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Overview, Facilitation, and Strategies Involving Municipal Geothermal District Energy Systems in Ohio

Matthew R. Fulton

Andrew R. Thomas

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Prepared by:

Matthew R. Fulton[1]
Andrew R. Thomas[2]

Energy Policy Center

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1717 Euclid Avenue Cleveland, Ohio 44115
http://urban.csuohio.edu

[1] Matthew R. Fulton is an economics student at California State Polytechnic University in Humboldt, California. He was the recipient of a National Science Foundation grant to conduct undergraduate research with The Great Lakes Wind Energy Challenges focusing on "Regulatory Frameworks for the Integration of Renewable Power Systems" at Cleveland State University.

[2] Andrew R. Thomas directs the Energy Policy Center in the Levin College of Public Affairs and Education. He can be reached at a.r.thomas99@csuohio.edu

Contents

Executive Summary

District Energy systems have existed for over a hundred years in the United States, yet have been largely underutilized due principally to the sprawling nature of building construction in the US, which makes transportation of thermal load more challenging. But District Energy – especially when combined with microgrids – can meet climate change requirements and efficiency improvements for customers. District Energy is usually defined as a shared thermal load among buildings co-located on a campus or in a downtown setting. It may or may not have multiple customers, but if it does, it usually triggers regulatory oversight. This distinction is important for developers to understand, since networked geothermal in residential or commercial districts is anticipated to grow as society seeks to constrain carbon dioxide emissions.

District Energy systems that serve multiple customers are classified as a utility in Ohio. As such, system operators will need to follow regulatory and statutory rules set forth for utilities. As the technology of geothermal energy extraction advances and green initiatives provide financial incentives to develop, these systems may proliferate, especially as a supplement to fossil fuels. To facilitate this adoption, system developers and governments will need to understand the regulatory structure associated with networked District Energy.

Under the Ohio Revised Code, private companies seeking to operate a district energy utility in a municipality must first seek permission from that municipality. Once a franchise agreement is awarded, the municipality regulates the utility through its council, unless otherwise delegated to the Public Service Commission of Ohio (PUCO). In unincorporated areas, the district energy utility will be regulated by the PUCO. Municipalities typically have their own ordinances that cover awarding of franchises, and how utilities will be regulated. In addition to the municipal rules regulating utilities, district energy utilities will need to comply with zoning ordinances, and for geothermal systems, obtain drilling permits.

Networked geothermal systems are less common in the U.S. than natural gas-based thermal systems. New geothermal systems primarily use closed-loop thermal transport to avoid wastewater emissions. In cold weather regions, new district energy systems are likely to include a hybrid approach, wherein geothermal energy and heat pumps are supplemented by small natural gas fueled boilers.

As United States looks to decarbonize its energy systems, there is likely to be a surge in interest in multi-customer District Energy. Some of this will be in response to the August 2022 Inflation Reduction Act, which provides incentives for geothermal energy, heat pumps and other technologies that will encourage thermal load supply from electricity, geothermal sources, or blended natural gas and hydrogen.

Interest in networked thermal will be especially high for low-income neighborhoods, which have been targeted by the IRA for clean energy development. In northern climates, many

such areas have no air conditioning, and residents are increasingly at risk with the intensity and duration of hot weather resulting from climate change. Geothermal systems (and heat pumps) provide both heat and air conditioning to buildings. District Energy through networked geothermal, heat pumps and peaking boilers provides a promising strategy for providing safe spaces for low-income families during extreme heat or cold events.

1.0 Introduction

1.1 Defining District Energy.

Growing demand for energy will have important implications to climate change. Utility companies operating large grid systems have heretofore been insufficiently incentivized to utilize renewable energy as a primary source to meet this demand in growth. One solution is to use locally generated power in combination with thermal systems, thereby improving efficiencies. One strategy for optimizing electrical and thermal systems is through District Energy.

District energy is defined as one or more central plants creating thermal energy that is transported through a network of pipes to multiple nearby buildings. It can serve a variety of end-use markets, but it is most commonly found in the United States on college campuses or in central business districts of cities.[3] District Energy systems use a central plant, typically powered by natural gas or other fossil fuels, to boil and cool water which is then piped through a district system to provide thermal energy for air conditioning, dehumidification, and heating for buildings in a defined region. Leveraging economies of scale, district energy offers cost and space efficiencies to customers, who are able to forego the installation and maintenance of independent boilers and natural gas lines. Furthermore, district energy systems can reduce energy consumption by as much as 50% when compared to traditional heating and cooling systems.[4] General applications of this technology include university campuses, downtown business districts, healthcare facilities, military bases, and industrial complexes, among others.[5]

