



VIRGINIA DEPARTMENT OF ENERGY EVALUATION OF DATA CENTER WASTE HEAT REUSE FEASIBILITY AND POLICY RECOMMENDATIONS

***REPORT TO GOVERNOR, THE CHAIRMAN OF THE HOUSE
COMMITTEE ON COMMERCE AND LABOR AND THE SENATE
COMMITTEE ON LABOR AND COMMERCE, AND THE
SECRETARY OF COMMERCE AND TRADE***

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Contents

Report Overview	3
Research Context	4
Background on Waste Heat Technologies	5
Waste Heat Opportunities & Challenges	10
Benefits & Opportunities Overview	10
Waste Heat Reuse Benefits	12
Potential End Use Case Scenarios	13
Challenges and Barriers	14
Cost	14
System Seasonality & Heat Load Mismatch	15
Public Sentiment	15
Challenges Connecting Data Centers with Waste Heat Users	16
Location Risks	16
Timelines & Planning	16
VA Landscape and Opportunity Overview	16
Virginia Data Center Waste Heat Reuse Initiatives	17
Key Opportunity Regions	21
Economic Opportunities	24
Data Center Considerations	26
Knowledge Sharing Framework	28
Existing Channels of Communication	28
Key criteria for helpful information for decision makers	29
Best Practices & Policies	30
Waste Heat Use at Scale in Europe	31
Meta Data Center—Odense, Denmark	32
Equinix (FR4, FR6, & FR8)—Frankfurt, Germany	32
STACK Infrastructure, OSLO1A—Oslo, Norway	32
Amazon Web Services Dublin-Tallaght District Energy—Dublin Ireland	33

Data Center Waste Heat Reuse in the United States	34
NLR (Formerly NREL) Laboratory Heating—Golden, Colorado	34
NLR (Formerly NREL) Urban Renewable Building and Neighborhood Optimization (URBANopt) Program	34
Amazon Headquarters—Seattle, Washington.....	35
Findings	35
Policy recommendations	36
Conclusion.....	41
Acknowledgements.....	42
References	42
Appendix.....	49
Appendix 1—Definitions.....	49
Appendix 2—Public Comments	49
Appendix 3—Stakeholder Organizations.....	51

Report Overview

This report is created pursuant to Chapter 591 of the 2026 Virginia Acts of Assembly. The act directed the Virginia Department of Energy (Department) to evaluate the feasibility of the development of data center waste heat technologies in the Commonwealth. The Act directed the Department to address several issues: (1) Identification of opportunities for beneficial use of waste heat from data centers; (2) Determination of appropriate channels and tools for information sharing across various stakeholder groups (data centers, end-users, localities) to help with evaluation of practical applications of data center waste heat use; (3) Provide recommendations to accelerate the use of waste heat from data centers addressing benefits and challenges, as well as an assessment of estimated costs to develop infrastructure. Additionally, the Department was directed to host a workgroup with involvement from relevant stakeholders to help inform the report through expertise, assistance, and feedback on the Department’s efforts to accelerate data center waste heat use in the Commonwealth. Below is the full statutory language:

§ 1. The Department of Energy (the Department) shall lead efforts to accelerate the use of waste heat from data centers in the Commonwealth and shall (i) identify opportunities for beneficial use of waste heat from data centers; (ii) determine ways to appropriately share information and facilitate communication between existing and proposed data centers and potential public and private heat users, including residential, commercial, and public buildings, district heating systems, and industries that use low-temperature heat, within the Commonwealth that allow data centers, potential heat users, and the public to assess the potential for the use of waste heat from data centers and to establish connections between data centers and heat users; (iii) evaluate best practices and policies for using waste heat implemented in other localities, states, or countries; (iv) develop recommendations to accelerate the use of waste heat from data centers in the Commonwealth that identify the potential for using waste heat from data centers, its benefits and challenges, and recommendations for approaches to increase the use of waste heat from data centers in the Commonwealth and include an assessment of the estimated costs necessary to develop supporting infrastructure and associated programs; and (v) convene a work group that includes representatives from the Virginia Economic Development Partnership Authority, the data center industry, local governments, gas and electric utilities, relevant state agencies, potential users of waste heat, and other interested stakeholders to provide expertise, assistance, and feedback on the Department's efforts to accelerate the use of waste heat from data centers in the Commonwealth. The Department shall submit a report of its efforts, findings, legislative proposals, and other state or local policy recommendations to promote the use of waste heat from data centers in the Commonwealth to the Chairs of the House Committee on Labor and Commerce and the Senate Committee on Commerce and Labor no later than September 1, 2026.

In executing this evaluation of policy options, the agency conducted independent research and met with stakeholders, including (1) Virginia Economic Development Partnership Authority, (2) the Data Center Industry, (3) Local Governments, (4) Gas & Electric Utilities, (5) Relevant State Agencies, (6) Potential End Users, and (7) other relevant stakeholders. The Department hosted three stakeholder sessions and received feedback from stakeholders on the draft report. Stakeholder resources and feedback are present throughout this final report.

Research Context

The legislation directs the Department of Energy to identify opportunities for beneficial use, facilitate communication between data centers and potential heat users, evaluate best practices, develop recommendations and cost estimates, and convene a work group to inform those efforts before reporting to the General Assembly.

This report builds on a growing body of work that has examined the opportunities and constraints of data center heat reuse in Virginia and comparable regions. A 2025 Northern Virginia Regional Commission (NVRC) workshop¹ brought together district energy, utility, academic, and data center perspectives to examine the practical conditions for heat reuse

¹ Northern Virginia Regional Commission. (2025). *District energy and data centers workshop: Synthesis report* (George Mason University and International District Energy Association collaborators). Northern Virginia Regional Commission. <https://www.novaregion.org/DocumentCenter/View/15172/District-Energy-and-Data-Center-Workshop-with-GMU-and-IDEA?bidId=>

deployment in Northern Virginia. A 2011 McGuire Woods white paper² for NVRC provided a foundational analysis of Virginia law and clarified how local authority, public versus private ownership models, and potential SCC oversight shape the legal environment for district energy systems. Relmage Appalachia's 2026 "Catching Heat"³ report explored how data center waste heat could support economic development and community benefits in rural and Appalachian settings, particularly where future data center growth may intersect with industrial development, institutional loads, and regional revitalization goals.

This report intends to build on these works and synthesizes them through a coordinated lens that reflects Virginia's varied regions and the legislation's purpose of opening pathways for practical implementation.

Background on Waste Heat Technologies

Data centers are facilities to house critical IT infrastructure such as servers, storage systems and networking equipment, that continuously store, process, and distribute digital information. The electricity required to run this equipment is converted into heat which needs to be rejected from the facility to prevent hardware failure. Typically, this "waste heat" goes to chillers, wet or dry cooling towers, or is directly emitted to the atmosphere. These options may substantially increase the amount of electricity and, depending on the heat rejection technology, water used. To make use of this byproduct, various heat capture technologies can be implemented.

A report from Equinix, a data center developer and operator which utilizes waste heat reuse technologies in Helsinki, Paris and Toronto, summarized data center waste heat reuse as follows:

*Data center heat export captures residual heat from IT equipment cooling systems and transfers it to third-party heat networks for community distribution instead of atmospheric waste. Heat exchangers separate data center cooling water from network infrastructure while heat pumps boost temperatures for residential & commercial heating requirements.*⁴

An illustration of how the heat export process from data center operations works can be found in Figure 1. The illustration below shows a system powered by clean and renewable

² McGuireWoods LLP and McGuireWoods Consulting LLC. (2011). *District energy systems: An analysis of Virginia law* (Prepared for the Northern Virginia Regional Commission). Northern Virginia Regional Commission. <https://www.novaregion.org/DocumentView.aspx?DID=3050>

³ Relmage Appalachia. (2026, February). *Catching Heat: The opportunities and challenges of using waste heat from AI data centers*. Relmage Appalachia. https://reimagineappalachia.org/wp-content/uploads/2026/02/Catching-Heat_Using-Waste-Heat-Generated-from-Data-Centers.pdf

⁴ Nkonge, N. (2024, June 5). *What is Data Center Heat Export and How Does it Work?* Equinix Blog. <https://blog.equinix.com/blog/2024/06/05/what-is-data-center-heat-export-and-how-does-it-work/>

energy sources. Additionally, the image below utilizes Celsius to describe the temperatures of the heat—converted, these temperatures are ~25°C-30°C/ 77°F-86°F and ~60°C-90°C/ 140°F-194°F.

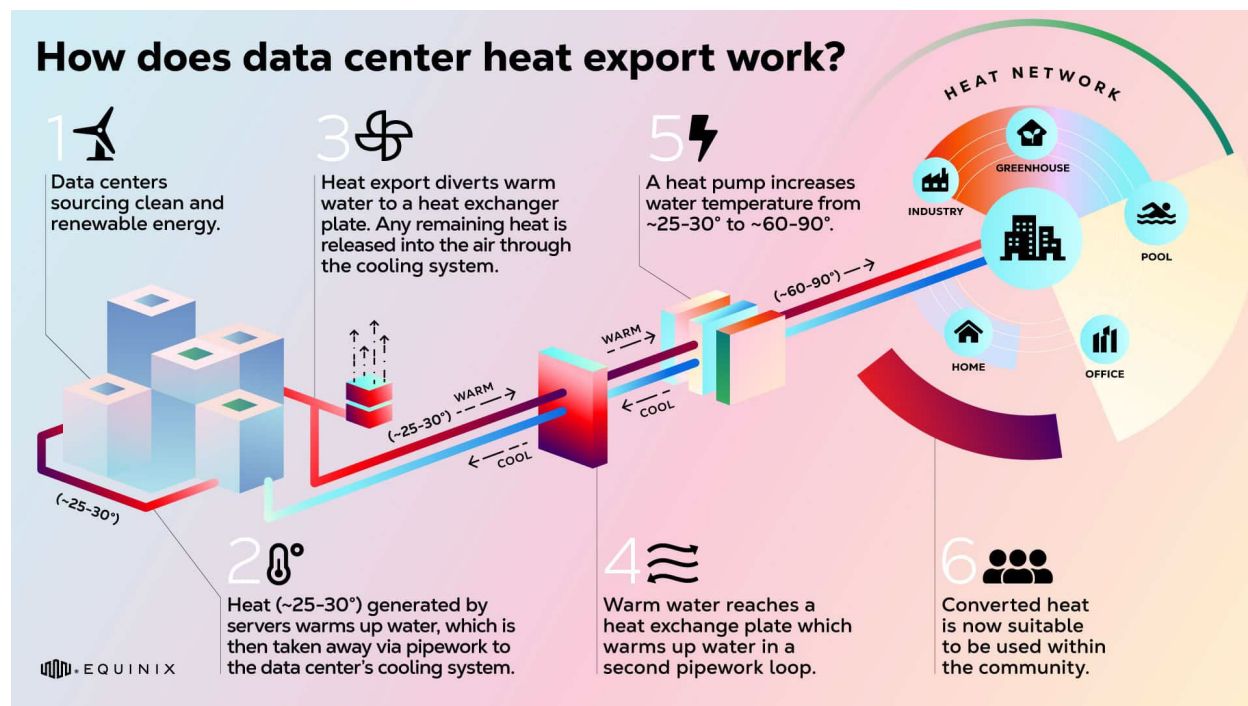


Figure 1--How does data center heat export work. (Nkonge, 2024)

One primary use of waste heat, after recovery, is through district energy systems, a type of thermal energy network—widely adopted in many European countries, including Denmark, Germany, Sweden, Finland, and Norway. Ireland, which is home to a growing number of data center campuses—especially around Dublin where 50-80% of electricity is powering data centers—is exploring efforts to develop district energy systems to capture waste heat from data center operations.⁵

A district heating network distributes heated water from a centralized source to multiple buildings, such as residential and commercial properties, via a series of underground insulated pipes in a closed loop. It has three main components—thermal energy generating plant (commonly known as an Energy Center), distribution network piping, and building interconnections.⁶ The receiving building has a heat interface unit that uses a heat exchanger to transfer the thermal energy into the building's internal heating network. The

⁵ Reut, T. (2026, July 14). *District heating 'should bring prices down'*. RTÉ. <https://www.rte.ie/news/business/2026/0713/1583067-district-heating-bill/>

⁶ Department of Energy (DOE). (2020). *Combined Heat and Power Technology Fact Sheet Series: District Energy Systems Overview*. https://www.energy.gov/sites/default/files/2021/03/f83/District_Energy_Fact_Sheet.pdf

district heating water is then sent back to the Energy Centre where it is reheated and recirculated, resulting in a closed loop system.⁷ By repurposing the heat, individual buildings can replace boilers that run on fossil fuels, lowering carbon emissions.⁸

In the United States, the first district heating system (steam) was established at the US Naval Academy in Annapolis, Maryland followed by a coal-fired steam heating system at the Massachusetts Institute of Technology.⁹ Lockport, New York saw the development of the “first commercially successful heating system” in the United States in 1877, which was created by Birdsill Holly, largely considered the “founder of modern district heating”. World War II gave rise to many district heating systems as a means of conserving energy and reducing dependence on oil with some funding support coming from the federal government. Many European countries continued to adopt and develop district energy systems to utilize excess heat for residential heating. The United States energy system was built more around remote power generation stations and district energy systems tend to be isolated to larger cities (New York City, Philadelphia, Boston, etc.) or on the campuses of universities, colleges, hospitals, or military bases.^{10 11}

For a district energy system coupled with a data center, the quality and usability of recovered heat depends heavily on the data center cooling architecture. As illustrated below [Figure 2], air-cooled data centers generally produce low grade waste heat that must be uplifted before it can serve a district heating network. Hybrid or liquid-cooled systems can recover heat at higher temperatures, reducing the amount of energy required for temperature uplift and improving the technical case for reuse. This distinction is important for Virginia because feasibility assessments should evaluate not only whether heat is available but whether it can be delivered to a heat network operator at the required temperature, timing, and reliability.

