



Chapter 7

Opportunities for Pennsylvanians: Navigating Geothermal for Landowners, Communities, and other Stakeholders

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Successfully deploying geothermal in Pennsylvania for heating, cooling, and power requires engaging valuable stakeholders like labor unions, environmental groups, and energy providers; addressing community concerns; leveraging the state's oil and gas expertise; and fostering innovation via research and federal support. Collaborative efforts can position geothermal as a vital resource for the Commonwealth.

INTRODUCTION

In the United States, places that have extensive oil and natural gas development—like Pennsylvania—can be attractive locations for geothermal projects.¹ Geothermal energy produced in the Commonwealth could support residential and industrial uses, and some baseload electricity generation. (See chapters 2 and 3). Today, an increased focus on Engineered Geothermal Systems (EGS) and Advanced Geothermal Systems (AGS), as described in Chapter 1, bolsters those opportunities.

Should energy companies decide to establish geothermal projects in the Commonwealth, they will

have to engage with a range of stakeholders. This chapter reviews some of the key constituencies affected by and central to geothermal energy development in the Commonwealth. For example, private landowners and governments stand to benefit from geothermal royalties. Government also plays a critical role in shaping the success of geothermal projects through regulatory oversight and policy development. As with all energy development, geothermal projects could have impacts as well as benefits. Pennsylvanians are likely to use past experiences with mineral resource extraction as a frame of reference for geothermal development.^{2,3}



Engagement with communities that could be impacted by geothermal development will be necessary to address concerns and bolster public support. Developers should also engage potential advocates (labor unions, environmental groups), potential sources of technical expertise (industries, research universities), and natural gas and electricity providers to explain the benefits of—and to solicit critical support for—geothermal development in Pennsylvania.⁴

Increased geothermal production offers significant opportunities for diverse stakeholders, and by engaging with them all, geothermal developers and state officials could create ongoing economic benefits, particularly in many rural parts of the state.

PRIVATE LANDOWNERS

Private landowners in Pennsylvania may benefit economically from geothermal lease agreements, royalties, and rights-of-way agreements. Given the history of energy development in the state, many landowners are familiar with these sorts of arrangements and should generally understand the potential financial gains they stand to make.⁵ With an appropriate level of compensation, landowners could be a catalyst for widespread adoption of geothermal heat and power, providing a reliable source of abundant energy to the state.⁶ Engaging landowners as prospective partners should be a primary concern for geothermal developers.

Understanding royalty expectations among land and mineral rights owners is essential to understanding how geothermal energy may develop in the Commonwealth, and how landowners may receive the geothermal industry.⁷ Royalties are generally tied to the revenues earned or volumes produced. The amount of royalties depends on a myriad of factors, including plot size, market price, and production levels. Over the past century, owners have been compensated for allowing access to various resources, including coal, natural gas, and oil. Those agreements might be a blueprint for access to heat on private property.⁸ (See *Chapter 4: Who Owns the Heat*)

While examples of payments for access to geothermal resources are scant, Pennsylvania's experience with royalties for other energy resources provides insights.

For example, when the Pennsylvania shale gas boom began in earnest, economists estimated that royalty payments to landowners in Pennsylvania exceeded \$16 million per year and injected significant capital into the economy.⁹ Studies conducted in the early years of the boom estimated that the monetary benefits for Pennsylvania property owners via royalties and leases exceeded those of local employment and wages.¹⁰ Payments were so substantial for some owners that Pennsylvanians coined the term *mailbox millionaires*.¹¹

To ensure equitable compensation to private owners of shale gas, the Pennsylvania General Assembly enacted the Guaranteed Minimum Royalty Act in 2013. The law protected landowners by setting expectations for compensation associated with oil and gas extraction through a guaranteed royalty rate equal to or greater than 12.5 percent of the value of the oil or gas produced from their land.

