

PAS QUICKNOTES

Data Center Waste Heat Recovery

The recent surge in artificial intelligence (AI) use has driven a similar increase in [data center development](#). In most cases, data centers are resource drains that negatively impact neighboring communities. An average data center uses between four and five times the energy of a similar-sized office building, and its servers generate so much heat that they need year-round, constant cooling. This waste heat can become a valuable [resource](#), however, when it is used instead of fossil fuels to heat nearby buildings. A growing number of projects in the [U.S.](#) and around the world are now using data centers as heat sources for nearby buildings.

BACKGROUND

Data centers are responsible for [4.4 percent](#) of U.S. electricity use. That number is expected to [double by 2030](#) with the AI boom. Cooling comprises [40 percent](#) of data center operating expenses. Globally, the energy represented by the [annual waste heat](#) from data centers roughly equals the natural gas use of [New York State](#).

Heat recovery projects have shown that these facilities can ease the energy burden of nearby structures, offering cost savings for residents, businesses, and institutions. Offsetting fossil fuel use with data center waste heat also reduces carbon emissions, mitigates the urban [heat island effect](#), and improves regional air quality—especially if the data center is powered by [renewable energy](#).

This waste heat has real monetary value, and recovering it makes financial sense. Studies have found internal rates of return between [16 percent](#) and [43 percent](#) for heat recovery projects in the U.S. One study evaluating the use of geothermal wellfields to store summer data center waste heat for winter use calculated an [11.9 percent](#) internal rate of return.

WASTE HEAT RECOVERY BASICS

In a data center waste heat recovery system, heat from the data center is captured from the air or water used to cool its servers, either through a [heat recovery chiller](#) or heat exchangers, and sent to a nearby heat load (user of heat) through connecting infrastructure, such as a [district energy system](#). In the U.S., such systems are usually found on institutional campuses and in the downtown districts of legacy cities.

The best candidates for heat recovery are larger data centers, with their greater generation of waste heat, and urban data centers, with their proximity to residential and commercial heat loads. Though designing new data centers to be heat-sharing resources is most efficient, existing data centers can often be retrofitted for waste heat recovery. In rural areas, data center waste heat can be sent to nearby [agriculture](#) or [aquaculture](#) facilities.

Heat recovery projects are not without obstacles. Large-scale data centers in urban and suburban areas present livability, walkability, and noise concerns; electrical infrastructure usually requires upgrades; and new physical infrastructure may be needed to connect a data center to its nearby heat load. Private data center operators, utilities, local government, developers, and end users of heat all need to work together to bring a project to fruition. Planners can play a key role in coordinating this process.

WASTE HEAT RECOVERY PROJECT EXAMPLES

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](#).

This PAS QuickNotes was prepared by Timothy Spencer, an energy and resilience planner.



The waste heat generated by increasing numbers of large U.S. data centers is a valuable resource that can be used to heat nearby residences and businesses, offsetting fossil fuel use. (Credit Gerville/Getty Images.)



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Creating Great Communities for All

Many Scandinavian cities have legacy district heating networks, making them good candidates for data center waste heat recovery. In Sweden, [Stockholm's Open District Heating](#) initiative partners with 20 data centers and other heat sources to meet the heating needs of 30,000 apartments each year. Across the Baltic, the Google data center in [Hamina, Finland](#), provides enough waste heat to meet 80 percent of that small city's needs. [Tallaght](#), a suburb of Dublin, Ireland, constructed a new heat recovery system and district heating network that sends waste heat from an Amazon data center to local municipal buildings, the Technical University of Dublin, and 131 affordable apartments, offsetting [1,400 tons of carbon emissions](#) annually. And in the industrial district of [Rjukan, Norway](#), the world's largest land-based trout farm was designed and built to use waste heat from a nearby data center.

In the U.S., [Amazon's Seattle Headquarters](#)—including the high-rise Doppler Building—is heated entirely with waste heat from a nearby [carrier hotel](#) with multiple data center tenants. In [San Jose, California](#), developer Westbank is working with utility PG&E to create a district energy system linking three data centers to 4,000 apartments in the downtown district.

PLANNING TOOLS FOR WASTE HEAT RECOVERY

Data center waste heat represents an underused but increasingly valuable local resource. Planners can explore the possibilities for their communities through the following approaches:

- Start a conversation with utilities about the potential benefits of incentivizing the development of heat-sharing infrastructure. Ask about areas or projects for which [district heating](#) might be feasible.
- Create a GIS map of [waste heat sources](#) and identify their proximity to heat loads or district heating candidate areas.
- Use [energy benchmarking program](#) data where available to identify areas with higher heating demand density.
- Identify and map environmental justice communities for priority heat access.
- Talk with data center developers about incorporating waste heat recovery systems as pilots or future projects.

To support implementation, consider the following regulatory tools:

- Offer [zoning incentives](#), such as relaxed building size or height limits, for data centers that share at least 10 percent of their waste heat.
- Add data center heat recovery goals to comprehensive plans, regional climate action plans, or sustainability and energy plans.
- Set measurable goals. For example, Germany's [Energy Efficiency Act](#) requires new data centers to recover 20 percent of waste heat by 2028.
- Develop [community benefit agreements](#) for projects that prioritize heat sharing.
- Offer expedited permitting for projects that provide heat sharing or other community benefits.

CONCLUSIONS

Data centers represent a potential community resource: their waste heat can be recovered to meet local heating needs. The [technology is robust](#), and the economics are favorable. By creating the right conditions for collaboration, planners can play a key role in transforming data centers into community partners in climate action for more sustainable local development.

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FURTHER READING

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