⁷ DOE-CHP eCatalog | *Organic rankine cycle (ORC) system basics*. (2022). Ornl.Gov. <https://chp.ecatalog.ornl.gov/benefits/orc-basics>

⁸ Stine, D. (2026). *Catching heat: Using waste heat generated from data centers: Appalachian responsible development opportunities, challenges, and policy options*. https://reimagineappalachia.org/wp-content/uploads/2026/02/Catching-Heat_Using-Waste-Heat-Generated-from-Data-Centers.pdf

⁹ DBDH. (2026). *District heating history*. <https://dbdh.org/district-heating-history/>

¹⁰ Garforth, P. (2024). *Research starter: Waste heat recovery*. EBSCO. <https://www.ebsco.com/research-starters/engineering/waste-heat-recovery>

¹¹ Department of Energy (DOE). (2020). *Combined heat and power technology fact sheet series: District energy systems overview*. https://www.energy.gov/sites/default/files/2021/03/f83/District_Energy_Fact_Sheet.pdf

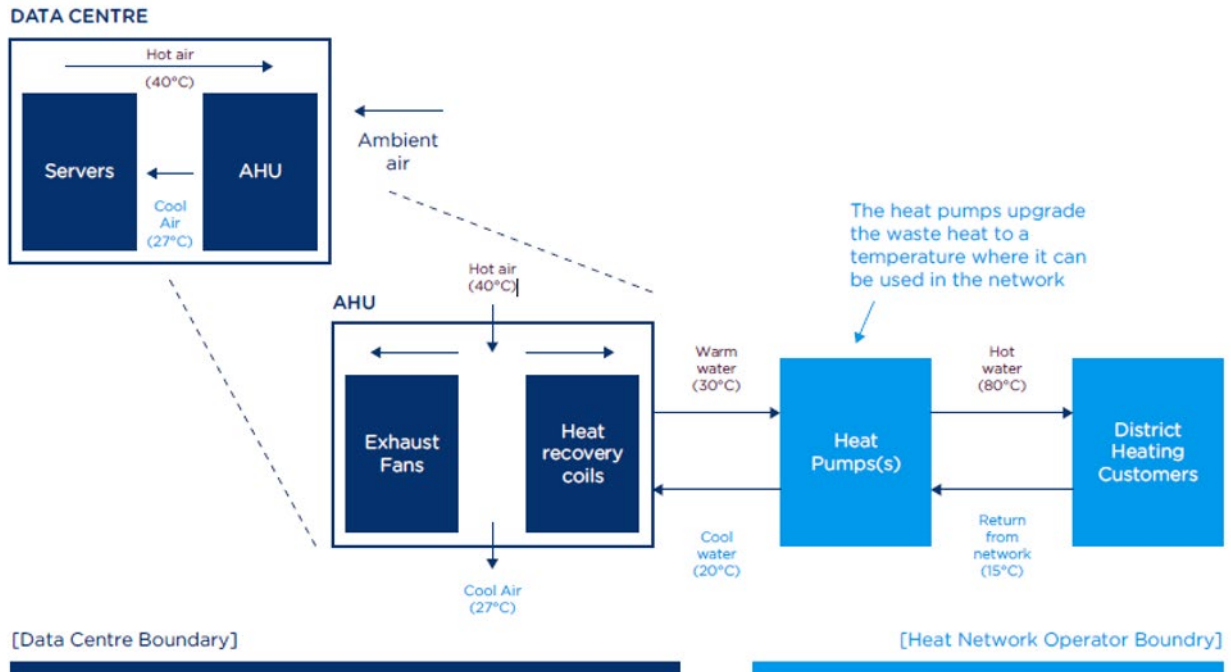


Figure 2--Data center waste heat recovery for district heating — air-cooled systems. [Source: Ansett, 2025]¹²

¹² Ansett, E. (2025). *Developing sustainable data centers: A strategic roadmap to achieve net zero carbon and reduce environmental impact [White Paper]*. Ramboll.

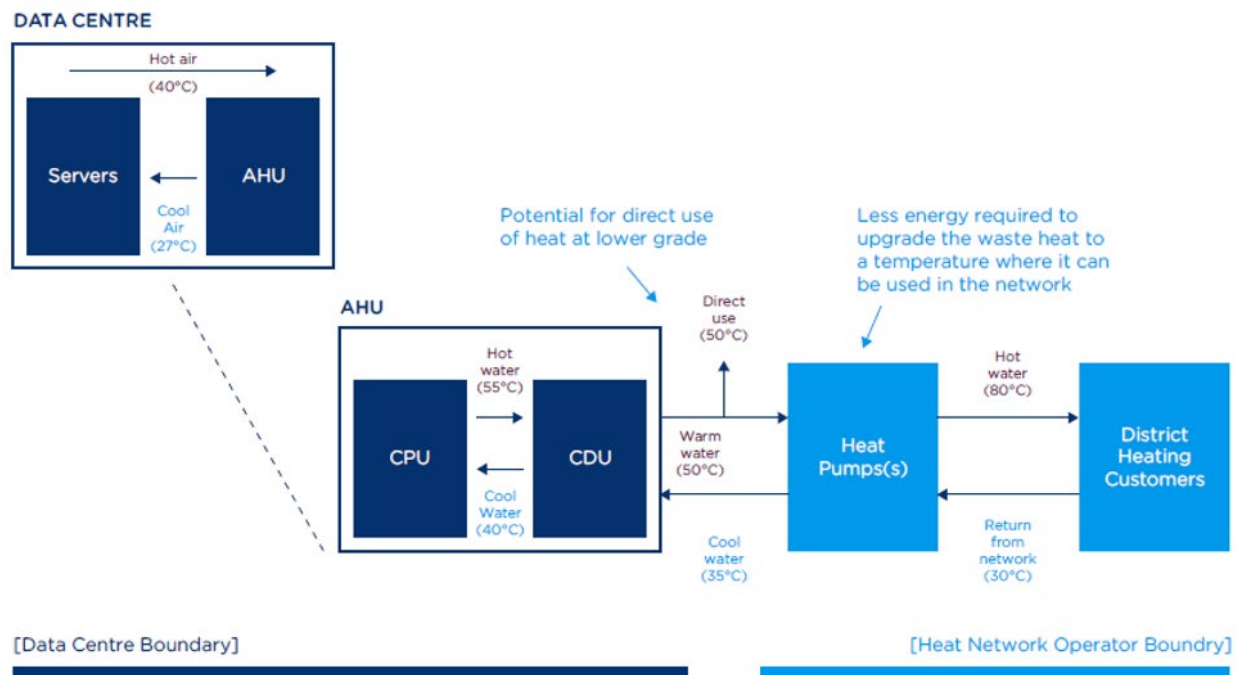


Figure 3--Data center waste heat recovery for district heating — hybrid and water-cooled systems. [Source: (Ansett, 2025)]¹³

Ambient loop networks, a subset of district energy networks, draw thermal energy from connected buildings rather than a central generation plant. Thermal energy is extracted from one building via a heat pump and used to heat water which is circulated to other customer buildings. The recipient buildings use the heated water for their cooling systems, and the now-cooled water is recirculated to be reheated. This method can also store thermal energy in shallow boreholes or aquifers, lessening stress on the grid.¹⁴ As a result, these systems are almost entirely self-sustaining since water and excess heat can be recycled back into the loop. By implementing systems that help data centers lower energy and water consumption, they minimize the negative impacts on nearby communities.¹⁵

¹³ Ansett, E. (2025). *Developing sustainable data centres: A strategic roadmap to achieve net zero carbon and reduce environmental impact* [White Paper]. Ramboll.

¹⁴ Cohen, R., Nguyen, L., Correll Smith, D. (2025). *Understanding thermal energy networks: A building decarbonization approach to achieving scale, equity, and high-quality union jobs*. <https://www.ilr.cornell.edu/sites/default/files-d8/2024-12/understanding-thermal-energy-networks.pdf>

¹⁵ Singh, A. (2026). *Thermal energy networks turn data center waste heat into a hot commodity*. EESI. <https://www.eesi.org/articles/view/thermal-energy-networks-turn-data-center-waste-heat-into-a-hot-commodity>

The ability to convert waste heat into a usable resource can benefit nearby industry as well. For the agriculture and food industry, the waste heat can warm greenhouses, pasteurize dairy products, process food, etc. The pharmaceutical and biotechnology industries can utilize the heat to run laboratories, clean equipment, and for temperature control.¹⁶ Hospitals can also benefit from district energy systems and potentially the waste heat from data centers where systems (district heating and building systems) are designed to operate on steam for sterilization.

These technologies can be combined with Organic Rankin Cycle systems which generate electricity with low to medium temperature heat sources. When used to recover waste heat, they can generate emission free electricity and can be combined with carbon capture systems, preheating equipment to conserve fuel for the process.¹⁷ In wastewater treatment, water entering the plants can be preheated to aid bacteria used to clean water. Treatment and desalination systems also benefit from using warmer water as well. Overall, wastewater treatment efficiency improves while energy costs are lowered.¹⁸

Waste Heat Opportunities & Challenges

Benefits & Opportunities Overview

Waste heat reuse is a technology that has multiple uses and potential benefits. Waste heat reuse can benefit data center operators by reducing costly energy loss and improving energy efficiency, while also reducing the carbon footprint and potentially lowering operating costs.¹⁹ Depending on the type of data center operation and cooling technology used, a significant amount of data center energy is lost as excess heat through exhaust gases, cooling water, and heat loss from equipment—waste heat reuse can “significantly reduce primary energy consumption from the industrial processes”.²⁰ A 2025 report from the International Energy Agency (IEA) asserts “nearly all electricity consumption in data

¹⁶ Gardiner, D., Dixon, A., Kent, E., Schuster, H. (2025). *Data center heat reuse: the opportunity for states*. <https://www.dgardiner.com/wp-content/uploads/2025/12/Data-Center-Heat-Reuse-The-Opportunity-for-States.pdf>

¹⁷ Stine, D. (2026) *Capturing heat: using waste heat generated from data centers: Appalachian responsible development opportunities, challenges, and policy options*. https://reimagineappalachia.org/wp-content/uploads/2026/02/Catching-Heat_Using-Waste-Heat-Generated-from-Data-Centers.pdf

¹⁸ Ibid.

