JOINT STATE GOVERNMENT COMMISSION

General Assembly of the Commonwealth of Pennsylvania

Underground Power Lines in Pennsylvania

Staff Study

August 2026

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<table>
<tr><td colspan="2" align="center"><u>REPORT</u>

2025 House Resolution 254
Underground Power Lines in Pennsylvania</td></tr>
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The Joint State Government Commission was created in 1937 as the primary and central non-partisan, bicameral research and policy development agency for the General Assembly of Pennsylvania.[1]

A fourteen-member Executive Committee composed of the leadership of both the House of Representatives and the Senate oversees the Commission. The seven Executive Committee members from the House of Representatives are the Speaker, the Majority and Minority Leaders, the Majority and Minority Whips, and the Majority and Minority Caucus Chairs. The seven Executive Committee members from the Senate are the President Pro Tempore, the Majority and Minority Leaders, the Majority and Minority Whips, and the Majority and Minority Caucus Chairs. By statute, the Executive Committee selects a chairman of the Commission from among the members of the General Assembly. Historically, the Executive Committee has also selected a Vice-Chair or Treasurer, or both, for the Commission.

The studies conducted by the Commission are authorized by statute or by a simple or joint resolution. In general, the Commission has the power to conduct investigations, study issues, and gather information as directed by the General Assembly. The Commission provides in-depth research on a variety of topics, crafts recommendations to improve public policy and statutory law, and works closely with legislators and their staff.

A Commission study may involve the appointment of a legislative task force, composed of a specified number of legislators from the House of Representatives or the Senate, or both, as set forth in the enabling statute or resolution. In addition to following the progress of a particular study, the principal role of a task force is to determine whether to authorize the publication of any report resulting from the study and the introduction of any proposed legislation contained in the report. However, task force authorization does not necessarily reflect endorsement of all the findings and recommendations contained in a report.

Some studies involve an appointed advisory committee of professionals or interested parties from across the Commonwealth with expertise in a particular topic; others are managed exclusively by Commission staff with the informal involvement of representatives of those entities that can provide insight and information regarding the particular topic. When a study involves an advisory committee, the Commission seeks consensus among the members.[2] Although an advisory committee member may represent a particular department, agency, association, or group, such representation does not necessarily reflect the endorsement of the department, agency, association, or group of all the findings and recommendations contained in a study report.

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[1] Act of July 1, 1937 (P.L.2460, No.459); 46 P.S. §§ 65–69.

[2] Consensus does not necessarily reflect unanimity among the advisory committee members on each individual policy or legislative recommendation. At a minimum, it reflects the views of a substantial majority of the advisory committee, gained after lengthy review and discussion.

Over the years, nearly one thousand individuals from across the Commonwealth have served as members of the Commission's numerous advisory committees or have assisted the Commission with its studies. Members of advisory committees bring a wide range of knowledge and experience to deliberations involving a particular study. Individuals from countless backgrounds have contributed to the work of the Commission, such as attorneys, judges, professors and other educators, state and local officials, physicians and other health care professionals, business and community leaders, service providers, administrators and other professionals, law enforcement personnel, and concerned citizens. In addition, members of advisory committees donate their time to serve the public good; they are not compensated for their service as members. Consequently, the Commonwealth receives the financial benefit of such volunteerism, along with their shared expertise in developing statutory language and public policy recommendations to improve the law in Pennsylvania.

The Commission periodically reports its findings and recommendations, along with any proposed legislation, to the General Assembly. Certain studies have specific timelines for the publication of a report, as in the case of a discrete or timely topic; other studies, given their complex or considerable nature, are ongoing and involve the publication of periodic reports. Completion of a study, or a particular aspect of an ongoing study, generally results in the publication of a report setting forth background material, policy recommendations, and proposed legislation. However, the release of a report by the Commission does not necessarily reflect the endorsement by the members of the Executive Committee, or the Chair or Vice-Chair of the Commission, of all the findings, recommendations, or conclusions contained in the report. A report containing proposed legislation may also contain official comments, which may be used to construe or apply its provisions.[3]

Since its inception, the Commission has published over 460 reports on a sweeping range of topics, including administrative law and procedure; agriculture; athletics and sports; banks and banking; commerce and trade; the commercial code; crimes and offenses; decedents, estates, and fiduciaries; detectives and private police; domestic relations; education; elections; eminent domain; environmental resources; escheats; fish; forests, waters, and state parks; game; health and safety; historical sites and museums; insolvency and assignments; insurance; the judiciary and judicial procedure; labor; law and justice; the legislature; liquor; mechanics' liens; mental health; military affairs; mines and mining; municipalities; prisons and parole; procurement; state-licensed professions and occupations; public utilities; public welfare; real and personal property; state government; taxation and fiscal affairs; transportation; vehicles; and workers' compensation.

Following the completion of a report, subsequent action on the part of the Commission may be required, and, as necessary, the Commission will draft legislation and statutory amendments, update research, track legislation through the legislative process, attend hearings, and answer questions from legislators, legislative staff, interest groups, and constituents.

[3] 1 Pa.C.S. § 1939.

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August 2026

To the Members of the General Assembly of Pennsylvania:

We are pleased to release ***Underground Powerlines in Pennsylvania***, a staff study conducted at the direction of House Resolution 254 of 2025. The report is a comprehensive presentation of electric transmission and distribution in Pennsylvania and focuses on the advantages and disadvantages of placing powerlines underground. The report investigates the pros and cons of underground powerlines. On the one hand, underground powerlines avoid increasingly common and long outages caused by severe weather. On the other hand, undergrounding powerlines can be cost-prohibitive.

One of several recommendations presented for the General Assembly's consideration is that a pilot program be established to encourage electric companies to explore undergrounding as a viable option.

The full report is available at http://jsg.legis.state.pa.us.

Respectfully submitted,

Glenn J. Pasewicz
Executive Director

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INTRODUCTION

There are many challenges facing Pennsylvania's energy grid and in 2026 the most discussed is ensuring there is adequate electricity supplied from power generation sources for everyone: from emerging large load customers such as data centers, to industries and businesses, to meeting the everyday need of Pennsylvania households. While adequate electrical supply and sufficient capacity for transmission and distribution infrastructure to carry this electricity is essential for modern life in Pennsylvania, these critical services need to be resilient. Extreme weather is occurring more frequently in Pennsylvania, and the number of billion-dollar storms faced by the state has increased over the last 30 years.[4] These and other weather events lead to power outages in the state.

While these storm-related disruption of electrical service are often momentary blips on the customers end as new technology and modern system design allow power to be quickly rerouted, other outages can lead to repairs that last for days. Such outages cost utilities millions of dollars in repairs and are passed on to Pennsylvania ratepayers who are ultimately the ones paying for the state's energy infrastructure through their electric bills. Accordingly, it is part of Pennsylvania State government responsibility to ensure its citizens are adequately prepared for these outages and that electric distribution companies are making appropriate investments to harden critical infrastructure against predictable weather-related threats that are increasing in frequency and severity.

House Resolution 254 of the Legislative Session of 2025-2026 tasked the JSGC with creating a report on whether electrical reliability concerns noted within the Commonwealth might be resolved through 'undergrounding', which is the process of replacing overhead electrical lines with electrical lines buried beneath the earth. The resolution asked for information about the cost, viability, and challenges relating to creating additional underground electrical services within the Commonwealth.

As if to highlight the necessity of protecting Pennsylvania's electrical infrastructure, a severe thunderstorm hit Central Pennsylvania over the July 4th holiday weekend interrupting service for hundreds of thousands of customers, many for over 48 hours. See Figure 1. This, and other weather-related events seen in recent years have engaged citizens and increased calls to protect Pennsylvania's electrical lines against storms.

[4] "Weather-Related Power Outages Rising," Climate Central, April 24, 2024, https://www.climatecentral.org/climate-matters/weather-related-power-outages-rising; And "Billion-Dollar Weather and Climate Disasters," National Centers for Environmental Information, 2024, https://www.ncei.noaa.gov/access/billions/summary-stats.

Figure 1
Electrical Service Disruption in PA from July Storm
2026

Source: Mattew O'Haren, "Storm Aftermath, July 5, 2026," https://www.pennlive.com/news/2026/07/downed-trees-crushed-cars-and-days-without-power-aftermath-of-central-pa-storms.html.

This report will provide a picture of what Pennsylvania's electric distribution system looks like today, the reliability challenges it faces, the monetary, health and social costs of forestalling hardening actions, and what undergrounding strategies have been employed by other states.

While the JSGC staff compiled existing research on underground power lines and related topics, we would also like to express our gratitude to the organizations who provided us with assistance. The Pennsylvania Public Utility Commission educated us on their agency's role in overseeing reliable electrical service throughout the Commonwealth and what is currently being done by energy companies to improve reliability. We would also like to thank Scenic Pennsylvania for sharing their research on the potential lifecycle costs and methods used when burying power lines.

A BRIEF HISTORY OF ELECTRICAL SERVICE

Electric distribution and transmission in Pennsylvania are part of a nationwide network of infrastructure which coordinates the movement of electricity to match supply and demand for electricity across the country. Within Pennsylvania, the Public Utility Commission (PUC) is responsible for regulating the businesses which deliver electrical service for the majority of customers.

Overview of Changes in the Electrical Grid

In 1884 Thomas Edison created the first commercial power plant in the United States at Pearl Street on the island of Manhattan. Afterward, the adoption of electricity for commercial uses proliferated. Resultingly, electrical power needed a means to move from the source of generation to its users. Early direct current electricity wires had low voltage and, accordingly, energy could not be transmitted far, which kept regulation of power lines predominately a local matter. Only after a switch to alternating current did the range expand to an interstate level.[5] In the 1900s, power production was associated with economies of scale: the bigger an electric plant, the more cost effective it is to operate.[6]

The federal Public Utility Holding Company Act of 1935 created the framework for what would become the traditional electricity model.[7] "These large power plants necessitated financing mechanisms, via holding companies with multiple investors or later, access to low-cost financing via the debt markets. These progressively more advanced methods of equity and debt financing enabled new infrastructure (power plants, transmission and distribution lines) to be built and paid for over time, but without the risk of falling on a single company or investor."[8]

At the time, US policy incentivized "vertical integration" with one company owning multiple stages of power production. The consolidation was achieved by merging or acquiring businesses like suppliers, manufactures, or distributors.[9] Large regional monopolies of power production developed, which led to multiple societal benefits such as a lower cost, universal access, and increased reliability of service.[10] Despite its benefits, there were also shortcomings as

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[5] Tuttle, David, Gurcan Gulen, Robert Hebner, et. al, "The History and Evolution of the U.S. Electricity Industry," University of Texas, 2016, https://energy.utexas.edu/sites/default/files/UTAustin_FCe_History_2016.pdf., 4.
[6] Tuttle and Gulen. "History and Evolution of the US Electricity Industry."
[7] 15 U.S.C. §§79 et seq. The act was repealed in 2005 by the Energy Policy Act of 2005 (Pub.L. 109-58).
[8] Tuttle and Gulen "History and Evolution of the U.S. Electricity Industry," 3.
[9] Adam Hayes, "What Is Vertical Integration?" Investopedia, April 6, 2025, https://www.investopedia.com/terms/v/verticalintegration.asp.
[10] Tuttle and Gulen "History and Evolution of the U.S. Electricity Industry," 3.

vast swaths of rural America were left without power until the Rural Electrification Act of 1939 greatly expanded electricity access for rural agricultural throughout the country, including in Pennsylvania.[11]

However, the power production status quo changed in the 1970s when fuel prices increased, environmental concerns came to the forefront of public consciousness, technology burgeoned, and the opinion took hold that vertical integration models were not economically efficient.[12] Consequently, by the late 1970s and 1980s some state governments began to deregulate the energy sector. Deregulation resulted in construction of more natural gas and gas-fired power plants and created more competition in the energy market. The regional monopoly model had to change as a result. By the 1990s, policy makers across the country restructured electricity systems through new technology, and competition was the preferred way to reduce the cost of electricity.[13] In many places, including Pennsylvania, the cost of generating electricity is now unbundled from delivering it, allowing consumers to shop for their electricity producers.

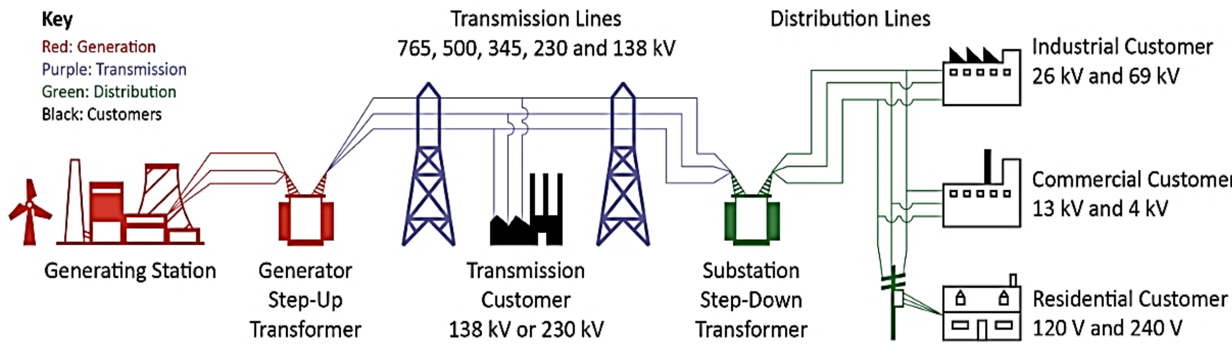
Delivering electricity was simpler in traditional energy markets. Suppliers made the power and transported it to the customers. Today, the grid is more complex and includes distributed resources like solar and wind power that require designs to move power both towards and away from the site of generation. Power companies and regulators have adjusted to manage these changes. The new era of deregulation, new technologies, and aging assets have created a push to replace and upgrade hard infrastructure such as power lines and inverters, as well as soft systems such as controls, sensors, software, and communications networks.

The Grid

Power plants create electricity that passes into the "grid," a common term for the "network for the transmission of electricity throughout the state, region or nation. The term is also used to refer to the layout of an electric distribution system."[14] Broadly, there are two types of power lines: transmission and distribution. Transmission lines are high voltage power lines that transport electricity from where it is produced to a local distribution system, which includes substations, transformers to reduce the voltage, and the wires that deliver electricity to homes and businesses.[15] Figure 2 includes a diagram showing the path electricity takes from site of generation to end users. The majority of this report focuses on distribution lines that deliver electricity to individual homes and businesses, essentially the retail market for electricity.

[11] Tuttle and Gulen, "History and Evolution of the U.S. Electricity Industry," 6.
[12] Tuttle and Gulen, "History and Evolution of the U.S. Electricity Industry," 6,7.
[13] Tuttle and Gulen, "History and Evolution of the U.S. Electricity Industry," 8,9.
[14] Pennsylvania Public Utility Commission, "Electric Terms Dictionary," PA PUC, 2026, https://www.puc.pa.gov/electricity/electric-terms-dictionary/.
[15] "Electric Terms Dictionary," Pennsylvania Public Utility Commission.

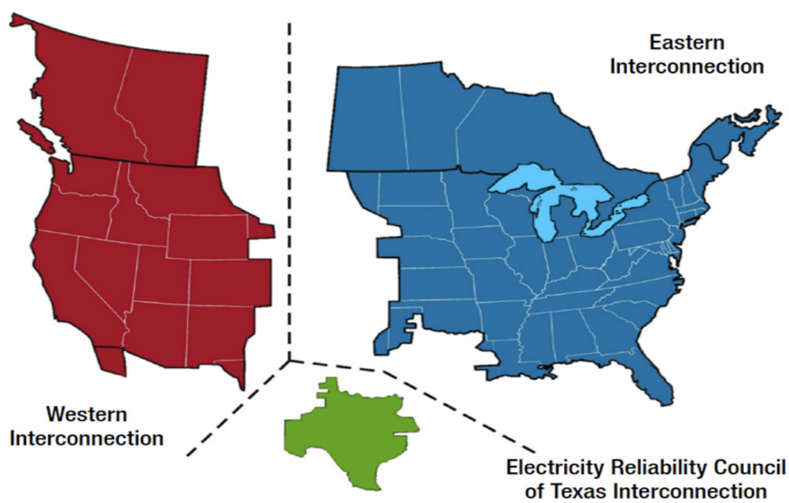
Figure 2
Electricity Generation, Transmission and Distribution
2025



Source: North American Electric Reliability Co., "Understanding the Grid," NERC.com, Sept. 2025, https://www.nerc.com/globalassets/who-we-are/september-2025-understanding-the-grid.pdf .

The US electric grid is a complicated and highly connected network composed of power generation plants, transformers, transmission lines, substations, and distribution lines delivering power to over 163 million residential, commercial, and industrial customers.[16] There main interconnections in the continental US, the East, West, and Texas comprise the nation's electric grid. See Figure 3. The Eastern Interconnection is located east of the Rocky Mountains and includes Pennsylvania's electricity infrastructure. One of the reasons for the complexity of these interconnections is many organizations contribute to, operate, and ensure that it works as intended. The organizations are governmental agencies, quasi-governmental partnerships, and private, including independent power producers, investor-owned utilities, energy co-ops, and municipalities.

Figure 3
US Grid Interconnections
2022



Source: US Dept of Energy, "Power Grid Fundamentals and Electricity Pricing," Jan. 2022, https://www.energycap.com/ebooks/power-grid-fundamentals-and-electricity-pricing/.

[16] "Electric Power Annual," US Energy Information Administration, 2025, https://www.eia.gov/electricity/annual/table.php?t=epa_01_02.html.