As of 2023, about three quarters of U.S. district energy systems burn natural gas in a central plant to generate thermal energy, usually in a boiler. Coal provides another 16% of the

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[3] *See,* https://www.energy.gov/eere/amo/articles/combined-heat-and-power-technology-fact-sheet-series-district-energy

[4] One example, Banja Luka, a city in Bosnia and Herzegovina, participated in the UN's *District Energy in Cities Initiative*, which was a program to help EU cities redevelop and maintain District Energy systems. According to the UN, this redevelopment of the city's district energy infrastructure "increased the share of renewables by 75 per cent, cut harmful air pollutants by 94 per cent and saved US$1 million a year in fuel costs." *See*, United Nations Environment Programme. (2019). *District Energy: A Secret Weapon for Climate Action and Human Health*. UNEP. https://www.unep.org/news-and-stories/story/district-energy-secret-weapon-climate-action-and-human-health

[5] Department of Energy. (2020). *Combined Heat and Power Technology Fact Sheet Series: District Energy*. Energy.gov. https://www.energy.gov/eere/amo/articles/combined-heat-and-power-technology-fact-sheet-series-district-energy

fuel, and the rest of the plants are run by fuel oil, renewables, biomass, biogas, geothermal, solar thermal and electricity. District Energy Systems tend to be highly resilient and are frequently used with mission-critical facilities for this reason. They also offer considerable promise to enable resilient and cost effective microgrids, since they can be combined with cogeneration to improve efficiency. There are around 660 district energy systems in operation in the United States.[6]

There are two models for District Energy deployment: single customer, multiple building energy systems (behind the meter – also known as campus district energy) and a multi-customer utility (in front of the meter -- also sometimes referred to as "downtown" or "utility" district energy systems). By far the most common form of district energy in the United States is the campus energy system.[7] Such systems are far easier to finance and operate. Importantly, they also require little government oversight. Multi-customer systems, on the other hand, require government regulation and the management of long-term contracts among multiple customers. These systems are more common in Europe and Asia, where densely populated cities make thermal distribution more attractive.[8]

As United States looks to decarbonize its energy systems, however, there is likely to be a surge in interest in multi-customer District Energy. Some of this will be in response to the August 2022 Inflation Reduction Act, which provides incentives for geothermal energy, heat pumps and other technologies that will encourage thermal load supply from electricity, geothermal sources, or blended natural gas and hydrogen.[9]

1.2 Geothermal Systems and District Energy.

District energy is itself, not a new technology; it has been utilized in various forms for over

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[6] *Id.* This number is of course highly dependent upon how you define district energy.

[7] For a map of district energy systems in the United States*, see* https://www.districtenergy.org/resources/resources/system-maps. The International District Energy Association's 2015 map identifies a variety of single customer, behind-the-meter systems, including those found at airport, university, government, industrial, and medical facilities. The most common district energy systems are those found at colleges and universities, which alone greatly outnumber the downtown/utility systems. *Id.*

[8] Around 60 million Europeans get their heat from district energy systems. *See,* S. Stefanini, "District Heating Roundtable: Policy across RED, EED and EPD," February 17, 2022, found at: https://energypost.eu/district-heating-roundtable-policy-across-red-eed-and-epbd-must-take-account-of-conditions-in-all-member-states/

[9] *See, e.g.* G. Zorpette, "2022: The Year the Hydrogen Economy Was Launched," https://spectrum.ieee.org/hydrogen-economy-inflation-reduction-act, August 17, 2022. Production tax credits of up to $3.00/kg will be available for reduced carbon emission hydrogen generation. This could make clean hydrogen competitive as a blend with natural gas.

a hundred years in the U.S., including geothermal applications.[10] Geothermal systems, for human timelines, can provide a continuous source of clean energy from beneath the earth. As of 2021, there were 23 geothermal district energy systems operating in the U.S. with a capacity of 75-megawatt equivalent of thermal energy (MWth).[11] Modern efforts to promote public awareness, together with federal, state, and local government financing and tax incentives, have engendered new interest in geothermal energy. Likewise, energy security issues have also stimulated new interest, especially in Europe, which is urgently looking to curtail natural gas imports in light of Russian aggression in Ukraine. Indeed, as pressing as responding to climate change has been, it is energy security that has led to fossil fuels being rapidly replaced in Europe by heat pumps, biogas, renewable natural gas, and geothermal strategies.[12]

Geothermal district energy primarily utilizes one of two technologies to facilitate thermal transfer: direct use or geo-exchange. A direct use system harnesses groundwater from aquifers already heated by the earth in an open loop system.[13] Heated ground water is extracted from the earth, distributed through the district, cooled, and then discharged back into the environment. Boise, Idaho deploys a direct use open loop geothermal district energy system. These types of systems tend to be economical in regions with a high temperature gradient, such as found in the American West. However open-loop systems invite regulation of discharge, which can be problematic.

