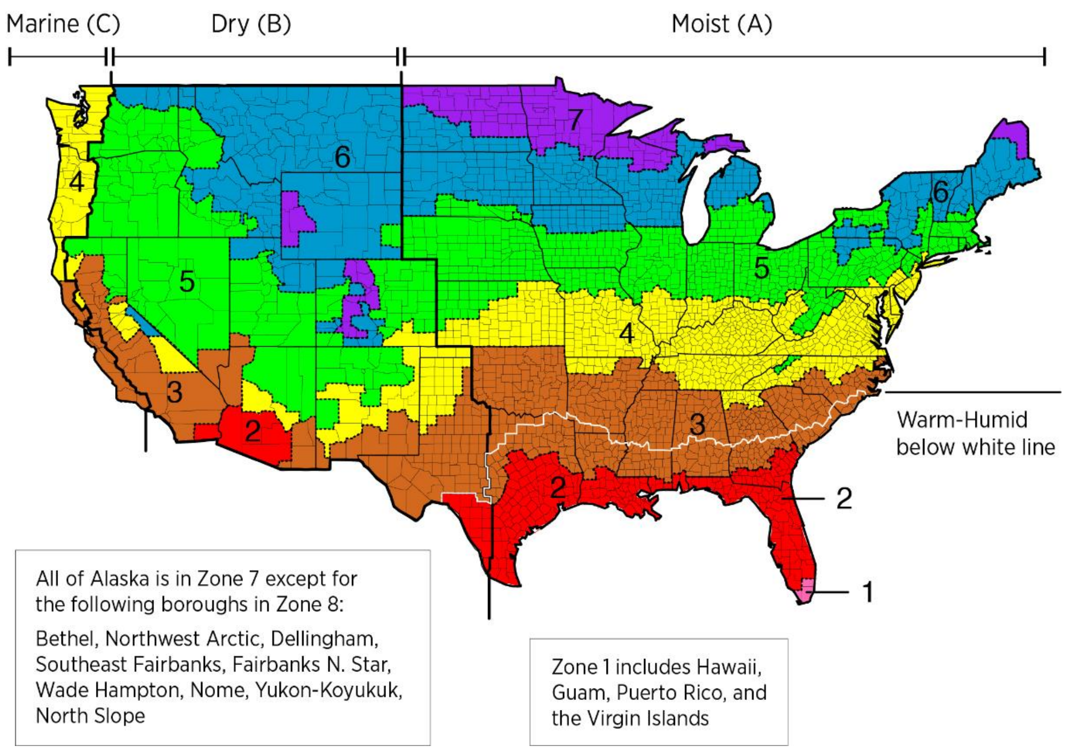


Figure C-1. CZ map for the United States. (Source: 2012 IECC, accessible at https://codes.iccsafe.org/content/IECC2012.)

[42] https://www.energycodes.gov/prototype-building-models

Figure C-2 shows the simulation results of the contribution of OA infiltration and ductwork leakage to the annual heating and cooling energy of the prototype SFHs at each CZ. The OA infiltration and ductwork leakage contribute 48% to 77% of the annual energy consumption for space heating. The contribution is higher in colder CZs because of the larger temperature difference between the ambient and the indoor air. For the annual space cooling energy consumption, the contribution ranges from −39% to 27%. The negative contributions are only for the three CZs (3C, 4C, and 5C) with marine weather, where the ambient temperature is mild and OA infiltration can cool the SFHs, thus reducing the cooling energy consumption. In terms of the annual heating and cooling energy consumption, the contribution of OA infiltration and ductwork leakage is between 21% and 71% for SFHs built following the 2006 edition of the IECC.

This analysis clearly indicates that OA infiltration and ductwork leakage contribute significantly to the annual heating and cooling energy consumption of SFHs, especially in cold climates. OA infiltration and ductwork leakage can be reduced by sealing the gaps, holes, and cracks in the ceilings, exterior walls, and ductwork, as well as applying weather strips to windows and doors.[43] According to previous studies, air sealing can reduce heating energy consumption by 30%–50% (Chan 2013, Hassouneh et al. 2012, Jokisalo et al. 2009, Lozinsky and Touchie 2018, Pasos et al. 2020, Sawyer 2014).

A case study for an SFH at CZ 5A indicates that the annual heating and cooling energy is reduced by 36% by delivering only the needed OA according to the 2007 edition of ASHRAE Standard 62.2 (ASHRAE 2007) with a dedicated outdoor air system (DOAS) instead of through the uncontrolled infiltration. Additionally, the required capacity of the geothermal heat pump (GHP) and the required size of the ground heat exchanger (GHE) are reduced by 30% and 16%, respectively. The reduced size of the GHP and GHE leads to a cost reduction, which may offset the expense for air sealing and the addition of a DOAS. Therefore, it is strongly recommended to include air sealing in a GHP retrofit because it can not only achieve deeper reduction in energy consumption and carbon emissions but also reduce the size and cost of GHP system. The reduced size of the GHP is critical in avoiding the winter peaking of electricity demand resulting from the electrification of space heating in buildings.

[43] https://sealed.com/resources/the-definitive-guide-to-air-sealing-your-house/

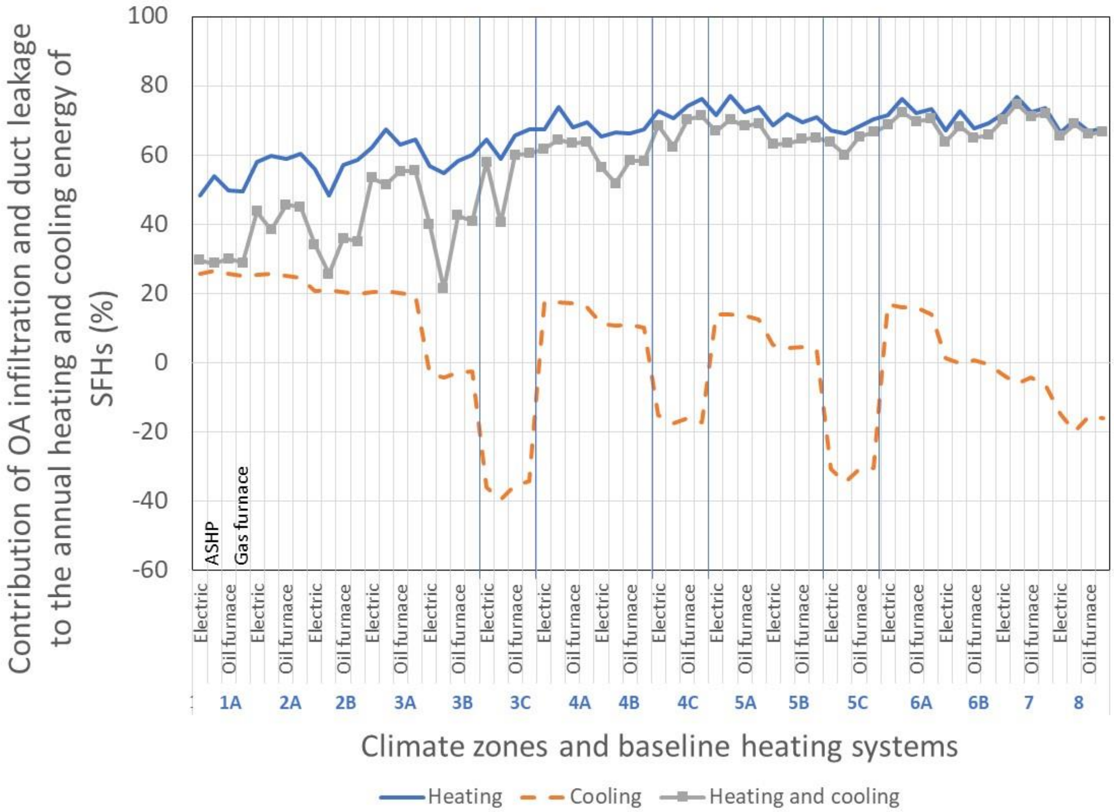


Figure C-2. Effects of OA infiltration and duct leakage on annual heating and cooling energy consumption of US Department of Energy prototype SFHs (designed following the 2006 edition of the IECC standard) at various CZs in the United States.

APPENDIX D. ADDITIONAL END-USE LOAD PROFILE DATA ANALYSIS

APPENDIX D. ADDITIONAL END-USE LOAD PROFILE DATA ANALYSIS

Table D-1. Characteristics of existing buildings included in NREL's end-use load profile database that are applicable for geothermal heat pumps (GHPs)

	Residential				Commercial			
	All	**GHP valid***	**With GHP system‡**	**%**	**All**	**GHP valid***	**With GHP system**	**%**
Number of housing units (10^6)	133.124	102.18	—	76.8	—	—	—	—
Floor space (10^6 ft^2)	234,458	185,937	—	79.3	54,942	41,908	1,059	76.3♦
Heating energy use (10^6 kWh) †	1,817,080	1,436,900	—	79.1	208,642	193,227	1,090	92.6♦
Cooling energy use (10^6 kWh) †	269,681	247,583	—	91.8	114,588	89,242	2,914	77.9♦

*Residential buildings that are applicable for GHP retrofit (excluding mobile homes, heating fuel none/other, cooling none); commercial buildings that are applicable for GHP retrofit (excluding district heating and/or cooling systems, GHP system, heating none, cooling none/evaporative)

♦ it is the percentage of commercial buildings that are included in NREL's end-use load profile database, which only accounts for 64% of existing commercial buildings in the US.

†Fan and pump energy excluded

‡No indication provided for residential buildings that already use a GHP

APPENDIX E. RELIABILITY ANALYSIS METHOD

APPENDIX E. RELIABILITY ANALYSIS METHOD

The calculated electricity demand with the geothermal heat pump (GHP) retrofit in 2021 was obtained by first calculating the demand reduction owing to the retrofit in 2021, and then subtracting it from the anticipated electricity demand in 2021. Because the end-use load profile data set does not include 2021 energy consumption data of individual balancing areas (BAs), researchers have proposed to calculate the demand reduction with the GHP retrofit based on available data in 2018 first, then forecasting the demand reduction of individual BAs in 2021 using a machine learning approach referred to as multilayer perceptron (MLP) (Suter 1990).

The detailed procedures of using MLP for forecasting the demand reduction in 2021 are as follows.

1. For the year of 2018, determine the ratios of the total building demand for individual BAs within the Electric Reliability Council of Texas (ERCOT). The *building demand ratio* is defined as the total building demand of a given BA to the total building demand of the ERCOT. Notably, the building demand accounts for most of the total demand in each BA. Without additional information on the nonbuilding demand of each BA, the building demand ratio is assumed to represent the ratio of the total demand of each BA to the total demand of the ERCOT.
2. Multiply the building demand ratio by the total demand of the ERCOT in 2018 to determine the total demand of each BA in 2018.
3. Determine the ratios of daily demand reduction for individual BAs in 2018. The daily demand reduction ratio is defined as the daily demand reduction of a given BA to the total daily demand of the same BA. The daily demand reduction is obtained by summing the hourly reduction, which can be obtained by the methodology described in Section 3.
4. Train the MLP by using the daily demand reduction ratios and weather conditions in 2018. Commonly considered weather conditions include average temperature, dew point, humidity, wind speed, and atmospheric pressure.
5. Apply the trained MLP to forecast the daily demand reduction ratio of each BA in 2021 with the weather conditions in 2021.
6. Determine the total demand of each BA in 2021 based on the building demand ratios in 2018 and the anticipated demand of ERCOT in 2021.
7. Multiply the forecasted daily reduction ratio by the total daily demand of each BA to determine the daily demand reduction of each BA in 2021.
8. Determine the total daily demand reduction of the ERCOT by summing the forecasted daily demand reduction of individual BAs.
9. Distribute the daily demand reduction of the ERCOT to each hour based on the ratio of hourly demand to the total daily demand of the same day.

In these steps, weather conditions are used as inputs for the MLP model because of their substantial effect on the electricity consumption of buildings. Cold and hot weather conditions necessitate the operation of heating and cooling systems, respectively, which contribute significantly to the overall electricity consumption of buildings. The correlation matrix between the average temperature and daily building electricity demand can be calculated based on the temperature data and electricity consumption data in 2018.

WARMTH Act Testimony.docx.pdf
Uploaded by: Katie Fry Hester
Position: FAV

Katie Fry Hester
Legislative District 9
Howard and Montgomery Counties

Education, Energy, and
Environment Committee

Chair, Joint Committee on
Cybersecurity, Information Technology
and Biotechnology

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THE SENATE OF MARYLAND
ANNAPOLIS, MARYLAND 21401

Testimony in Support of the SB 570 - Public Utilities - Thermal Energy Network Systems - Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)

February 28, 2024

Chairman Feldman, Vice-Chair Kagan, and members of the Education, Energy, and Environment Committee:

The Inflation Reduction Act (IRA) offers time-bound funds that will provide an opportunity for historic investment in Maryland's energy infrastructure. These funds give us the opportunity to fully electrify many low-and-moderate income homes, but not all. In order to best utilize these funds, we must invest them so that we can not only make a big impact on our state's infrastructure but also learn lessons for future electrification from fund sources we have not yet identified.

This legislation engages a portion of Maryland's IRA funds to create community scale networked geothermal heating and cooling systems (GHP). In particular, it requires that each gas company in the state works with community organizations and municipal and county governments to identify pilot communities and propose these projects to the Public Service Commission (PSC). Based on the cost benefit analysis, the PSC will approve the pilots. The gas companies will be responsible for building the systems and collecting significant data once the projects are operational.

