Catching Heat:

Using Waste Heat Generated from Data Centers:

Appalachian Responsible Development Opportunities, Challenges, and Policy Options

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ReImagine Appalachia

Executive Summary

Appalachia is seeing rising interest in AI data centers, particularly in rural areas. This has led communities where AI data centers are under consideration to raise several important questions such as (1) what impact will these centers have on the price paid for electricity and water; (2) how can development, particularly energy and water consumption, be managed responsibly; (3) how can workforce opportunities be structured to support stable, high-quality employment; (4) how can site selection balance redevelopment of existing industrial land with preservation of agricultural space; and (5) how can regional manufacturing and supply chains be integrated into project development.

This study focuses on yet another question: Can the region capture the abundant low-temperature waste heat produced by data centers and convert it into tangible community and economic benefits?

Just as a smartphone can overheat and slow down when running too many apps, data centers must carefully control temperature to keep equipment working and data safe. Most centers still rely on air cooling: cold air is blown over the servers, warm air is collected and then cooled again. Often, that cooling uses water-based systems like evaporative coolers or cooling towers, which can consume a lot of water. All of this creates a key question: where does the heat go, and how can we get rid of it without wasting too much energy or water?

This study discusses other approaches to managing and reusing waste heat, showing how the challenge of data center heat can become an opportunity with appropriate planning and new technology. The results can benefit both data centers, and the communities where they reside, if local infrastructure exists to capture, upgrade, and deliver it to nearby users. Options include:

- **Community uses**, which are most plausible within a few miles of a data center and typically require a district heating network or broader "thermal energy network" approach, such as to critical community buildings (police/fire stations) or useful assets (greenhouse for food insecure populations).

- **Industrial pathways**, such as co-locating data centers with compatible heat users (manufacturing, food processing, biotech, water/wastewater infrastructure) that enable continuous offtake and stronger economics.

AI data center waste heat recovery benefits include:

- **Environmental:** Capturing and reusing waste heat can cut greenhouse gas emissions and local air pollution by replacing fossil-fuel heating and reduce water use.

- **Economic:** Heat sales can create a new revenue stream, while efficiency gains can lower operating costs and reduce reliance on externally sourced cooling water.

- **Community:** Because data centers often create relatively few long-term local jobs, waste-heat reuse can deliver a more visible, lasting local benefit and help address concerns about grid impacts.

Economic risks center on high upfront capital, uncertain utilization and offtake contracts, and the fact that retrofits are materially more expensive than designing for heat reuse from the outset, increasing investor caution. Technical barriers include the need for anchor heat industrial offtakers or district-scale community infrastructure; the time to build that infrastructure relative to data center construction; thermal losses and costs over longer pipe runs; and low-grade heat that often requires heat-pump upgrading.

Policy options to support AI waste heat utilization that are appropriate for Appalachia's rural environments include: (1) Regulatory streamlining to reduce time and uncertainty for data center developers and operators; (2) Project development support to de-risk projects: (3) Fiscal incentives to improve economics.

In conclusion, AI data center waste-heat reuse is neither automatic nor universally applicable. AI data center waste-heat reuse requires intentional planning and will not be justified or practical in all situations. If Appalachian policymakers and AI data center developers and operators link data center approvals to community benefits, AI data centers may have the potential to shift from low-job, high-load facilities to anchors of cleaner, more resilient regional energy and economic systems.

Table of Contents

Overview

While Virginia has long been a home of data centers, the demand for Artificial Intelligence (AI) services has led to proposed AI data centers throughout Appalachia, particularly in rural areas. This region, defined by the Appalachian Regional Commission, includes 13 states and over 400 counties. ReImagine Appalachia focuses on four of those states in the Ohio River Valley, namely Kentucky, Ohio, Pennsylvania, and West Virginia, also known as coal country, where the economy has not worked for most people and places.

When AI data centers enter the region, it is important that economic, environmental and community leaders, and grassroots organizations, work together to find common ground towards the long-term goal of building a 21st century economy that's good for workers, communities, and the environment. Because energy use is a key component of this conversation, this ReImagine Appalachia report examines the opportunities and challenges of utilizing AI data center waste heat in Appalachia to reduce energy and water consumption and mitigate the impact on the communities that host these data centers.

The waste-heat question matters because heating for homes, businesses, and industry is both a major expense and a point of vulnerability, especially in colder parts of Appalachia where winter energy bills are high. Heat-intensive industries like metals and chemicals manufacturing face high fuel costs and are exposed to price spikes and supply disruptions. At the same time, economic development strategies that transform shuttered coal plants to modern manufacturing hubs, create new opportunities for co-locating industry with AI data centers that generate waste heat. ReImagine Appalachia believes it is important to explore how this waste heat could help lower costs, improve reliability, and support cleaner growth across the region.

Since data centers convert most of their electricity into low-temperature heat, treating that "leftover" heat as a usable local resource could turn a new digital facility into something that tangibly lowers energy burdens and improves resilience for nearby towns, rather than merely adding load to already-stressed grids.

At the same time, Appalachia has many communities navigating a post-industrial transition and constrained public infrastructure; waste-heat recovery might strengthen the local value proposition of data-center siting (more benefit per megawatt) while also sharpening accountability on, and mitigating or offsetting, the tradeoffs. These tradeoffs can include higher electricity rates, added electricity transmission needs, and water demands for cooling.

Policies to support this transition can occur not only at the federal, state, and local level, but the private sector as well. Most companies that commission data centers, like Google and Meta, have sustainability policies that incentivize them to reduce their carbon footprint. In addition, some regions with AI data centers are beginning to see an increase in consumer electricity prices, also creating an incentive for these companies to reduce their energy consumption to avoid facing public backlash.

Recovery of waste heat from AI data centers could be part of the response to these concerns. This report analyzes the technical, economic, and policy opportunities and challenges, as well as potential policy options that government, data center developers and operators, and communities could take, supported by real-world case studies and examples in Appalachia.

How AI Data Centers Generate and Manage Heat

Let's start with some technical fundamentals. AI data centers are big warehouses composed of servers – the electronic devices that process data and perform computations. (See Figure 1)

Figure 1

Google's New Albany data center campus in Central Ohio

Source: Google, Accessed December 2025

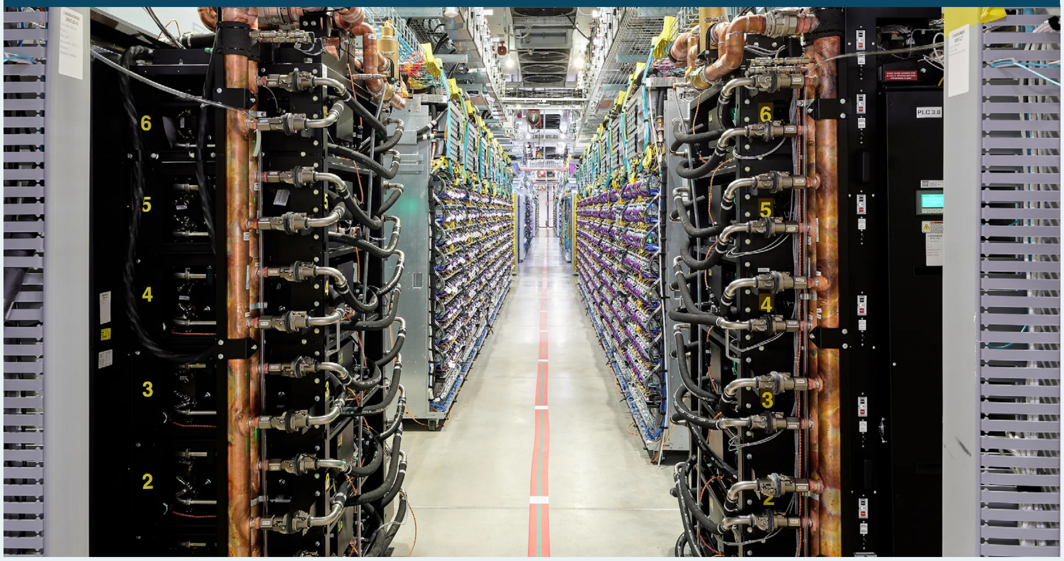
AI Data Center Heat Generation

The primary components within servers are computer processing (CPU) and graphics processing (GPU) units, which generate heat. Other significant sources of heat in data centers include power conversion from AC to DC and networking equipment, such as switches and routers, which facilitate data transfer..

Data centers typically have "hot" and "cold" aisles of servers – an idea that has been around since it was originated by IBM in 1992. In the cold aisles, the front of the servers face each other and draw in cold air to cool the electronic equipment within them. The back of the servers is where heat generated during computation is dissipated, forming hot aisles. (See Figure 2)

Figure 2

New Albany Ohio Google Data Center Coolant Distribution Units

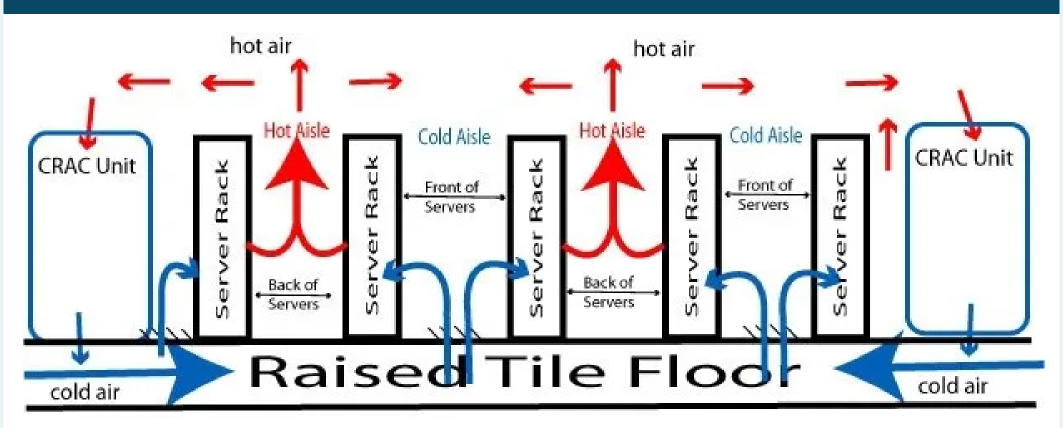


Source: [Google](), Accessed December 2025

Under both aisles is a raised tile floor with cold air generated by a computer room air-conditioning (CRAC) unit. (See Figure 3) Data centers must be able to reject 100% of their heat safely under all operating and fault conditions.

Figure 3

Side view of hot aisle/cold server aisle data center layout



Source: [U.S. Department of Energy](), Accessed December 2025

AI Data Center Waste Heat Management

Most AI data centers manage server heat by moving it to cooling equipment. This equipment includes Computer Room Air Conditioner (CRAC) and CRAH (Computer Room Air Handler) that pull hot air off the server. Today, AI data center waste heat is typically vented to the atmosphere, dispersed via water, or cooled using various technologies. You might think of it as the heat generated by the air conditioning unit outside your home, but at a far larger scale. For example, an AI data center might release thousands to hundreds of thousands of kilowatts of heat, depending on its size and technology, compared to about 10-20 kilowatts of heat for a home.