While the actual amount of royalties paid to private landowners is not publicly reported, in 2020, the Pennsylvania Independent Fiscal Office (IFO) calculated an estimate of royalties paid to landowners in recent years using the market value of natural gas and assuming a 13.5 percent royalty rate (found to be average;¹² see Table 7.1). Outside of Pennsylvania, studies have found that for each million dollars of natural gas produced, \$132,000 in royalty payments was generated.¹³

Other energy projects, such as wind farms, have also generated significant royalty payments for private landowners in Pennsylvania.¹⁴ In the Commonwealth, there are 27 privately operated wind farms, and like natural gas development, wind farms typically compensate property holders for access to the land and the amount of energy produced. While numbers are not readily available for Pennsylvania, an economic study conducted in Texas found that two counties with abundant wind farms generated approximately \$11.5 million in royalties annually.¹⁵

Royalty agreements may prove paramount to the success of geothermal projects on private lands in Pennsylvania.^{16,17} Geothermal energy developers and operators should work with landowners to establish equitable compensation agreements that benefit both parties.



Estimated Private Landowner Royalties from Natural Gas in Pennsylvania

Calendar Year	Market Value of Natural Gas	Estimated Royalty Payments
2018	\$ 11,554,000,000	\$ 1,559,790,000
2019	\$ 9,692,000,000	\$ 1,301,670,000
2020	\$ 4,626,000,000	\$ 624,570,000
2021	\$ 18,010,000,000	\$ 2,431,350,000
2022	\$ 36,990,000,000	\$ 4,993,650,000
2023	\$ 7,064,000,000	\$ 953,640,000

Table 7.1: The spike in estimated royalties in 2021 and 2022 was mainly due to a large increase in the price of natural gas caused by geopolitical and economic forces. Pennsylvania Independent Fiscal Office. (2020). Natural Gas Royalties Increase in 2017. <http://www.ifo.state.pa.us/download.cfm?file=Resources/Documents/RB%202019%20Natural%20Gas%20Royalties.pdf>

That said, while Pennsylvania landowners certainly have experience with energy development, research on geothermal energy projects shows that landowners could use more education to make informed decisions. A dearth of information about geothermal projects and their risks and benefits increases skepticism.¹⁸ Studies suggest that landowners may be more willing to allow energy development if they feel that steps have been taken to reduce negative externalities and if the developer has had experience with such projects in the past.¹⁹ In other words, geothermal developers should pursue efforts to educate landowners about the benefits of development and mitigation of negative externalities.

GOVERNMENTAL ENTITIES

Like private landowners, government agencies could enjoy a range of benefits from geothermal energy development. And they will be key players in charting the future of geothermal energy in the Commonwealth.

Increased revenue for local, state, and federal agencies may be generated through leases and royalties for geothermal development on public land. Lands could include parks, forests, game lands, university properties, and military facilities. In some cases, the landholdings of government agencies may be significant, with the

potential to host multiple geothermal energy projects. There are, for example, approximately 2.2 million acres of state forests, 1.5 million acres of state game lands, 283,000 acres of state park lands, and 622,000 acres of federal land in Pennsylvania.²⁰ (See *Chapter 2: Where to Develop Geothermal.*)

When energy is developed on federal lands, local governments can benefit as well. Today, the Bureau of Land Management manages more than 531 geothermal leases in 11 Western states and Alaska. On average, geothermal leases generate over \$12 million in federal royalties each year. Half of that is shared with the states and a quarter with local counties.²¹ In 2023, federal geothermal rents, bonus bids, and royalties combined amounted to \$25.3 million.²²

Again, experiences with oil and gas development are instructive. Nationally, an economic study examining taxation of oil and gas production estimated that approximately 10 percent of all revenue from extraction was collected by state and local governments. In Pennsylvania, governmental entities benefited handsomely from royalties via shale gas development. Both the Pennsylvania Game Commission and the Department of Conservation and Natural Resources (DCNR), for example, have received millions of dollars



Estimated State Agency Royalties from Natural Gas in Pennsylvania

Fiscal Year	PA Game Commission	DCNR
2018-19	\$ 39,923,902	\$ 66,781,972
2019-20	\$ 50,554,313	\$ 64,945,055
2020-21	\$ 54,793,673	\$ 57,497,750
2021-22	\$ 171,899,459	\$ 115,434,485
2022-23	\$ 306,864,414	\$ 165,288,329
2023-24	\$ 82,529,361	\$ 65,978,653

