Overcoming Legal and Regulatory Barriers to District Geothermal in New York State

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Final Report

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Abstract

This study examines the legal and regulatory issues confronting the development of district geothermal energy systems in the State of New York. Although geothermal technology is a reliable and economically feasible zero-emission source of building heat, resolving property rights and permitting issues required to cross property boundaries and public rights-of-way raise the cost and uncertainty of district geothermal systems, resulting in net diseconomies of scale of an otherwise cost-saving technology. We evaluate geothermal projects along a continuum of complexity—from single owner systems—including a single owner of multiple buildings on a single parcel of land (such as a college campus)—to systems that involve multiple owners of buildings on numerous parcels of land (such as serving a downtown core). This study considers how property rights and permitting regimes governing geothermal projects can inform potential business models to advance the technology and presents recommendations for State authorities to consider in order to scale geothermal energy technology to meaningfully contribute to New York State's meeting its greenhouse gas emission-reduction mandates under the Climate Leadership and Community Protection Act.

Keywords

Geothermal energy, decarbonization, permitting, regulation, business models

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Acronyms and Abbreviations

kWh	kilowatt hour	1,000 watts of electricity used continuously for one hour
kW_{th}	kilowatt thermal	1,000 watts of thermal power
MW_{th}	megawatt thermal	1,000 kilowatts of thermal power

Summary

New York State's Climate Leadership and Community Protection Act (Climate Act) mandates ambitious statewide reductions in greenhouse gas emissions of 40 percent from 1990 levels by 2030 and 85 percent reductions by 2050.[1] Achieving the Climate Act's reduction goals requires decarbonizing gas and electricity use across all economic sectors, including heating applications in the buildings sector.

In the residential, commercial, and industrial sectors in New York State, greenhouse gas emissions from on-site combustion, providing building space and water heating, process heating, and other on-site applications accounted for 37 percent of statewide emissions from fuel combustion in 2016. When the emissions from electricity generation are considered, emissions from buildings in these sectors account for 56 percent of the State's fuel combustion emissions.[2]

If methane emissions caused by leakage from natural gas extraction, transmission, and distribution are considered, overall methane emissions associated with end-user natural gas consumption further increases the amount by over three percent.[3] These additional emissions due to leakage occur along the entire value chain of natural gas production, transmission, and distribution, and thus are not confined to New York State or counted in its emission accounting.

To place the challenge of decarbonizing the building sector into perspective, New York State must fully decarbonize over 400 buildings each day for thirty years to meet the Climate Act's 2050 mandate.[4]

Geothermal can play a critical role in reducing emissions associated with the building sector. Geothermal, deployed at an economy-wide scale alongside electrification of the building and transportation sectors, powered by solar, wind, energy efficiency, and demand reductions will be essential to achieving mid-century greenhouse gas reduction goals. We define geothermal energy to include systems that transfer energy from the earth's subsurface geology, a surface water body, or raw or treated sewage, through a system of heat exchangers and pipes to use as heating and cooling for use in buildings or to supplement industrial processes.

Scaling up geothermal to fully contribute to carbon reductions will require deploying geothermal in both single- and multiple-property configurations. While single-property geothermal is already energy-efficient, cost-effective, and increasing in adoption, district geothermal serving multiple properties using a common ground loop remains uncommon. District geothermal, although potentially more energy-efficient than single-property systems, remains cost-prohibitive in significant part due to legal and regulatory factors.

From a performance perspective, the greater number of buildings and users served on a common loop, particularly if the user loads are diverse, the greater the potential economic advantages of geothermal energy. A common system serving multiple users requires less overall capacity and thus reduces overall equipment and operating costs. Diverse users drawing thermal energy at different times and connecting varied sources of waste heat and other thermal sources and sinks further enhance system operation and financial performance.

The greater energy efficiencies of district geothermal achieved through economies of scale of a common loop must be balanced against the diseconomies of the property rights and permitting costs required to implement these systems. Because district geothermal systems require installing heat exchange equipment and pipes across multiple properties, crossing roads or other rights of way, or interfering with utility or other infrastructure, district geothermal presents property rights and permitting issues that are costly and time-consuming to resolve. Regulation of drilling at deeper depths constrains system design, potentially resulting in suboptimal design and additional costs. These problems may be particularly acute in urban settings or retrofits of already-built residential neighborhoods. District systems are further hobbled by a lack of regulations governing whether and how utilities may seek to own and operate geothermal assets, thereby hindering the ability of utilities to engage in the geothermal business as well as creating uncertainty as to the ultimate development of the market for geothermal heat services.

Property rights, permitting requirements, and regulatory complexities have thus added significant cost, delay, and uncertainty to projects, discouraging the development of geothermal systems beyond single property systems. Further, regulation of the business model for owning and operating these systems remains a threshold issue for New York State. The issue should be addressed by the legislature to remove uncertainties and to provide a roadmap for geothermal development. Legislation should enable geothermal to scale rapidly within a financially sustainable business model. Whether geothermal follows a regulated model like electricity and natural gas distribution, remains unregulated, or a hybrid combining regulated and unregulated elements is a critical issue that will define how geothermal technology develops in the State.

This paper explores the legal and regulatory barriers to district geothermal and possible legal mechanisms and business models to overcome transactional diseconomies. For purposes of this inquiry, New York State Energy Research and Development Authority (NYSERDA) defines district geothermal as a single integrated system (networked loop) either serving at least two large buildings (the two buildings summing to at least 40,000 square feet of conditioned space to be heated by the community-style heat pump system) or serving the conditioned space of at least 10 buildings of any size to be heated by the community-style heat pump systems.

This paper is organized into seven sections. The first section briefly describes various district geothermal design options and their potential implications for creating transactional diseconomies. Sections two and three discuss the property rights and environmental law and permitting aspects of district geothermal systems in New York State. Section four considers the Public Service Commission's authority to regulate geothermal and the principles it might adopt in shaping the market for geothermal heat. The fifth section draws on the prior sections in examining drivers that influence geothermal development and articulates 11 business models along a continuum from single-property geothermal to variations of district geothermal systems. This section considers various possible options for district geothermal models to advance the technology on a cost-effective basis. Section six evaluates the practical, legal, and economic case for utility district geothermal in the State. The final section recommends actions to State legislators, State agencies, municipalities, and project developers to help overcome legal and regulatory diseconomies to ensure that geothermal achieves its full potential in reducing greenhouse gas emissions in the State of New York.

1 Geothermal System Design

Geothermal energy technologies and project designs are diverse. In their simplest form, these systems transfer thermal energy from the earth's subsurface geology, a surface water body, or raw or treated sewage, through a system of heat exchangers and pipes to use as heating and cooling for use in buildings or to supplement industrial processes.

Geothermal systems employ an indoor heat exchanger or ground source heat pump that supplies heating and cooling to end users by extracting thermal energy from fluid that circulates in a ground loop buried underground, in an aquifer, or connecting to a deep rock reservoir. Relatively consistent sub-surface temperatures enable ground source heat pumps and direct use systems to supply space heating in cold weather climates and hot water heating year-round. Efficient space cooling in summers is also possible using ground source heat pumps.

Geothermal systems can be categorized by depth and type of geothermal source, ranging from shallow wells of several hundred feet that rely on low temperature thermal exchange, through intermediate systems of the thousands of feet, and deep wells of over 30,000 feet. Shallow systems at depths of even several feet to approximately 600 feet operating at temperatures of below 50°C can be cost-effective for direct heating and heat pump applications. Deep reservoir systems that may extend thousands of feet exploit much higher temperature hot dry rock, often used for large-scale power generation, district heating, and combined heat and power (cogeneration) applications.[5]

Unlike deep hot dry rock resources, shallow geothermal resources are widely available. This paper focuses on shallow thermal exchange systems that can be deployed in a district design serving multiple properties.

For shallow systems, the piping may be installed by drilling horizontally or vertically. Facilities with adequate space can employ horizontal excavation or drilling, typically to depths of 6 to 10 feet for excavations and possibly deeper for horizontal drilling. For building sites where land is scarce, vertical drilling systems are utilized. Several boreholes—or "wells"—are drilled typically to depths of 200 to 500 feet, or deeper if regulations are favorable to deeper wells.[6]

Once bored, pipes are fitted vertically into the borehole to extract or reject heat from and to the subsurface. For shallow systems, piping is usually made of high-density polyethylene (HDPE) or other material, typically rated for a useful life of well over a hundred years or longer.[7]

Shallow geothermal systems of the kind addressed in this paper are typically closed loop but may also be open loop design. Closed loop systems circulate the working fluid to transfer heating and cooling—usually water or anti-freeze[8]—in a closed system of pipes. Closed loop systems are designed so that no working fluid is released to the environment, and increasingly use substances that are nontoxic in the event of an unintended release, such as propylene glycol.[9]

Open loop systems use groundwater or surface water, such as from a pond, lake, or river, and either return the water to the original source or otherwise dispose of it back into the environment.

Other thermal sources include installing geothermal loops into building foundations and tapping into water and sewer utility systems in closed loop geothermal design.[10]

The next section on regulation describes the environmental regulations governing both closed and open loop systems, and special situations, such as the use of water bodies as thermal sources and sinks.

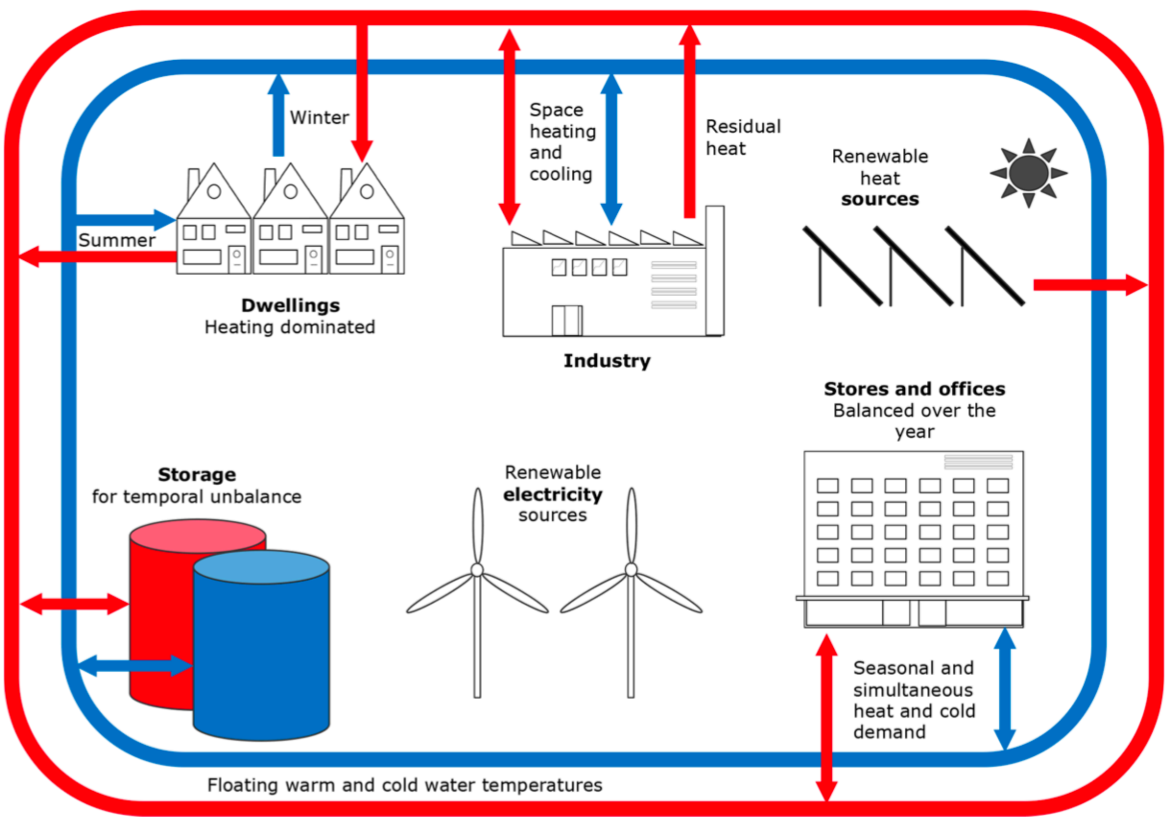
Both closed and open loop systems can be configured as direct or indirect systems. In direct exchange systems, heating or cooling is supplied directly to the building or application by the pipe carrying the thermal transfer fluid without an intermediate heat exchanger. Direct exchange systems are significantly more efficient at heat extraction and rejection than indirect systems. In indirect heat exchange systems, fluid circulating through the system is piped to a heat exchanger, which in turn supplies a building's HVAC system or other application.

Beyond basic geothermal systems, enhanced fully integrated "5th generation" geothermal systems that feature centralized heat pumps and further integrate distributed energy resources and other energy efficiency technologies are already in use and could expand in the future as smart technologies enable greater integration. In enhanced systems, greater efficiencies can be achieved by designing geothermal systems to utilize excess heat within the building being served. Enhanced designs include coupling with combined heat and power (CHP) systems, as well as integrating geothermal systems with solar thermal systems, wind power, hot and cold floating thermal storage, and distributed renewables such as solar photovoltaic, wind, and storage that generate heating or cooling to supplement geothermal.

In district geothermal systems, distributed renewables can be connected to the geothermal common loop, forming an array akin to a smart electricity grid in which bi-directional flows of heating and cooling are created. A set of hot and cold pipes are used. When heat is consumed by a building or application, the rejected cooled fluid is released to the cold pipe, and when cooling is drawn from the cold loop, the rejected heated fluid is released to the hot loop, effectively recycling thermal resources. The placement of storage and renewables along the grid regulates thermal temperatures based on user requirements. Small-scale district projects have demonstrated these solutions, capable of servicing almost full-thermal heating demand. However, these solutions have yet to be piloted on a city scale.[11]

Figure 1. Advanced Fully Integrated Geothermal System

Source: Boesten et al., 5th Generation District Heating and Cooling Systems as a Solution for Renewable Urban Thermal Energy Supply, 39 Advances in Geosciences 129, 131 fig. 1 (Sep. 20, 2019).



Finally, a major design element is whether a geothermal system is introduced into an already built environment or is planned as part of new development. Retrofitting existing buildings and facilities generally involves additional complexities and costs due to the need to accommodate existing infrastructure. These accommodations include upgrading existing building heating distribution systems, associated equipment, and electrical systems.

Each design element has land use, permitting, and regulatory implications. If geothermal systems become commonplace, design considerations may also influence urban planning decisions to optimize energy efficiency. The next section presents the property rights, permitting, and regulatory aspects of district geothermal systems.

2 Property Law

District geothermal systems by their design serve multiple users, requiring resolution of property rights issues among property owners and permitting issues that delay and increase the cost of implementing these systems.

Present property rights, permitting, and regulatory regimes are not designed to facilitate the adoption of district geothermal on a society-wide scale. In very significant respects, property, permitting and regulatory regimes raise complications that pose barriers to the adoption of district geothermal systems. These complications include:

- Obtaining easements to locate geothermal infrastructure across public rights of way, or across third-party properties.
- Easements for subsurface geothermal systems can impose restrictions and obligations on how private property owners may use their land, with implications for property values; thus property owners may decline participation in district geothermal system development or refuse to grant necessary access onto or across their property without adequate protections or compensation.
- The co-location of geothermal systems with other utility infrastructure requires cooperation that can invite rent seeking and obstructionist behavior among utilities.
- Municipalities presently lack local standards and permitting regimes for district geothermal systems.
- The State of New York's laws and regulations governing public utilities create uncertainties as to the business model for district geothermal, leaving unanswered whether utilities may offer district geothermal services, and how these services may be regulated and priced.

All these complications potentially impose significant costs that threaten the economic viability of district geothermal system development. Resolving legal issues and obtaining cooperation and consent among required stakeholders is also time consuming and will cause delays in implementing district geothermal at large scale.

This section discusses the property rights, permitting, and regulatory issues that must be resolved for district geothermal to scale economically and efficiently to meet Climate Act mandates.

2.1 Property Law Concepts

This section summarizes basic property law concepts essential for understanding the legal barriers to district geothermal systems. Property law is predominantly State law.

Fee Simple Ownership refers to the complete set of private property rights, commonly analogized to a bundle of rights. The bundle typically includes:[12]

- **The Right to Possess**, a valuable right from which other rights extend, meaning the actual, physical occupation or the constructive possession of the owner.[13]
- **The Right to Use** private property was traditionally absolute, provided the use did not infringe on the rights of others, and historically enforced through common-law nuisance.[14] State statutes and local laws that regulate zoning and development have imposed use restrictions on private land since the 20th-century.[15]
- **The Right to Derive Income** entitles owners of real property to the products and economic benefit derived from the permitted use of their property.[16]
- **The Right to Destroy**. Property owners may alter their properties and remove fixtures, permanent structures, or natural resources. The law limits this to protect historic property, endangered species, and natural habitats, and will step in where the property at issue holds substantial value to society.[17]
- **The Right to Exclude Others** is the right of a property owner to determine who enters onto the property and what an invitee may do there. The law limits this right to protect larger societal interests, such as proscribing businesses excluding people based on race or other protected classes. **Trespass** is the traditional means of enforcing the right to exclude others from private property. Under New York law, "a person is guilty of trespass when he knowingly enters or remains unlawfully in or upon premises."[18]
- **The Right to Transfer or Alienate** refers to an owner's ability to sell all or a subset of their property rights to another.[19]

The bundle of property rights may be divided and transferred to different property owners, such as, for example, a right to harvest the product of land (such as fruit) without transferring a possessory interest in the underlying land. Property rights can also be defined temporally.

Easements. Easements are an especially important lesser right in land in the context of district geothermal systems. Easements provide their holders a limited right to use another's real property for specific purposes without the transfer of a possessory interest in the land itself.[20] Easements typically comprise a servient estate holder who owns the land burdened by the easement and a dominant estate holder who owns the benefited land and the easement over the servient estate. A common example of an easement is the right of the dominant estate to install a water or sewer line through a neighboring servient estate.

Private Right-of-Way. A private right-of-way is a type of easement that grants a nonowner a limited privilege to pass through the property of another. Driveways are a common example that allow the easement holder to pass over the surface of their neighbor's land for the purpose of accessing a dominant property.[21]

Surface and Subsurface Rights. Surface property rights generally include rights to the subsurface below the property.[22] Property owners are free to separate surface, subsurface, and airspace property rights and transfer these separated rights to different parties, such as transfer of mineral rights, water extraction rights, and designation of the use of property at different elevations for specific purposes.

Traditionally, ownership of surface rights was conceived to extend underground to the center of the earth. New York State rejects the traditional theory of land ownership extending indefinitely downward in favor of ownership being "limited to the extent to which the owner of the soil may reasonably make use thereof."[23] New York State courts have thus held that a third-party's 30-foot deep encroachment constituted trespass,[24] whereas a sewer constructed at a depth of more than 150-feet did not violate the surface owner's property rights.[25] New York State courts allow landowners with good title to bring legal action to remove encroachments to ensure the title's marketability at the time of sale.[26]

2.2 Forms of Property Ownership

The previously described property can be owned by a single person (including a legal person) or multiple persons. The number of owners and the relationship among owners defines different types of estates, the relevant forms under New York State law being:

- **Severalty**, which describes property owned by a single person.
- **Joint tenancy**, in which joint tenants each possess vested, undivided interests in the property, may dispose of their interests separately, and possess rights of survivorship in the event of a joint owner's death.[27]
- **Tenancy in common,** in which owners each hold a right to possession and use to the entire estate,[28] even if the percentage of ownership is unequal, and may alienate their interests individually, without rights of survivorship among the tenants in common.[29]
- **Tenancy by the entirety**, reserved only for spouses, extends property ownership to the entire estate without the right to separate their interests or to convey any rights individually.[30]

2.2.1 Business Associations to Jointly Own and Manage Property

Except for tenancy by the entirety, which is only available to spouses, legal persons can own property in the forms identified above. The form of property ownership dictates the consents required for conveyances of property rights and are therefore important from the perspective of transferring property rights, including through the grant of easements.

In addition to these property ownership forms, property may be held by a business association—a corporation, partnership, limited liability company, trust, or another variant like a joint venture—that enables joint control over assets through common management. Another variant includes separate ownership of different plots of land that are managed in a coordinated manner through a common agreement among separate property owners.