¹⁹ Yuan, X., Liu, J., Sun, S.; Lin, X., Fan, X., Zhao, W., Kosonen, R. (2024). *Data center waste heat for district heating networks: A review*. *Renewable and Sustainable Energy Reviews*. Vol 219. <https://www.sciencedirect.com/science/article/pii/S1364032125005362>

²⁰ Jagdale, A. & Aljbouir, J. (2024). *Data Center Heat Reuse: Technology Innovation Quick Insight*. EPRI.

centers becomes usable heat, of which around 70-80% is recoverable using heat pumps”.²¹
A 2024 EPRI report identified several “Sustainability and Financial Opportunities for Data Center Heat Reuse”:

1. Improved Energy Efficiency
2. Circular Economy Integration
3. Water Conservation
4. Carbon Footprint Reduction
5. Biodiversity Support
6. Thermal Management Innovation
7. Operational Resilience
8. Sustainable Building Design
9. Environmental Compliance
10. Sustainable Cooling Alternatives
11. Heat Driven Dehumidification
12. Thermal Energy Storage Integration
13. Revenue Generation
14. Cost Considerations
15. Regulatory Compliance²²

In Virginia, the development of data center operations is driving increasing power demand and the need for new generation, potentially increasing costs for all ratepayers. As much as 40% of data center electricity is dedicated to cooling and heat capture and reuse can potentially reduce data center power demand by 10-30%²³. If this technology is adopted at scale by multiple data centers, it could help reduce energy demand and reduce the need for consumers to pay for new generation. Data center waste heat reuse can provide clean heat to many different sectors with benefits for dense urban localities and residential neighborhoods through district heating, controlled environmental agriculture (CEA) greenhouses, manufacturers in the food and beverage and pharmaceutical industries, hotels and resorts, and residential buildings and campuses.

²¹ Voswinkel, F., Delmastro, C., Reidenbach, B., Kvarnström, O. (2025, December 8). *Opportunities for district heating in the changing energy landscape*. International Energy Agency (IEA).

<https://www.iea.org/commentaries/opportunities-for-district-heating-in-the-changing-energy-landscape>

²² Jagdale, A. & Aljbour, J. (2024). *Data center heat reuse: Technology innovation quick insight*. EPRI.

²³ Gardiner, D. (2026, June 25). *Data center heat reuse [powerpoint slides]*. Virginia energy data center waste heat feasibility study workgroup. Microsoft Teams.

Waste Heat Reuse Benefits

Improved Energy Efficiency

Waste heat capture and reuse can improve energy efficiency for data center operators by reducing “non-IT energy consumption”.²⁴ While additional technologies like heat pumps are likely needed to upgrade the waste heat from data centers, exporting the heat into district energy systems can benefit communities by providing alternative heat resources for space heating (during colder months) and hot water reducing reliance on other energy sources. Additionally, EPRI asserts that “combined with renewable energy, recovered heat can help data centers achieve energy-neutral or energy-positive operations.”²⁵

Financial Benefits

Under the right configuration and with the appropriate contract agreements, there are several potential financial benefits for waste heat reuse including opportunities for revenue generation, where the data center can monetize waste heat by selling it to off-takers.²⁶ On the community side, in areas with existing district energy systems connecting with a data center operator for waste heat can reduce the potential for additional and costly energy infrastructure build out.²⁷ In areas with more stringent clean energy goals or energy mandates, investment in this technology “can enhance the financial viability of heat recovery projects”.²⁸

Environmental Impact & Community Benefits

Adoption of waste heat reuse technologies has the potential to reduce data center water consumption, which is largely needed for operational cooling.²⁹ Waste heat reuse can mitigate some of the local impacts from data centers which have caused concerns in communities. These projects can reduce water use and noise substantially, as well as reduce air pollution from new power generation.

District Energy Benefits

To address the full potential benefits of data center waste heat, it is appropriate to consider the benefits of district energy systems as this is the primary technology making waste heat usable. A 2024 IEA report highlights many opportunities for district heating in the context of

²⁴ Jagdale, A. & Aljbour, J. (2024). *Data center heat reuse: Technology innovation quick insight*. EPRI.

²⁵ Ibid.

²⁶ Ibid.

²⁷ Ibid.

²⁸ Ibid.

²⁹ Gardiner, D., Dixon, A., Kent, E., Schuster, H. (2025). *Data center heat reuse: the opportunity for states*. <https://www.dgardiner.com/wp-content/uploads/2025/12/Data-Center-Heat-Reuse-The-Opportunity-for-States.pdf>

an evolving energy system. The report asserts district heating to be the most efficient technology to recover waste heat and notes the benefits of its application as a tool to support electrification with flexibility to incorporate low-cost renewables and reduce burden on the grid.³⁰ A 2021 DOE Office of Energy Efficiency & Renewable Energy overview of district energy systems also emphasizes many of the benefits of district energy systems to include enhanced energy efficiency, energy security and resilience.³¹ A further illustration of the benefits of district energy systems to stakeholders is captured below [Figure 4].

Benefits to Customers	- Higher energy efficiency - Lower building costs (no separate boilers, chillers, or other related hardware) - Easier building operation and maintenance - Enhanced building aesthetics and comfort (reduced noise and vibration) - Improved reliability (industrial-grade district energy equipment is more robust than commercial equipment installed at building level)
Benefits to Cities and Communities	- Reduced first cost for new development - Flexibility in use of fuel sources, including local or regional fuel sources (wood waste, biomass, waste heat, etc.) that keep energy dollars recirculating in local economy - Architectural and aesthetic advantages, with roofs free of mechanical equipment - Grey water/treated sewage effluent usable for condenser water (owing to central plant scale), conserving potable water for consumption - Capacity to provide baseload power and heat for microgrids, enhancing resilience and reducing regional greenhouse gas emissions
Benefits to Grid Infrastructure	- Reduced peak demand (enabled by aggregating loads and shifting peak demand with thermal energy storage) - Fewer natural gas peaking stations - Lower transmission and distribution costs
Benefits to the Environment	- Reduced air emissions, including greenhouse gases, as a result of greater fuel efficiency of district energy systems that include CHP - Increased adoption of renewable energy sources at scale, replacing higher-emitting central station generation with low- and zero-emitting technologies - Improved stormwater management owing to free roof space, which can be used for low-impact storm water management strategies and mitigation of excessive runoff

Figure 4--District Energy Benefits by Stakeholder [Source: Department of Energy]³²

Potential End Use Case Scenarios

There are several potential end uses for waste heat captured from data centers and other industrial processes. The heat load from data centers is most applicable to low

³⁰ Voswinkel, F., Delmastro, C., Reidenbach, B., & Kvarnström, O. (2025, December 8). *Opportunities for district heating in the changing energy landscape*. International Energy Agency. <https://www.iea.org/commentaries/opportunities-for-district-heating-in-the-changing-energy-landscape>

³¹ Department of Energy (DOE). (2020). *Combined heat and power technology fact sheet series: district energy systems overview*. https://www.energy.gov/sites/default/files/2021/03/f83/District_Energy_Fact_Sheet.pdf

³² Department of Energy (DOE). (2020). *District energy systems overview*. US Department of Energy Office of Energy Efficiency and Renewable Energy (EERE). https://www.energy.gov/sites/default/files/2021/03/f83/District_Energy_Fact_Sheet.pdf

temperature heating needs and is generally not suitable for high temperature processes in manufacturing. Through stakeholder workgroup discussions and review of several bodies of research, below are some potential applications for data center heat reuse.

- Connections with existing district energy networks to heat residential communities, hotels, swimming pools at community centers, university campuses, hospitals, military campuses, and government buildings.
- Agricultural centers, CEA greenhouses, or multi-use agribusiness commerce parks.
- Food and beverage processing facilities.
- Pharmaceutical industry and medical research facilities.
- Thermal evaporation process to produce clean water.

Besides the end-use sectors, already mentioned, the technology can also be applied to end-use processes such as:

- Space heating,
- Domestic hot water,
- Sanitary water,
- Cleaning water,
- Hot water for heating processes (e.g. pasteurization);
and
- Pool heating.

Challenges and Barriers

Virginia's challenge is not a single, uniform barrier to waste heat reuse, but a set of cost, market, and institutional hurdles that vary across regions. These barriers include high infrastructure costs, weak business cases (where engineering works but financial case is weak because the value of recovered heat is modest relative to the build out cost), unsettled legal and regulatory pathways, underdeveloped heat markets, and supply-chain and planning timelines that can take years to align.

Cost

Cost is the most commonly cited barrier for adoption of technology. Retrofitting existing data centers or existing buildings with infrastructure to support heat capture and district heating is costly, time-consuming, and in most cases uneconomical compared to the alternative. Early research recognizes the potential of data center waste heat as a novel energy source for district heating systems because it can increase overall efficiencies but

notes that operators are hesitant to adopt the technology due to unknown costs.³³ Novel heat sources are ranked according to short term marginal generation costs to help determine the maximum price utilities should pay for waste heat energy.³⁴ An investment analysis recognized that there are economic benefits for data center operators in certain scenarios. The investigation determined that waste heat reuse is not economical for most small data center operations because the cost of equipment outweighs the benefits but for medium and large case scenarios the technology is more economical.³⁵

Stakeholder workgroup discussion assessed other alternatives and determined that new builds of data center heat reuse systems paired with new or existing district heating were generally more economical project types but still required significant up-front capital.

System Seasonality & Heat Load Mismatch

The largest obstacle with waste heat recovery systems is the seasonal demand of heating in Virginia's climate. Despite generating heat constantly, the majority of end users only require heat in the fall and winter. Also, the waste heat may not be hot enough for residential uses and require additional heating or heat pump technology to be usable.³⁶ The mismatch of heating needs from consumers and heat loads from data center operators was discussed at length with the stakeholder group, highlighting that a one-size-fits-all solution is not applicable to this technology. Due to the mismatch, data center operators suggest a back-up heat source is needed to ensure system reliability. In Denmark, electric or fuel oil boilers are often used as back-up and peaking plants in the district heating system.

Public Sentiment

Siting and zoning issues come up frequently in the energy sector as barriers. There have been local movements across the Commonwealth that oppose the building of new energy infrastructure from solar to natural gas to transmission lines. Some new data center projects have experienced opposition from local residents. Adding a waste heat element may present both positives (for example, additional community benefit through lower-cost energy, reduced water use, air pollution, and noise, or clean heat to co-located business

³³ Thommessen, C., Verheyen, J., Roes, J., & Hoster, H. (2025, December 15). *Estimating the value of novel heat sources in district heating systems from the perspective of energy utilities using a merit order approach*. Applied Energy. Vol. 401, Part A. <https://doi.org/10.1016/j.apenergy.2025.126594>

³⁴ Ibid.

³⁵ Pärssinen, M., Wahlroos, M., Manner, J., Syri, S. (2019, January). Waste heat from data centers: An investment analysis. Sustainable Cities and Society. Vol. 44. (pp. 428-444)

³⁶ Yuan, X., Liu, J., Sun, S.; Lin, X., Fan, X., Zhao, W., Kosonen, R. 2024. *Data center waste heat for district heating networks: A review*. Renewable and Sustainable Energy Reviews. Vol 219. <https://www.sciencedirect.com/science/article/pii/S1364032125005362>

users) and negatives (for example, further construction within the local area) in terms of public perception of projects.

Challenges Connecting Data Centers with Waste Heat Users

Data centers and potential users of their waste heat typically find it difficult to connect with each other as potential partners, as neither is likely to be aware of the other's development plans. It is efficient for data centers and their heat users to be located near to each other as it can be expensive and complicated to transport heat long distances.

Location Risks

The viability of waste heat reuse is inherently location specific. Feasibility depends on the exact data center design, heat temperature, load profile, distance to the user(s), topography, rights-of-way, utility infrastructure, permitting requirements, land ownership, and the user's operating schedule. End users at specific locations will need to be interviewed and engineering assessment performed to assure long-term viability and sustainable use of waste heat infrastructure if constructed.

Data centers are often zoned separately from potential consumers by design, however, future planning strategies could consider co-location of data centers by light manufacturing or other potential end-users, such as food and beverage processing plants, that would act as a continuous off-taker year round.³⁷ While the siting of the industrial zones can be seen as a barrier, some opportunities may arise near the "boundaries" of those commercial/industrial and residential zones.

Timelines & Planning

For the most successful outcomes, district heating and waste heat reuse requires advanced planning and stakeholder coordination. For example, the UVA Fontaine Research Park, described below in the Virginia Initiatives section, took 10-15 years of planning to come to fruition. Other factors impacting the potential for buildout in a timely manner include an underdeveloped market and supply chain issues.