Geo-exchange, or heat pumps, are closed or open loop systems of pipes buried either vertically or horizontally within the earth's surface. The systems are then filled with fluids that absorb the underground ambient temperatures.[14] The pumps have two purposes. First, they concentrate the thermal energy using refrigerants, compressors, and expansion valves. And second, they circulate the fluid through the system, thereby enabling space heating and cooling. Geo-exchange is the most prevalent technology facilitating geothermal energy, making up 71.6% of installed geothermal capacity.[15] Systems utilizing geo-exchange have been operating for

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[10]According to the National Renewable energy Laboratory, the first geothermal district heating system in the US was created in Boise, Idaho in the 1890s. The system is still being utilized today and is the largest geothermal district energy system in existence after being expanded in the 1980s, providing heat for 92 building in the downtown district. See, *2021 U.S. Geothermal Power Production and District Heating Market Report*. National Renewables Energy Laboratory. P.27. https://www.nrel.gov/docs/fy21osti/78291.pdf

[11] *See*, *2021 U.S. Geothermal Power Production and District Heating Market Report*. National Renewables Energy Laboratory. Executive Summary, ix. https://www.nrel.gov/docs/fy21osti/78291.pdf

[12] "District Heating is Necessary to Repower EU's Heating Sector," June 24, 2022, https://energypost.eu/district-heating-roundtable-policy-across-red-eed-and-epbd-must-take-account-of-conditions-in-all-member-states/

[13] United States EPA. (2022). *Geothermal Heating and Cooling Technologies*. EPA. https://www.epa.gov/rhc/geothermal-heating-and-cooling-technologies

[14] United States EPA. (2022). *Geothermal Heating and Cooling Technologies*. EPA. https://www.epa.gov/rhc/geothermal-heating-and-cooling-technologies

[15] Lund, J. W., & Toth, A. N. (2020). *Direct Utilization of Geothermal Energy 2020 Worldwide Review*. Klamath Falls, OR: Oregon Institute of Technology.

decades. Stockton University, New Jersey, combined this technology with its existing campus heating and cooling infrastructure in 1994 to reduce reliance on fossil fuels and to lower costs.[16]

In 2019, the Home Energy Efficiency Team (HEET) published a GeoMicroDistrict Feasibility Study which outlined a model for a networked closed-loop ground source heat pump (GSHP) system to supply customers with space heating and cooling.[17] This model utilized existing natural gas pipeline rights of way to significantly reduce legal hurdles in acquiring private and public property easements. In 2022, Eversource, in collaboration with HEET, broke ground on a test site in Framingham, MA to ascertain the achievability of a GeoMicroDistrict. In a spring 2023 update, HEET reported that the tests confirmed the feasibility of the project, and that completion could be expected in September 2023.[18] This pilot project will service 37 buildings, totaling 140 customers, with thermal energy for space heating and cooling.[19]

The Eversource pilot project is relevant to other eastern U.S. states that have lower geothermal gradients. It will provide clean and efficient power to residents and businesses – while also demonstrating how to manage the regulatory and contractual framework through which it can be facilitated. In Ohio, as in most states, a facility that supplies heating or cooling to multiple customers is deemed by law to be a public utility, unless it is expressly exempted. Regulatory oversight of utilities requires additional planning for District Energy.

District Energy systems in cold weather climates may find it preferable to use a hybrid system of heat pumps and natural gas. Some District Energy providers recommend the use of "peak load boilers" to supplement heat pumps to ensure that sufficient heat is available in extremely cold weather. Such boilers can be economically installed in district energy systems, protect against extreme cold, and provide system redundancy in the event of electricity and pump outages. Carbon dioxide emissions could be further reduced by using hydrogen-natural gas blends.[20]

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[16] In 1994, Stockton University created a ground coupled heat pump geothermal system consisting of 400 vertical bore holes 425 feet deep with 64 miles of interconnected pipeline. The system was financed by federal utility rebates and state grants and has facilitated significant reductions in electricity and natural gas consumption and greenhouse gas emissions. HEET, & BuroHappold Engineering. (2019). *GEO MICRO DISTRICT Feasibility Study*. https://heet.org/wp-content/uploads/2019/11/HEET-BH-GeoMicroDistrict-Final-Report-v2.pdf