The business association or common agreement provides a mechanism for coordinating decisions regarding property, which in turn can reduce the transactional costs of coordinating consents of multiple property owners. Section 5 evaluates various business models for district geothermal, which include multiple properties managed by business associations and common agreements, both of which present opportunities for lower cost district geothermal.

2.3 Creating Easements

Easements are created in one of several ways, with those relevant to our inquiry as follows:

- **Express Easements** are conveyed via a written instrument, such as a deed, signed, and acknowledged by the creator. In New York State, easements for the development or extension of subsurface infrastructure not already in existence must be express.[31]
- **Implied Easements** derive from a reasonable necessity of the easement holder. A reasonable necessity typically occurs when the dominant parcel is land-locked and an easement across an adjacent property is "indispensable to the reasonable use" of the landlocked parcel.[32] No implied easement exists when found to be a convenience and not a necessity.[33]
- **Easements by Necessity** only arise upon severance of adjacent tracts of land by showing that the severance created an immediate necessity, such as a newly severed landlocked property requiring access to a street.[34]
- **Prescriptive Easements** form when a dominant property makes continuous and overt use of a servient property for a statutorily determined length of time, with the prescribed easement limited to the use that occurred.[35]
- **Easements by Estoppel** arise when a purchaser of real property reasonably relies on a representation that an easement existed in favor of the subject property, but an actual conveyance instrument omits mention of the easement.[36]

Easements typically cannot be expanded without the mutual consent of both parties. Thus, the existence of an easement agreement for one purpose, such as to run a sewer line, does not include the right to install other unrelated infrastructure.[37] This applies to both private and public entities: municipalities may not use an easement granted across private property for a particular purpose outside of the terms of the agreement.[38]

2.4 Public Rights of Way

Public rights of way over land—roads and highways—"over which the public have a general right-of-passage," [39] are created and controlled by the State or a municipal subdivision (county, city, town, or village)[40] as set out in the New York Vehicle and Traffic Law.[41]

Surface and subsurface public rights of way are created through voluntary dedication or statutory eminent domain proceedings.[42] In certain instances, continued use of a right-of-way for at least a 10-year period results in the formation of a public street.[43] How the public right-of-way formed appears to impact the subsurface right of contiguous property owners to "encroach" into the subsurface of a right-of-way.

Where no express highway right-of-way exists and the right-of-way forms after a period of public control, the law treats the way akin to a prescriptive easement granted to the public by the servient, now abutting, landowners.[44] For this reason, abutting landowners retain a right to lay water pipes within the right-of-way to supply a dwelling, or to build areaways, cellars, and other similar structures.[45] Where such pipes or structures cause no interference with the public right-of-way, the public entity may not remove the pipes or structure without providing the abutting landowner with compensation.

However, contiguous property owners who seek such subsurface development in the public right-of-way typically must obtain the permission of the municipality through a local legislative body or administrative permits.[46] Municipalities are interested in maintaining public safety, convenience, security, and comfort. For this reason, municipalities usually require property owners to obtain permits prior to commencing work within or under the public right-of-way. This allows assurance that any use of or development within the right-of-way protects "all the public uses, servitudes, and appropriations" essential to its functions.

Additional dedicated right-of-way for utility easements often exist along, within, or beneath the public right-of-way.[47] Responsibilities for maintaining the shared public right-of-way will depend on the specific agreements between the municipality and the private utilities. However, New York State courts have held that when a municipality undertakes sewer, water, or street repairs, private utilities may bear the costs of repairing, moving, or updating their utility infrastructure.[48]

2.5 Planning, Zoning, and Land Use Regulations

Property rights are created by law and therefore subject to government-imposed limitations or intervention.

Under New York State planning and zoning laws, the State and its municipal subdivisions possess powers to impose conditions on private property use and development for purposes of community resource protection, including regulating permitted uses of property, as well as the scale, location, and intensity of development.[49] These laws generally prioritize societal interests such as public health, safety, and a clean environment.[50]

The powers of municipalities to regulate private land derive from the New York State Constitution, which authorizes the State legislature to adopt laws that protect public health, safety, and the general welfare (the "police power").[51] State legislation thus authorizes municipalities to adopt comprehensive plans—a nonbinding policy document—and subsequent zoning laws that must be "in accordance with a well-considered plan."[52] Although the State legislature granted municipalities the authority to adopt land use regulations, it remains in their discretion whether or not to do so.

The laws that comprise the State's land use planning and zoning regime are collectively referred to as zoning enabling statutes. For any given municipal action, such as the expansion or maintenance of public sewer or water systems, multiple laws will govern a matter.[53]

These laws include the General City Law,[54] the Town Law,[55] the Village Law,[56] the General Municipal Law,[57] the Municipal Home Rule Law,[58] and additional legislation that addresses specific issues, such as the Environmental Conservation Law,[59] the Public Health Law,[60] the Highway Law,[61] the Real Property Law,[62] and the Real Property Tax Law.[63]

Eminent Domain is the power of state and local governments to acquire privately owned property when necessary to achieve a valid public purpose. When a government acquires property this way, state law defines "acquisition" as the "vesting of title, right, or interest to, real property for a public use, benefit, or purpose, by virtue of the condemner's exercise of the power of eminent domain."[64]

New York State adopted general procedures for eminent domain land acquisition in the Eminent Doman Procedures Law (EDPL),[65] which explicitly allows use of eminent domain to establish public highway rights of way.[66] Courts have historically allowed use of eminent domain to develop public utility infrastructure, subject to rational basis review.[67] The EDPL generally requires a two-step process comprising a hearing and findings procedure under which the government must establish the "(1) public use, benefit, or purpose; (2) approximate location; (3) general effect on the environment and nearby residents; and (4) such other factors as the [public entity] considers relevant."[68]

Constitutional considerations require that regulatory or administrative procedures respect procedural due process rights and meet fairness requirements. Any regulation must be within the scope of authority delegated to the municipality and, where a taking of private property does occur, the government must provide the private property owner with just compensation.

2.6 Default Rules to Resolve Stakeholder Disagreement

While many believe their possession of property provides absolute rights, municipalities do have certain powers to establish default rules, effectively modifying private property rights, to overcome a lack of consent or consensus among stakeholders. Municipalities often adopt default rules to override lack of consent, or to allocate responsibilities and costs among property owners. Examples of default rules include municipalities requiring that:

- Neighbors share the cost of building and maintaining common fences.[69]
- A property owner grant access to an adjacent property owner for the purpose of maintaining a retaining wall or other wall that sits on a property boundary when entry is necessary.[70]
- A servient landowner be responsible for maintaining a sewer line running over his land for the benefit of the dominant estate, such as from intrusion from tree roots.[71]
- A property owner is responsible for maintaining the portion of a sewer line located on public property that connects his property to the sewer main, typically called a lower lateral line.[72]
- State and municipal rules requiring utilities holding easement rights to grant access to other utilities, with guidelines for pricing.[73]

These are all examples of default rules that shift rights among property owners, municipalities, and utilities, including access, responsibility for maintenance, and cost. In the context of district geothermal systems, these kinds of default rules could be extended to facilitate the development and maintenance of a district system that is located on multiple properties encompassing both private and public land.

3 Environmental Laws and Permitting Regimes

Geothermal energy systems are subject to environmental laws and regulations, municipal building codes, and permitting regimes and standards.

While most of these regulations are state or local requirements, the federal environmental protection laws, typically administered by delegation to the states, could regulate aspects of geothermal energy systems. For example, a district geothermal system that crosses or utilizes a water body, especially open loop systems that discharge water into lakes or rivers, or otherwise pose a risk to drinking water sources or affect interstate waterways, could be regulated by federal law.

Accordingly, this section discusses federal laws—the Coastal Zone Management Act, the Clean Water Act, and the Safe Drinking Water Act—and New York State environmental protection laws that could apply to geothermal energy systems, particularly water protection and drilling regulations, and permitting regimes typically administered by municipalities.

3.1 Coastal Zone Management Act

The Coastal Zone Management Act allows coastal states to develop a coastal management program setting out enforceable policies that guide federal actions that affect coastal lands and waters.[74] Once a state's management program is approved, federal projects within the state's coastal areas, or that would affect the state's coastal land or resources, must comply with the state's Coastal Zone Management Program.[75]

3.2 Clean Water Act

The Clean Water Act (CWA) authorizes the approval of state programs in lieu of federal administration and sets forth the underlying powers that states possess in regulating water pollution under the CWA. These include the authority to issue pollution discharge permits in conformance with or stricter than federal requirements (minimum technology-based and water quality-based controls), authority to provide for public participation in the permit issuance process, authority to develop a pretreatment program to regulate indirect discharges of pollutants into municipal treatments works, and the authority to adopt state water quality standards.[76] Additionally, the CWA, allows states to "veto" a federal permit or license by refusing to certify that the construction and operation of the permitted projects would not violate the state's water quality standards under CWA Section 401.[77]

The New York Department of Environmental Conservation (NYSDEC), which administers the State's environmental laws, administers CWA water quality certification permits.

3.3 Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) is intended to protect public drinking water supplies, including underground sources of drinking water. The Environmental Protection Agency (EPA) has established that underground sources of drinking water are underground aquifers with less than 10,000 milligrams per liter (mg/L) total dissolved solids and which contain enough groundwater to supply a public water system.[78] The SDWA directs the EPA to establish regulations setting minimum requirements for state water quality. States with permitting programs that meet EPA requirements are eligible to retain primary enforcement responsibility.[79] New York State retains such delegated enforcement authority.

The EPA and states with delegated enforcement authority administer the SDWA through the Underground Injection Control program. Under this program, standing column wells and open loop diffusion wells are considered Class V injection wells.[80] Pursuant to SDWA regulations, owners or operators of all injection wells, including electric geothermal injection wells, are prohibited from engaging in any injection activity that allows the movement of fluids containing any contaminant into underground sources of drinking water "if the presence of that contaminant may cause a violation of any primary drinking water regulation… or may otherwise adversely affect the health of persons."[81]

In most cases, Class V wells are "authorized by rule," meaning that an injection well may be operated without a permit so long as the owner submits inventory information to the EPA and verifies that they are authorized to inject, operate the well in a manner that does not endanger sources of underground drinking water, and properly close the well when it is no longer in use.[82] Owners must submit inventory information to the EPA prior to starting construction, as well as operating data for each well including the source of fluids to be injected, average and maximum daily injection rates, and the volume of fluid being injected.[83] After reviewing the owner's inventory information, the EPA will determine whether an individual permit is necessary.

If the EPA determines that a permit is required, the permit will include conditions that must be met by the well operator to not endanger sources of drinking water such as constructing the well to prevent communication between potential contaminants and drinking water sources through grouting and other techniques, monitoring the fluids that go into the well, implementing best management practices, and reporting to the EPA.[84]

3.4 New York State Water Withdrawal Permits

Open loop systems over a certain size will require a water withdrawal permit under the New York Water Resources Law. Water withdrawal permits are required for all water withdrawal systems with the capacity to withdraw 100,000 gallons per day or more of surface water, groundwater, or a combination thereof. Capacity is based on the total maximum potential withdrawal of all sources for a facility, as opposed to typical or actual withdrawal volumes.[85]

Closed loop, standing column, or similar non-extractive geothermal systems are exempt from the permitting requirements. Systems proposing to withdraw from a well on Long Island should apply to the Long Island Wells Program to obtain a Long Island Well Permit.[86] Applicants whose systems would withdraw water subject to the jurisdiction of a basin commission (such as the Delaware River Basin Commission) should apply directly to the Commission for a permit.

System owners must submit a water withdrawal application form to the New York State Department of Environmental Conservation (NYSDEC), as well as information regarding the proposed facility, engineering reports, maps of the location, information regarding the water body, an Environmental Assessment Form, and a Water Conservation Program Form demonstrating that the applicant has developed and implemented a Water Conservation Program that incorporates environmentally sound and economically feasible water conservation measures.[87] Permit holders are also subject to annual reporting requirements which include the amount of water withdrawn in a year, a description of water use, estimated amount of water returned to the water body, the average monthly and yearly volumes of water lost, and conservation measures taken during the reporting year.[88]

3.5 State Pollutant Discharge Elimination System Permit

Geothermal systems may also require a State Pollutant Discharge Elimination System (SPDES) Permit depending on the type of geothermal system, whether the system discharges to groundwater or surface water, the classification of the receiving water body and whether the system discharges heat or some type of water or heat treatment chemicals.[89] However, all systems are subject to best use criterion established for every water body in the State,[90] and as such, a review by NYSDEC is required to determine whether a particular system requires a SPDES permit. Generally, systems that discharge heat or water treatment chemicals into surface waters must obtain a SPDES permit. Additionally, open loop residential systems with a design flow greater than 1,000 gallons per day or that use water treatment chemicals, as well as all commercial open loop systems, require a SPDES permit. A SPDES permit may be required for a closed loop system depending on the circumstances, and a review by NYSDEC is required.

Permits require temperature monitoring and reporting and may limit how much heat may be discharged from the system depending on the receiving waterbody's classification.

Additionally, the Division of Fish and Wildlife requires that the location, design, construction, and capacity of cooling and water intake structures that result in thermal discharges be equipped with best technology available (BTA) to minimize adverse environmental impacts, such as the impingement of fish on the intake screen and the entrainment of eggs through the cooling system.

At the time of application, the division may impose additional conditions appropriate to the system, which may require the applicant to provide biological information on the water body and an analysis of available technology or operational measures that can be employed to minimize any potential impingement and entrainment. The BTA required for compliance will vary depending on the system and the water body classification, and the division will consider applicable costs when making this determination.

3.6 Office of Renewable Energy Siting Approval

Geothermal systems equal to or greater than 25 MW_{th} planned capacity are subject to the permitting requirements of the Office of Renewable Energy Siting (ORES).[91] A 25 MW_{th}-equivalent geothermal system would support a small community of approximately 2,000 homes.[92] ORES regulations provide for an application process similar to Article 10 of the Public Service Law for siting major electric generating facilities, as well as uniform standards and conditions for all proposed projects. Applicants are required to work with municipal authorities in which the proposed facility is to be located, obtain several environmental approvals from ORES prior to applying, and file an application including exhibits addressing areas of impacts on land use, public health, safety and security, noise and vibration, cultural resources, endangered and threatened species, visual impacts, water quality, and wetlands. Applications are also subject to a comment period and public hearing procedures.

3.7 Drilling Permits

New York State imposes different requirements for geothermal wells drilled less than 500 feet and wells over 500 feet, based on permitting regimes that were designed for non-geothermal systems, but adapted for these purposes.

Wells that are less than 500 feet deep are regulated by the NYSDEC Division of Water. The Division of Water requires the submission of driller and pump installer registration and certification, and preliminary notice and well completion reports for open loop or standing column systems.[93] Completion reports are waived for closed loop geothermal systems with boreholes drilled up to 500 feet deep.[94]

For wells in Long Island (Nassau, Suffolk, Kings, and Queens counties), a 6 NYCRR Part 602 Permit, known as a Long Island Well Permit, is required for all open loop or standing column geothermal systems with boreholes drilled up to 500 feet deep with the capacity of more than 45 gallons per minute.[95] The Long Island Well Permit application includes a joint application to the Army Corp of Engineers, and the Environmental Assessment Form.[96]

The NYSDEC Division of Mineral Resources regulates the drilling, construction, operation, and plugging of geothermal wells deeper than 500 feet.[97] To obtain a permit, an applicant must apply to the Division of Mineral Resources along with information regarding well locations, depth, use, casing material, cementing procedures, drilling fluid, and cutting disposal methods. Importantly, all well owners must obtain a permit before commencing any regulated well activity, including any preparatory work.[98]

As part of the application, a well owner must also submit an Environmental Assessment Form, which will be used by the NYSDEC to evaluate the environmental impacts of the well, and to decide whether any “special permit conditions, a Supplemental Environmental Impact State, or any additional NYSDEC permits are required.”[99]

NYSDEC also imposes reporting requirements throughout the permitting and drilling process. During the permitting process, the owner must submit a site plan, a casing and cementing plan, and report drilling milestones such as the start date of drilling, date of casing and cementing, the date when drilling reaches total depth, and the date of pump installation.[100] A well drilling and completion report must also be filed by the owner summarizing the drilling details within 30 days after the completion of the well.[101]

Thereafter, an annual report describing the status and use of the well must be submitted, and owners must immediately notify the Division of Mineral Resources of any leak, spill, or other incident that may affect the environment or the health, safety, welfare, or property of any person.[102] A separate permit must be obtained before a well may be permanently plugged and abandoned by the well owner.[103]

Importantly, prior to obtaining a well drilling permit for a well that may produce brine, saltwater, or other polluting fluids in sufficient quantities to harm the surrounding environment, the well owner must obtain a permit for the safe and proper disposal of such produced fluids.[104] Depending on the applicable method of disposal, NYSDEC may require the well owner to obtain additional permits for discharge and/or disposal.

NYSDEC also mandates minimum standards for all wells pursuant to the division's Casing and Cementing Practices to protect groundwater by preventing the migration of fluids.[105] However, NYSDEC imposes stricter permitting conditions for wells that will be drilled through primary and principal aquifers, as well as for wells where subsurface conditions are unknown or where high pressures are expected.[106]

The Division of Mineral Resources will also consult with the New York State Office of Parks, Recreation and Historic Preservation (NYS Parks) to determine whether the proposed location of a well is within a State-listed historic area, which would require additional permissions.[107] If applicable, NYS Parks will review the project and ensure the well will not negatively impact cultural resources.[108] The permit application process takes approximately six to eight weeks, but may take longer depending on the project. Additionally, filing fees for the application materials vary depending on the depth of the well.[109] Drilling permit requirements and restrictions under both regimes are summarized in the table below.

Table 1. Requirements for Closed Ground Source Loops

Source: Well Owner and Applicants Information Center, NYSDEC, available at https://www.dec.ny.gov/energy/1522.html (accessed March 6, 2021); Well Operator Responsibility, NYSDEC, available at https://www.dec.ny.gov/energy/1639.html (accessed March 6, 2021); Ground Source Heat Pump Drilling Regulations Discussion, Presentation by NY-GEO (Nov. 12, 2020).

Under 500 Feet	500+ Feet
Driller and pump installer certification and registration	
Municipalities may impose additional requirements	
	Organizational Report (Form 85-15-12)
	Application for permit to drill well (Form 85-12-5)
	Environmental Assessment (Form 85-16-5)
	Financial Security Worksheet (Form 85-11-2)
	Certified site plan
	Casing and cementing plan
	Drilling progress reports
	Periodic drilling drift correction
	Well drilling and completion report (Form 85-15-7)
	Annual reports of status and use of well
	Incident reports of leakage or condition posing risk to environment or the health, safety, welfare, or property of any person
	Permit to plug and abandon

3.8 Municipal Geothermal Approvals and Permits

In New York State, few municipalities have developed permitting guidelines for geothermal systems. Those that have developed guidelines only address single property closed loop systems.[110]

No municipality has developed guidelines for multi-property district systems, open-loop systems, and systems that involve special design considerations, such as thermal extraction from water bodies. With technological improvements and the need to rapidly scale the development of these systems to advance decarbonization efforts, municipalities should consider development of such permitting regimes. Ideally, permitting regimes should be standardized across New York State to the greatest extent possible. This is an area where the State can play a critical role as facilitator to develop and disseminate model codes and standards.

Without a permitting regime and standards for equipment, developers and municipal officials are left to navigate the various zoning, building, mechanical, environmental, and other regulations that may apply to geothermal systems but were not designed specifically for these systems. This ad hoc approach in the absence of a dedicated geothermal permitting regime increases costs, uncertainty, and risks, and delays the approval process. For project designs in which multiple stakeholders—property owners, utilities, and government agencies—must consent or grant approval, lack of a permitting regime and standards risks the inability of stakeholders to reach decisions or consensus, resulting in deadlock and bureaucratic paralysis. Application of zoning and other regulations not designed for geothermal systems, such as setback requirements, may even block geothermal projects altogether in dense urban and peri-urban areas where small lot sizes are common.

The table below presents the various potential permits and approvals required for a closed-loop district geothermal system that involves subsurface infrastructure crossing private property boundaries and various public rights of way, and may feature other design complications, such as sourcing thermal energy from a water body.

