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The Future of Thermal Energy Networks

An Executive Briefing for EPC and Development Firms

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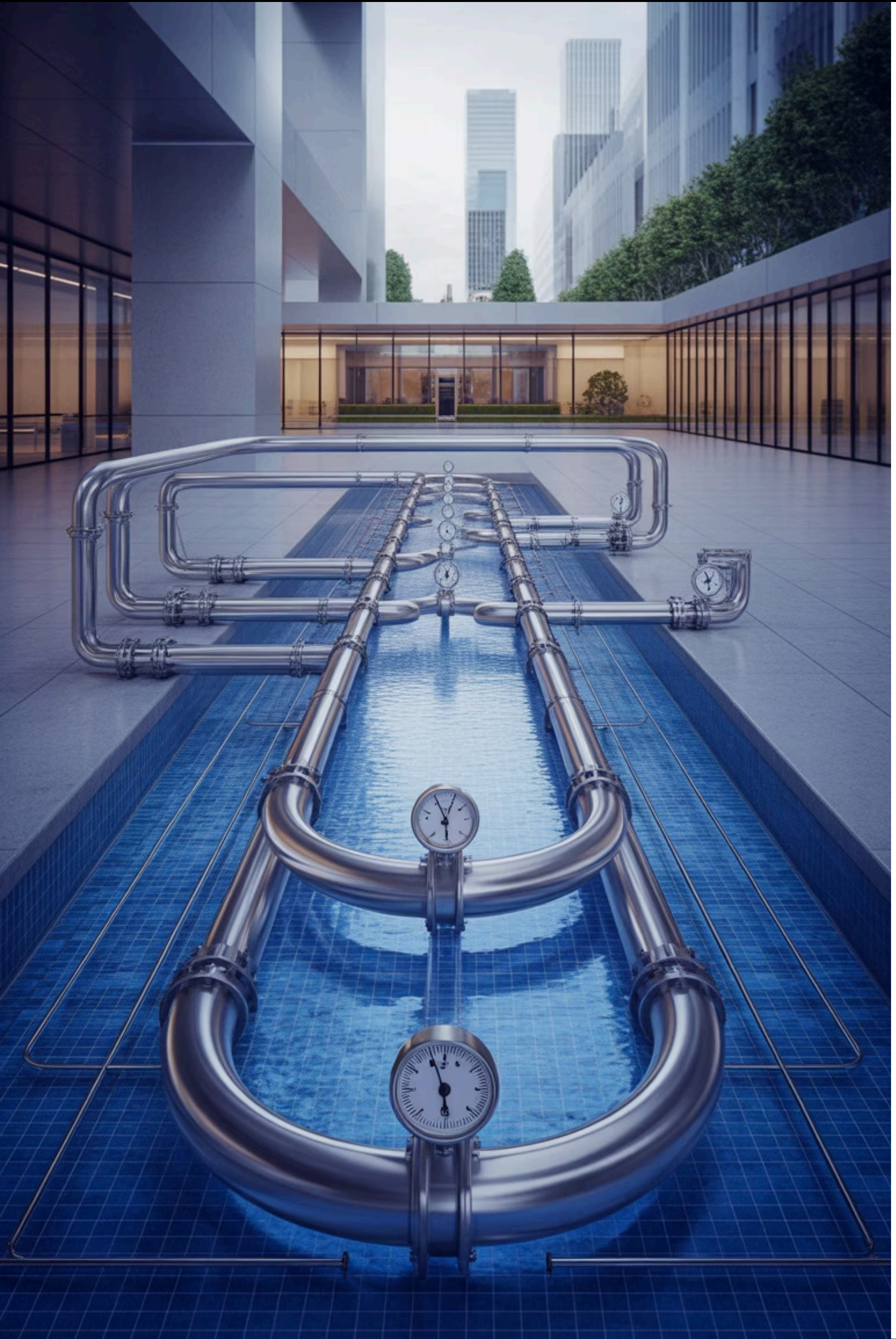
Executive Summary

Thermal Energy Networks (TENs) are redefining the future of district-scale heating and cooling. Drawing on the foundational work presented at the 2025 ASHRAE Annual Conference, this briefing deepens the technical and economic analysis of TENs for the energy and infrastructure industry.

It examines the core principles of ambient temperature loops (ATLs), the operational logic of thermal diversity, and the integration of renewable and waste heat sources. These networks enable new models of stakeholder engagement, cost efficiencies, and carbon reduction—creating substantial opportunities for EPC firms and developers.



Overview of District Energy Systems

TENs represent the next evolution in district energy design, moving beyond conventional two-pipe or four-pipe systems to a single-pipe ambient temperature loop (ATL). ATLs circulate a heat transfer medium—typically water—within an optimal temperature range (50°F to 85°F), unlocking efficient energy transfer between connected buildings.

Key Technical Foundations

Thermal Diversity

By interconnecting buildings with different heating and cooling profiles—such as residential consumers, commercial prosumers, and industrial generators—TENs maximize the reuse of both surplus and deficit thermal energy. Data centers or office buildings can reject waste heat into the ATL, which is then captured by residential or industrial users needing heat.