[17] HEET, & BuroHappold Engineering. (2019). *GEO MICRO DISTRICT Feasibility Study*. https://heet.org/wp-content/uploads/2019/11/HEET-BH-GeoMicroDistrict-Final-Report-v2.pdf

[18] *See*, https://heet.org/2023/04/17/update-networked-geothermal-in-framingham-ma/

[19] *See*, https://www.eversource.com/content/residential/about/transmission-distribution/projects/massachusetts-projects/geothermal-pilot-project

[20] *See,* "Why hybrid heating systems are better than heat pumps for district heating schemes," Open Access Government, November 26, 2020, at https://www.openaccessgovernment.org/hybrid-heating-systems-heat-pumps-district-heating/98644/.

2.0 State and Local Regulations Controlling District Energy Systems.

2.1 Applicable Ohio Law

A facility in Ohio which provides thermal load to multiple customers is deemed a public utility unless it is otherwise exempted. Under Section 4905.02 (A), a public utility "includes every corporation, company, co-partnership, person, or association…defined in Section 4905.03,"[21] except under certain circumstances. Under section 4905.03 (H), public utility company definitions include "[a] heating or cooling company, when engaged in the business of supplying water, steam, or air through pipes or tubing to consumers within this state for heating or cooling purposes."[22] One important exemption from Section 4905.02 ((A)(3)) is "a utility owned or operated by a municipal corporation,"[23] which utility is specifically deemed to *not* be a "public utility company" for purposes of 4905.

In Ohio, municipalities are explicitly granted certain authorities by the State Constitution, one of which applies to the ownership or operation of a utility. Under the Ohio Constitution, Article XVIII:

> Any municipality may acquire, construct, own, lease and operate within or without its corporate limits, any public utility the product or service of which is or is to be supplied to the municipality or its inhabitants, and may contract with others for any such product or service. The acquisition of any such public utility may be by condemnation or otherwise, and a municipality may acquire thereby the use of, or full title to, the property and franchise of any company or person supplying to the municipality or its inhabitants the service or product of any such utility.[24]

This privilege exempts the municipal utility from being classified as a public utility company, and, as a consequence, from Public Utility Commission of Ohio (PUCO) regulation. It also offers a pathway through which a private entity might operate a geothermal district energy system: private entities may contract with the municipality to operate a District Energy system.

A utility operating under contract with a municipal corporation is regulated by the municipal legislative authority under which it is established. This municipal legislative authority governs the creation, operation, and tariff structure of the municipal utility. This right is established by Title 7, Section 715.06 of the Ohio Revised Code which sets forth that, "[a]ll municipal corporations may: (A) Establish, maintain, and operate municipal lighting, power, and

[21] *See*, https://codes.ohio.gov/ohio-revised-code/section-4905.02

[22] *See*, https://codes.ohio.gov/ohio-revised-code/section-4905.03

[23] *See*, https://codes.ohio.gov/ohio-revised-code/section-4905.02

[24] *See*, https://codes.ohio.gov/ohio-constitution/section-18.4

heating plants."[25] A municipality's rights to contract for operation of District Energy is further set forth in Section 715.34, which provides:

> Any municipal corporation may use, or by ordinance grant, for periods not exceeding twenty-five years, the use of its streets, avenues, alleys, lanes, and public places to lay pipes, conduits, manholes, drains, and other necessary fixtures and appliances under the surface thereof, to be used for supplying such municipal corporation and its inhabitants with stream or hot water, or both, for heat or power purposes, or both.
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> In all such grants the municipal corporations shall reserve the right to regulate, at intervals of not less than five years, the prices which the grantee may charge for such heat or power.[26]

District Energy is most likely to be economical where multiple buildings are located in close proximity – most commonly found in urban areas. This means most new systems are likely to be regulated by city councils. However, municipalities may (and some do) delegate the regulation of District Energy to the Public Utility Commission of Ohio.

2.2. Franchises and Municipal Utility Regulation.

Under the Ohio Revised Code, private companies seeking to operate a utility in a municipality must first seek permission from that municipality. Pursuant to Section 4933.03, any utility company seeking operations within a municipal corporation's jurisdiction in any "street, alley, or public property" must seek consent before operating.[27]

Municipalities have their own ordinances and rules for granting that consent, and for regulating utilities that operate in their jurisdictions. This includes the right to grant a franchise or concession to private companies to operate on behalf of the municipal utility. For example, in Cleveland, Ohio, under Chapter 35 of the city "Code of Ordinances" (entitled "Franchises"), a utility must obtain approval to operate on public grounds.[28] Under this ordinance, the city specifies the quality and type of service to be administered, tariffs, and other matters pertaining to public interest. Furthermore, no franchise ordinance may exceed contract terms of more than 25 years, although extensions are permissible.