Table 2. Possible Permit and Approval Requirements for District Geothermal Systems

Stakeholder	Permit/Approval
Private Property Owners: Served by system	• Agreement between developer and property owner to install the system on private property, with additional agreement on pricing, maintenance, and decommissioning.
Private Property Owners: Not served by system	• Private easement from the property owner to developer, utility, and/or neighboring property to install and maintain parts of the district system on or across private property. • Agreement among parties on compensation, maintenance, and decommissioning.
Municipalities: Legislative Bodies: • Town/Village Board • Planning Board • ZBA Administrative Departments: • Planning • Building • Public Works • Highway • Engineering • Fire • Local Health	• Local departments (e.g., Public Works, Planning and/or Building, Highway, or Engineering) may establish a permit process to approve utility work within a municipal right-of-way or request an easement for a subsurface crossing of the right-of-way.[111] Municipal permitting schemes for single property closed loops are typically overseen by Planning and Building Department, or treated similarly to the building or mechanical permit process.[112] • One or multiple of these administrative bodies, with input from local Fire and Health Departments, may administer permit approvals for closed loop district geothermal. • Responsible administrative bodies ensure compliance with local building setbacks from water supply wells, sewage disposal structures, stormwater recharge structures, potential sources of contamination, any on-site utility, sewage and water line, any building foundation, and property lines. All systems must comply with the New York State Uniform Building and Fire Code. • Developers must fulfill permitting requirements, which may include submitting professionally certified (1) site plans, (2) plot plans, and (3) certifications that the proposed system complies with all applicable regulations.[113]
County or Municipality Department of Public Works County Department of Health	• When located within a county highway, a county public works department may also establish requirements and standards for street works permits within and under the county's right-of-way.[114] • If connected to a water or sewer system or potentially affecting sewer and water pipes existing in the public right-of-way.

Table 2 continued

Stakeholder	Permit/Approval
NYS Department of Transportation	• State Highways: All subsurface crossings of state highway must conform with 17 NYCRR Part 131 and the NYSDOT's "Requirements for the Design and Construction of Underground Utility Installations Within the State Highway Right-of-Way."[115] DOT Form PERM 32, which requires detailed information on all anticipated utility structures within the state highway, must be completed.[116] Regional highway work permit contacts are listed online by DOT.[117] • NYS Thruway: Utility crossing of the NYS Thruway must also comply with the American Association of State Highway and Transportation Officials "Policy on the Accommodation of Utilities Within Freeway Right-of-Way,"[118] except as otherwise specified by NYSDOT.[119] • Railroads: Any project that requires "a gas, water, sanitary, or communication line be relocated or installed … under the tracks" triggers railroad approval, which is coordinated by the NYSDOT's Design Services Bureau, Rail Agreements Unit.[120] A railroad agreement between the developer, the railroad, and NYSDOT may be necessary.[121]

NYS Department of Environmental Conservation	• Coordination with developer and NYSDEC for submission of all required documentation and completion of any subsequent approvals that arise under the federal and state laws discussed above, including:
	  o CWA Section 401 Water Quality Permits.
	  o SPDES Permits for either water discharge or thermal extractions or other concerns over drinking water pollution.
	  o Division of Water Approval or Division of Mineral Resource Approval for wells less than 500 feet or over 500 feet, respectively.

Office of Renewable Energy Siting	• If a district geothermal system is greater or equal to 25 MW_{th}, additional siting requirements of the Office of Renewable Energy Siting apply.
NYS Department of Health	• New York State Department of Health (DOH) regulates the use of potable water after heat exchange. In an opinion rendered in May 2019, DOH concluded that water used in conjunction with heat exchangers may not be returned to the public water system.[122] DOH cited the U.S. Environmental Protection Agency's guidance document WSG 170 from 2003.[123]
NYS Public Service Commission NYS Department of Public Service and NYS Historic Preservation Office	• Establish rules for subsurface work in the public right-of-way and the process for informing all impacted utilities.[124] • Oversee and approve pricing for geothermal service, if regulated.[125] • If any historical or cultural resource is encountered that is not yet cataloged, ensure such is reported to the Department of Public Service Staff and the NYS Historic Preservation Office.[126]
Utilities: • Electricity • Gas • Water • Sewer • Cable • Telephone	• Confirm no interference with subsurface power lines and utility infrastructure or conflict with utility franchise agreements. • Developer working in a right-of-way where utility infrastructure exists to timely notify all utility operators of the intended project, wait until a set commencement date to begin construction, confirm utility response as "all clear" or that affected utilities marked the location of their infrastructure, confirm utility location and present utility-placed marks, and undertake all construction with care as to not harm existing utility infrastructure.[127] • If project design potentially interferes with infrastructure owned by other utilities, utility and developer may enter into an agreement on compensation, maintenance, decommissioning, and liability.[128] • Electrical approval and expansion to accommodate equipment like heat pumps and exchangers.[129]
Railroads	• NYSDOT provides that railroads should be advised of proposed utility crossing and each railroad will implement its procedure to grant the utility permission to occupy the railroad property through an easement or permit.[130] • Other states refer to these separate agreements as "Right of Entry Agreements," which are standard submissions for a utility developer to submit before working in the railroad right-of-way.[131] • Agreement on compensation, maintenance, and decommissioning.

4 State Utilities Regulation

New York State unbundled its power and gas markets, prohibiting utilities from owning generation assets except in exceptional circumstances. Distribution utilities are thus only permitted to own and operate transmission and distribution facilities, purchasing gas and electricity from non-regulated sources at market prices.

The State's electricity and gas distribution utilities are regulated by the New York State Public Service Commission, which sets the rates utilities can charge their customers and establishes service standards for utilities.

Generally, there are two types of utilities, investor-owned utilities and public utilities, the latter primarily municipal-owned. New York State also has a small number of cooperative utilities.

The Public Service Commission regulates investor-owned utilities and municipal-owned utilities, except the Long Island Power Authority and municipal utilities that purchase their power exclusively from the New York Power Authority. Commission jurisdiction applies to approximately 75 percent of State energy sales.[132]

For utilities under its jurisdiction, the Commission acts to ensure that regulated utilities provide safe and adequate service at just and reasonable rates.[133]

As part of its responsibilities, the Public Service Commission reviews and approves utility companies' applications for rate cases. Investor-owned utilities are granted monopolies over their service territories in exchange for regulated pricing based on the investment in infrastructure and operating costs plus an approved rate of return thereon. To be approved for inclusion in the rate base, investments must be prudent, resulting in assets that are used and useful, and the resulting rates "just and reasonable" (Federal Power Commission et al. versus Hope Natural Gas Company, 320 U.S. 591 [1944]).

Recovery of research, development, and demonstration costs may be approved by the Public Service Commission; however, legal standards governing inclusion in the rate base effectively require that allowed investments present a reasonable chance of success based on scrutiny under the prudent investment test. Failed projects and facilities retired before the end of their useful life can impose significant burdens on ratepayers.

The Public Service Commission also approves the siting of electricity and gas transmission under Article VII of the Public Service Law.[134] In siting decisions, the Commission issues a Certificate of Environmental Compatibility and Public Need, which requires that "the location of the facility as proposed conforms to applicable state and local laws,"[135] unless it finds the local law unreasonably restrictive.[136]

4.1 Public Service Commission Jurisdiction Over Geothermal

No State legislation currently governs geothermal energy distribution. The Public Service Law does not specifically mention geothermal energy, raising the question of whether the Public Service Commission possesses authority over the regulation of utility involvement and business models for geothermal energy services. Although the question cannot be definitely settled in the absence of legislation, the broad powers granted to the Public Service Commission over energy resources and conservation suggest regulation of geothermal could be determined to come within their mandate and therefore their jurisdiction extends to geothermal energy services.

Pursuant to Section 5(1)(b)-(c) of the Public Service Law:

> The jurisdiction, supervision, powers, and duties of the public service commission shall extend under this section:
>
> b. To the manufacture, conveying, transportation, sale or distribution of gas (natural or manufactured or mixture of both) and electricity for light, heat or power, to gas plants and to electric plants and to the persons or corporations owning, leasing or operating the same.
>
> c. To the manufacture, holding, distribution, transmission, sale or furnishing of steam for heat or power, to steam plants and to the persons or corporations owning, leasing or operating the same.

Section 5(1)(b) grants the Public Service Commission authority over gas and electricity manufacture, conveying, sale or distribution for the purpose of heat, but not granting authority over heat itself. Similarly, Section 5(1)(c) grants the Commission authority over the manufacture, holding, distribution, transmission, sale or furnishing of steam for the purpose of heat, but not heat itself.

The Public Service Law's provisions defining investor-owned utilities and municipal-owned utilities omit any mention of geothermal or heat from sources other than gas, speaking only in terms of electricity, gas, steam, and other traditional utility services.[137]

Notwithstanding the absence of a specific grant of authority concerning heat in general or geothermal in particular, in carrying out its responsibilities, the legislature vested the Public Service Commission in Section 5(2) with broad powers to ensure the public interest in "economy, efficiency, and care for the public safety, the preservation of environmental values and the conservation of natural resources." Section 5(2) was added to the Public Service Law in 1970 to "enable the Commission to meet the challenges of modern technology, now and in the future, and to respond more fully to public need."[138] As such, the Commission "has the responsibility to adjust its regulatory framework in response to evolving circumstances and foreseeable trends, in order to meet customers' needs."[139]

Further, under Public Service Law Section 4(1), the legislature expressly endowed the Commission with "all powers necessary or proper to enable it to carry out the purposes of [the Public Service Law]."

Finally, New York State's Energy Law requires that "any energy-related action or decision" by the Commission be "consistent with the forecasts and the policies and long-range energy planning objectives and strategies contained in the [State Energy Plan]."[140] The State Energy Plan was recently amended in 2020 to incorporate the emission reduction targets mandated under the Climate Act.[141]

Clearly, the State legislature adopted a broad and adaptive view of Commission authority.

New York State courts have recognized the Commission's grant of authority to be broad, rather than narrow. In Matter of Energy Association of New York State versus Public Service Commission, 169 Misc. 2d 924 (Sup. Ct. Albany Cnty. 1996), the court described the Commission as possessing "broad discretion." Similarly, citing Section 4(1) of the Public Service Law, the court in Matter of Consolidated Edison Company of New York versus Public Service Commission, 47 N.Y.2d 94, 102, 104 (1979), reversed on other grounds, Cent. Hudson Gas & Elec. Corp. versus Pub. Serv. Comm'n, 447 U.S. 557 (1980), described the Commission as possessing "vast power" to implement its mandate. Further, the latter court's evaluation of the Commission's powers was also supported by its authority for the "general supervision of all gas corporations and electric corporations" and "all gas plants and electric plants" under Section 66(1) of the Public Service Law.

Importantly, New York State courts have recognized this "broad discretion" of the Commission to confer the authority to choose the means of achieving the legislative objective" and its authority to adopt different methodologies or combinations of methodologies in balancing ratepayer and investor interests.[142]

Consistent with the judiciary's view of Public Service Commission authority, the Commission has interpreted its authority to include "adopting proactive responses to the problems of, and opportunities created by, new technologies that might otherwise create stranded utility assets under conventional regulatory methods."[143] Thus, the Commission has approved and required energy efficiency and demand management programs on the basis that these programs "bear a reasonable relationship to the purpose of the enabling legislation."[144]

Similarly, the Commission has directed utilities to explore non-pipe alternatives (NPAs) as a means of addressing supply constraints and to defer traditional infrastructure through individual utility rate cases and filings, as well as generic statewide proceedings.[145] For example, in 2017, the Commission approved Con Edison's Smart Solutions program which contained several initiatives, including an enhanced gas energy efficiency program, a gas demand response pilot, a non-pipe alternative portfolio, and shareholder incentives.[146] Most recently, in 2021, the Commission initiated a Gas Planning Proceeding, directing utilities to consider energy efficiency, electrification, demand response, and other non-pipe alternatives to meet forecast gas demand.[147]

Significantly, the Public Service Commission itself has exercised this broad power over energy resources in its Reforming the Energy Vision, which specifically promotes geothermal,[148] and has approved the KeySpan Energy Delivery New York (KEDNY)/KeySpan Energy Delivery Long Island (KEDLI) geothermal demonstration pilot on Long Island on the grounds that the pilot would "explore the use of geothermal technologies to improve sustainability and overall system efficiency by displacing peak gas consumption rather than by addressing those needs through the addition of pipeline capacity."[149]

At the time of writing, the Commission is presently considering geothermal pilot proposals in rate cases— the 2019 KeySpan Energy Delivery New York (KEDNY)/KeySpan Energy Delivery Long Island (KEDLI) rate case,[150] the 2020 Niagara Mohawk rate case,[151] and the 2020 Central Hudson rate case.[152]

4.2 Commission Approach to Regulating Distributed Energy Resources

If the Commission were determined to possess authority or granted authority to regulate geothermal energy services, a corollary question is how it might proceed to regulate this energy source.

The closest analog in the Public Service Law to geothermal is the provision governing steam heat. Section 49 of the Public Service Law recognizes that the principles governing steam heat customers are similar to that of gas and electricity customers: “The rights and responsibilities of customers receiving residential steam service from steam corporations shall be substantially comparable to those of gas and electric customers under this article. The commission shall take such actions as it deems necessary and proper to achieve this objective.”

While the steam heat provisions are not controlling for geothermal, as mechanically produced steam is distinct from geothermal, the analogous treatment of gas, electricity, and steam suggests that these principles also might be applied to geothermal if the Commission were granted or deemed to possess jurisdiction over geothermal.

Further evidence of how the Commission might proceed to regulate district geothermal can be found in the regulatory policies governing the structure of energy services in New York State initiated in the mid-1990s and culminating in New York State’s Reforming the Energy Vision (NY REV) proceedings launched in the mid-2010s.

Beginning the mid-1990s, the Commission adopted a set of policies governing gas and electricity, to create more competitive, transparent energy markets enabled by the evolution in technology.[153] These policies required gas and electricity utilities to divest themselves of their electricity generation and gas supply assets so that new entrants could enter the generation and supply business. By restructuring energy markets to allow competition, the Commission aimed to drive down the cost of services for consumers. To enable market competition, utilities that still provide transmission and distribution services bill customers for energy services “unbundling” individual components, enabling transparency in pricing, separable competing services, and ultimately, customer choice.

Following the adoption of these divestment and market restructuring orders for the gas and electricity sectors, the Commission entered into a series of settlements with New York State utilities under which all gas and electricity utilities operating within the State were required to divest their generation assets, with the exception of the Rochester Gas and Electric utility, which specified terms for any future divestments, and specifically exempted nuclear generation assets due to their special nature, pending the State finding alternative arrangements for divesting nuclear assets.[154]

Divesting utilities of generation assets to promote competitive markets remains Commission policy today as reflected in NY REV. NY REV, which mandates the Public Service Commission to realign the incentives to utilities to accelerate the adoption of new clean, distributed energy technologies would presumably also guide their thinking on whether utilities are permitted to engage in geothermal business. Under NY REV, the Public Service Commission ordered the further restructuring of regulated New York State utilities, giving them a hybrid role, allowing them to retain their former function for distribution system planning and construction, but also assume a role in grid operations situated between the New York ISO's wholesale market and consumers. In this role they act as "distributed system platforms" (DSPs), facilitating transactions between energy providers and consumers, while being incentivized to introduce third-party distributed energy resources (DERs) and other measures to optimize system investment and performance in their grid planning and market operation roles.

Given the central role of DSPs, and the Commission's policy to open the generation market to greater competition and ensure transparency, utilities/DSPs are not permitted to own generation assets themselves as this would allow them to exercise improper market power.

Also, importantly, under NY REV, DER providers are not to be subject to rate regulation by the Public Service Commission under Article 4 of the Public Service Law.[155] If geothermal is treated as a DER, geothermal providers would presumably not be regulated under Article 4.

However, NY REV is a set of principles, the details to be worked out, rather than a prescriptive regulation. The Public Service Commission recognized that uncertainties as to jurisdiction would arise, which would have to be decided on the basis of policy and, to the extent it existed on point, law. According to the Commission, "[t]he definition of DER services is potentially broad enough to cover a wide range of home energy services that have not traditionally been subject to Commission oversight. … A clear criterion of applicability is needed, in order to avoid an overly broad and unworkable extension of regulatory authority over private transactions." [156] Thus, under REV, utility-owned DERs and microgrids remain an open question. The Commission called for demonstrations of various business models of third-party DER services and "utility DER services," disfavoring utility ownership of DERs and strongly encouraging partnering utilities with third parties.[157]

The Commission set out its views on utility ownership of DERs in its State Environmental Quality Review Act Findings Statement of February 26, 2015, attached to its Order Adopting Regulatory Policy Framework and Implementation Plan for REV:[158]

1. A determination that, subject to Staff monitoring, utility ownership of Distributed Energy Resources (DER) will only be allowed if (1) procurement of DER has been solicited to meet a system need, and a utility has demonstrated that competitive alternatives proposed by non-utility parties are clearly inadequate or more costly than a traditional utility infrastructure alternative; (2) a project consists of energy storage integrated into distribution system architecture; (3) a project will enable low or moderate income residential customers to benefit from DER where markets are not likely to satisfy the need; or (4) a project is being sponsored for demonstration purposes.

Commission guidance on REV demonstration projects provides further insight into the criteria the Commission employs in evaluating utility proposals for DER, geothermal and other projects.[159] Consistent with the overall goal of market design in which utilities do not own generation assets, the Commission's Principles for REV Demonstration provides in relevant part:

- REV demonstrations should include partnerships between utilities and third-party service providers.
- Demonstrations should delineate how the generated economic value is divided between the customer, utility, and third-party service provider(s).
- The market for grid services should be competitive. The regulated utility should only own distributed energy resources if market participants are unwilling to address the need and the utility is acting as the service provider of last resort (in this instance, "provider of last resort" and "needed" means that no one in the market is providing the solution and the distributed solution is less costly than alternatives for the problem).
- While some demonstrations may be bilateral, and therefore may not be "competitive" per se, utilities and service providers should propose rules (data, terms, standards, etc.) that will help create subsequently competitive markets.
- Demonstrations should inform pricing and rate design modifications.

Together, the Public Service Commission's policies of prohibiting utilities owning and operating generation, except in circumstances such as the utility serving as a provider of last resort, and excluding DERs from regulation under the Public Service Law, creates uncertainty as to whether the Commission will take the position that a regulated investor-owned utility can own geothermal assets, and whether the Commission would extend a regulatory framework over geothermal if it is treated by the Commission as a DER.

We address the merits of various geothermal business models and possible corresponding regulatory treatment in section 5 of this paper.

5 Geothermal Business and Regulatory Models

The fundamental challenge for expanding district geothermal is to identify business models that enable the technical advantages of geothermal technology to achieve economies of scale that overcome the transactional diseconomies inherent in the property and permitting challenges described in the prior sections.

This section identifies a range of possible business models along a continuum from the single property system through progressively expanded and integrated district geothermal systems.

To progress along this continuum, regulation of the industry must also evolve in order to coordinate stakeholders to support the full development of geothermal energy.

As the business model and regulatory framework evolve together, how heat services are delivered and priced also changes.

The continuum of distinct possible business models supports evaluation of how best to encourage the development of geothermal, whether and how to regulate it, and price its product.

5.1 Drivers of Geothermal Business Models

This section presents five factors that influence business models for geothermal energy: rights of way, technical drilling barriers, regulatory drilling barriers, ownership structure influencing project economics, and regulatory regime governing utility entry into geothermal heat services. Each of these barriers are either creatures of law, regulation, and policy, or in the case of technical drilling barriers, can be mitigated by policy.

5.1.1 Rights-of-Way and Approvals

As described in section 2 addressing property rights and section 3 addressing permitting, developers must obtain either fee simple ownership or easements in order to drill and install a shared ground loop across multiple properties. Crossing property lines, streets, railroad tracks, existing utility infrastructure all will require the grant of an easement and approval by the owner or authority responsible for their operation.

The costs of acquiring rights of way can be expensive and time-consuming. Each utility that has installed infrastructure in the subsurface should be consulted as part of the approval process to ensure that proposed designs and implementation will not disturb their operations. To safely install geothermal piping in the subsurface without interfering with other utilities will likely require site visits to individual properties by these other utilities. The costs and risk of damage incurred by these utilities will likely generate resistance to granting their approval.