This legislation is timely and has many benefits:

1. Decarbonizing to meet Maryland's greenhouse gas reduction goals requires greater electrification of buildings and transportation. As Maryland electrifies, we need to maximize efficiency to limit upgrades needed to the electric grid. Specifically, we need to flatten the projected winter peak energy usage. Coupled with building envelope improvements, networked geothermal systems have been proven to reduce electricity demand.[1]

2. A US Department of Energy study finds the "mass deployment of GHPs can electrify the building sector without overburdening the US electric power system. In all GHP deployment scenarios considered, significant reductions are realized in the needed power generation and capacity, energy storage capacity, transmission build-outs, seasonal capacity that can contribute toward resource adequacy, CO2 emissions, and marginal and cumulative system costs of

[1] https://www.energy.gov/eere/articles/us-department-energy-analysis-highlights-geothermal-heat-pumps-pathway-decarbonized

electricity across the United States..”[2]

3. This legislation offers a new business model for gas utilities that relies on 100% clean energy and utilizes existing pipeline workforce skills. In Massachusetts, both Eversource and National Grid have pilot projects through which they will own the networked geothermal system and it will be rate-based in the same way their gas and electric assets are currently rate-based.[3] These projects have broken ground and will come on line in the next year. In states such as New York, legislation has been passed in order to remove barriers preventing utility providers from operating networked geothermal systems.[4]

4. Networked geothermal systems are the best opportunity for neighborhood scale shifts to fully electric heating and cooling. By operating on the neighborhood level, the state has the opportunity to implement projects that will move the needle toward our 2031 and 2045 goals. These systems are already operating in areas across the country and providing savings for institutions[5] and residents[6].

Lastly, the legislation includes a requirement that these pilot projects will be in neighborhoods with 80% low-and-moderate income residents and prioritize overburdened and underserved communities. And, the labor standards in the bill prioritize maintaining work for those who currently work on gas infrastructure and ensure prevailing wages for construction on the projects. Because GHP work is similar to gas distribution work, minimal additional training ensures job security. Workers on our gas system have kept us safe and warm for decades. We need to ensure their job security in a new clean thermal energy system.

I respectfully request a favorable report on SB 570.

Sincerely,

Katie Fry Hester

Senator Katie Fry Hester
Howard and Montgomery Counties

[2]page xxiv, https://www.osti.gov/biblio/2224191
[3] https://www.eversource.com/content/residential/about/transmission-distribution/projects/massachusetts-projects/geothermal-pilot-project
[4] https://www.nysenate.gov/legislation/bills/2021/S9422
[5] https://www.coloradomesa.edu/facilities/sustainability/geo-systems.html
[6] https://www.cnbc.com/2022/09/01/geothermal-powered-housing-development-saves-homeowners-big-bucks.html

SB570 - MDLCV Support - WARMTH Act.pdf

Uploaded by: Kristen Harbeson

Position: FAV

MARYLAND LEAGUE OF CONSERVATION VOTERS

February 29, 2024

Support SB 570 - Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)

Dear Mr. Chairman and Members of the Committee:

Maryland LCV supports SB 570 - Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act), and we thank Senator Hester for her leadership on this issue.

Both the December 2023 Maryland Department of the Environment (MDE) Climate Pollution Reduction Plan and the November 2021 Building Energy Transition Plan shared a framework for decarbonizing Maryland's buildings and other emitting sectors in order to reach our state's climate targets – the most ambitious in the country. SB 570 is critical to meeting the goals laid out in these Plans.

According to the Climate Pollution Reduction Plan, nearly all of the state's electricity consumption was used in the building sector. In 2017, buildings accounted for almost 20% of the state's greenhouse gas emissions. 13% of state emissions were for direct use in buildings, which is primarily space and water heating. Geothermal heat pumps provide clean, renewable and efficient electric heating and cooling to buildings. As of August 2022 there were already 3,268 residential and commercial geothermal heat pump systems in Maryland.

Networked geothermal systems are larger and connect more buildings to the benefits of geothermal heat pumps. Building efficiency gains resulting from networked geothermal can aid in reducing the buildings' share of Maryland's electricity consumption and, subsequently, building sector emissions.

Several states, neighborhoods, and companies are beginning to adopt networked geothermal for their efficiency and sustainability benefits. They include a 6 million gross square feet of an auto manufacturer's R&D facilities, a 2.2 million square feet campus of a Fortune 100 chemicals company, other large campus industrial facilities, a 400 home neighborhood in Whisper Valley, Texas, and the New York State Public Service Commission and Con Edison's large-scale geothermal energy network pilot program. Several of Maryland's utilities are already incorporating district and networked geothermal solutions in their future generation planning.

In addition to being clean and efficient, geothermal heat pumps have been offered as an indoor air quality solution, as they filter dust, allergens, mold, and other airborne contaminants. Finally, geothermal heating and cooling is more cost effective than the use of fossil fuel appliances (i.e. propane/gas furnaces, etc.). Marylanders are spending an average of $191 each month on electricity – 12% higher than the national average. For these reasons, geothermal heating and cooling should be pursued at a large scale as a means to improve energy, economic, and health equity in Maryland. Poor indoor and outdoor air quality are disproportionately affecting Maryland's overburdened and underserved populations. High energy burdens are disproportionately found among propane users, in Baltimore City's low-income and majority-Black areas, and in rural areas primarily on the Eastern Shore but also in Southern and Western Maryland. SB 570 also ensures energy and economic equity by prioritizing the leadership of local, small, and minority-owned and -serving businesses working in the building industry.

Maryland asserted itself as a leader in climate solutions when we set the most ambitious state climate targets in the country. A pilot networked geothermal program, similar to New York's, will be a worthwhile strategy as Maryland looks toward meeting these goals amongst a future climate increasing heating and cooling demand.

SB 570 continues the process of meeting Maryland's climate targets, which includes building decarbonization goals. **Maryland LCV urges a favorable report on this important bill.**

SB0570-Public Utilitities - Working for Accessible

Uploaded by: Laurie McGilvray

Position: FAV

Committee: **Education, Energy and Environment**
Testimony on: **SB0570-Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act**
Organization: **Maryland Legislative Coalition Climate Justice Wing**
Submitting: **Laurie McGilvray, Co-Chair**
Position: **Favorable**
Hearing Date: **February 29, 2024**

Dear Chair and Committee Members:

Thank you for allowing our testimony today in support of SB0570. The Maryland Legislative Coalition (MLC) Climate Justice Wing, a statewide coalition of nearly 30 grassroots and professional organizations, urges you to vote favorably on SB0570.

Maryland has a statutory requirement to reduce greenhouse gas emissions to 60% of 2006 levels by 2031. Once this milestone is achieved, we are further required to transition to a net-zero economy by 2045. Meeting these targets is urgent and imperative, and both solar and wind projects are behind schedule in meeting those targets. Under the RPS, geothermal is listed as contributing only 1% of MD's energy needs compared with the 14.% for solar and 2.5% for wind. Maryland's path to achieving its GHG reduction goals is so narrow and has so many favorable (and perhaps unrealistic) assumptions that it really is important to overachieve in some areas. Networked geothermal systems are a super efficient, inflation resistant, reliable way to heat and cool buildings. These systems can be constructed today. They are an already proven, carbon-free technology. They minimize additional electric demand on the grid.

Geothermal heat pumps (GHPs) have been available since the 1940's, and are significantly more efficient than air-source heat pumps. The U.S. Department of Energy estimates that GHPs reduce energy consumption and emissions by up to 44% compared to air-source heat pumps and 72% compared to standard air-conditioning equipment. However, individual GHPs are significantly more expensive than other choices, though they can pay back that extra cost in 5 to 10 years. By networking a neighborhood, savings result from sharing the costs of the boreholes and also sharing waste heat generated in local businesses (primarily from refrigeration and other cooling required year-round, including data centers).

Problem: While geothermal heat pumps are a well-tested technology, and their use in districts, such as universities, is proliferating, their use in networked systems to heat small neighborhoods is more recent. Ensuring an equitable transition for residents and businesses in the impacted neighborhood and for affected gas utility workers also needs careful planning.

Solution: SB0570 would create pilot projects and gather experience and data to assess how well networked geothermal systems will work in different areas in Maryland.

Maryland would not be the first state to pilot thermal energy networked systems using geothermal heat pumps.   Colorado, Massachusetts, Minnesota and New York have passed laws that allow or mandate gas utilities to undertake thermal energy network pilot projects. Illinois, Maine, Vermont and Washington are exploring similar laws.

For example, Eversource, a Massachusetts gas utility, is well-along to completing a networked geothermal pilot in Framingham, consisting of 32 residential and 5 commercial buildings and 140 customers, including a community college, public housing authority, and a fire station.

Maryland should follow the lead of these forward thinking states and implement a networked geothermal pilot program by passing SB0570. The MLC Climate Justice Wing strongly supports SB0570 and urges a **FAVORABLE** report in Committee.

350MoCo
Adat Shalom Climate Action
Cedar Lane Unitarian Universalist Church Environmental Justice Ministry
Chesapeake Earth Holders
Chesapeake Physicians for Social Responsibility
Climate Parents of Prince George's
Climate Reality Project
ClimateXChange – Rebuild Maryland Coalition
Coming Clean Network, Union of Concerned Scientists
DoTheMostGood Montgomery County
Echotopia
Elders Climate Action
Fix Maryland Rail
Glen Echo Heights Mobilization
Greenbelt Climate Action Network
HoCoClimateAction
IndivisibleHoCoMD
Maryland Legislative Coalition
Mobilize Frederick
Montgomery County Faith Alliance for Climate Solutions
Montgomery Countryside Alliance
Mountain Maryland Movement
Nuclear Information & Resource Service
Progressive Maryland
Safe & Healthy Playing Fields
Takoma Park Mobilization Environment Committee
The Climate Mobilization MoCo Chapter
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WISE

SB570_MDSierraClub_fav 29February2024.pdf
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Committee: Education, Energy and the Environment
Testimony on: SB 570, "Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)"
Position: Support
Hearing Date: February 29, 2024

The Maryland Chapter of the Sierra Club urges a favorable report for SB 570. The pilot projects proposed under the WARMTH Act will test an innovative approach to meeting Maryland's climate goals for buildings.

This bill calls for each investor-owned gas utility (including Baltimore Gas and Electric, Washington Gas, Columbia Gas, and five smaller gas utilities) to propose one or two thermal energy network system (TENS) pilot projects to demonstrate this approach to delivering high efficiency, carbon-free heat and hot water for overburdened and underserved neighborhoods. Thermal energy network systems take advantage of the constant temperature in the ground six feet below the surface. They use boreholes drilled in the ground and transfer heat in the winter and cooling in the summer through pipes laid in the streets. Low-income residents who choose to participate in a TENS pilot would receive replacement appliances and heat pumps as well as weatherization at no cost to the resident. Labor standards in the proposal will assure that employees of the contractors or utilities building the pilots receive appropriate pay and benefits. The infrastructure outside the home would be rate-based and has the potential to provide gas utilities with a new business model by substituting return on assets from a thermal energy network system for the return on assets earned from new gas infrastructure. The two-year test would be evaluated for its cost effectiveness and its climate impact by the Public Service Commission (PSC).

No customer in an area for a proposed TENS will be forced to participate and customers will be able to opt out during the pilots.

The WARMTH Act calls for 80% of the customers in the pilots to come from low- or moderate-income housing. These households have been poorly served by Maryland's energy efficiency programs. Low-income households account for 20-25% of the total households in Maryland. A disproportionate percentage of these households are Black, Hispanic, and Asian. Energy burdens for low-income Marylanders are six times those of the average Marylander; low-income Maryland residents spend, on average, 12% of their income on energy bills compared to 2% for Marylanders as a whole. These burdens are higher, in part, because many low-income families live in housing that has poor insulation, broken and inefficient fossil-fuel burning HVAC systems, drafty windows, and unreliable electrical systems. Much of the heating and cooking equipment in these homes also poses a health risk. Replacement of appliances with fully electric versions and weatherization for low-income residents would be fully covered under the WARMTH Act by the Inflation Reduction Act and other federal benefits, the EmPOWER program, Department of Housing and Community Development funds and Strategic Energy

Investment Funds. By focusing the pilots on overburdened and underserved communities and providing the appropriate level of weatherization and appliance replacement, the pilots have the potential to lower costs for these residents and demonstrate that we can effectively serve these communities. Coordination with local groups will help ensure communities understand and accept the TENS pilots when they are deployed in their neighborhoods.

TENS also has the potential to eliminate the health risk from burning methane gas in buildings. Gas leaks can increase levels of nitrous oxides, benzene, and particulates inside buildings, all of which generate health risk. Inside our homes, it also increases the likelihood that children will develop asthma. One study showed that children in homes with gas stoves have a 42% higher risk of asthma.[1] Benzene is also a known carcinogen.

Maryland's Climate Pollution Reduction Plan, recently published, noted that "the lifecycle emissions benefits of networked geothermal, which could be significant when avoided electricity generation emissions are included, would deliver lower lifecycle emissions."[2] Fuel burned in buildings accounts for approximately 13% of greenhouse gas emissions in Maryland. As Maryland works to achieve its climate goals to reduce greenhouse gas emissions by 60% (from 2006) by 2031 and achieve net zero emissions by 2045, many households will electrify their homes with heat pumps, heat pump hot waters heaters, and other efficient electric appliances. Thermal energy network systems can be as much as six times as efficient as gas or electric resistance heating and twice as efficient as air source heat pumps. They could dramatically reduce greenhouse gas emissions if the pilots are successful and TENS projects are widely deployed.