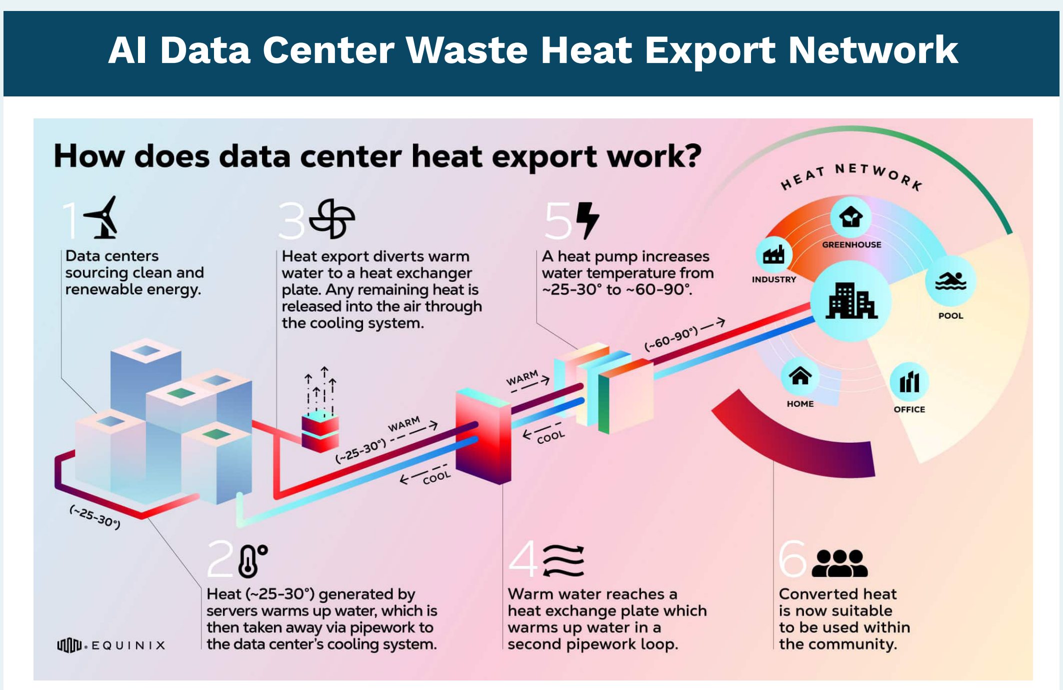
Some centers are now adopting higher-performance cooling approaches such as direct-to-chip liquid cooling, evaporative cooling, and immersion cooling, which can reduce reliance on traditional air conditioning. This newer technology can make waste heat easier to capture because the heat is carried in a fluid rather than dispersed into room air.

An analysis by the American Council for an Energy Efficient Economy found that typical data center waste heat temperatures are 77–95°F (25–35°C) for air-cooled systems, 122–140°F (50–60°C) for water-cooled systems, and up to 194°F (90°C) for two-phase refrigerant-cooled systems. The higher end temperature occurs during the summer months.

An alternative is to export the heat for other uses. (See Figure 4) Current waste heat recovery technology provides the ability to capture server heat into a water loop using heat exchangers, then use heat pumps to raise the temperature to levels useful for end users such as industrial, commercial, community, or home use.

Importantly, waste heat recovery does not eliminate the need for cooling equipment—the IT load still must be protected—but it adds heat-reuse hardware so that some of the heat the cooling system already collects is reused rather than wasted. In addition, building new AI data centers designed for waste heat recovery is less expensive than retrofitting old ones.

Figure 4



Source: Equinix, June 5, 2024

How Can AI Data Center Waste Be Used?

AI data center waste heat can be reused with nearby communities (within a few miles) or as part of an industrial park that includes AI data centers as well as other activities such as manufacturing, agriculture, and power generation.

Community Use

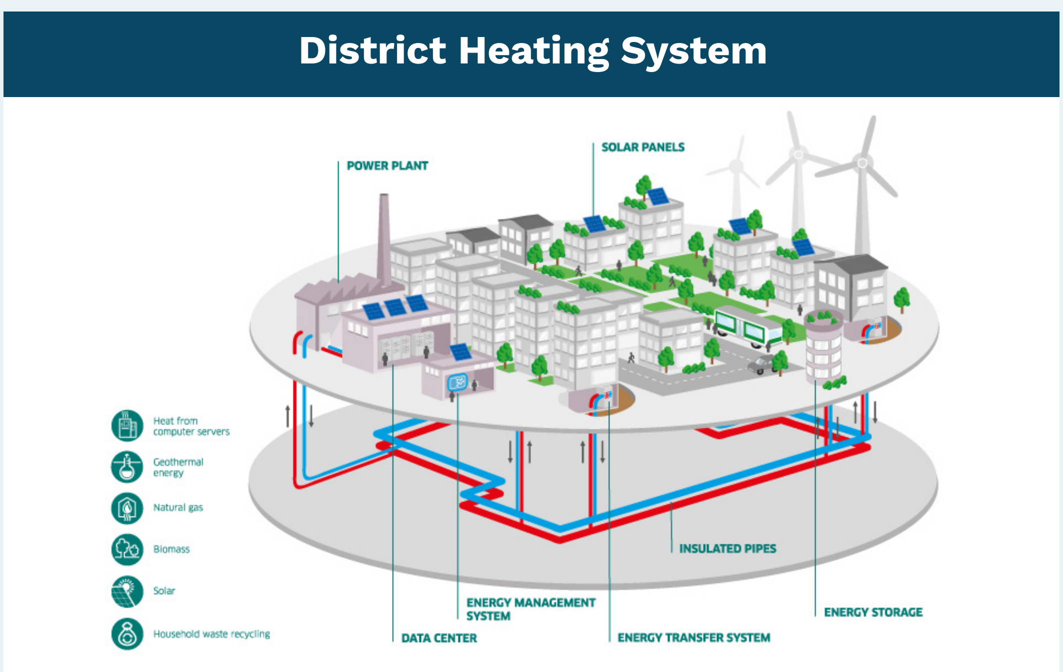
In some communities, data centers may primarily backstop reliability and support new digital jobs; in others, they can double as anchors for thermal networks, flexible electric loads, and local clean-energy investments that benefit schools, hospitals, and small businesses. The right mix of cooling technology, waste-heat reuse, and grid services will depend on local housing stock, industrial loads, climate, and utility constraints, so planning should start with each community's priorities and constraints rather than a one-size-fits-all data center template.

In the case of communities' use of the heat generated by data centers, this may occur through district heating networks or thermal energy networks (TEN). Heat can be distributed providing low-carbon heating to benefit communities by heating buildings, swimming pools, and greenhouses. Many rural communities in Appalachia, for example, have food insecurity challenges, particularly a lack of access to fresh food.

District Heating Networks

District heating networks (See Figure 5) are a system of insulated pipes, typically underground, not dissimilar to the heated baths used in the Roman Empire. District heating networks have evolved over the centuries, and today's systems are suitable for reusing data center waste heat.

Figure 5



Source: Engie, 2013

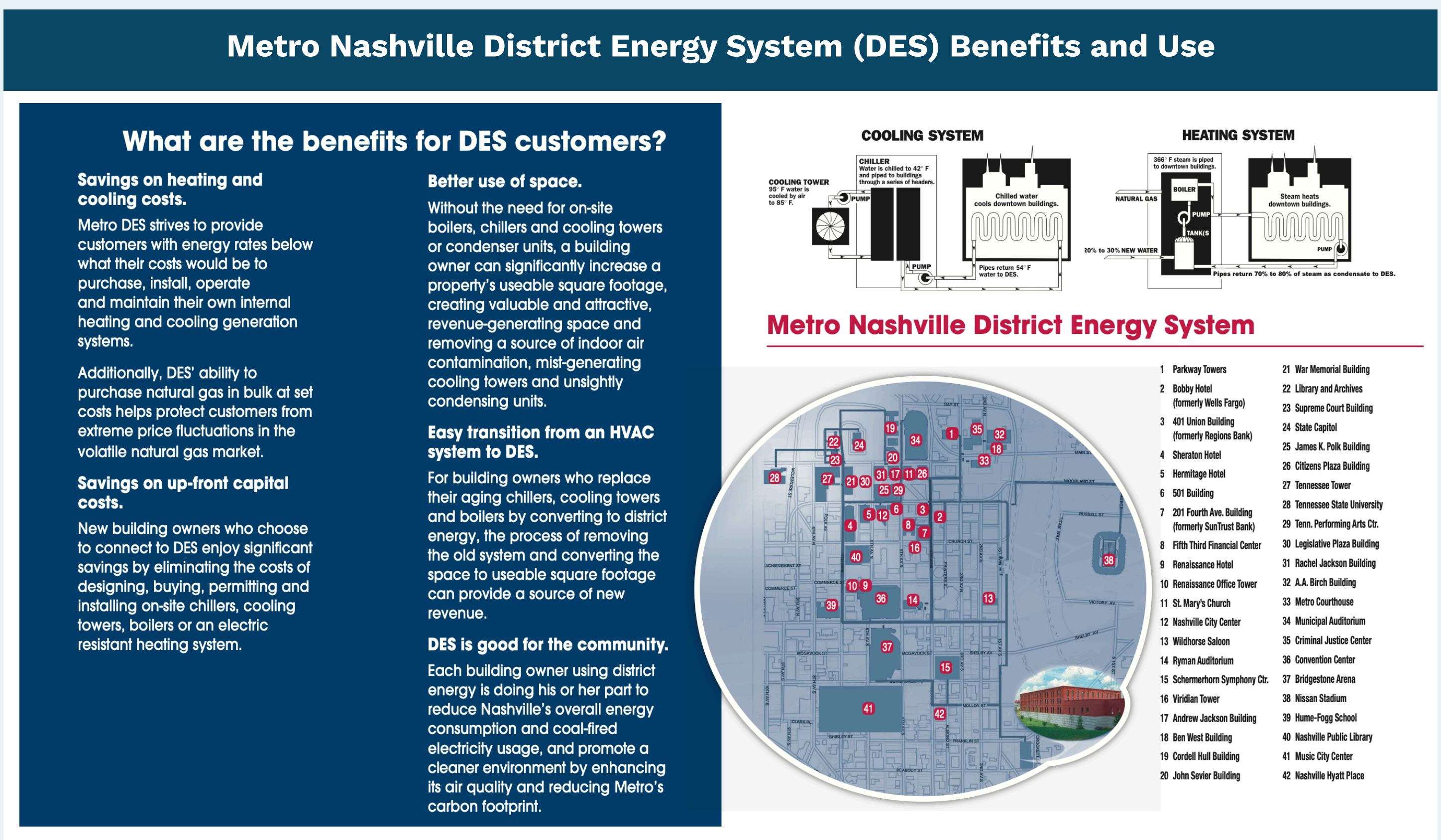
In the United States, district heating systems are typically found on university and hospital campuses, research centers, military bases, airports, industrial facilities, and central business districts. The idea of reusing heat is not new in Appalachia, either.

The Erie Steam Heat System, for example, was owned by Pennsylvania Electric Company (Penelec), located in Erie, Pennsylvania. Steam was generated at the Front Street Electric Generating Station, which burned coal to produce electricity and steam. The system distributed steam over 7 miles of underground mains, supplying heat to over 200 customers, including hospitals, homes, and businesses. The system played a significant role in meeting the community's heating needs, with commercial customers accounting for the majority of the load and revenue.

Many Appalachian colleges and universities also have such systems. The Appalachian State University Innovation District (Boone, NC) and the University of Kentucky Central Campus District Energy System (Lexington, KY) are both installing a TEN system to support campus needs.