VA Landscape and Opportunity Overview

Virginia is home to the largest data center market in the world, housing 35% (almost 150) of hyperscale data centers worldwide.³⁸ Since the 1990s, when America Online (AOL)

³⁷ Stine, D. (2026) *Capturing Heat: Using Waste Heat Generated from Data Centers: Appalachian Responsible Development Opportunities, Challenges, and Policy Options*. https://reimagineappalachia.org/wp-content/uploads/2026/02/Catching-Heat_Using-Waste-Heat-Generated-from-Data-Centers.pdf

³⁸ Virginia Economic Development Partnership (VEDP). 2026. The World's Largest Data Center Market. <https://www.vedp.org/industry/data-centers>

established a headquarters in Northern Virginia and Equinix its first data center campus, Virginia has built a robust data center market and industry which serves as a significant economic engine for the state.³⁹ Virginia's significant collection of data center campuses, critical infrastructure, such as the first subsea cable connection in the mid-Atlantic, sales tax incentives, and proximity to the nation's capital continue to make it an advantageous location for data center operation. Additionally, the Commonwealth's largest Investor-Owned Utility (IOU), Dominion Energy Virginia, has considerable expertise in data center infrastructure and service. Dominion's 2026 Q1 Earnings Call presentation revealed that since December 2025 its data center contracted capacity has grown 5%, from 48.5GW to 51GW.⁴⁰ The Joint Legislative Audit and Review Commission's (JLARC) 2024 Data Center Report puts economic impact of data centers in the Commonwealth at \$5.5 billion in labor income and \$9.1 billion in GDP annually.⁴¹ EPRI's Powering Intelligence 2026 Report highlights that Virginia is the only state in the nation where data centers consume over 20% of electricity demand with that estimated to grow to between 39 and 57% by 2030.⁴² In light of Virginia's position as a leader in the data center industry, warnings from PJM and NERC regarding energy supply challenges and Virginia's clean energy goals, it is paramount to explore alternative energy pathways.

Virginia Data Center Waste Heat Reuse Initiatives

Several regions and localities across the Commonwealth have done significant work on data center waste heat reuse adoption. From several feasibility studies to work group collaboration and pilot programs, Virginia localities are leading the way to make data center waste heat reuse a reality.

Home to "Data Center Alley", the Northern Virginia Regional Commission (NVRC) has been studying the potential of data center waste heat reuse coupled with district energy systems since 2011. Part of NVRC's initial efforts in 2011 involved considering data center waste heat reuse coupled with district energy systems in the comprehensive energy and climate plans for Loudoun County and Arlington. Consultant Peter Garforth shared:

As part of the Loudoun County plan, we collectively (Garforth International LLC (GIL) / NVRC) made the recommendation to implement a "Scale Project" around a

³⁹ Virginia Economic Development Partnership (VEDP). 2019. The Dawn of Data. Virginia Economic Review: Fourth Quarter 2019. <https://www.vedp.org/news/dawn-data>

⁴⁰ Dominion Energy Virginia. (2026, May 1). Q1 2026 Earnings Call [PowerPoint Slides]. https://s2.q4cdn.com/510812146/files/doc_financials/2026/q1/2026-05-01-DE-IR-1Q-2026-earnings-call-slides-vTC.pdf

⁴¹ Joint Legislative Audit and Review Commission (JLARC). (2024). Report to the Governor and the General Assembly of Virginia: Data Centers in Virginia. <https://jlarc.virginia.gov/pdfs/reports/Rpt598.pdf>

⁴² Electronic Power Research Institute (EPRI). (2026). Powering Intelligence 2026: Updated Scenarios of U.S. Data Center Electricity Use and Power Strategies [White Paper].

neighborhood / data centre integration using heat recovery combined with modern district energy structures to jump-start district heating and cooling services in the wider community. This Scale Project was to pilot the policy, institutional and market structures at a scale that was “large enough to be serious” and “small enough to have a chance of happening”. This recommendation was supported by at least one data centre developer at the time. The Plan as a whole was formally approved by the County Board of Loudoun.

In the Arlington Plan, while not directly tied to data centres, the development of neighbourhood scale district energy in defined and quantified areas of the County was also part of the recommendation. The then accelerating development in Crystal City was recommended as the “Scale Project”. The Arlington Plan was endorsed by a community task force and approved by the County Board.

Garforth added that since the recommendation in 2011 and despite support from relevant stakeholders and regulatory bodies, there has been no real progress in these two counties in creating District Energy Utilities to serve either locality.

NVRC’s most recent 2025 Synthesis Report concluded that potential for data center heat reuse coupled with district energy systems has strong potential in the Commonwealth arguing that the biggest barrier is not the technology but rather commercial alignment in the areas of construction timelines and incentives for “data center developers, district energy operators, utilities, and public authorities”.⁴³ The report noted the opportunity for adoption of this technology at scale in Virginia through stakeholder collaboration focused on “area-based heat planning, GIS-enabled thermal mapping, and early land-use coordination”.⁴⁴ In addition to studies, NVRC has developed an interactive map identifying data centers with proximity to public facilities to help identify potential district energy opportunities.⁴⁵ The report emphasizes the importance of early planning, coordination, and infrastructure. In collaboration with NVRC, Energy Staff at several Northern Virginia jurisdictions have been researching the applicability of district energy near data centers. For example, the Loudoun County Board of Supervisors’ Transportation and Land Use Committee added district energy to the County’s Environment and Energy Workplan in April 2024.

⁴³ International District Energy Association (IDEA), Ministry of Foreign Affairs of Denmark (MFA), Northern Virginia Regional Planning Commission (NVRC), & Ramboll. (2025). Synthesis Report: Data Centers & District Energy Northern Virginia Workshop.

⁴⁴ Ibid.

⁴⁵ Northern Virginia Regional Commission (NVRC). NVRC Map. Arc GIS.
<https://www.novaregion.org/1598/Data-Centers#map>.

In Central Virginia, the University of Virginia is leveraging operational expertise of owning and operating existing district energy systems on UVA Grounds to develop a model of sector coupling, connecting a new Central Energy Plant that will provide heating and cooling to the newly constructed Paul and Diane Manning Institute of Biotechnology from a planned data center. The data center will be constructed in close proximity to the campus's Central Energy Plant which will provide cooled water to the data center and "return waste heat back to the plant to be used for hot-water heating for all buildings".⁴⁶ At the second stakeholder workgroup meeting, UVA Director of Energy and Utilities, Paul Zmick, Ph.D. presented to the group about this project and the district energy system on the UVA campus in Charlottesville. The Fontaine Data Center has a planned initial capacity of 4MW with a final capacity of 16MW and will utilize a 44°F/ 64°F loop for air cooling, as well as an 80°F/ 100°F loop for direct liquid cooling (DLC).⁴⁷ The project's current phase is building out to the approximate 4MW initial capacity with high performance computing (HPC) cooling from an 80°F/ 100°F chilled water system, with heat recovered by full lift heat recovery chillers. Zmick also reviewed several operating scenarios explaining the technology:

When there is a large compute load, nearly the entire heating demand to the Fontaine Research Park will be satisfied by waste heat from the HPC Machine at a COP of 19. During times of lower heating demands, but still large compute loads, excess heat will be rejected through cooling towers. During times of lower compute loads, but large heating demands are present, heat recovery chillers will amplify heat from chilled water geothermal systems to supplement electric boilers to produce heating hot water.

The Fontaine Research Park helps UVA work towards their clean energy goals and is slated to be open by 2029. The total project cost to date is \$102 million.⁴⁸

In Southside Virginia, GO Virginia Region 3 has been researching the potential of data center colocation with industrial campuses, specifically controlled environment agriculture (CEA) greenhouses. At the second stakeholder workgroup meeting, Program Director for Southern Virginia/GO Virginia Region 3, Bryan David, presented on their 2025 *Colocating Data Centers & Greenhouses Feasibility Report* created in collaboration with

⁴⁶ Kelly, M. (2026, March 9). New Data Science Entrepreneurship Building planned for UVA's Emmet-Ivy Corridor. UVA Today. <https://news.virginia.edu/content/new-data-science-entrepreneurship-building-planned-uvas-emmet-ivy-corridor>

⁴⁷ Zmick, P. (2026, July 9). Data Centers and District Energy at UVA [PowerPoint slides]. Virginia Energy Data Center Waste Heat Feasibility Study Workgroup. Microsoft Teams.

⁴⁸ Velazquez, D. (2026, June 17). University of Virginia's Planned Data Center Grows to \$102M. Government Technology. <https://www.govtech.com/education/higher-ed/university-of-virginias-planned-data-center-grows-to-102m>

the Resource Innovation Institute. The feasibility report concluded that while colocating a data center with one greenhouse is not economically viable due to mismatch of heat loads, “colocating data centers with multiple, large-scale greenhouses and other complementary industrial businesses would provide a number of economic and quality of life benefits for Virginia communities”.⁴⁹ The report also notes colocation of data centers at industrial farm parks is beneficial to data centers and rural localities because it helps pushback against negative sentiment of data centers by helping to sustain jobs through agriculture work and help localities meet sustainability commitments. Beyond the presentation and feasibility report, the white paper submitted to the Department serves as a reference resource for the report: *The Southern Virginia Data Center–CEA Greenhouse Colocation Opportunity as a Public Policy Model for Competitive Business Investment, Job Creation, and Accelerated Data Center Waste Heat Use*. The white paper develops the public policy case, financing structure, and siting analysis in more depth than the workgroup presentation alone, including the case that rural Virginia's lower land costs and existing agricultural base make it a genuine economic-development opportunity for this technology.

Arlington-based environmental consulting firm David Gardiner and Associates has done significant research on data center waste heat opportunities, provided policy recommendations and maintains a waste heat reuse newsletter, listserv and working group focused on waste heat adoption at scale. David Gardiner and Associates work has helped build several related member-based coalitions at the Renewable Thermal Collective and the Combined Heat and Power Alliance, where they continue to provide support.

Research groups led by Xudong (Andrew) Fan, Ph.D., Assistant Professor of University at Buffalo, and Xijin (Emma) Zhang, Ph.D., Assistant Professor of George Mason University, are developing complementary modeling capabilities to support data center waste heat reuse planning and stakeholder coordination. Dr. Fan's research group is developing an AI-enabled, automated thermal-hydraulic-economic-environmental assessment tool to rapidly evaluate “what-if” scenarios for data center waste heat recovery and reuse. The tool maps and simulates thermal networks to optimize heat redistribution while assessing economic and environmental performance. In parallel, Dr. Zhang's research group is developing building energy simulation and data-driven methods to estimate the location, magnitude, timing, and temperature requirements of potential stakeholders' heating needs. Together, these efforts aim to connect available data center waste heat with suitable end users, identify promising opportunities for thermal-network development and support early-stage feasibility assessment, infrastructure planning, and stakeholder

⁴⁹ Smith, D. & Eddy, R. (2025, June). Colocating Data Centers & Greenhouses Feasibility Report. Resource Innovation Institute.

engagement. Drs. Fan and Zhang presented this work to the Loudoun County Sustainable Energy Committee on behalf of their respective faculty-led research groups.

Additionally, there are several data center operators, developers, IT solution experts and digital infrastructure experts in the Commonwealth with experience and expertise in data center waste heat reuse. A few identified during the stakeholder workgroup include:

- Equinix—Digital infrastructure solutions firm with expertise in data center colocation and operator of a Heat Export program. Equinix operates 23 data centers in the Commonwealth.⁵⁰
- STACK Infrastructure—Data center developer with experience in Europe with waste heat reuse and data center design. STACK Infrastructure operates 2 data center campuses in Virginia.⁵¹ A new data center campus has just been confirmed in Berryhill, Virginia.⁵²
- Alfa Laval—a global provider of products related to heat transfer, separation, and fluid handling with a goal of helping to transition to cleaner fuels and increase electrification.⁵³ Alfa Laval maintains an office and manufacturing facility in Richmond, Virginia.
- Ramboll—a global engineering, architecture, and consultancy firm with experience in district energy planning, data center heat recovery, and integrated energy infrastructure. Ramboll America’s head office is in Arlington and Ramboll supported the Northern Virginia data centers and district energy workshop which helped to frame practical pathways for data center waste heat reuse. Ramboll’s international data center and district heating expertise, including experience from European markets, provides local expertise and a useful perspective for Virginia as it evaluates how to move data center waste heat from feasibility toward implementation.