While the recent report of the PSC's Electrification Study showed modest peak demand growth from electrification through 2031,[3] utilities have been concerned that the increased load from electrification of heat and hot water could cause large increases in winter peak load for Maryland's electricity distribution systems. Because the temperature of the ground below six feet is a constant 55 degrees Fahrenheit and thermal energy network systems transfer heat that exists in the ground, they do not generate the potential summer or winter peak electric demand of other forms of electric heat. As a result, the impact on summer or winter load is small or even potentially positive, reducing load.[4]

The proposed legislation contains strong labor protections. It will encourage the utilities to offer the construction work on the project to their own employees and any contractor will be required to pay prevailing wages, provide benefits and retirement plans, offer employment to Maryland residents, and develop a plan for minority participation.

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[1] Meta-analysis of the effects of indoor nitrogen dioxide and gas cooking on asthma and wheeze in children, International Journal of Epidemiology, December 2013, Pages 1724-1737, Weiwei Lin, Bert Brunekreer, Ulrike Gehring, https://academic.oup.com/ije/article/42/6/1724/737113?login=false

[2] The Climate Pollution Reduction Plan cite is: Maryland's Climate Pollution Reduction Plan, Maryland Department of the Environment, December 2023, page 41, https://mde.maryland.gov/programs/air/ClimateChange/Maryland%20Climate%20Reduction%20Plan/Maryland%27s%20Climate%20Pollution%20Reduction%20Plan%20-%20Final%20-%20Dec%2028%202023.pdf

[3] Maryland PSC Electrification Study, December 2023, page 3. https://www.psc.state.md.us/wp-content/uploads/Corrected-MDPSC-Electrification-Study-Report-2.pdf

[4] By 2027 all Maryland utilities are expected to be winter peaking according to the PSC's Electrification Study.

The PSC will play an important role in ensuring the pilot TENS projects are in the interest of ratepayers and will help Maryland achieve its climate goals. Proposals will be evaluated by the PSC for ratepayer impacts, cost effectiveness, the impact on greenhouse gas reduction, the impact on electrification, benefits for customers and employees, avoided gas pipe replacement costs, the impact on investments, and costs of distribution and transmission, etc. The construction and operation of the pilots will be monitored by the PSC, and data will be collected by gas utilities and independent researchers. The PSC will evaluate the results of the pilots in 2029.

Gas utilities currently achieve returns for shareholders by earning a regulated return on assets, largely from gas pipeline mains and services in the ground. Thermal energy network systems have the potential to offer gas utilities a new asset base that does not involve distributing (and, almost inevitably, leaking) natural gas. Instead of creating stranded assets by investing to replace gas pipes, the gas utilities could invest and earn a return on borehole and pipe assets to carry warmth and cooling to buildings.

The Maryland Chapter of the Sierra Club is supportive of these pilots which could lead to decarbonization of heat and appliances in Maryland buildings, in line with the goals of the Climate Solutions Now Act. The TENS approach to decarbonization would be more efficient than electric resistance heat or air source heat pumps and lower winter and summer peak demand for electricity, while providing an alternative business model for utilities. The customer and labor protections are appropriate. The PSC will evaluate the cost effectiveness and climate impact of the pilots.

The Maryland Chapter of the Sierra urges approval of this legislation.

Christopher T. Stix
Clean Energy Legislative Team
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SB570 Support.pdf
Uploaded by: Michael McHale
Position: FAV

INTERNATIONAL BROTHERHOOD OF ELECTRICAL WORKERS - LOCAL UNION No. 24

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Baltimore Port Council
Baltimore Metro Council - AFL-CIO
Central MD Labor Council - AFL-CIO
Del-Mar-Va Labor Council - AFL-CIO
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Written Testimony of
Michael McHale, Business Agent, IBEW LOCAL 24
Before the Senate Education, Energy, and the Environment Committee On
SB 570 Public Utilities – Thermal Energy Network Systems – Authorization and Establishment

<u>Support</u>

February 28, 2024

Chairman Feldman and Committee Members,

My name is Michael McHale, Business Manager and 39-year member of IBEW Local 24. I am writing to express my strong **support** of **SB 570**. By promoting the adoption of geothermal heating and cooling systems, this legislation aligns with our state's aggressive climate action plans to reduce emissions. It provides a tangible pathway towards achieving our targets and transitioning to a net-zero status by 2045.

The WARMTH Act protects the livelihoods of existing workers, while creating opportunities for a new workforce. By requiring gas companies to collaborate with community organizations and local governments, this legislation creates family-sustaining jobs in the transition to clean thermal energy systems. The bill's emphasis on maintaining work for those employed in gas infrastructure and ensuring prevailing wages for construction projects demonstrates a commitment to protecting workers' rights and fostering job security in a rapidly evolving energy landscape.

SB 570 represents a forward-thinking approach to energy policy that balances environmental stewardship, social equity, and economic prosperity. By piloting networked geothermal systems this legislation offers a blueprint for a more sustainable and inclusive future for Maryland. I respectfully request that you vote **favorably** on **Senate Bill 570.**

Sincerely,

Michael McHale
Business Manager
IBEW Local 24

SB0570 OPC Testimony.pdf
Uploaded by: Mollie Woods
Position: FAV

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BRANDI NIELAND
DIRECTOR, CONSUMER
ASSISTANCE UNIT

BILL NO.:	Senate Bill 0570 - Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)
COMMITTEE:	Education, Energy, and the Environment Committee
HEARING DATE:	February 29, 2023
SPONSOR:	Senator Hester
POSITION:	Favorable

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The Office of People's Counsel ("OPC") supports Senate Bill 570 to establish a pilot thermal energy network system. Networked geothermal is an innovative technology that could help Maryland achieve its decarbonization goals while bringing benefits to customers, utilities, and workers.

SB 570 would require large gas companies[1] to develop a plan for a pilot networked geothermal system. Pilots would last for two years and gather information to assess how networked geothermal systems may advance climate goals, lower the costs of electrification, and avoid gas infrastructure costs. The bill will allow the Maryland Public Service Commission ("PSC"), and the gas companies it regulates, to gather essential information on the viability and regulation of networked geothermal systems.

Networked geothermal systems may be an important part of the mix of technologies that together will be necessary to meet the State's greenhouse gas reduction goals. The Climate Solutions Now Act of 2022 establishes a goal of 60 percent GHG

[1] OPC supports the forthcoming amendment that would limit applicability to large gas companies.

emissions reductions by 2031 and net-zero GHG emissions by 2045. Emissions from the building sector—driven by emissions for space heating, water heating, cooking, and industrial heating processes—account for 16% of Maryland's GHG emissions.[2] The Maryland Department of the Environment's recently released Climate Pollution Reduction Plan recommends new policies for decarbonizing Maryland's building sector,[3] with the aim to "transition almost all of Maryland's fuel-burning buildings to be all-electric by 2045. . . ."[4]

Networked geothermal could help the State meet its GHG goals several ways. First, it would reduce fossil fuel consumption by obviating the need to use natural gas for building and water heat. Second, geothermal systems are highly efficient—more efficient even than modern electric heat pumps for heating homes,[5] which themselves are 2.2-4.5 times more efficient than efficient gas furnaces.[6] Third, geothermal systems may be especially effective at helping manage energy loads, reducing or delaying the need for new electric infrastructure.

Networked geothermal systems are already used in some settings to efficiently heat and cool buildings on college campuses and other settings. Massachusetts and New York are both running pilot programs to evaluate their potential to efficiently heat and cool residential and commercial buildings in neighborhoods. SB 570 would create a similar pilot program for Maryland's gas utilities.

SB 570 contains important consumer protection measures. It ensures that customers opting-in to the pilot will not have to pay out-of-pocket for any necessary home electrification—including appliance purchases—or weatherization projects. It limits the costs non-pilot customers will pay through rates by directing the Maryland Energy Administration to coordinate funding sources to pay for necessary customer

[2] Md Dep't. of Env't, *Maryland's Climate Pollution Reduction Plan* (Dec. 2023) at 34.
[3] *Id.* at 39-40 (proposing a"Zero Emission Heating Equipment Standard" and "Clean Heat Standard").
[4] *Id.* at 40.
[5] U.S. Dep't of Energy, *Geothermal Heating & Cooling*, https://www.energy.gov/eere/geothermal/geothermal-heating-cooling ("Geothermal heat pumps can reduce energy consumption and emissions up to 44% compared to air-source heat pumps and 72% compared to standard air-conditioning equipment.").
[6] Claire McKenna, Amar Shah, and Mark Silberg, *It's Time to Incentivize Residential Heat Pumps*, RMI (June 8, 2020), https://rmi.org/its-time-to-incentivize-residential-heat-pumps/#:~:text=The%20United%20States%20has%20made,fossil%20fuel%20use%20in%20building.

appliances. We understand that a forthcoming amendment will further protect pilot participants by ensuring that they are not responsible for any customer-side costs resulting from the decommissioning or discontinuation of a pilot. We support that amendment.

Pilot programs provide an important opportunity to assess technological innovations that could result in savings for utility customers while advancing State policy goals. Without requiring innovative pilots, utilities may be prone to stagnation and the forces of inertia that make it easy to continue relying on conventional technologies. While the costs of pilot programs are borne by all ratepayers, a well-constructed pilot should benefit all customers. Further, SB 570 contains important cost containment measures. The pilot scope is limited to 1-2 projects per utility and provides that the PSC can only approve a plan if it is in the best interest of the public and ratepayers. Maryland needs innovative approaches to facilitate a cost-effective transition away from reliance on fossil-gas. OPC supports limited pilot programs, like the WARMTH Act, that have potential to benefit customers and help the State achieve its climate goals.

Recommendation: OPC requests a favorable Committee report on SB 570.

Advanced Energy United SB 570 Testimony.pdf

Uploaded by: Nick Bibby

Position: FAV

SB 570 – Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act

Senate Education, Energy, and Environment Committee
February 29th, 2024

Nicholas Bibby, Maryland State Lead, Advanced Energy United

Position: Support

Mr. Chairman and Honorable Members of the Committee:

Advanced Energy United ('United') is writing in support of House Bill 397, the Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act. This legislation represents a crucial step forward for Maryland, requiring gas companies to develop pilot thermal energy network systems.

United is a national industry association that educates and advocates for policies that allow our member companies to compete to repower our economy with clean, reliable, and affordable energy. We represent over 100 businesses working across the energy sector, including large-scale and distributed renewables, geothermal, energy storage, energy efficiency, transmission developers, electric vehicle (EV) manufacturers, charging infrastructure providers, and more.

The decarbonization of buildings is crucial to Maryland's ambitious but achievable clean energy and Climate Solutions Now Act goals. As we navigate evolving technology, market trends, and policies related to our gas and electric utilities, Thermal Energy Networks (TENs) have emerged in states like Massachusetts, New York, and Illinois as an attractive clean resource option to heat and cool our homes and businesses. As such, United believes that this bill to add TENs to Maryland's clean energy toolkit is important and timely.

TENs are an Attractive Replacement for Fossil Fuel Use in Buildings

TENs offer an appealing alternative to fossil fuel use in buildings, providing clean, renewable, and efficient energy directly sourced from the earth. By replacing the reliance on fossil fuel natural gas, TENs contribute to emissions reduction, enhance indoor and outdoor air quality, and can – under the right framework – increase heating and cooling affordability. The WARMTH

Act intentionally seeks to gather data from diverse pilot project designs to best understand the framework that will be most beneficial to Marylanders.

TENs Offer a New Approach for Gas Utilities and Workers
The current gas utility business model – to deliver fossil fuel through long-lived pipeline infrastructure, cannot continue indefinitely under Maryland's climate and clean energy commitments. It is also threatened by market forces, including competition from high-performing, non-combustion clean appliances and rising and volatile costs of natural gas and natural gas infrastructure. Acknowledging this, TENs provide an innovative path forward for gas utilities and their workforce, capitalizing on existing skills and expertise within the gas utility sector.

TENs are a "Grid-Ready" Electrification Solution
TENs that leverage ground source (or "geothermal") heat pumps offer extremely energy-efficient heating and cooling without adding significant load on the electric grid by relying on very consistent ground temperatures throughout the year. A recent study by the Oak Ridge National Laboratory and National Renewable Energy Laboratory found that if approximately 70% of buildings in the country were retrofitted with ground source heat pumps and building envelope improvements, electric demand would be 13% lower (with 24,500 fewer miles of transmission needed) compared to decarbonization without ground source heat pumps. These results translate into billions of dollars of savings for energy customers, on the order of $19 billion per year by 2050[1]. Of note, these figures do not consider additional efficiencies of networked geothermal systems.

TENs Promote Inclusiveness and Diversity
The WARMTH Act recognizes the importance of inclusiveness and diversity in the development of thermal energy network systems by authorizing municipal corporations, counties, and community organizations to submit neighborhoods for consideration, by requiring coordination with community groups in pilot system design, and by providing grants to community-based organizations to do participant outreach. This approach reflects a commitment to energy equity within the gas transition.

For these resources, United strongly supports Senate Bill 570. By embracing this legislation, Maryland has the potential to be part of a leading cohort of states in the development of thermal energy network systems. We respectfully request a favorable vote from this Committee.

[1] Oak Ridge National Laboratory, *Grid Cost and Total Emissions Reductions Through Mass Deployment of Geothermal Heat Pumps for Building Heating and Cooling Electrification in the United States.* November 2023. Available at: https://info.ornl.gov/sites/publications/Files/Pub196793.pdf

Testimony in support of SB0570.pdf
Uploaded by: Richard KAP Kaplowitz
Position: FAV

SB0570_RichardKaplowitz_FAV

2/292024

Richard Keith Kaplowitz
Frederick, MD 21703

TESTIMONY ON SB#/0570 – FAVORABLE

Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)

TO: Chair Feldman, Vice Chair Kagan, and members of the Education, Energy, and the Environment Committee

FROM: Richard Keith Kaplowitz

My name is Richard K. Kaplowitz. I am a resident of District 3. I am submitting this testimony in support of SB#0570, Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)

Maryland faces two critical needs. The primary need is to act responsibly to create policies and procedures that ensure climate protection; a plan to deal with climate change. This critical need is to manage sources of energy that involve fossil fuel sources to mitigate the negative effects of the use of fossil fuel. The second critical need to have available multiple sources to provide heating for persons in Maryland, warmth when it is cold.