Granting easements over a property limits the property owner's ability to use its own property, and can adversely affect private property rights, or diminish private property values. Compensating the grant of an easement and its impact on the servient property can be difficult to value,[160] potentially resulting in deadlock in negotiations.

Without government intervention, geothermal developers must negotiate with property owners and affected utilities to grant approval, which may be conditioned upon agreement on compensation, maintenance, decommissioning, and indemnification for liability.

The costs of obtaining rights of way have been well documented for roads, pipelines,[161] telecommunications, railroads, subways and intracity surface rail, and other types of infrastructure that necessarily crosses property lines. These costs may include a one-time acquisition fee, annual fees, excessive or escalating fees,[162] and the time and cost of organizational staff and legal professionals to procure rights.

Resolving rights of way issues can be complex, with follow-on effects for future infrastructure projects as technology and public needs change. In the 19th century, the federal government facilitated railroad expansion through a series of public land grants in fee simple to the railroad companies, and eventually enacted the General Railroad Right-of-Way Act of 1875 Act, 43 U.S.C. § 934, to facilitate railroad expansion westward while balancing the interests of municipalities and individual property rights owners.

Today, the rights created in favor of railroads now complicate expansion of other modern utility services, such as telecommunications. In the 2010s, several Midwest states seeking to ensure that municipalities can expand and upgrade utility services on a cost-effective basis have addressed the problem by adopting legislation that established pricing for easements crossing railroad tracks.[163] Broadband advocates before the Federal Communications Commission proposed a "model code" to prevent railroads from blocking utilities or charging excessive rights of way fees.[164]

In New York State investor-owned electric and gas utilities resolve rights of way issues by entering into franchise agreements with municipalities. Municipal-owned utilities enjoy a grant of authority by the State legislature to acquire property and easement rights.[165] These franchise agreements and statutory powers would advantage electric and gas utilities in utility geothermal development if permitted to enter this business, but they also could be used to prevent others from providing geothermal heat services, similar to the conflict between railroads and telecommunications utilities in the Midwest.

5.1.2 Drilling Regulatory Restrictions

As previously described in section 3, New York State imposes different requirements for geothermal wells drilled less than 500 feet and wells over 500 feet. Permitting requirements for wells over 500 feet in depth are designed for oil and gas production, which are considerably more rigorous and costly.

The different permitting regimes effectively limit geothermal system design to shallower depths for many developers of residential and individual building systems. Consequently, more wells must be drilled than would be required if deeper wells were employed to support the same system capacity. The greater number of wells increases overall costs due to greater drilling time, materials requirements, particularly costly well casing, expanded site restoration area, and increased production of cuttings and water.

Enabling deeper wells modestly to 750 feet significantly expands the percentage of households that could be supported by a single borehole system. According to NY-GEO estimates, whereas only 50–60 percent of existing homes can be served by an up to 500-foot borehole, 90–95 percent can be served by an up to 750-foot system, expanding the reach of geothermal by roughly 40 percent of existing homes in the State, or 3.2 million homes.[166]

In turn, lower system development costs resulting from fewer boreholes reduces the cost to consumers, enhancing the economics of geothermal projects, and encouraging adoption of the technology, in some cases saving between $3,000 to over $4,000.[167]

In dense urban areas, drilling fewer boreholes is not only a cost issue but can be essential in making projects feasible. Fewer, deeper boreholes reduce drill rig setups and lateral piping requirements, minimize site area disruption and traffic/parking disruption, and reduce potential interference with existing utilities, such as storm sewer, electric, gas, and telecommunications infrastructure. Deeper boreholes also help optimize project design to enable greater geothermal load capacity.[168]

5.1.3 Drilling Barrier Cost and Liability

Beyond legal and regulatory barriers to district geothermal, drilling costs pose another significant barrier to district geothermal, specifically where complex site and geologic conditions increase project complexity.

Geothermal drilling employs large, heavy mobile drill rigs that produce large volumes of sludge that must be removed from the work site. Drilling a district system presents challenges that can be more easily avoided in single property systems through site selection. In contrast, district systems require drilling a larger area in a relatively dense formation. Drilling in constrained urban areas or drilling in areas with geologically challenging conditions means higher risk, slower progress, and higher cost.

For closed loop, vertical ground coupled heat pump systems, drilling costs dominate overall development costs. Drilling costs account for over half to almost two-thirds of total system cost for both medium density mixed-use and low-density residential systems, respectively. Combined drilling and loop pipe installation accounts for roughly three-quarters of total cost in both these medium- and low-density environments.[169]

Significantly, drilling and loop installation also substantially contribute to variability in overall project costs as the other components of the geothermal system involve standard equipment. According to one study, system costs ranged from roughly $3,000/ton to $40,000/ton of capacity for vertical ground source heat pump systems. Variability on a per ton basis may be due to site conditions, the need to retrofit existing heating and cooling systems, or the cost of drill rig set up for small projects relative to the actual capacity installed.[170]

Geothermal drilling operations may encounter several complicating conditions that have significant safety and regulatory consequences. Drilling in areas with excessive groundwater will complicate the drilling process. Saltwater produced from boring cannot be reinjected and must be removed from the site. In high-density rock, fluids that contain corrosive elements or a high solid content slow the rate of penetration and shorten drill bit life.[171] In certain parts of New York State, shallow natural gas pockets create extreme fire hazards, which cannot be drilled safely. Similarly, hydrogen sulfide commonly encountered during drilling is corrosive to equipment, highly toxic, and flammable; high-level short-term exposure can cause death.[172] Unknown infrastructure or other manmade artifacts also complicate drilling, particularly in urban areas.

Heightened operating complexities combined with traditional legal liability rules and regulatory requirements potentially make district systems prohibitively risky and expensive, with risks multiplying exponentially as one moves along the continuum from a simple single property to a large district project. These complexities drive increasing costs for labor due to enhanced safety precautions and specialized equipment, slower work progress, more stringent permitting requirements, and higher insurance premiums.

Small single-property systems will only be viable on sites with suitable geology. For large district systems, developers must contend with greater risk because complicating conditions cannot be as easily selectively avoided if present within the project's geographic area.

Lack of reliable geologic data is a common and significant source of risks for geothermal projects. The exploratory phase of a project should include test drilling to characterize the geology to the proposed system's depth. A well-designed exploration program can mitigate drilling and construction risks and inform project design, resulting in a more efficient system. For larger deep geothermal projects, completion of exploratory drilling may be a condition for raising project financing.[173]

In New York State and elsewhere, single-property systems that comprise the majority of systems often do not undertake test drilling as part of project design, instead drilling the "test" bore as the first bore of the construction drilling phase. In practice, test bores are typically only done for projects of 30 tons or more because testing is required for those projects seeking utility rebates under the New York State Clean Heat program.[174] For district systems, a "wildcatting" approach is highly risky. As the areal extent and risks of a geothermal system increase along the continuum from single property to fully integrated district systems, the investment in exploratory assessment has been demonstrated to produce net economic benefits.[175]

5.1.4 Ownership Structure

In New York State, utilities administer a State subsidies program for heat pumps and the federal government incentivizes geothermal through the United States Tax Code.

Incentivizing geothermal through utility subsidies for heat pumps and the federal investment tax credit for capital equipment benefits the owner of geothermal assets as these programs provide a tax credit based on ownership. Thus, the ownership structure for geothermal assets and the tax benefits that accrue to ownership favor certain business models over others.

Under the Federal Tax Code, homeowners are eligible for a tax credit against federal income taxes of 26 percent of the amount spent on purchasing and installing a qualifying geothermal heat pump system through 2023, which declines thereafter. This tax benefit is only available for systems installed in a taxpayer's home used as a residence (not rental properties) and applies to the portion of the geothermal system they purchase.[176] Thus, homeowners who install and pay for their own household geothermal system, as opposed to contracting geothermal heat services from a utility, are tax advantaged.

Commercial property owners are eligible to receive a 10 percent tax credit based on the cost of the system,[177] and accelerated depreciation treatment on a Modified Accelerated Cost Recovery System basis.[178] Qualifying commercial properties must be constructed, reconstructed, erected, or acquired by the taxpayer, and use of the property must commence with the taxpayer.[179]

Due to these restrictions tying the tax credit to ownership, utilities are not eligible for either the residential geothermal subsidy or the commercial property tax incentive, which, all other factors assumed equal, advantage homeowner business models over the utility heat services model.

Importantly, independent of government subsidies, when consumers own their geothermal system, as opposed to a utility service or a structured financing approach, the economics will almost inevitably be superior to third-party service or shared ownership. The only exception to this is when a third-party can provide the service or own the infrastructure more efficiently than the consumer's economics owning the productive asset.[180]

Section 6 presents financial case studies of utility-owned and privately-owned geothermal systems that demonstrate in financial terms the influence of government subsidies benefiting owners of assets, and the impact that has on the cost to the consumer and relative competitiveness of different business models. Section 6 further examines ratemaking issues in geothermal pricing. Together, these discussions demonstrate that subsidies and tax benefits associated with ownership structure cannot be easily addressed to normalize competitiveness among business models without causing other unintended consequences, such as undermining competitive market discipline or creating windfalls to non-household geothermal providers.

Thus, policymakers must decide whether to address the relative competitiveness of different business models through intervention by adjusting state and even federal laws, or by ratemaking procedures in the case of utility providers, and whether such intervention will create other unintended economic consequences. At some point, intervention must reach its limit and rely on markets to take over within the incentive structures created by policy. Balanced against intervention, policymakers should embrace policies that promote market discipline, incentivizing the goal of driving costs down, such as by allowing an open competition among business models.

5.1.5 Regulation of Utility Provision of Geothermal Services

Whether investor-owned or municipal utilities will be permitted to provide geothermal heat services, how their activities will be regulated, and how heat services priced will influence the development of district geothermal business models. The present lack of regulation creates uncertainty for utilities contemplating offering geothermal heat services. These issues are analyzed in depth in sections 4 and 6 of this paper.

5.2 Continuum of Business Models

Geothermal development can follow one or more of several business models that range from the simplest unitary system to fully integrated enhanced geothermal district systems. This section identifies eleven conceptual models; more models may exist or develop as technology and regulation evolve. Along this continuum, technical efficiencies increase, but the number of stakeholders and legal complexities also potentially increase, giving rise to transaction cost diseconomies.

Distinguishing each model helps identify those business model typologies in which the technical economies outweigh the transactional diseconomies. Those models exhibiting positive economies present opportunities under the regulatory status quo. Distinguishing models also helps to assess specific steps needed to change the regulatory status quo in order to facilitate expansion of district geothermal.

5.2.1 Single Property—Single Owner

The simplest geothermal business model is single property-single owner. This model presently represents the vast majority of geothermal project designs. Contained within a single property, projects do not require easements or consents from third parties.

Developers may still encounter delays with permitting as most municipalities have limited experience with geothermal. However, a closed loop system that is no more than 500 feet deep is lightly regulated in New York at the State level.

5.2.2 Single Property—Single Owner—Multiple Users

The single property–multiple users model involves a single-property owner who hosts a geothermal system on a single property that serves multiple users or tenants. This presents the simplest of property rights and permitting arrangements but allows the system operator to increase revenues by serving multiple tenants.

College campus geothermal systems fall under this model. A further evolution of this model is National Grid's installation of a geothermal system at a mobile home park on Long Island that is owned and operated by a single owner but serves multiple mobile home households. The mobile home park owner/operator charges tenants for this service as part of their rent, a simple and low-cost administrative arrangement.

5.2.3 Single Property—Build-Own-Operate-Transfer (BOOT)

A variant of the single property model is for the developer to build, own, and operate the geothermal system on a single property owned by a third-party, and to eventually transfer ownership and operation of the system at a contractually specified point in time. These build-own-operate-transfer or "BOOT" arrangements are commonly used to finance capital intensive infrastructure projects.

5.2.4 Single Property—Common Developer—Subdivide into Multiple Properties

Developers may achieve economies of scale by installing geothermal on a single property to serve multiple users and later subdivide the property into separate properties for sale. Prior to subdivision, the developer can efficiently specify the grant of easements and common agreement for maintenance, management, pricing, and financial and other responsibilities for the geothermal system, typically administered through an owner's association or similar entity established for this purpose and supported by association charges.

This model presents the simplest property and permitting possible at the time of construction. Once subdivided, complexities in administration may arise that can be resolved through strong documentation and institutional arrangements that are established by the developer and accepted by each future owner as a condition of sale.

Developers that pursue this model of installing geothermal in their residential housing or commercial developments report advantages in marketing a differentiated product, moving inventory faster at higher, more resilient prices, and the attendant benefits of lower borrowing costs.

5.2.5 Single Property—Multiple Users/Owners

A geothermal system installed on a single property that serves its multiple users/owners can be managed by a business association such as a corporation or a common property ownership arrangement such as joint tenancies.

The paradigms for this model are certain cooperative housing developments that sit on a single property for tax purposes, with each cooperative building on the property its own entity that operates independent of the others.

Geothermal development following this model benefits from a single property offering simplified property rights and permitting requirements and the economies of multiple users. A common agreement for maintenance, management, pricing, financial, and other responsibilities of the system, and a common management body such as an owner's association or similar entity, would need to be established for this purpose and supported by association charges. These arrangements would likely already exist for other functions concerning a shared property.

5.2.6 Multiple Properties—Multiple Owners Under a Common Agreement

A variation on the prior model is a geothermal system installed across multiple properties that serve multiple users/owners under a common agreement.

Similar to the prior model, this model is also found in cooperative buildings. However, in this model, each building sits on its own individual property for tax purposes, each cooperative building is its own entity and operates independent of the others, but all buildings are roughly identical in nature (and energy use) and share common management.

Geothermal development following this model involves more complex property rights arrangements as a system will cross property boundaries and require cooperation across properties and organizations. A common agreement for maintenance, management, pricing, and financial and other responsibilities of the system, and a common management body such as an owner's association or similar entity would be needed to be established for this purpose and supported by association charges. However, like the prior model, these arrangements would likely already exist for other shared functions concerning a commonly managed group of properties.

5.2.7 Multiple Properties—Different Owners—No Regulation

Multiple properties each with different owners, without any preexisting relationship, increases the number of stakeholders and the complexity of legal arrangements significantly. Cost and delay also increase as the number of stakeholders and properties increase.

Although this model presents high-transaction diseconomies, it also presents perhaps the greatest opportunity as it represents the vast majority of existing suburban and rural building stock and could be applied across urban properties as well.

Geothermal development following this model will involve complex property rights arrangements as a system will cross property boundaries and require cooperation across properties and organizations.

In the absence of dedicated geothermal regulation, this model relies entirely on contract law and preexisting regulations not designed for geothermal systems, in other words, the status quo. This model involves the greatest degree of regulatory uncertainty.

The project developer must price services based on market conditions and contractually provide for maintenance, management, financial and other responsibilities of the system, and a common management body. These arrangements would be contractual between the developer and systems users.

5.2.8 Multiple Properties—Different Owners Market Pricing

A variation on the multiple properties—different owners model introducing regulation that specifies geothermal services are to be provided on a competitive basis with government setting standards for service but leaving pricing to the market.

Like prior models involving multiple properties with different owners, geothermal development following this model involves more complex property rights arrangements as the system will cross property boundaries requiring easements across properties and public rights of way.

Depending upon the nature of regulation, this model relies on regulation to build public confidence in standards of service. However, the project developer must price services based on market conditions, and contractually provide for maintenance, management, financial and other responsibilities of the system, and a common management body.

5.2.9 Multiple Properties—Different Owners—Regulated Utility

A variation on the multiple properties—different owners' models would be the introduction of regulation that adopts a regulated utility model such as municipal-owned utilities and investor-owned utilities with geographic monopolies regulated by the Public Service Commission for standards of service and pricing. Extending Public Service Commission authority to regulate geothermal would likely require legislation.

Like prior models involving multiple properties with different owners, geothermal development following this model involves more complex property rights arrangements as the system will cross property boundaries and require easements across properties and public rights of way.

The model would be advantaged by a regulatory arrangement that provides certainty and transparency to consumers, with the Public Service Commission empowered to adjudicate stakeholders' interests.

Private, unregulated service providers would still maintain a role in the market as service providers and contractors to utilities.

5.2.10 Multiple Properties—Different Owners—Municipal Utility

A further variation on the multiple properties—different owners' model is municipal-owned district geothermal systems. These systems include wholly municipal owned and operated systems, municipal-owned and developer-operated systems, and potentially private systems granted franchise rights by the municipality.

The participation of a municipality enables economies of scale by exploiting municipal utility infrastructure, extending municipal rights of way and easement authority, thereby resolving property rights and public rights of way issues, and aggregating customer relationships. A municipal partner may also enable access to lower cost capital through bond issuances or other financing mechanisms.

Municipal utilities that operate water and sewer infrastructure may enable these thermal energy sources to be integrated into the geothermal system design. A municipal partner that aggregates customers, either because it acts as a municipal-owned utility or through its zoning or other municipal powers, enhances the system's economics.

Public-private partnership models require structuring of the relationship between the municipality and private operating entity to comply with regulations and to ensure favorable system economics. Depending on the specific ownership structure and scope of services, the Public Service Commission may or may not possess jurisdiction in regulating municipal-affiliated services.

5.2.11 Multiple Properties—Different Owners—Fully Integrated Enhanced Geothermal

The final variation on the multiple properties—different owners' model would be the introduction of regulation that mandates multiple utilities and service providers to coordinate their activities on a shared district geothermal system. As briefly described in the introduction to this paper, this model has been pursued at pilot scale in Europe.[181]

A regulated utility with a geographic monopoly would serve as the system operator regulated by the Public Service Commission for standards of service and pricing. Analogous to electricity grids that must accept distributed energy resources, the utility would be required to enable other utilities, such as water and sewer, and private service providers, such as thermal providers, to participate and provide services to the shared loop, provided they meet technical and other criteria specified by regulation.

Like prior models involving multiple properties with different owners, geothermal development following this model involves more complex property rights arrangements as the system will cross property boundaries requiring easements across properties and public rights of way.

Although the most complex in implementation, this model has the potential to further optimize resources to reduce greenhouse gas emissions and introduce competition to lower costs for consumers.

5.3 Identifying Opportunities and Policy Priorities Among Business Models

The table below characterizes these business models using a familiar "stoplight" analysis—green, yellow and red—indicating positive attributes for technical economies of scale, and three criteria indicating legal diseconomies of scale: ease of resolution of property issues, the complexity of regulatory issues, and ease of administration.

Green indicates positive characteristics, red negative characteristics, and yellow in-between.

As illustrated by the table below, the Single Property—Single Owner model does not exhibit economies of scale, though single-property projects deliver a positive return both economically and from an energy savings perspective. Importantly, they exhibit positive characteristics in terms of low transactional diseconomies. This model represents the greatest share of current market activity, suggesting that the geothermal market is presently shaped by transaction costs associated with the resolution of property, regulatory, and administration issues.

This conclusion is confirmed by the Multiple Properties—Different Owners—No Regulation model, which represents the status quo for district geothermal. This model shows precisely the opposite characteristics of the Single Property—Single Owner model and, predictably, has little market share. This model enjoys potentially positive technical economies of scale but is not pursued because the property, regulatory, and administration diseconomies are highly negative, outweighing its technical potential. If correct, policies improving legal and regulatory structure could improve district geothermal adoption.

In between these two models, the other models present opportunities for expanding geothermal. For the business community, project developers who screen potential projects based on property, regulatory, and administrative factors can exploit opportunities. For policymakers, these models can inform efforts to mitigate the present transactional diseconomies of district geothermal, particularly through addressing permitting and regulatory issues.