Key Opportunity Regions

The Department developed some opportunity zone maps to identify potential hot spots for technology development. The criteria for these maps outlined existing data centers and potential data centers, as well as public and critical infrastructure such as schools, hospitals and government buildings. As the project developed, however, it became clear

⁵⁰ (2026). Equinix: Virginia Data Center Locations. DataCenters.com. <https://www.datacenters.com/providers/stack-infrastructure/locations/united-states/virginia><https://www.datacenters.com/providers/equinix/locations/united-states/virginia>

⁵¹ (2026). STACK Infrastructure: Virginia Data Center Locations. DataCenters.com

⁵² Mamon, G. (2026, June 30). Stack Infrastructure says it’s moving forward with AI data center in Pittsylvania. Cardinal News. <https://cardinalnews.org/2026/06/30/stack-infrastructure-says-its-moving-forward-with-ai-data-center-in-pittsylvania/>

⁵³ Alfa Laval. (2026). What We Do. Alfa Laval. <https://www.alfalaval.us/about-us/our-company/>

that, due to the need for advanced planning and coordination and cost barriers to retrofit existing infrastructure, the most economical scenarios would likely be proposed data centers in early planning phases near existing district energy systems or near sites that have greenfield potential for building synergistic systems to off-take heat like farm parks or food and beverage processing facilities.

The Farm Park Playbook is developing a replicable siting methodology that screens VEDP's certified sites database and the Virginia Business Ready Sites Program offering a potential statewide model for identifying "waste heat ready" greenfield sites. This siting methodology is discussed in further detail in GO Virginia Region 3's white paper. The Playbook's Site Readiness and Infrastructure Capacity Assessment element outlines specific criteria, including energy and fiber capacity, water/wastewater and road infrastructure, zoning and permitting pathways, and phased-expansion capacity thresholds. The white paper also cites industry estimates of roughly \$45,000 per acre for rural Southern Virginia data center sites, compared to \$1-2 million per acre in Northern Virginia—a cost differential that positions rural colocation sites as credible competitors for large-scale investment.

While the most economical project will likely be a new build, there is still potential in areas with existing data centers, especially considering strong stakeholder engagement and coordinated partnerships in regions like Northern Virginia.

Although Virginia has the largest data center market in the world, the near-term physical heat reuse opportunity is constrained by limited existing thermal energy network infrastructure, lower heating demand than colder jurisdictions, and the tendency for large data center campuses to locate away from dense heat loads. This makes targeted planning, opportunity zoning, and pilot projects especially important.

The International District Energy Association (IDEA) maintains an interactive map detailing the locations of existing district energy systems. The figure below shows the existing district systems in the Commonwealth, which are primarily college & university campuses, military installations, airports, hospitals, and local utilities.

District Energy Systems



DIRECTIONS:

Use the tabs above to switch between maps for North America, the United States, and Canada...

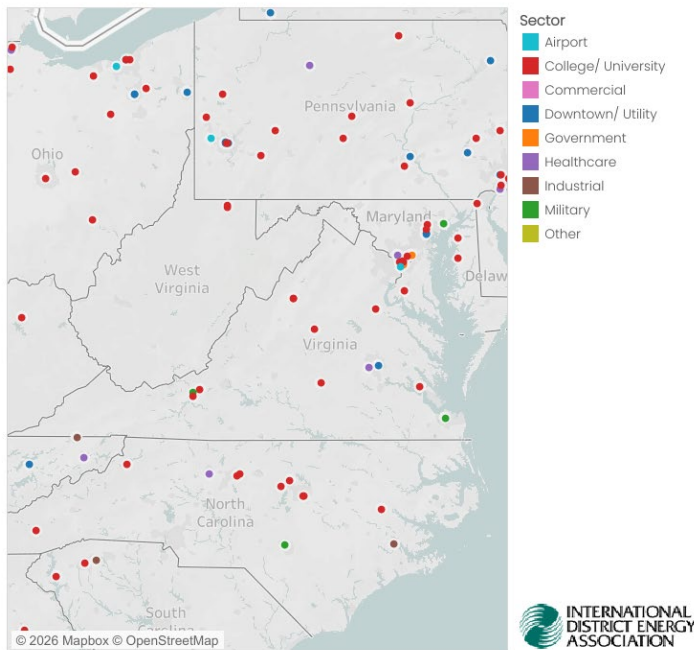


Figure 5--District Energy Systems in Virginia [Source: International District Energy Association (IDEA)]

According to IDEA, the following sites have existing district energy infrastructure:

- James Madison University—Harrisonburg, VA
- University of Mary Washington—Fredericksburg, VA
- Ronald Reagan Washington National Airport—Arlington, VA
- Virginia Polytechnic Institute and State University—Blacksburg, VA
- Radford University—Radford, VA
- US Army, Radford Ammunition Plant—Radford, VA
- Longwood University—Farmville, VA
- US Navy Southeastern Tidewater Energy Project—Norfolk, VA
- Virginia Commonwealth University—Richmond, VA
- Johnston-Willis Hospital Facility—Richmond, VA
- University of Virginia—Charlottesville, VA

Economic Opportunities

The business case for waste heat technologies still needs to be defined for data center operators and communities. Further research is needed in this area and is critical to developing this emerging market. The stakeholder workgroup discussed several opportunities and potential economic frameworks that make the adoption of data center waste heat reuse economically viable. Key to the success of this economic proposition is early planning and coordination.

The Virginia Economic Development Partnership (VEDP) presented on the economic potential of waste heat technologies. The presentation and discussion identified waste heat reuse as potentially transformative for Virginia communities and as a marketable asset, especially for the food and beverage and pharmaceutical industries. The discussion focused on identifying strategic ways to consider waste heat reuse applications as an economic asset. Strategic considerations included:

- Informed engineering design that factors in water and energy conservation
- Education and Community Benefits value proposition
 - Reduced energy costs, water use, noise, air pollution, and carbon footprint
 - Reduced electricity demand mitigating grid strain during peak
 - Supporting food/energy security
 - Providing clean heat to local residents or businesses.
- Co-location of data centers and end users is critical
- Early alignment with localities and land use planning
- Need to package the solution clearly for local adoption

Bryan David, the GO Virginia Region 3 Representative, presented on his work with Resource Innovation Institute on the economic potential of data center colocation with controlled environmental agriculture (CEA) on industrial farm parks with multiple operations receiving heat from a data center. Examples of CEA include indoor farming, vertical farming, or greenhouses.⁵⁴ GO Virginia Region 3, working with Resource Innovation Institute, proposed this solution as an economical way to build off “existing agricultural industry presence and heritage” and build data centers in rural Virginia.⁵⁵ The plan also involves leveraging the expertise of the Controlled Environment Agriculture Innovation Center based in Danville, as a partnership between Virginia Tech and the Institute for Advanced Learning Research.⁵⁶

⁵⁴ Virginia Tech Center for Economic and Community Engagement. (2023) *Controlled Environment Agriculture Strategy and Roadmap in GO Virginia Region 3*.

⁵⁵ Ibid.

⁵⁶ Ibid.

The most economical model, according to the research is “an integrated Farm Park model that utilizes a combined heat power (CHP) microgrid to provide cooling of the data center water loop while providing power, heating, cooling and CO₂ enrichment for the greenhouse and other collocated businesses in the farm park hub”.⁵⁷

The model, as envisioned, pairs public ownership of the shared power and heat generation and distribution infrastructure with a competitively procured private operator, financed through tax-exempt public infrastructure bonds. The intent is for the data center, greenhouse, and future tenants to draw power and heat at cost (priced to cover debt service, operating costs, and capital equipment costs, not a private return), removing the risk that the shared infrastructure could later be sold to a private party on different terms. This financing and governance structure is developed in more detail in the white paper and reiterated in the Playbook's Public Infrastructure Financing and Site Improvement Strategy and Governance, Infrastructure Stewardship, and Strategic Coordination Framework elements. Below is an illustration of the economic model of the farm park [Figure 6].

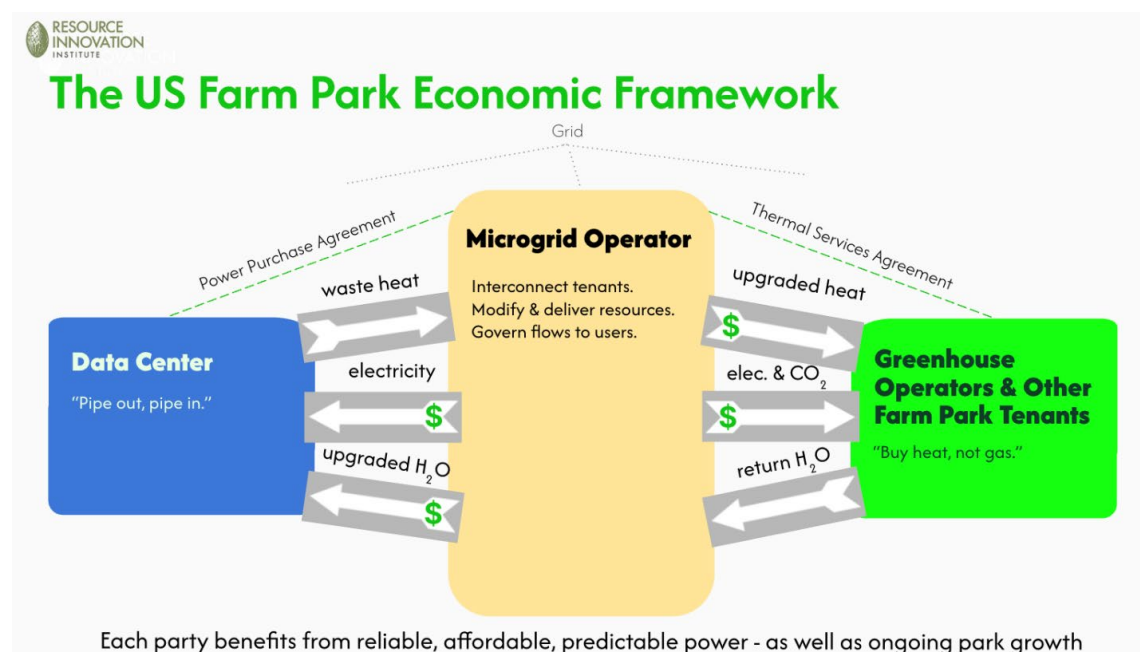


Figure 6--US Farm Park Economic Framework [Source: Research Innovation Institute]

The farm park model provides many potential economic benefits including job creation and workforce diversification, economic multiplier effect (bringing like-industries to the area - agriculture attracting other agriculture, data centers attracting more IT etc.), local food

⁵⁷ Smith, D., & Eddy, R. (2025, June). *Colocating data centers & greenhouses feasibility report*. Resource Innovation Institute.

production and resilience, and tax base and investment.⁵⁸ GO Virginia 3 and the Resource Innovation Institute also created a Farm Park Implementation Playbook, as a reference for developing waste heat adoption at scale.

Many data centers will locate in or near population centers. It will be important to develop waste heat reuse economic development models which will work in more populated areas, where commercial and public buildings, such as hotels, hospitals, and schools, as well as residential buildings will be the primary heat users.

The business case for heat reuse may be stronger for the district energy provider, heat user, or community than for the data center operator itself. For data centers, avoided cooling costs may be modest relative to total capital and operating costs, while the perceived risks of delayed delivery, added complexity, or reduced reliability can be significant. This reinforces the need for early commercial alignment, clear risk allocation, and policy tools that recognize both the system-level benefits and the project-level costs.

Data Center Considerations

International District Energy Association President and CEO, Rob Thornton, posits that there are two types of data center operations that lend themselves to district energy adoption:

Urban retail data centers: Retail – or boutique – data centers with energy demand in the 10-20 MW range and located in cities often serve multiple local data users. These are often located in a city with an existing district energy system.

*Large remote data centers: Large, hyper-scale data centers with energy demand starting at 100 MW and reaching as high as 1 GW are being built in remote locations for single users, requiring robust firm power supplies. A combined heat and power (CHP) installation with a gas turbine, thermal energy storage and an absorption chiller can essentially operate as a district energy system for a large data center or cluster of data centers”.*⁵⁹

Resource Innovation Institute’s research with GO Virginia Region 3 highlights the importance of matching the appropriate technologies with waste heat reuse potential. While there are several opportunities for waste heat technology adoption by data center developers, it is important to identify the data center design and waste heat type. Figure 7

⁵⁸ Smith, D., & Eddy, R. (2025, June). *Colocating data centers & greenhouses feasibility report*. Resource Innovation Institute.

⁵⁹ Thornton, R. (2025, July 8). How to Put the Heat from Data Centers to Good Use. DataCenter Knowledge. <https://www.datacenterknowledge.com/cooling/how-to-put-the-heat-from-data-centers-to-good-use>

from the Resource Innovation Institute’s *Colocating Data Centers & Greenhouses Feasibility Report* outlines these differences.