Federal Transmission Regulators

The bulk power system includes the sources for electric generation and the high-voltage transmission equipment. There are several major organizations at the bulk power system that manage the supply and reliability of electricity, such as the Federal Energy Regulatory Commission (FERC) and the North American Electric Reliability Corporation (NERC). There are seven regional transmission organizations (RTOs). PJM is Pennsylvania's RTO and manages it and 12 other states, including the surrounding states except for New York. Overall, these organizations ensure that power is supplied to substations for distribution. However, the national and regional organizations do not regulate local energy distribution.[17]

- FERC regulates interstate transmission and oversees the sale of wholesale electricity. It oversees NREC, RTOs, Independent Service Operators, and utilities under its purview.
- NERC is an intercontinental non-profit corporation responsible for assuring the reliability and security of the bulk power system across North America.
- RTOs, (such as PJM) are third-party independent grid operators that organize the electricity generators, ensure there is fair access to transmission infrastructure, and conduct regional planning so that the right infrastructure is in the right place.

These organizations exist to organize the massive electricity system that sprawls throughout the country and to ensure such systems are collaborating in ways both efficient and productive. However, as lower voltage local distribution systems are excluded from the bulk energy system, it primarily falls to state and sometimes even local governments to respond to local government reliability concerns.

[17] "Delivery to Consumers," US Energy Information Administration, 2016, https://www.eia.gov/energyexplained/electricity/delivery-to-consumers.php.

State Regulation: Pennsylvania Public Utility Commission

The Pennsylvania Public Utilities Commission (PUC) regulates matters relating to electricity, gas, telecommunications, water, and motor transportation carrier services within the Commonwealth.[18] As of the 2025-2026 fiscal year the PUC regulates 11 electricity distribution companies, 446 electricity generation companies, and 276 telephone companies.[19] For the purposes of this report on undergrounding, electricity, and to a lesser degree telecommunications, are most relevant. Unlike other types of utilities, these lines are not always buried by default; instead, electricity and telecommunications are transported overhead in utility poles in a network that covers the entire state.

The PUC must balance important but sometimes counteracting forces in pursuit of its mission. When it comes to electricity, safety and reliable service must be balanced against affordability and generators and distributors' rights to make a reasonable return on their investments. Since the deregulation of the energy market, the PUC has been charged with facilitating a competitive market and informing consumers about their ability to shop from different energy suppliers, all the while working to maintain reliability rates that existed prior to deregulation.[20]

For telecommunication, the PUC works to ensure that residents of Pennsylvania have access to phone and internet lines, reasonable local rates, and an acceptable quality. The agency also works to increase accessibility to high-speed internet and administers affordability programs.[21] However, as the way internet service is delivered moves away from telephone lines and to copper TV cable, fiber, cellphone towers, and satellites, fewer internet utilities fall within the PUC's purview.

What makes utilities different from other regulatory proceedings is that rate cases, that is, the utilities' plans to change the rates charged to customers, are not on a periodic schedule and instead come when they are requested by the utility. The PUC must respond within a limited period, aiming to balance financial requirements of the utility with customer affordability.

[18] "A History of the Pennsylvania Public Utility Commission," PA Public Utility Commission, May 18, 2017, p2.
[19] "About the PUC," PA Public Utility Commission, May, Accessed May 4, 2026, https://www.puc.pa.gov/about-the-puc/.
[20] "About the PUC," PA Public Utility Commission.
[21] "A History of the Pennsylvania Public Utility Commission," PA Public Utility Commission.

In 2024, the PUC handled a record breaking 31 rate cases filed across all utilities, attributed to inflationary pressures and outdated equipment; a typical year sees between seven and nine rate cases.[22] However, the Commonwealth has older infrastructure, which requires increasing investments.[23] At the same time operational costs are increasing, as they are sensitive to fuel and labor cost increases. Interest rates were also cited as a potential factor for rising costs. The PUC can reduce the requested rate amounts, and its decisions may "Mandate for improved service reliability and infrastructure investments to ensure safe and dependable utility service for Pennsylvania residents and businesses."[24]

One of the PUC's charges is to ensure that an electric service is both affordable and reliable. Components of reliability include that it is adequate (there is enough power) and that it is dependable (it is there when needed). The PUC regulates only distribution lines, not transmission lines. As discussed later in this report, these proceedings have different implications for undergrounding distribution and transmission lines.

Composition of the Pennsylvania Distribution System

An electric distribution company (EDC) is a public utility that provides facilities for the jurisdictional transmission (as opposed to grid transmission) and distribution of electricity to retail customers.[25] There are several types of electric distribution companies (investor-owned, municipal, electric cooperative) that deliver power to the end users through the distribution system. The entity regulating these utilities depends on which type it is:[26]

- Investor-owned are for-profit companies accountable to shareholders and are regulated by the PUC.
- Municipal utilities are nonprofits controlled by the local governments they serve.
- Cooperatives are nonprofit and serve the interests of their members and are managed by an elected board.

Table 1 summarizes characteristics, presence, and structure of each type of EDC present in Pennsylvania. The type of EDC affects the electrical service reliability requirements and has a bearing on how undergrounding or other infrastructure hardening strategies are implemented.

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[22] Stephen DeFrank, "Prepared Testimony of Stephen M. DeFrank Chairman, PA. Public Utility Commission Before the PA. House Consumer Protection, Technology and Utilities Committee." PA Public Utility Commission, 2025. https://www.puc.pa.gov/media/3398/defrank-house_cptu_overview_testimony_032425.pdf.
[23] Steven DeFrank "Prepared Testimony before the PA House," 8.
[24] Steven DeFrank "Prepared Testimony before the PA House," 8.
[25] "Electric Terms Dictionary," Pennsylvania Public Utility Commission.
[26] "Your Path to Cleaner, Greener Energy ...Starts with Knowing Your Provider," Wisconsin Academy of Sciences Arts & Letters, September 5, 2018, https://www.wisconsinacademy.org/node/8075.

Table 1
Characteristics of Electricity Distribution Companies
2024

Provider Type	Investor-Owned	Municipal	Cooperative
Service Area	Large, urban and rural	Small to mid sized Municipalities	Small to mid-size rural
Structure	Private, for-profit	Public, nonprofit	Private, nonprofit
Business Model	Provide return on investment	Provide at-cost electricity rates	Provide at-cost electricity rates
Owned by	Shareholders	Local Government	Members
Regulated by	Public Utility Commission	Self-regulated by Local Government	Co-op Board of directors

Source: Inspired by Wisconsin Academy of Sciences, Arts & Letters. PA data provided by US EIA Table 10, 2024, Analysis by JSGC staff, 'behind the meter' companies excluded.

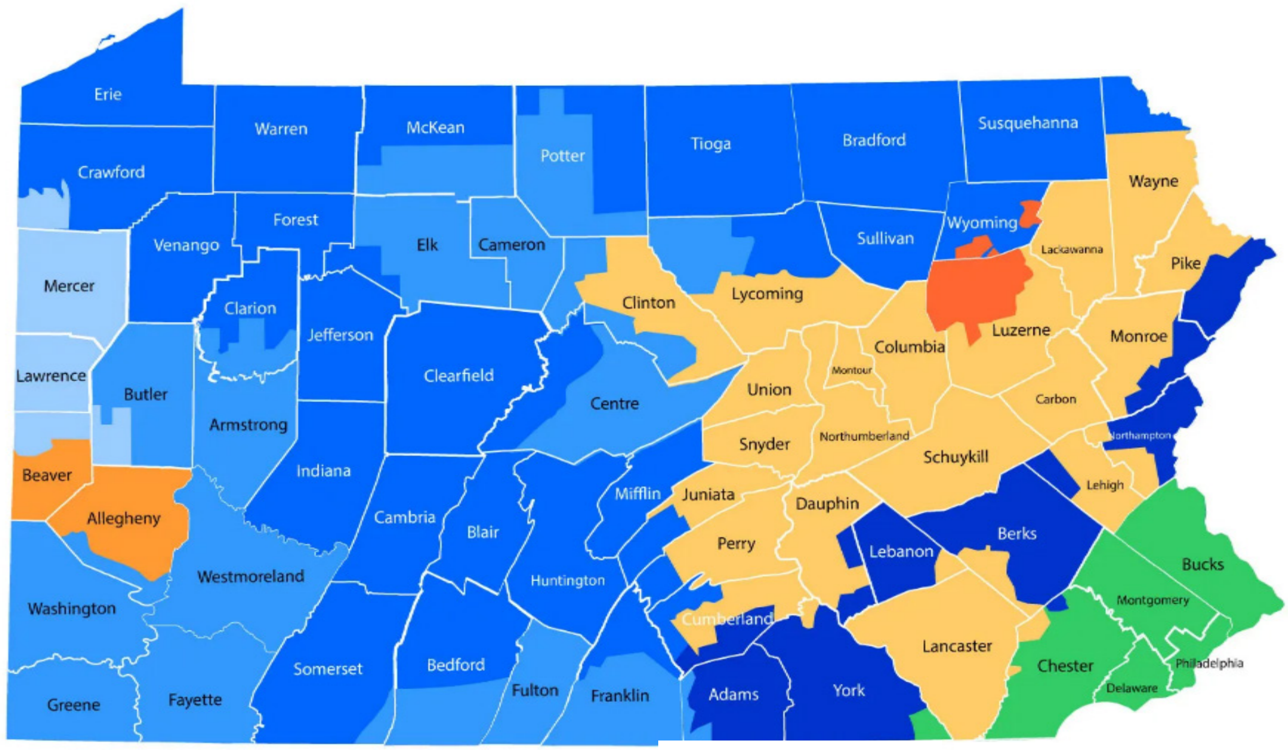
Investor-Owned Utilities comprise most of Pennsylvania's grid. Typically, one EDC serves each customer. While a customer's EDC is often the default supplier of electricity, in Pennsylvania a customer may shop to find the energy supplier that best meets their needs. A typical residential electricity bill is separated into a supplier charge for the amount of electricity used and a distribution charge which covers the cost of maintaining infrastructure and delivering the electricity.

Location of Electric Distribution Companies

There are eleven EDCs in Pennsylvania. With the consolidation of companies acquired by the FirstEnergy Company, however, four of the companies merged and now interact with the PUC as a single organization, although they maintain separate rates. The IOUs operating within Pennsylvania can be sorted into large and small. The larger IOUs are FirstEnergy, PPL, PECO, and DLC. The electricity infrastructure owned by these companies includes most distribution lines in the state, owning 98.6 percent of all distribution lines. Smaller IOUs include Wellsboro Electric Co., UGI Electric, Citizens' Electric Co. of Lewisburg, and Pike County Light & Power. Whether large or small, these electric distribution companies are regulated by the PUC, although they may be subject to differing reporting requirements based on size.[27]

[27] "Electric Distribution Company Act 129 Reporting," PA Public Utilities Commission, 2026, https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/electric-distribution-company-act-129-reporting/.

Map 1
Electric Distribution Companies in Pennsylvania
2026



Source: PAPUC, "Electric Distribution Company Act 129 Reporting," 2026, https://www.puc.pa.gov/filing-resources/issues-laws-regulations/act-129/electric-distribution-company-act-129-reporting/.

Map 1 shows most of the EDCs within the state. While these companies report information about their operations to the PUC, they do not always do so in uniform ways, and each may use different metrics. Therefore, there is not a single uniform record of the distribution infrastructure in Pennsylvania. Some companies discuss service area covered, or length of the route the wires run, while others use total number of miles for each wire (as it is common for two or three wires to be strung between poles). According to federal data, there are 7,741 distribution circuits within Pennsylvania.[28] The length of circuits varies and are typically 2-15 miles long for feeder main lines (which move electricity from substations closer to customers) but extends to 4-25 miles if laterals are included (secondary service lines that carry power to neighborhoods).[29] Table 2 provides more context on the size of EDC operations and the extent of their infrastructure.

[28] "EIA-861, Distribution Systems, 2024," US Energy Information Administration, 2025, https://www.eia.gov/electricity/data/eia861/.
[29] "The Basics of Primary Distribution Circuits," Electrical Engineering Portal, August 28, 2017, https://electrical-engineering-portal.com/primary-distribution-circuits.

Table 2
Investor-owned EDCs within Pennsylvania
2025

Utility Name	Distribution Circuits	Service area (sq miles)	Customer Count
Citizens Electric Co.[30]	9	41	7,220
Duquesne Light Co.[31]	634	817	613,818
PPL Electric Utilities Corp.[32]	1,285	10,000	1,470,255
PECO Energy Co.[33]	2,172	2,100	1,688,261
Pike County Light & Power Co.[34]	1	44	5,318
UGI Utilities, Inc.[35]	55	410	62,634
Wellsboro Electric Co.[36]	8	178	6,496
FirstEnergy Corp.[37]	3,060	32,400	2,076402
Total	7,224	45,990	5,930,404

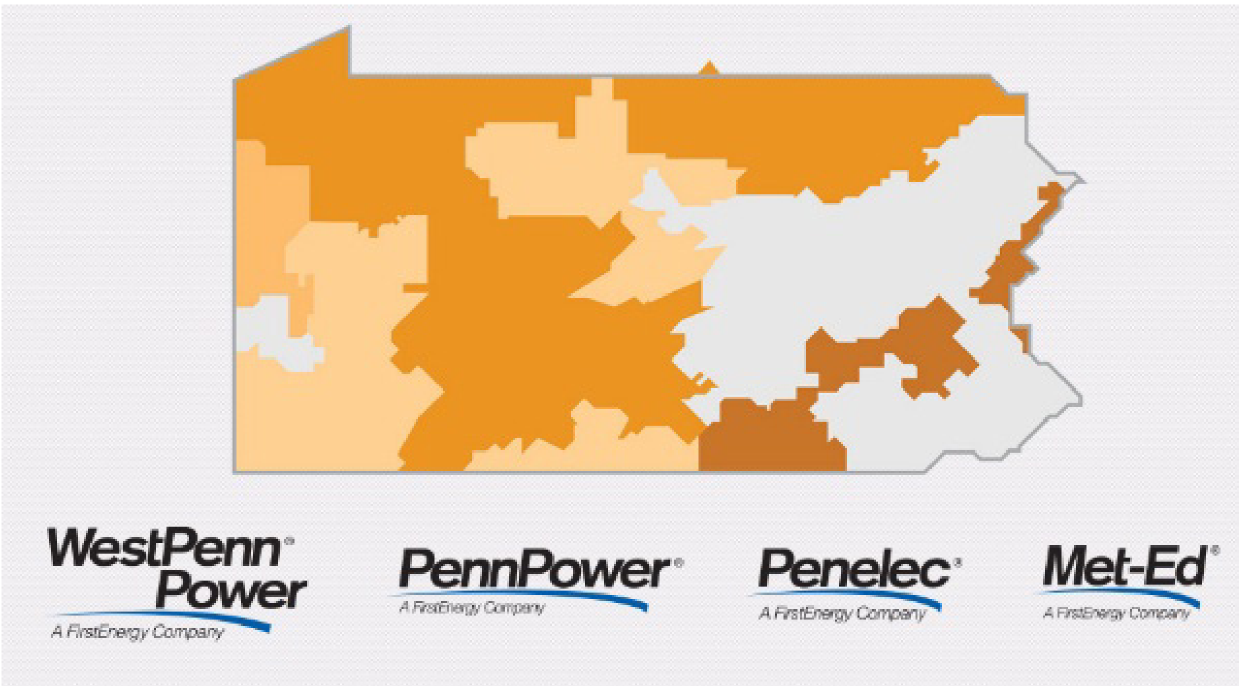
Source: US EIA, Electric Power Annual: With Data for 2024 " Table 11.2 Reliability metrics using IEEE o of US Distribution System by State" and " Table 11.2 Reliability Metrics using any method of US distribution system by state," Oct. 16, 2025, https://www.eia.gov/electricity/annual/. Service area provided in footnotes.