Table 7.2: As reported by the Commonwealth. Sources: Pennsylvania Game Commission. (2022). Fiscal 2021-22 Annual Report. https://www.pgc.pa.gov/InformationResources/MediaReportsSurveys/Documents/PGC_Annual_Report_2022_WEB.pdf. And Department of Revenue. (2024). May 2024 - Report of Revenue and Receipts. https://www.pa.gov/content/dam/copapwp-pagov/en/revenue/documents/news-and-statistics/reportsstats/revenureceipts/documents/2023-24/2024_05_bfmmonthlyreport.pdf

annually from royalties, with payments spiking in fiscal years 2021-22 and 2022-23 due to geopolitical and economic forces, as shown in Table 7.2.

The Commonwealth does not aggregate data on local government royalty payments, but it appears that counties, boroughs, and townships have also received considerable royalty payments. Conversations with officials in Washington County, one of the top gas-producing counties in the state, revealed that land leased for gas development in two county parks generated an estimated \$27 million in lease and royalty payments since 2007. Two-thirds of that revenue has been generated since 2012, and the county has used the revenue to develop parks and recreation programs.

In addition to royalties, lease payments, and the like, other mechanisms could also create revenue for state and local governments. For instance, Act 13 of 2012 provided for the imposition of an unconventional gas well fee (sometimes called an impact fee), which has generated millions of dollars for state agencies and municipal governments to use for specific purposes, such as public infrastructure and safety (see Figure 7.1).

The benefits to governments from geothermal energy development go beyond the financial and economic; there are clear environmental and public health gains

too. Widespread deployment of geothermal systems would reduce energy-related air emissions. Geothermal projects that repurpose orphaned and abandoned wells could also help state and local governments reduce fugitive methane emissions as well as other economic, environmental, and public health risks.^{23,24,25} As Pennsylvania considers its energy initiatives, geothermal energy could be a primary tool in reducing the state's emissions.²⁶

Of course, governments are not just passive beneficiaries of energy development. In their regulatory and policy-making capacities, they will also play central roles in shaping the future of geothermal energy development in Pennsylvania. (See *Chapter 4: Who Owns the Heat* and *Chapter 5: Additional Policy and Regulatory Issues*.) Geothermal developers should expect to engage with borough and township authorities, DCNR, the Department of Environmental Protection (DEP), the Public Utility Commission (PUC), the Department of Transportation (PennDOT), and others that will oversee geothermal energy projects and associated infrastructure on private and public lands. Table 7.3 summarizes the oversight functions of unconventional natural gas development in Pennsylvania, illustrating how various governmental entities might be involved in the oversight of geothermal energy development.