Data Center Type	Typical Outlet Temperature	Cooling Method	Notes
Legacy Architecture (Not Designed for Reuse)	30–40 °C (86–104 °F)	Air-cooled or low-temp chilled water loops	Dominant in older data centers; waste heat not reused; not suitable for thermal recovery.
Standard Water-Cooled (Non-AI Workloads)	45–55 °C (113–131 °F)	Rear-door heat exchangers, direct-to-chip liquid cooling	Used in many modern enterprise/cloud data centers; suitable for low-grade heat reuse. Supplemental heating systems required on coldest days.
AI/HPC-Optimized (High-Density Workloads)	55–70 °C (131–158 °F)	Direct liquid cooling, immersion cooling	Emerging trend in AI data centers; high outlet temps enable efficient heat recovery and reuse applications. May not require supplemental heat.
AI/HPC with Two-Phase Refrigerant Systems	Up to 90 °C (Up to 194 °F)	Direct liquid cooling, immersion cooling for experimental or mobile deployments	Liquid refrigerant that boils into vapor upon absorbing heat; would not require supplemental heat.

Figure 7-- Data Center Waste Heat by Type [Source: Research Innovation Institute]⁶⁰

This chart highlights the trend towards liquid and immersion cooling for data centers. As the chart indicates, these cooling approaches, especially immersion cooling, capture more heat from the data center and can deliver higher levels of heat to potential off-takers without the need for a heat pump. These technologies also can reduce water use substantially as they can operate in the closed loop. In other words, increased adoption of cooling technologies that capture more heat improves the potential for waste heat reuse.

A stakeholder workgroup presentation from data center operator STACK Infrastructure identified key considerations data centers make in weighing the feasibility of waste heat adoption based on their operating experience in Europe. STACK infrastructure outlined five key factors for decision-making: (1) proximity to off-takers, (2) existing infrastructure (i.e. district energy systems to plug into), (3) IT Load (ramping load considerations), (4) Connectivity (matching of output heat to off-taker need), and (5) Contracts (outlining specific agreements related to heat guarantee, cost, equipment maintenance and payment expectations). The STACK infrastructure presentation highlighted the importance of understanding the very specific technical needs of each project—namely matching specific temperature needs with appropriate off-takers, assessing need for additional technologies such as heat pumps and recognizing that IT load and heat is not guaranteed, especially for a large campus with multiple and varied data center operations.

⁶⁰ Smith, D., & Eddy, R. (2025, June). *Colocating data centers & greenhouses feasibility report*. Resource Innovation Institute.

Similar technical issues and potential areas for further research and analysis were identified in the stakeholder survey:

- Respondents indicated that all waste heat is not equally usable.
 - Data center heat is often low-temperature and may need heat pumps to meet heat network operator temperature requirements.
 - The feasibility screen should include supply temperature, return temperature, required lift, and heat pump COP
 - Heat reuse must be designed so it does not reduce data center cooling redundancy, service availability, maintainability, or customer commitments.
 - External heat users should not become a single point of failure for heat rejection
- Respondents stated the importance of determining whether the heat is treated as a commodity, community benefit, energy efficiency measure, utility service, or something else. That classification affects key aspects of a potential project, including contracts, rates, incentives, ownership, risk allocation

Knowledge Sharing Framework

Existing Channels of Communication

The Department is tasked with developing a framework of information sharing to facilitate the development of waste heat recovery technologies through connecting relevant stakeholders, namely connecting excess heat producers with potential excess heat end-users. Through the study's stakeholder workgroup meetings, several existing communication channels and collaborative efforts were identified. The Northern Virginia Regional Commission (NVRC) has been studying and collaborating since 2011 to identify feasible opportunities for district energy systems and data center waste heat recovery. This collaborative effort has identified several key stakeholders from localities to universities, to industry experts, many of whom have contributed to and participated in this study. David Gardiner and Associates, based in Arlington, Virginia, has created a waste heat newsletter and on-going work group aimed at connecting industry stakeholders to address data center waste heat recovery potential and application. Many members of the study stakeholder workgroup also participate in international and regional cohorts focused on district energy like the International District Energy Agency (IDEA). Key to continuing this work will be building on existing communication channels and leveraging these networks of engaged stakeholders.

The Department's Data Center Waste Heat Feasibility Work Group had productive meetings with robust discussion, with the typical meeting attendance around 35-40 participants from diverse backgrounds, including manufacturing experts, economic development experts, locality and planning experts, local sustainability experts and data center operators. This group shows strong engagement and demonstrates the potential moving forward to support a sustainable communication framework.

Key criteria for helpful information for decision makers

The stakeholder workgroup and research identified many information needs to help decision makers adopt waste heat technologies. Decision-makers include the data center industry, localities and planning professionals, economic development professionals, and the public. Information needs could include:

- Map of Opportunity Zones
- Data related to excess heat available and heat needs of potential off-takers
 - Standards and KPIs such as ISO/IEC 30134-6 Energy Reuse Factor (ERF) that quantify the total data center energy consumption that is recovered and reused outside the data center boundary, typically in the form of waste heat⁶¹
- Guidebook/Tool kit for Localities
 - Waste Heat 101—explaining the basics of the technology.
 - Potential Uses—outlining applications of the technology.
 - Template for MOU/Community Benefit Agreements—guidance on beneficial contract terms for waste heat producers and waste heat receivers.
 - Model Ordinances—technical basics for siting or co-locating data centers with district energy systems or industrial business parks.

Existing Tools & Resources for Planners & Localities

The tools listed below can serve as reference points for technical staff at planning departments, planning commissions, and localities.

- NLR Urban Renewable Building and Optimization—
<https://www.nlr.gov/buildings/urbanopt>
- Resource Innovation Institute—*Colocating Data Centers & Greenhouses: Feasibility Report (June 2025)*
- Resource Innovation Institute, Institute for Advanced Learning and Research and GO Virginia Region 3—*Elements of the Farm Park Implementation Playbook [Working Draft-Planning Framework]*

⁶¹ Westerhoff, A & Wilkens, M. (2026). *ISO/IEC 30134 Whitepaper: Overview of different data centre infrastructure KPIs* [Whitepaper]. ISO. <https://www.iso.org/committee/654019.html?view=documents>

- International District Energy Association (IDEA)—
<https://www.districtenergy.org/about/about-idea>
- American Planning Association (APA) Planning Advisory Service *Quicknotes: Data Center Waste Heat Recovery*
- EPA State & Local Energy and Environment Program *Benchmarking and Building Performance Standards Policy Toolkit—Section 1: Building Energy Benchmarking and Transparency: Overview for State and Local Decision Makers*
- Sustainable Energy Authority of Ireland—*District Heating Feasibility Standardised Template A “How-To-Guide”*—<https://www.seai.ie/sites/default/files/2025-03/District-Heating-Feasibility-Study-Template-How-to-Guide.pdf>
- Climate Mayors—*Data Centers and the Climate Landscape: An Actionable Resource for US Mayors* (January 2026)
- Ramboll—*Developing Sustainable Data Centres: A strategic roadmap to achieve net zero carbon and reduce environmental impact* (2025)

Best Practices & Policies

Data center waste heat reuse and sector coupling with district energy systems is an emerging industry in the Commonwealth and not adopted at scale in the US. The best frame of reference for successful project implementation comes from Europe which has the most real-world examples. There are significant differences between the US and Europe that have enabled wider adoption and application of waste heat reuse in Europe. Differences include: (1) Infrastructure—widescale adoption of district energy, (2) Climate—colder, (3) Regulatory structures and mandates—clean energy directives and excess heat reporting requirements. Successful district heating typically requires a minimum of four parties working in concert over many years: the heat source operator, government planners incorporating district heating into development plans well in advance, a network operator to capture and distribute heat, and end-user buildings designed with district heating connections from the outset, generally within approximately 1.25 miles of the source. The absence of any one of these makes a project very difficult to execute. Generally, best practices for successful projects have included early planning, data sharing and transparency, and coordinated industry. Key to success is proper engagement with stakeholders and decision makers, education and engagement with communities, and clean business models outlining community benefits and business contracts.

A recent Bipartisan Policy Center (BPC) Report titled *Key Considerations for Data Center Development* (2026) outlines five key considerations for successful and mutually beneficial

data center development including: (1) Transparency and communication, (2) Power and water: utilization, infrastructure, and affordability, (3) Quality of Life: Facility risk and community impact, (4) Land use and environmental impacts, and (5) Economic Development.⁶² These recommendations mirror the key considerations in successful projects and can serve as a guide for best practices for data center waste heat reuse projects.

Waste Heat Use at Scale in Europe

Waste heat recovery technology has most been adopted at scale in Europe in countries that have developed extensive district energy networks and thermal energy networks. On a European level, the European Union mandates the implementation of energy efficiency measures, reporting of energy use and development heating and cooling strategies from the member states as part of the EU Energy Efficiency Directive (EED). These place requirements on data center operators, such as mandatory reporting of renewable energy and heat-reuse fraction. It also requires regular investigations into energy efficiency opportunities. Denmark has focused on capturing excess heat from industrial users, including data centers. To aid the development of this report, representatives from the Danish Energy Agency shared the country's process for adoption and application of heat reuse, from data collection to mapping and build out. Waste heat recovery technologies have been part of the Danish energy plan since the 1970s, where they first captured excess heat from power plants' flue gases and used it to heat residential areas through district energy systems.⁶³ According to the Danish Energy Agency, nearly "70% of residential heating demand is covered through district heating systems".⁶⁴ The Danish Energy Agency summarized their regulatory framework in five steps: (1) Heat mapping, (2) Incentives and voluntary agreements, (3) Reporting of energy use and excess heat, (4) Heat planning and heating acts, and (5) Efficient use of energy in buildings and industry.⁶⁵ A key strategy in adoption of this technology is information gathering and transparent data sharing to identify excess heat and match with potential waste heat end users. The European Union and several European countries have energy efficiency mandates and clean energy goals that facilitate the adoption of this technology at scale.

A few European data center waste heat projects were discussed during the development of this report including: (1) Meta data center waste heat reuse project in Odense, Denmark,

⁶² Kline Tyndall, K., Cowie-Haskell, A., Turyahikayo, S., Byham-Maier, Z., Hill, D.R., Profeta, T. (2026, July 29). *Key Considerations for Data Center Development* [Report]. Bipartisan Policy Center. <https://bipartisanpolicy.org/report/key-considerations-for-data-center-development/>

⁶³ Danish Energy Agency. 2026. *Excess heat utilization and efficiency: Experiences from Denmark with Data Centers* [White Paper].

⁶⁴ Ibid.

⁶⁵ Ibid.

(2) Equinix in Frankfurt, Germany, and (3) STACK Infrastructure OSLO1A data center in Oslo, Norway, and (4) Amazon Web Services Dublin-Tallaght District Energy in Dublin, Ireland.

Meta Data Center—Odense, Denmark

A representative from the Danish Energy Agency presented at the first meeting of the stakeholder group and highlighted the success of the Meta Data Center operation in Odense, Denmark. This project has been operational since 2019 with the district energy system providing heat for 100,000 households and the connected data center can provide heat to approximately 11,000 of those households.⁶⁶ The heat recovery system has the following components: (1) Heat source: 27° C (80° F), (2) Heat supply: 75° C (167° F), (3) Heat pump: R717/COP 4.7, (4) Energy storage.

Equinix (FR4, FR6, & FR8)—Frankfurt, Germany

Data center developer and colocation expert Equinix connected three data center campuses to a new district heating scheme in Germany—FR4 (Operational since 2010), FR6 (Operational since 2017), and FR8 (Operational since 2021).⁶⁷ The data centers connected to the Frankfurt heating system supplies heating to roughly 1,000 households and has been operational since 2025.⁶⁸ NVRC visited this operation in January 2026 as part of a partnership with the German Embassy to learn more about Germany’s adoption of heat reuse technologies. This collaboration highlighted some learning opportunities from Germany which has the second highest concentration of data centers in the world after the United States and is also struggling with grid stress from “geographically unbalanced loads and supplies”.⁶⁹

STACK Infrastructure, OSLO1A—Oslo, Norway

Data center developer STACK Infrastructure, which is constructing a new data center campus in Pittsylvania⁷⁰ presented to the stakeholder group at the second meeting and highlighted the success of heat reuse at their OSLO1A campus in Norway. The OSLO1A

⁶⁶ Bühler, F. (2026, June 25). *Excess heat utilization in Denmark* [PowerPoint Slides]. Virginia Energy Data Center Waste Heat Feasibility Study Workgroup. Microsoft Teams.