Ordinances can be used to grant franchise rights, but are not agreements between the municipality and the utility. Franchise Agreements, on the other hand, are agreements between

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[25] *See*, https://codes.ohio.gov/ohio-revised-code/section-715.06

[26] *See*, https://codes.ohio.gov/ohio-revised-code/section-715.34

[27] *See*, https://codes.ohio.gov/ohio-revised-code/section-4933.03

[28] *See,* https://codelibrary.amlegal.com/codes/cleveland/latest/cleveland_oh/0-0-0-1006

the municipality and the utility. The Franchise Agreement (also sometimes referred to as concessions) sets forth the terms and conditions under which the utility may operate. The National Renewable Energy Laboratory conducted a study of municipal utility franchise agreements, and concluded that "municipalities across at least 30 states have the authority to pursue franchise agreements."[29] Herein, a franchise agreement is defined as:

> A negotiated contract between a municipality and an electric service provider that grants the utility the right to serve customers in the city's jurisdiction. The contract often specifies the period of service and a fee remitted back to the municipality. These agreements commonly include stipulations regarding a utility's right of way to install and maintain electrical infrastructure.[30]

Under Ohio law, District Energy systems operated by private entities and that include multiple customers require Franchise Agreements from the municipalities in which they plan to operate.

2.3 Zoning, Drilling and Other Permit Requirements

In addition to a Franchise Agreement from the municipality, zoning requirements and drilling permits may be required from the local authority. These may include such things as well siting permits, management of disturbances to riparian or floodplains, and regulations regarding local slope and soil characteristics.[31]

Constructing a networked geothermal system in accordance with state law adds some additional complexity. With either closed or open-loop systems, Section 1521.05 of the Ohio revised code requires that the developer maintain careful logs of all borehole operations. This includes depth and other construction characteristics, water levels, geological properties, owner and operators' information, and other requirements.[32] Additionally, new logs are recommended for subsequent boreholes where significant geological differences appear. This will aid regulators in assessing the geology of the properties involved in the system while also characterizing the system's layout.[33]

An open loop system requires considerably more attention from planners to meet requisites under Ohio law. An open loop networked system may, for instance, withdrawal significant amounts of water. System planners will need to be aware of the Water Withdrawal

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[29] Cook, J. J., Grunwald, B. U., Holm, A., & Aznar, A. (2020). Wait, cities can do what? Achieving city energy goals through franchise agreements. *Energy Policy*, *144*, 111619. https://doi.org/10.1016/j.enpol.2020.111619

[30] *See*, https://www.nrel.gov/solar/market-research-analysis/municipal-franchise-agreements.html

[31] *See*, (2012) https://epa.ohio.gov/static/Portals/28/documents/sccgw/GHCS.pdf, pp.4-5.

[32] *See,* https://codes.ohio.gov/ohio-revised-code/section-1521.05

[33] *See,* (2012) https://epa.ohio.gov/static/Portals/28/documents/sccgw/GHCS.pdf, p.6.

Registration, which is an extension of the Great Lakes Charter of Ohio. This registration is required for any facility withdrawing 100,000 or more gallons per day (gpd). The registration must disclose the registrants name and address, the location of the water source, capacity of water withdrawal, how the water will be used, and where it will be discharged.[34] Open Loop systems must also comply with the Great Lakes-St. Lawrence River Basin Water Resources Compact, pursuant to which water withdrawn from within the Lake Erie Basin may not be discharged outside of the basin without additional permitting.[35]

Discharging fluids, whether to surface water or underground, calls for additional oversight. For discharging to surface water, the Ohio Environmental Protection Agency's (OEPA) "National Pollution Discharge Elimination System General Permit" constrains discharge based upon volume and temperature.[36] Discharges to ground water from geothermal capacity are classified as Class V injection wells and are permitted through the OEPA Injection Control Program.[37] Under the applicable law, injections must meet safe water drinking standards and fluids containing additives must seek additional permitting.