Headquartered in Ohio, the FirstEnergy distribution network extends beyond the borders of the state, to New Jersey, West Virginia and Maryland.[38] The origins of the company date back to the Pennsylvania Power Company (PENN POWER) purchase by Ohio Edison in 1944. Out of all the EDCs within the state, FirstEnergy covers the largest territory and serves the most customers in Pennsylvania. The company operates an estimated 269,000 miles of distribution lines and 9,500 miles of transmission lines across its interstate coverage.[39] This area is composed of four regions which used to be distinct electric distribution companies. See Map 2. While these subsidiaries have all been owned by FirstEnergy since at least 2016 but maintain separate systems for customer

[30] "About Us," Citizens' Electric Co., accessed July 22, 2026, https://citizenselectric.com/about-us/.
[31] "Service Map," Duquesne Light Co., accessed July 22, 2026, https://duquesnelight.com/service-reliability/service-map.
[32] B.L. Johnson, PPL Electric, "Index for Filing Requirements Parts I and II," PUC Docket No. R-2025-3057164, https://www.puc.pa.gov/pcdocs/1897451.pdf, 10.
[33] Kenneth Kulak, "Re: Letter of Notification of PECO Energy Company Filed Pursuant to 52 PA. Code 57.71 et sq. for Approval of the siting and construction of the 220-101 Line Located in Norristown, West Norriton Township, and Upper Merion Township, Montgomery County, Pennsylvania" Docket No. A-2025, https://www.puc.pa.gov/pcdocs/1894395.pdf, 2.
[34] "Review of Report: Storms, vegetation and aging power grid challenge state's electric reliability," Pike County Courier, Sept., 2022, https://www.pikecountycourier.com/news/local-news/report-storms-vegetation-and-aging-power-grid-challenge-state-s-electric-reliability-ba3640883.
[35] "Direct Testimony of Eric W. Sorber," UGI Utilities Inc., Feb. 8, 2021, https://www.ugi.com/wp-content/uploads/2021/02/BOOK%20III%20%28Direct%20Testimony%20Nos.%201%20thru%205%29_ADA.pdf, 3.
[36] "About Us," Wellsboro Electric Co., May 2023, https://wellsboroelectric.com/about-us/.
[37] "Corporate History of FirstEnergy Corp., Metropolitan Edison Company, Pennsylvania Electric Company and Pennsylvania Power Company," PA Public Utility Commission, 2010, https://www.puc.pa.gov/pcdocs/1079044.pdf.
[38] "About Us." FirstEnergy Corp., 2024. https://www.firstenergycorp.com/about.html.
[39], "Company History," FirstEnergy Corp., July 21, 2025, https://www.firstenergycorp.com/about/company_history.html.

accounts, although in recent years they have become more consolidated and submit documentation to the PUC as one entity.[40]

Map 2
First Energy Service Area
Pennsylvania
2023

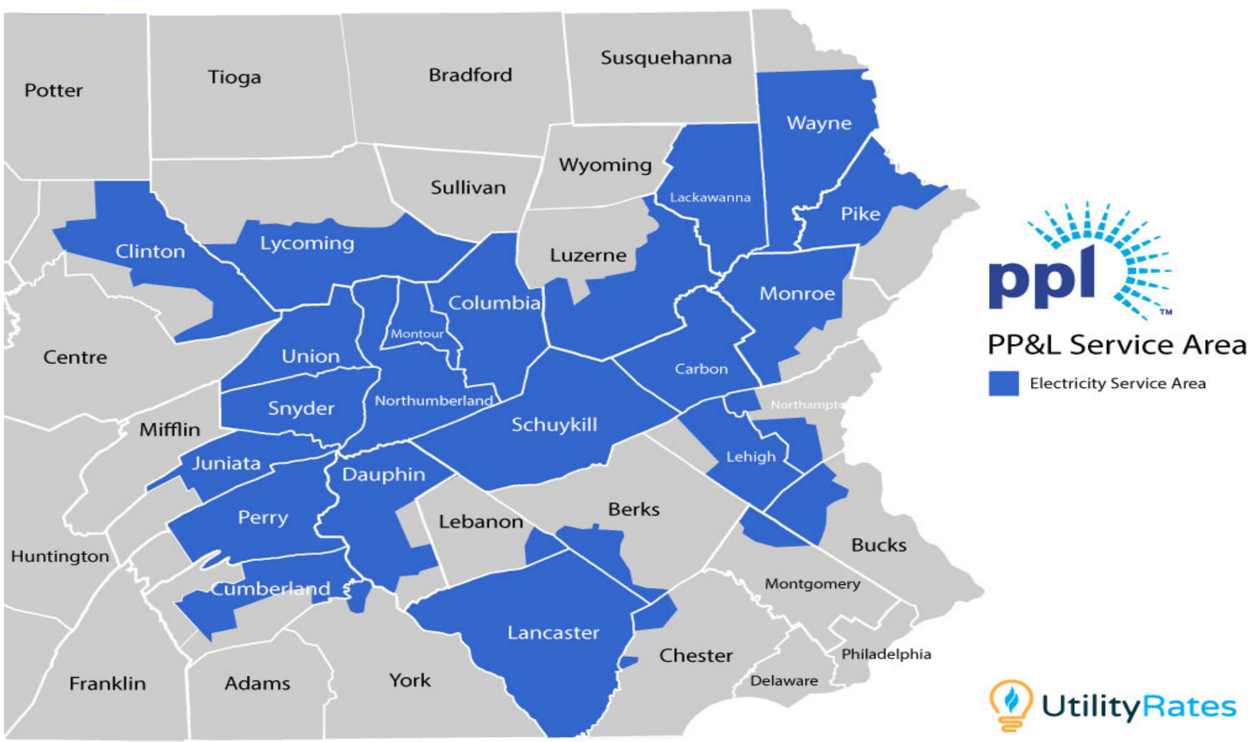


Source: FirstEnergy, "FirstEnergy's Pennsylvania Subsidiaries Receive Approval to Consolidate into Single Operating Company," Firstenergycorp.com, 2023, https://www.firstenergycorp.com/newsroom/news_articles/firstenergy-pennsylvania-subsidiaries-receive-approval-to-consolidate.html.

[40] "FirstEnergy's Pennsylvania Subsidiaries Receive Approval to Consolidate into Single Operating Company," FirstEnergy Corp., December 7, 2023, https://www.firstenergycorp.com/newsroom/news_articles/firstenergy-pennsylvania-subsidiaries-receive-approval-to-consolidate.html.

Pennsylvania Power and Light Company (PPL) was founded in 1920 through the consolidation of eight smaller power companies in Pennsylvania. In 2023 PPL had 1.4 million customers in 29 counties. PPL maintains approximately 48,000 miles of power lines (both electric distribution and transmission).[41] This includes 5,000 miles of transmission lines operating at 69kV (kilovolts) or higher, 375 substations, and more than 43,000 miles of distribution lines (less than 69kV).[42]

Map 3
PP&L Service Area
2026



Source: Electricity Ratings LLC, "PPL," Utility Rates, 2026, https://www.utilityrates.com/utility-companies/ppl#service_map_PP&L.

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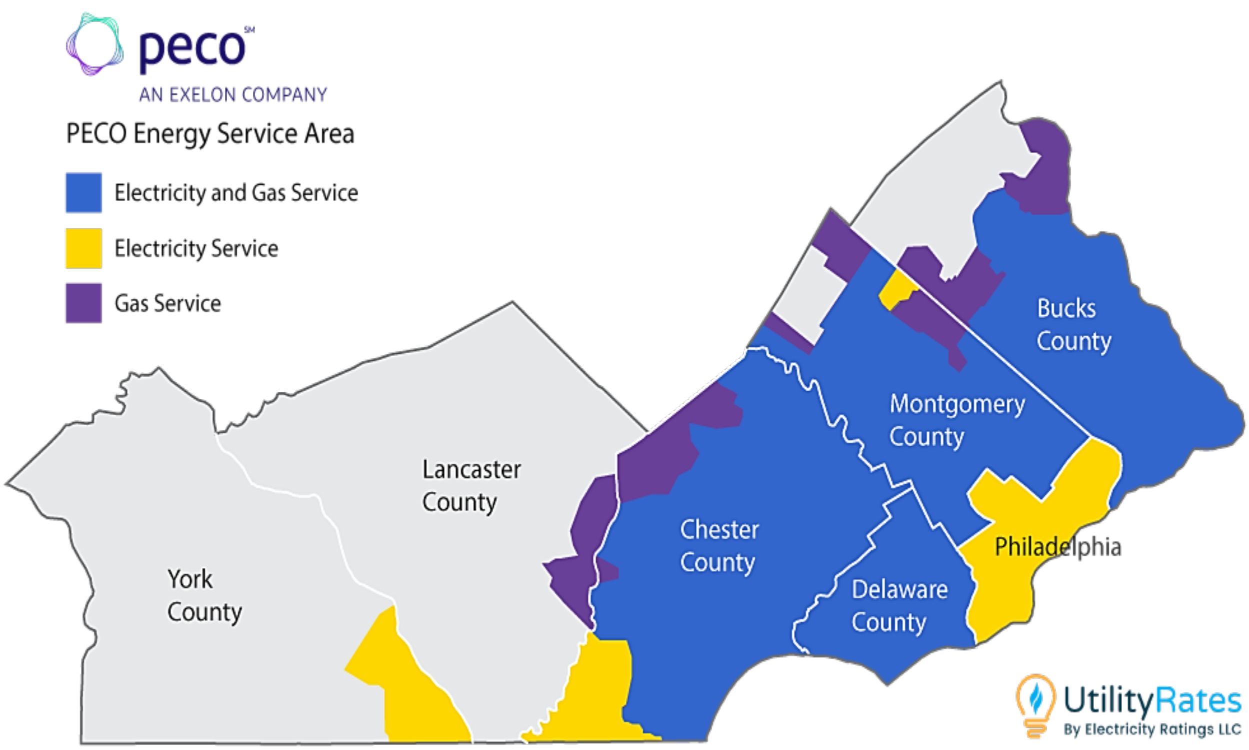
41 Frank, Francis, "PPL Overview." *Electrificationcoalition.org*, June 2023, https://electrificationcoalition.org/wp-content/uploads/2023/06/About-PPL.pdf.

42 PPL Electric Co., "Application of PPL Electric Utilities Co. Filed Pursuant to 52 Pa. Code Chapter 57, Subchapter G, for Approval of the Siting and Construction of the North Lancaster-Honey Brook #1 & $2 138/69 kV Transmission Line in Lancaster County, Pennsylvania," Available from PA Public Utility Commission, https://www.puc.pa.gov/pcdocs/1295724.pdf

The Philadelphia Electric Company (PECO) is an electric distribution company owned by Exelon, operating in southeastern Pennsylvania. The origin of PECO dates back to 1902 when 20 electric companies within Philadelphia were consolidated so that the city would have only one provider of reliable service. Today, PECO owns 1,100 miles of high voltage transmission, and 13,000 miles of aerial distribution.[43] A 2025 report placed its count of underground power lines at 17,100 miles of main stem and Urban Residential Distribution underground wires.[44]

Map 4
PECO Service Area
2026



Source: Electricity Ratings LLC, "PECO Energy Company," Utility Rates, 2026, https://www.utilityrates.com/utility-companies/peco.

The smallest of the 'large' EDCs, Duquesne Light Company (DLC) was founded by George Westinghouse in Pittsburgh in 1912. DLC owns and operates 7,000 miles of distribution wires and 700 miles of transmission wires which extend through Allegheny and Beaver counties.[45]

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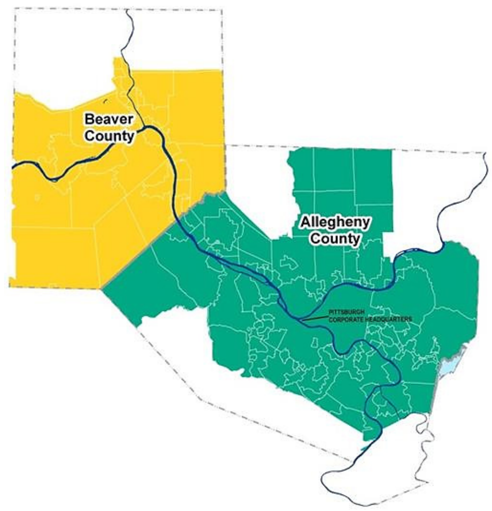
[43] "PECO Electric Company in Pennsylvania," PowerSetter, January 16, 2025, https://www.powersetter.com/utilities/peco/.

[44] Richard Webster & PECO, "Regrading: Petition of PECO Energy Company for Approval of Its Electric Long-Term Infrastructure Improvement Plan for the Period January 1, 2026 through December 31, 2030," PA Public Utility Commission, August 20, 2025, https://www.puc.pa.gov/pcdocs/1892003.pdf.

[45] "Report on the Statements of Transmission Service Charge for the 12-Month Periods Ended February 29, 2020, February 28, 2019, AND February 28, 2018," PUC Docket No. D-2020-3021686 https://www.puc.pa.gov/pcdocs/1726625.pdf, 1.

Overall, these four largest investor-owned EDCs will receive the most attention in this reliability and undergrounding report since they distribute electricity to the vast majority of electricity customers within the Commonwealth. In later chapters, this report examines the reliability of the electric service, as well as initiatives they have undertaken to improve services to Pennsylvanians.

Map 5
Duquesne Light Map
2023



Source: Duquesne Light Company, "Service," Duquesnelight.com, 2023, https://duquesnelight.com/service-reliability/service-map.

Small EDCS

While large investor-owned EDCs constitute the majority of the power lines in the state, there are four smaller, investor-owned EDCs within the state that operate differently due to their size. While Act 129 of 2008 established energy efficiency and conservation measures for large EDCs, those with under 100,000 customers are held to a different set of standards.[46] For example, they do not need to submit infrastructure improvement plans to the PUC, although some companies may still elect to file such plans. Overall, it should be noted that the small EDCs have typically had greater success in reaching the reliability standards set by the PUC in recent years while larger EDCs have struggled. Part of the reason for this discrepancy is larger EDCs experience threats over a larger service area. The following are the four small EDCs.

Citizens Electric of Lewisburg & Wellsboro Electric Co.

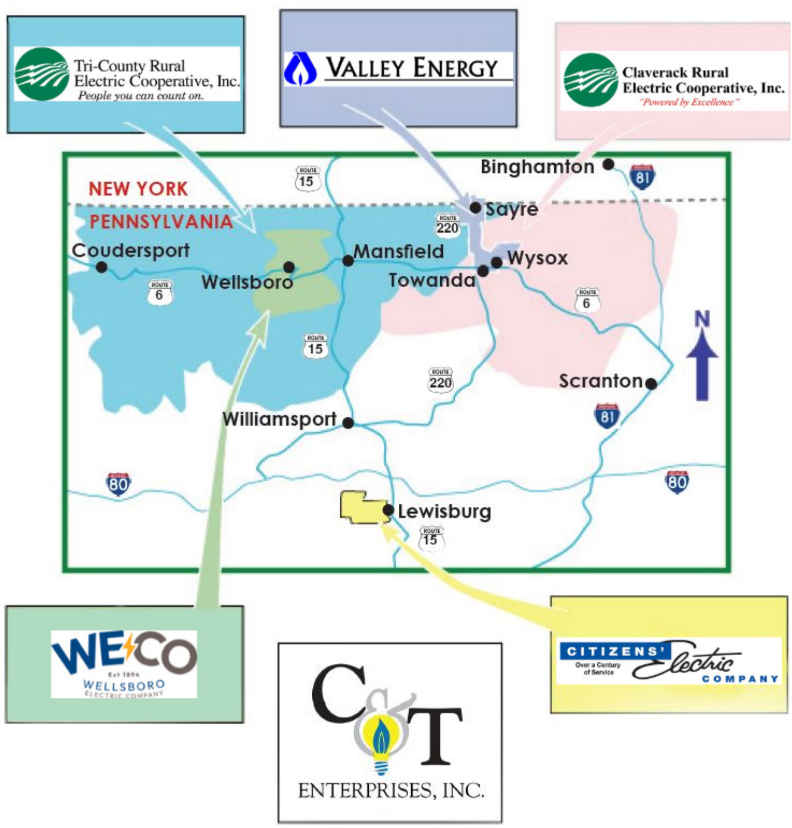
Two of Pennsylvania's small EDCs are jointly owned by C&T Enterprises Inc., company formed in collaboration by two of Pennsylvania's Rural Electric Co-ops.[47] The first small EDC

[46] "Reliability," PA Public Utility Commission,, 2024, https://www.puc.pa.gov/filing-resources/reports/reliability/. Act 129 is the act of October 15, 2008 (P.L. 1592, No. 129) which amended the Public Utility Code (66 Pa.C.S.).
[47] "About Us," C&T Entreprises Inc., June 2021, https://ctenterprises.org/about-us.

was formerly a Co-op itself, however today Citizens Electric is now an IOU, covering approximately 55 square miles of territory in the borough of Lewisburg, and Buffalo, East Buffalo, and small portions of Kelly and West Buffalo Townships in Union County.[48] The IOU is "Operating one 69,000 volt substation and approximately 220 miles of 12,470 volt overhead and underground distribution lines."[49]

The second small EDC currently owned by C&T Enterprises is the Wellsboro Electric Company, which was founded in 1894. It serves the majority of Tioga County in the townships of Middlebury Center, Charleston, Delmar, and the borough of Wellsboro.[50] See Map 6. The company's assets include over 570 miles of overhead lines (both transmission and distribution) as well as 29 miles of underground lines. Being part of a rural area, the population density averages 11 customers per mile of line.[51]

Map 6
Small EDCs in Northern Pennsylvania
2021



Source: C&T Enterprise, Inc., "About Us," June 2021, https://ctenterprises.org/about-us.

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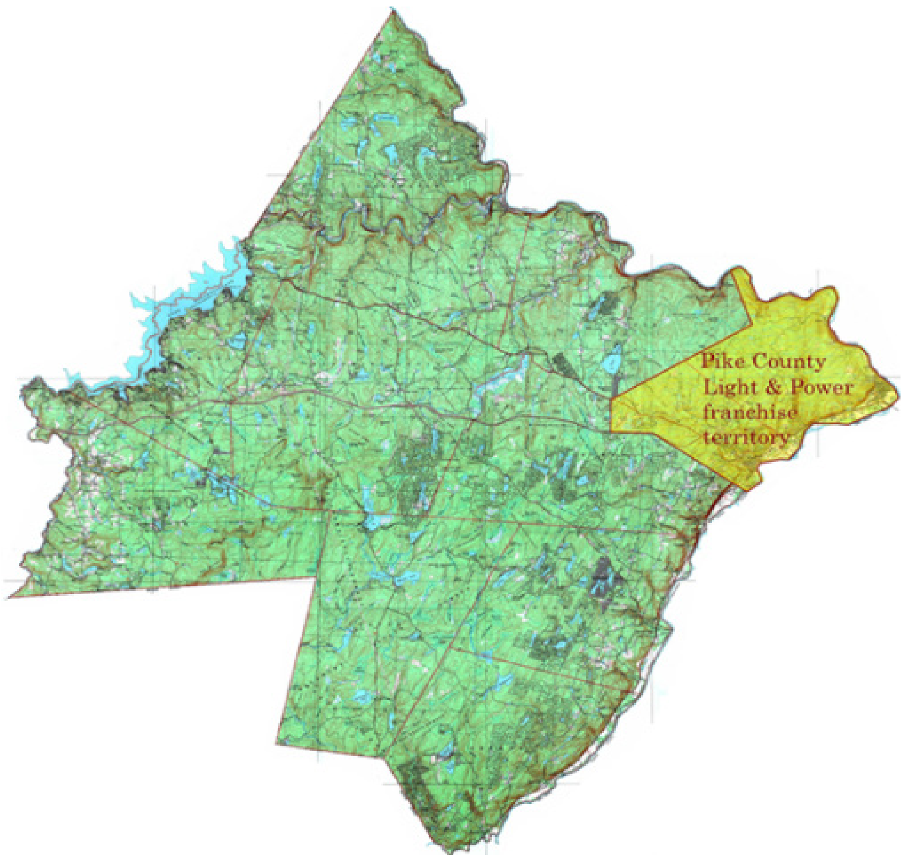
48 "About Us," Citizens' Electric Company of Lewisburg, PA, Accessed May 7, 2026, https://citizenselectric.com/about-us/.
49 "Pike County Light & Power," Pike County Light & Power, June 7, 2026, https://pclpeg.com/.
50 "Frequently Asked Questions," Wellsboro Electric Co., June 15, 2023. https://wellsboroelectric.com/customer-service/faq/.
51 "About Us," Wellsboro Electric Co., May 2023. https://wellsboroelectric.com/about-us/.