⁶⁷ Swinhoe, D. (2023, July 17). *Equinix joins district heating scheme in Frankfurt, Germany*. Data Center Dynamics. <https://www.datacenterdynamics.com/en/news/equinix-joins-district-heating-scheme-in-frankfurt-germany/>

⁶⁸ Medearis, D. (2026, June 25). *June 26 Briefing on District Energy and Data Centers* [PowerPoint Slides]. Virginia Energy Data Center Waste Heat Feasibility Study Workgroup. Microsoft Teams.

⁶⁹ Morrill, J. (2026, January 14). *Data Centers: Heat Reuse, Grid Interconnection, and Noise Issues in Germany—and the Potential in NoVA* [PowerPoint Slides]. Office of Environmental and Energy Coordination Presentation to EQAC.

⁷⁰ Mamom, G. (2026, June 30). *Stack Infrastructure says its moving forward with AI data center in Pittsylvania*. *Cardinal News*. <https://cardinalnews.org/2026/06/30/stack-infrastructure-says-its-moving-forward-with-ai-data-center-in-pittsylvania/>

campus began providing heat and hot water to 5,000 homes in 2022 and was the “first time heat reuse technology has been retrofitted to a data center in Norway”.⁷¹ The data center waste heat in these locations is also used to keep the roads clear of snow and ice.

Amazon Web Services Dublin-Tallaght District Energy—Dublin Ireland

Unlike Germany and Scandinavia, there is limited municipal District Energy tradition in Ireland. In that respect, Dublin is more of an analogue to Northern Virginia. The Technological University of Dublin’s Tallaght campus has benefited from waste heat generated by an Amazon Web Services data center since 2023.⁷² This project illustrated the benefits of “integrated planning” and is a product of collaboration between a power system operator and a distribution grid operator.⁷³ Heat Works, Ireland’s first not-for-profit energy utility, receives waste heat from AWS, which “supplies 100% of the heat to the network.”⁷⁴ Figure 8 illustrates the ownership configuration and the benefits of adopting this technology in an emerging market with a substantial data center presence. Interest in the technology continues to grow in Ireland and efforts to enable its development are moving forward. A “Heat Bill” with the goal of developing district heating in Ireland is proposed for consideration later this year.⁷⁵

⁷¹ STACK Infrastructure. (2022, September 21). STACK Infrastructure Connects Data Center to Hafslund Oslo Celsio System for City-wide Heat Reuse. STACK Infrastructure. <https://www.stackinfra.com/about/news-press/press-releases/stack-infrastructure-connects-data-center-to-hafslund-oslo-celsio-system-for-city-wide-heat-reuse/>

⁷² Roach, A & Lockwood, T. (2026, January 27). This university campus is heated by an AI data center. Your home could be next. CNBC. <https://www.cnbc.com/2026/01/27/data-centers-ai-district-heating-aws-amazon-ireland.html>

⁷³ Ibid.

⁷⁴ Ibid.

⁷⁵ Reut, T. (2026, July 14). District heating ‘should bring prices down’. RTÉ. <https://www.rte.ie/news/business/2026/0713/1583067-district-heating-bill/>



Figure 8--AWS-Dublin-Tallaght District Energy System [Source: Garforth International, Stakeholder Feedback, 2026]

Data Center Waste Heat Reuse in the United States

While there are several existing district energy systems in the United States, there is a significant gap in development compared to Europe. The pairing of data center waste heat with district energy systems is still in an early market phase at scale but there are a few projects to review as reference: (1) NREL Laboratory heated by a data center in 2010, (2) NREL development of Urban Renewable Building and Neighborhood Optimization (URBANopt) system, (3) Amazon headquarters in Seattle heated by non-Amazon data center.

NLR (Formerly NREL) Laboratory Heating—Golden, Colorado

In 2010, the U.S. National Renewable Energy Laboratory (NREL) built a 220,000 square-foot lab and office building heated entirely by a data center in Golden, Colorado. Since then, heat recovery technology has become standardized.⁷⁶

NLR (Formerly NREL) Urban Renewable Building and Neighborhood Optimization (URBANopt) Program

The National Renewable Energy Laboratory (NREL) [National Laboratory of the Rockies (NLR)] is developing the Urban Renewable Building and Neighborhood Optimization

⁷⁶ Spencer, T. (2026, March 6) PAS Quicknotes: Data Center Waste Heat Recovery. American Planning Association. https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/PAS-QuickNotes-117.pdf

(URBANopt) platform to analyze the use of waste heat sources within geographically cohesive building districts. This tool facilitates the integration of waste heat into district energy systems, enhancing overall efficiency.⁷⁷

Amazon Headquarters—Seattle, Washington

In Seattle, Washington, per the Building Decarbonization Coalition, “Amazon’s headquarters repurposes waste heat from a non-Amazon data center, the neighboring Westin Building Exchange. Instead of venting excess heat from its cooling towers, the Westin pipes it to Amazon, where it warms the building’s offices. The system will eventually heat 5 million square feet and is projected to save 80 million kWh of electricity over 25 years”.⁷⁸

Findings

- Development and adoption of waste heat recovery technologies is feasible at scale in Virginia but requires advanced planning and collaboration with relevant stakeholders. The technical feasibility and economics of waste heat reuse depend heavily on the grade and temperature of recoverable heat, the data center cooling architecture and proximity to viable consumers and operators. Legacy air-cooled data centers often produce lower-grade heat that may require heat pumps or other temperature-lift equipment before it can serve district heating or other end uses. By contrast, liquid-cooled, direct-to-chip, immersion, or hybrid systems can produce higher-grade heat, reducing the energy required for temperature uplift and improving the technical and economic case for reuse. As a result, feasibility assessments should distinguish between heat that is theoretically recoverable and heat that can be usefully delivered to a district heating operator at the required temperature, timing, and reliability.
- The technology provides many benefits to community members, as well as data center operators, including reduced energy costs, reduced operating costs and reduced carbon emissions. It can potentially reduce many impacts from data centers which concern communities including water use, noise, and air pollution, and could provide an opportunity for Virginia to model “community-friendly data centers”.

⁷⁷ Jagdale, A., & Aljbour, J. (2024). *Data center heat reuse: Technology innovation quick insight*. EPRI.

⁷⁸ Basic, A. Can Data Centers Heat Our Buildings?: Using Thermal Energy Networks to Reuse Data Center Waste Heat [Brief]. Building Decarbonization Coalition. https://buildingdecarb.org/wp-content/uploads/BDC_Can-Data-Centers-Heat-Our-Buildings_Brief.pdf

- There is significant interest in adoption and build out of this technology from relevant stakeholders, including state agencies, such as VEDP, localities, planning agencies, industry experts, data center developers, district energy system operators and industry developers.
- Existing efforts and body of research focused on this technology and its application in Virginia is a critical base for continuing the development of this technology.
- More research is needed to assess the workforce needs for the development of this market.
- More research is needed to assess the financial capital expenditure barriers for adoption of this technology.

Policy Recommendations

A review of several research studies on the feasibility of data center waste heat reuse and its application and the stakeholder workgroup yielded several viable policy recommendations to promote the adoption of and development of waste heat reuse technologies. Workgroup stakeholders suggested a number of policy recommendations that fell into several categories: (1) Planning, mapping and data transparency, (2) Permitting, siting and regulatory integration, (3) Design standards and technical requirements, (4) Financial Incentives and funding mechanisms, (5) Market facilitation and partnerships, (6) Innovation, pilots and knowledge sharing, and (7) Local government tools and policy alignment. A key learning from stakeholder discussion and literature review is the importance of information sharing, stakeholder collaboration and advanced planning to ensure development aligns with infrastructure and benefits community goals, such as lowering carbon emissions and energy prices or reducing grid strain. Several organizations have analyzed some of the potential policy barriers to this emerging technology in Virginia addressing many key issues including: (1) relevant regulatory bodies and guidance documents, (2) potential ownership models and financing mechanisms, and (3) community planning and engagement.

McGuire Woods 2011 report, *District Energy Systems: An Analysis of Virginia Law*, commissioned by NVRC outlined several regulatory frameworks to facilitate district energy development in the Commonwealth. Many of these frameworks are still relevant today and helpful to understanding the regulatory landscape of Virginia energy infrastructure. The McGuire Woods' report evaluates the overlapping authorities and jurisdictions, highlighting Virginia's status as a "Dillon's Rule" state, Virginia's public utility regulation through the State Corporation Commission (SCC), environmental regulations, planning and zoning

commissions, federal regulations and contractual relationships.⁷⁹ The analysis identified three potential ownership arrangements that could help balance regulatory authorities and support beneficial funding mechanisms for projects—(1) Private ownership and operation, (2) Public ownership and operation, (3) Mixed public/private arrangements. Critically, the report concluded that there are no significant regulatory barriers to adoption of this technology, only advanced planning and coordination with relevant regulatory bodies, decision-makers and industry are needed.

Permitting and regulatory requirements will vary by ownership model, project location and system configuration. Common touchpoints may include local land-use, zoning, site plan, building, mechanical, electrical, and right-of-way approvals; utility coordination and interconnection requirements; environmental review where new energy or water infrastructure is involved; and potential State Corporation Commission considerations depending on whether the system is structured as a regulated utility service, private energy service, public infrastructure asset, or mixed public-private arrangement. As these pathways can be complex, projects would benefit from early (pre-application) and ongoing engagement with local permitting bodies, utilities, economic development staff and state agencies to identify approval requirements before major design or commercial commitments are made and throughout the subsequent development process. For example, continuous utility and load serving entity engagement, from initial planning through permitting and energization utilities, would allow for the identification and development of key aspects, such as substation siting, permitting, billing, and rate implications. Commercial agreements should also address the risk that data centers may not be able or willing to guarantee heat availability over the full financing period for downstream infrastructure. IT loads, tenant mix, cooling design, ownership changes and operational priorities can shift over time creating uncertainty for district energy providers, off-takers and lenders. To manage this risk, projects may need backup heat sources, minimum heat delivery provisions where appropriate, termination and step-in rights, transparent operating data and commercial terms that recognize the difference between available waste heat as a byproduct and firm thermal capacity as a contracted service.

Cost remains one of the largest barriers to adoption, particularly where project benefits are distributed across multiple parties while capital costs are concentrated in one entity. Successful projects may require blended financing and partnership structures, including grants, tax credits, abatements, low-interest financing, utility programs, economic development funding, public-private partnerships, anchor off-taker agreements,

⁷⁹ McGuire Woods Consulting. (2011). District Energy Systems: An Analysis of Virginia Law (Prepared for the Northern Virginia Regional Commission).

performance-based incentives and shared infrastructure models. The appropriate financing mechanism should reflect the project's public benefits, including energy efficiency, grid relief, water conservation, emissions reduction, economic development and community resilience while also ensuring that the party investing in infrastructure has a clear pathway for cost recovery.

The comprehensive report by Deborah D. Stine, Ph.D. and Relmagine Appalachia titled *Catching Heat: Using Waste Heat Generated from Data Centers: Appalachian Responsible Development Opportunities, Challenges, and Policy Options* (2026) summarized policy options into three categories: (1) regulatory streamlining, (2) project development support, (3) financial incentives.⁸⁰ By creating regulatory streamlining, states and localities can help respond to the most critical decision indicator for data centers, "Speed to Power", with regulatory tools including permit acceleration, clear requirements and creating a single review process coordinated across relevant agencies.⁸¹ Project development support is beneficial to data centers and communities because it can help de-risk projects by establishing site readiness guidance, connecting excess heat creators with excess heat users, and providing interconnection guidance.⁸² As discussed previously, the biggest barrier to the adoption of waste heat reuse technology and district heating is cost, therefore, fiscal incentives would help to make the project more economical for the operator and the off-taker. Regulatory tools can include "grants, tax credits/abatements, low-interest financing, and performance-based incentives tied to outcomes".⁸³

David Gardiner and Associates' 2025 report, *Data Center Heat Reuse: The Opportunity for States* outlined several policy recommendations aimed at addressing the following barriers: (1) Matchmaking data center operators with potential off-takers, (2) Project development costs, (3) Market design blocking first movers.⁸⁴ David Gardiner and Associates' policy recommendations are in-line with other study recommendations aimed at creating data sharing and transparency, improving economics of the technology and facilitating quicker adoption of technology.