Well siting should follow standards of practice, including being located at least 50 feet from pollutants such as commercial or residential sewage systems and waste management facilities. Additionally, the extraction well should be sited at a reasonable distance from other public or privately owned ground water sources. Under section 1521.17 of the Ohio revised code, a system operator can be held liable for the drawdown of these resources.[38] Furthermore, for the efficiency of the system, the space between the extraction and discharge wells should be 50 feet in consolidated geology and 100 feet in unconsolidated.[39]

For closed-loop applications, other than boreholes and local construction permits, there are no specific laws regulating construction. As a result, utilities building such systems will be guided principally by industry standards.[40] Geothermal systems utilizing geo-exchange use water mixed with additives, therefore, underground piping must be compatible with a variety of heat transfer fluids, corrosion resistant, and pressure tested. As with the open-loop system, the closed-loop system should be sited 50 feet from any pollutants such as sewage lines or waste management facilities. Due to the lack of siting and permitting associated with a closed-loop system, the location of the installation may be obscured. For this reason it is recommended that

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[34] *Id.,* p.6.

[35] *See,* https://codes.ohio.gov/ohio-revised-code/section-1522.11

[36] *See,* (2012) https://epa.ohio.gov/static/Portals/28/documents/sccgw/GHCS.pdf, p.8. Additional requirements must be met for discharging over 100,000 gpd, including a Notice of Intent filed with the OEPA.

[37] *See*, (2012) https://epa.ohio.gov/static/Portals/28/documents/sccgw/GHCS.pdf,. p.9.

[38] *See,* (2012) https://epa.ohio.gov/static/Portals/28/documents/sccgw/GHCS.pdf, p.10.

[39] *Id.,* p.10.

[40] *See,* (2012) https://epa.ohio.gov/static/Portals/28/documents/sccgw/GHCS.pdf, p.14.

pipes be laid with locator wire to ensure that future projects that involve subsurface infrastructure do not interfere.[41]

Vertically integrated closed-loop systems should follow applicable grout standards to prevent the permeation of contaminants into or out of the boreholes. Grout must meet the standards set forth by Chapter 3701-28 or Chapter 3745-9 of the Ohio revised code to ensure the safety of the system.[42] Furthermore, grout should be installed within a window of 24 hours of drilling completion.

3.0 Business Models for Municipal District Energy Systems.

3.1 Publicly Owned District Energy System.

The municipally owned district energy company can structure its ownership of a District Energy system as a wholly public entity or as a hybrid entity with public-private cooperation. Under the wholly public model, the municipality bears all risk of developing the project. If such a project presents a low internal rate of return (IRR), the municipality can more readily socialize this risk across its large project portfolio than can a private company.[43] Furthermore, due to lower financing costs and risks with publicly backed development, the IRR of wholly public projects may be higher, making the project less expensive even if projected revenues are the same for either ownership structure.[44]

Networked geothermal District Energy systems servicing multiple customers has yet to be developed in Ohio. A publicly backed project could provide the regulatory certainty and financial backing that might trigger early adoption. Additionally, a publicly owned District Energy utility may be more motivated to offer service to marginalized customers, promoting equity within the system. This is especially relevant in a post climate change world, as described by recent literature on the topic of urban heat islands (UHI). UHI is a phenomenon wherein dense urban cityscapes "combined with growing average global temperatures…exacerbates human health risk."[45] For many lower-income residents, this is about much more than cost savings or comfort: geothermal space cooling could be a matter of mortality. For these reasons, a wholly public model may be

[41] *See,* (2012) https://epa.ohio.gov/static/Portals/28/documents/sccgw/GHCS.pdf, p.16.

[42] *See,* (2012) https://epa.ohio.gov/static/Portals/28/documents/sccgw/GHCS.pdf, p.17.

[43] United Nations Environment Programme. (2016). Business models for District Energy: A Continuum from public to private. *District Energy in Cities*, pp. 88–90. https://doi.org/10.18356/b750e4d4-en

[44] *Id.,* pp. 88-90.

[45] Chakraborty, et al. (2019). Disproportionately higher exposure to urban heat in lower-income neighborhoods: A multi-city perspective. Environmental Research Letters, p.1. https://doi.org/10.1088/1748-9326/ab3b99. *See also:* J. Bedayn, "Record heat waves illuminate plight of poorest Americans who suffer without air conditioning," Associated Press News, July 30, 2023, https://apnews.com/article/heat-wave-low-income-race-death-air-conditioning-f897e336d6d99ee2a53024f42ad7b8b5.

the most viable near-term strategy to stimulate adoption.