Table 3. Continuum of Business Models

	Technical Economies	Property	Regulatory	Admin
Single Property—Single Owner	[red]	[green]	[green]	[green]
Single Property—Single Owner—Multiple Users	[green]	[green]	[yellow]	[green]
Single Property—BOOT	[green]	[green]	[yellow]	[green]
Single Property—Common Developer—Subdivide	[green]	[green]	[yellow]	[green]
Single Property—Multiple Users/Owners	[green]	[yellow]	[yellow]	[green]
Multiple Properties—Multiple Owners—Common	[green]	[yellow]	[yellow]	[green]
Multiple Properties—Different Owners—No Regulation	[green]	[red]	[red]	[red]
Multiple Properties—Different Owners—Market Pricing	[green]	[red]	[yellow]	[yellow]
Multiple Properties—Different Owners—Regulated Utility	[green]	[red]	[yellow]	[yellow]
Multiple Properties—Different Owners—Municipal Utility	[green]	[red]	[yellow]	[yellow]
Multiple Properties—Different Owners—Fully Integrated	[green]	[red]	[yellow]	[yellow]

6 Utility Geothermal

This section examines the potential for utilities to provide geothermal heat services. The analysis applies to both investor-owned and municipal-owned utilities.

This section considers the policy and economics of utility geothermal. It presents the Niagara Mohawk district geothermal proposal presented in its 2020 rate case to evaluate utility geothermal pricing and rate design issues.

6.1 Question of Utility Geothermal

Presently, the Public Service Law does not provide that geothermal heat services are within the scope of permissible services that investor-owned and municipal-owned utilities may provide. Further, the Public Service Commission is not specifically authorized to regulate geothermal heat services.

Amendment of the law to clarify the scope of Public Service Commission jurisdiction, as well as investor-owned and municipal-owned utility authority, is desirable. However, as discussed in section 4, the Public Service Commission possesses broad jurisdiction that could potentially encompass the authority to decide whether to authorize utilities to provide geothermal heat services.

Policy may inform the legal analysis concerning jurisdiction. Consistent with the Commission's policy of divesting utilities of generation assets, as reflected in the Commission's market structure orders and most recently the NY REV, utilities could be allowed to partner with nonregulated geothermal companies to provide clean heat services to utility customers. This arrangement adheres to the Commission's principle that utilities not own DERs such as geothermal systems, except as a provider of last resort or other exceptional circumstances, and to ensure that the DER component is not subject to regulation under Section 4 of the Public Service Law.

Yet, in view of the Commission's emphasis on benefit-cost considerations for exceptional circumstances within the REV framework, there is at least one argument for the Commission to allow utilities to enter the geothermal business. A utility model may well be appropriate if it were determined that regional utilities would facilitate scaling geothermal, just as in the early days of the gas and electricity industries, decades before restructuring.

Along with considering whether utilities should be allowed to provide geothermal heat services, the legislature should also address transactional diseconomies inherent in district geothermal in order to enable the technology to achieve its full potential.

If a utility district geothermal model is ultimately allowed, private ownership of geothermal will likely continue to provide advantages for consumers. Preserving consumer choice and the ability of the nonregulated private market to compete will impose competitive incentives for utilities to maintain reasonable pricing for geothermal heating services.

Utilities engaging in geothermal through an affiliated subsidiary, analogous to investor-owned utility affiliate generation, provides a potential model. Municipal utilities should also be permitted to engage in providing geothermal heat as well.

The next section examines the experience of utilities with scaling up their services in the early 20th century to evaluate scaling as justification for utilities to enter the geothermal service business.

6.2 How Incumbent Utilities Scaled

The early expansion of water, electricity, gas, and telecommunication services depended on and were facilitated by grants of rights to private utilities to lay pipes, lines, and other infrastructure within public rights of way. Cities began to allow utility development in public rights of way for water-works systems that supplied potable water via underground pipes around 1800. By the mid-1800s, gas lights, followed by local electricity services, began competing for access to increasingly crowded public rights of way.[182]

Through the early 1900s, gas and electric utilities operated largely without state regulation, allowing municipalities to establish the rules for running wires and pipes under city streets and to set rates in early franchise agreements.[183] These early franchises established utility rights, operating standards, and obligations for developing infrastructure in the public right-of-way.[184] Franchises were typically contracted for 20 to 50 years between cities and private utilities that authorized the utility to dig up streets, install infrastructure, and operate within a given territory.[185] In exchange, cities, and utilities set price ceilings and minimum service thresholds.[186]

In New York State since the 1880s, the State legislature could revise a municipal franchise agreement, but it was a municipality's role to anticipate demand and plan for utility infrastructure construction. For example, New York City passed the NYC Consolidation Act of 1885 and established the Electric Subway Commission. This commission was vested the authority to construct and operate an electrified subway system, which encompassed permission to install underground electrical lines. The following year, the Electric Subway Commission granted a franchise to the Consolidated Telegraph and Electrical Subway Company to "construct electrical subways for the use of all legal companies operating electrical wires" in the City.[187]

At the end of these franchise agreements, municipalities often took ownership of the utilities. By 1910, most water-works franchises ended and passed into local government possession; gas and electric utilities typically continued to operate privately.[188]

Also, during this period, most of the competing gas and electric companies had merged forming regional utilities,[189] with the result that individual municipalities could not provide the regulatory structure that would ensure public access to utilities and keep costs reasonable, leading to the rise of State-level public service commissions.[190] New York State established its Public Service Commission in 1907.[191]

Even with the shift to Public Service Commission regulation, municipalities retained some authority over local facility siting. Municipalities continue to control utility access to their public rights of way and are often best positioned to coordinate with utilities on construction within the right-of-way.[192] Franchise agreements between cities and utilities continue as standard practice to establish rules, rights, and obligations for the utility's operation within municipal boundaries. The standardization of rights and obligations between municipalities and utilities concerning rights-of-way access and such issues as indemnification, permitting, and insurance requirements greatly simplifies the expansion of utility infrastructure, narrowing implementation issues to planning and scheduling of work.

Despite this retention of local authority, the Public Service Commission exercises regulatory oversite over many of these franchise agreements under the Public Service Law and forbids transfer of a gas or electric franchise without the Commission's consent. When a municipal franchise includes the construction and operation of a gas or electric plant, the utility must receive a Certificate of Public Convenience and Necessity from the Commission.[193]

Where utilities require access to private property, utilities in the first instance seek to negotiate easements under applicable laws with private property owners, which are recorded on the servient property deed. When an agreement cannot be reached and access to a certain land parcel is necessary for the development of the utility system, local governments could acquire the land through their powers of eminent domain. New York State's Eminent Domain Procedure Law continues to provide governments the ability to take private property in fee simple through the condemnation process for the public benefit, subject to the provision of just compensation.[194] Negotiated agreements with private landowners remain the preferred method of obtaining utility access across private property for a system that does not serve the burdened property.

Municipal franchise agreements could provide utilities with unique advantages in building out district geothermal services within existing easements and public rights of way that would help facilitate scaling geothermal. These rights would be particularly advantageous to overcoming legal and cost barriers to district geothermal in medium- and high-density urban areas.

6.3 Regulating and Pricing Geothermal

New York State presently lacks a framework for regulating geothermal energy and methodology for consumer pricing. In the absence of a regulatory framework, district geothermal proceeds in an uncertain regulatory environment and any pricing arrangements proposed by these projects are necessarily ad hoc. This section examines the National Grid Niagara Mohawk 2020 district geothermal project proposal to evaluate potential pricing arrangements and rate design options if the Public Service Commission were to permit regulated investor-owned utilities to become providers of geothermal heat services.

6.4 National Grid's Niagara Mohawk Rate Case

National Grid's Niagara Mohawk electric and gas utility proposed in its 2020 authorization to develop a Multiple Properties—Different Owners district geothermal project in the Albany, New York area.

The Niagara Mohawk project proposes geothermal for roughly 200 existing or new residential homes to be identified and possibly other users that are presently heated by oil-fired furnaces. Instead of extending Niagara Mohawk's gas infrastructure, the company proposed to develop a cleaner geothermal solution, which could be supplemented by electric heat when needed.

The Niagara Mohawk project is ambitious, attempting to tackle the complex, yet high-impact Multiple Properties–Different Owners model. In the business model continuum, this model sits at the extreme in terms of exhibiting high-transactional diseconomies for property, regulatory, and administrative issues.

Although Niagara Mohawk is not specifically authorized to engage in the geothermal business as a regulated investor-owned utility, it sought to test a regulated business model for geothermal in order to contribute to meeting the Climate Act carbon reduction goals.[195] As a non-pipe alternative offsetting further gas investment, Niagara Mohawk sought Public Service Commission approval to include the investment in its regulatory rate base and to defer and amortize its costs over the estimated 50-year life of the geothermal system.[196]

6.5 Project Economics

Niagara Mohawk proposed to invest $12.88 million in geothermal assets, $1 million to hire two full-time employees to support the geothermal program, and a one-time $100,000 expense to cover non-labor program operating expenses for fiscal years 2022 through 2025.[197]

Niagara Mohawk's geothermal investment would comprise one or more shared loops, which the utility estimated has a useful life of 50 years, which would be amortized over that same period.[198]

Customers would be required to purchase and install their own heat pump system, which would cost an estimated $12,000–$25,000 at present prices without incentives and operate and maintain the system at their own expense.[199]

Niagara Mohawk proposed to charge geothermal customers a regulated rate to recover the cost of installation and maintenance of the loop plus the approved rate of return. Specifically, Niagara Mohawk proposed to charge geothermal customers a fixed monthly fee based on their peak heating demand, as measured by the capacity of their heat pump, representing each customer's use portion of the shared loop capacity. The fixed monthly fee was set at the projected weighted average cost per ton for the overall system and would start at $22.69 per ton per month. The monthly fee would be adjusted over time as the system expanded, gradually declining, assuming the cost of adding new units would be reduced in the future.[200]

For a five-ton system typical for a single-family home, customers would be charged $113.45 per month. Importantly, under Niagara Mohawk's proposal, customers would continue to be charged this monthly fixed charge in perpetuity, even after the cost of the system is fully recovered. The utility would continue to operate and maintain the system and could seek to adjust the regulated rate as operating, maintenance and replacement costs change.

From the perspective of consumers, Niagara Mohawk's proposed district geothermal system would be competitive for households presently using propane and uncompetitive for households burning oil for heating. Based on Niagara Mohawk's proposal, average costs for fuel oil and electricity in the 2019–2020 period, and the costs of boiler maintenance and replacement, propane consumers would save approximately $37,500 over 25 years, the period corresponding to the effective useful life of the heat pump[201] that they purchase, assuming the Niagara Mohawk customer financed the heat pump component.[202] Niagara Mohawk's proposal is more costly relative to oil based on current prices, costing an additional $6,000 over 25 years. The utility geothermal proposal is the least competitive with natural gas, costing an additional $12,000 in heating costs over 25 years.

Importantly, the Niagara Mohawk district proposal would cost consumers more than purchasing one's own single household geothermal system. If consumers purchase their own system, consumers capture the entire value of their investment, including tax and utility incentives, as opposed to sharing these benefits with the utility. Also, once paid off, consumers have no cost to operate the system other than the cost of electricity to run the heat pump and system maintenance.

Propane fuel households that purchase their own geothermal system save $63,000 over 25 years, doubling their savings relative to Niagara Mohawk's geothermal. Oil burning households that purchase their own system save $19,600 over 25 years. Even gas households purchasing their own geothermal system would save $14,000 over 25 years, albeit with higher costs in the early years.

The utility district proposal is disadvantaged across all fuels, whereas single household geothermal systems are competitive. However, oil and gas customers purchasing their own geothermal system on a fully financed basis would incur additional out-of-pocket costs in the early years until a replacement fossil fuel boiler would have been required, which in the model was assumed at year 16. Savings would only begin to accrue once the geothermal loan is paid off, which is year 20 in the model.

The diagrams below show the value of the investment decisions for the six scenarios described above— Niagara Mohawk's district proposal and a single household system—both compared to propane, oil, and natural gas heating consumers. Assumptions used in the models are set out in the table following the diagrams.

Figure 2. Propane Consumers—Household Geothermal versus Utility Geothermal

Source: Authors using RETScreen Expert software.

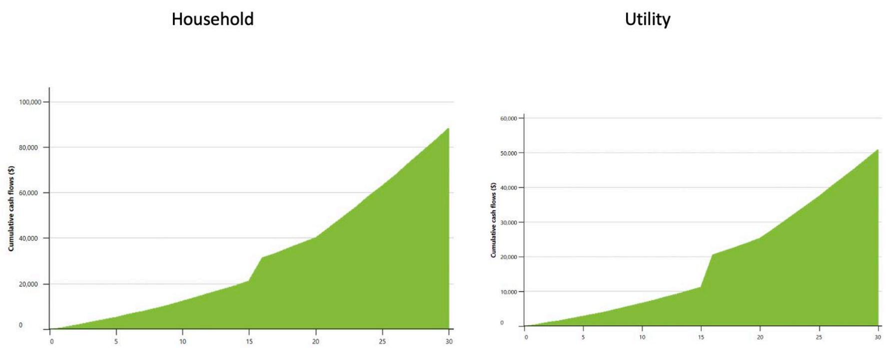


Figure 3. Oil Consumers—Household Geothermal versus Utility Geothermal

Source: Authors using RETScreen Expert software.

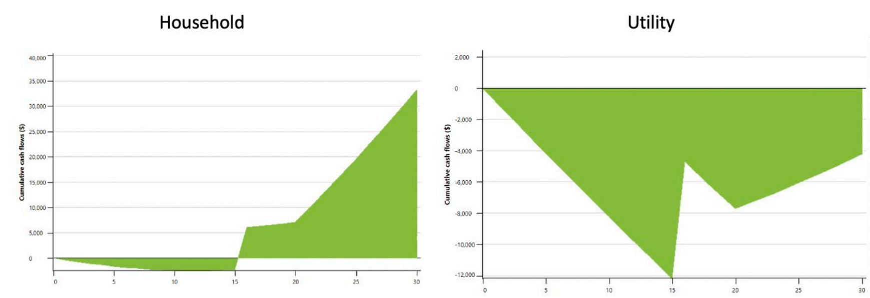


Figure 4. Gas Consumers—Household Geothermal versus Utility Geothermal

Source: Authors using RETScreen Expert software.

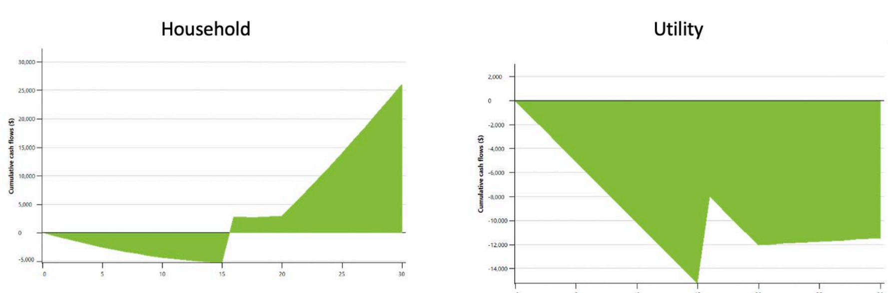


Table 4. Model Assumptions

Equipment and Installation Costs			
Ground Source Heat Pump – 5 Ton	$23,000		
Ground Loop	$15,000 household	$0 utility system	
Contingency for property conditions	15%		
Thermal Efficiency			
Oil 83%[203]	Propane 80%[204]		
Gas 80%[205]	GSHP Coefficient of Performance 4.15[206]		
Financing and Incentives			
New York State Heat Pump Subsidy	$1,500 per ton for 5-ton system totaling $7,500		
Federal Tax Credit	26% of Equipment Cost Net Subsidies		
Equipment Vendor Financing	20 years at 5% interest for 100% of Cost		
Project Period	25 years = effective useful life of heat pump		
Operating Costs			
Electricity (GSHP) - 6,215 kWh at $0.15/kWh[207]	$932/year		
Savings – Annual			
Avoided fuel consumption[208]	Oil $1,964 (770 gallons)	Gas $1,790 (1,065 ccf)	Propane $3,300 (1,200 gallons)
Price of fuel per 10,000 BTU	Oil $0.19	Gas $0.25	Propane $0.37
Avoided boiler maintenance	$400		
Avoided summer cooling	$70		
Avoided water heating	$70		
Savings – Periodic			
Avoided boiler replacement Year 16	$6,000		
Utility Geothermal Additional Costs			
Monthly fixed charge for 5-ton system	$113.45		
Other			
Inflation for Electricity and Fuel	2% annually		
Carbon Price per ton CO_2 Emitted	$125/ton if carbon price, otherwise none		
Carbon Emissions Avoided Annually	Oil 10 tons	Gas 6 tons	Propane 7 tons

6.5.1 Additional Cost of Niagara Mohawk's Utility Geothermal Proposal

Niagara Mohawk proposed to build 869 three-ton ground loop systems, the cost of the heat pump being born by the customer. Over 55 years, Niagara Mohawk estimated it would collect almost $44 million in recovering its investment and allowed rate of return.[209]

If these same systems were built by private geothermal companies, the total cost to consumers over 55 years would be less than $11 million on a fully financed basis, with the system paid off in 20 years. Relative to a private system, Niagara Mohawk's proposal costs over $38,000 more per household over this period, an increase of 312 percent the cost of a private system.[210]

The significant additional cost of utility geothermal as proposed by Niagara Mohawk would impose additional energy costs on households that run counter to societal goals of promoting household financial independence and delivering energy services at the lowest possible cost to consumers.

An economically competitive geothermal option, especially for those who cannot install their own system, such as residents of multiunit buildings or urban environments, can significantly contribute to reducing building carbon emissions.

Taking consumer affordability and environmental considerations into account, reducing the cost of utility geothermal by promoting competitive, transparent, and economically efficient markets is essential before Public Service Commission approval or before any other policy intervention is considered in respect to utility geothermal.

6.5.2 Rate Design for Competitive, Transparent, and Efficient Markets

Rate design can help reduce the overall burden to customers, however, rate design generally does not make uneconomic projects economically sustainable, but rather allocates cost to align incentives to meet policy goals and to ensure equity and fairness among stakeholders.

In evaluating rate design options for pilot district geothermal projects, the Public Service Commission should evaluate rate design options based on principles consistent with its overall view of promoting competitive, transparent, and efficient energy markets.[211]

As set out in section 4 in greater detail, the Commission has adopted principles for demonstration projects that include:

- Separation of utilities from generation assets, with partnerships between a utility and third-party service provider.
- Providing economic value for customers, the utility, and third-party service provider(s).

- A competitive market in which a utility only acts as the service provider in exceptional circumstances, such as when a market remains unwilling to provide services on commercially acceptable terms, or to enable low- and middle-income customers to receive the benefits of DERs.[212]
- If demonstration projects are initially uneconomic, rules should promote the development of competitive markets.
- Demonstrations should inform pricing and rate design modifications.[213]

Rate design approaches should therefore aim to promote competitiveness, transparency, and efficiency in the delivery of geothermal heat services to consumers. Ensuring that consumers remain free to choose to install their own household system imposes market discipline on utility geothermal providers. Any subsidization of utility geothermal consumers should only be justified after costs are reduced to the point these systems are economic, taking externalities into account, and then adopted on a targeted basis.

The sections that follow address approaches to reducing the cost of utility geothermal services and the circumstances in which policy intervention to subsidize these services is justified.

6.5.3 Reducing the Cost of Utility Geothermal

For utility district geothermal to succeed, the cost to consumers must be competitive with other heat options, the systems must generate revenues adequate for the utility to recover their costs, and, for investor-owned utilities, earn an allowed rate of return on their investment to ensure their continued investment in geothermal.

While the Niagara Mohawk geothermal heat services proposal is economic in the long run for propane customers, it is uncompetitive for oil and natural gas customers, and more expensive than privately owned single-property geothermal systems. Thus, the cost of Niagara-Mohawk's geothermal must be reduced to be attractive. Cost reductions could be achieved by:

- Driving cost reductions in equipment and installation through competitive tenders.
- Close scrutiny of costs and elimination of unjustified or unreasonable consumer charges.
- Resolving the regulatory framework, providing a uniform permitting regime and granting easements in gross that are traditionally provided to utilities to build out infrastructure.

This section evaluates options for improving pricing models for district geothermal heat services, using the Niagara Mohawk proposal as an example.

As utilities seek approval to enter this new industry that they do not yet have legal authority to enter, utilities might be incentivized to make their pricing competitive in their initial bids. The terms of entry will establish precedents for legal and business models available to the industry. The prospect of losing their gas distribution businesses due to decarbonization mandates may incent utilities to price these services competitively.[214] However, the return to the utility for entering this business line must be adequate to reward investors, otherwise, the utility will be unable to retain investors and attract capital to this new business model.