For 50 years, Cordia's plant on Pittsburgh's Northshore has had a district steam/chilled water system supporting the Andy Warhol Museum, PNC Park, the Carnegie Science Center, and Allegheny General Hospital. The Metro Nashville District Energy System provides not only heating and cooling services to commercial buildings but also project planning for those who wish to connect to the system. (See Figure 6)

Figure 6



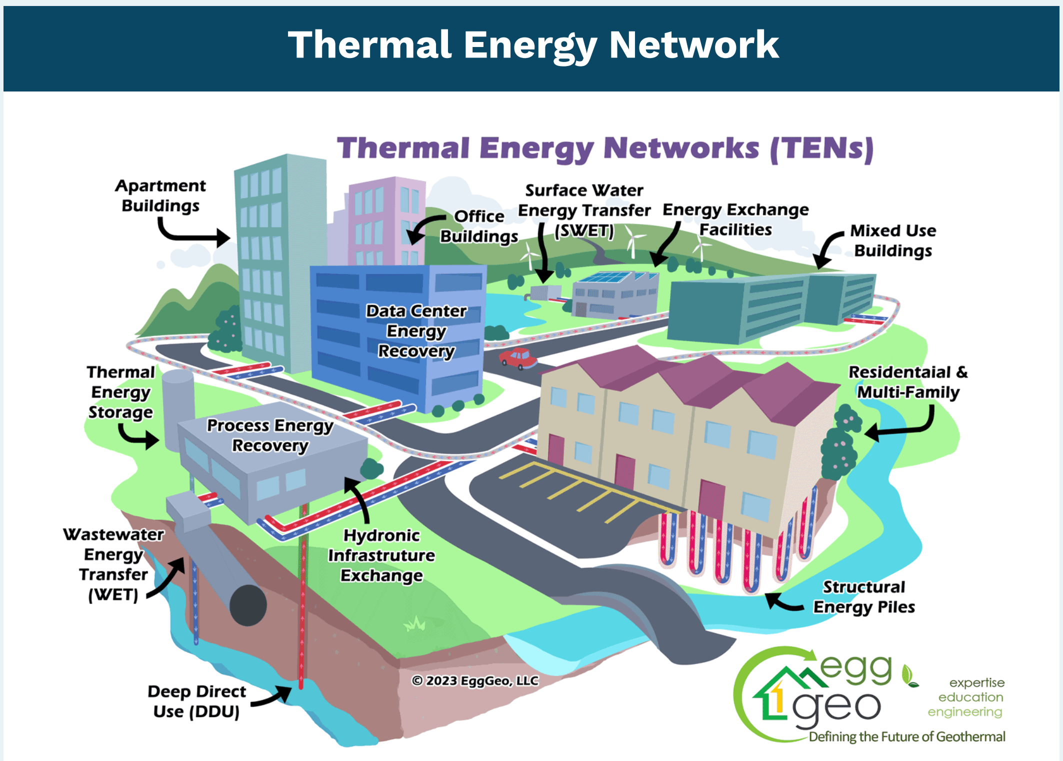
Source: Nashville District Energy, Accessed December 2025

Thermal Energy Networks (TEN)

Thermal energy networks (See Figure 7) is a newer, broader term: the pipes carry water at near-room temperature, and each building uses a heat pump to take heat from the network for heating or send heat back into it for cooling—so the system can move heat both ways, share it between buildings, and make low-temperature waste heat more useful. Thermal Energy Networks (TEN), located throughout Appalachia, share thermal energy, such as waste heat, via insulated or water pipes. Key principles are that they:

- Connect multiple buildings, sometimes with different owners.
- Supply and receive thermal energy from connected buildings
- Transfer renewable, passive, or waste heat from sources to sinks, rather than generating new heat or cooling.

Figure 7



Source: Egg Geo, Accessed December 2025

Model Community Application of AI Data Center Waste Heat Utilization

Throughout the United States, there are models of how AI data center waste heat reuse can support communities (See Table 1).

The most significant effort announced thus far is in San Jose, California, by Arcadis and Terra Ventures to build one of the most sustainable data centers in the world. Waste heat from the data center will be used to power absorption chillers, instead of traditional air-cooled chillers, to produce chilled water and heat an on-site greenhouse that will grow fresh produce for the local community.

Longer-term examples include heating a greenhouse at University of Notre Dame, buildings at Syracuse University, and a housing project in New York City. In addition, there are other waste heat uses at Amazon and the U.S. Department of Energy (DOE) National Renewable Energy Laboratory and Oakridge National Laboratory. These all provide valuable data for the application of this technology elsewhere in the United States. In particular, they show the benefit of commercial, industrial, and community proximity for AI data center waste heat reuse.

Table 1

Real-World U.S. Data Center Waste Heat Reuse Examples

Location	Data Center/Provider	Heat Users	Outcome/Scale
Chelsea, NY, USA	Con Edison & data center	NY Housing Authority (300+ apartments)	Low-carbon heating and cooling for public housing; construction begins 2025
Seattle, WA, USA	Westin Building Exchange, Amazon HQ	Amazon headquarters offices	5 million sq ft heated; project saves 80 million kWh over 25 years
Verona, WI, USA	Epic Systems Corp.	Corporate campus buildings	Year-round campus heating/cooling via thermal energy network (TEN); reduced costs and emissions
San Jose, CA, USA	Pacific Gas & Electric, Westbank	Up to 4,000 new apartments	Planned; will use heat from 3 new data centers for heating/cooling

Data Source: Building Decarbonization Coalition, "Can Data Centers Heat Our Buildings? Using Thermal Energy Networks to Reuse Data Center Waste Heat," July 2025.

Industry Use

An alternative to community use of waste heat is for nearby industrial facilities. Waste heat from AI data centers could support a range of industrial uses when compatible facilities are located nearby and could accept continuous low- to medium-temperature heat. Provided below are some possible industrial applications, Table 1 provides real-world examples, and Box 1 provides a case study.

Agricultural Sector

Waste heat could be utilized in the agriculture sector, offering a potential alternative in rural areas lacking district heating systems. Examples include warming greenhouses and vertical farming, growing algae, farming lobsters and eels, drying grains and wood, warming swine and broiler houses and dairy operations, and heating water for fish farming.

Chemical and materials manufacturing

Recovered heat could preheat feedwater or process streams before higher-temperature reactors or distillation units, improving efficiency in plants that use cascaded temperature levels. It could also supply compatible low- to medium-temperature industrial drying processes for wood, paper, or similar materials.

Food and beverage processing

Data center waste heat could preheat water for the processing of food and beverages, including cleaning, sterilization, and clean-in-place (CIP) systems, reducing gas or steam use by raising inlet water temperatures before boilers. It could also provide low-temperature heating for space and ventilation in large production halls, offsetting direct-fired or steam-coil heating.

Pharmaceuticals and biotechnology

Waste heat could preheat water for equipment washing and autoclaves, lowering boiler or electric-heater loads in the pharmaceutical and biotechnology industry. It could also support stable temperature control in HVAC and dehumidification systems for cleanrooms through hydronic heating coils supplied by data center heat pumps.

Power, Combined Heat and Power (CHP), and carbon-management systems

When coolant temperatures are sufficiently high, waste heat could be coupled with small Organic Rankine Cycle (ORC) systems to generate supplemental on-site electricity, typically feasible at return-water temperatures above about 80 °C (about 176 °F). It could also support sorbent regeneration or process preheating in certain carbon-capture systems, reducing additional fuel requirements for CO_2 removal.

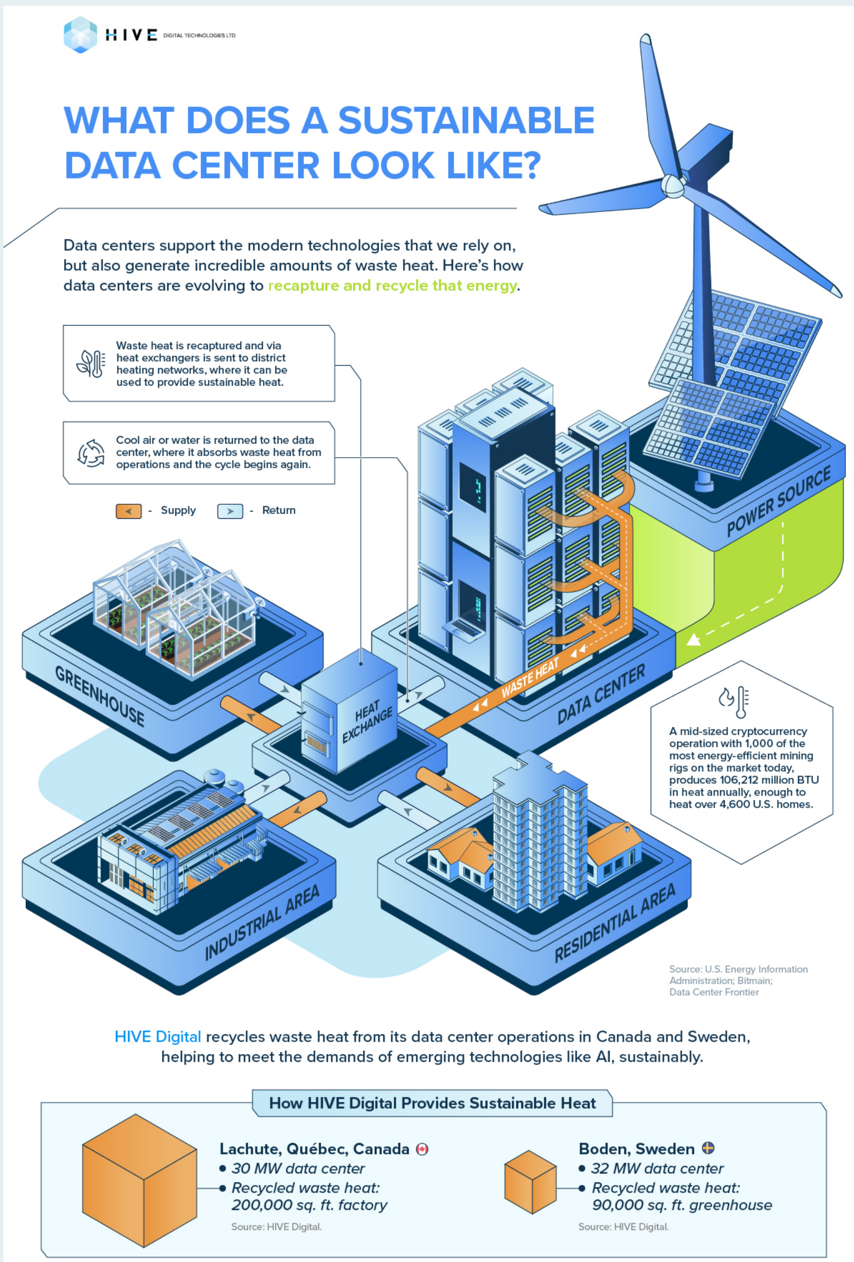
Water and environmental infrastructure

Waste heat from data centers can be reused to warm water entering wastewater treatment plants or sludge-digestion systems. This added warmth helps the helpful bacteria that clean the water work more effectively and reduces the need for extra energy to heat the process. The same heat can also support parts of water-treatment or desalination systems that work better with warm water, improving efficiency while lowering energy costs.

BOX 1

AI Data Center Waste Heat Industrial Use Case Study

Hive Digital Technologies, a Vancouver-based digital infrastructure firm, reuses waste heat from its data centers in Canada and Sweden by directing it to heat nearby facilities, such as factories and greenhouses. The company, which builds data centers for cryptocurrency mining and AI, powers its operations with green energy, primarily hydroelectricity (see figure below from Visual Capitalist).



Source: Visual Capitalist, 2024

Two of its operations illustrate how waste heat can be used.

- **Lachute, Quebec, Canada:** At its 30 MW data center, Hive captures heat from its servers and uses a heat-exchange system to warm a neighboring 200,000-square-foot swimming pool manufacturing factory. This helps the factory significantly reduce its energy consumption during colder months.
- **Boden, Sweden:** Hive's 32 MW data center provides heat for a nearby 90,000-square-foot greenhouse, enabling the sustainable local production of vegetables in a region close to the Arctic Circle.