County and Municipality Gas Impact Fee Spending in 2021

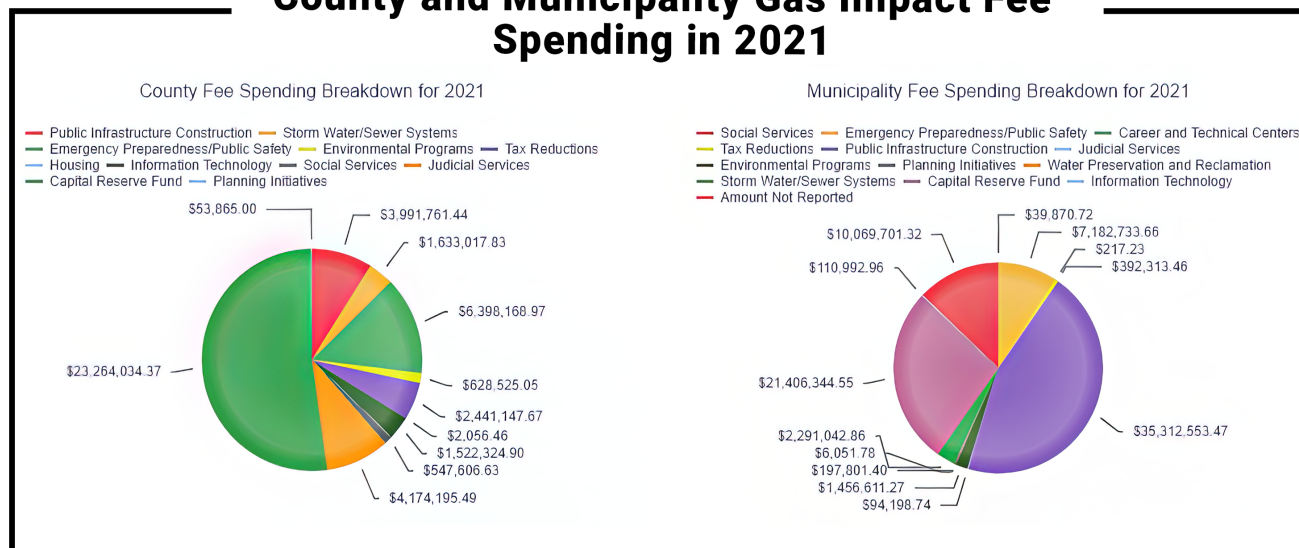


Figure 7.1: Source: Act 13 Public Utility Commission. (n.d.). Disbursements and Impact Fees. Retrieved from <https://www.act13-reporting.puc.pa.gov/Modules/PublicReporting/Overview.aspx>

IMPACTED COMMUNITIES

As discussed earlier, geothermal energy deployment will present a host of benefits, as well as potential concerns, for the communities where development occurs. The impacts will vary depending on the location, design, and operation of a specific project. As outlined in Chapter 1: Where to Develop Geothermal?, deployment is mostly expected to occur where unconventional natural gas wells already exist. Many of those areas overlap with areas identified for recent federal tax incentives, including Opportunity Zones created as part of the Tax Cuts and Jobs Act signed into law by President Trump, and Energy Communities defined in the Inflation Reduction Act signed by President Biden (see Figure 7.2). These incentives will increase the economic benefits for projects located in these areas.

Assuming development occurs in the areas with the highest potential, geothermal developers should expect to work primarily in rural Pennsylvania communities with small economic bases. Many of these communities face higher unemployment rates and lower wages than their Pittsburgh and Philadelphia Metropolitan Statistical Areas (MSAs) counterparts. Furthermore, as shown in Table 7.5, many counties identified as possible priority areas for geothermal development have experienced significant population loss since 1983.

Geothermal projects could provide a much-needed boost to the local economies in these regions. As noted, geothermal development could increase revenue through royalties, leases, and perhaps something akin to the Act 13 unconventional gas well fee. In addition, geothermal projects could create new jobs and help stabilize wages. Research on economic impacts of renewable energy suggests that investments in hydroelectric, biomass, solar, wind, and other projects have had positive effects on local employment and wages.^{27,28} Similar results were observed amidst the shale gas boom, though to a lesser degree.²⁹

It is important to remember that these communities have also disproportionately experienced environmental impacts from industry and energy development over the years.^{30,31,32,33,34} Many of those impacts may be repeated with geothermal development—noise, dust, traffic during construction, concerns about operations, and other nuisances.³⁵ Research shows that even the most ardent supporters of shale gas development expressed frustration with dust, traffic, noise, and road damage associated with the industry.^{36,37,38} (See Chapter 6: Environmental Considerations.)

A recent study of geothermal energy found that negative perceptions of unconventional natural gas development significantly impact perceptions of



Natural Gas Oversight in Pennsylvania

Entity	Local Zoning	Municipal Planning Code	Land Access	Well Drilling Permit	Landowner Notification	Gas Well Bond	Containment Plan	Emergency Response Plan	Waste Disposal Permits	Road Occupancy	Impoundment Permits	Water Use Permits	Wastewater Permits	Stream & Wetlands Permits	Air Emissions	Erosion & Sedimentation	Production & Waste Reports	Inspection & Environmental Compliance	Impact Fees	Pipelines	Electric Connection	Grid Integration (Other)
County & Municipality	●	●	●	○	○			○		○		○		○		○					○	
DEP				●	●	●	●	●	●		●	●	●	●	●	●	●	●		●		
DCNR			○									○	○	○							○	
Game Commission			○											○							○	
PUC																			●	○	●	●
PennDOT			●							●										○		

Table 7.3: Solid dots indicate direct involvement of local and state governmental entities, while empty dots indicate indirect involvement. Source: Author interviews with DEP and other state officials

EGS and AGS. However, the study also found a degree of ambivalence to geothermal rather than outright rejection.³⁹ The findings suggest that communities may be willing to consider new geothermal technologies if they are used appropriately and transparently, with stringent development conditions to minimize environmental risk. Further, most shale communities are considered environmental justice communities,⁴⁰ and as such, require special consideration under state and federal guidelines.