This bill attempts to ensure gas companies will behave in a responsible manner in creation of a pilot thermal energy network system that will satisfy the two goals of providing warmth while mitigating negative impacts of natural gas usage to accomplish that. We need to know if natural gas can be used without attendant harm to the environment.

This bill will make gas companies responsible for better planning on how that resource can be used without damaging the climate. It will serve to make collection of data to make future decisions more informed.

I respectfully urge this committee to return a favorable report and pass SB0570.

SB0570_WARMTH_ACT_ECM_HoCoCA.org_FAV.pdf

Uploaded by: Ruth White

Position: FAV

HoCo Climate Action HoCoClimateAction.org
Howard County, Maryland

SB0570 - Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)
Hearing Date: February 29, 2024
Bill Sponsor: Senator Hester
Committee: Education, Energy, and the Environment
Submitting: Ruth White for **HoCo Climate Action**
Position: Favorable

HoCo Climate Action is a 350.org local chapter and a grassroots organization representing approximately 1,400 subscribers. It is also a member of the Climate Justice Wing of the Maryland Legislative Coalition. We urge you **to support SB0570, Warmth Act,** which provides an opportunity to pilot networked geothermal systems in Maryland.

Pilots established by The Warmth Act will aid in programs to decarbonize buildings, a path begun by commitments under the Climate Solutions Now Act of 2022. In addition, Governor Moore has ongoing commitments to decarbonization through: (1) the Maryland Climate Plan: Maryland's Climate Pollution Reduction Plan: Policies to Reduce Statewide Greenhouse Gas Emissions 60% byu 2031 and Create a Path to Net-Zero by 2045; (2) recent pledge in the Northeast States for Coordinated Air Use Management to (along with 8 other states) set goal for heat pumps to meet at least 65% of residential-scale heating, air conditioning and water heating shipments by 2030 and 90% by 2040; and (3) announcement February 9th to spend $90 million on reducing carbon pollution in Maryland with $50 million toward decarbonizing community buildings including multifamily housing.

Under the WARMTH ACT, utilities will submit plans for pilots for thermal energy networks systems (often called networked geothermal) to the Public Service Commission. These pilots will be in distinct neighborhoods to show the feasibility of replacing gas with large thermal (geothermal) systems providing heat and air conditioning on a neighborhood basis. This technology is already used by Maryland university systems and more. The pilots will demonstrate how decarbonization can work by replacing all necessary appliance upgrades, home retrofits and panel upgrades. The pilot provides for collaboration by cities, counties or community organizations at the neighborhood level, so all in the neighborhood are engaged and see the benefit of the projects.

These pilots will: (1) make strategic use of IRA funds: (2) demonstrate effective means of electrifying everything in homes one neighborhood at a time; (3) provide proven, community-scale change which is seen already in systems in use across the country, systems which are already providing savings for institutions and residents; (4) focus on neighborhoods with 80% low- and moderate-income residents and will prioritize overburdened and underserved communities.

For all these reasons, and many more others will submit in their testimony, we support this bill, envisioning these pilots as providing a key vision for strategic and effective, rapid expansion of heat pump technology and decarbonization of our buildings.

We urge your favorable vote for SB0570.

Howard County Climate Action
Submitted by Ruth White, Steering and Advocacy Committee
www.HoCoClimateAction.org
HoCoClimateAction@gmail.com

SB 570 Greg Akerman BDCBT (SUPPORT).pdf
Uploaded by: Victoria Leonard
Position: FAV

Electrical Workers
Insulators
Boilermakers
United Association
Plumbers & Gas Fitters
Sprinkler Fitters
Steam Fitters
Roofers
Cement Masons
Teamsters
Laborers
Bricklayers
Ironworkers
Sheet Metal Workers
Elevator Constructors
Painters
Operating Engineers
Carpenters

February 29, 2024

The Honorable Brian Feldman, Chair
The Honorable Cheryl Kagan, Vice Chair
Senate Committee on Education, Energy, and the Environment
Miller Office Building
Annapolis, Maryland 21401

SB 570: Public Utilities - Thermal Energy Network Systems - Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act Position - Support

Thank you Chair Feldman and Vice Chair Kagan and members of the Senate Committee on Education, Energy, and the Environment for the opportunity to submit written testimony in support of SB 570.

The BDCBT represents 28 construction trade unions across Maryland, Northern Virginia, and the District of Columbia. Combined, our trade unions represent more than 30,000 thousand skilled craft professionals in the construction industry.

The BDCBT supports SB 570. SB 570 establishes a pilot for networked geothermal systems in Maryland. Networked geothermal systems are a proven technology that Maryland can use to reduce greenhouse gas emissions. Networked geothermal systems are an efficient, inflation resistant, reliable way to heat and cool buildings. They also minimize additional electric demand on the grid.

One of the key features of SB 570 that the BDCBT supports are its labor standards. Specifically, SB 570 prioritizes the payment of prevailing wages on pilot projects and maintaining employment for those who work on gas infrastructure.

Maryland has a statutory requirement to reduce greenhouse gas emissions to 60% of 2006 levels by 2031. Once this milestone is achieved, the state must transition to a net-zero economy by 2045. Meeting these targets is urgent and imperative. The transition to a carbon-free economy provides benefits to public health and opportunities to invest in Maryland's overburdened and underserved communities. Networked geothermal systems should be part of the solution.

We urge the committee to issue a favorable report on SB 570.

Greg Akerman
President

SB570_IndivisibleHoCo_FAV_Peter Alexander.pdf
Uploaded by: Virginia Smith
Position: FAV

IndivisibleHoCoMD

SB570

Public Utilities – Thermal Energy Network Systems – Authorization and Establishment
(Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)
Testimony before the Education, Energy, and the Environment
Hearing February 29, 2024
Position: Favorable

Dear Chair Feldman and Vice-Chair Kagan, and members of the committee, my name is Peter Alexander, and I represent the 700+ members of Indivisible Howard County. Indivisible Howard County is an active member of the Maryland Legislative Coalition (with 30,000+ members). We are providing written testimony today **in support of SB570.** We appreciate the leadership of Senator Hester for sponsoring this legislation.

Maryland has a statutory requirement to reduce greenhouse gas emissions to 60% of 2006 levels by 2031 and transition to transition to a net-zero economy by 2045. The transition to a carbon-free economy provides benefits to public health and opportunities to invest in Maryland's overburdened and underserved communities.

As another step toward these objectives, the WARMTH Act provides an opportunity to pilot networked geothermal systems in Maryland. This legislation is a strategic investment in the future of Maryland and has several benefits including (1) strategic application of Inflation Reduction Act funding, (2) reducing electricity grid burden, thus avoiding unnecessary grid expansion, (3) offering a new business model for gas utilities that relies on 100% clean energy and utilizes existing pipeline workforce skills, and (4) provides the state an opportunity to implement projects that will advance our 2031 and 2045 climate goals by enabling neighborhood-scale shifts to fully electric heating and cooling.

SB570 requires gas companies to work with community organizations, municipal, and county governments to identify and propose pilot projects to the Public Services Commission (PSC) which the PSC can approve based on a cost benefit analysis. The utilities will build and manage the construction in connecting to ground source heat pumps (GHP) in people's homes. Because GHP work is similar to gas distribution work, minimal additional training ensures job security. Utilities will recover the cost of the networked system, and IRA funds will cover the costs of the electric appliances which pilot properties will receive. The pilots will be in neighborhoods with 80% low- and moderate-income residents and will prioritize overburdened and underserved communities. Labor standards in the bill prioritize maintaining work for those who work on gas infrastructure and ensure prevailing wages for construction on the projects.

We respectfully urge a favorable report.

Peter Alexander, PhD
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Woodbine, MD 21797

GHHI Written Testimony - SB570.pdf

Uploaded by: Wesley Stewart

Position: FAV

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February 28, 2024

Senator Brian J. Feldman, Chair
Senate Education, Energy, and the Environment Committee
2 West Miller Senate Building
Annapolis, Maryland 21401

Re: **FAVORABLE** – SB570 – Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Hear (WARMTH) Act)

Dear Chairman Feldman and Members of the Committee:

On behalf of the Green & Healthy Homes Initiative (GHHI), I submit for the record our testimony in support of SB570. GHHI is a 501(c)(3) national nonprofit organization headquartered in Baltimore, MD. Our mission is to address the social determinants of health, opportunity and racial and health equity through the creation of healthy, safe and climate resilient homes.

Piloting geothermal projects across the state that will achieve these goals will provide important clarity to how the state can achieve this vision and provide immediate benefits to the communities served through this initiative.

GHHI is the nation's lead authority on the benefits of a whole-house approach that aligns, braids and coordinates energy efficiency, health and safety to create an integrated home repair and retrofit delivery model to improve health, economic and social outcomes in line with the state's climate goals. The GHHI model has been supported by the US Department of Energy (DOE) and the US Department of Housing and Urban Development (HUD) as well as numerous states, cities and counties throughout the US. By delivering a standard of excellence, GHHI's work aims to eradicate the negative impact of historic disinvestment, the legacy of ill-conceived and unjust housing by creating holistically healthy housing for children, seniors and families in Maryland's low wealth communities. GHHI's work has been recognized through national best practice awards from the US Environmental Protection Agency (EPA) and HUD. In 2023, GHHI was awarded the Buildings Upgrade Prize award from the DOE in recognition of its proposed initiative to complete electrification of low-income households in East Baltimore through a community-driven, whole home initiative with health and safety, workforce, and efficiency benefits.

<u>Impact of Fossil Fuel Appliances on Health</u>
Growing evidence has highlighted the negative health impacts of fossil fuels from residential usage. In September 2023, GHH, CASA, CCAN, and RMI published the report *Cutting Through*

the Smog[1] which highlighted that fossil fuel furnaces, HVAC systems, water heaters and other equipment emit more than three times as much health-harming nitrogen oxides as the Maryland's power plants. This disproportionately affects low-income residents and residents of color where pollution, environmental justice, and health issues are most likely to compound. The report highlights that outdoor pollution from fossil fuel equipment in Maryland caused an estimated 163 premature deaths in 2017 alone, driving about 3,500 cases of respiratory symptoms, 6,500 lost workdays, and $1.3 billion in public health impacts per year. That is just based on outdoor air pollution.

Furthermore, just last week the EPA and National Academies released a consensus study report, *Health Risks of Indoor Exposure to Fine Particulate Matter and Practical Mitigation Solutions*[2]. That report notes "natural gas combustion is a substantial source of UFPs [ultrafine particles]-, particularly if the particles are not properly exhausted above a stove or vented from appliances such as water heaters, dryers, or heating systems." The report concludes, "There is ample evidence that exposure to indoor fine particulate matter causes adverse health effects." These health impacts include respiratory effects, cardiovascular effects, neurological effects, and more.

Nitrogen oxides and fine particulate matter are just two of the major pollutants from fossil fuel combustion. Other pollutants include the carcinogen benzene, volatile organic compounds, and carbon monoxide. Moving to electric technologies such as electric heat pumps connected to geothermal systems eliminates the source exposure of fossil fuel combustion and toxic gas leakage from furnaces. A full electrification project further adds benefits from eliminating other sources of pollution including water heaters, stoves, dryers, and more.

Importance of Energy Affordability in Low-Income Households

This pilot can play a key role in advancing energy affordability in the state of Maryland. Geothermal heat pumps are one of the most efficient heating technologies available today. According to the EPA, geothermal heat pumps can reduce energy consumption up to 44% compared with air source heat pumps and up to 72% compared with electric resistance heating with standard air-conditioning equipment. They maximize the high efficiency of heat pump technologies while minimizing efficiency losses during colder temperatures thanks to the ground-sourced thermal energy.

In the Brattle Study on the electrical distribution systems submitted to the General Assembly this past December, ground source heat pumps are noted as the technology with the lowest per-customer electrification peak impact—even lower than the impact of modeled air source heat

[1] CASA, Green & Healthy Homes Initiative, Chesapeake Climate Action Network, and RMI, *Cutting Through the Smog: How Air Quality Standards Help Solve the Hidden Health Toll of Air Pollution From Maryland's Homes and Businesses* (September 2023), available at https://www.greenandhealthyhomes.org/publication/cutting-through-the-smog/

[2] National Academies of Sciences, Engineering, and Medicine. 2024. *Health Risks of Indoor Exposure to Fine Particulate Matter and Practical Mitigation Solutions.* Washington, DC: The National Academies Press. https://doi.org/10.17226/27341

pump with fossil fuel-back-up equipment[3]. This efficiency during peak demand has the dual benefit of reducing energy costs to the household (thus reducing energy burden), while also minimizing the demand on the electrical distribution system (thus reducing the need for increased capacity and electrical generation).

Reducing demand on the electrical distribution system will reduce infrastructure costs that often are borne by ratepayers. Given the already high statewide energy burdens (the percentage of household income used to pay for utility costs) and the expected rise in gas infrastructure costs from STRIDE, minimizing electric infrastructure costs is an especially important equity priority. GHHI is the lead facilitator of the Maryland Energy Efficiency Advocates (MEEA) coalition that participates in the EmPOWER proceedings and various PSC and DHCD workgroups. In those spaces, MEEA and others have consistently raised concerns about how energy cost burdens create inequities for low-income communities, and disproportionate burdens on communities of color. In our recent comments to the PSC on Limited Income Mechanism for Utility Customers (Public Conference 59), we noted that in 2022, Marylander home energy bills required 37% of income for Marylanders with incomes below 50% of the Federal Poverty Level.[4]. The energy burden gradually decreases as household income increases. Households with incomes 185% – 200% of the Federal Poverty Level had energy burdens of 8%.[5] Another analysis of residential energy affordability found that around 400,000 Marylanders have an energy burden over 6%, which is the threshold researchers use to define high burden.[6] Maximizing energy efficiency both in energy burdened homes and system wide, as this pilot will support, is essential to an equitable transition to Maryland's clean energy future.