By reusing waste heat, Hive reduces its energy footprint by increasing energy efficiency and minimizing the need for its neighbors to use traditional heating methods. Its waste heat partnerships demonstrate how data centers can be integrated into local communities to provide a direct, positive benefit.

Model Industry Application of AI Data Center Waste Heat Utilization

Several companies are utilizing or developing technologies to utilize AI data center waste heat in Appalachia. Examples include:

- **In Ohio**, SAIHEAT has established the SAI NODE Marietta facility to demonstrate how waste heat from liquid-cooled computing can be recovered and used for local greenhouse heating, positioning Marietta as a small-community U.S. example of data-center-driven thermal reuse rather than an extensive urban district-heating system.
- **In Pennsylvania**, Gneuton has launched a patented system that uses waste heat from gas turbine-powered AI data centers to drive a closed-loop thermal distillation process that produces millions of gallons of purified water annually, transforming excess heat into a sustainable water resource and helping data centers reduce their environmental footprint.
- **In Virginia**, the University of Virginia is planning a new on-campus research data center at Fontaine Research Park that will be integrated with an adjacent energy plant using geothermal heating and cooling, enabling the data center's waste heat to be captured and reused as part of the university's broader campus thermal energy strategy.
- **In West Virginia**, Fidelis New Energy proposed that the Monarch Cloud Campus in Mason County would co-locate up to 1,000 MW of hyperscale data centers with low-carbon hydrogen production and controlled-environment agriculture, using waste heat and captured CO_2 from both the hydrogen facility and the data centers to supply adjacent greenhouses and reduce the cost and emissions of regional food production.

Technology development is also advancing in both industry and academia. For example, ThermalWorks, based in New York, is developing integrated heat-recovery cooling systems that deliver higher-grade waste heat directly from modular data-center chillers, reducing capital barriers and making recovered heat more valuable for nearby industrial, commercial, or community uses rather than treating heat recovery as a costly add-on.

In parallel, researchers at Rice University are using a data center in Ashburn, Virginia, to evaluate a solar-boosted Organic Rankine Cycle system that adds low-cost rooftop solar collectors to a liquid-cooling loop, raising the temperature of waste heat and converting it into clean electricity. Their analysis shows the approach could increase recovered power by up to roughly 80 percent while lowering generation costs

In Ohio, EnergiAcres, "a system integrator and sustainability developer specializing in unlocking energy potential by connecting producers with high-value consumers," is pursuing a first-of-its-kind AI data center and agricultural integration campus in Mansfield, Ohio. (See Box 2 for details)

Table 2 provides international examples of community and industry data center waste heat applications.

BOX 2

EnergiAcres' Proposed "Gas → Data → Food" Campus Model

EnergiAcres, "a system integrator and sustainability developer specializing in unlocking energy potential by connecting producers with high-value consumers," is pursuing a first-of-its-kind AI data center and agricultural integration campus in Mansfield, Ohio.

The project demonstrates how energy infrastructure could anchor both digital and physical productivity. The model co-locates a 400–500 MW behind-the-meter combined heat and power (CHP) facility with a hyperscale data center and controlled-environment agriculture (CEA) operations such as greenhouses and refrigerated logistics.

Under its "gas → data → food" framework, waste heat and captured CO_2 from on-site generation are repurposed to support crop growth, cold-chain refrigeration, and district heating. The circular system improves power utilization efficiency while creating year-round agritech jobs and food supply resilience. EnergiAcres holds site control and manages permitting and infrastructure development, while a third-party power operator owns the generation asset through a long-term Power Purchase Agreement (PPA) with the data center tenant.

This model could tackle a national challenge: grid interconnection delays that often exceed seven years for high-density computing projects. By sourcing energy on-site, Mansfield's development aims to reach first power in under 24 months, saving up to $500 million in opportunity costs. The site has secured a 99-year city land lease, direct fiber connectivity, and 100 MW grid interconnect capacity from FirstEnergy to supplement CHP output.

Beyond powering AI, EnergiAcres' approach supports a circular local economy. Greenhouse operators, logistics firms, and suppliers become thermal and energy "off-takers," transforming what would be waste into shared value. The result is a mixed-use industrial park that combines clean-energy efficiency, agricultural production, and technology employment under one campus-scale development.

EngriAcres concept illustrates how energy transition goals can be linked with regional economic development. The project's success depends on outcome-based incentives—such as tax credits tied to verifiable heat-recovery use and local job creation—rather than prescriptive technology mandates.

Working in partnership with Penn State and other institutions, EnergiAcres is refining this approach to demonstrate how thermal microgrids can underpin competitive AI infrastructure while advancing agricultural and community benefits.

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Table 2

Examples of Community and Industry Data Center Waste Heat Applications

Application	Organization	Location	Type of data center
Commercial / residential heating via district heating networks	atNorth	Kista, Sweden	Colocation
	Stack Infrastructure	Oslo, Norway	Colocation
	Westin Building Exchange	Seattle, Washington, US	Colocation
	Amazon Web Services	Dublin, Ireland	Hyperscale
	Meta	Odense, Denmark	Hyperscale
	Yandex	Mäntsälä, Finland	Hyperscale
	H&M	Stockholm, Sweden	Enterprise
	Volkswagen Financial Services	Braunschweig, Germany	Enterprise
	Nikhef Housing	Amsterdam, Netherlands	High performance computing
Direct commercial / residential heating	Cloud&Heat	Frankfurt, Germany	Edge
	National Renewable Energy Laboratory	Golden, Colorado, US	High performance computing
	BIT	Ede, Netherlands	Colocation
Agriculture	Equinix	Paris, France	Colocation
	Microsoft	Middenmeer, Netherlands	Hyperscale
	Google	Middenmeer, Netherlands	Hyperscale
	QScale [under construction]	Quebec City, Canada	Colocation / High performance computing
Heating swimming pools	Deep Green	Exmouth, UK	Edge
	Digital Realty	Paris, France	Colocation
	NorthC	Aalsmeer, Netherlands	Colocation
Commodity dehydration: wood pellets	EcoDataCenter	Falun, Sweden	Colocation / High performance computing
Aquaculture:			
Trout farming	Green Mountain	Telemark, Norway	Colocation
Lobster farming	Green Mountain	Stavanger, Norway	Colocation
Algae farming	ScaleUp	Berlin, Germany	Colocation / Cloud
	Windcloud	Enge-Sande, Germany	Colocation

UPTIME INSTITUTE 2023 uptime INTELLIGENCE

Source: Uptime, 2023

What are the Potential Opportunities and Challenges of Waste Heat Recovery from Data Centers?

For rural communities in Appalachia, using waste heat recovery from AI data centers could heat entire towns – if they were within a few miles of the data center and had a thermal energy network. Even connecting waste heat to community critical buildings, like the police and fire stations, schools, libraries, recreation centers, public swimming pools, or a greenhouse to provide fresh food, could provide economic benefits for the entire community.

Co-locating data centers with other industries in need of heat can also create a symbiotic relationship. Today, there are numerous examples of a similar relationship between combined heat and power systems (CHP, also called cogeneration), serving industry needs. These systems simultaneously produce electricity and useful heat from a single fuel source, achieving much higher overall energy efficiency than separate generation.

For example, a Solvay Specialty Polymers plant in Marietta, Ohio, built in 2015, uses a natural gas-fired turbine to generate electricity to meet the plant's power needs, then captures the turbine's waste heat to provide the steam needed for polymer manufacturing. Over 20 years, the company will save an estimated $6 million in utility costs due to its CHP system.

As described in Table 3, waste heat recovery from data centers has the potential for environmental, economic, and community benefits.

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Table 3

AI Data Center Waste Heat Recovery Opportunities	
Environment	By converting AI data center waste energy into heating for homes, office buildings, and industrial processes, carbon emissions and air pollution can be reduced compared to when fossil fuels were previously used to generate heat. Water consumption can be reduced when combined with new liquid-cooling technology or advanced closed-loop water systems.
Economic	Data center operators can potentially generate new revenue streams by selling recovered heat to district heating networks or directly to nearby industrial or commercial facilities. They can also reduce the operational costs, including energy use by about 10-30% as well as the costs associated with external water sources used to reduce heat.
Community	Given that the long-term job creation benefits from data centers is low (see Box 3), data center developers may need to identify additional benefits communities can receive for hosting data centers in their communities. Waste heat provides an opportunity to provide those benefits. They can also respond to concerns about the potential stress of data centers on the local electricity grid by shifting heating loads in winter and making better use of base load energy used by data centers year-round. (see Box 4)

BOX 3

AI Data Centers and Local Job Creation: Critical Assessment

A 2025 Ohio River Valley Institute analysis finds that while AI-driven data center investment has attracted attention from policymakers as an economic development engine, the facilities themselves contribute limited long-term employment and local economic impact. This is because data centers are highly capital-intensive and non-labor-intensive, according to their analysis, meaning they spend comparatively little on local labor and generate few permanent, high-quality jobs relative to their size.

In Pennsylvania, for example, they note that data centers directly employed roughly 15,000–18,000 workers in 2023–24, amounting to about 0.25% of total state employment, and this share has not shown meaningful growth. Even generous industry estimates translate to an average of 27–111 employees per facility, which is economically modest relative to the scale of investment involved. Much of the capital outlay in data center projects goes to servers, networking equipment, and power infrastructure sourced from outside the host community, further limiting local economic spillovers.

Temporary construction jobs do often occur during the build phase, they say, leading to short-term boosts in building trades and local services, but these impacts fade quickly once facilities are operational.

The analysis also highlights that tax incentives and rate relief offered by states and counties can erode public revenues, while electricity rate increases tied to rising data center demand may suppress broader economic activity. Without changes in how data centers are taxed and regulated, the report argues, they are unlikely to become meaningful engines of sustained job growth or broad economic prosperity in host regions.

Petra Mitchell, CEO of Catalyst Connection, a nonprofit that supports small and medium-sized manufacturers in Southwest Pennsylvania, offers another perspective. She notes that it is essential to understand that each AI data center requires thousands of components, including power and electronics, cooling and heat management, steel and concrete.

If policies supported the development of a robust local manufacturing supply chain for AI data centers, there could be significant potential for job growth and economic impacts, leading to community benefits well beyond the construction and operation of data centers. Possible policies include offering expedited permitting and incentives for projects that source regionally and hire locally, expanding technical worker retraining and apprenticeship opportunities that support the whole data center support system, and coordinating regional supply-chain mapping to identify strengths, gaps, and matchmaking opportunities.

BOX 4

How Waste Heat Reuse Could Clear a Grid Bottleneck for AI Data Centers

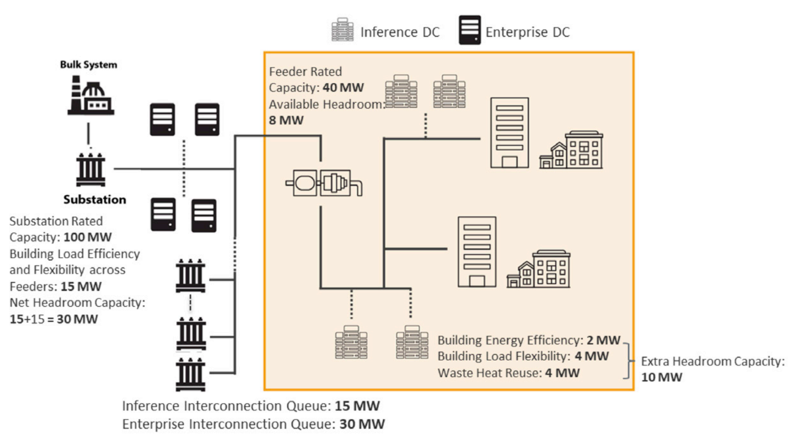
Some AI data centers are running into a power roadblock: local power lines and substations often do not have enough spare capacity to accommodate AI data center needs. As a result, these centers may face long interconnection delays and costly grid upgrades. An alternative is to use nearby buildings and waste-heat networks as partners. AI data centers can then connect faster and at lower cost, instead of waiting years for traditional grid reinforcements by reducing the electricity needs at nearby sites.