Geothermal could help transition gas utilities to a decarbonized business model and manage regulatory risk. Although the value of mitigating regulatory risk remains contingent until the Climate Act is operationalized, entering the geothermal business offers value to utilities that should at least motivate them to price services reasonably to ensure consumer uptake.

Competitively Bid Services Niagara Mohawk estimated costs without having competitively bid drilling and loop installation services. Competitive bidding could potentially reduce the overall cost of services.

Niagara Mohawk estimated first-year drilling and loop installation costs of almost $28 per foot installed for a three-ton system,[215] assuming 150 feet of loop required per ton of system heating capacity.[216] Niagara Mohawk's estimate is higher than the $15 to $20 range in the experience of private geothermal installers, barring complications presented by subsurface conditions or infrastructure.[217]

A four- to five-ton system, which would be required to serve an average size detached home, would require longer loops. This would require either complying with NYSDEC 500+ foot drilling regime requirements, installing a second loop, or employing lateral loops, all of which increase total system cost.

Overhead. Close scrutiny of the Niagara Mohawk proposal suggests cost reductions may be achieved under traditional cost-based recovery principles. Niagara Mohawk proposed an overhead charge of 28 percent of investment in the ground loop. If the drilling and installation work is contracted out to third-party firms, overhead charges should be considerably less than for work performed in-house. Further, the overhead charge should be scrutinized for whether it is limited to direct labor costs associated with construction of the system, or whether it includes labor overhead costs associated with maintenance that should be expensed on an annualized basis. It also should not double count any labor associated costs that are charged directly, such as the proposed two full-time employees.

Significantly, private geothermal providers are subject to competitive pressures to reduce overhead costs when quoting drilling and equipment costs to their customers, potentially making the Niagara Mohawk proposal significantly costlier. As discussed above, even without the overhead charge, Niagara Mohawk's proposed drilling and loop costs are likely higher than those of private systems. Further, Niagara Mohawk customers could also face higher costs for the heat pump when sold separately from the loop.

Rate Base. Niagara Mohawk proposed to charge geothermal heat customers a fixed fee in perpetuity, even after geothermal heat loop assets had fully depreciated, as it continues to operate and maintain the system. The utility should be required to price services assuming that the shared loop drops out of the rate base once fully depreciated, and thereafter only charge for required operation and maintenance costs. Maintenance costs should be estimated systemwide and then allocated amongst customers. The pricing for maintenance of the shared loop in the post-depreciation period should be greatly reduced, akin to the cost of an extended warranty for an asset. Because Niagara Mohawk proposed to charge customers on a fixed fee basis in perpetuity, the proposal does not appear to be priced in a manner reflecting the principle that fully depreciated assets drop out of the rate base.

Allowed Rate of Return. Niagara Mohawk's proposed allowed rate of return, reflecting a weighted average cost of capital based on both debt and equity, is 9.5 percent,[218] roughly double the cost of private debt financing available through private geothermal installers.[219] The allowed rate of return is charged on the utility's unrecovered capital costs that are approved for inclusion in the rate base. Although the allowed rate of return is the accepted approach for investor-owned utilities, these rates nevertheless remain uncompetitive when compared to market lending rates.

Earning Adjustment Mechanism. Niagara Mohawk earns incentive payments for promoting the adoption of heat pumps among its customers in its service territory, which are not addressed in its geothermal proposal. These incentives are funded by the System Benefits Charge collected from gas and electricity utility customers statewide.

These incentives are significant. In 2020, Niagara Mohawk received $4,561 per ground source heat pump installed by customers in its territory.[220] As Niagara Mohawk proposed a new geothermal revenue stream replacing gas revenues or even expanding its customer base by converting delivered fuel customers, the utility does not require an earning adjustment mechanism to promote adoption of heat pumps. If a utility would earn the incentive payment in providing geothermal heat services, it effectively triple-dips, earning geothermal revenues, earning additional revenues for electricity to operate the heat pump, and taking the heat pump earning adjustment mechanism incentive as well.

Regressive Cost Shift. Niagara Mohawk residential electricity customers who are on the standard service SC-1 tariff will experience disproportionately higher delivery charges for excess consumption due to the additional electricity consumption to operate the heat pump. For some household geothermal systems, this can amount to roughly $600 per year.[221] Electricity customers will also experience higher System Benefits Charges, which are also calculated on a per kilowatt hour basis. Addressing regressive cost shifts for all or low- and middle-income consumers through accommodations in rate design could enable these customers to adopt geothermal energy services.

Optimize System Design. Design of the Niagara Mohawk proposal could potentially enhance its efficiency and economics by diversifying its users to include businesses and institutional users that have offsetting heating and cooling loads. By diversifying heating loads, the system may better manage coincident demand and expand its access to diverse sources of waste heat, thereby balancing heating and cooling demand.

Generally, systems with two or more buildings that have a diversity of heating and cooling loads, are located in close proximity to each other, and exploit common ownership are the strongest candidates for reducing installation and operating costs.[222] In addition, a system design that expands the system using a neighborhood block may reduce drilling and installation costs.[223]

Limit Fixed Charges. Under the traditional investor-owned utility regulatory scheme, services are priced based on cost plus the rate of return on investments in infrastructure approved by the Public Service Commission. This would result in a rate paid by utility customers that is typically a combination of the volume of the commodity used (electricity, gas, or in this case, heat), a fixed charge for customer-specific costs (meters), and possibly a demand charge.

Niagara Mohawk proposed to charge geothermal consumers using a fixed charge based on the capacity of the heat pump installed. This is a proxy for actual heat consumed.

Fixed charges tend to be highly regressive, especially for low- and middle-income consumers. When used, fixed charges should be limited to those costs of infrastructure specific to the customer and should be reasonable. Lifeline rates or subsidies for low- and middle-income consumers should also be adopted to ensure equity, as would be applied to any energy option offered through the utility.

Volumetric pricing is preferable as it balances equities best among consumers. Equipment is available that monitors flow and temperature, enabling Niagara Mohawk to charge customers on a volumetric rate basis. The cost and accuracy of monitoring equipment should be evaluated to determine if volumetric pricing is feasible now or becomes feasible in the future.

Environmental Attributes. Niagara Mohawk's proposal was silent as to environmental attributes associated with reductions of carbon emissions. Environmental attributes may have significant value, either to comply with anticipated New York State requirements for utilities to reduce emissions, or as a tradeable asset if emission trading is permitted. Niagara Mohawk should be required to account for these attributes and commit their application to reduce their own emissions without transfer to third parties. Otherwise, the transfer of these attributes potentially undermines the environmental integrity of district geothermal and constitutes a potential revenue stream not reflected in their proposal.

Depreciation Period. Niagara Mohawk's consumer charge levels were based on recovering their investment over a 50-year period for the geothermal loop portion of the project. Recovery periods should be based on a depreciation study that estimates the useful life of the individual components of the system. Geothermal loops made of high-density polyethylene pipe are warranted by manufacturers for up to 55 years, gas utilities depreciate polyethylene pipes used for natural gas for 65–80 years or longer, and manufacturers commonly claim these pipes will have useful lives of 50–100 years or more.[224]

Accordingly, the recovery period for the proposed investment should reflect a longer period appropriate to geothermal applications. However, extending the depreciation period beyond 50 years will not significantly reduce the annual cost to consumers because the allowed rate of return multiplied by the undepreciated asset component will be significantly greater than the annualized depreciation recovery component during most of the recovery period. In the aggregate, extending the depreciation period would increase the total amount collected from consumers.

6.6 Policy Interventions to Enable Utility Geothermal

Policy intervention to promote the adoption of geothermal will be necessary to transition consumers, especially urban users whose only option may be a utility geothermal program. This section discusses the justifications for intervention, and how to target subsidies in order to enhance their effectiveness and reduce overall cost.

6.6.1 Avoiding Stranded Costs

Avoiding stranded costs associated with further investment in fossil infrastructure is an increasingly valuable attribute of geothermal and any other non-fossil energy infrastructure that justifies policy intervention.

In the Public Service Commission's integrated gas planning docket, the staff signaled that traditional gas infrastructure faces an uncertain future in light of the Climate Act. In its proposal for planning gas infrastructure, the staff stated that the Climate Act must guide future gas planning decisions and provided detailed guidance directing gas utilities to conduct sensitivity analysis comparing non-pipe alternatives to traditional gas infrastructure on a benefit and cost basis, assuming traditional gas infrastructure to be fully depreciated by 2050.[225]

To put the potential magnitude of stranded costs in perspective, the United States built $35.8 billion in natural gas infrastructure in 2019, reflecting steadily increasing investment levels since the 2000s. Of the 2019 investment total, distribution infrastructure accounted for $21.6 billion, or 60.4 percent, of natural gas infrastructure costs. [226]

New York State accounted for 9.4 percent of national residential gas consumption, corresponding to $2.0 billion spent on distribution infrastructure in 2019.[227] An alternative measure, the State is home to 6.5 percent of national residential gas end-users, which includes detached homes and multi-unit buildings.[228] Based on the number of end-users, New York State's share of national natural gas distribution infrastructure investment was $1.4 billion in 2019.

Investments of between $1.4 billion to $2 billion in natural gas distribution infrastructure, not including investments in transmission, storage, and other general expenses, deepens the State's exposure to stranded costs while the State legislature has committed to reduced emissions. To meet the Climate Act's targets, from a 2020 baseline, gas distribution utilities must on average start reducing their emissions by roughly 6 percent per year from 2021 to 2030 to meet the 2030 target of 40 percent reductions against 1990 levels, and by just under 3 percent per year to meet the 2050 target of 85 percent reductions against 1990 levels.[229]

Under the Public Service Commission's 2050-time horizon to depreciate gas infrastructure investments, distribution investment made today that typically receive an estimated 60-year useful life will be retired in half that time. Thus, consumers will pay double for that infrastructure relative to the utility society will receive from its investment, and each year, that cost increases. An investment made in 2035 will be retired in a quarter of its useful life, causing consumers to pay essentially four times the value of the investment's usefulness.

Each year New York State continues to invest in natural gas infrastructure, the returns diminish, and utilities must spend more in the coming decades on maintaining existing gas infrastructure.

No prudent business would continue to invest in assets given the inverse relationship between increasing costs and diminishing utility of investment, unless they expected ratepayers or taxpayers to step in and cover the resulting losses.

At the State's estimated average annual expenditure of $1.7 billion per year for gas distribution infrastructure, the stranded costs portion of these investments will accumulate to $9.8 billion over 10 years, increasing to almost $16 billion over 15 years.

Saddling ratepayers with these stranded costs preclude affordable utility rates. These dead-weight costs would be added to utility bills for a disused system, beyond what ratepayers must pay for the system then in use, and their actual consumption.

Stranded costs have persuaded neighboring Massachusetts to reach similar conclusions concerning the wisdom of continuing to invest in gas infrastructure. In response to a series of gas line explosions and fires that occurred in Massachusetts' Merrimack Valley in 2018, the Massachusetts Legislature introduced the "FUTURE Act" (An Act for a Utility Transition to Using Renewable Energy, H.2849, S.1940 [2019]) to accelerate the repair of gas leaks and encourage a conversion to piping renewably sourced hot and cold water instead of natural gas. One study of the economic effect of the FUTURE Act concluded that it would reduce the cost of gas system repair from $17.1 billion to $6.3 billion, a savings of roughly

$10.8 billion over the next 30 years.[230] Another study of district geothermal in Massachusetts similarly found that "more than a quarter of the gas pipes under Massachusetts streets are aging, and must be replaced over the next 20 years," which is expected to cost more than $9 billion.[231]

6.6.2 Social Cost of Carbon

Geothermal heat services avoid carbon emissions that should be reflected in their valuation. The New York State Department of Environmental Conservation has adopted a social cost of carbon to guide policy decisions, with a 2020 central value of $125 per metric ton of CO_2.[232]

If consumers were required to pay the social cost of carbon for their emissions through a tax, penalty, or carbon trading scheme, the comparative cost of geothermal relative to fossil heat would improve as additional costs would then be reflected in the price of fossil-fuel heat, resulting in a truer comparison of options with all costs internalized.

Using NYSDEC's social cost of carbon, a typical single-family home in the State that consumes 1,065 centum cubic feet (ccf) of natural gas per year for heating would avoid approximately six tons of CO_2 per year, which using the New York State social cost of carbon, would reflect $750 in avoided externalities.

If gas consumers internalized these costs, the Niagara Mohawk geothermal proposal to provide geothermal heating at a cost of $113 per month for a five-ton geothermal system would become competitive with natural gas at current gas prices, assuming geothermal heat could completely displace gas consumption without the need for supplemental heat from a non-geothermal source. With a cost of carbon at $125 per metric ton, the Niagara Mohawk proposed geothermal system saves the gas consumer roughly $13,000 over 25 years.

The avoided emissions when switching from gas to geothermal are even greater considering the gas distribution system's overall methane leakage. System-wide lifecycle leakage rates for methane are estimated to be 3.14 percent.[233]

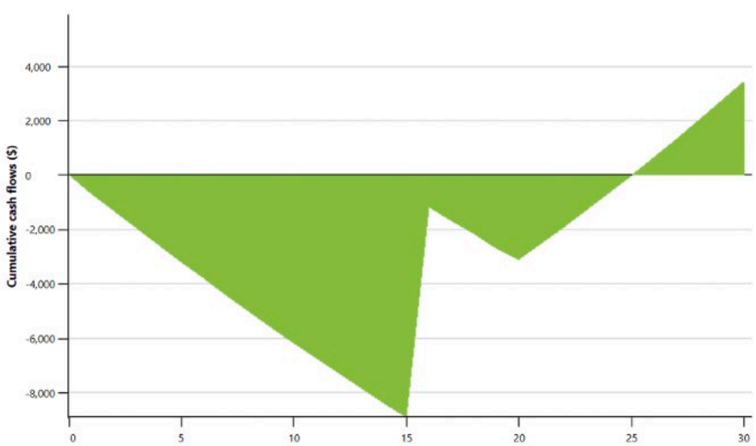
Using New York State's social cost of carbon at $125 per ton, the utility geothermal scenario above suggests a total subsidy of $3.4 billion per year would be required to incentivize 4.5 million State residential gas households to transition to geothermal.[234] However, even at a carbon price of $60 dollars per ton, the cost of shifting to utility geothermal is identical to staying with gas over 25 years, based on current low gas prices. Thus, at less than half the New York State social cost of carbon, the cost to subsidize the transition of gas consumers to utility geothermal would only be $1.6 billion per year, within the $1.4 to $2.0 billion range that the State already spends on gas infrastructure.

Figure 5. Utility Geothermal versus Natural Gas—$125/ton Carbon Price

Source: Authors using RETScreen Expert software.

Figure 6. Utility Geothermal versus Natural Gas—$60/ton Carbon Price

Source: Authors using RETScreen Expert software.



These costs of transition are further reduced when one considers that household-owned geothermal is already marginally competitive with natural gas, producing a small yet positive return, and competitive with propane and oil. Thus, if no subsidy would be required for households electing the household system option, a significant proportion of New York State's 3.2 million detached homes could transition without subsidies, as well as a portion of the remaining 4.5 million attached and multi-unit residences, further lowering the overall cost of transition.[235]

Significantly, but not quantified above, transitioning to geothermal involves no additional costs for fuel, eliminates the risk of stranded costs due to carbon regulation, and the subsidy falls away after the transition, whereas natural gas investment to maintain the system will continue to grow.

6.6.3 Infant Industry Subsidy

As district geothermal is presently not cost-competitive for gas consumers, the overall cost to geothermal consumers could be reduced by applying for an infant industry subsidy.

Infant industry subsidies defray the additional cost of a new technology until the technology's adoption reduces the cost of services to competitive price levels acceptable to consumers. The infant industry subsidy should be calibrated to cover only those additional costs above the level that the technology would be priced competitively for consumers, and it should disappear once the technology is cost competitive on its own merits.

Importantly, the infant industry subsidy should only be used when it brings about a reduction in the costs of the particular technology through upscaling or learning effects. As long as district geothermal is subject to transactional diseconomies of the kind described in this report, it is unlikely to achieve significant learning effects.

The Niagara Mohawk pilot is uneconomical for gas customers due to a combination of low gas prices, the loss of federal tax incentives payable to consumers, and legal and regulatory diseconomies that the proposed pilot cannot cure. Niagara Mohawk's own projections show only modest expected learning effects, not enough to achieve "subsequently competitive markets" in the language of the Commission's Principles for NY REV Demonstrations, without addressing the legal and regulatory diseconomies described in this paper. Under these conditions, an infant industry subsidy may not be appropriate until diseconomies are addressed through the legislature, or the utility proposes a business model that is otherwise able to achieve an economically competitive outcome through learning effects.

Further, due to the economics of geothermal relative to oil and gas, subsidies are only needed to benefit existing gas consumers, whereas oil customers may only require concessional financing during the earlier years to address the higher operating costs prior to the boiler replacement that would have been required if the household continued using fossil fuels. The model scenarios assume boiler replacement would have occurred in year 16. However, if boiler replacement occurs sooner, the accelerated savings further reduces the initial period of higher operating costs and result in additional savings.[236] Thus, a more targeted approach specific to gas and oil customers would potentially be more effective and less costly.

6.6.4 Targeted Subsidies and Policies

Socialization of the entire cost of geothermal systems or spreading the cost to utilities of providing geothermal heating service over all utility customers, would reduce the cost to consumers purchasing utility geothermal service. Broad cost socialization could potentially address pilot projects but could not serve as an effective pricing model for a complete transition to geothermal as the proportion of geothermal consumers increases relative to gas consumers.

Even at a small scale, broad socialization of geothermal system costs poses several issues that should be carefully considered.

Most fundamentally, socialization imposes the costs of geothermal on a large group of utility customers who don’t receive services from geothermal investments. By imposing the cost on a group that does not receive geothermal services, socialization violates the principle that customers are charged for the services they receive. This severs the relationship between pricing, cost of service, and performance. By relaxing these relationships, socialization weakens utility accountability to ratepayers that can lead to additional cost burdens on consumers and society.

When socialization is applied to projects that are uneconomic relative to target customers, socialization of costs relaxes budget constraints that can institutionalize inefficiency if discipline is not otherwise introduced through some other mechanism.

A feed-in-tariff, widely employed outside the United States, is an example of a policy that socializes the costs of presently uneconomic technologies that exhibit learning effects with scaling. Feed-in-tariff policy typically employs a committee to reset tariffs downwards as covered technologies reduce in price, in order to recreate market discipline.[237] However, unlike technologies like solar and wind that commonly receive support through feed-in-tariffs, district geothermal may not exhibit significant learning effects, at least until legal, regulatory, and other diseconomies are addressed.

In the case of the Niagara Mohawk proposal, indiscriminate socialization would also lead to inequities for low- and middle-income gas consumers who will certainly be among those subsidizing wealthier consumers because only wealthier households are likely able to afford the large up-front cost of the heat pump that they must purchase to participate.

Further, given the broad disparities in economics for propane, oil, and gas customers, achieving uniform pricing via socialization of costs for all customers would give propane and oil consumers an unnecessary windfall in their transition to geothermal. This would cause geothermal subsidies to be more costly than necessary.

Implementing the transition to geothermal while minimizing overall cost to ratepayers and taxpayers could be accomplished through a combination of policies that work together to force transition to clean technologies while mitigating the cost impact on consumers. Policies to force transition include phasing out fossil-fuel burning boilers where clean alternatives are available and requiring transition to geothermal or other clean technologies through stretch codes.[238] Within mandated transition, consumers should remain free to choose between utility geothermal, private ownership of geothermal, or some other clean heating system.

To mitigate the costs to consumers, targeted subsidies could include concessionary consumer financing available for all fuel consumers. No or low-cost financing significantly improves the economics of all geothermal—both household and utility systems—including for gas consumers. Enhanced assistance to help cover the costs of heat pumps for low- and middle-income consumers would enhance access and equity to geothermal heat services. Additional incentives for low- and middle-income customers might include subsidizing a portion of the increase in higher-than-normal energy service bills.