3.2 Public-Private Ownership Model for District Energy.

Under a hybrid structure, and in accordance with Ohio law, a municipal corporation may jointly operate a utility with a private partner, providing flexibility in the ownership structure. The municipality can delegate utility operations through a concession contract or a franchise agreement. Under this arrangement, the private party builds, owns and operates the system under municipal regulation (unless delegated to the PUCO). Either party or both can undertake the financing role, through public debt instruments, private equity, or a combination of both. Equity can be acquired by the public party in other ways than public debt, such as providing tax allowances, offering land or by underwriting demand risk by committing to long-term service contracts.[46]

Within the broad language of Article XVIII of the Ohio Constitution, a municipality could also lease District Energy infrastructure from or to a private entity, while engaging the private party to operate the facilities. This might be especially attractive for systems that are supported by federal grants that might require the municipality to own the infrastructure. This is most likely to occur in low income commercial or residential areas – locations where developers might otherwise be hesitant to invest.

3.3 Fully Private Ownership Structures.

For operations outside of a municipality (i.e., an unincorporated area), a private District Energy company with multiple customers would be regulated by the PUCO. While these regulations may not vary much from the regulations imposed by a municipality, without the participation from a municipal corporation, a novel project such as networked geothermal district energy may face considerable constraints. Private investment in such a project may be unattractive, at least until a system such as the Eversource project is proven elsewhere. But more importantly, a District Energy utility operating in rural, unincorporated areas may find it more difficult to find multiple customers sufficiently close together to make the investment work.

4.0 Case Studies.

4.1 Southeast False Creek Neighborhood Energy Utility (SEFC NEU), Vancouver, Canada.

SEFC NEU provides district heating utilizing waste heat from the regional sewage facilities in conjunction with heat pumps. The ownership structure of this organization is wholly public, designed and implemented for the purpose of reducing carbon dioxide emissions and to

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[46] United Nations Environment Programme (2016). Business models for District Energy: A Continuum from public to private. *District Energy in Cities*, pp. 92-97. https://doi.org/10.18356/b750e4d4-en

showcase the commercial viability of novel District Energy applications.[47] The project was developed relatively quickly, as city officials pushed to have the project completed in time for the 2010 Olympic games, five years after its first feasibility study.

Demand risk was mitigated by the city, which controlled 17% of the initial system load and further by service-area bylaws enacted to require connection. Due to public ownership, tariff contracts are not opaque, as may be the case for some private utility companies (in Ohio, PUCO and most municipal utility tariff rates are public). This allowed for unobstructed cost-benefit analyses for residents and business seeking interconnection in areas exempt from the service bylaws. Shortly after completion, the system was servicing approximately 16,000 people.[48]

The project was fully financed by debt obtained through municipal and state-owned funds totaling approximately 32 million Canadian Dollars.[49] The debt was structured in such a way that it mimicked a 60%-debt 40%-equity split, which is how capital investment is normally structured in British Columbia for private utilities. The purpose of this was to prove that such a project is financially feasible for private sector firms, thus stimulating adoption.

4.2 Rotterdam District Heating, Netherlands.

Warmtebedrijf Rotterdam is a district energy company in the city of Rotterdam, Netherlands founded in 2010 that utilizes waste heat from the local waste incinerator and industrial activities at the Port of Rotterdam to provide space heating for the region. This company is owned in a joint venture, primarily by the municipality with minority stake held by E.On Benelux, a large private utility in the Netherlands. Warmtebedrijf Rotterdam was heavily financed by the municipality, with a 38 million-euro direct investment and an underwritten 149 million-euro bank loan.[50] For additional investment and management aid the municipality sought the involvement of E.On Benelux.

The company has two subsidiaries, Warmtebedrijf Exploitatie N.V. and Warmtebedrijf Infra N.V. The first subsidiary oversees customer relations including managing contracts and business growth, while the latter manages capital allocation, takes on debt and structures the company's projects.[51] The two companies work under a 30-year agreement wherein

[47] *Id.,* p. 89.

[48] *Id.,* p. 89.

[49] *Id.,* p. 89.

[50] Rao, L., Chittum, A., King, M., & Yoon, T. (2017). Governance Models and Strategic Decision-Making Processes for Deploying Thermal Grids. *International Energy Agency, pp.* 33–35. https://www.districtenergy.org/viewdocument/governance-models-and-strategic-dec

[51] *Id.,* pp. 33-35.

Warmtebedrijf Exploitatie N.V pays Warmtebedrijf Infra N.V. for thermal transmission, which it uses to pay off debt and maintain the system.

Shortly after incorporation, the municipality began another joint venture, the "New Heatway," for the purpose of supplying heat to Rotterdam's residential districts. The New Heatway consists of a 26 km pipeline owned by the municipality of Rotterdam, the Province of South Holland, and others.[52] The municipality played a crucial role in mitigating demand risk, ensuring the viability of the project.