This concept is discussed in "Considerations for Distributed Edge Data Centers and Use of Building Loads to Support Large Interconnections," a 2025 National Renewable Energy Laboratory (NREL) report.

When nearby homes, offices, and factories are able to use AI data center waste heat for space heating and hot water instead of relying on their own electric or fuel-based systems, their electricity demand drops, which effectively "frees up" grid capacity on the same feeders and substations that the AI data center needs.

As illustrated in the table and figure below, NREL's analysis finds that by combining building energy efficiency, flexible building loads, and waste-heat reuse, the grid is able to interconnect new 15–30 megawatt data center loads that originally could not be accommodated. The "headroom" is how much extra power the local grid can safely deliver beyond what customers are already using.

	Feeder	Substation
Rated Capacity	40 MW	100 MW
Available Headroom	8 MW	15 MW
Data Center Interconnection Queue	Inference: 15 MW	Enterprise: 30 MW



Updated grid capacity with building energy efficiency, flexibility, and waste heat reuse (NREL, 2025)

What are the Opportunities and Challenges to Reducing Energy Consumption Through AI Data Center Waste Heat Recovery?

For energy consumption reductions directly attributable to waste heat, a Microsoft analysis estimates that between 0.69 MWh (in the winter) and 0.86 MWh (in the summer) of heat energy can be reused for every 1 MWh of electrical energy consumed in a data center.

As an illustration, consider a 24-MW data center located in Ohio. If the facility operates near full load during the core winter heating season (roughly December through March), the waste heat it produces could, in principle, supply a substantial share of the seasonal space-heating energy for approximately 15,000–20,000 nearby homes, assuming typical winter heating needs of roughly 2.5–3 MWh per electrically heated Ohio household.

Realizing this potential, however, would require district-scale piping, heat exchangers, and neighborhood distribution networks capable of using the heat in real time, without relying on long-term thermal storage.

Further, reaching 15,000–20,000 homes with this waste heat is constrained by distance, infrastructure cost, and the physics of moving low-temperature heat. In practice, hot-water district heating networks tend to be most efficient over just a few miles, with well-insulated modern systems still losing several percent of heat along the pipes, and costs rising sharply with length and pipe diameter.

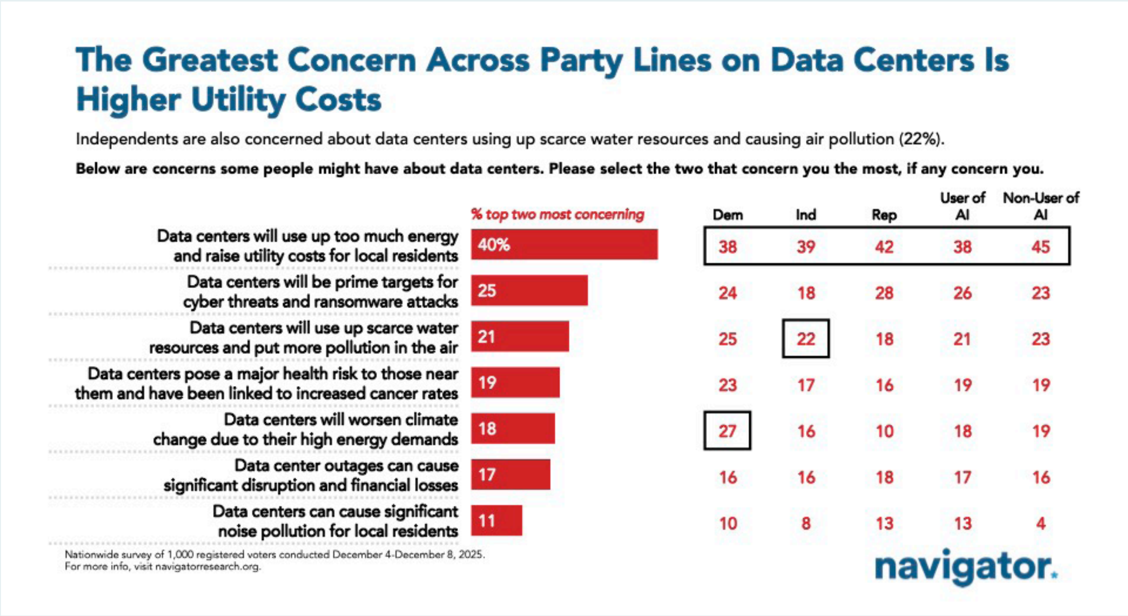
This means that only homes located relatively close to the data center—such as those in adjacent neighborhoods or along existing or planned district-heating corridors—are realistically reachable, while more distant households would require expensive new mains, careful routing under roads and rights-of-way, and possibly higher operating temperatures or additional heat pumps to overcome transmission losses, all of which can reduce or delay the economic case for serving the full 15,000–20,000-home potential.

A related challenge is that many Americans do not want AI data centers located near their homes. (See Box 5)

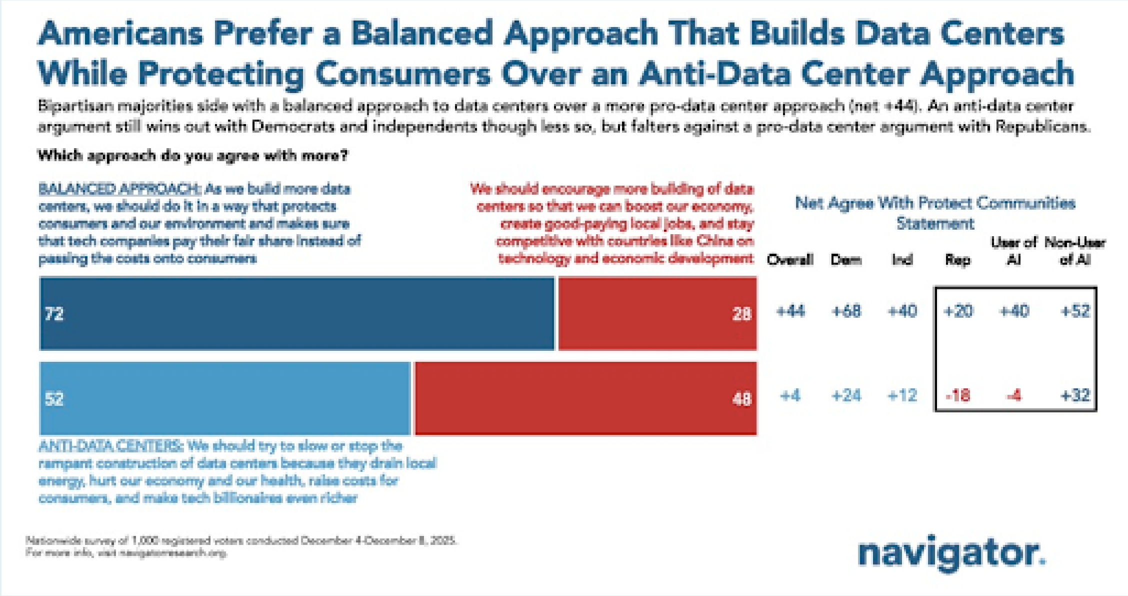
BOX 5

What do Americans Think About AI Data Centers?

A December 2025 Navigator poll found that "Americans don't have a strong sense that they [AI data centers] are good or bad for the country or for the communities where they are located" because they feel uninformed. This may be why it takes discussion of a data center in their community for Americans to take the time and energy to learn more about it.

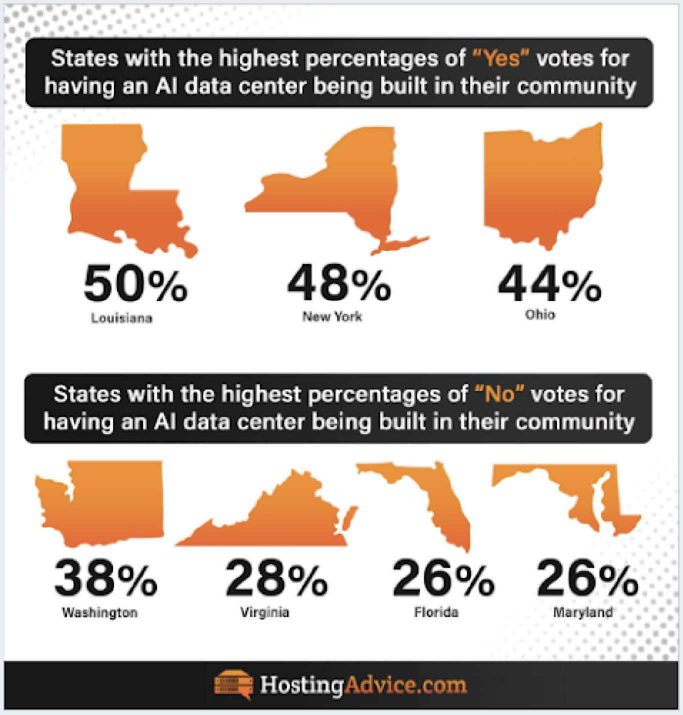


Overall, Americans prefer a balanced approach on AI data center public policy, as illustrated in the graphic below.



BOX 5, cont.

An important note is that there is significant variation among states, as illustrated in the figure below, and undoubtedly within communities in each state. In February 2025, Hostingadvice.com published the results of a poll they conducted of residents in 16 states, including several in Appalachia, and found that "93% of Americans Support AI Data Center Development — Just Not Near Them." A Data Center Watch study, for example, found that "$64 billion in U.S. data center projects have been blocked or delayed by a growing wave of local, bipartisan opposition."



Not included in the list of public concerns regarding data centers are declining property values; however, a George Mason University analysis found that property values increased the closer they were to a data center, not decreased, in Virginia, where many U.S. data centers are located today. Of course, opinions will vary relative to local conditions.

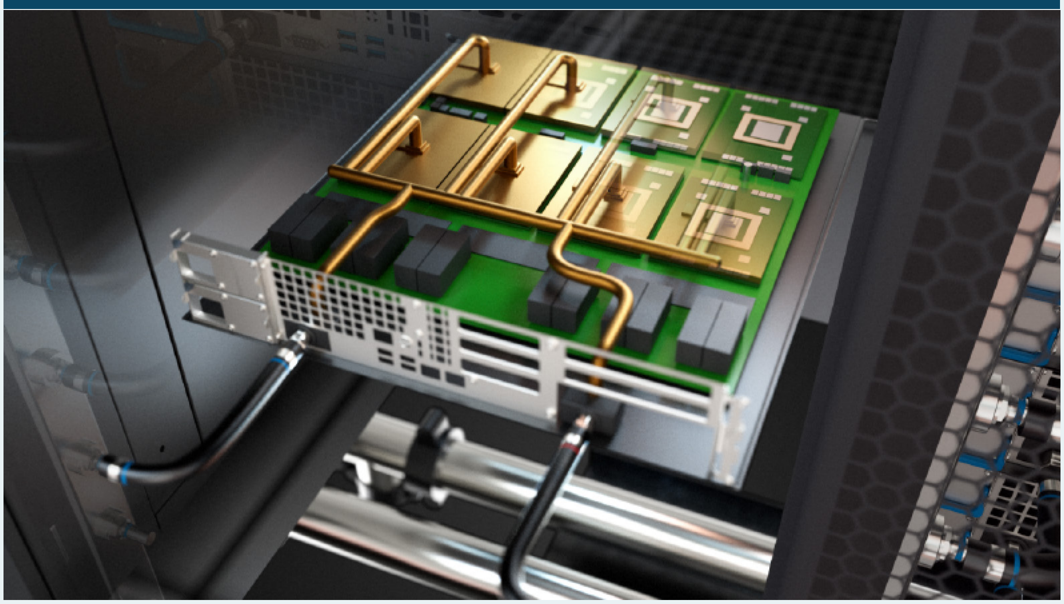
Ultimately, the decision to gather waste heat from data centers is very local and could be considered for each data center during the planning stage. If the ability to gather waste heat were incorporated into the design stage, even if the use of that heat was not clear at the time of construction, it could offer opportunities for the community that might make the data center more acceptable than it is in some communities today.