Finally, imposing a carbon price on natural gas, propane and oil fuels consumption can help finance these subsides and mobilize consumers to shift from fossil fuels to clean energy alternatives. As demonstrated above, a carbon price far lower than New York State's $125 social cost of carbon price can effectively incent this transition.

6.7 Utility Geothermal Monopoly

Some gas utilities have argued that allowing a mixed model of district and private geothermal systems would cause the "balkanization" of their service territory, ultimately leading to inefficient and potentially less safe and reliable service.[239] The natural monopoly argument for geothermal heat is less compelling than for gas and electricity distribution as small district geothermal systems can operate independently of each other in an efficient manner, and the terms of electrical monopoly are being rewritten since distributed energy resources are increasingly integrated into the power grid.

Utility arguments for geothermal monopoly should be evaluated in the context of competing options and circumstances. Utility geothermal does not presently enjoy an economic advantage over household geothermal for rural and low-density suburban areas where detached homes and large plots of land are the norm. Although design can enhance shared loop efficiency, utility geothermal will likely remain more costly to consumers than owning their own system except possibly where shared loop systems with diversified users can deliver exceptional efficiencies greater in magnitude than the financial advantages of the single user loop system. Importantly, design efficiencies of this magnitude may only be achievable in a subset of cases.

Significantly, however, in medium- and high-density urban environments, small property plots inadequate to serve thermal loads and subsurface municipal and utility infrastructure may preclude single-property geothermal systems, making district systems on a utility or private basis the only viable geothermal option.[240]

6.8 Municipal-Owned Versus Investor-Owned Geothermal Economics

Although the legal issues surrounding municipal-owned and investor-owned utility models are similar, as described more fully in section 4, the economics of geothermal heat services offered by these different utility ownership models may differ.

In New York State, no municipal-owned utility has proposed providing geothermal heat servicers to date. It is therefore difficult to evaluate the relative economics of utility-owned versus municipal-owned geothermal heat services.

There are, however, potential opportunities presented by municipal-owned geothermal that should be further explored. These include whether a not-for-profit entity could offer geothermal heat services at a more competitive price point to consumers, and whether municipal ownership of water and sewer services could synergize with district geothermal system designs that incorporate these elements and heat sources and sinks.

This paper does not attempt to resolve these questions, leaving them as issues for further study, and ultimately for resolution by market actors in the context of the paper's recommendation to embrace open competition to provide geothermal heat services.

7 Recommendations

Scaling district geothermal along the full continuum of business models requires the implementation of policies that overcome barriers and enable adoption of the technology. This section sets out recommendations for policies based on the analysis presented in this paper.

7.1 Default Rights for Easements and Public Rights-of-Way

Default rules that require the grant of easements through public and utility rights of way will help overcome legal diseconomies, reducing the time and cost of arranging property rights. Default rules should recognize geothermal as essential as water, sewer, and electrical services. At the same time, default rules promoting geothermal must be carefully designed to avoid undermining private property rights or diminishing private property values. If done properly, default rules could enhance property values and enjoy public support.

Default easement rules should also promote a competitive market in geothermal heat services by requiring utilities and geothermal providers to cooperate to ensure access across property boundaries and pre-existing easement rights on reasonable terms.

7.2 Dedicated Geothermal Drilling Permit and Standards Regime

New York State's current regulatory regime for drilling was not designed for geothermal. Practical, dedicated, and uniform statewide regulations and standards for district geothermal would help improve geothermal penetration for shallow systems. Specifically, a dedicated regime should eliminate the State's 500-foot threshold in favor of a regime that requires adherence to recognized industry standards specifically designed for shallow geothermal systems and enforces these standards uniformly to ensure environmental integrity.

Standards specific to shallow geothermal conditions in New York State could be developed or adapted from existing standards, such as those promulgated by the International Ground Source Heat Pump Association, which are presently only required for projects that obtain utility rebate support.

7.3 Integrating Geothermal into Stretch Codes and Infrastructure Improvements

Investment in infrastructure is the ideal time to assess and integrate geothermal into development plans and codes.

Wherever possible, geothermal should be integrated with upgrades to new and retrofit buildings, and municipal infrastructure such as water, sewer, roads, and other systems that can support geothermal development. The State and local governments should consider requiring geothermal space set-asides and access points in zoning and development codes in order to enable geothermal ready infrastructure. Requiring integration of geothermal infrastructure alongside other infrastructure enables us to reduce the cost of geothermal and tackle difficult property rights of way issues.

Critical points in time when geothermal upgrades could be required might include:

- Greenfield housing developments for a specified number of single-family homes.
- Greenfield commercial and multiple-unit buildings meeting specified thresholds.
- Redevelopment of existing property meeting specified thresholds.
- Property transfers.
- Sunsetting of existing infrastructure heating systems requiring replacement with geothermal or other net zero heating systems.

7.4 Public Service Commission Authority

The New York State legislature should amend the Public Service Law to confirm that the Public Service Commission possesses the authority to regulate geothermal heat services provided by utilities and establish the parameters of their authority.[241]

7.5 Dedicated Geothermal Docket

The Public Service Commission is responding to various investor-owned utilities proposing geothermal heat services pilots in rate case proceedings. Given the uncertainty in Public Service Commission jurisdiction to approve utilities engaging in the geothermal business, rate case proceedings are not an ideal forum for reaching decisions that could set precedent for the various legal, market structure, and rate design issues presented by pilot proposals.

A dedicated geothermal docket or a special proceeding within the Public Service Commission's existing integrated gas docket should be established to consider issues better evaluated in their full context, beyond a single utility's particular proposal in a rate case. These issues include:

- Value of geothermal services.
- Business models, including utility geothermal and overall market structure.
- Rate policy, including accounting and charging for geothermal assets.

7.6 Amending the Public Service Law to Allow Utility Geothermal

Scaling geothermal as rapidly as possible ultimately requires exploiting the scale, business platforms, and technical capabilities of existing utilities. Amending the Public Service Law to enable utilities to own and operate geothermal assets will enable these utilities to roll this technology out to consumers who are already their customers.

Allowing investor-owned and municipal-owned gas utilities to enter the geothermal business provides a zero-carbon business alternative to their present business model. Providing this alternative reduces the potential cost and disruption presented by utility transition to zero carbon and helps overcome utility resistance to this transition.

While utility geothermal should be permitted, households and businesses should retain the right to choose between purchasing geothermal heat services from a utility, building and owning their own individual system, or joining a privately managed district system. Enabling consumer choice will help promote a competitive market, incentivizing service providers to deliver value on a cost-competitive basis.

In order to ensure a competitive market, utility authorization should be conditioned upon utilities cooperating with other geothermal providers to require access to utility easements on reasonable terms.

If utility geothermal heat services are permitted, the State's universal service requirement to connect buildings located within 100 feet of a gas or electricity transmission line upon request for service, and the costs of connection borne by the utility and amortized across all gas or electricity customers through approved tariffs,[242] should be evaluated for inclusion of geothermal heat services.

7.7 GIS Mapping of Thermal Energy Sources and Sinks

The risks and costs associated with the drilling phase of geothermal projects can be reduced by centralizing data collection and making publicly available a database of exploratory drilling assessments and final drilling results in a standard format. Mapping known pockets of natural gas, hydrogen sulfide, and other complicating risk factors would help developers manage risk.

Mapping thermal energy resources would provide local governments, developers, investors, and site hosts with information about the most cost-effective design options for developing district geothermal systems. Mapping natural and man-made thermal sources, such as water and sewer infrastructure, will be essential to exploit the full potential of geothermal energy, toward fully integrated district geothermal systems.

7.8 Drilling Support

Policy support for test drilling could help overcome barriers associated with the cost and risk of drilling geothermal wells. Several jurisdictions have established risk mitigation funds that reduce risk by providing insurance,[243] subsidizing drilling costs through grants, or ensure a guaranteed rate of return through a feed-in tariff or other mechanism.[244]

7.9 Valuing Social Cost of Carbon and Distributed Energy Resources into Geothermal Pricing

State policy should enable clean energy resources to reflect their full value, or alternatively internalize the cost of fossil-generated electricity and heat services.

Imposing a carbon price, valuing the full range of services provided by clean distributed heat resources, including avoiding further stranded costs of fossil infrastructure, would enable geothermal pricing to monetize these components and accelerate the adoption of geothermal technology. The reasons for internalizing heating externalities and valuing geothermal services fully are compelling. How to compensate clean heat providers for these services should be a priority question for policymakers.

Appendix A. Database of Geothermal and Heat Exchange Projects Surveyed

Table A-1

System	State Province	City	Energy Source	Cools	Type	Number of Customers	Square Footage	Cross right-of-way	Loop Type	Year Complete	Business Model
Toronto Deep Lake Water Cooling	ON	Toronto	Steam and Water-Source Cooling	Yes	District	80 Buildings	N/A	Yes	Open loop, water utility	2004	Multiple Properties — Different Owners — Municipal Regulated
Lulu Island Energy Corp – Alexandra	BC	Richmond	Ground-Source Heat Pump	Yes	District	9 buildings, 1,456 residential units	1,678,000	Yes	Closed Loop	2015; ongoing expansion	Multiple Properties — Different Owners — Municipal Regulated
West Union Downtown Business	IA	West Union	Ground-Source Heat Pump	Yes	District	12 Buildings	330,000	Yes	Closed Loop	2013	Multiple Properties — Different Owners — Municipal Regulated

Table A-1 continued

System	State Province	City	Energy Source	Cools	Type	Number of Customers	Square Footage	Cross right-of-way	Loop Type	Year Complete	Business Model
Oberlin College	OH	Oberlin	Ground-Source Heat Pump	Yes	District	Campus and Off-Campus Customers	N/A	Yes	Closed Loop	Under Construction	Multiple Properties — Different Owners — Market Pricing
Sun Rivers Golf Resort	BC	Kamloops	Ground-Source Heat Pump	Yes	District	850 Homes	N/A	No	Closed Loop	2018; ongoing expansion	Single Property — Common Developer — Subdivide Into Multiple Properties
Whisper Valley	TX	Austin	Ground-Source Heat Pump	Yes	District	237	N/A	No	Closed Loop	2019; ongoing expansion	Single Property — Common Developer — Subdivide Into Multiple Properties
Elements at Prairie Center	CO	Brighton	Ground-Source Heat Pump	Yes	Campus	288 Units	265,000	No	Closed Loop	2019	Single Property — Single Owner

Table A-1 continued

System	State Province	City	Energy Source	Cools	Type	Number of Customers	Square Footage	Cross right-of-way	Loop Type	Year Complete	Business Model
Ball State University	IN	Muncie	Ground-Source Heat Pump	Yes	Campus	47 Buildings, Single-owner	5,500,000	Yes	Closed Loop	2017	Single Property — Single Owner
National Western Center	CO	Denver	Sewer heat exchange and ambient loop	Yes	Campus	Single Owner	N/A	No	Closed Loop	Under Constructio n	Single Property — Single Owner
Nashville International Airport	TN	Nashville	Water-Source Heat Pump	Yes	Campus	Single Owner	N/A	No	Closed Loop	2016	Single Property — Single Owner
Weber State University	UT	Ogden	Ground-Source Heat Pump	Yes	Campus	Single-owner	N/A	No	Closed Loop	2016	Single Property — Single Owner
Watchtower World Headquarters of Jehovah's Witnesses	NY	Warwick	Ground-Source Heat Pump	Yes	Campus	Single-owner	900,000	No	Closed Loop	2016	Single Property — Single Owner
Missouri University of Science & Technology	MO	Rolla	Ground-Source Heat Pump	Yes	Campus	Single-owner, 15 buildings	2,170,000	No	Closed Loop	2014	Single Property — Single Owner
Cornell University	NY	Ithaca	Water-Source Cooling	Yes	Campus	Single-owner	4,000,000	Yes	Closed Loop	2000	Single Property — Single Owner

Table A-1 continued

System	State Province	City	Energy Source	Cools	Type	Number of Customers	Square Footage	Cross right-of-way	Loop Type	Year Complete	Business Model
Epic Systems Headquarters	WI	Verona	Ground-Source Heat Pump	Yes	Campus	Single-owner, 25 buildings	1,793,000	No	Closed Loop	2018	Single Property — Single Owner
Ohlone College Newark Center	CA	Newark	Ground-Source Heat Pump	Yes	Campus	Single-owner	130,000	No	Closed Loop	2008	Single Property — Single Owner
City College of San Francisco	CA	San Francisco	Ground-Source Heat Pump	Yes	Campus	Single-owner	318,700	No	Closed Loop	2009	Single Property — Single Owner
Ohlone College Fremont Campus	CA	Fremont	Ground-Source Heat Pump	Yes	Campus	Single-owner	N/A	No	Closed Loop	Under Constructio n	Single Property — Single Owner
Carleton College	MN	Northfield	Ground-Source Heat Pump	Yes	Campus	Single-owner	N/A	No	Closed Loop	2021	Single Property — Single Owner
Mission Rock	CA	San Francisco	Water-Source Heating and Cooling	Yes	Campus	11 Buildings	3,500,000	No	Open Loop	Under Constructio n	Single Property — Single Owner
Beaver Barracks	ON	Ottawa	Ground-Source Heat Pump	Yes	Campus	Single Owner, 254 rental units	N/A	No	Closed Loop	2012	Single Property — Single Owner

Table A-1 continued

System	State Province	City	Energy Source	Cools	Type	Number of Customers	Square Footage	Cross right-of-way	Loop Type	Year Complete	Business Model
Vancouver International Airport	BC	Vancouver	Ground-Source Heat Pump	Yes	Campus	Single Owner	3,500,000	No	Closed Loop	2020	Single Property — Single Owner
Weeksville Heritage Center	NY	Brooklyn	Ground-Source Heat Pump	Yes	Single-Building	10 Heat pump units, single-owner	16,400	No	Closed Loop	2012	Single Property — Single Owner
Staten Island Museum at Snug Harbor	NY	Staten Island	Ground-Source Heat Pump	Yes	Single-Building	5 Heat pump units, single-owner	16,800	No	Closed Loop	2012	Single Property — Single Owner
Brooklyn Children's Museum	NY	Brooklyn	Ground-Source Heat Pump	Yes	Single-Building	23 Heat pump units, single-owner	55,000	No	Open Loop	2008	Single Property — Single Owner
Queens Botanical Garden	NY	Queens	Ground-Source Heat Pump	Yes	Single-Building	8 Heat pump units, single-owner	16,000	No	Open Loop	2007	Single Property — Single Owner
Lion House at Bronx Zoo	NY	Bronx	Ground-Source Heat Pump	Yes	Single-Building	6 Heat pump units, single-owner	40,000	No	Standing Column Well	2006	Single Property — Single Owner
St. Patrick's Cathedral	NY	Manhattan	Ground-Source Heat Pump	Yes	Single-Building	Single-owner	76,000	No	Standing Column Well	2017	Single Property — Single Owner

Table A-1 Continued

System	State Province	City	Energy Source	Cools	Type	Number of Customers	Square Footage	Cross right-of-way	Loop Type	Year Complete	Business Model
Center for Architecture	NY	Manhattan	Ground-Source Heat Pump	Yes	Single-Building	Single-owner	15,000	No	Closed Loop	2003	Single Property — Single Owner
William L. Buck School	NY	Valley Stream	Ground-Source Heat Pump	Yes	Single-Building	Single-owner	40,000	No	Water utility	2015	Single Property — Single Owner
Cornell NYC Tech – Bloomberg Center	NY	Roosevelt Island	Ground-Source Heat Pump	Yes	Single-Building	Single-owner	150,000	No	Closed Loop	2017	Single Property — Single Owner
Tallman Hotel	CA	Upper Lake	Ground-Source Heat Pump	Yes	Single-Building	Single-owner	N/A	No	Closed Loop	2007	Single Property — Single Owner
Nebraska Innovation Campus (NIC)	NB	Lincoln	Sewer heat exchange and ambient loop	Yes	Campus	6 buildings with 55 public and private tenants	1,800,000	No	Closed loop	2015	Single Property — Single Owner — Multiple Users

In addition to the geothermal, sewer, and water-source district thermal projects, we also researched notable district systems with alternate thermal sources for their relevance in right-of-way, property rights, ownership, and regulation concerns. Non-geothermal studied include hot spring-fed systems in Pagosa Springs, CO and the Boise Warm Springs Water District, ID. We also researched District Heat Montpelier in Vermont, which relies on a biomass boiler, and CoolCo District Cooling in Cincinnati, OH which utilizes electric chillers. We also researched fossil-fuel sourced systems including Proctors Marquee District in Schenectady, NY, St. Paul District Energy, MN, Duluth Energy Systems, MN, and the University of British Columbia Neighborhood District Energy Service (NDES). The NDES plans to convert from natural gas to geothermal as the project progresses.

Endnotes

[1] Climate Leadership and Community Protection Act, S. 6599, A. 8429, 2019-20 Reg. Sess. (N.Y. 2019), §1(12)(a).

[2] New York State Greenhouse Gas Inventory: 1990–2016, NYSERDA at S-6, fig. S-3 (July 2019).

[3] *Revised Regulatory Impact Statement: 6 NYCRR Part 496, Statewide Greenhouse Gas Emission Limits,* NYSDEC at 19 (2020), available at https://www.dec.ny.gov/docs/administration_pdf/revisedris496.pdf.

[4] New York has at least 4.5 million buildings. See *Toward a Clean Energy Future: A Strategic Outlook 2021-2024,* NYSERDA at 52 (2020).

[5] Idaho National Laboratory, The Future of Geothermal Energy: Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century, U.S. DOE at 1-5, 1-15, 1-18 (Nov. 2006).

[6] Personal Communications with John P. Ciovacco, President, Aztech Geothermal (Feb. 18, 2021). See also *Geothermal Heat Pumps,* Home Energy Community of Practice (July 30, 2019), available at https://home-energy.extension.org/geothermal-heat-pumps/.

[7] *PPI TN-27: Frequently Asked Questions HDPE Pipe for Water Distribution and Transmission Applications,* The Plastics Pipe Institute at 5 (Nov. 2009), available at https://plasticpipe.org/pdf/tn-27-faq-hdpe-water-transmission.pdf.

[8] To achieve decarbonization, an important consideration in regard to heat pumps is the climate impact of the working fluid. See Steven Winter Associates, *Heat Pump Retrofit Strategies for Multifamily Buildings,* NRDC at 7 (April 2019), available at https://www.nrdc.org/sites/default/files/heat-pump-retrofit-strategies-report-05082019.pdf. Installer training is critical to ensuring that refrigerant leakage is minimized.

[9] *Guidelines for Ground Source Heat Pump Wells,* Mass DEP at 4, 16 (Dec. 2013), available at https://www.mass.gov/doc/guidelines-for-ground-source-heat-pump-wells/download (referencing the Canadian Geoexchange coalition's definition of closed loop systems as ones that "prevent the discharge or escape of its fluid into the subsurface" and establishing that Massachusetts only permits propylene glycol and ethanol as antifreeze additives in these systems.); Fingers Lakes Institute, *Geothermal Heating and Cooling: Introduction,* Hobart & William Smith Colleges at 2, available at https://www.hws.edu/fli/pdf/geo_heating_cooling.pdf (accessed March 17, 2021) ("The closed loop system is environmentally friendly because water in the loop prevents contamination to the external environment."); Blog, *Geothermal Ground Loop Frequently Asked Questions,* Dandelion Energy (Nov. 19, 2019), available at https://dandelionenergy.com/geothermal-ground-loop-frequently-asked-questions (certain closed loop system developers in New York State use mixtures of water and propylene glycol, a "food-grade, non-toxic antifreeze.").

[10] See generally Heather Anderson, *William L. Buck Elementary School's Innovative Geothermal System Saves $600,000,* 14 GeoOutlook 26 (2017), available at https://www.geooutlook.org/epub/GO2017No1/#26; Omid Ghasemi-Fare, Geothermal Energy Harvesting through Pile Foundations – Analysis Based Prediction & Performance Assessment (May 2015) (Ph.D. dissertation, Pennsylvania State University) available at https://etda.libraries.psu.edu/files/final_submissions/10689; Michael Gray, Analysis of Geothermal Pile Foundations Under Combined Axial & Moment Loading (Dec. 2013) (M.S. thesis, Washington State University), available at http://www.dissertations.wsu.edu/Thesis/Fall2013/m_gray_120313.pdf.