Pike County Light & Power Co

Pike County Light & Power Company, founded in 1910, has grown to provide electric services to 5,200 customers across Westfall, Milford, and northeast Dingman Townships and the boroughs of Matamoras and Milford, a service area in eastern Pike County.[52] Pike has approximately 100 miles of overhead electric distribution lines and 40 miles of underground distribution lines, making approximately 28.5 percent of its service area underground.

Map 7
Pike County Service
2018



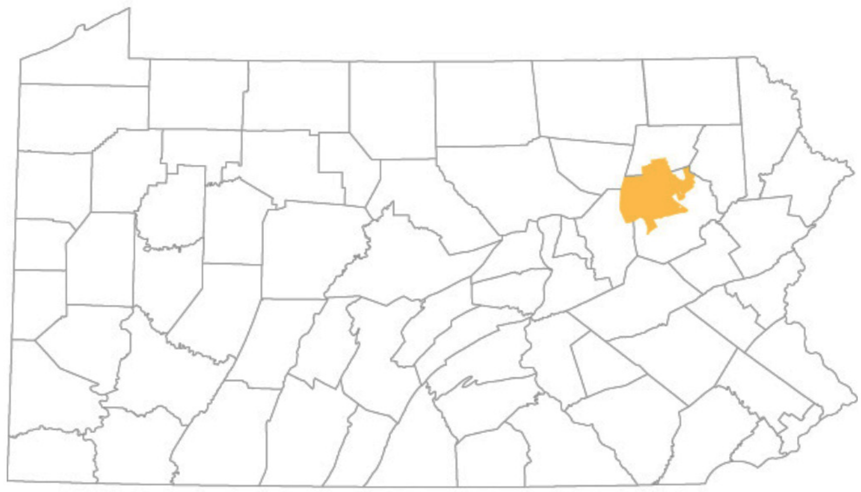
Source: Pike County Light & Power, "Service Areas," 2018, https://pclpeg.com/service-area.

[52] "Pike County Light & Power," Pike County Light & Power, June 7, 2026, https://pclpeg.com/.

UGI Utilities, Inc.

UGI Utilities is a subsidiary of United Gas Improvement Corp. While UGI is most widely known as a King of Prussia based natural gas utility, it also provides electricity services to a small portion of the state. UGI has 2,700 miles of transmission and distribution lines and 14 substations. It serves approximately 63,000 customers in Luzerne and Wyoming Counties. In spring of 2026, UGI announced that the electricity portion of its business will be sold to Argo Infrastructure partners.[53]

Map 8
UGI Electric Service
2026



Source: UGI Utilities, "Geographic Footprint," 2026, https://www.ugi.com/about-us/geographic-footprint/.

As previously noted, not all EDCs within the Commonwealth are owned by investors. Certain municipalities have chosen to run their own publicly managed distribution utilities; distribution lines in rural areas are predominantly run by cooperatives. It should be noted that the PUC *does not* regulate electric power co-ops (operated by its members) or municipal authorities.

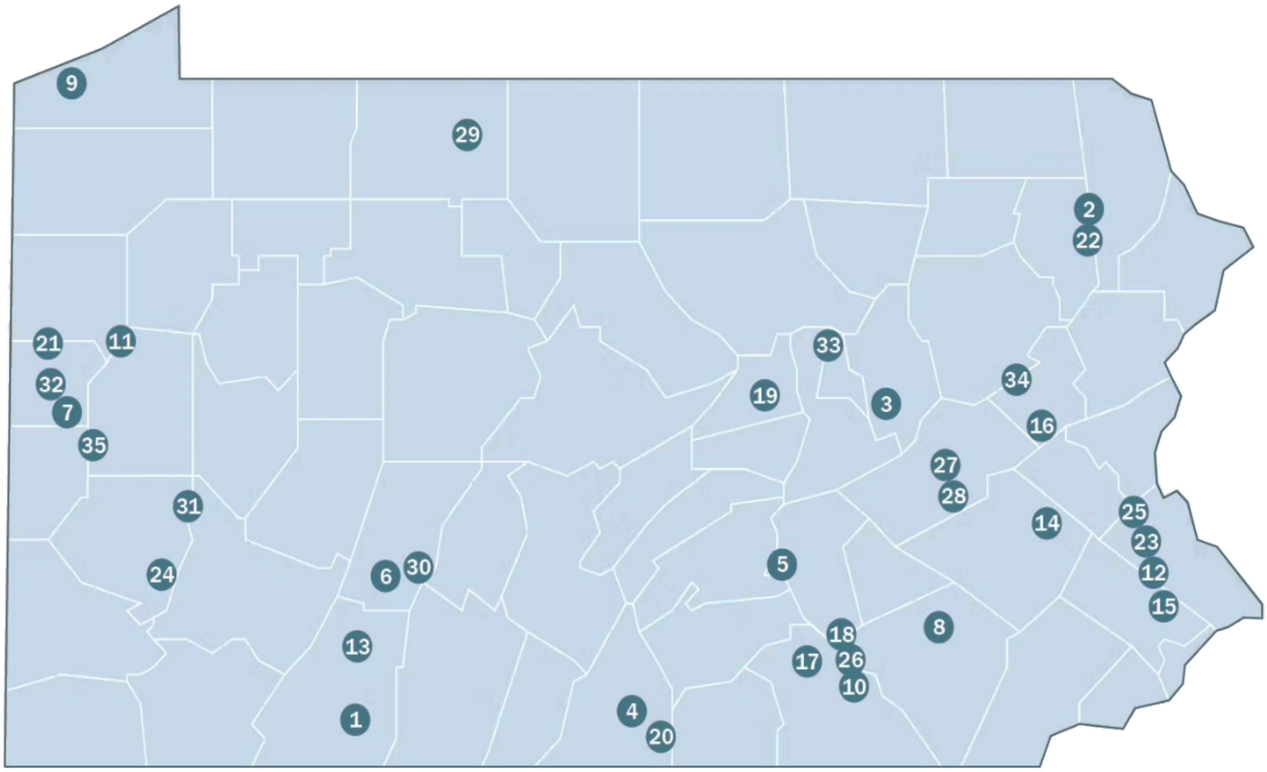
Municipal Authorities

There are 35 boroughs with community-owned electric distribution systems that operate the networks on behalf of their residents. In aggregate, they serve 180,000 customers in Pennsylvania.[54] Chambersburg, Franklin County is the largest municipal utility with 11,000 customers, double the size of the next largest municipal authority, which is Ephrata in Lancaster County.[55] Municipal electric utilities claim to be 6.9 percent more affordable and twice as fast to

[53] "UGI Utilities and Argo Infrastructure Partners Reach Agreement on Purchase and Sale of UGI's PA Electric Utility," UGI Utilities Inc., April 28, 2026, https://www.ugicorp.com/news-releases/news-release-details/ugi-utilities-and-argo-infrastructure-partners-reach-agreement.
[54] "Meet PMEA," PA Municipal Electric Assoc., 2026. https://www.papublicpower.org/.
[55] "Chambersburg Breaks Ground to Improve Critical Gas, Stormwater, and Transportation Infrastructure in the Boro ugh," Borough of Chambersburg., August 5, 2024,
https://chambersburgpa.gov/pdf/CHAMBERSBURG%20BOROUGH%20BREAKS%20GROUND%20TO%20IMP

restore power during storms.[56] For these reasons, along with their self-governing structure, municipal EDCs will largely be excluded from this undergrounding report.

Map 9
Locations of Municipal Electric
2020



1. Berlin	7. Ellwood City	13. Hooversville	19. Mifflinburg	25. Quakertown	31. Tarentum
2. Blakely	8. Ephrata	14. Kutztown	20. Mont Alto	26. Royalton	32. Wampum
3. Catawissa	9. Girard	15. Lansdale	21. New Wilmington	27. St. Clair	33. Watsontown
4. Chambersburg	10. Goldsboro	16. Lehighton	22. Olyphant	28. Schuylkill Haven	34. Weatherly
5. Duncannon	11. Grove City	17. Lewisberry	23. Perkasie	29. Smethport	35. Zelienople
6. East Conemaugh	12. Hatfield	18. Middletown	24. Pitcairn	30. Summerhill	

Source: PA Municipal Electric Assoc., "Members Map," PMEA, 2020, https://www.papublicpower.org/members-map.

Rural Electric Cooperatives

The Pennsylvania Rural Electric Association was formed in 1942. Today, 13 Pennsylvania and one New Jersey co-ops comprise the association.[57] These organizations have full ownership and control over their electric distribution assets and are not subject to PUC regulations. Instead, the co-ops are answerable to their members and are led by an elected board. Rural electric co-ops

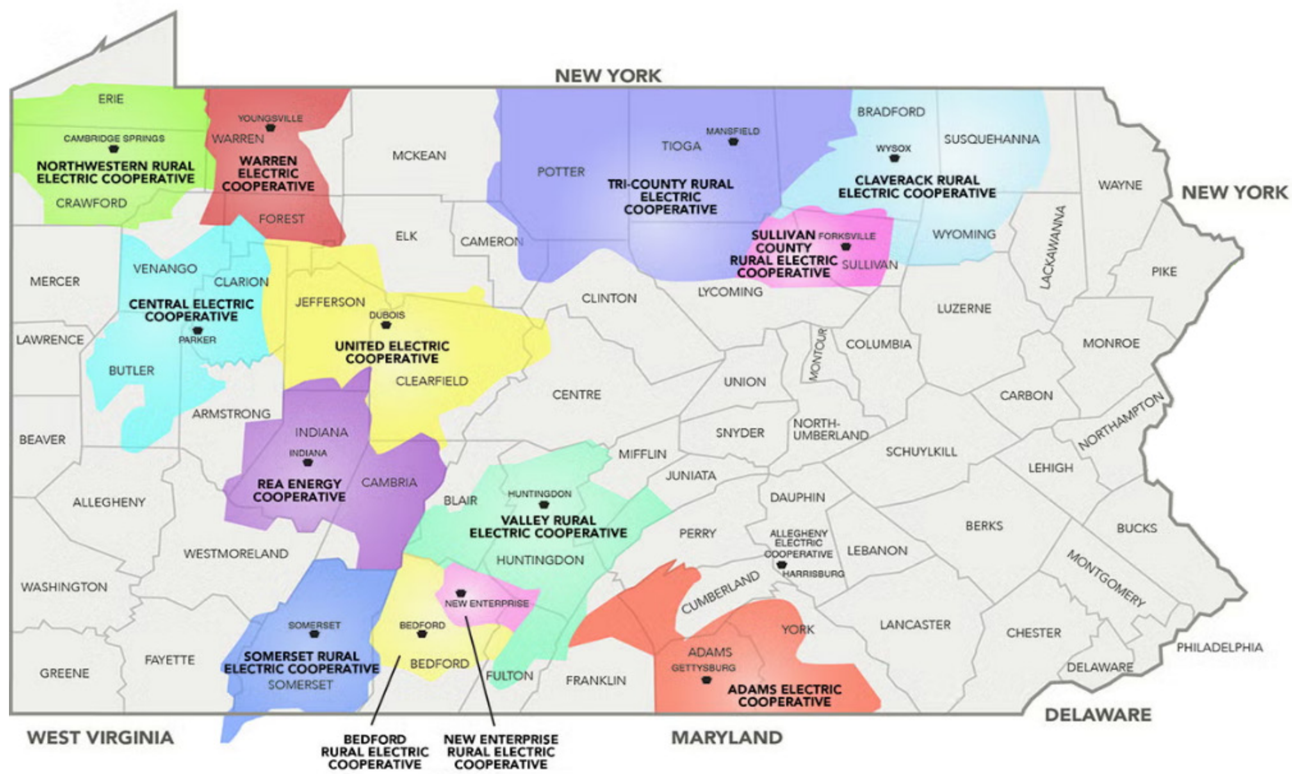
ROVE%20CRITICAL%20GAS,%20STORMWATER%20AND%20TRANSPORTATION%20INFRASTRUCTURE.pdf

[56] "Meet PMEA," PA Municipal Electric Assoc., 2026. https://www.papublicpower.org/.

[57] A full list of Pennsylvania Rural Electric Association members can be found at https://www.prea.com/member-cooperatives.

cover 4 percent of the states' residents across 42 counties. This area covers approximately a third of the Commonwealth's land. Due to the low population density in rural areas, these distribution lines account for only 12.5 percent of Pennsylvania's total and deliver power to approximately 238,000 predominantly rural households.[58]

Map 10
Electric Cooperative Locations
2026



Source: Pennsylvania Rural Electric Association, "Member Cooperatives." Prea.com, accessed May 7, 2026, https://www.prea.com/about-us.

As with other EDCs, Co-ops may offer to underground their customers' electric service if they are willing to pay for excavation and refilling trenches. In such cases, the co-op may provide conduit and offer limited technical advice. Due to the frequently rural nature of their service areas and low subscriber counts per line mile, undergrounding wires may be an impractical solution, except in areas where vegetation management is expensive and possibly ineffective. While there are reports of electric co-ops across the country adopting underground strategies to harden their systems against storms, a review of newsletters, websites, and association groups by Commission staff did not reveal any significant undergrounding initiatives occurring in 2026.

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[58] "About Us," Pennsylvania Rural Electric Assoc., accessed May 7, 2026, https://www.prea.com/about-us.

One hint as to why the Commonwealth's electricity infrastructure is particularly at risk from storm damage lies within the name: Pennsylvania was named for its forests. In 2019, the USDA estimated that 57 percent of the state is covered by forest.[59] There are nearly 7.95 billion trees with the state, an estimated 613 trees per person.[60] These trees are vital to the Pennsylvania way of life, from capturing carbon and clearing sources of air pollution, providing homes for wildlife, and space for recreation. Further, Pennsylvania is a leader of the hardwood industry.[61] Despite these many benefits, trees and other types of vegetation can be hinderances depending on the context.

Since 2015, trees and other types of vegetation have been the leading threat to Pennsylvania electricity reliability. Space near overhead power lines is contained within a right of way.[62] While trees within the right of way are trimmed frequently as part of regular maintenance, trees outside the right of way might have overhanging limbs that knock into power lines and have been identified as the number one threat to the grid's reliability by the PUC.[63] While in recent years electric distribution companies have increased vegetation management practices, questions remain over the adequacy, efficacy, and sustainability of these measures.

The current energy distribution funding mechanisms assume that storms will be relatively rare, and electricity distribution companies within the Commonwealth have a largely reactive process by design. Storms appear and cause damage, and the utilities hastily work to restore service. The utilities are reimbursed through funds collected in electric bills; excess funds, if there are any, are returned to the customers.[64] As repair costs across the Commonwealth grow, more consideration needs to be given to storm damage relative to lifecycle costs.

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[59] *Forests of Pennsylvania, 2019.* Madison, WI: US Dept. of Agriculture, 2020 https://www.fs.usda.gov/nrs/pubs/ru/ru_fs251.pdf.

[60] *Forests of Pennsylvania, 2019.* Madison, WI: US Dept. of Agriculture, 2020

[61] "Forests and Trees," PA Dept. of Conservation and Natural Resources, Accessed May 4, 2026, https://www.pa.gov/agencies/dcnr/conservation/forests-and-tree.

[62] "Power Outages from Vegetation and Weather Continue to Challenge Pennsylvania's Electric Reliability, PUC Report Shows," PA Public Utility Commission, September 3, 2024, https://www.puc.pa.gov/press-release/2024/power-outages-from-vegetation-and-weather-continue-to-challenge-pennsylvanias-electric-reliability-puc-report-shows-09032024.

[63] "Power Outages from Vegetation and Weather Continue to Challenge Pennsylvania's Electric Reliability, PUC Report Shows," PA Public Utility Commission.

[64] David MacGregor, "The Commonwealth Court of Pennsylvania Affirms That Utilities Can Recover Storm Damage Expenses through an Automatic Adjustment Clause outside of a Base Rate Case Proceeding," Post & Schell, P.C., December 21, 2016, https://www.postschell.com/insights/the-commonwealth-court-pennsylvaniaaffirms-that-utilities-can-recover-storm-damage.

On the part of EDCs within the state, there may be a reluctance to engage in costly reliability projects that could delay other infrastructure priorities, draw scrutiny for state regulators, and drive up costs to consumers. However, Pennsylvanians also pay when hardening measures are not taken, as there is a cost associated with lost economic activity caused by poor electric reliability. Beyond pure monetary terms, there are also safety costs to losing power that can threaten lives. Such factors will be examined in greater detail in the subsequent chapter of this report.