Benefits of Weatherization and Housing Interventions Pre-Electrification

In completing this pilot, the initiative will deliver layered intentions that ensure homes are healthy, safe, energy efficient, and energy resilient. As noted earlier, GHHI has developed the holistic energy efficiency, health and housing service delivery model that is implemented in our nationally recognized, Maryland-based direct service program. The model was adopted by the US Department of Housing and Urban Development and is currently being advanced in partner jurisdictions nationally. The pilot will create an opportunity to deliver this model as homes are weatherized before electrification.

Studies for the US Department of Housing and Urban Development have shown the benefits of GHHI's whole house approach in Baltimore as follows:

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[3] The Brattle Group, 2023. *An Assessment of Electrification Impacts on the Maryland Electric Grid.* Prepared for the Maryland Public Service Commission. Available at https://www.psc.state.md.us/wp-content/uploads/Corrected-MDPSC-Electrification-Study-Report-2.pdf

[4] Fisher, Sheehan & Colton, *The Home Energy Affordability Gap 2022, Maryland (April 2023)*, available at http://www.homeenergyaffordabilitygap.com/.

[5] Ibid.

[6] Arjun Makhijani, et al, Energy Affordability in Maryland: Integrating Public Health, Equity and Climate, Executive Summary (Feb. 2023), available at https://www.psehealthyenergy.org/wp-content/uploads/2023/02/Energy-Affordability-in-Maryland-2023_-Final-Report-1.pdf.

- 66% reduction in asthma related hospitalizations
- 62% increase in school attendance by addressing chronic absences due to asthma
- 88% increase in parental work attendance related directly to healthier children
- 30% reductions in asthma related ER visits
- 99% reductions in childhood lead poisoning
- Reductions in household injuries for children and trip and fall injuries for seniors
- Increased mobility and accessibility in the home for older adults who are able to Age in Place in the homes and communities where they choose to live
- Reductions in greenhouse gas emissions, energy consumption and overall energy costs.

Cost Savings and System Change

- Improved service delivery to low-income households and reductions in deferral rates from housing program services that clients are otherwise eligible to receive
- Program and government cost savings from efficiencies in implementing comprehensive assessment and housing intervention models utilizing cross-trained assessors and contractors
- Government innovation through the utilization of an integrated, comprehensive housing intervention model by state agencies that attracts new federal and philanthropic investment
- Reductions in medical costs including Medicaid costs
- Reductions in energy consumption and energy costs
- Reductions in housing maintenance costs

Between the federal government passing historic investments in climate, infrastructure, and housing through the Bipartisan Infrastructure Law and the Inflation Reduction Act, and the state of Maryland's leadership in climate commitments and planning, we are looking at a historic intersection of need, opportunity, and funding. Meeting this moment for climate, health, and equity will require innovative approaches and comprehensive solutions. This pilot program will help Maryland lead in the housing and energy transitions that are necessary to create a sustainable future. I urge the Committee to support the passage of SB570.

Respectfully Submitted,

DocuSigned by:
Ruth Ann Norton
1A42B3060D6A435...

Ruth Ann Norton
President and CEO

SB0570; HB0397-Pavlak-FWA-Thermal Energy Network S

Uploaded by: Alex Pavlak

Position: FWA

February 29, 2024

SB0570; HB0397 – Thermal Energy Network systems FAVORABLE WITH AMENDMENTS

The idea is sound, but the proposed program is too big, too grand. While the concept is theoretically feasible it has not been demonstrated at scale. It should be downsized to a small number of limited scope pilot systems.

Maryland's role should be the deployment of limited scale pilot systems.

Amendment #1 – State the purpose, the program objective.

- Gather data to quantify the cost of Neighborhood Geothermal Heat Pump Networks. The direct cost is turnkey installation. The indirect cost is any additional and incidental cost such as stubborn neighbors and thermal insulation.
- Compare this concept with existing and proposed zero carbon alternatives such as SMR nuclear district heating, micro reactors, biofuel combustion and air source heat pumps…

Amendment #2 – Reduce the scope of the program.

- Two modest systems, one for new construction, one for retrofit.
- Limit Maryland investment, most of the financing subsidy coming from federal sources.

Amendment #3 – Compete Maryland utilities for the two systems.

Amendment #4 – Establish an agency such as MEA of the PSC as a program office. This is too complex to be run by the legislature.

Dr. Alex Pavlak; Future of Energy Initiative; www.pavlak.net; www.FutureOfEnergyInitiative.org
315 Dunham Ct., Severna Park, MD 21146; (410) 647-7334; (443) 603-3279(c); alex@pavlak.net

BGE_EEE_SWA_Senate Bill 570- Working for Accessibl
Uploaded by: Charles Washington, Vice-President of Government & Externa
Position: FWA

Position Statement

Support with Amendment
Education, Energy, and the Environment
2/22/2024

Senate Bill 570- Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act

Baltimore Gas and Electric Company (BGE) is pleased to support with amendments *Senate Bill 570* **-** *Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act. Senate Bill 570* requires each gas company to file with the Public Service Commission (Commission) a proposal for one or two thermal energy network systems pilot programs by July 1, 2025.

BGE is a key partner and has an important role to play in achieving the state's climate goals. Maryland's energy transformation should include investments in network geothermal, battery storage, and other emerging technology that proves viable, but will also rely on the electric and gas distribution systems. BGE supports an *integrated energy delivery system* utilizing multiple sources of energy to maximize customer choice and assist the state in attaining its decarbonization objectives at the lowest cost.

Senate Bill 570 would require gas companies to establish a network geothermal pilot program. Network geothermal works by creating a neighborhood of ground source heat pumps (GSHP), each connected to a common network of underground pipes that tap into the earth's constant underground temperatures. If properly coordinated, network geothermal could reduce the use of gas and other fossil fuels as a heating source, significantly reducing GHG emissions while also reducing incremental costs of new electric infrastructure expansion that would be needed to support all-electric heating, according to an independent analysis by Energy + Environmental Economics (E3)[1].

For much of 2023, BGE has been in conversations with gas companies executing networked geothermal pilot programs in other states, and the company is working with an experienced consultant to understand the potential of the technology in Maryland. The preliminary results of our discussions indicate that when compared with full electrification, network geothermal is cost effective. Networked geothermal compares particularly favorably due to the tax credit that is available until 2032, as a result of the Federal Inflation Reduction Act of 2022 (IRA).

While BGE sees promise in network geothermal for achieving the state's energy goals, the company commits to working with the sponsor and the committee to address challenges with the timeline and program requirements prescribed in *Senate Bill 570*. *Senate Bill 570* requires

[1] BGE engaged E3 to conduct a study analyzing viable pathways to achieve the state's goals and to identify potential impacts to customers in BGE's service area.

Charles Washington| Brittany Jones | Guy Andes| Dytonia Reed| 410.269.5281

gas companies to establish a pilot program by July 1, 2025. The timeline for the legislation is ambitious, resource-intensive, and concerning. Approval from the Commission could easily take longer than six months before a company could even begin implementation. Further, to meet the current timelines, a utility would have already needed to undertake a feasibility study, conduct engagement and outreach with stakeholders, identify a pilot location and site-specific study, and develop an RFP for the engineering and design to accommodate requirements associated with *Senate Bill 570*. We recommend a more measured timeline for implementing the network geothermal pilot program.

Second, the legislation requires that each pilot program includes 80% of customers from low to moderate-income housing (LMI). BGE recommends amending the legislation to require the LMI requirement for one of the two pilots to achieve a more representative cross section of our service territory. LMI customers are likely to have lower cooling demands than their heating demands due to financial limitations; this thermal imbalance could result in higher costs and significantly lower efficiencies, adversely skewing pilot results. BGE supports giving more flexibility in the program design to ensure that the pilots are economically viable and representative of the potential results that can be achieved in a scaled deployment.

Additionally, the pilot program can potentially be implemented cost-effectively if federal incentives can be fully leveraged; however, *Senate Bill 570* as drafted would preclude this from happening. IRA incentives and Internal Revenue Service (IRS)tax credits are available for purchasing behind-the-meter equipment and investments in the network infrastructure. The IRS mandates that the entity seeking tax credits must own BOTH the network infrastructure and the behind-the-meter GSHPs to qualify for the 40% IRA tax credit. If the utility purchases the ground source heat pumps, in addition to owning the geothermal network, the 40% IRA incentive could apply. As currently drafted, *Senate Bill 570* does not allow the utility to own the behind-the-meter heat pumps, so the federal incentive would be lost. BGE respectfully asks that the legislation be amended to enable gas utilities to own the necessary behind-the-meter assets to maximize federal incentives and lower the costs to our customers.

BGE is preparing to deploy a network geothermal pilot program and welcomes the opportunity to help the state achieve its energy and decarbonization goals. For these reasons, BGE supports *Senate Bill 570* with amendments and respectfully requests a favorable committee report.

SB570_DHCD_SUPPORT_WITH_AMENDMENTS.pdf
Uploaded by: Chuck Cook
Position: FWA

WES MOORE
Governor

ARUNA MILLER
Lt. Governor

JACOB R. DAY
Secretary

JULIA GLANZ
Deputy Secretary

Maryland
DEPARTMENT OF HOUSING AND COMMUNITY DEVELOPMENT

DATE: **February 29, 2024**

BILL NO.: **Senate Bill 570**

TITLE: **Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)**

COMMITTEE: **Senate Education, Energy, and the Environment Committee**

Letter of Support with Amendments

Description of Bill:
Senate Bill 570 would require each gas company operating in Maryland to propose to the Public Service Commission a pilot geothermal energy network system that would provide certain residences with an efficient, low-cost heating and cooling system and appliances. The program would be focused on low- to moderate-income neighborhoods. The bill also authorizes local jurisdictions and community organizations to submit neighborhoods to gas companies for consideration and establishes requirements and authorizations for the development and implementation of proposed thermal energy network systems. IT also requires the Maryland Energy Administration to coordinate with DHCD to provide services or funding for weatherization of low-to moderate income housing within the pilot system's area.

Background and Analysis:
Geothermal energy is a renewable energy source that has the potential to help Marylanders in two ways: First, by providing consumers with a low-cost, renewable, and clean source of home energy as well as more energy-efficient appliances, and second, by reducing reliance on fossil fuels and, therefore, helping the state meet its greenhouse emissions goals. Creating this pilot program will allow DHCD to provide services to a population that may otherwise not be aware of the energy efficiency and weatherization resources available to them.

DHCD agrees with the amendments proposed by the Maryland Energy Administration:

1. On p. 11, lines 10-19, cap total behind-the-meter costs at $3 million. Federal rebates under the Inflation Reduction Act can provide a maximum of $12,400 for low- to moderate income (LMI) households. Under recent guidance from the I.R.S., the federal Investment Tax Credit may not be available for a project that is owned jointly by a utility and a property owner. Federal rebates will likely cover less than half of the total behind-the-meter costs for heat pumps, water heaters, panel and electric upgrades, installation, appliance replacement, project management, and other construction costs. Costs incurred by the Maryland Environmental Service (MES) to administer the contracts do not appear to be addressed in the bill, raising the question of whether MEA will be expected to shoulder those costs as well. MEA needs to budget with certainty.

2. Delete mention of $12 million on p. 11, line 22, such that it reads: "THE ADMINISTRATION SHALL RESERVE ~~$12,000,000 OF~~ FEDERAL FUNDING FROM THE U.S. DEPARTMENT OF ENERGY [.] As written here, a pilot with $12M of federal funding could include at least 950 homes (assuming a maximum of $12,400 per rebate per homes). MEA would be responsible for the remaining behind-the-meter program costs, which could exceed $20 million.

3. **Older appliances.** Consider adding to the PSC criteria a requirement that the utilities choose a pilot where many of the homes have appliances that are at or near the end of their useful lives.

4. **Discontinuation.** Consider on P. 9 inserting in subsection D a provision to protect customers in the event a pilot is discontinued such as (3) IN THE EVENT A PILOT SYSTEM IS DECOMMISSIONED OR DISCONTINUED BEFORE THE END OF THE USEFUL LIFE OF THE APPLIANCES INSTALLED UNDER THIS SUBTITLE, THE COMMISSION SHALL MAKE SURE THAT CUSTOMERS PARTICIPATING IN A PILOT SYSTEM DO NOT INCUR ADDITIONAL EXPENSES RELATED TO DECOMMISSIONING OR INSTALLING NEW APPLIANCES.

5. **Community-based organization funding.** Please add "or any other state or federal funding source" to the provision on p. 10, line 26.

DHCD Position:

The Maryland Department of Housing and Community Development respectfully requests a **favorable report as amended** on Senate Bill 570, with the addition of the amendments, above, proposed by the Maryland Energy Administration.

SB570 WARMTH FWA.pdf
Uploaded by: Landon Fahrig
Position: FWA

TO:	Chair Feldman, Vice Chair Kagan, and members of the Senate Education, Energy, and the Environment Committee
FROM:	MEA
SUBJECT:	SB 570 - Public Utilities - Thermal Energy Network Systems - Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)
DATE:	February 29, 2024

MEA Position: FAVORABLE WITH AMENDMENTS

This bill would require each gas company to propose a pilot geothermal energy network system that would provide certain residences, especially those in low to moderate income (LMI) neighborhoods, with a highly efficient, low cost heating and cooling system and appliances.