To avoid the issues prevalent during the early years of the shale gas boom, geothermal developers should conduct education and outreach campaigns tailored to Pennsylvania’s rural communities. As part of the campaign, developers should detail the process of

geothermal development, the economic benefits of projects to communities, and how they will mitigate negative externalities.

OTHER KEY STAKEHOLDERS TO ENGAGE

As mentioned, numerous other constituencies could be affected by, be strong advocates for, or benefit from geothermal energy development in Pennsylvania. Geothermal developers will want to engage with labor unions, environmental interests, industries, research institutions, natural gas and electricity providers, and other entities to explain the benefits of potential projects, garner support, and accelerate deployment.



Overlap of Geothermal Favorability and Economic Incentives

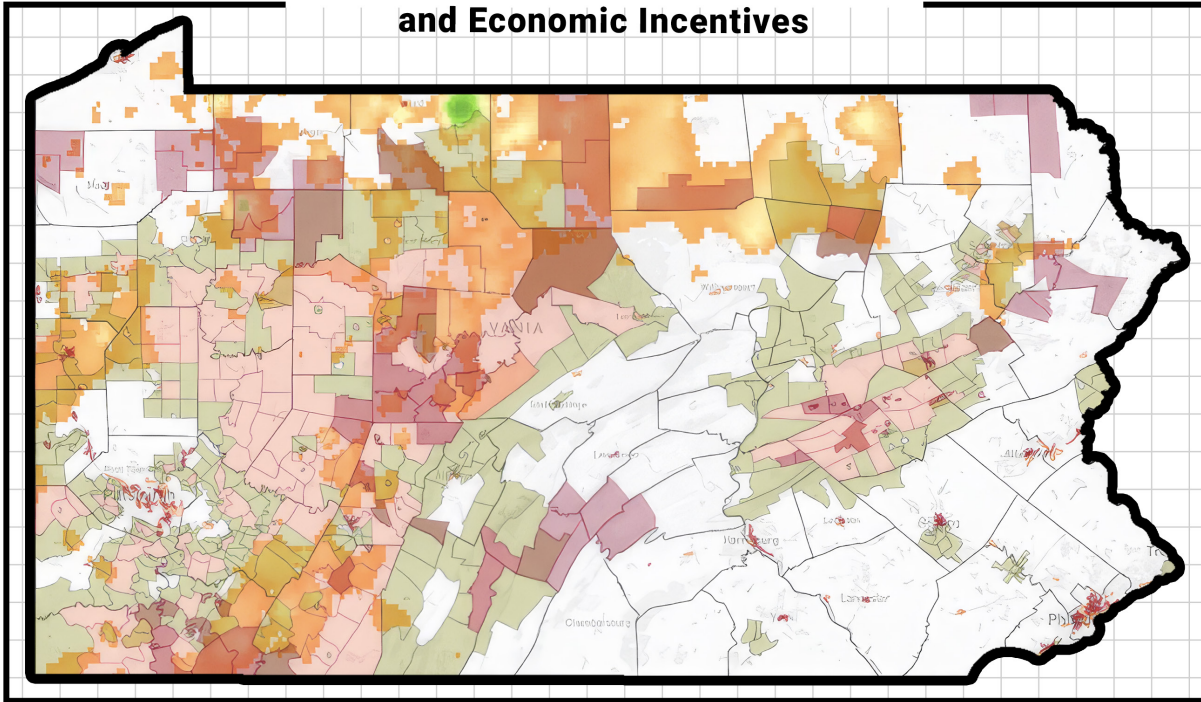


Figure 7.2: Pink, maroon, and tan areas show Opportunity Zones and Energy Communities. Yellow, orange, and green show areas capable of reaching 300°F (150°C) within 5km. See figures 2.3, 2.4, and 2.5 for further detail on temperatures. Source: [GeoMap](#)