What are the Opportunities and Challenges to Reducing Water Consumption Through AI Data Center Waste Heat Recovery?

In addition, AI data center operators can reduce both energy and water consumption by transitioning from traditional cooling methods (e.g, evaporative cooling towers and mechanical chillers) to new liquid-cooling technologies (e.g., direct-to-chip, cold plates, or immersion). These new technologies transfer heat from GPUs/CPUs into a closed hydronic loop, significantly reducing or eliminating evaporative losses. (See Figure 8)

Figure 8

A 3D Illustration of Direct-To-Chip Cooling, Where Cold Plates Sit Atop the Chip to Remove Heat



Source: Vertiv, Accessed December 2025

These new technologies help with both energy and water consumption. An April 2025 study, authored by Microsoft and other researchers, published in the journal Nature, found that advanced cooling methods, such as cold plates and immersion cooling, could reduce “greenhouse gas emissions (15–21%), energy demand (15–20%), and blue water consumption (31–52%) in data centers.”

These liquid and immersion cooling methods also make heat reuse in data centers much easier and more valuable, as they deliver hotter, more concentrated, and easier-to-pipe heat than traditional air-based systems. As a result, these emerging cooling technologies can become the enabling infrastructure for district heating, building heating, and other waste-heat applications around AI data centers.

What are the Potential Technical, Economic, and Policy Challenges of Waste Heat Recovery from AI Data Centers?

While technologies exist to capture and reuse waste heat from data centers for heating buildings, community facilities, and industrial operations, adoption in the United States remains limited at the moment due to intertwined technical, economic, and political challenges that often determine whether projects become a reality.

Appendix A summarizes the technical, economic, and policy challenges of waste heat recovery, and possible responses to those challenges. A 2017 poll of German data center operators, however, found that the biggest barriers to the use of waste heat were not technical or economic challenges but insufficient options for utilizing the heat and consumers. A more recent poll of U.S. data center operators would be useful in better understanding these challenges.

What Policy Options Could Support Appalachian Data Center Waste Heat Use?

This section begins with a discussion of incentives for action, the current state of federal and state-level policy to support the use of AI data center waste heat, and concludes with an analysis of an array of policy options that Appalachian policymakers could consider.

Potential Incentives for Policy Action

As discussed earlier, a wide variety of actors could take actions to support this goal. Although federal, state, and local government policy leaders could take action, it is also the case that data center developers and operators could take these actions independently. Many have stronger sustainability policies, for example, than that of federal and state governments.

Communities can also play a active role, particularly by asking questions of AI data center developers before construction begins to encourage them to consider waste heat management as an option. Just asking the questions can be a powerful tool, particularly for companies with sustainability policies.

State Policymakers

Appalachian state governors from both parties and state legislatures are taking policy actions to recruit data centers to their states. Today, states are competing against each other to attract data centers, making regulatory options unlikely in this competitive environment. As a result, incentives and voluntary actions, rather than regulations, are currently the most feasible option to encourage data center companies to incorporate waste heat use into their operations.

Community leaders can, through public pressure, push for a more responsible development approach that mitigates harms and maximizes community benefits regardless of the policy mechanism. Some states, however, are preempting local government actions.

The incentive for Appalachian state governors and legislators to take action is that they face growing public opposition when they support a data center in their state's communities. Public opposition occurs because when communities weigh the possible benefits and costs of data centers, they perceive that the costs exceed the benefits. In particular, a January 2025 poll found that Virginia voters believe that data centers are a key driver of rising electricity costs, and they hold lawmakers most responsible for the problem. As a result, policymakers may be seeking actions that make these communities more willing to support data centers.

In addition, some states have climate and energy efficiency goals that AI data center waste heat management could support. For example, some states have enacted or are proposing linking tax incentives for AI data centers to job creation thresholds, wage and sustainability requirements, brownfield siting, and use of former powerplant locations. Overall, actions such as these could increase the potential for AI data centers benefits to exceed costs from a community perspective.

Data Center Developers and Operators

Why might data center developers and operators take policy actions regarding waste heat from data centers? From a financial perspective, policies that allow them to construct their data center as quickly as possible may be a motivating factor. While states compete to attract data centers, companies are racing to build them as quickly as possible to meet consumer demand for AI services.

In addition, most companies have sustainability policies focused on reducing greenhouse gas emissions from energy use and water consumption. The degree to which companies take those policies seriously will vary, but some are clearly committed, as evidenced by their focus on renewable energy to power these centers.

Further, data centers are often facing skepticism and opposition from local community members. As discussed earlier, local communities are increasingly expressing concerns about the benefits they will receive relative to the costs their community will incur. Opposition creates delays and sometimes shuts down a potential site where there has already been significant investment.

Data center companies that collaborate with communities, helping more members believe the benefits exceed the costs, might be motivated to incorporate waste heat that can serve community needs. They may also wish to participate in community discussions that result in community benefit agreements given concerns some communities have regarding the potential adverse impact of AI data centers in their communities relative to the benefits.

Community

For communities, the incentive for action might be the benefits that waste heat can provide to their residents. Possibilities include:

- Lowering heat costs for public buildings, an expense currently paid through local taxes;
- Reducing energy costs for local industry by co-locating in an industrial park and sharing with neighboring industries;
- Heating greenhouses that can grow fruits and vegetables, access to which is often a challenge for rural communities in food deserts, and also respond to food insecurity in Appalachia;
- Reducing the strain on local electric grids, particularly during winter peaks;
- Encouraging data centers to locate on former coal power plant and mine lands, which offer many assets such as existing electricity transmission infrastructure, if the state provides incentives to companies that locate on these lands per policy options above;
- Decreasing freshwater needed by AI data center for evaporative cooling by shifting more heat into reuse (district heating, greenhouses, industrial processes);
- Cutting greenhouse gas emissions and local air pollution by displacing fossil-fueled energy sources with low-carbon waste heat.

The challenge for communities is that they will need support to build the infrastructure connecting waste heat to community buildings unless the federal or state government provides technical and financial resources. This support could include conducting feasibility studies and providing construction, financial, and management of projects. In addition, state policies could encourage natural gas utilities to take actions to support communities.

Moreover, communities might need to be cautious in making these investments unless they are assured that the data center will operate a sufficient number of years and will produce a sufficient amount of heat for the waste heat recovery options to work financially.

Current and Proposed Government Policies

Current and proposed government policies include actions at the national and state level, in both the executive and legislative branches.

Federal

In the legislative branch, the November 2025 bipartisan Liquid Cooling for AI Act of 2025 (H.R. 5332 / S. 3269) introduced in both chambers of Congress would assess the research and development (R&D) needs and conditions affecting liquid cooling utilization in data centers and require DOE to submit a report to Congress with recommendations for liquid cooling and heat reuse R&D. Heat reuse is defined as "the capture and transfer of waste heat from liquid loops for beneficial secondary use through appropriate interfaces and controls." The bill also includes "A survey of existing opportunities for reusing waste heat produced by data centers" by the U.S. Government Accountability Office (GAO).

In addition, a proposed amendment to the Energy Independence and Security Act of 2007 would support funding of the deployment of energy distribution technologies that significantly increase energy efficiency including "district heating and cooling systems."

In the executive branch, the Biden Administration issued an executive order that would have required plans for "waste-heat utilization in constructing and operating the AI data center at the site," but the Trump Administration overturned this. In 2024, the U.S. Department of Agriculture (USDA) Rural Energy for America Program (REAP) provided $145 million in grants to rural businesses for projects such as installing waste heat recovery modules. The Trump Administration has paused the program, but it appears funding may resume once Congress passes the FY2026 budget.

The previously enacted federal Investment Tax Credit (ITC) includes "waste energy recovery property," which can cover systems that capture industrial waste heat and convert it to useful energy. Further, many Appalachian communities are "energy communities," because they are closely tied to the fossil fuel industry, making them eligible for a 10% Energy Community Tax Credit Bonus. This tax credit makes communities with shuttered coal plants, coal mines, and brownfield sites, very common in Appalachia's Ohio River Valley, particularly attractive for the co-location of data centers with industrial or agricultural facilities.

In Europe, some countries mandate the integration of heat recovery for new data centers or those that use more than 1 megawatt (MW) of power. For example, in Germany, new data centers must reuse at least 10% of their energy (including waste heat) beginning on July 1, 2026, with this share increasing to 15% in 2027 and 20% in 2028, and these targets must be met within two years of commissioning following an optimization phase.

State

AI data center policy is very active at the state level, though the Trump Administration is making attempts to develop a uniform federal policy and eliminate state laws. As a result, this analysis only provides illustrations at this point in time.

The best source of current information on state activity is the National Conference of State Legislators Artificial Intelligence Legislation Database. An alternative option is to focus on energy efficiency focused non-governmental organizations, such as the American Council for an Energy-Efficient Economy (ACEEE), the ClimateXChange, and the Environmental and Energy Study Institute as they regularly monitor state activity on relevant topics.

Current U.S. State Policy

In looking at possible state policy, many Appalachian states may already have measures focused on energy efficiency resource standards or binding utility savings targets that could be repurposed or modified to focus on AI data center waste heat utilization. One model might be California's Building Energy Efficiency Standards, also known as Title 24, that establish performance-based metrics that encourage efficiency improvements in cooling and power distribution, often involving heat recovery technology.

Some states with large rural areas also have existing policies to encourage the use of waste heat. For example, the Alaska Energy Authority provides technical assistance, including technology evaluations, to communities considering innovative heat recovery technology. Other states, including California, Colorado, Massachusetts, Maryland, Minnesota, New York, Washington, and Vermont, have policies that encourage the development of thermal energy networks.

Proposed U.S. State Legislation

As provided in Appendix B and C, legislators in a number of states have proposed legislation related to either AI data center waste heat utilization or support of thermal energy networks (TEN) or district heating systems. While none of these bills advanced during their legislative sessions, they may be a sign of future activity as more AI data centers are proposed around the nation.

In their report, Data Center Heat Reuse: The Opportunity for States, David Gardiner & Associates developed a set of suggested policy options to address the challenges of incorporating data centers (see Appendix D). These are a good starting point for discussion; however, most AI data centers are likely to be located in rural areas where many residents may not be located close to the data center. These data centers may not be within the few miles needed to move waste heat. While most existing data center heat reuse models focus on district heating in urban areas, rural areas may have a greater interest in:

- agricultural uses (e.g., greenhouses to provide fresh produce, drying of common farm goods),
- productive use of brownfield sites (e.g., former coal plant, industrial, and mine lands), and
- community support mechanisms (e.g., meeting the energy needs for community properties such as police and fire stations, community centers, and libraries).

In addition, given the ever-changing nature of AI data center related technology as well as the need for a systems approach, AI data center developers and their partner companies need as much flexibility as feasible to meet energy reliability, environmental, economic, and other societal needs. For example, new technologies may provide opportunities to reduce not only energy but water consumption as well, and the two may be interlinked.