Self-Balancing Efficiency

The ambient loop's variable fluid flow eliminates the need for extensive balancing and control valves, reducing both installation complexity and long-term operating costs.

Decoupled Secondary Loops

Each building or stakeholder connects via an isolated secondary loop with its own pump and heat exchanger, maintaining independent hydraulics and ensuring the network remains stable and scalable.

ASHRAE 2025 Insight

Marc Miller's ASHRAE conference paper "**38820 - Thermal Energy Networks: The Future of Decarbonization and Electrification"** highlighted that the key to maximizing ATL efficiency is leveraging thermal load shedding and sharing, supported by strategic stakeholder diversity. Greater network diversity smooths the temperature cascade along the loop, ensuring effective energy delivery even to end-of-loop stakeholders.

Stakeholder Integration: Consumers, Prosumers, and Generators

TENs thrive on the diversity of connected stakeholders:

Consumers

(e.g., residential housing) exclusively use thermal energy from the network.

Prosumers

(e.g., commercial offices) both consume and generate energy, using internal heat sources and sharing surplus.

Generators

(e.g., geothermal plants, data centers, industrial facilities) inject thermal energy into the loop, often leveraging waste streams.

Stakeholder Benefits

This stakeholder model enables cities and business districts to:

- Reduce peak energy demands.
- Minimize infrastructure requirements by offsetting loads through energy recycling.
- Transform buildings from passive users into active contributors within the energy ecosystem.

Technical Example (ASHRAE 2025):

In winter, waste heat from a data center can offset the heating requirements of a hospital and high-rise apartments without relying on fossil fuel boilers. Unused energy is stored in the ground or water bodies—acting as a thermal battery—available for later extraction.

Integration with Geothermal and Waste Heat Recovery Systems

A defining feature of advanced TENs is their ability to exploit a variety of renewable and recovered heat sources:

Geothermal Wells:

Provide constant, renewable baseline heating and cooling. Integration with ATL networks reduces the number and size of required wells by leveraging internal energy transfers, yielding significant capital savings.

Waste Heat Recovery:

Industrial processes, wastewater plants, and especially AI/data centers produce substantial waste heat. TENs harness this energy, routing it to where it is most needed—such as surf parks, pools, or adjacent commercial/residential buildings.

Heat Sink Diversity:

Surplus energy can be dissipated or stored using earth, lakes, or purpose-built tanks for improved system flexibility and resilience.

Technical Advantage:

The self-balancing ATL and decoupled loop strategy mean each stakeholder manages its own temperature differential (delta T) via variable-speed pumping, maximizing efficiency and reducing pump energy use (as noted in Miller's ASHRAE 2025 study).

Economic Potential and Real-World Applications

Implementation of TENs presents clear economic and environmental benefits:

Capital and Operating Savings

The one-pipe ATL design reduces piping, fitting, and installation labor. Variable-speed, pump-controlled systems cut operating costs associated with constant high-pressure pumping. Decoupled loops minimize the need for system rebalancing when facilities are added or modified.

Revenue and Decarbonization

Data center waste heat can be sold or credited to adjacent users—creating new utility business models. By supporting electrification and reducing reliance on gas-fired boilers or chillers, projects qualify for sustainability grants and ESG investment.

Scalable and Future Ready

TENs allow phased development without large up-front overbuild. The addition of new stakeholders improves overall system performance through increased diversity.

Real-World Case Studies and Educational Impact

Eversource Geothermal Pilot - Framingham, MA:

A groundbreaking deployment connecting 135 buildings to a utility-operated geothermal ATL, demonstrating network flexibility, stakeholder diversity, and fossil fuel elimination.

National Grid Networked Geothermal - Dorchester, MA:

A large-scale public housing project retrofitted for geothermal heating and cooling, enabling the transition from gas appliances to electrification.

Surf Parks and Water Features - Data Center Heating:

Using data center waste heat to maintain optimal water temperatures in large recreational lagoons and surf parks, extending seasonality and lowering operational costs.

Marc Miller's Educational Contributions to TENs and Geothermal Systems

The industry's progress in adopting Thermal Energy Networks and advanced geothermal solutions has been accelerated by Marc Miller's direct involvement in practitioner education. Through a series of technical webinars with HalfMoon Seminars—such as "Geothermal Hydronic Fundamentals and One-Pipe Ambient Temperature Loops," "Geothermal: Exploring Thermal Energy Networks and Hybrid Geothermal Systems," and "Geothermal System Basics," —Marc has equipped engineers, contractors, and designers nationwide with actionable expertise on practical design and field implementation.

The technical and economic evidence from current deployments and peer-reviewed research (ASHRAE 2025) confirm that TENs are a transformative solution for efficient heating and cooling at scale. They maximize energy reuse, minimize infrastructure and operating costs, and create new revenue opportunities aligned with global decarbonization objectives. EPC firms and developers who understand and implement TENs will be positioned to lead the sustainable transformation of cities, campuses, and industrial developments.

Download the briefing and learn where the industry is headed.