Potential Advocates

The geothermal industry can benefit from partnering with labor unions, a skilled and motivated workforce and a powerful advocate for a supportive policy environment.⁴¹ Geothermal energy projects require significant labor throughout construction, operation, and maintenance phases. The Bureau of Labor Statistics (BLS) and Geothermal Energy Association estimate that a 50-megawatt (MW) geothermal plant requires between 697 and 862 workers for completion, including jobs in construction management, engineering, geology, and hydrology.⁴² BLS data indicates that union membership for the geothermal labor force could range from 4.9 to 20.8 percent, based on the oil and natural gas extraction and utilities sectors, respectively.⁴³ In addition to increased opportunities, studies have found that laborers benefit from increased wages from renewable energy projects. One study found that installation of a large wind farm was associated with a 2 percent permanent increase in wages.⁴⁴ Another

study found that net-zero energy transitions could lead to approximately \$200 billion in wages over the next decade and another \$200 billion or more by 2050.⁴⁵ Given these potential benefits, unions could be strong advocates for policies that support the growth of the geothermal sector. For example, as detailed in *Chapter 5: Additional Policy and Regulatory issues*, states like New York and Maryland recently passed legislation, with wide support from organized labor, that allows gas utilities to operate thermal energy networks (TENs). In Pennsylvania, unions recently helped advocate for the Commonwealth to become a hydrogen hub under the federal Bipartisan Infrastructure Law of 2021.⁴⁶

Environmental advocates are another valuable constituency. While some may need reassurance about mitigation of potential negative impacts, the environmental community could be strong advocates for an always-on source of clean energy. They may also welcome the reuse of abandoned oil and gas wells in Pennsylvania because it represents an opportunity to



Population Change since 1983 in Counties with Potential for Geothermal Development

County	Population Change (%)
Allegheny	-13.2
Armstrong	-16.3
Beaver	-16.8
Bradford	-4.1
Butler	32.8
Clarion	-14.0
Crawford	-8.4
Erie	-5.0
Fayette	-20.0
Forest	30.6
Greene	-15.6
Jefferson	-9.4
Lawrence	-18.9
McKean	-20.8
Mercer	-13.8
Potter	-7.7
Susquehanna	0.0
Tioga	2.1
Venango	-22.9
Warren	-21.2
Washington	-2.7
Westmoreland	-9.2

Table 7.5: Source: (United States Census Bureau, 2022)

mitigate fugitive methane emissions and reduce the need for new wells (minimizing the associated impacts of drilling and exploration), while decreasing the overall carbon footprint of energy production.⁴⁷ Incentivizing utilities to adopt TENs would further reduce fugitive methane emissions from otherwise leaking distribution networks. Environmental justice and environmental advocates may also be supportive of more widespread industrial use of geothermal, which would likely improve air pollution, as geothermal heat produces significantly less pollution than fossil fuel combustion. (See *Chapter 2: Where to Develop Geothermal* and *Chapter 6: Environmental Considerations* for more.)

Other non-profit non-governmental organizations (NGOs), such as ones focused on sustainable economic development, could likewise find geothermal development in the Commonwealth to be aligned with their missions. For example, repurposing abandoned wells for geothermal energy can help create job opportunities in the renewable energy sector and contribute to the growth of the green economy.⁴⁸ As noted, geothermal production can also help stimulate economic growth and improve the living standards of local communities.⁴⁹ A range of NGOs could be helpful advocates for geothermal energy deployment.

Potential Sources of Technical Expertise and Innovation

The Commonwealth's extensive experience with resource extraction and energy projects means there are a lot of stakeholders in the region with a wealth of relevant technical expertise who are equipped and eager to facilitate geothermal development. (See Figure 7.3.)