This analysis breaks down policy options into the following three categories:

- **Regulatory Streamlining**: Reduce time and uncertainty by accelerating permits, clarifying requirements, and coordinating reviews across agencies through a single, predictable process.
- **Project Development Support**: De-risk projects by providing technical assistance, site readiness services, interconnection guidance, and matchmaking with utilities, offtakers, and community partners.
- **Fiscal Incentives**: Improve project economics by lowering upfront and operating costs through grants, tax credits/abatements, low-interest financing, and performance-based incentives tied to outcomes.

Illustrative policies in each of these categories is described below:

Regulatory Streamlining

- **Streamlined permitting or increase position in electricity grid interconnection review queue** for companies interested in constructing data centers, as an incentive to work with local communities in that region to integrate waste heat management from the data center to best serve community needs. This could include:
    - Pre-certifying sites' access to utility, fiber, and energy with standard terms and conditions.
    - One-stop permitting by providing a single point of contact, fixed permit review timelines, permitting checklists, and model drawings that developers can self-validate.

Project Development Support

- **Provide county-level funding to identify and pre-permit infrastructure corridors** (easements and rights-of-way), complete environmental desktop assessments, and publish integrated maps showing utilities, fiber, water, and potential anchor loads to certify them as "thermal-ready."
- **Develop and distribute standardized "shovel-ready" site cards** with uniform terms and conditions to streamline project development and attract investment.
- **Offer Front-End Engineering Design (FEED) and feasibility study grants** (covering 50–80% of project costs) to evaluate project viability, model heat and energy balances, and design interconnection concepts across grid, gas, and thermal systems. This could also include development of the commercial structure (e.g., Heat Purchase Agreement) and tie payments to milestone completion to prevent speculative spending.

Fiscal Incentives

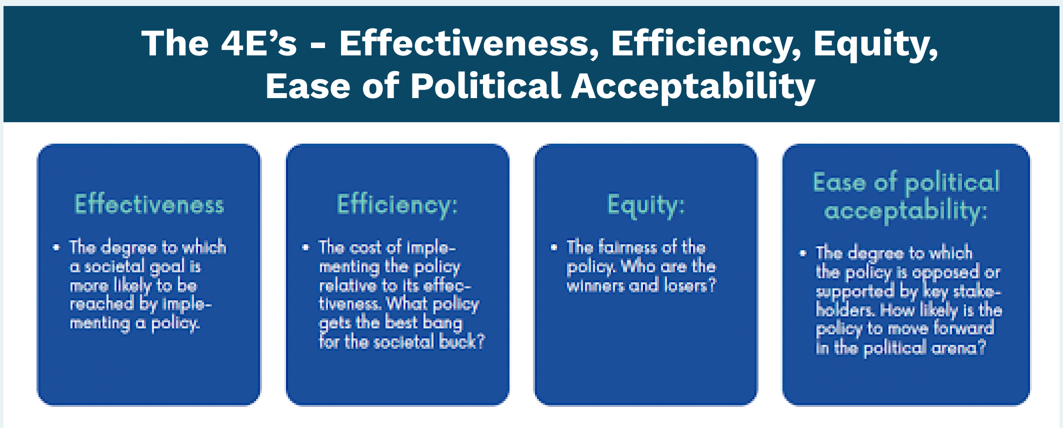
- **Establish flexible capital incentives to reduce upfront costs for investing in a waste heat project.** These could include:
    - Refundable or Transferable Investment Tax Credit (20–30%) for qualified thermal network and heat pump infrastructure, including heat exchangers, insulated mains, booster heat pumps, control systems, and metering.
    - Sales and Use Tax Exemptions with Accelerated Depreciation: Extend these to eligible thermal equipment and distribution pipe to improve project cash flow.
- **Give a local property tax abatement for 5–10 years or provide incentives to gas utility companies for the installation of thermal mains**, the insulated underground pipes that form the backbone of thermal energy networks, tying abatement eligibility to verified delivered-heat performance.
- **Provide siting incentives and integrated planning** for data center companies that repurpose brownfield sites, like shuttered coal plants and legacy coal infrastructure, for innovative data center

heat recovery activities. All of the above incentives could be "stackable" – that is, more than one can be used if they locate a data center on a brownfield.

- **Provide a time-limited (e.g., 5–7 years), technology-neutral production incentive that rewards verified thermal energy delivered to local end users**. Companies could receive bonuses for projects located in low-income census tracts or on brownfield sites.

Since all policies have pros and cons, Appendix E analyzes each based on the 4E's: effectiveness, efficiency, equity, and ease of political acceptability. (see Figure 9) By understanding the pros and cons of different policy options, policymakers can determine which best suits their state and communities.

Figure 9



Source: Stine, Deborah D., "From Expertise to Impact: A Practical Guide to Informing And Influencing Science and Technology Policy"

Summary

AI data center growth in Appalachia presents a chance to convert low-temperature waste heat from a liability into a community and economic asset, especially where nearby users and thermal networks can be developed.

By using district heating or broader thermal energy networks to serve critical facilities, homes, and greenhouses, or by co-locating data centers with industrial heat users, communities can reduce emissions, water use, and energy burdens while improving project economics through heat sales and efficiency gains.

However, success depends on overcoming technical limits of low-grade heat, distance-related losses, and the need for anchor customers, alongside high upfront capital costs and uncertain long-term offtake.

Targeted regulatory streamlining, project-development support, and fiscal incentives suited to rural conditions can lower these barriers and align private investment with public goals.

Ultimately, AI data center waste-heat reuse is not automatic, but when tied to clear community benefits in siting and approval processes, these centers can potentially evolve from low-job, high-load facilities into anchors of cleaner, more resilient regional energy and economic systems.

Appendix A: Technical, Economic, and Policy Challenges of Waste Heat Recovery and Possible Responses to Those Challenges

Category	Challenge	Possible Response to Challenge
Technical		
Location and heat-demand mismatch	Many AI data centers are located far from where people live for economic, security, or reliable power access. Nearby heating demand may therefore be limited. In addition, low-temperature waste heat is costly and inefficient to transport more than a few miles.	Focusing heat-reuse projects on sites with dense housing, campuses, or industrial users within roughly three miles, and connecting them through district- or campus-scale thermal networks designed for short-distance heat delivery.
Temperature and technical mismatch	Data-center waste heat is typically low-grade—around 86°F–122°F (30–50 °C) with conventional systems—below the supply temperatures expected by many buildings and district-heating networks. Upgrading this heat requires large heat pumps and additional equipment, increasing cost, complexity, and energy use.	Co-locate data centers with industrial sites or thermal networks already designed for low-temperature inputs or liquid-cooling systems, reducing the need for extensive heat upgrading.
Legacy cooling and retrofits	Existing air-cooled data centers can be challenging to integrate into efficient heat-reuse systems because air is a poor heat carrier, making heat capture and transport inefficient. Retrofitting to liquid cooling and hydronic loops is possible, but disruptive, and often competes with upgrades for power and capacity.	Prioritize heat-reuse integration in new AI data center construction, where liquid cooling and thermal loops can be designed in from the start at lower cost and risk.
Economic		
Infrastructure investment and capital cost	Heat reuse requires substantial upfront investment by AI data center developers in buried piping, heat exchangers, heat pumps, and building connections. Although modest relative to the total capital cost of a large AI data center, this is a separate investment with its own risk profile.	Complement the economics with additional incentives for data center developers, such as expedited permitting, zoning flexibility, tax credits, utility rate considerations, or public recognition tied to decarbonization and community-benefit goals.
Revenue, utilization, and payback risk	The business model for recovered heat is often unclear, with uncertain tariffs, contracts, and long-term offtake. If fewer buildings connect than expected, or if heating demand declines due to efficiency upgrades, utilization drops, and payback periods lengthen. This may make some investors cautious.	Anchor customers and long-term heat offtake contracts can stabilize demand, improve utilization, and provide the revenue certainty needed to make heat-recovery investments more bankable.
Retrofitting vs. new build	For existing air-cooled data centers, retrofitting for heat reuse is costly and operationally risky, while simpler upgrades focused on power efficiency or capacity expansion may offer clearer returns.	Focus heat-reuse efforts on new builds or major expansions, and limit retrofits at existing facilities to low-risk pilots or situations where site conditions strongly favor heat recovery.
Policy		
Permitting, codes, and utility rules	Installing new thermal networks may require rights-of-way, road-opening permits, and coordination with building codes and utility regulations that often do not account for data-center–to–district-heating connections. These hurdles may slow projects, raise soft costs, and deter developers under pressure to bring AI capacity online quickly.	Adopt standardized permitting pathways, pre-approved rights-of-way, and clear regulatory guidance that explicitly recognizes data-center waste heat as a utility resource, reducing uncertainty, delays, and transaction costs.
	Communities may support heat reuse but still raise concerns about AI data centers' electricity demand, water use, noise, land impacts, and limited local employment. Heat recovery can become one element in broader negotiations over "responsible" data center development, while political resistance or leadership changes add uncertainty to long-lived heat-network investments.	Position heat reuse within a broader community-benefits framework that also addresses power, water, noise, land use, and workforce impacts, supported by formal agreements and long-term commitments that remain durable across political transitions.

Appendix B: Proposed Bills in State Legislatures Related to AI Data Center Waste Heat Utilization

State/Bill	Core waste-heat provision	Policy type	How it works
California AB 1095 (2025–26)	Treats data-center waste heat energy as eligible for renewable energy credits (RECs) when it is converted to electricity and used onsite, and directs the Energy Commission to develop a metric so that waste heat used for building heating can also earn RECs based on avoided energy use.	Fiscal Incentives	Uses RECs and access to clean-energy finance to make heat-reuse projects pencil out, effectively turning captured heat into a revenue-earning "resource" rather than a by-product.
Virginia HB 2578 (2025)	Requires the Department of Energy to identify opportunities for beneficial use of waste heat from data centers, including mapping data centers and potential heat users and preparing a strategic plan to accelerate heat reuse statewide.	Project Development Support	Builds the planning, data, and coordination backbone (mapping, strategy, stakeholder work group) needed to move specific heat-reuse projects from concept to pipeline, but does not itself mandate reuse.
New Jersey S.4143 (2024–25)	Requires AI data centers to file an energy-use plan that, among other items, must "utilize the heat generated by the computers" for water or space heating in the AI data center or in adjacent buildings.	Regulatory Streamlining (with embedded technical requirement)	Bakes heat-reuse into the basic regulatory pathway for AI data centers: to secure approval, projects must show how they will use their own waste heat, effectively making reuse part of standard design and permitting expectations.
Minnesota HF 2928 (2025–26)	Requires covered data centers to report their energy use and "efforts made to reduce waste heat and to utilize it as thermal energy or electricity," alongside carbon-free energy progress.	Project Development Support (via transparency and soft pressure)	Establishes waste-heat reduction and utilization as a reportable performance metric, which supports project identification and creates reputational and regulatory pressure to adopt reuse over time, without prescribing a specific reuse percentage.

Appendix C: Proposed Bills in State Legislatures Related to Thermal Energy Networks (TEN)

State/Bill	Core waste-heat provision	Policy type	How it works
Washington HB 1514 (2025)	Expands state oversight to larger thermal energy network providers and directs the utilities commission to monitor and support TEN interoperability standards, enabling networks that can carry waste heat from various sources (industrial, commercial, etc.).	Regulatory Streamlining	Creates a clear regulatory home for TEN providers, reducing uncertainty and making it easier to permit and operate networks that can move waste heat between buildings.
Maine LD 1619 (2025)	Establishes a commission to study thermal energy networks statewide, including technical, regulatory, and financing pathways to deploy networks that can use low-carbon heat sources such as waste heat.	Project Development Support	Builds shared analysis and recommendations (via a formal report) that can feed into future legislation and help local governments and utilities identify and design TEN and waste-heat projects.
Connecticut HB 6929 (2025)	Authorizes a grant and loan program for thermal energy networks "on the customer's side of the meter," enabling funding for systems that distribute thermal energy, including recovered waste heat, among multiple buildings.	Fiscal Incentives	Creates a dedicated financing vehicle for TEN projects; even though initial legislation is unfunded, once capitalized it can directly support design and construction of waste-heat-based networks.
Illinois HB 3609 (2025–26)	Directs the Illinois Commerce Commission to adopt rules after TEN pilot projects are built, providing a regulatory framework for broader deployment of thermal energy networks that can incorporate waste heat from any large source.	Regulatory Streamlining	Uses rulemaking linked to pilots to standardize how TENs are treated, lowering transaction costs for future waste-heat and networked thermal projects.