MEA has amendments to the bill as introduced, and to the proposed sponsor amendments, both detailed below.

- As introduced, MEA would like a $3 million cap on total behind the meter costs for the reasons detailed below.
- On the proposed sponsor amendments, MEA would like to make sure that any unallocated federal money reserved under the IRA can be re-allocated before the money expires.

MEA supports networked geothermal as one way to help Marylanders electrify their homes and buildings and meet the state's urgent greenhouse gas goals. Unlike networked geothermal pilot projects by Eversource and National Grid in Massachusetts, which are completely funded by utility ratepayers, the Maryland pilot would task the State (MEA) with helping to consolidate state and federal resources to subsidize all behind-the-meter costs.

To the extent that the Strategic Energy Investment Fund or "SEIF" is used to fund the program in the future, it is likely that that expenditure will have a limiting effect on other MEA programs.

I. MEA has five amendments to the bill as introduced.

1. On p. 11, lines 10-19, cap total behind-the-meter costs at $3 million. Federal rebates under the Inflation Reduction Act can provide a maximum of $12,400 for low- to moderate income (LMI) households. Under recent guidance from the I.R.S., the federal Investment Tax Credit may not be available for a project that is owned jointly by a utility and a property owner. Federal rebates will likely cover less than half of the total behind-the-meter costs for heat pumps, water heaters, panel and electric upgrades, installation, appliance replacement, project management, and other construction costs. Costs incurred by the Maryland Environmental Service (MES) to administer the contracts do not appear to be addressed in the bill, raising the question of whether MEA will be expected to shoulder those costs as well. MEA needs to budget with certainty.

2. Delete mention of $12 million on p. 11, line 22, such that it reads: "THE ADMINISTRATION SHALL RESERVE ~~$12,000,000 OF~~ FEDERAL FUNDING FROM THE U.S. DEPARTMENT OF ENERGY [.] As written here, a pilot with $12M of federal funding could include at least 950 homes (assuming a maximum of $12,400 per rebate per home). MEA would be responsible for the remaining behind-the-meter program costs, which could exceed $20 million.

3. Older appliances. Consider adding to the PSC criteria a requirement that the utilities choose a pilot where many of the homes have appliances that are at or near the end of their useful lives.

4. Discontinuation. Consider on P. 9 inserting in subsection D a provision to protect customers in the event a pilot is discontinued such as (3) IN THE EVENT A PILOT SYSTEM IS DECOMMISSIONED OR DISCONTINUED BEFORE THE END OF THE USEFUL LIFE OF THE APPLIANCES INSTALLED UNDER THIS SUBTITLE, THE COMMISSION SHALL MAKE SURE THAT CUSTOMERS PARTICIPATING IN A PILOT SYSTEM DO NOT INCUR ADDITIONAL EXPENSES RELATED TO DECOMMISSIONING OR INSTALLING NEW APPLIANCES.

5. Community-based organization funding. Please add "or any other state or federal funding source" to the provision on p. 10, line 26.

II. MEA Amendments on Utility Ownership, as proposed by the sponsor.

MEA understands there are sponsor amendments in which the utility assumes responsibility and (at least preliminary) ownership of the behind-the-meter geothermal HVAC system and associated equipment, but not appliances. MEA is concerned about setting a precedent for utility ownership of behind-the-meter appliances and HVAC systems. Nonetheless, MEA recognizes that temporary utility ownership of geothermal HVAC systems in this particular pilot would allow Marylanders to take advantage of new and time-limited federal funding. This is a narrow set of circumstances that should have no precedential value.

A utility-ownership model could allow Marylanders to benefit from the Business Energy Investment Tax Credit (ITC). Under recent guidance from the I.R.S., the ITC –which would cover 30% or more of total project costs)– may not be available for a geothermal project that is owned jointly by a utility and a property owner, as proposed here.[1] That, ultimately, could be advantageous to ratepayers as long as utilities do not overcollect on program expenses.

With the proposed sponsor amendments, the utility would be responsible for the procurement and installation of the ground source heat pumps, associated electric panel upgrades, wiring, installation fees, demolition, general contractor fees, contingency, and possibly the water heater/boiler. A portion of those costs could be covered by the ITC, which would also apply to front-of-the-meter costs such as installing the below-the-ground pipes and geothermal loop outside of the building(s). To the extent allowed by federal law, MEA may be able to use federal IRA rebate money to help subsidize costs not covered by the ITC (such as electric stoves and dryers), or duplicative costs such as the hot water heater.

In case the pilot project fails to materialize or is not eligible to receive IRA funds, **MEA must be able to re-allocate any unspent IRA funds to other Marylanders before the federal deadline.**

I. MEA proposes three amendments on the utility-ownership model, in the sponsor amendments.

1. P. 11 FUNDS RESERVED UNDER SUBPARAGRAPH (I) OF THIS PARAGRAPH SHALL BE COMMITTED TO AN APPROVED PROJECT NOT LATER THAN DECEMBER 31, 2026, ~~AND ALLOCATED NOT LATER THAN DECEMBER 31, 2029~~, AND SPENT NO LATER THAN DECEMBER 31, 2031 ~~2029.~~

2. p. 12 A utility shall….PURSUE ALL TAX CREDITS AND FEDERAL FUNDING AVAILABLE FOR BEHIND-THE-METER AND FRONT-OF-THE-METER PROJECTS.

3. ANY REMAINING AFTER ALL FUNDS AND TAX CREDITS AVAILABLE UNDER SUBSECTION (B) OF THIS SECTION HAVE BEEN APPLIED MAY BE RECOVERED THROUGH RATE ADJUSTMENTS OR ANOTHER MECHANISM APPROVED BY THE COMMISSION. THIS SECTION MAY HAVE NO PRECEDENTIAL VALUE IN FUTURE UTILITY REGULATORY PROCEEDINGS.

MEA urges the committee to issue a **favorable report as amended**.

Our sincere thanks for your consideration of this testimony. For questions or additional information, please contact Joyce Lombardi at joyce.lombardi1@maryland.gov or 443.401.1081.

[1] U.S. Treasury Guidance on Section 48 of the Internal Revenue Code, (Nov. 17, 2023) available at https://www.federalregister.gov/d/2023-25539/p-376 (specifically excluding a project in which there is different ownership of a geothermal underground loop and a geothermal heat pump system). See, also Proceeding on Motion of the Commission to Implement the Requirements of the Utility Thermal Energy Network and Jobs Act, Rochester Gas and Electric, New York Public Service Department, Case 22-M-0429 (December 2023)(mentioning ITC guidance as reason for initial utility ownership of HVAC system and underground loop during networked geothermal pilot, p. 55).

SB 570 MDE SWA.pdf
Uploaded by: Les Knapp
Position: FWA

The Maryland Department of the Environment
Secretary Serena McIlwain

Senate Bill 570

Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)

Position: Support with Amendments
Committee: Education, Energy, and the Environment
Date: February 29, 2024
From: Hadley Anthony

The Maryland Department of the Environment (MDE) **SUPPORTS** SB 570 **WITH AMENDMENTS.**

Bill Summary

Senate Bill 570 would require gas companies to develop a plan to pilot a thermal energy network system or systems by October 1, 2024, and submit a proposal or proposals to the Public Service Commission (PSC) by July 1, 2025. Proposals must consider local community input, ensure that at least 80% of served customers are low to moderate income residential customers, and include a cost-benefit analysis of associated avoided cost savings related to electric distribution and transmission as well as gas pipe replacements. The PSC would approve, modify, or reject a plan. The PSC and the Department of Labor would also be authorized to consider, review, and enforce a community benefit agreement.

Position Rationale

This bill aligns with Maryland's climate goals to reach 60% greenhouse gas emissions (GHG) reductions, compared to 2006 levels, by 2031 and to reach net-zero emissions by 2045. Maryland must continue investing in clean energy technologies that meet the policy demands of the day, including considerations for supporting equitable outcomes, supporting a clean energy workforce, and supporting achievable and cost-effective regulatory designs. Networked geothermal systems have enormous GHG reduction potential due to high efficiency, existing technological availability, and electric demand reductions that can align with grid reliability. The bill also supports MDE's environmental justice goals by including prioritization of investments in underserved or overburdened communities.

The Maryland Energy Administration will be offering several amendments, which MDE also supports. These amendments include capping the total behind-the-meter costs at $3 million, removing mention of $12 million in federal funding to reserve, requiring the PSC to choose a pilot where many of the homes have appliances at or near the end of their useful lives, inserting a provision to protect customers in the event a pilot program is discontinued, and adding the language "or any other state or federal funding source" to the provision around community-based organization funding.

For the reasons detailed above, MDE urges a **FAVORABLE WITH AMENDMENTS** report for SB 570.

Contact: Les Knapp, Government Relations Director
Cell: 410-453-2611 (cell), Email: les.knapp@maryland.gov

ABC_UNFAV_SB0570.pdf
Uploaded by: Martin Kraska
Position: UNF

Associated Builders and Contractors, Inc.
Maryland Joint Legislative Committee

The Voice of Merit Construction

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February 29, 2024

To: Senate Education, Energy, and Environment Committee

From: Associated Builders & Contractors

RE: SB 570 - Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)

Position: Unfavorable

Associated Builders and Contractors (ABC) represent more than 1500 construction and construction-related companies through its four Maryland chapters. Our members believe in the tenets of free enterprise, investing in their workforce and giving back to the communities in which they live, work and play.

Senate Bill 570 would require each gas company to develop a plan for a pilot thermal energy network system or systems on or before October 1, 2024; requiring each gas company to submit a certain proposal or proposals to the Public Service Commission for approval on or before July 1, 2025; authorizing a municipal corporation, county, or community organization to submit neighborhoods to gas companies for consideration as part of a pilot system.

ABC opposes SB 570, our primary concern with the legislation is around the provisions that would require community benefit agreements (CBA). CBA's impose substantial financial burdens on contractors, particularly smaller and minority-owned businesses, by mandating higher wages and strict compliance measures. These additional costs make projects less economically viable and, in many cases, prohibitively expensive, ultimately deterring investment in communities. While we understand the intentions behind community benefit agreements to promote community development and inclusion, we believe that the current framework outlined in the proposed legislation poses significant challenges and drawbacks for contractors, subcontractors, and ultimately, the communities they serve.

ABC appreciates your consideration and, for these reasons, respectfully requests a **unfavorable** report on Senate Bill 570.

Martin "MJ" Kraska
Government Affairs Director
Chesapeake Shores Chapter

MD 2024 SB 570 Columbia Gas Testimony Final.pdf

Uploaded by: Carville Collins

Position: INFO

Columbia Gas of Maryland

A NiSource Company

INFORMATIONAL – Senate Bill 570
Authorizing and Establishing Gas Company Pilot Thermal Energy Network Systems
Senate Education, Energy and the Environment Committee

Columbia Gas of Maryland, Inc. (Columbia) appreciates the introduction of SB 570, legislation requiring natural gas utilities to develop and submit a proposal to the Maryland Public Service Commission to establish a thermal energy network system pilot program in their service territory. Columbia understands up to 13 states may be currently in the planning, regulatory or construction stages of creating thermal energy network systems.

Columbia supports public policies promoting an environment of innovation, research, development and deployment needed for greenhouse gas emissions reductions in Maryland that maintain customer affordability and system reliability. The idea of creating pilot thermal energy network systems or "geothermal pilot programs" should be examined further. Columbia believes the most important factor in pursuing this idea is the cost impact to natural gas utility ratepayers. Through our initial research on this idea, we have found the utility companies pursuing geothermal pilot programs have very large customer bases over which to spread the cost of these systems.

Columbia has undertaken preliminary cost estimates for a geothermal pilot program in its service territory and is concerned with the associated cost and financial impact to its customers. Columbia serves approximately 34,000 customers in the western Maryland counties of Garrett, Allegany and Washington. Initial costs estimates are $300,000 to $500,000 for feasibility studies and at least $10 to $15 million to create a modest geothermal pilot program in western Maryland. Such a program paid for by a small customer base like ours would result in our customers incurring a significant per customer cost.

Columbia has spoken with the bill sponsor in the House of Delegates and suggested an amendment that would allow smaller gas utility companies – defined as a company with less than 75,000 customers – to have the option of developing a thermal energy network system pilot program if it determined such a program could be created affordably for its customers. The House bill sponsor has agreed to accept the proposed amendment.

Columbia supports an identical amendment to SB 570 that would make participation in thermal energy network systems optional, rather than mandatory, for smaller gas utility companies in Maryland:

AMENDMENT TO SENATE BILL 570
(First Reading File Bill)

On page 15, after line 3, insert:

7-1007.

(A) THE REQUIREMENTS OF THIS SUBTITLE APPLY TO A GAS COMPANY WITH LESS THAN 75,000 CUSTOMERS ONLY IF THE GAS COMPANY FILES A PROPOSAL FOR ONE OR MORE PILOT SYSTEMS WITH THE COMMISSION.

(B) A GAS COMPANY WITH LESS THAN 75,000 CUSTOMERS ELECTING TO FILE SUCH A PROPOSAL SHALL PROVIDE AT LEAST 60 DAYS WRITTEN NOTICE TO THE COMMISSION OF ITS INTENT TO FILE A PROPOSAL.

With this amendment or an equivalent provision making participation optional for small gas companies, Columbia is neutral on SB 570. Adding cost-effective reasonably priced thermal energy network systems to Maryland's energy mix creating an even larger "all of the above approach" to reduce greenhouse gas emissions to meet Maryland's ambitious climate goals is an idea worth examining.