Pennsylvania's oil and gas industry, for instance, with its estimated 40,000 workers across specialties, is poised to be a major stakeholder in geothermal development. The existing knowledge bases in well design, drilling, reservoir detection, hydraulic fracturing, and fluids and water management, are all transferable to geothermal. Geologists, drillers, and landmen can plan and build next-generation geothermal wells with minimal retraining. Information and technologies currently owned and used by the oil and gas industry can not only help reduce costs and risks, especially in the early stages of geothermal development, but also serve as a foundation on which



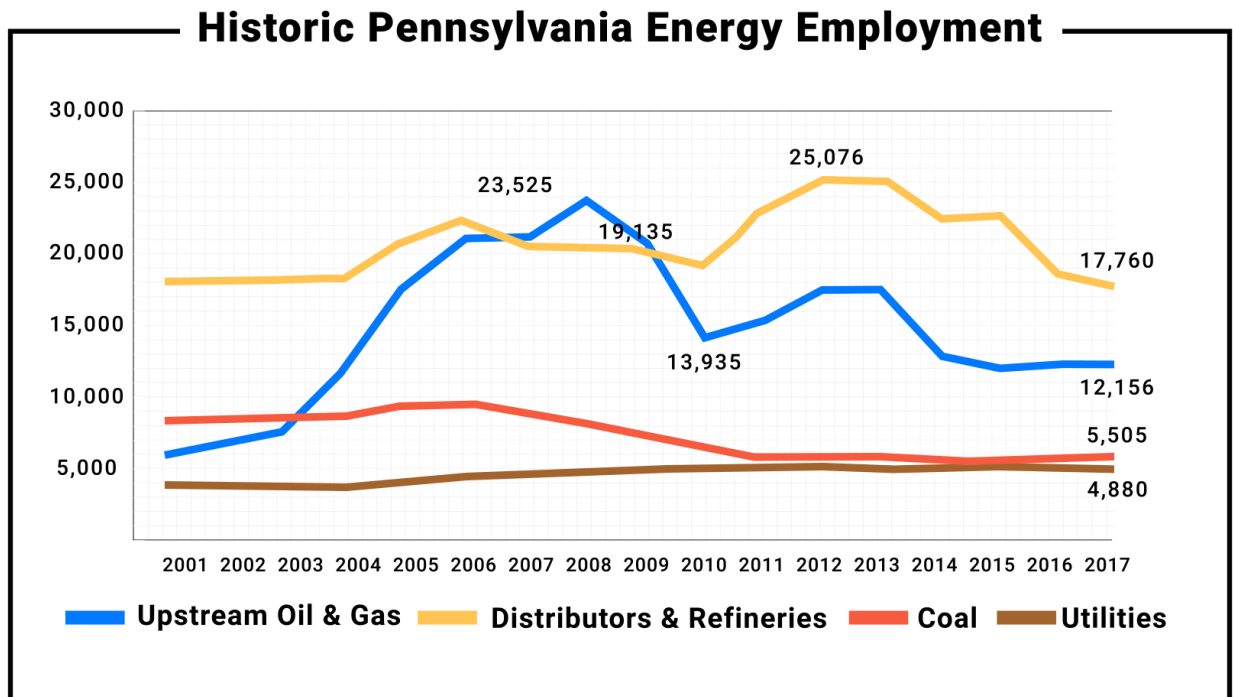


Figure 7.3: Number of workers. Excludes transportation fuel retailing. Source: Bureau of Labor Statistics (BLS), Quarterly Census of Employment and Wages. Source: Bureau of Labor Statistics (BLS), Quarterly Census of Employment and Wages

future geothermal-specific research can be built. There are Pennsylvania-based companies already actively engaged in geothermal development. For example, CNX Resources, a prominent natural gas driller and operator based in Canonsburg, is currently conducting a preliminary investigation for a potential geothermal pilot project. Atlas Copco Secoroc LLC, an oil and gas services company based in Fort Loudon, received \$1 million from the Department of Energy (DOE) in 2011 to perform technical research to “enable drilling at high temperatures encountered in deep geothermal wells.”⁵⁰ Today the company is applying air compressor technology to drilling applications for faster completion.⁵¹ And a number of Pennsylvania entities recently submitted a proposal for a DOE grant for EGS pilot projects.