Public Utility Commission Reliability Monitoring

The PUC is responsible for ensuring that electricity services throughout the Commonwealth are safe and reliable and that such services are cost effective for ratepayers. Accordingly, the PUC possesses the authority to promulgate rules on distribution electric lines within the state including regulations regarding underground wires. As previously noted, "The Electricity Generation Customer Choice and Competition Act" requires the competitive energy market to remain as reliable as it was when it was regulated.[65] The PUC has adopted metrics tracking energy reliability for each major EDC for this reason. The metrics adopted by the PUC are nationally recognized industry standards created by the Institute of Electrical and Electronics Engineers (IEEE)[66]:

- SAIFI: System Average Interruption Frequency Index shows the frequency of outages. Lower values of this metric mean less interruptions and better electric reliability.
- CAIDI: Customer Average Interruption Duration Index or shows the duration of outages. The lower the number of minutes, the faster the utility restored service to customers.
- SAIDI: System Average Interruption Duration Index or shows the frequency of sustained outages. Low values of this number equate to better reliability.

To measure how reliable electric service is, the PUC has created benchmarks for EDCs comparing their performance to those of the five years prior to the deregulation of the energy market. The PUC notes that an "EDC that consistently fails to achieve benchmark performance is considered out of compliance with the performance regulations and may require a robust corrective action plan, re-organization of management objectives, and/or regulatory penalties."[67] While these benchmarks were created with the understanding that EDCs will face some disruptions from inclement weather, increases in the number of storms have caused an increasing number of EDCs within Pennsylvania to fail to achieve their benchmarks in recent years.

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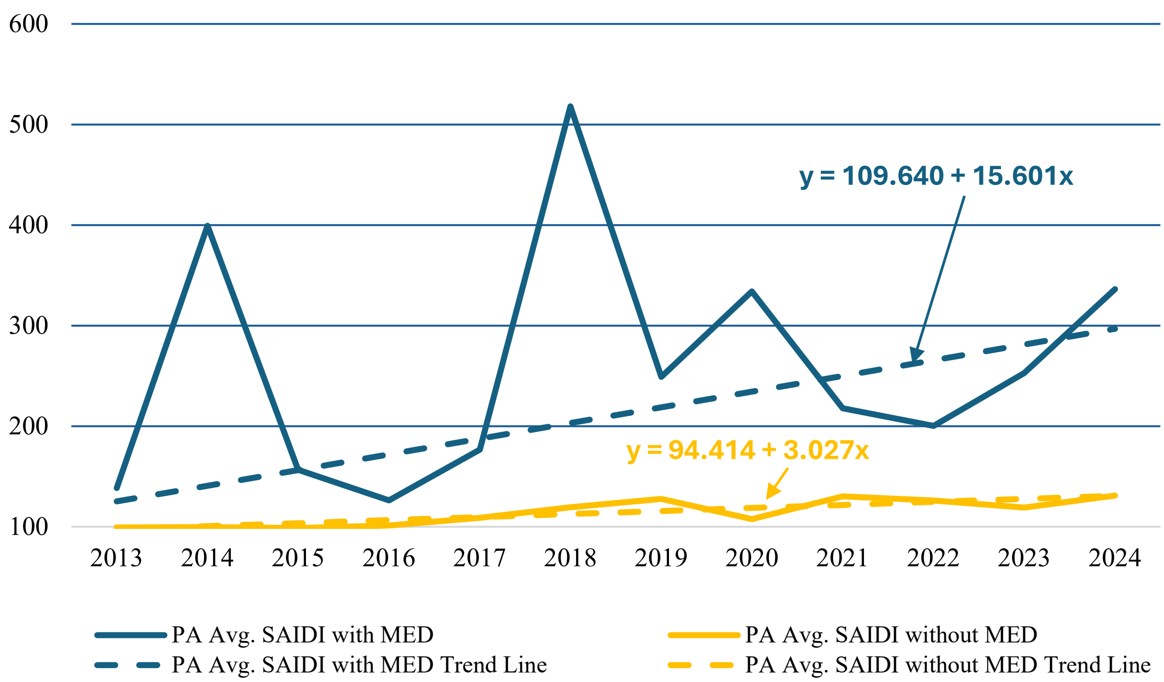
[65] 66 Pa.C.S. § 2801 et seq., added by the act of December 3, 1996 (P.L. 802, No. 138).
[66] Paul Diskin, "2024 Pennsylvania Electric Reliability Report," August 2025, https://www.puc.pa.gov/media/3782/24_-electric-reliability-report_final.pdf.
[67] Paul Diskin, "2024 Pennsylvania Electric Reliability Report," August 2025.

According to the PUC's reliability reports, many EDCs have struggled in recent years. Each year, the PUC reports both a rolling one- and three-year averages based on quarterly reports sent from the EDCs. For the latest information available at the time of this report, during the 2024 year, only three out of eleven EDCs achieved their reliability benchmarks for both 12 month and three-year periods. While DLC and PECO have consistently met SAIFI measures since 2018, PPL has not met them since 2024, when PPL experienced 17 outage events, the highest of any EDC since 1993.[68] In fact, 2024 was a high point in reportable outage events since 1993 with 74 events. Of the 11 EDCs, DLC, PECO, and PPL had spent the most on their improvement plans and tended to perform better on SAIFI. Despite increased spending on reliability, SAIFI worsened across the board in 2024 except for two smaller EDCs. More information about the performance of specific EDCs operating within the Commonwealth may be found on the PUC's website, and a new report detailing 2025 reliability metrics will be released in late summer of 2026.

Graph 1
PA SAIDI With and Without Major Event Days
2026



Source: JSGC Staff Analysis of "Annual Electric Power Industry Report, Form EIA-861 detailed data files," Years 2013-2024, data provided by US, EIA, https://www.eia.gov/electricity/data/eia861/, accessed June 5, 2026.

[68] Paul Diskin, "2024 Pennsylvania Electric Reliability Report," August 2025.

Looking at the four largest EDCs who cover the largest service areas within the state reveals that over the last decade, the average number of minutes for outages across normal operations has increased on average by 3 minutes a year.[69] When outages from major event days (MED) are included, it has increased by an average of 16 minutes a year. In 2024, the average estimated time that Pennsylvania spent without power per year was 131 with MED excluded and 336 minutes including MED.[70] See Graph 1.

The PUC expects that reported data for 2025 will show that measures like CAIDI have increased due to EDC spending on automation technology that leads to faster response and repair of outages. However, as noted in the reliability report, while reducing outage times is critically important, prevention is a desirable long-term goal.[71] Looking at the increases in outages due to major events helps strengthen the case for hardening measure such as undergrounding, because as noted in the previous chapter of the report, major events are becoming the norm rather than the exception.

While overall EDC reliability performance appears to be worsening, analysis has revealed that the reliability of Pennsylvania electric service is approximately in line with its neighboring states. Taken all together, these states had similar levels of outages when MED were removed. With MED, the region trended higher than Pennsylvania alone. See Graph 2. Regardless of MED, New York, New Jersey, Delaware and Maryland were consistently achieving fewer minutes of outages, and Ohio's SAIDI scores were closest to Pennsylvania's. West Virginia was an outlier that experienced significantly higher outages than its neighbors did. As a region its trend was only a minute more a year without MED, and approximately 9 more minutes of outages a year with them included.[72]

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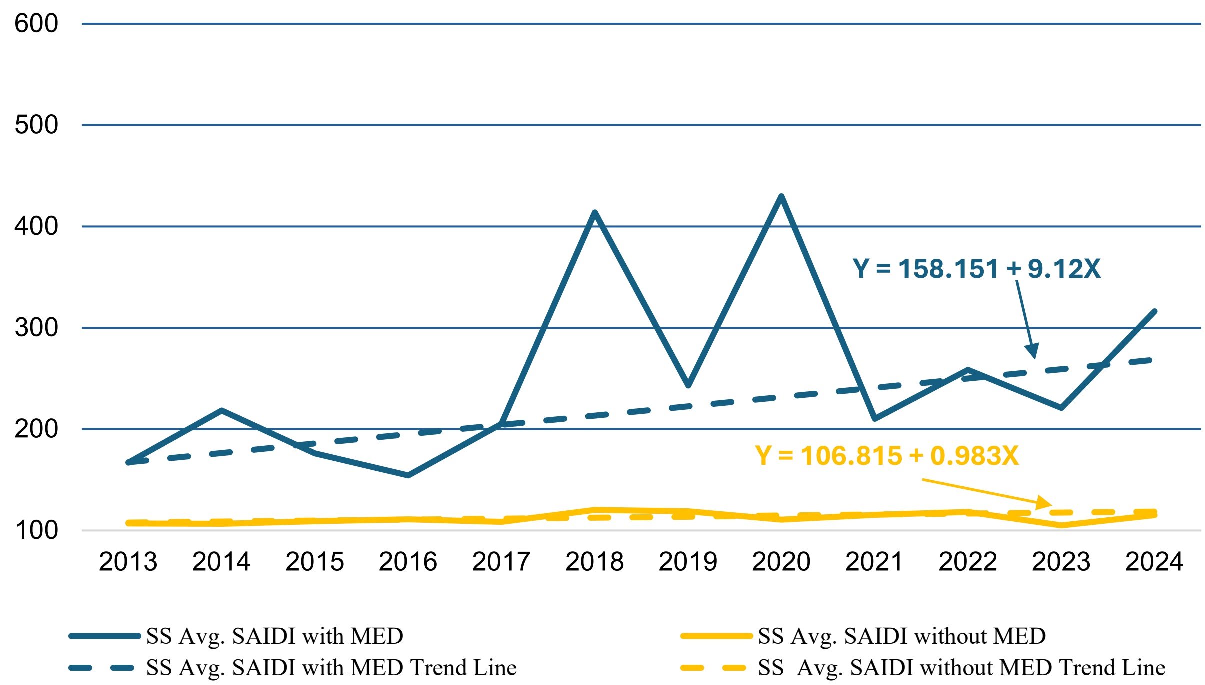
[69] JSGC Staff Analysis of "Annual Electric Power Industry Report, Form EIA-861 detailed data files," Years 2013-2024, Data provided by US Energy Information Admin., https://www.eia.gov/electricity/data/eia861/, Outlier years 2014 and 2018 excluded.
[70] JSGC Staff Analysis of "Annual Electric Power Industry Report, Form EIA-861 detailed data files," Years 2013-2024, Data provided by US Energy Information Admin., https://www.eia.gov/electricity/data/eia861/.
[71] Paul Diskin, "2024 Pennsylvania Electric Reliability Report," August 2025.
[72] JSGC Staff Analysis of "Annual Electric Power Industry Report, Form EIA-861 detailed data files," Years 2013-2024, Data provided by US Energy Information Admin., https://www.eia.gov/electricity/data/eia861/. Outlier years 2018 and 2020 excluded.

Graph 2
PA and Surrounding States SAIDI
With and Without Major Event Days
(Minutes of Outages)
2026



Source: JSGC Staff Analysis of "Annual Electric Power Industry Report, Form EIA-861 detailed data files." Years 2013-2024, Data provided by US. EIA. https://www.eia.gov/electricity/data/eia861/. Accessed June 5, 2026

Graph 3 demonstrates a similar trend reveals itself when comparing Pennsylvania's performance to that of the nation as a whole. The United States has an average SAIDI of 126 minutes, only slightly lower than Pennsylvania's 131. With major event days included in this calculation, the US jumps to 611 minutes compared to Commonwealth's 336 minutes. Including MED, average outage time within the US is growing by 26 minutes a year. Overall, when MED are excluded, Pennsylvania is a very good approximation for a nation as a whole.[73] Pennsylvania will likely never be the worst performing state in reliability. Despite the worsening weather, it is not comparable to the extreme storms experienced Maine, Georgia, Florida, South Carolina and Texas.

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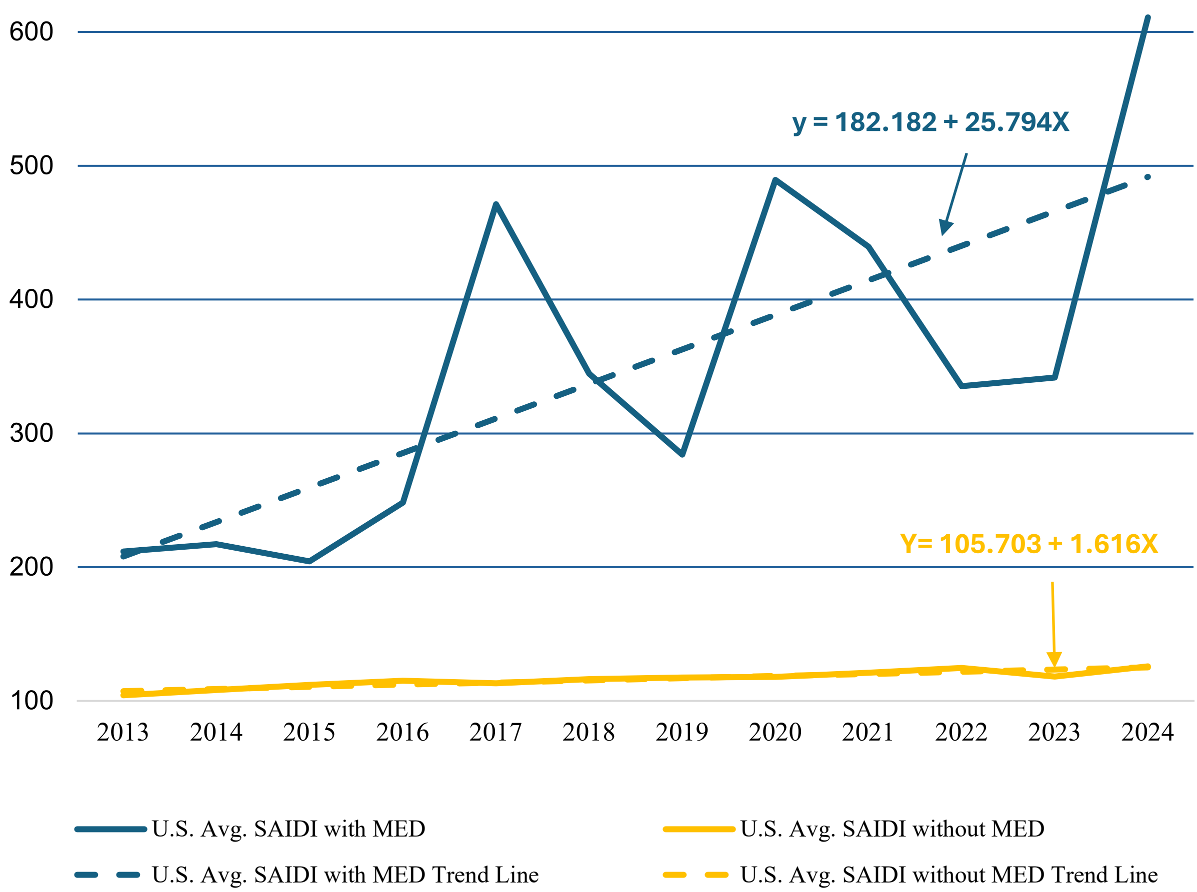
[73] JSGC Staff Analysis of "Annual Electric Power Industry Report, Form EIA-861 detailed data files," Years 2013-2024, Data provided by US Energy Information Admin., https://www.eia.gov/electricity/data/eia861/.

Graph 3
US SAIDI
With and Without Major Event Days
2026



Source: JSGC Staff Analysis of "Annual Electric Power Industry Report, Form EIA-861 detailed data files." Years 2013-2024, Data provided by US. EIA. https://www.eia.gov/electricity/data/eia861/. Accessed June 5, 2026

Overall while the relatively flat national SAIDI (excluding MED) shows that actions are being taken by state regulators and EDCs to keep service reliable, the growing resilience gap between average outage times increased from an average of hour and two-thirds to over six hours over an eleven year period.[74] Hardening infrastructure through measures such as stronger poles, more vegetation management, and undergrounding power lines may help to shrink the so called 'resiliency gap' that has been widening as additional MED days are excluded.

[74] JSGC Staff Analysis of "Annual Electric Power Industry Report, Form EIA-861 detailed data files," Years 2013-2024, Data provided by US Energy Information Admin., https://www.eia.gov/electricity/data/eia861/.

Commission staff recommend that the PUC consider presenting analysis of company performance both with and without major event days in their annual reliability reports. Similarly, greater tracking and transparency surrounding the amount of time necessary for an EDC to completely restore service after major outage events may encourage strategies like strategic undergrounding, which have the potential to reduce such lengthy outages.

Bringing greater transparency and more public accountability for electricity distribution companies' performance during severe weather may help encourage necessary investment in hardening their systems. If system performance does not improve following increased hardening measures, it may be necessary to statutorily increase PUC enforcement abilities so that the EDCs are held to a standard that is in the best interest of Pennsylvania's future rather than tying performance to reliability metrics that existed prior to deregulation.

Power Outages

The changing global climate is likely to alter the variables that the Commonwealth must consider regarding the reliability of its electricity distribution system because extreme weather events can compound the risk of power outages.[75] Overhead power lines and other components of electrical grid are vulnerable to the pressure of high winds from hurricanes, tornadoes, and windstorms and from ice buildup during winter storms, all of which occur with increasing frequency in Pennsylvania.[76] Recent data on power outages demonstrates the effect of increasing extreme weather events on the state's electrical grid.