⁸⁰ Stine, D. (2026). *Catching Heat: Using Waste Heat Generated from Data Centers: Appalachian Responsible Development Opportunities, Challenges, and Policy Options*. Relmagine Appalachia.

⁸¹ Ibid.

⁸² Ibid.

⁸³ Ibid.

⁸⁴ Gardiner, D., Dixon, A., Kent, E., Schuster, H. (2025). *Data Center Heat Reuse: The Opportunity for States*. <https://www.dgardiner.com/wp-content/uploads/2025/12/Data-Center-Heat-Reuse-The-Opportunity-for-States.pdf>

The policy analysis presented here is limited by time constraints and further policy analysis is needed to fully address the breadth of this topic. Given this limitation the Department provides the following recommendations to continue the development of this topic:

1. Recognizing the success and active engagement of the Data Center Waste Heat Reuse Feasibility Study Workgroup, the Department proposes to extend the stakeholder workgroup and continue meeting regularly to maintain engagement, constructive discussion and address issues needing further research and discussion, such as cost barriers, workforce development needs and locality and planning needs.
2. Virginia Energy will use material from this study and future efforts to create waste heat resources for localities, data center operators, potential end users and other key stakeholders.
3. The Commonwealth should consider further research and development of a framework for reporting and mapping excess heat from data centers and other industrial processes to identify potential economic and infrastructure opportunities. Two possible options include:
 - a. The Commonwealth could encourage local and regional heat planning in areas experiencing significant data center growth. These plans could identify existing and future heat demands, existing district energy or thermal energy network infrastructure, potential off-takers, grid constraints, and areas where data center siting or expansion could preserve future waste heat reuse opportunities. Localities could use these plans to inform zoning, permitting, economic development strategies, and “waste heat ready” site designations.
 - b. The Commonwealth could encourage standardized feasibility studies for proposed and existing data centers to evaluate waste heat reuse potential, off-taker alignment, infrastructure needs, costs, ownership models, implementation risks, and measurable community benefits before major siting, utility service, or design decisions are finalized. These studies should specifically assess the grade and temperature of available waste heat, the cooling architecture of the data center, the need for heat pumps or other temperature-lift equipment, proximity to viable off-takers, seasonal heat demand, system reliability, and whether liquid-cooled or hybrid designs could improve the technical and economic case for heat reuse. Feasibility studies could also classify opportunities by market segment, including whether the project involves an existing or new data center, legacy air cooling

or high-performance liquid cooling, proximity to an existing or planned thermal energy network, and the density and reliability of nearby heat demand.

4. The Commonwealth should consider incentivization of waste heat recapture technologies and waste heat reuse applications. There is clear interest and engagement in the Commonwealth around developing a waste heat reuse market and better utilization of lost energy and heat from data centers and other industrial processes. There are several noted benefits of the adoption of the technology at scale and marketable economic opportunities for having “district ready” or “waste heat ready” sites. Waste heat reuse/recapture should be used as a point of comparison for other proposals to reduce carbon emissions, promote energy efficiency or create economic development opportunities throughout the state while balancing the interests of ratepayers, local communities and other key stakeholders and ensuring proper verification of expected results. Consideration of whether waste heat constitutes a “public utility” as that term is employed within state and federal regulation may also be necessary to ensure that policy options can be successfully implemented.
 - a. Policies which could incentivize reuse of data center waste heat include: accelerating siting and permitting of data centers that reuse heat, potentially in designated development zones; requirements that all new large data centers are “heat reuse ready” to enable heat reuse in a future district heating system; undertaking waste heat reuse pilot projects for factories and large commercial buildings; and linking the Commonwealth’s tax incentive for data centers to the reuse of waste heat to ensure data centers deliver “community friendly data centers”. Further research would be required to determine which options would be most cost-effective in incentivizing the most promising project types.

Additional implementation strategies for consideration by localities, industry and planners include:

- Define “District Ready Sites”/ “Waste Heat Ready Sites,” which could include standardized design. One example definition of a heat reuse ready data center would require the data center to:
 - Use liquid or immersion cooling given that heat recovery from air cooling is not cost- or temperature-effective.
 - Have sufficient plot space to install heat recovery equipment, such as a heat exchanger and heat pump(s), in the future.

- Install pipes and control valves that could be connected to future piping infrastructure for heat reuse.
- Have the right-of-way for future piping between the data center and potential offtaker(s).
- Localities can develop heat ready site plans or encourage district energy systems in new builds.
- Evaluate thermal energy storage, including daily storage and seasonal storage, as part of feasibility studies where heat production and heat demand are mismatched. Storage can improve utilization of data center waste heat, reduce peak heating needs, increase resilience and support electric grid flexibility.

Conclusion

The stakeholder workgroup discussion and presentations indicated that the Commonwealth has potential to grow and develop a viable heat reuse industry. As the home to the largest data center market in the world—with more data centers planned every month—there are several dedicated experts and professionals focused on highlighting the potential benefits data centers provide to communities and strengthening system reliability through cleaner technologies.

Virginia's data center waste heat reuse market is still in an early stage and should be treated as an emerging market rather than a mature compliance market. Policy should therefore focus first on awareness, mapping, feasibility studies, local heat planning, pilot projects, and future-ready siting before considering more prescriptive requirements.

Based on stakeholder discussion and reviewed examples, new-build opportunities generally offer the most favorable economics because waste heat recovery, heat pumps, distribution piping and off-taker interconnections can be planned before site layout, cooling architecture, and utility service decisions are finalized. Retrofits can be successful, particularly where data centers are located near existing district energy systems or large heat users, but they often face higher costs, space constraints, operational disruption risks and more challenging commercial alignment. For Virginia, the strongest near-term opportunities are likely to be new data center developments, campus expansions, industrial parks, university or public-sector campuses and planned mixed-use or agricultural developments where heat reuse can be integrated into early site planning.

While the stakeholder group accomplished a significant amount of work in a short period of time, greater opportunity exists with continued conversations and further technical

research to actualize this technology adoption and application at scale to the benefit of industry and communities.

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Full list of Stakeholder organizations provided in Appendix 3.

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Appendix

Appendix 1—Definitions

Waste Heat: Waste heat is a byproduct of many industrial processes, including power generation and manufacturing. (EPRI, 2024)

Thermal Energy Network: (TENs) use a shared network of water-filled pipes that transfer heat in and out of buildings. (BDC, 2026)

District Energy: Energy produced in a centralized plant, other than in an electric power plant, that is consumed or stored as steam, hot water, or chilled water. This energy is distributed through a network of pipes to meet demand for process steam, heat, or cooling within a commercial or residential building, multibuilding facility, group of buildings, or an industrial facility. (U.S. Energy Information Administration, *Glossary*, “District Energy”).

Appendix 2—Public Comments

On June 15, 2026, Virginia Energy opened a public comment period on Town Hall to capture input on the Data Center Waste Heat Reuse Feasibility Study. Below are the comments that were submitted.

Commenter: Anonymous

Oppose

Maybe this should have been thought about BEFORE Virginia decided that having the most data centers, was a title worth having! It's astounding that our government is so far removed from Virginia constituents, and what they do and don't want! We don't want these dang data centers!! And they are being sneaky and shady from the get-go in how they are gaining their ability to exist. And they take OUR water! Yall do realize that humans

NEED water to live and survive, right?! So STOP the data center takeover and tell the governor to stop telling US to conserve OUR water! Tell the data centers to find their own water source and funding!!

CommentID: 240574

6/25/26 9:41 am

Commenter: Anonymous

Stop already

Data centers are becoming a plague that Virginia does not need. Farm and forest land are being forever lost to data centers, battery storage facilities and the like. Once it is gone, these lands cannot be recovered due to the necessary ground work to support these data centers. The noise, air, and water pollution created is causing real harm to our citizens, wildlife, and area eco-systems. Stop already!

CommentID: 240590

7/2/26 1:59 pm

Commenter: Anonymous

No more Data Centers

Data centers do nothing but harm everything around it and make areas inhabitable for us and nature. It's taking away our clean water, raising peoples electric bills (which doesn't make any sense, because we shouldn't have to pay for environmental destruction that we didn't ask for), and they practically produce no jobs for people. Data Centers should be banned from being built, we don't need them, want them, and will never **EVER** want them. Also, the amount climate change that has happened because of these abominations is insane; it's harder for farmers to properly grow crops and ecosystems are being disrupted and/or destroyed. If our voices truly matter and our lives are to be taken into consideration, then actions should be taken towards getting Data Centers shut down and stopping them from being built entirely.

CommentID: 240713

7/15/26 2:57 pm

Commenter: Anonymous

Waste Heat is a Proven Concept

Data center waste heat reuse isn't some experimental idea, it's already standard practice at facilities across Europe, where the heat that used to just get dumped into the atmosphere now gets piped straight into homes and buildings nearby. It's a relatively simple concept: these facilities are running 24/7 and generating a constant stream of heat as a byproduct anyway, so instead of throwing that energy away, it gets captured and reused for something people actually need. As data centers keep expanding here in the US, especially with AI driving so much new construction, we have a real opportunity to build that heat recovery in from the start rather than treating it as an afterthought. It's a practical way to get more value out of infrastructure we're building regardless, and it's worth pushing for now, while these facilities are still in the design phase, rather than retrofitting later. Europe didn't wait for perfect conditions to start doing this, there's no reason the US should either.

CommentID: 240727

7/15/26 3:34 pm

Commenter: Anonymous

Thermal Management

The public sentiment seems to be negative because most people don't understand Datacenters and how they impact our lives. We could actually take the heat off the servers and make beneficial use of it! Heat homes. Heat Industrial Process. And....when you off load the heat you don't have to use the energy to displace it.

Capex win and an opex win. Water..... build with non-evaporative cooling and you get to keep your water! We need to change the narrative on datacenters.

CommentID: 240729

7/15/26 3:44 pm

Commenter: Anonymous

Communities can benefit from Data Centers

I get why this thread is so heated, and honestly, the frustration is fair nobody wants to watch their electricity bill creep up or see a giant windowless building show up next to their neighborhood without so much as a heads up. But I think it's worth stepping back for a second and talking about why these facilities exist in the first place, because I don't think "big tech greed" is the whole story.

Think about what you did today. Checked your bank balance, texted a friend, pulled up directions, maybe had a video call with your doctor, streamed a show, backed up photos of your kids. Every single one of those things ran through a data center somewhere. They're not some abstract crypto-mining scheme they're the plumbing underneath basically all of modern life, including stuff we'd consider essential now, like telehealth, remote work, and school systems that went digital after 2020 and never fully went back.

That's a real shift in how we should think about these buildings. A well-designed data center can actually feed something back heating for nearby buildings, support for local infrastructure upgrades, sometimes even funding for water systems that end up benefiting everyone nearby, not just the facility. It's not a magic fix for every issue people are raising here, but it's a genuine example of the industry evolving instead of just extracting and moving on. And this is what this bill is tackling.

I just think it's worth having a fuller picture before writing these off completely. The problems being raised are legitimate and companies should be held to higher standards on transparency and local investment. But these facilities aren't going away, since they're tied to how we all live now, so it's probably more useful to push for smarter, more reciprocal versions of them (heat reuse being one solid example) rather than treating them as pure villains in the story.

Appendix 3—Stakeholder Organizations

Advantus Strategies
Alfa Laval
Amazon
City of Norfolk Department of Transportation
City of Richmond
City of Newport News
Danish Embassy
Danish Energy Agency
David Gardiner & Associates

Delegate Rip Sullivan
Department of Forestry
Department of General Services
Energy Commission of Virginia
Ever-Green Energy
George Mason University
Henrico County
International Brotherhood of Electrical Workers (IBEW)
International District Energy Association (IDEA)
Loudoun County Environmental Commission
Loudoun County Government
National Laboratories of the Rockies
Northern Virginia Electrical Cooperative (NOVEC)
Northern Virginia Regional Commission
Prince William County Department of Planning
Prince William County Office of Sustainability
Prince William Department of Economic Development & Tourism
Ramboll
Rappahannock Electric Cooperative
Roanoke Natural Gas
SCC
Southeast Sustainability Directors Network
STACK Infrastructure

University at Buffalo
University of Virginia
Virginia Association of Counties
Virginia Commonwealth University
Virginia Economic Development Partnership (VEDP)
Virginia Energy Workforce Consortium (VEWC)
Virginia Housing
Virginia Manufacturers Association (VMA)
VMDAEC
GO Virginia Region 3