Add to all this: Utility workers and pipefitters can install and repair thermal energy networks in the same rights of way and with similar tools and techniques as used for natural gas (see Natural Gas and Electricity Providers

below). Process engineers can design, develop, and maintain direct use systems. (See Chapter 3: Geothermal Direct-Use Opportunities.) Next-generation geothermal presents immediately applicable job opportunities requiring near-identical skills and expertise for tens of thousands of Pennsylvania workers.

Pennsylvania’s 300-plus colleges and universities, six of which are designated as having high research activity, also share in the Commonwealth’s rich energy history and have conducted important and impactful research relevant to geothermal. Some of these universities boast multi-disciplinary research capabilities, spanning from complex technical and engineering capacities to regulatory and policy work. Many of these schools have formed centers or other initiatives dedicated to emerging energy technologies, including geothermal energy. Some are already involved in projects that could have an impact on geothermal development. Penn State University’s Renewable Thermal Energy Working Group,



University of Pennsylvania's Kleinman Center for Energy Policy, Lehigh University's Energy Research Center, and Carnegie Mellon University's Wilton E. Scott Institute for Energy Innovation are all either engaged in or are suited to begin working in the geothermal sector. As well, many of the Commonwealth's universities, including Temple University and the University of Pittsburgh, are home to professors whose work is dedicated to geothermal development.

Federal agencies, such as the National Energy Technology Laboratory (NETL), which has an office in South Park, PA, will also play a critical role in steering the development of geothermal development. In the West, NETL is a partner with the Energy and Geoscience Institute at the University of Utah and the Geothermal Technologies Office (within the DOE's Office of Energy Efficiency and Renewable Energy) to develop enhanced geothermal systems at the Frontier Observatory for Research in Geothermal Energy (FORGE) in Utah. In Pennsylvania, NETL could potentially help fund research projects, facilitate public-private partnerships, and provide technical expertise to overcome the scientific and engineering challenges associated with next-generation geothermal energy development.

Natural Gas and Electricity Providers

As of this writing, several Pennsylvania natural gas distribution companies, including the municipally owned Philadelphia Gas Works, are exploring installation of or conversion to utility-scale geothermal district heating and cooling networks.⁵² While common in the western United States and Europe, and even on some Pennsylvania university campuses (such as Lehigh University), geothermal district heating and cooling networks at utility scale would be relatively novel in the Commonwealth and region. Natural gas providers could be key allies in the Commonwealth, as they have been in New York and Maryland.

As shown in *Chapter 2: Where to Develop Geothermal*, some locations in Pennsylvania could also host geothermal electricity generation projects, which means electricity providers also have a stake in how geothermal development proceeds in the Commonwealth. Recent studies suggest that current technologies could provide up to 15 MW of capacity per geothermal well to local

electricity supplies.⁵³ Utilities in Pennsylvania do not own generation; rather, utilities and competitive electricity suppliers procure generation to supply to customers. That makes electricity providers potential customers for geothermal project developers. However, geothermal electricity costs may need to come down to achieve widespread interest from providers. If subsidies and other incentives were offered for projects, the deployment of geothermal could increase by more than 20 percent.⁵⁴ (Policy support is addressed in detail in *Chapter 5: Additional Policy and Regulatory Issues*.) Electricity generation from geothermal projects might also require new transmission and distribution infrastructure (e.g., poles and wires) and integration into existing infrastructure,^{55,56} which means engagement with distribution utilities, transmission operators, and PUC officials.

CONCLUSION

Pennsylvania could be an attractive choice for geothermal energy production. Development will depend on geothermal developers' engagements with an array of key stakeholders. Education and outreach efforts are needed for private landowners, governmental entities, impacted communities, and potential advocates—to explain the potential economic, environmental, and other benefits of geothermal development, as well as the measures that will be taken to mitigate negative externalities. Geothermal developers will also benefit from engaging with industries and institutions that have extensive technical expertise, to gain from their experience and accelerate the deployment and innovation of geothermal technologies. Coordinating with natural gas and electricity providers, too, will help ensure there is interest and infrastructure to support deploying geothermal energy for local heating, cooling, and power. By engaging with all these important stakeholders, a range of Pennsylvanians can reap the benefits of geothermal energy in the Commonwealth.



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