February 29, 2024

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SB570_LOI_ Public Utilities - Thermal Energy Netwo
Uploaded by: Kevin O'Keeffe
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February 29, 2024

To: Members of Senate Education, Energy, and the Environment Committee

From: Independent Electrical Contractors (IEC) Chesapeake

Re: Letter of Information for Senate Bill (HB) 570 – Public Utilities - Thermal Energy Network Systems - Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)

Independent Electrical Contractors (IEC) Chesapeake represents more than 200 electrical and low voltage businesses who employ approximately 15, 000 workers in the mid-Atlantic region. In addition, IEC Chesapeake has approximately 1,000 electrical apprentices.

IEC Chesapeake would like to provide the Committees with informational comments opposing the required use of Community Benefit Agreements in SB 570. The required use of Community Benefit Agreements has the potential to create a disadvantage for merit shop contractors in Maryland. More than eighty percent (80%) of construction in Maryland is performed by non-union contractors. It is unwise public policy to put merit shop contractors at a competitive disadvantage on construction projects in Maryland. Most certified MBE contractors are non-union.

In addition, the mandated requirement of Community Benefit Agreements may significantly drive up the costs of projects at time when the state is facing significant budgetary challenges. We respectfully ask that the Committees eliminate the requirements for the use of Community Benefit Agreements.

Thank you for your consideration. If you have any questions, please contact Grant Shmelzer, Executive Director of IEC Chesapeake, at 1-301-621-9545, extension 114 or at gshmelzer@iec-chesapeake.com or Kevin O'Keeffe at 410-382-7844 or at kevin@kokeeffelaw.com.

About Us

Independent Electrical Contractors (IEC) Chesapeake represents members throughout Delaware, Maryland, Virginia, West Virginia, and Washington, D.C. Our headquarters are located in Laurel, Maryland. IEC Chesapeake has an extensive apprenticeship program for training electricians. In addition, IEC Chesapeake promotes green economic growth by providing education and working with contractor members, industry partners, government policy makers and inspectors to increase the use of renewable energy.

Washington Gas SB570_WARMTH Act_Neutral_.pdf
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Position: INFO

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COMMITTEE: EDUCATION, ENERGY, AND THE ENVIRONMENT

TESTIMONY ON: SB 570 PUBLIC UTILITIES – THERMAL ENERGY NETWORK SYSTEMS – AUTHORIZATION AND ESTABLISHMENT (WORKING FOR ACCESSIBLE RENEWABLE MARYLAND THERMAL HEAT (WARMTH) ACT)

POSITION: NEUTRAL

HEARING DATE: FEBRUARY 29, 2024

Washington Gas respectfully submits this neutral testimony on **Senate Bill 570 – Public Utilities – Thermal Energy Network Systems – Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)**

Washington Gas ("the Company") provides safe, reliable natural gas service to more than 1.2 million customers in Maryland, Virginia, and the District of Columbia. Washington Gas has been providing energy to residential, commercial, government, and industrial customers for more than 175 years, and currently serves more than 500,000 Maryland customers in Montgomery, Prince George's, Charles, St. Mary's, Frederick, and Calvert Counties. Gas employs over 400 people within Maryland, including contractors, plumbers, union workers, and other skilled tradespeople. We strive to improve the quality of life in our communities by maintaining a diverse workforce, working with suppliers that represent and reflect the communities we serve, and giving back through our charitable contributions and employee volunteer activities.

Background

The Company appreciates the opportunity to inform legislation concerning the development of Thermal Energy Network Systems ("TENS") pilots in Maryland through the Working for Accessible Renewable Maryland Thermal Heat Act ("SB 570"). TENS involve harnessing the low-grade geothermal resource indirectly - in combination with a heat pump - to provide heating and cooling to a building. Temperatures at about 30 feet below the surface remain relatively constant year-round—between about 50°F (10°C) and 59°F (15°C). For most areas in the United States, this means soil temperatures are usually warmer than the air in winter and cooler than the air in summer.[1] Ground-source heat pumps ("GSHP") are a type of heat pump that use this constant ground temperature of the earth as the heat exchange medium, instead of the outside air temperature.[2] According to the EPA, geothermal heat pumps can reduce energy consumption --

[1] Department of Energy – Geothermal Technologies Office. Geothermal Heat Pumps
[2] Department of Energy. Geothermal Heat Pumps

and corresponding emissions -- up to 44% compared with air-source heat pumps ("ASHPs") and up to 72% compared with electric resistance heating with standard air-conditioning equipment.[3] TENS entail multiple GSHPs sharing a common system of interconnected looped pipes carrying constant temperature water to and from the premise, and geothermal boreholes deployed at a street segment scale. The idea is that these can be interconnected with additional underground pipe systems and scaled over time to serve entire neighborhoods, municipalities, or territories – much akin to how today's utility networks operate.[4]

Legislation and regulatory proceedings similar to SB 570 encouraging gas utilities to implement TENS pilots have been passed in several states; Massachusetts gas utilities are leading in the development of these pilots. Both Eversource and National Grid have begun construction on TENS and expect to have a pilot program up and running by the fall of 2024.[5] [6] Other states, including Minnesota[7] and New York[8], have passed legislation promoting networked geothermal and utilities in those states have pilot proposals under review for approval with their respective Commissions.

Interest in using thermal energy to heat and cool homes is growing because of the substantial limitations and drawbacks arising from all-electric households and appliances, especially related to the overall impacts on the electric grid required to support electrification. US DOE's Oak Ridge National Lab recently stated the impact of widespread GHP deployment include:[9]

1. Net reduction in annual electricity consumption and greenhouse gas (GHG) emissions
2. Reduced need for annual power generation
3. Reduced need for power generation capacity and storage capacity
4. Alleviating transmission build-out requirements
5. Reduced summer and winter resource adequacy requirement

Washington Gas is an innovative company and is supportive of leveraging its unique talent and expertise to provide alternative energy sources and believes the deployment of this technology has the potential to offer several benefits to its Maryland customers. Washington Gas would be among the first gas-only utilities to deploy TENS with its customer base. However, the Company has concerns with specific provisions in SB 570 and has offered several amendments, included at the end of this document. The Company is taking a neutral stance on SB 570 and is optimistic that a fair and equitable TENS pilot program can be developed in Maryland.

Avoided Costs

Unlike ASHPs, TENS do not burden an increasingly constrained electric grid and help to avoid the high costs otherwise needed to upgrade the State's electricity generation, transmission, and

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[3] Department of Energy – Benefits of Geothermal Heat Pump Systems
[4] Home Energy Efficiency Team (HEET). Networked Geothermal: System Components & Benefits (2023).
[5] Eversource. Geothermal Pilot Project in Framingham (Jan. 2024).
[6] National Grid. Networked Geothermal Program (Nov. 2023).
[7] Minesota. Natural Gas Innovation Act (2021).
[8] New York. Senate Bill S9422 (2022).
[9] Department of Energy – Oak Ridge National Lab Grid Cost and Total Emissions Reductions Through Mass Deployment of Geothermal Heat Pumps for Building Heating and Cooling Electrification in the United States (November 2023)

distribution system to serve new electric heating loads. In particular, the State's electric grid is projected to switch to become "winter-peaking" (instead of summer-peaking) in the case of high ASHP adoption.[10] A winter system peak is driven largely by the use of electric heating during the coldest hours of the year, often when renewable energy is not outputting to the grid. TENS can alleviate stress on the grid during this new peak, lowering the amount of electricity generation, transmission, and distribution capacity needed to accommodate the winter peak. SB 570 does not explain which mechanisms the State may use to fairly compensate gas customers or incentivize the use of such systems in the interest of avoiding these significant grid upgrade costs, nor does it specify whether gas customers will be compensated at all. For reference, in November 2023, Con Edison in New York proposed to its regulators that network costs for its thermal energy network pilots should be recovered from both its electric and gas customer classes, in order to minimize overall rate impacts and avoid cross-subsidization, due to anticipated reductions in electricity usage and overall electric infrastructure needed to serve the avoided incremental load.[11]

Customer Choice

If SB 570 is passed, the Company is open to partnering with customers that are interested in participating in an initial TENS pilot. However, the legislation does not examine what may happen to customers that choose to opt-out of a TENS pilot. Customer choice must be paramount when piloting relatively unproven technologies. Some customers may not wish to participate in a pilot and may prefer to continue using natural gas. The Company's customer base continues to grow in Maryland, and Marylanders continue to express interest in new natural gas connections. There is a natural hesitancy for customers to bring new energy sources and appliances into their homes and SB 570 offers no guarantee that they will be provided the same comfort and reliability as their prior configurations, or whether they will be able to revert to their original appliances if the pilot is unsuccessful. In Massachusetts, Eversource Energy's TENS pilot program, which is the furthest along of any such pilot in the country, had a customer participation rate of ~80% and guaranteed that participants can continue using natural gas for their stoves, water heaters, and clothes dryers for the pilot's duration and may return to their original equipment and gas service afterwards.[12] Using networked ground-source thermal energy to heat and cool homes is a nascent technology and customers that may be unsure about the pilot should be assured that they will not be forced to convert their appliances if they do not want to; this will encourage participation and help to facilitate buy-in from local communities.

Requirements for TENS Pilot Proposals

The Company has not done a full evaluation of the requirements laid out in SB 570, but it is clear that the 80% LMI threshold and requirement for a pilot system to be at the "end of the gas system"

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[10] Maryland Public Service Commission. PSC Electrification Study Scenario Shows Moderate Growth in Electricity Demand, Significant Gas Demand Reduction (Dec. 29, 2023).

[11] Con Edison. Case 22-M-0429, Proceeding to Implement the Utility Thermal Energy Network and Jobs Act. STAGE 1 FILING – FINAL UTEN PROJECT PROPOSALS (November 30, 2023). *"As proposed in the January UTEN Proposal, the Company proposes to recover costs from electric customers through the Monthly Adjustment Clause for Company customers and through a surcharge for New York Power Authority customers…The rate impact for the pilots and UTENs will, in the longer term, be lower when recovered across the larger electric rate base than the gas rate base and paired with the offsetting impact of increased electricity usage."*

[12] Eversource. Geothermal Pilot Reference Guide

within the legislation will meaningfully restrict the segments of the gas network for which the initial pilots may be proposed. While LMI customers can benefit from a TENS pilot, the Company is concerned about energy affordability and the long-term financial sustainability of these systems. Proponents point out that GSHPs have no variable fuel costs but, as seen in Massachusetts, pilot-scale TENS have high upfront costs, costing between $70,000-$100,000 per participating customer.[13] [14] In Massachusetts, much of this cost is shouldered by a mix of state and federal funding sources, as well as surcharges assessed on non-participating customers. This model is not sustainable if the costs of future systems do not fall with scale, potentially straining the State's budget and, by proxy, the State's taxpayers in the short-term, and burdening participating customers and the utility in the long-term. The LMI requirements in SB 570 would mean that, in the case of financial unsustainability, these costs would be placed on select neighborhoods with the highest energy burdens.

Additionally, the requirements would not maximize the effectiveness of the pilot. The purpose of a pilot is to explore the benefits and physical operations of a TENS, and in order to productively do that the pilot must be able to include a diverse customer base, including multiple building types and sizes (e.g., single-family homes, multi-family, commercial, mixed-use, etc.). Eversource's pilot is designed to serve a neighborhood with several different types of buildings, including residential homes, a community college, and the local fire department, for a total of five (5) commercial buildings and 32 residential buildings that previously received delivered fuels (heating oil or propane) or natural gas services.[15] Maryland should take a similar approach to fully understand what the potential benefits and drawbacks are of a TENS pilot. This approach is consistent with the bill's goal to facilitate the proposal of TENS pilots in communities that express interest in participating, including those that do not meet the unnecessarily stringent and contradictory LMI requirements.[16] It is important for emerging technologies, such as TENS, to be accessible and applicable for a broad range of customers. While the economics and operational feasibility of TENS remains unproven and require real-life evaluation in Maryland, the State should refrain from preemptively limiting the scope of customer participation during this evaluation period.

<u>Cost Recovery</u>

A TENS pilot by a gas-only utility is unprecedented in Maryland, and while the concept is promising, it needs to be squared with existing and proven utility regulatory processes and financial structures. SB 570 does not consider what may happen to both the utility and its participating customers if the pilot system is not made permanent. Cost recovery for the utility and

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[13] National Grid. Geothermal District Energy Demonstration Program (Dec. 15, 2021). The Massachusetts DPU approved a budget not to exceed $15.6 million. The National Grid pilot intends to serve 150-200 customers, and therefore has a cost to customer ratio of $78,000 - $104,000.
[14] Eversource Energy. General Increase in Base Distribution Rates for Gas Service and a Performance Based Ratemaking Mechanism (Oct. 30, 2020) The Massachusetts DPU approved Eversource's proposed geothermal demonstration project scenario 2 with a budget of $10,261,606 and a customer count of 140, making the cost to customer ratio $73,297.19.
[15] Eversource. Geothermal Pilot Reference Guide
[16] On page 8 of SB 570 it states, "A municipal corporation, county, or community organization may submit neighborhoods to gas companies for consideration as part of a pilot system."

protections for the customers must be guaranteed to ensure no parties are burdened by the undeniably high costs associated with testing this concept on behalf of the State.

Jobs and Workforce Alignment

TENS require drilling boreholes and laying pipe in the rights-of-way and operating a shared utility network. These are all skills and competencies held by today's gas utilities and their workforces, who will be critical to enabling clean energy in Maryland. The Company's expertise in these areas should be leveraged to evaluate and implement TENS.