Source: David Gardiner & Associates, Data Center Heat Reuse: The Opportunity for States, 2025

Appendix D: Possible State Policies in Response to Key Barriers

Barrier	Policy recommendation
Barrier 1: It is difficult for data centers to locate heat offtakers.	Support projects that demonstrate the technical feasibility of data center heat reuse.
	Establish matching platforms for data centers and heat end users.
	Develop district thermal energy networks to provide heating and cooling to neighborhoods and campuses as an alternative to on-site thermal generation.
	Leverage local and regional planning to collocate data centers and heat offtakers.
Barrier 2: Data center heat reuse projects face project development risks and higher costs for new energy providers.	Offer tax credits for the reuse of data center heat.
	Provide grants or low-interest loans for data center heat reuse.
Barrier 3: An uneven playing field makes it difficult to be the first mover.	Establish energy efficiency standards for data centers that allow data center heat reuse to meet the requirements.
	Require plans for heat reuse in permitting of new data centers.
	Establish a fee for a data center's greenhouse gas emissions from electricity consumption.

Appendix E: Comparative Analysis of Policy Options to Support AI Data Center Waste Heat Utilization

Policy Option	Summary	Effectiveness	Efficiency	Equity	Ease of Political Acceptability
Policy Type: Regulatory Streamlining					
Pre-certify site access	Standard access conditions	**Pro:** Simplifies development pipeline. **Con:** Requires strong inter-agency coordination.	**Pro:** Reduces early-stage delays. **Con:** Upfront administrative cost.	**Pro:** Levels access for smaller developers. **Con:** Benefits regions with existing utilities.	**Pro:** Levels acceBureaucracy reduction popular politically. **Con:** Risk of seen favoritism in site listing.
One-stop permitting	Streamlined review process	**Pro:** Shortens permitting timeline. **Con:** May overburden lead agency.	**Pro:** Improves cost predictability. **Con:** Initial setup complex.	**Pro:** Transparent permitting helps fair access. **Con:** Limited reach if staff capacity low.	**Pro:** Widely supported by business. **Con:** Pushback from local control advocates.
County-level pre-permitting	Thermal-ready corridor mapping	**Pro:** Enables integrated planning and heat use synergies. **Con:** Requires substantial early investment.	**Pro:** Optimizes infrastructure siting. **Con:** Costly GIS and environmental work.	**Pro:** Can target disadvantaged areas. **Con:** Uneven benefits if counties vary in capacity.	**Pro:** Local development appeal. **Con:** May face fiscal resistance.
Standardized site cards	"Shovel-ready" marketing tool	**Pro:** Attracts investors with clarity. **Con:** Oversimplifies site complexities.	**Pro:** Reduces due diligence costs. **Con:** Maintenance of accuracy required.	**Pro:** Easier access for small developers. **Con:** May favor already-developed zones.	**Pro:** Business-friendly optics. **Con:** Must manage transparency concerns.
Policy Type: Project Development Support					
FEED and feasibility grants	Front-end project grants	**Pro:** Improves project viability. **Con:** Risk of speculative studies.	**Pro:** Encourages targeted design efficiency. **Con:** Moderate administrative cost.	**Pro:** Supports equitable entry for smaller firms. **Con:** Limited total grant pool.	**Pro:** Framed as innovation support. **Con:** Needs safeguards against waste.
Community integration support	State-backed local heat reuse	**Pro:** Strengthens local adoption and infrastructure use. **Con:** Complex coordination across entities.	**Pro:** Leverages existing community capacity. **Con:** Administrative burden for state.	**Pro:** High equity by engaging local stakeholders. **Con:** Potential uneven readiness.	**Pro:** Popular due to community benefits. **Con:** Funding-dependent and slow rollout.

Appendix E, *cont.*

Policy Option	Summary	Effectiveness	Efficiency	Equity	Ease of Political Acceptability
Policy Type: Fiscal Incentives					
Investment Tax Credits (ITC)	Refundable tax credits	**Pro:** Strong signal to investors. **Con:** Favors firms with tax appetite unless refundable.	**Pro:** Simple eligibility framework. **Con:** Foregone revenue may be high.	**Pro:** Can improve local clean energy access indirectly. **Con:** Less direct community targeting.	**Pro:** Consistent with existing policy models. **Con:** May face budgetary scrutiny.
Sales tax exemptions	Cost-offset for equipment	**Pro:** May lower the equipment cost barrier. **Con:** Long-term return on investment is uncertain.	**Pro:** Easy to administer. **Con:** Modest incentive magnitude.	**Pro:** May aid smaller projects. **Con:** Uniform benefit not income-sensitive.	**Pro:** Politically modest and familiar. **Con:** May need legislative action.
Property tax abatement	5–10 yr thermal abatement	**Pro:** Encourages capital-intensive thermal build-out. **Con:** Local revenue loss risk.	**Pro:** Predictable incentive structure. **Con:** Verification of performance adds cost.	**Pro:** Tie to performance boosts fairness. **Con:** Unequal across tax jurisdictions.	**Pro:** Familiar local tool. **Con:** May spark local fiscal debate.
Production-based thermal incentive	Verified heat-delivery reward	**Pro:** Aligns payout with real outcomes. **Con:** Verification challenges.	**Pro:** Pay-for-performance may be efficient. **Con:** May require a monitoring framework.	**Pro:** Can target bonuses to low-income zones. **Con:** May underfund smaller projects.	**Pro:** Market-oriented and fair. **Con:** Needs proof of measurable output.
Brownfield siting incentive	Repurpose legacy sites	**Pro:** Strong place-based redevelopment impact. **Con:** Environmental remediation complexity.	**Pro:** Uses existing infrastructure. **Con:** Project readiness may be slower.	**Pro:** Direct equity wins are possible for distressed areas. **Con:** Limited to specific geographies.	**Pro:** High public appeal for reuse. **Con:** Regionally limited benefit.

Glossary

Anchor customer (anchor tenant): A large, reliable heat user that commits early, such as a hospital, university, greenhouse complex, or industrial plant, making a heat network financially viable.

Appalachian Regional Commission (ARC) region: The multi-state geographic footprint defined by ARC for Appalachian counties, often used for regional planning and analysis.

Air-cooled data center: A facility where servers are cooled primarily with air-handling equipment; generally harder to reuse heat because air carries less heat efficiently than water.

Brownfield: Previously developed land that may be underused or contaminated; often targeted for redevelopment due to existing infrastructure and land availability.

Capacity factor (load factor): How consistently a facility operates near its maximum electrical load over time; higher load factors usually mean more predictable heat output.

Clean-in-place (CIP): An industrial cleaning process (common in food and beverage) that uses heated water and cleaning solutions without disassembling equipment.

Community Benefits Agreement (CBA): A binding contract between a developer and community representatives that specifies benefits, timelines, reporting, and enforcement.

Coefficient of Performance (COP): A measure of heat-pump efficiency: heat delivered divided by electricity used. Higher COP means more heat delivered per unit of electricity used.

Cooling loop (coolant loop): A closed circuit that carries heat away from computing equipment, using air, water, or other fluids.

Curtailment: A reduction in a facility's electricity use (or a generator's output) to maintain grid reliability or manage congestion.

Data center: A facility housing servers and networking equipment that provides computing and data services; converts most consumed electricity into heat.

Demand (thermal demand / heat load): The amount of heat needed by buildings or industrial processes, often measured in MWh-thermal; can be seasonal (space heating) or continuous (process heat).

District energy (district heating): A system that produces and distributes heat to multiple buildings through a network of insulated pipes.

Distribution network (thermal network): The pipes, pumps, and controls that move heated water (or other heat-transfer fluids) from a source to users.

Energy efficiency upgrades: Measures that reduce electricity or fuel use, such as insulation, building controls, and equipment retrofits; can reduce heat demand and affect project utilization.

FEED study (Front-End Engineering Design): Early-stage engineering that refines technical design, costs, and risks before major capital investment decisions.

Heat exchanger: Equipment that transfers heat from one fluid to another without mixing them, such as transferring heat from a data center loop to a district heating loop.

Heat offtake (offtake): The purchase and use of recovered heat by a customer; usually governed by an offtake agreement specifying quantity, temperature, price, and reliability.

Heat offtake agreement: A contract that defines delivery conditions and payments for heat, similar in concept to a power purchase agreement.

Heat pump: A device that upgrades low-temperature heat to a higher, usable temperature for heating networks or industrial processes.

High-grade vs. low-grade heat: A qualitative distinction based on temperature and usefulness; low-grade heat (often around 30–50 °C from conventional systems) typically needs upgrading, while higher-grade heat can be used more directly.

Hydronic loop: A water-based heating loop used to distribute heat within a building or across a campus/district system.

Immersion cooling: A liquid-cooling approach where servers are immersed in a dielectric fluid; often enables higher-quality heat capture.

Interconnection: The process of connecting a large electrical load (or generator) to the grid, including technical studies and required upgrades.

Levelized Cost of Heat (LCOH): The average cost per unit of heat delivered over a project's lifetime, including capital, operations, maintenance, and energy inputs.

Load growth: An increase in electricity demand on the grid, often driven by new large users such as data centers.

Marginal cost: The additional cost of adding a feature, such as designing for heat reuse during new construction versus retrofitting later.

Megawatt (MW): A unit of power (rate of energy use). A 24 MW load means consuming 24 megajoules per second continuously when fully loaded.

Megawatt-hour (MWh): A unit of energy (amount used over time). Running at 24 MW for one hour uses 24 MWh.

Organic Rankine Cycle (ORC): A power generation method that can convert heat into electricity using an organic working fluid; generally requires sufficiently high temperatures to be practical.

Payback period: The time required for savings or revenues to recover upfront capital costs; longer payback increases investor caution.

Permitting (road-opening permits, building permits): Government approvals required for construction activities, such as digging streets for pipes or modifying building systems.

Power Usage Effectiveness (PUE): A data center efficiency metric: total facility power divided by IT equipment power. Lower PUE indicates less overhead energy.

Recovered heat (waste heat reuse): Capturing heat that would otherwise be released to the environment and using it for heating or industrial processes.

Return temperature / supply temperature: Supply is the temperature delivered to users; return is the temperature coming back to the plant. Many networks require minimum supply temperatures to meet building needs.

Rights-of-way (ROW): Legal permissions to install infrastructure such as pipes along roads, utility corridors, or private land.

Soft costs: Non-hardware costs such as engineering, legal work, permitting, community engagement, and project management.

Temperature lift: The temperature increase a heat pump must provide to make waste heat usable; larger lifts typically reduce efficiency and increase cost.

Thermal storage: Storing heat for later use, such as in hot water tanks or underground storage; can help manage timing mismatches between heat supply and demand.

Utilization (heat utilization rate): The share of available recovered heat that is actually delivered and used; low utilization weakens project economics.

Water Usage Effectiveness (WUE): A metric tracking water used per unit of IT energy; helps compare cooling strategies and water risk.

4Es framework: A policy analysis lens: Effectiveness, Efficiency, Equity, and Ease of political acceptability.