In Pennsylvania, 52 Pa. Code §67.1.b sets the requirement for utility companies to report outages to the Pennsylvania Public Utility Commission (PUC):

> All electric, gas, water, steam and telephone utilities shall notify the Commission when 2,500 or 5.0%, whichever is less, of their total customers have an unscheduled service interruption in a single event for 6 or more projected consecutive hours.[77]

Between 1994 and 2024, there were 988 total reportable outage events that meet these criteria and therefore recorded by electric distribution companies (EDCs). Graph 4 shows the count of each year's events over the last 31 years. In the 1990s, the average number of outages per year was under 15. In the 2000s, there were over 29 outages per year on average. The average in the 2010s increased to nearly 34 events per year, and the average in the 2020s thus far is over 54 per year. The PUC has indicated that 2024 was a 32 year high in the number of reportable outages occurring within the state.[78]

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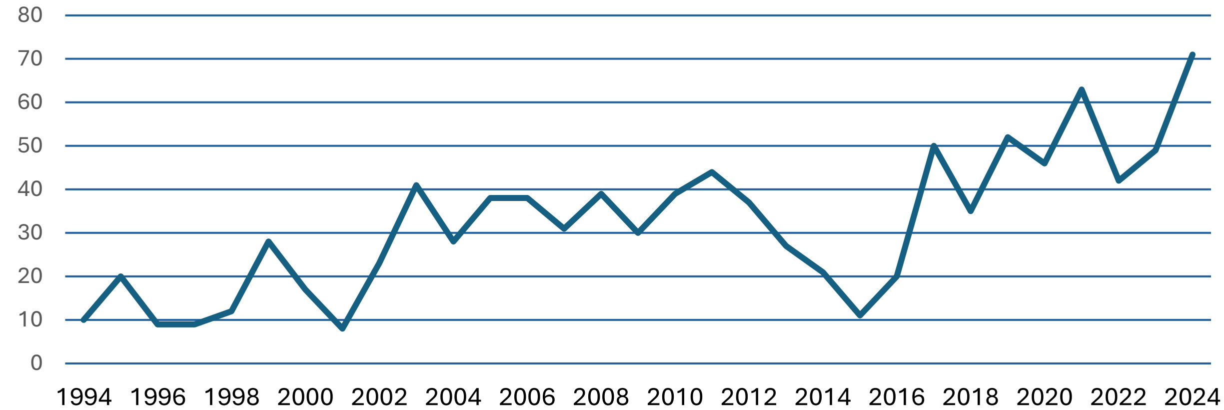
[75] Tekai Eddine Khalil Zidane et al., "Power Systems and Microgrids Resilience Enhancement Strategies: A Review," *Renewable and Sustainable Energy Reviews* 207 (January 2025): 1, https://doi.org/10.1016/j.rser.2024.114953.
[76] Chong Wang et al., "Resilience Enhancement With Sequentially Proactive Operation Strategies," *IEEE Transactions on Power Systems* 32, no. 4 (2017): 2849, https://doi.org/10.1109/TPWRS.2016.2622858.
[77] Public Utilities, 52 Pa. Code §67.1.b, accessed March 13, 2026, https://www.pacodeandbulletin.gov/Display/pacode?file=/secure/pacode/data/052/chapter67/chap67toc.html.
[78] Paul Diskin, "2024 Pennsylvania Electric Reliability Report," August 2025, 6.

Graph 4
Count of Reportable Outage Events in Pennsylvania
1994-2024



Source: Paul Diskin, *Pennsylvania Electric Reliability Report 2024;* Table 4.

Likewise, the number of Pennsylvania customers affected by power outages has steadily increased over the years as Graph 5 demonstrates, the number of customers affected varies greatly from year to year but is trending upward. PUC notes that the increase is comparable across all EDCs with varying levels of infrastructure improvement plans, indicating a systemic cause of increasing outages beyond the aging grid.[79]

Graph 5
Count of Customers in Pennsylvania Affected by Reportable Outages
1994-2024

Source: Paul Diskin, *Pennsylvania Electric Reliability Report 2024*; Table 5.

[79] Paul Diskin, "2024 Pennsylvania Electric Reliability Report," August 2025, 6.

Notably, however, the average number of customers affected by a reportable outage has decreased over the years, as Graph 6 demonstrates. This trend toward decrease persists even if the anomalous data from 1998 of 203,261 affected customers is disregarded. This improvement is likely due to modern systems which are capable of quickly isolating damage and rerouting power.

Graph 6
Average Number of Customers Affected Per Reportable Outage by Year
1994-2024

Source: Diskin, *Pennsylvania Electric Reliability Report 2024*; Table 5; the averages calculated by JSGC staff.

Role of Weather Events

Weather events contribute to most outages in Pennsylvania. The most recent state hazard mitigation plan published in 2023 by the Pennsylvania Emergency Management Agency (PEMA) identifies and profiles 33 natural and anthropogenic hazards relevant to the Commonwealth.[80] Drawing upon this list, the diverse and idiosyncratic categories of outage causes reported by PUC across 11 years were consolidated to five:

- Hailstorm
- Hurricane, Tropical Storm, Nor'easter
- Tornado, Windstorm
- Transportation Incident
- Winter Storms

Commission staff supplemented this list with *equipment failure* and *vegetation* as outage causes in addition, resulting in the seven categories that are shown in Table 3. Commission staff has gathered and processed the data from 2014 to 2024 for analytic purposes. Mainly, the staff has

[80] *Commonwealth of Pennsylvania 2023 Hazard Mitigation Plan* (Michael Baker International, 2023), https://www.pa.gov/content/dam/copapwp-pagov/en/pema/documents/m, xiv-xviii.

categorized and consolidated stated causes of outages, e.g., Tropical Storm Debby remnants from August 2024 is included in the same category as Hurricanes and Nor'easters.

Table 3
Reportable Outages by Causes
2014-2024

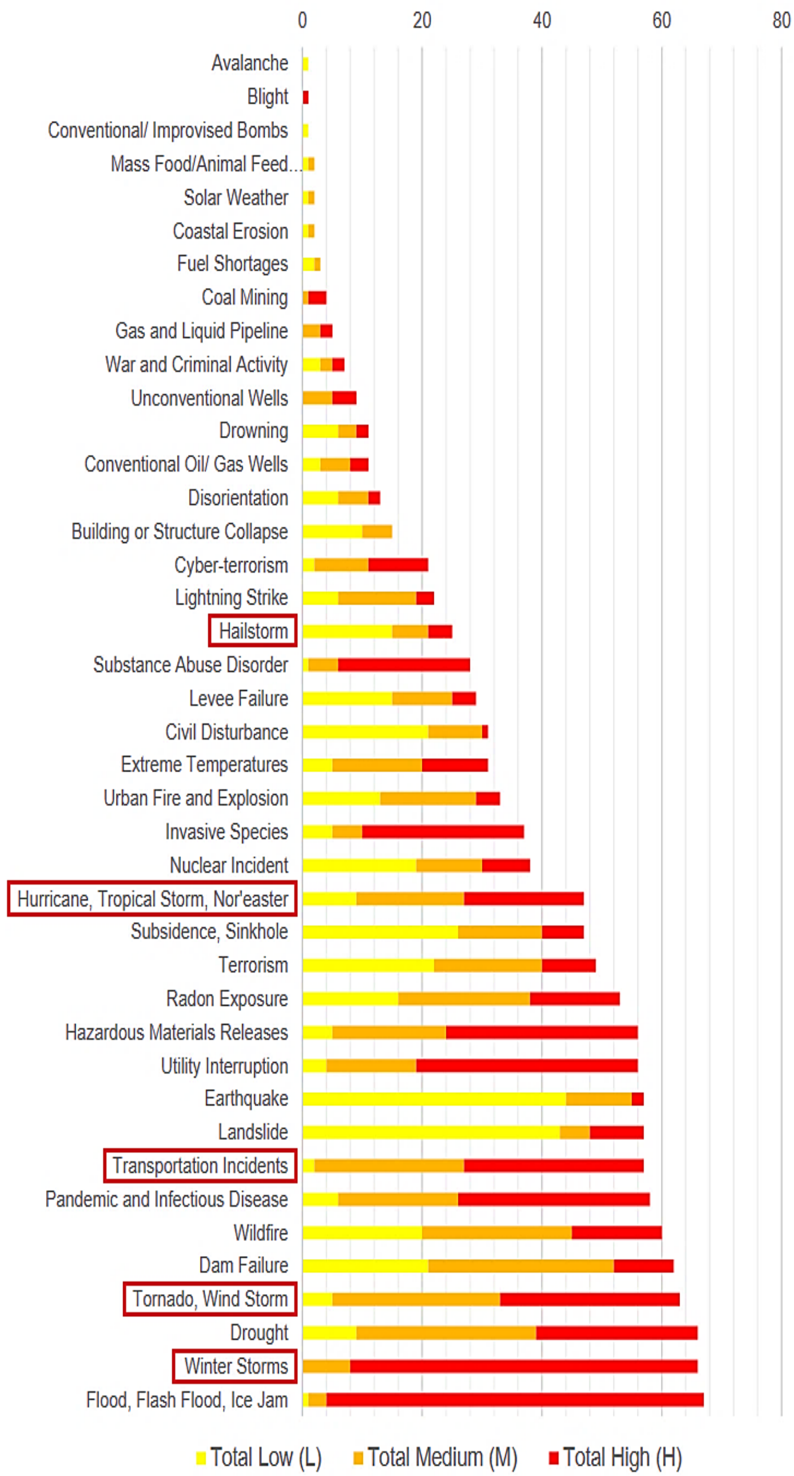
Consolidated Causes	Total Count
Equipment Failure	12
Hailstorm	1
Hurricane, Tropical Storm, Nor'easter	14
Tornado, Wind Storm	332
Transportation Incident	1
Vegetation	51
Winter Storms	56
Total Reportable Outage Events	467

Source: Compiled from PUC annual reliability reports (2014-2024); "Electric Service Reliability Report," *Pennsylvania Public Utility Commission*, accessed March 13, 2026, https://www.puc.pa.gov/filing-resources/reports/electric-service-reliability-report/.

Storms that accompany high winds cause the most damage, with tornadoes and windstorms resulting in 332 outages between 2014 and 2024, or approximately 30 outages per year. Winter storms that accompany icy conditions cause the second most damage, with 56 outages, or approximately 5 outages per year. Vegetation, e.g., a tree falling, closely follows with 51 outages. Equipment failure is uncommon, causing fewer outages than hurricanes.

This pattern corresponds to hazards most relevant to Pennsylvania municipalities. Graph 7 highlights what county officials consider to be relevant hazards according to their risk assessments. Red rectangular markers indicate the categories adopted for classifying outages. PEMA reviewed hazard mitigation plans published by county governments and universities throughout the Commonwealth and summarized the profiled hazards. Most officials view winter storms, tornadoes, and windstorms as relevant and high-risk hazards. Comparatively, hurricanes, tropical storms, nor'easters, and hailstorms are not considered to be as urgent. They nevertheless rank in the middle among 41 profiled hazards.

Graph 7
Count and Characterization of Hazards Profiled in County Hazard Mitigation Plans across Pennsylvania



Source: *Commonwealth of Pennsylvania 2023 Hazard Mitigation Plan*, 111; Figure 4.1.4-1; red rectangular markers added by JSGC staff.

As PUC's data demonstrate, the effects of climate change are becoming more pronounced with more reportable outages and more affected customers. In the future, Pennsylvania's climate is set to become even more prone to extreme weather events such as windstorms and winter storms, which are known to cause most outages.

Severe Storms, Tropical Cyclones, and Winter Storms

According to the National Oceanic and Atmospheric Administration, storms are generally the most frequent and costliest disasters in Pennsylvania. Tallying up all events that affected Pennsylvania which cost over $1 billion, severe storms, tropical cyclones, and winter storms in total constituted 100 out of 114 disasters, or 87.7 percent, and resulted in 86.5 percent of the total cost between 1980 and 2024. See Table 4.

Table 4
Billion Dollar Events
Pennsylvania
1980-2024

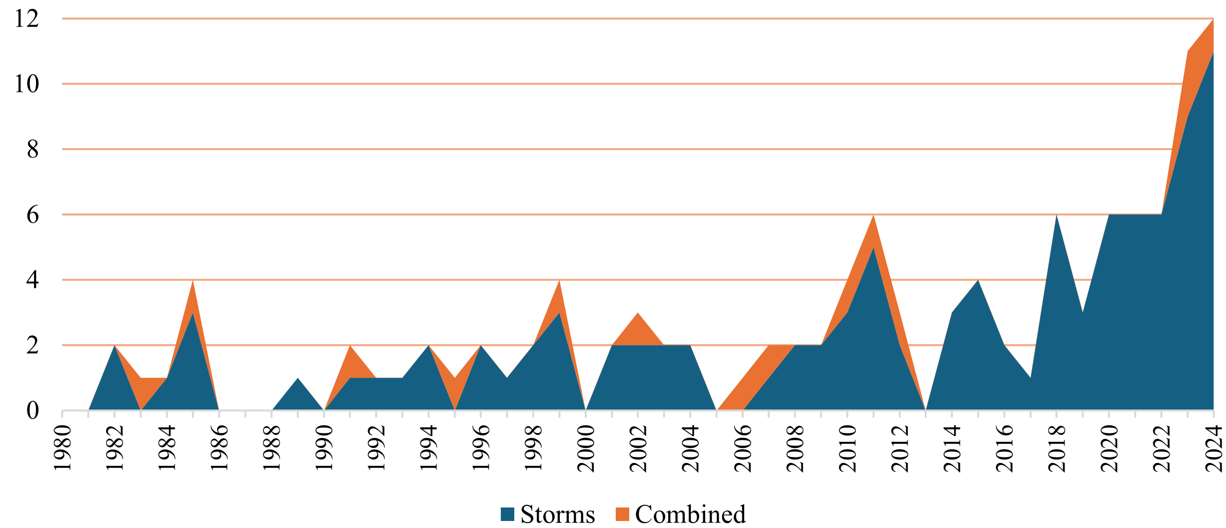
Disaster Type	Events	Events per Year	Percent Frequency	Total Costs $ Billion (CPI adjusted)	Percent Total Costs
Drought	8	0.2	7.0%	$2.5	8.7%
Flooding	5	0.1	4.4	1-2	4.5
Freeze	1	0.0	0.9	.10-.25	0.4
Severe Storm	64	1.4	56.1	5-10	32.5
Tropical Cyclone	16	0.4	14.0	10-20	40.5
Wildfire	--	--	--	--	--
Winter Storm	20	0.4	17.5	2-5	13.5
All Disasters	114	2.5	100.0	20-50	100.0

Source: Smith, "US Billion-Dollar Weather and Climate Disasters, 1980 - Present (NCEI Accession 0209268)."

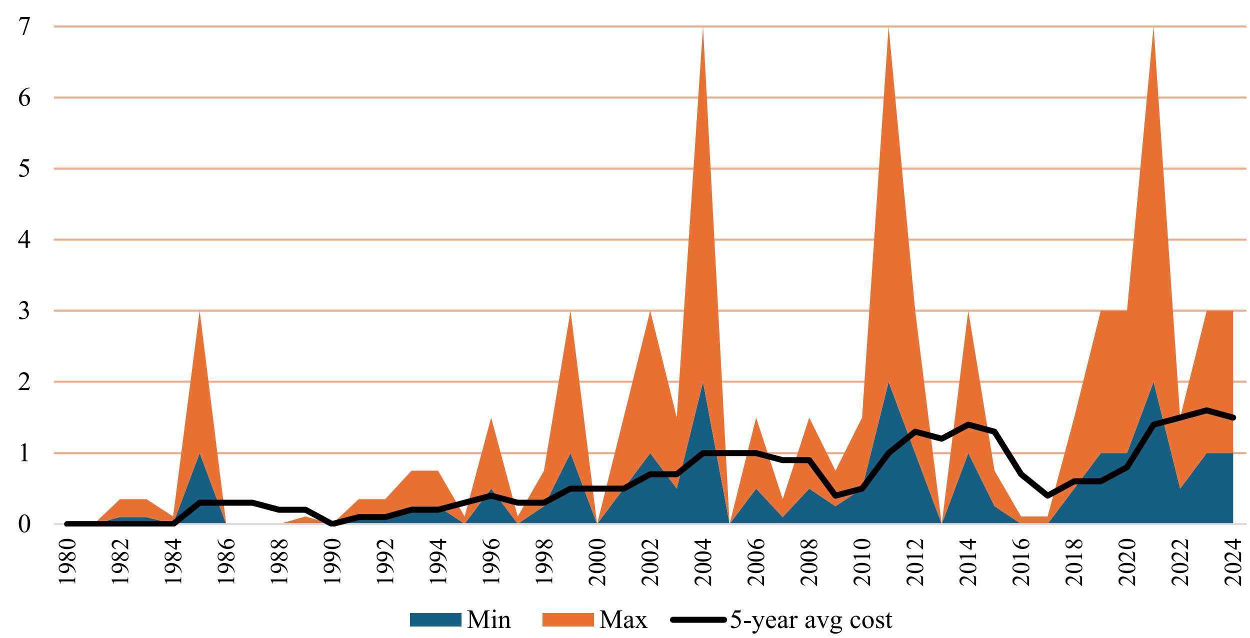
Since 2010, the storms collectively constituted 67 out of 73 disasters, or 91.8 percent, and resulted in 93.4 percent of the total cost.[81] As Graph 8 demonstrates, the frequency of natural disasters has been increasing since 2010, and severe storms, tropical cyclones, and winter storms account for the absolute majority of that increase. This is relevant for undergrounding as the majority of past instances of reported power outages have been due to storms and storm-related events.

[81] Adam B. Smith, "U.S. Billion-Dollar Weather and Climate Disasters, 1980 - Present (NCEI Accession 0209268)," NOAA National Centers for Environmental Information, 2020, https://doi.org/10.25921/STKW-7W73.

Graph 8
Billion-Dollar Event Count by Year, 1980-2024
(Consumer Price Index Adjusted)



Graph 9
Cost Range in Billions of Weather and Climate Events by Year, 1980-2024
(Consumer Price Index Adjusted)



Source: Smith, "US Billion-Dollar Weather and Climate Disasters, 1980 - Present (NCEI Accession 0209268)," Graph created by JSGC staff.

The total cost of these billion-dollar events has also risen over the last forty years. See Graph 9. However, this source provides an incredibly wide range between its maximum and minimum costs associated with such events highlighting the uncertainty over the true cost of how damaging such events are. In recent years the 5-year average cost has neared $1.5 billion a year.