Decision Whether to Make Pilot Systems Permanent

SB 570 limits the parties whom the Public Service Commission must consult on whether a TENS should be made permanent at the end of the pilot period to the Maryland Energy Administration ("MEA") and Maryland Office of People's Counsel ("OPC"). The gas utility operating the TENS pilot and the participating customers will also have important perspectives on the benefits and drawbacks of the TENS concept and must be involved in the process of determining if a pilot is made permanent. This should be codified in SB 570.

Conclusion

At Washington Gas, our core values are safety, collaboration, integrity, inclusion, and learning. The Company is committed to working with stakeholders to help achieve Maryland's GHG emission reduction targets. There is a role for existing and future technology innovation to support diverse pathways to decarbonizing Maryland. and the State can leverage existing infrastructure to preserve affordability, reliability, safety, and security of service. The Company is advocating for TENS pilots to be explored in a responsible way to benefit the State's energy customers and ecosystem.

Washington Gas agrees that networked geothermal energy systems could ultimately be both beneficial and promising for customers, although questions and challenges remain. We look forward to working with the Committee if the legislation moves forward. Washington Gas respectfully requests the attached amendments be considered and included in SB 570. Thank you for your consideration of this information.

Contact:
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ADDENDUM: PROPOSED AMENDMENTS

Amendment 1 – Definition of public interest

Context:

TENS pilots should be explored for those areas where they can provide the greatest net benefit to the public. Approving projects that do not meet this threshold would not be in the best interest of Maryland's ratepayers.

WGL Position:

"Public interest", in the context of 7-1002 (C)(2): "if the Commission determines that a proposal is in the public interest, the Commission shall approve the proposal", should be defined to mean that the projected benefits of the pilot will outweigh the projected costs, calculated by using the same test that the Commission must use to determine the projected costs and benefits of the projects proposed for inclusion.

Proposed Amendment:

WGL proposes the following section be amended as shown by red text:

> Insert a new definition 7-1001(K) that states: A pilot system is in the "public interest" if the net benefits are greater than the net costs using the cost test described under 7-1002 (C)(3)(I).
> Note: the existing 7-1001 (K) will become 7-1001 (L)

Amendment 2 – Allowing "pilot system" to include any area of Maryland

Context:

About 1 in 10 Maryland households use heating oil, propane, or kerosene for heating,[17] fuels which are commonly delivered via truck to homes that are not connected to the State's gas system. The absence of gas infrastructure should not disqualify customers from having access to TENS, nor should it disqualify utilities from developing TENS pilots in areas that are well suited to the technology.

WGL Position:

The current definition of "Pilot System" includes " ... to Replace Gas Infrastructure with a Thermal Energy Network System", implying that the only pilots that can be proposed are in areas currently served by natural gas. Gas companies should be able to offer pilot systems in other areas, such as those currently served by electric resistance heating, fuel oil and propane, allowing for greater GHG reductions and potential cost reductions to end-users.

Proposed Amendment:

WGL proposes the following section be amended as shown:

> 7-1001 (I) should read: "Pilot System" means a pilot thermal energy network system developed by a gas company ~~to replace gas infrastructure with a thermal energy network system~~.

[17] EIA. Maryland State Energy Profile. December 21, 2023

Amendment 3 – Key dates for pilot program

Context:

TENS are a relatively new technology that are currently not offered by the State's electric, gas, or water utilities. The State's utilities should be given sufficient time to properly assess, design, and develop TENS pilots, including engaging external consultants, to ensure pilots best serve the public interest.

WGL Position:

Key pilot program dates should be delayed in order to provide sufficient time for utility planning.

Proposed Amendment:

WGL proposes the following section be amended as shown by red text:

7-1002 (A)(1) should read: On or before July 1, 2025 ~~October 1, 2024~~, each gas company shall:

7-1002 (B)(1) should read: On or before March 31, 2026 ~~July 1, 2025~~, each gas company…

7-1002 (C)(1) should read: On or before September 1, 2026 ~~December 31, 2025~~, the Commission may approve, approve with modifications, or reject a proposal.

7-1002 (F)(3) should read: Funding under this Subsection may be provided only before January 1, 2027 ~~October 1, 2025~~

Amendment 4 – Minimum number of low- and moderate-income (LMI) customers and related requirements for pilot system proposals

Context:

It is important for LMI households to be able to reap the benefits of novel energy technologies such as TENS. It is also important for novel energy technologies such as TENS to remain accessible and maximize benefits to all customers in Maryland.

WGL Position:

The requirement for all pilot proposals to serve at least 80% LMI customers should be removed and instead require that at least one (1) pilot proposal from each gas utility must serve at least 40% LMI customers. Gas utilities should not be required to propose any additional pilots, but any additional pilot proposals will not have an LMI requirement and gas utilities may propose any number of additional pilots. This would allow utilities to propose pilots for geographic areas and customers that considering other factors.

Proposed Amendment:

WGL proposes the following section be amended as shown by red text:

> 7-1002 (B)(1) should read: On or before March 31, 2026 ~~July 1, 2025~~, each gas company shall submit ~~either~~ at least one ~~or two~~ proposal ~~proposals~~ for a pilot system to the Commission for approval.
>
> 7-1002 (B)(2) should read: ~~A~~ At least one proposal for a pilot system from the gas companies shall ensure that at least 40 ~~80~~% of its customers are from low- or moderate-income housing.

Amendment 5 – Customer solution retaining gas service

Context:

Eversource Energy (MA) has stated that customers participating in their networked geothermal pilot program, which is the furthest along of any networked geothermal pilot in the country, are able to continue using natural gas for stoves, water heaters, and clothes dryers.[18]

WGL Position:

Customers who opt out before a pilot system is built should be able to choose to keep their existing gas appliances. This would make the pilot program less risky for natural gas utilities and their customers and grant more freedom to the participating neighborhood by ensuring gas can still be delivered to the buildings for gas-powered appliances if customers choose.

Proposed Amendment:

WGL proposes the following section be amended as shown by red text:

> Insert a new section 7-1002 (B)(3)(I) that states: Customers that choose to opt out of a pilot system before the proposal for the pilot system is submitted may choose to retain any and all existing natural gas appliances, at their choice.

Amendment 6 – Focus pilots on appropriate areas of gas system

Context:

Defining what qualifies as the "end of the gas system" is nuanced, and keeping this requirement may unduly limit the areas of their networks for which gas utilities can propose cost-effective and beneficial projects.

WGL Position:

The requirement for the proposal to address neighborhoods at the end point of the gas system should be removed. Removing this language allows for other types of customers to be considered for a TENS pilot, including commercial buildings.

Proposed Amendment:

WGL proposes the following section be removed:

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[18] Eversource. Geothermal Pilot Reference Guide "We don't intend to touch any hot water systems, gas stoves or gas dryers."

Remove 7-1002 (B)(6)(IX): Neighborhoods at the end point of a gas system where a full transition from gas systems to electrification could be facilitated within the pilot period or within 5 years after the pilot period concludes;

Note: All subsequent numerals in 7-1002 (B)(6) should be renumbered.

Amendment 7 – Commission approval of pilot systems

Context:

Utilities have to know they will receive direction from the Commission in the form of rejection or approval with or without modifications by a certain date.

WGL Position:

It should be clarified that the Commission must issue a decision with regards to pilot proposals. This will ensure that gas utilities get a decision from the Commission on their proposed pilots by December 1, 2025.

Proposed Amendment:

WGL proposes the following section be amended as shown by red text:

7-1002 (C)(1) should read: On or before September 1, 2026 ~~December 31, 2025~~, the Commission must ~~may~~ approve, approve with modifications, or reject a proposal.

Amendment 8 – Decision to make pilot systems permanent

Context:

As currently constructed, the bill limits those who should advise the Commission on whether a pilot system should be made permanent at the end of the pilot period to the Maryland Energy Administration ("MEA") and Maryland Office of People's Counsel ("OPC"). . This arrangement should be expanded to explicitly require inputs from the utilities who will own and operate the TENS pilots and the participating customers that take service under these pilots.

WGL Position:

The gas utility that owns a TENS pilot and customer that owns the connected heat pump should be involved in determining whether a pilot system should be made permanent. The current arrangement ignores the expertise that gas utilities will gain operating and maintaining TENS, which should factor into decisions concerning the long-term viability of specific projects. Similarly, participating customers who will be reliant on the systems for heating and cooling should they be made permanent must be given the opportunity to comment on whether the technology is acceptable for meeting their future energy needs.

Proposed Amendment:

WGL proposes the following section be amended as shown by red text:

7-1002 (D)(2)(I) should read: Once the 2-year period under paragraph (1) of this subsection has passed, the Commission, in consultation with the Administration, ~~and~~ the Office of People's Counsel, the electric company, gas company, or water company that owns and manages the pilot system, and the participating customers, shall determine whether to make the pilot system permanent. This decision should include utility monitoring metrics on efficiency, cost and robust customer satisfaction determinants over the course of at least three heating and cooling seasons to determine levels of success and next steps. Recovery for these activities will be included in the recovery mechanism.

Amendment 9 – Cost recovery for non-permanent systems

Context:

A prudent plan for a pilot system includes a description of the procedure that must be followed if a pilot project is not made permanent. The utilities and their customers must be protected in this scenario.

WGL Position:

The bill should contain language stating that the gas utility will be able to recover all costs associated with decommissioning the pilot system in an accelerated fashion if it is determined that the pilot system will not be made permanent. This would allow gas utilities to recover all costs associated with a TENS pilot if a given pilot system is not made permanent. For example, costs related to system decommissioning.

Proposed Amendment:

WGL proposes the following section be amended as shown by red text:

Insert a new section 7-1002 (D)(2)(III) that states: If a pilot system is not made permanent, as described under subparagraph (I) of this paragraph, the Commission shall approve recovery of all costs necessary for a gas company to comply with this decision

Amendment 10 – Customer access to program funding

Context:

The bill draws on EmPOWER and other funding sources to finance home electrification and energy efficiency upgrades. Financing like-for-like gas appliance replacements or upgrades and weatherization upgrades will allow an ‘apples-to-apples’ analysis of energy savings and costs with modern equipment.

WGL Position:

Weatherization and appliance replacement funding should be able to be given to customers who choose to opt out of a TENS pilot. It should also finance like-for-like gas appliance replacements or upgrades and weatherization upgrades that can deliver energy efficiency and emissions savings to customers who choose to opt out of pilot projects.

Proposed Amendment:

WGL proposes the following section be amended as shown by red text:

Insert a new section 7-1003 (A)(2) that states: The Administration shall ensure that customers in a given neighborhood that opt out of a pilot system and choose to retain their gas service have access to funding sources and energy savings measures described in 7-1003 (A)(1).

Note: The existing 7-1003 (A)(2) will become 7-1003 (A)(3), and the existing 7-1003 (A)(4) will become 7-1003 (A)(5).

Amendment 11 – Cost recovery for proposal development

Context:

Allowing utilities to recover necessary costs associated with proposal development will incentivize them to propose new pilot systems.

WGL Position:

The requirement that the costs incurred from developing a proposal must be "reasonable and in the public interest" as determined by the Commission should be removed and instead account for the expected costs as described in this bill. The requirement for carrying costs to be appropriate as determined by the Commission should be removed. This more fully aligns the gas utility with its costs.

Proposed Amendment:

WGL proposes the following section be amended as shown by red text:

7-1002 (G)(3) should read "the Commission shall approve a request under paragraph (1) of this subsection on finding that the proposed plan and costs are necessary to meet and respond to the requirements outlined in this section. ~~are reasonable and in the public interest~~."

7-1002 (G)(4) should read "At a gas company's next rate case proceeding following the approval of a request under this subsection, the Commission shall authorize recovery of prudently incurred costs associated with developing the proposal and any carrying costs ~~that the Commission determines are appropriate~~."

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Uploaded by: Patricia Westervelt
Position: INFO

February 29, 2024

The Honorable Brian J. Feldman
Chair, Senate Education, Energy, and the Environment Committee
2 West, Miller Senate Office Building
Annapolis MD 21401

Re: ***Letter of Information – Senate Bill 570 – Thermal Energy Network Systems - Authorization and Establishment (Working for Accessible Renewable Maryland Thermal Heat (WARMTH) Act)***

Dear Chair Feldman and Committee Members:

The Maryland Department of Transportation (MDOT) offers the following information on Senate Bill 570 for the Committee's consideration.

Senate Bill 570 requires that to the extent practicable and authorized by the U.S. Constitution, an approved pilot system applicant and the Maryland Environmental Service (MES) must comply with the State's Minority Business Enterprise (MBE) Program.

Senate Bill 570 requires within six months after the approval of a pilot system, the Governor's Office of Small, Minority, and Women Business Affairs (GOSBA), in consultation with the Office of the Attorney General (OAG) and the gas company operating the approved pilot system, must establish a clear plan for setting reasonable and appropriate MBE participation goals. Requirements of the State's Certified Local Farm and Fish Program must also be considered in the goalsetting and establishment of procedures for the pilot program.

To evaluate compliance with relevant federal law and constitutional requirements regarding race-conscious contracting programs, MES and MDOT must initiate an analysis of the thermal energy industry to determine whether statistically significant disparities exist in the availability versus utilization of women and minority owned firms, which is likely attributable to marketplace discrimination. Efforts to apply the MBE program to nascent industries or private actors operating in the State (e.g., gas companies), require a predicate study/analysis be conducted to determine the legal defensibility of such measures. For the Committee's awareness, MDOT is statutorily required to produce various disparity studies/analyses for other nascent industries prior to the 2026 legislative session.

The Maryland Department of Transportation respectfully requests the Committee consider this information during its deliberations of Senate Bill 570.

Respectfully submitted,

Pilar Helm
Director of Government Affairs
Maryland Department of Transportation
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