[11] Boesten et al., *5th Generation District Heating & Cooling Systems as a Solution for Renewable Urban Thermal Energy Supply*, 39 Advances in Geosciences 129 (Sep. 20, 2019), available at https://doi.org/10.5194/adgeo-49-129-2019.

[12] John Sprankling & Raymond Coletta, *Property* 26 (3d ed. 2015). The most important "sticks" are often identified as the rights, to use, exclude, destroy, and alienate.

[13] Joseph Rasch & Robert Dolan, *N.Y. Law & Practice of Real Property* §§ 2:8-2:9 (2020).

[14] Sprankling & Coletta, *supra* note 12, at 69.

[15] *Id.;* Rasch & Dolan, *supra* note 13, § 16:2.

[16] Rasch & Dolan, *supra* note 13, § 16:1.

[17] Sprankling & Coletta, *supra* note 12, at 95.

[18] *Id.;* N.Y. Penal Law § 140.05.

[19] Rasch & Dolan, *supra* note 13, §§ 2:12, 16:1.

20 *Id*. § 18:1.

21 *Hoffmann v. Delbeau*, 33 N.Y.S.3d 289, 290 (App. Div. 2d Dept 2016) (indicating *Lewis v. Young*, 705 N.E.2d 649 (N.Y. 1998)).

22 See *Butler v. Frontier Telephone Co.,* 79 N.E. 716, 718 (1906) ("[t]he surface of the ground is a guide, but not the full measure; for within reasonable limitations land includes not only the surface but also the space above and the part beneath.").

23 See *Boehringer v. Montalto*, 254 N.Y.S. 276, 278 (Sup. 1931) (deeming the right to construct a sewer at a depth of over 150 feet not a breach of covenant against encumbrances); Rasch & Dolan, supra note 13, § 16:4.

24 509 Sixth Avenue Corp. v. New York City Transit Authority, 203 N.E.2d 486 (N.Y. 1964).

25 *Boehringer, supra* note 23, at 278.

26 N.Y. Real Property Actions & Proceedings Law § 871.

27 N.Y. Estates, Powers & Trusts Law § 6-2.1(a)(2); *Matter of Lorch,* 33 N.Y.S.2d 157, 165-66 (Sur. Ct. Queens Co. 1941).

28 *Myers v. Bartholomew*, 697 N.E.2d 160, 161 (N.Y. 1998).

29 N.Y. Est. Powers & Trusts Law § 6-2.1(a)(3); *Graffeo v. Paciello*, 848 N.Y.S.2d 264, 265 (2007).

30 N.Y. Est. Powers & Trusts Law §§ 6-2.1, 6-2.2; Rasch & Dolan, *supra* note 13, § 4:6.

31 N.Y. General Obligations Law § 5-703 (" An … interest in real property … cannot be created, granted, assigned, surrendered or declared, unless by act or operation of law, or by a deed or conveyance in writing, subscribed by the person creating, granting, assigning, surrendering or declaring the same, or by his lawful agent, thereunto authorized by writing …"); N.Y. Real Property Law § 291 (requiring the conveyance to be duly and properly recorded).

32 *Simone v. Heidelberg,* 877 N.E.2d 1288, 1291 (N.Y. 2007); see also *Silvercrest v. St. Christopher-Ottile,* 194 A.D.2d 720, 721 (1993) (holding that because the city sewer line ran next to the dominant estate where a direct connection could be made, the existence of a sewer line across a servient estate was not plainly apparent nor necessary to support recognition of an implied easement).

33 Rasch & Dolan, *supra* note 13, § 18:39.

34 See *Willow Tex, Inc. v. Dimacopoulos,* 465 N.Y.S.2d 641, 645-46 (Sup. Ct. Queens Co. 1983).

35 *Dermody v. Tilton,* 926 N.Y.S.2d 237, 238-39 (App. Div. 4th Dept 2011).

36 *Feigen v. Green Harbour Beach Club, Inc.*, 204 N.Y.S.2d 381 (Sup. Ct. Nassau Co. 1960); *Green v. Collins*, 86 N.Y. 246 (1881); Rasch & Dolan, supra note 13, § 18:22.

37 Manhasset Bay Associates v. Town of North Hempstead, 541 N.Y.S.2d 119 (App. Div. 2d Dept 1989).

38 *Macord v. City of New Rochelle,* 39 N.Y.S.2d 47, 49-50 (Sup. Ct. Westchester Co. 1942).

39 *People v. County of Westchester*, 26 N.E.2d 27, 29 (N.Y. 1940).

40 N.Y. Vehicle & Traffic Law § 134 (defining a public highway as "[a] highway, road, street, avenue, alley, public place, public driveway or any other public way); see People v. Thew, 376 N.E.2d 906, 907 (1978); Dvorske et al., New York Jurisprudence Highways, Streets, & Bridges §§ 58-63 (2021).

41 N.Y. Veh. & Traf. Law §§ 115, 131, 171(1), 340-c, 341, 349; N.Y. Village Law § 6-612.

42 2 Russell J. Davis, New York Jurisprudence Dedication § 46 (2021); 2 Coltoff et al., New York Jurisprudence Eminent Domain § 34 (2021).

43 N.Y. Village Law § 6-626; Dvorske, *supra* note 40, § 63.

44 See N.Y. Highway Law § 189 (establishing a statutory 10-year minimum of use as a public road to create a Town highway). Case law shows that the necessary period of continuous use to form a public road under the theory of prescription was twenty years under common law. See also *De Haan v. Broad Hollow Estates, Inc.*, 161 N.Y.S.2d 706, 708 (1957) and *Hastings Petroleum Corp. v. Village of Hastings-on-Hudson*, 165 N.Y.S.2d 912, 915 (1957).

45 *Appleton v. City of New York*, 114 N.E. 73 (N.Y. 1916); *Wells v. Village of Croton on Hudson,* 124 N.Y.S. 1058 (Sup 1910); Dvorske, supra note 40, § 252.

46 Dvorske, *supra* note 40, § 252 n. 6 (citing *Appleton, supra* note 45 (municipalities are authorized as part of their duty to regulate and supervise use of the right-of-way to require a permit for abutting landowners to construct a vault under the public right-of-way)).

47 Henry C. Hodgkins, Franchises of Public Utilities as They Were & As They Are, 2 *Amer. Water Works Association* 739, 739-58 (1915).

48 *See NYC v. Con Edison,* 713 N.Y.S.2d 40, 42 (2020).

49 *Guide to Planning & Zoning Laws of New York State,* NYS Department of State at 15 (2015), available at https://www.sjcny.edu/files/images/nys-guide-to-planning-and-zoning-laws.pdf [hereinafter NYS Zoning Laws].

50 *Id.* at 15; *Beginner's Guide to Land Use Law*, Land Use Law Center at 4, available at https://law.pace.edu/sites/default/files/LULC/LandUsePrimer.pdf (accessed March 12, 2021) [hereinafter *Land Use Primer].*

51 N.Y. Constitution, art. 2, § 10; *Land Use Primer, supra* note 50, at 50.

52 N.Y. General City Law § 28-1; N.Y. Town Law § 272-A; N.Y. Village Law § 7-722; *Land Use Primer, supra* note 50, at 5.

53 Preface to NYS Zoning Laws, *supra* note 49.

54 N.Y. Gen. City Law §§ 1 to 171.

55 N.Y. Town Law §§ 1 to 342.

56 N.Y. Village Law §§ 1-100 to 23-2208.

57 N.Y. General Municipal Law §§ 1 to 1001.

58 N.Y. Municipal Home Rule Law §§ 1 to 59.

59 N.Y. Environmental Conservation Law §§ 1-0101 to 75-0119.

60 N.Y. Public Health Law §§ 1 to 5003.

61 N.Y. High. Law §§ 1 to 354.

62 N.Y. Real Prop. Law §§ 1 to 602.

63 N.Y. Real Property Tax Law §§ 100 to 2016.

64 N.Y. Eminent Domain Procedure Law § 103(A). As to practice under the Eminent Domain Procedure Law, see §§ 108:128 to 108:281; as to public use, generally, see § 108:12. Coltoff et al., *Carmody-Wait 2d New York Practice* § 108:1 (2021).

65 N.Y. Em. Dom. Proc. Law §§ 101-709.

66 N.Y. High. Law § 173; Dvorske, *supra* note 40, §§ 43, 61.

67 Blog, Amy Lavine, *Eminent Domain & Public Utilities in New York,* Public Authorities (Dec. 5, 2011), available at https://publicauthorities.wordpress.com/2011/12/05/eminent-domain-and-public-utilities-in-new-york/.

68 N.Y. Em. Dom. Proc. Law § 204[b]; see *Nat'l Fuel Gas Supply Corp. v. Schueckler*, 150 N.E.3d 1192, 1196 (N.Y. 2020).

69 N.Y. Town Law §§ 300, 303-04.

70 N.Y. Real Prop. Acts. Law § 881; see *Sunrise Jewish Ctr. of Valley Stream, Inc. v. Lipko,* 305 N.Y.S.2d 597, 599 (Sup. Ct. 1969).

71 Ross Valley, California, Sanitary District Ordinance No. 100, *Section 13(G).*

72 See White Plains City Code § 7-7-5.1 (establishing a property owner's responsibility to repair and maintain in good condition and at their own expense sanitary sewers that serve their property "from and including the point of connection at the public sanitary sewer"); see also *Service Line Protection Program*, NYC DEP, available at https://www1.nyc.gov/site/dep/pay-my-bills/service-line-protection-program.page (instructing that in New York City, private property owners bare responsibility to maintain sewer service lines extending from the property to the city's sewer mains) (accessed March 17, 2021).

73 See *infra* notes 163-165 and surrounding text.

74 Coastal Zone Management Act, 16 U.S.C. §§ 1451-1465; Jason Bressler, Blocking Interstate Natural Gas Pipelines: How to Curb Climate Change While Strengthening the Nation's Energy System, 44 Colum. J. of Env. Law 137, 145 (2019).

75 *Id.*

76 Clean Water Act, 33 U.S.C. §§ 1251-1387; Colburn T. Cherney & Karen M. Wardzinski, *State & Federal Roles Under the Clean Water Act,* 1 Nat. Resources & Env. 19, 19-20 (1986).

77 Bressler, *supra* note 74, at 140.

78 Safe Drinking Water Act, 42 U.S.C. §§ 300f-300j-26; 40 C.F.R. § 144.3.

79 42 U.S.C. § 300h-1(b)(3); Section 300h(b)(3)(A) of the SDWA also provides that the EPA's UIC regulations shall "permit or provide for consideration of varying geologic, hydrological, or historical conditions in different States and in different areas within a State."

80 *Geothermal Systems & Their Application in New York City,* NYC Office of Sustainability at 36, 41 (Feb. 2015), http://www.nyc.gov/html/planyc/downloads/pdf/publications/2015_Geothermal.pdf [hereinafter MOS Report].

81 40 C.F.R. § 144.12(a); *The Class V Underground Injection Control Study: Electric Power Geothermal Injection Wells,* U.S. EPA at 37 (Sep. 1999), available at https://19january2017snapshot.epa.gov/sites/production/files/2015-08/documents/classvstudy_volume17-geothermalelectricpower.pdf.

82 *Federal Requirements for Class V Wells,* U.S. EPA, available at https://www.epa.gov/uic/federal-requirements-class-v-wells (accessed March 10, 2021).

83 *Id.*

84 *Id.*

85 *Water Withdrawal Permits & Reporting,* NYSDEC, available at https://www.dec.ny.gov/lands/55509.html (accessed March 10, 2021).

86 6 NYCRR §§ 601.9(e), 602.1.

87 *Joint Application Form,* NYSDEC, available at https://www.dec.ny.gov/docs/permits_ej_operations_pdf/jointapp.pdf (accessed March 10, 2021).

88 *Annual Water Withdrawal Reporting Requirements,* NYSDEC, available at https://www.dec.ny.gov/lands/86940.html (accessed March 10, 2021).

89 Heat is considered a pollutant pursuant to 6 NYCRR Part 704.

90 N.Y. Env't Conserv. Law § 13-0103; 6 NYCRR Part 701.

91 Pursuant to the Accelerated Renewable Energy Growth & Community Benefit Act, S. 7508-B, A. 9508, 2020-21 Reg. Sess. (N.Y. 2020), the Office of Renewable Energy Siting is responsible for siting and permitting new major renewable energy facilities in New York State, which are defined as "any renewable energy system, as such term is defined in section sixty-six-p of the public service law… with a nameplate generating capacity of twenty-five thousand kilowatts or more". Section 66-p of the Public Service Law defines renewable energy systems as "systems that generate electricity or thermal energy through use of the following technologies: solar thermal, photovoltaics, on land and offshore wind, hydroelectric, geothermal electric, geothermal ground source heat, tidal energy, wave energy, ocean thermal, and fuel cells which do not utilize a fossil fuel resource in the process of generating electricity."

92 A 25 MW_{th} system based on 2.93 kW_{th} per heating ton (3.517/(12,000 BTU/10,000 BTU)) would support 1,700 homes using 5-ton systems and 2,130 homes using 4-ton systems. See *Kilowatts to Refrigeration Tons Conversion,* RapidTables, available at https://www.rapidtables.com/convert/power/kw-to-ton.html (accessed April 14, 2021).

93 *Geothermal Wells,* NYSDEC, available at https://www.dec.ny.gov/lands/61176.html (accessed March 10, 2021).

94 *Id.*

95 *Id.*

96 *Long Island Water Withdrawals,* NYSDEC, available at https://www.dec.ny.gov/lands/117175.html (accessed March 10, 2021).

97 N.Y. Env't Conserv. Law § 23-0305(14).

98 *Id.*

99 MOS Report, *supra* note 80, at 36; *Well Permitting Requirements,* NYSDEC, available at https://www.dec.ny.gov/energy/1783.html (accessed March 10, 2021).

100 *Well Permitting Requirements, supra* note 99; *Well Owner & Applicants Information Center*, NYSDEC, available at https://www.dec.ny.gov/energy/1522.html (accessed March 10, 2021).

101 *Well Operator Responsibility,* NYSDEC, available at https://www.dec.ny.gov/energy/1639.html (accessed March 10, 2021).

102 *Id.*

103 *Id.*

104 6 NYCRR § 554.1(c).

105 *Designing & Drilling Your Well Permit,* NYSDEC available at https://www.dec.ny.gov/energy/1628.html (accessed Mar. 10, 2021).

106 *Id.*

107 MOS Report, supra note 80, at 37.

108 *Id.*

109 *Well Permit Fee Calculator,* NYSDEC (accessed Mar. 10, 2021) https://www.dec.ny.gov/energy/1779.html

110 See, e.g., City of Peekskill, New York, Requirements for Geothermal Permit, on file with authors [hereinafter City of Peekskill].

111 The legal authority for towns and cities to establish right-of-way work permits derives from the N.Y. High. Law §§ 170-218, while Village authority derives from the N.Y. Village Law. See *Application* for Street-Sidewalk Opening Permits, City of Beacon Hwy Dep't, available at https://www.cityofbeacon.org/wp-content/uploads/2020/11/Application-for-Sidewalk_Street-Opening-Permit.pdf; *Application for Permit to Do Work On & Within A Town Road Area,* Town & Village of Harrison Dept. of Public Works, available at https://www.harrison-ny.gov/sites/g/files/vyhlif671/f/uploads/application_package_complete.pdf; *Utility Road Opening Permit,* Town of East Fishkill Engineering Dept., available at http://www.eastfishkillny.gov/Pdf/Utility-Road-Opening-Permit-19-12.pdf.

112 City of Peekskill, *supra* note 110.

113 *Id*.

114 Authority derived from the N.Y. High. Law §§ 110-39. See generally, *Permit Work Within County Right of Way*, Ulster Cnty. Dep't of Public Works Div. of Eng'g (May 2019), available at https://ulstercountyny.gov/sites/default/files/documents/public-works/Ulster%20County%20Permit%20Policy%20Standards.pdf.

115 17 NYCRR Part 131; see also *Requirements for the Design & Construction of Underground Utility Installations within the State Highway Right-of-Way*, NYSDOT (Feb. 1997), available at https://www.dot.ny.gov/divisions/engineering/design/dqab/dqab-repository/bluebook.pdf.

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220 Calculation based on the portion of Niagara Mohawk's 2020 positive earning adjustment of $2,700,000 attributable to installation of 190 ground source heat pumps based on metric tons of carbon dioxide avoided ("MT CO2"), using the formula MT CO2 Avoided = (424 Incremental EVs * 38.5 lifetime MT CO2) + (646 Air Source Heat Pumps * 52.5 lifetime MT CO2) + (190 Ground Source Heat Pumps * 125 lifetime MT CO2). See National Grid and Niagara Mohawk Corporation, Earning Adjustment Mechanisms, 2020 Annual Report, Cases 17-E-0238 and 17-G-0239 (March 1, 2021).

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[227] *Annual Energy Consumption – Table 6-6: Residential Natural Gas Consumption by State 2019*, American Gas Ass'n, available at https://www.aga.org/contentassets/6894914d95e6467fae106015cbcb2abc/table6-6.pdf (accessed March 11, 2021).

[228] *Annual Energy Consumption – Table 8.5: Natural Gas Residential End Users by State 2019*, American Gas Ass'n, available at https://www.aga.org/contentassets/d2be4f7a33bd42ba9051bf5a1114bfd9/table8-5.pdf (accessed March 11, 2021).

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[230] Joshua R. Castigliego & Liz Stanton, *Planning for the Future: Massachusetts Cleans Up Its Heating*, Policy Brief 1 (Sept. 2020), available at https://static1.squarespace.com/static/5936d98f6a4963bcd1ed94d3/t/5f6a14ed7619436f3c776fe8/1600787695803/Planning+for+the+Future_AEC+Brief_22Sept2020.pdf.

[231] GeoMicroDistrict Feasibility Study, supra note 169, at 1.

[232] The $125 per metric ton figure assumes a discount rate of 2% and is based on an average of modeled results. *Estimating the Value of Carbon: Two Approaches*, NYSERDA & Resources for the Future 6 (Jan. 2021).

[233] The 3.14 percent leakage estimate accounts for methane leaking from production, pipelines, and equipment. *Revised Regulatory Impact Statement, supra* note 3, at 19.

[234] *Annual Energy Consumption – Table 8.5: Natural Gas Residential End Users by State 2019*, American Gas Ass'n, available at: https://www.aga.org/research/data/energy-consumption/ (accessed March 11, 2021).

[235] New York Housing Statistics, available at https://www.infoplease.com/us/census/new-york/housing-statistics (accessed March 11, 2021).

[236] If boiler replacement would occur in year 3 as opposed to year 16, the geothermal consumer saves $2,340 assuming a 3 percent interest rate (i.e., using the savings to pay down a mortgage with a 3 percent interest rate.

[237] A feed-in tariff establishes a fixed rate of compensation for the production of electricity from renewable energy sources. This rate usually varies by the size of a facility, the type of technology, and sometimes resource potential in the geographic area served. The rate is fixed by a regulatory body for a period of years long enough to ensure the project is attractive to investors and can obtaining financing. As technologies covered by the feed-in-tariff reduce in price, the tariff for new projects is reduced. The costs are borne by all ratepayers.

[238] A stretch code is a "voluntarily adopted, 'locally mandated code or alternative compliance path that is more aggressive than [the] base code, resulting in buildings that achieve higher energy savings.'" Caitlin McCoy, U.S. City *Climate Commitments: Obstacles and Opportunities in the Building Sector Post-Paris Agreement*, 34 MD. J. Int'l L. 249, n. 67 (citing *Stretch Codes*, New Buildings Inst., available at https://newbuildings.org/code_policy/utility-programs-stretch-codes/stretch-codes/ (accessed June 4, 2021)).

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[241] Massachusetts considered granting its utility commission such authority in a proposed bill. See An Act for a Utility Transition to Using Renewable Energy S.1940, H.2849, 2019-20 Reg. Sess. (M.A. 2019).

[242] N.Y. Pub. Serv. Law § 31(4); 16 NYCRR Parts 230.2 and 230.3. Related statutory requirements are found in the N.Y. Trans. Corps. Law § 12.

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[244] Best Practices Guide for Geothermal Exploration, supra note 173, at 17.

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