Under the concession agreement, tariffs are heavily regulated by the municipality, wherein rates must be competitive with heating companies that offer traditional thermal generation sources such as fossil fuels.[53] Furthermore, the municipality made direct efforts to obtain long-term, end-user contracts with large consumers, such as building developments and housing projects.

4.3 West Union Green Transformation Project, West Union, Iowa.

West Union, a small rural town in northeast Iowa, was aided by the Iowa Economic Development Authority (IEDA) in 2008 to develop a sustainable energy system to serve its downtown district.[54] The IEDA brought together various sustainability experts and federal and state departments to aid in conceptualizing the redevelopment project. A geothermal district energy system was the outcome of their evaluation, and with funding from the USDA Rural Community Development Initiative, the team hired IBC Engineering Services to conduct a feasibility study.[55]

The feasibility study proved the project to be viable and West Union sought funding for the project, estimated to cost $10.2 million. In 2009 it was able to secure $7.5 million in private investment and in 2010 it secured the remaining $2.7 million from various state and federal programs.[56] This funding was essential because no off-take contract agreements had yet been made by property owners for interconnection. This was largely because property owners were unsure of the governance and rate structure of the system. However, West Union officials reassured property owners as to the viability of the system by narrowing the project ambition and providing auditing information.[57]

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[52] *Id.,* pp. 33-35.

[53] *Id.,* pp. 33-35.

[54] Jeff Geerts (2013), International District Energy Association. p.20. https://www.districtenergy-digital.org/districtenergy/2013Q1/MobilePagedReplica.action?pm=1&folio=18#pg20

[55] *Id,.* p. 21.

[56] *Id.,* p. 21.

[57] *Id.,* p. 21.

In 2011 a bid took place to secure a contractor to build the system and in 2012 construction began. West Union owned the infrastructure and calculated rates necessary to cover maintenance and administrative costs; however, they leased the system to an LLC comprised of end-users. Shortly after construction the system had secured 11 long-term and 3 short-term offtake contracts from property owners for service in 2013 when the system came online.[58]

The system is closed-looped, comprised of two loop fields and a distribution network utilizing heat pumps to facilitate thermal transfer. The Courthouse field is comprised of 132 vertically drilled boreholes and the Lions Park field contains 252.[59] The distribution network transfers a fluid containing 75% deionized water and 25% food grade propylene glycol to heat pump stations for heating or cooling. The fluid is then available to be piped to the basements of 57 buildings in the downtown district.[60] Further steps were taken in system development to ensure future scalability.

5.0 Conclusion

Municipalities in Ohio are looking at strategies to reduce carbon emissions, to reduce costs for its residents and businesses, and to provide safe spaces for residents in response to extreme heat and cold weather. Tax credits from the 2022 U.S. Inflation Reduction Act may provide cost-effective strategies for networked District Energy systems to meet these goals. Municipalities can operate these systems as a division of the municipality, by granting franchises to private utilities, or both. To date, most District Energy utilities in Ohio have been either on campuses or in downtown business districts, and most use natural gas to create thermal load. However, tax credits and other federal incentives may lead to District Energy systems being built around waste heat or networked geothermal systems.

A networked District Energy system utilizing geothermal and heat pumps to serve customers would be the first of its kind in the state of Ohio. Due to the privileges extended to municipalities by the Ohio Constitution, either a wholly public or hybrid ownership structure may be ideal for the initial adoption of a networked geothermal district energy system. This conclusion is reinforced by the case studies identified herein. In each, public sector involvement was a critical aspect of the project's viability.

The unprecedented nature of such a project presents risks that may make private sector investment either too costly or unavailable. However, if projects such as the one developed by Eversource in Massachusetts prove to be economically viable, it may invite more private sector attention. Furthermore, as seen in the Rotterdam and Vancouver projects, demand risk was

[58] *Id.,* p. 21.

[59] Geerts, J. (2013). *West Union, Iowa District Geothermal Heating and Cooling System* (pp. 8–9). Iowa Economic Development Agency.

[60] *Id.,* pp. 8-9.

mitigated through concession contracts, offtake contracts and service-area regulations requiring local connection. These offtake agreements and demand regulations may be necessary to attract private sector involvement under a hybrid ownership structure. And depending on the capacity of a municipality to wholly oversee the creation and implementation of such a system, private sector involvement may be crucial.

Public sector involvement will be critical to promote adoption of these systems in low-income regions, where the benefit to end-users is greatest, but where reward for the utilities is marginal. In addition to demand risk mitigation measures, a municipality may also impose taxes to socialize the cost of the system. Even in locations where end users have more wherewithal to pay, public participation to novel geothermal strategies to approaches to decarbonize energy systems may be necessary for early proof-of-concept projects.