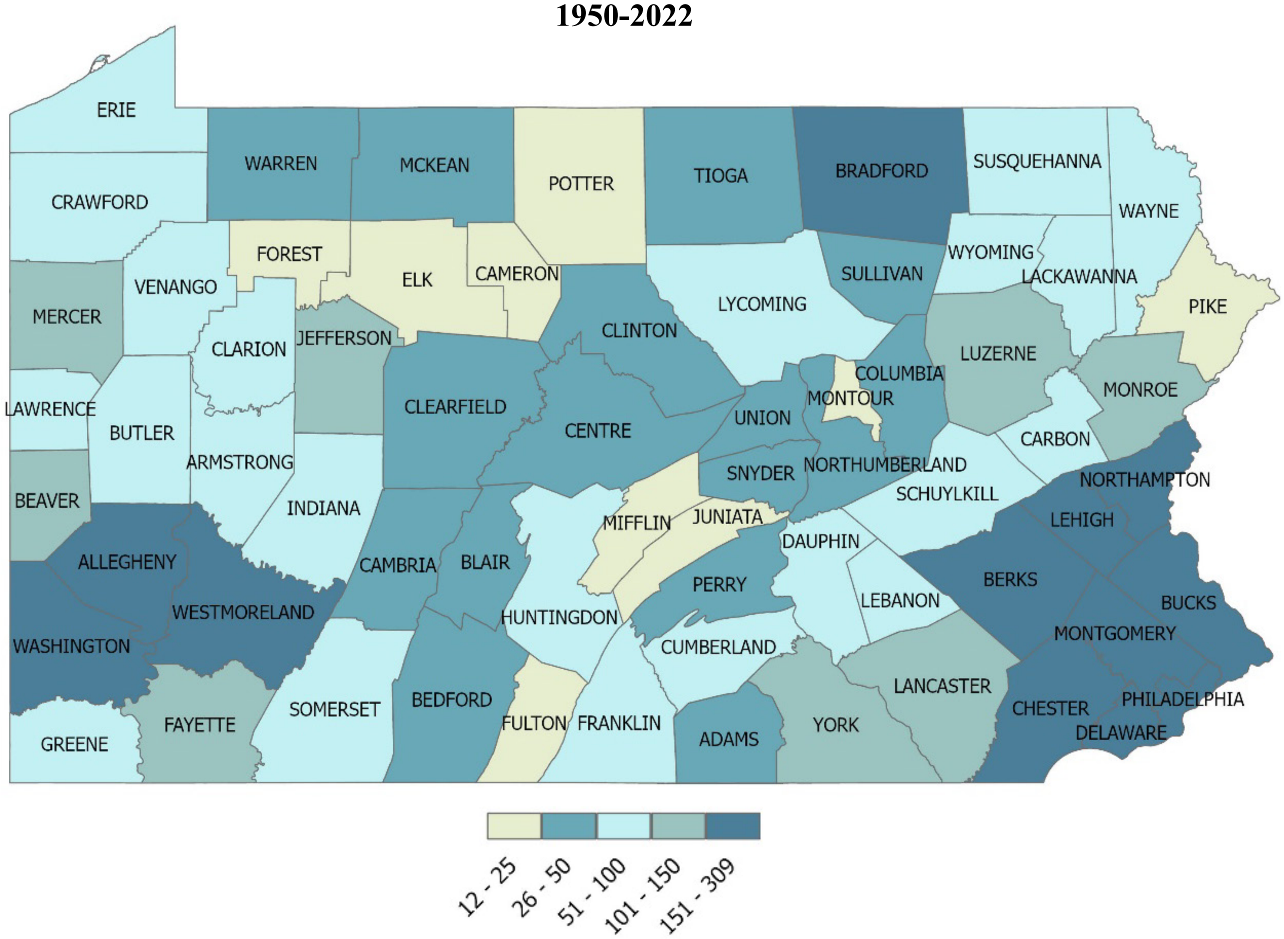
While the number of and damage from storms has risen, tropical cyclones are likely to have comparatively limited effects on the state due to Pennsylvania's inland location. Researchers from the Pacific Northwest National Laboratory (PNNL) and the Electric Power Research Institute (EPRI) modeled future outages across the Gulf Coast, the Eastern Seaboard, and Puerto Rico by applying the simulated data of 900,000 synthetic tropical cyclones based on historical and changing climate patterns.[82] The simulation results show a widespread increase in outages and the number of affected people in all coastal counties from Texas to Maine. The States like Rhode Island, Florida, Massachusetts, and Connecticut are expected to experience heightened risk from tropical cyclones. In Pennsylvania, southeastern counties such as Philadelphia, Delaware, Chester, Montgomery, Bucks, and Berks are predicted to experience more frequent outages due to tropical cyclones.[83] However, the researchers predict that the degree of risk increase in these counties would be lower than that experienced by New England and Florida.[84]

Precipitation and Flooding

Flooding is the most common and widespread of all natural disasters caused by weather in the US and is prevalent in Pennsylvania as well.[85] According to the Federal Emergency Management Agency (FEMA), there have been 17 major disaster or emergency declarations in Pennsylvania since 2017. Four of them involved flooding as an explicitly stated reason: Severe Storms and Flooding in November 2018; Severe Storms and Flooding in December 2016; Severe Storms, Tornadoes, and Flooding in October 2013, and; Severe Storms and Flooding in July 2011.[86] Map 11 shows three areas of the state especially prone to flooding: the Delaware Valley around Philadelphia, the counties surrounding Pittsburgh, and Bradford County in the northeast.

[82] Julian R. Rice et al., "Projected Increases in Tropical Cyclone-Induced U.S. Electric Power Outage Risk," *Environmental Research Letters* 20, no. 3 (2025): 1, https://doi.org/10.1088/1748-9326/adad85.
[83] Rice et al., "Projected Increases in Tropical Cyclone-Induced U.S. Electric Power Outage Risk," 5.
[84] Rice et al., "Projected Increases in Tropical Cyclone-Induced U.S. Electric Power Outage Risk," 5.
[85] "Flood Basics," *NOAA National Severe Storms Laboratory*, accessed March 13, 2026, https://www.nssl.noaa.gov/education/svrwx101/floods/.
[86] "Disasters and Other Declarations," *Federal Emergency Management Agency*, accessed March 13, 2026, https://www.fema.gov/disaster/declarations.

Map 11
Historical Flood Events
1950-2022



Source: *Commonwealth of Pennsylvania 2023 Hazard Mitigation Plan*, 250.

As Figure 4 demonstrates, Pennsylvania will experience more precipitation and more consecutive dry days, meaning a higher likelihood of extreme precipitation events punctuated by longer dry days.[87] In fact, the Pennsylvania Department of Environmental Protection (DEP) raised the projected increase in statewide average annual precipitation in the mid-21st century from 8 percent in its 2021 edition of the Climate Impact Assessment to 9 percent in its 2024 edition.[88] This comports with a literature review of hydrological research articles by the US Geological Survey (USGS) from 2025. The scientific consensus states that the Northeastern US will experience heavier and prolonged precipitation events from hereon.[89]

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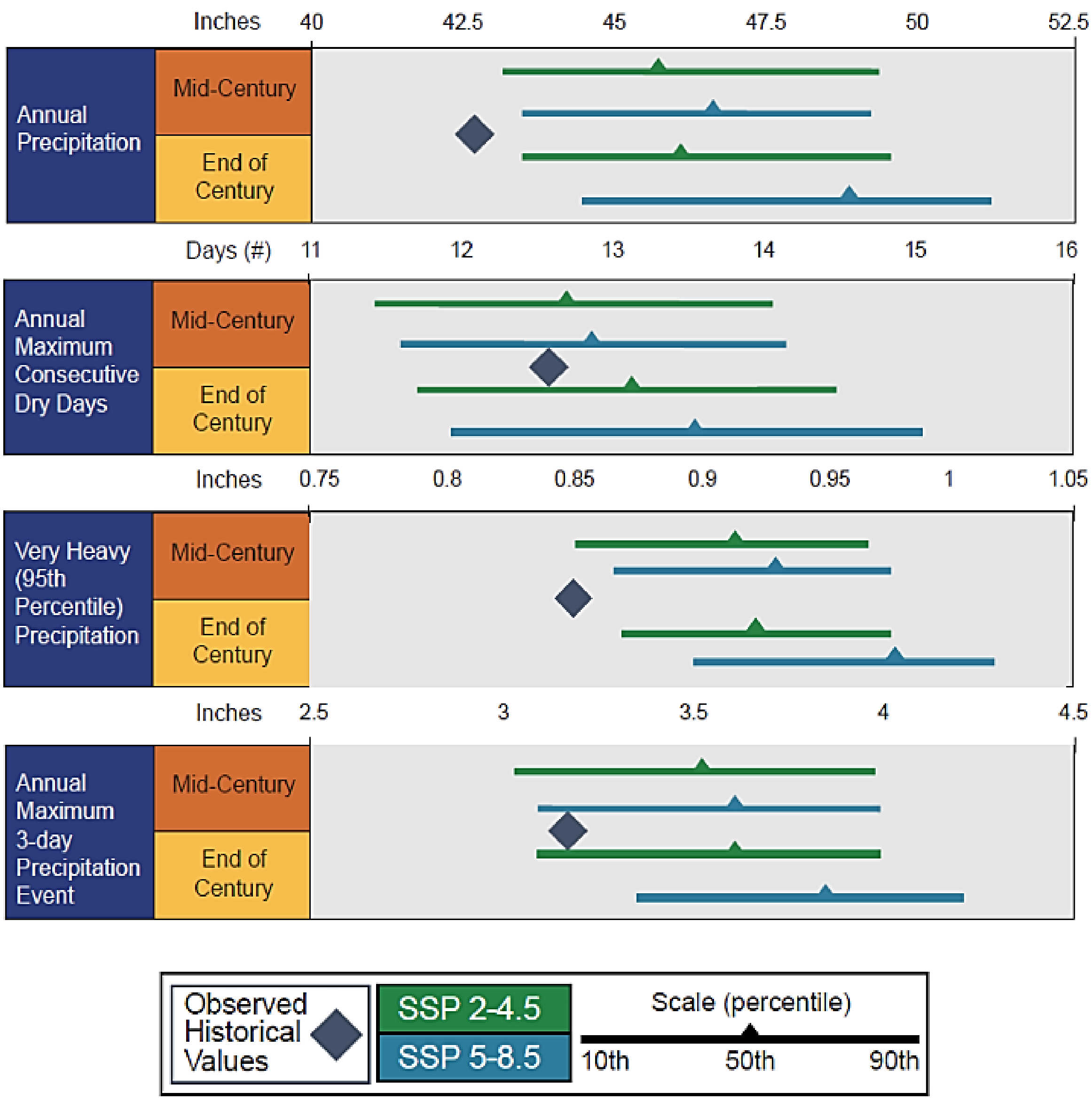
[87] SSP stands for Shared Socioeconomic Pathways. According to the DEP, Scenarios of projected greenhouse gas emissions, socioeconomic situations, and atmospheric concentrations used in climate modeling. SSP 5-8.5 represents a global "unabated" scenario and SSP 2-4.5 represents a lower, "middle of the road", emission scenario.

[88] *Pennsylvania Climate Impacts Assessment, 2024*, 12, 22.

[89] Martha A. Scoll et al., Climate Change and Future Water Availability in the United States, Professional Paper no. 1894-E (U.S. Geological Survey, 2025), 9, https://pubs.usgs.gov/pp/1894/e/pp1894E.pdf.

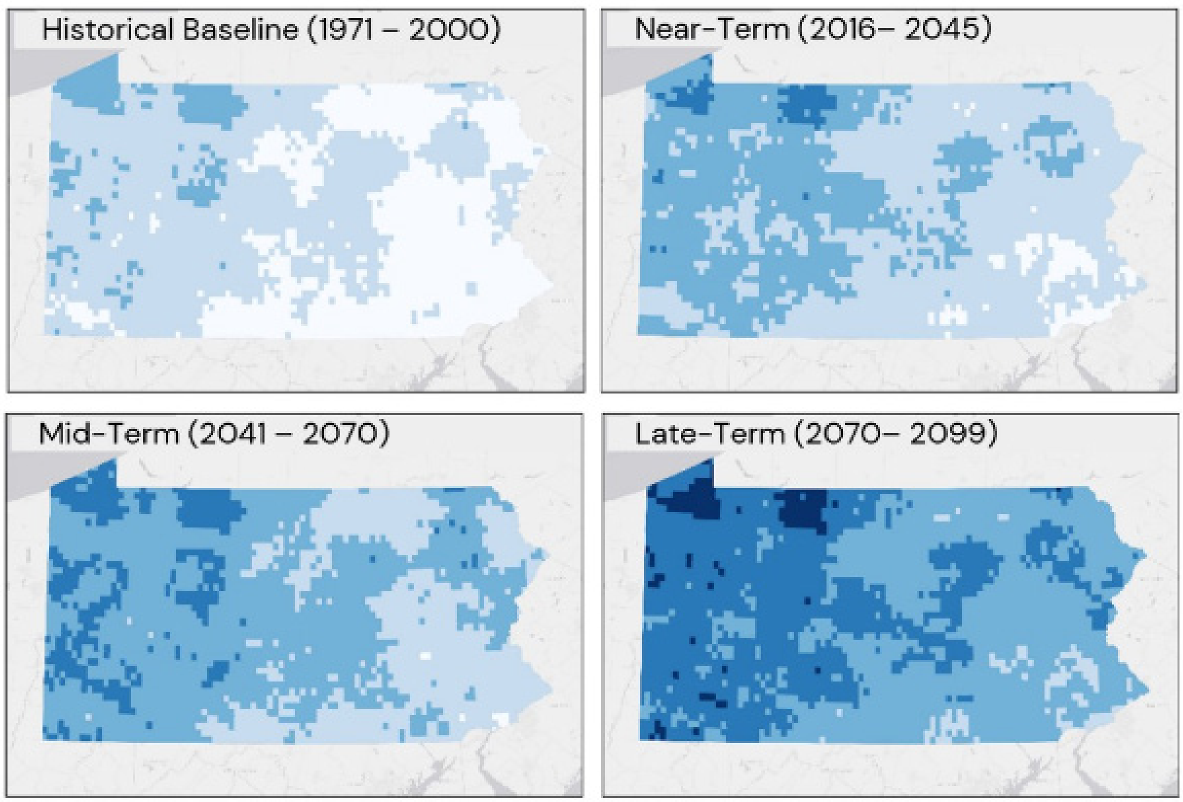
Figure 4
Mid-Century and End-of-Century Projections for Precipitation Trends under Mid-level (SSP 2-4.5) and Highest (SSP 5-8.5) Greenhouse Gas Emission Scenarios
2024



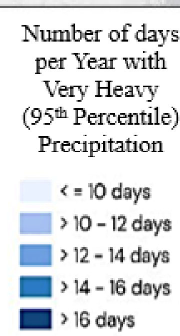
Source: *Pennsylvania Climate Impacts Assessment, 2024*, 14, https://greenport.pa.gov/elibrary/GetDocument?docId=9587655&DocName=PA%20CLIMATE%20IMPACTS%20ASSESSMENT%202024.PDF%20%20%3Cspan%20style%3D%22color%3Agreen%3B%22%3E%3C%2Fspan%3E%20%3Cspan%20style%3D%22color%3Ablue%3B%22%3E(NEW)%3C%2Fspan%3E.

Figure 5 illustrates that under the highest emission scenario, every part of Pennsylvania will experience more days with "very heavy" precipitation, which is defined as rainfall heavier than 95 percent of the days with precipitation in a year.[90] By the end of this century, Pennsylvania is projected to experience three more days of "very heavy" precipitation compared to the observed baseline.[91] This uneven distribution of increasing precipitation will render the Commonwealth more vulnerable to flooding events including flash floods and landslides, which can affect the integrity of the undergrounded power lines. With DEP predicting wetter winters and springs, ice and snowstorms may affect overhead transmission lines more frequently.[92]

Figure 5
Observed and Projected Annual Days with "Very Heavy" Precipitation
2024



Source: *Pennsylvania Climate Impacts Assessment, 2024*, 27.
Based on 50th percentile of 23-model ensemble of LOCA downscaled data, SSP 5-8.5. The "very heavy" threshold varies by grid cell, based on the 95th percentile of observed rainy days. The full range of observed and projected values is shown divided into equal increments.



[90] *Pennsylvania Climate Impacts Assessment, 2024*, 27.
[91] *Pennsylvania Climate Impacts Assessment, 2024*, 27.
[92] *Pennsylvania Climate Impacts Assessment, 2024*, 29.

Summary of Weather Events

Severe weather is leading cause of power interruptions in US. Power interruptions cause problems for residences and are disruptive to businesses and supply change. The average duration of major power interruptions has been increasing over time. As noted elsewhere in the report one of the great challenges is an increase in the number of reportable storms. There were 42 in 2022, 49 in 2023, and a record breaking 73 storms in 2024. 2025 had eight named storms, three hurricanes, and two storms with hurricane strength winds.[93]

[93] Charles Murray, "Beyond Hardening: Rethinking Storm Resilience on the Power Grid Rethinking Storm Response and Resilience on the Power Grid," Factor This™, October 1, 2025, https://www.renewableenergyworld.com/power-grid/storm-response-and-resilience-power-grid/.

ECONOMIC AND HEALTH IMPACTS

Impact of Weather-Related Power Outages

There are 180 million miles of electrical, telephone, and cable lines in the United States.[94] These wires are vital but vulnerable to weather that grows increasingly disruptive. In the east, hurricanes and storms blow branches onto lines. In the west, wildfires destroy infrastructure by burning poles and melting lines. Both threaten the reliability of the distribution grid.

In 2013, the federal government estimated that the cost of weather-relate power outages was between $18 and $33 billion dollars per year.[95] A 2015 study by Pew found that power interruptions cost businesses in the US $150 billion per year.[96] Scenic America estimates that power outages amount to $17.1 billion a year in lost economic activity. To try and combat these outages, US utilities spend $33 billion per year on vegetation management.[97]

Compounding Impacts

At the same time, electrification and the rise of digital economy have made the US far more dependent on electricity than ever before, which has increased the public's demand for reliable electric service. Many sectors across all industries rely on electricity to complete everyday tasks, which exacerbates the economy-wide impact of a power outage event.

For example, a 2012 report by the Congressional Research Service (CRS) cited the digital economy, continuous process manufacturing, and fabrication and essential services, which altogether make up 40 percent of the US gross domestic product (GDP), as the sectors especially vulnerable to power outages.[98] In the third quarter of 2025, 58.9 percent of Pennsylvania's economy was made up of industries that at least, in part corresponded to the digital economy, manufacturing, and essential services.[99]

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[94] Scenic America, "Burying Utilities for Safety, Resiliency, and Scenic Beauty," accessed July 30, 2026, https://www.scenic.org/why-scenic-conservation/undergrounding-utility-wires/undergrounding-utility-infrastructure/.

[95] "Economic Benefits of Increasing Electric Grid Resilience to Weather Outages," Executive Office of the President, August 2013, https://www.energy.gov/sites/prod/files/2013/08/f2/Grid%20Resiliency%20Report_FINAL.pdf.

[96] The Pew Charitable Trusts, "America's Electric Grid: Growing Cleaner, Cheaper and Stronger," Pew.org, October 27, 2015, https://www.pew.org/en/research-and-analysis/reports/2015/10/americas-electric-grid-growing-cleaner-cheaper-and-stronger.

[97] Scenic America, "Burying Utilities for Safety, Resiliency, and Scenic Beauty."

[98] Richard J. Campbell, *Weather-Related Power Outages and Electric Systems Resiliency*, no. R42696 (Congressional Research Service, 2012), https://www.congress.gov/crs-product/R42696, 7.

[99] "Regional Data: SQGDP2 Gross Domestic Product (GDP) by State," *Bureau of Economic Analysis*, accessed March 13, 2026, https://apps.bea.gov/itable/. This figure includes the following industries: manufacturing; retail trade;

The growth of the digital economy has been especially significant for power generation and consumption. The annual electricity usage by US data centers, which require a constant supply of power to ensure minimal loss of data, more than tripled between 2014 and 2023 from growing from 30 to 100 terawatt-hours (TWh).[100] By 2028, the total annual power consumption is expected to triple once more to between 240 and 380 TWh.[101] In comparison, Pennsylvania consumed 149 TWh in 2024.[102]

Beyond the economy, electricity is also indispensable for daily life, as it is necessary for adequate cooling or heating, food safety, clean water, and healthcare. Thus, the Commonwealth's grid experiences a strain from two interrelated factors: the increasing frequency of severe weather events and the increasing reliance on electricity.

Reliable power supply is crucial for a modern society to function. With climate change resulting in more extreme weather events, suppliers, consumers, and regulators must consider what kinds of impacts weather would have on the electrical grid.[103] Specifically, extreme weather events such as ice storm, floods, and hurricanes can destroy power lines, either overhead or underground, and cause outages.[104] Storms affecting overhead power lines may be cited as an argument *for* undergrounding while floods affecting underground power lines may constitute an argument *against* undergrounding. Power outages caused by these events may have wide-reaching consequences for the affected population.

Statewide Interruption of Cost Estimate

In an effort to better quantify the financial impact outages have in Pennsylvania, Commission staff utilized the Interruption of Cost Estimate tool designed by Lawrence Berkely National Laboratory and developed in partnership with the US Dept. of Energy. Statewide electricity metrics reported by the US Energy Information Administration for 2024 (the most recent year available) were input into this tool along with residential and nonresidential customer counts from PA PUC in their 2024 Retail Electricity Report. Results showed that outages in 2024 cost customers in the state an estimated $7.8 billion. It should be noted that 98.4 percent of this sum was associated with non-residential (industrial or commercial) service interruptions, meaning that residential outages accounted for only $123 million of this expense. The average annual cost of service interruptions per residential customer was $23.4. Inputting previous years of customer counts and reliability data resulted in $5.5 billion in service interruption costs in 2022 and $6.1 billion in 2023.

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transportation and warehousing; information; finance and insurance; real estate and rental and leasing; professional, scientific, and technical services; management of companies and enterprises; administrative and support and waste management and remediation services.

[100] Geoff Hamm, *2024 United States Data Center Energy Usage Report* (Lawrence Berkely National Laboratory, 2025), https://doi.org/10.71468/P1WC7Q, 49.

[101] Hamm, *2024 United States Data Center Energy Usage Report*, 49.

[102] "Pennsylvania Electricity Profile 2024," *U.S. Energy Information Administration*, November 10, 2025, https://www.eia.gov/electricity/state/Pennsylvania/index.php; the total calculated from the addition of total retail sales and direct use electricity.

[103] Ben Clarke et al., "Extreme Weather Impacts of Climate Change: An Attribution Perspective," *Environmental Research: Climate* 1, no. 1 (2022): 1–2, https://doi.org/10.1088/2752-5295/ac6e7d.

[104] *Pennsylvania Climate Impacts Assessment, 2024*, nos. 7200-RE-DEP6046 (Pennsylvania Department of Environmental Protection, 2025), 68.

Health Impacts of Power Outages

A 2023 article reviewed 50 studies on social impacts of power outage in North America to identify a number of themes. There were 24 studies focused on the relationship between power outages and health impacts.[105]

- Physical health impacts: an increase in emergency department (ED) visits from failing infrastructure, e.g., carbon monoxide (CO) poisoning from improper use of private generators.
- Mental health impacts: a prolonged service interruption can lead to anxiety, depression, stress, and even post-traumatic stress disorder (PTSD); stressed individuals may become dependent on addictive substances to cope, resulting in injuries and deaths.
- Food-related impacts: increased spoilage leads to more food-borne illnesses.
- Medical devices: individuals reliant on at-home care or regular treatments using medical devices are especially vulnerable to power outages.

Another major area of research was for 'Populations of Concern,' as 29 studies identifying one or more populations at a greater risk for negative outcomes during power outages.[106] These studies found that:

- Children are more vulnerable to CO poisoning.
- English as a second language speakers had language barriers prevent effective dissemination of safety messaging.
- Because of the intersectionality of race and poverty, Black Americans experienced a greater risk of being victimized by criminal activities or mental health problems during outages.
- Older adults have higher dependence on medical equipment because of age and chronic illness and are vulnerable to outages. Some researchers, however, found older adults to be more self-reliant and resilient during outages.
- Rural populations can face delayed repairs and reconnections.
- Emergency and healthcare workers are vulnerable to burnouts and fatigue during outages because of increased burdens.

Additionally, there were six articles centered on evaluating whether criminal activities increase during outages, but none demonstrated a significant relationship between a natural hazard and increased criminality.[107] However, looting may occur in isolated instances, whereby people

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[105] Adam Andresen et al., "Understanding the Social Impacts of Power Outages in North America: A Systematic Review," *Environmental Research Letters* 18, no. 5 (2023): 6, https://doi.org/10.1088/1748-9326/acc7b9.
[106] Andresen et al., "Understanding the Social Impacts of Power Outages in North America," 8.
[107] Andresen et al., "Understanding the Social Impacts of Power Outages in North America," 10–11.

attempt to acquire essential items like food and water (pro-social looting) or non-essential goods like televisions and jewelry (anti-social looting).[108]

The commonality among these themes is the fact that power outages cause various kinds of life-threatening disruptions that can lead to public health emergencies.

Another review article by researchers from Columbia, Harvard, and Stanford focuses on adverse health outcomes discussed by other studies. The impacts discussed largely coincide with those considered by Andresen et al.[109]

- Carbon monoxide poisoning: indoor use of charcoal and gasoline-powered generators to replace the electricity.
- Cardiovascular, respiratory, and renal diseases:
  - Outages during cold weather can result in more hospitalization from cardiovascular diseases. Outages during a warm season lead to more renal diseases.
  - Interrupted use of electricity-dependent breathing assistance devices exacerbates existing respiratory diseases.
- Gastrointestinal illness: Food safety and water potability directly affect gastrointestinal health.
- Temperature-related illness: A power outage exposes individuals to indoor temperature extremes.
- Maternal and neonatal health: Inability to access adequate healthcare during outages poses threats to health for vulnerable populations.
- Mental health and wellbeing: Power outages are associated with acute disruption of access to heating or cooling, food, water, and healthcare, which increase stress and anxiety in affected individuals.
- Mortality: A study of public health impacts of the Northeast blackout of 2003 found accidental and non-accidental deaths in New York City increased by 122 percent and 25 percent respectively.[110]
  - Other researchers found similar increase in mortality during New York City's major blackouts in 1999, 2003, and 2006 but could not control for the effect of the concurrent heatwave for the 1977 outage.[111]

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[108] Andresen et al., "Understanding the Social Impacts of Power Outages in North America," 11.
[109] Joan A. Casey et al., "Power Outages and Community Health: A Narrative Review," *Current Environmental Health Reports* 7, no. 4 (2020): 374–377, https://doi.org/10.1007/s40572-020-00295-0.
[110] G. Brooke Anderson and Michelle L. Bell, "Lights Out: Impact of the August 2003 Power Outage on Mortality in New York, NY," *Epidemiology* 23, no. 2 (2012): 189–93, https://doi.org/10.1097/EDE.0b013e318245c61c.
[111] Casey et al., "Power Outages and Community Health," 377.

The negative impacts of power outages are unequally distributed. Geography of outage also matters, especially in relation to urban-rural disparities and intra-urban disparities. Rural communities often lack the tax base and technical expertise to devise, implement, and manage hazard mitigation plans. At the same time, many urban communities experience a higher level of socioeconomic and infrastructure disparities caused by entrenched residential segregation borne of past policy choices. This is consequential in the aftermath of weather-induced power outages. In the study of 2020 Hurricane Isaias' effect on rural and urban parts of Connecticut, University of Connecticut researchers analyzed customers affected by power outages and recovery time, thereby elucidating trouble spots and vulnerability in rural and urban communities.[112]

Because urban communities experience denser and more complex infrastructure development, trouble spots tend to be more concentrated. However, power outages affected 60 percent of rural residents compared to one-third of urban residents.[113] In spite of Isaias' predominantly affecting urban areas in southwest like Bridgeport and New Haven, rural towns in northwest experienced the longest duration of outages and the highest density of impacted customers.[114] The concentration of trouble spots, the density of affected customers, and outage duration were all strongly correlated with poverty in rural towns.[115] In urban towns, the presence of Hispanic and Black American residents, which is associated with socioeconomic disadvantages, showed a strong correlation with the density of impacted customers and outage duration.[116]

In the case of the 2021 Texas Power Crisis, up to four million households and businesses, or one-third of the state's customers, went without power during Winter storm Uri.[117] In a 2023 study, researchers from Columbia and Stanford found through an online survey that Black or African American respondents were 1.7 times more likely to report a severe outage compared to White or Caucasian respondents.[118] Also, the county-level analysis they conducted revealed an association between increasing concentration of Hispanic residents and higher odds of power outages lasting more than 24 and 48 hours.[119] Finally, households using Medicare electricity-dependent durable medical equipment (DME) were twice more likely to report outages that last more than a day, though counties with concentrated electricity-dependent DME users showed lower outage prevalence.[120]

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[112] Francesco Rouhana et al., "Examining Rural–Urban Vulnerability Inequality in Extreme Weather-Related Power Outages: Case of Tropical Storm Isaias," *Natural Hazards Review* 26, no. 3 (2025): 7–12, https://doi.org/10.1061/NHREFO.NHENG-2235.
[113] Rouhana et al., "Examining Rural–Urban Vulnerability Inequality in Extreme Weather-Related Power Outages," 7–8.
[114] Rouhana et al., "Examining Rural–Urban Vulnerability Inequality in Extreme Weather-Related Power Outages," 8–10.
[115] Rouhana et al., "Examining Rural–Urban Vulnerability Inequality in Extreme Weather-Related Power Outages," 11.
[116] Rouhana et al., "Examining Rural–Urban Vulnerability Inequality in Extreme Weather-Related Power Outages," 11.
[117] Nina M. Flores et al., "The 2021 Texas Power Crisis: Distribution, Duration, and Disparities," *Journal of Exposure Science & Environmental Epidemiology* 33, no. 1 (2023): 1, https://doi.org/10.1038/s41370-022-00462-5.
[118] Flores et al., "The 2021 Texas Power Crisis," 4, 9, 24–25; the researchers define "severe outage" as "a county having 10,000 customers without power for at least 24 consecutive hours during the crisis," which emphasizes the geographic component of power outages.
[119] Flores et al., "The 2021 Texas Power Crisis," 8, 20–21.
[120] Flores et al., "The 2021 Texas Power Crisis," 10–11.

EFFORTS TO INCREASE ELECTRIC RELIABILITY

Across the US, 60 percent of distribution lines have surpassed their 50-year life expectancy.[121] The requirements of the grid were much different 75 years ago from today as there was less demand for electricity, fewer customers, and weather was less volatile.[122] Today's power lines also have the capability to better incorporate distributed energy resources such as wind, and solar, where energy needs to be able to flow both toward and away from generation sites as needed. Distribution lines demand more investment simply because there are more of them. Across the country, twenty-five IOUs have spent $36.4 billion to upgrade their distribution grids. Between 2018 to 2023 spending on these systems grew by 35 percent.[123] It is estimated that approximately $1.5 to $2 trillion must be spent in grid modernization investments by 2030 to maintain the current reliability of the US grid. Without this investment, electricity services are likely to become less reliable and there will be costs to repair it as well as ripples in the economy.

Infrastructure hardening, advanced metering, and distribution automation represent 80 percent of the investments made to modernize the grid.[124] All of the country's largest IOUs are spending just under $3 billion on distribution automation that could improve reliability.[125] In recent years, utilities have looked into various ways of improving systems' reliability, including smart grids, microgrids, system hardening, and usage incentive:

- Smart grids containing sensors that allow operators to assess stability and distribute information to customers.
- Microgrids are smaller self-sufficient energy systems for distinct areas like schools, hospitals, or neighborhoods.
- Hardening measures against storms (e.g. stronger poles, underground wires).
- Usage incentives (to encourage reductions of energy usage at peak times).

Federal Investments to Improve Reliability

Over the last decade, there has been some progress in increasing the number of federal infrastructure investments. the Bipartisan Infrastructure Law funded two grant programs relevant to undergrounding the "Grid Resilience State and Tribal Formula Grant" and the "Grid Resilience

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[121] Wood Mackenzie, "Going Underground: Reinventing Resilience," S&C Electric Co., June 5, 2024. https://www.sandc.com/globalassets/sac-electric/documents/technical-paper-wood-mackenzie.pdf?dt=639128149560827881, 2.
[122] Wood Mackenzie, "Going Underground: Reinventing Resilience," S&C Electric Co.
[123] Wood Mackenzie, "Going Underground: Reinventing Resilience," S&C Electric Co., 3.
[124] Wood Mackenzie, "Going Underground: Reinventing Resilience," S&C Electric Co., 3.
[125] Wood Mackenzie, "Going Underground: Reinventing Resilience," S&C Electric Co., 3.

Utility Industry Grant."[126] These are available to improve grid resilience against extreme weather, wildfire and natural disasters. One of the eligible activities for these grants is conversion of above ground power infrastructure to underground. [127] What is notable about this historic infrastructure investment is that it awarded nearly $1.3 billion in the state and tribal program through October 2024.

The Grid Resilience and Innovation Partnerships (GRIP) is a $10.5 billion program administered by the Grid Deployment Office within the US Dept. of Energy.[128] Together these programs led to a combined federal and private investments of $722 million. While Federal GRIP funding could be used for undergrounding, thus far Pennsylvania's recipients have put it to other uses, such as development of smart grids [129] Individual projects can be seen in Table 5.

Table 5
Pennsylvania GRIP Grant Recipients
2024

Organization	Federal Cost	Recipient Cost	Status	Program	Area
Delaware County Electric Co-op	$27,681,725	$9,227,242	Awarded	Grid resilience utility and industry grant	Shared
Duquesne Light Co.	19,724,715	20,215,000	Awarded	Smart Grid	PA
Exelon Business Services	100,000,000	189,678,720	Selected	Smart grid grants	Shared
PECO	100,000,000	156,761,176	Awarded	Grid resilience utility and industry grant	PA
PPL	49,500,000	49,500,000	Awarded	Smart grid grants	PA
PA Total	296,906,440	425,382,138			

Source: US Dept. of Energy. "Grid Resilience and Innovation Partnerships (GRIP) Program Projects." Energy.gov, December 2024. https://www.energy.gov/oe/grid-resilience-and-innovation-partnerships-grip-program-projects.

126 117th Congress United States. Infrastructure Investment and Jobs Act, § 40101 (2021), https://www.congress.gov/117/plaws/publ58/PLAW-117publ58.pdf.
127 Eligible Recipients include electric grid operators, electricity generators, transmission owners and operators, distribution provider.
128 "Grid Resilience and Innovation Partnerships (GRIP) Program Projects," US Dept. of Energy, December 2024. https://www.energy.gov/oe/grid-resilience-and-innovation-partnerships-grip-program-projects.
129 "Grid Resilience and Innovation Partnerships (GRIP) Program Projects," US Dept. of Energy, December 2024. https://www.energy.gov/oe/grid-resilience-and-innovation-partnerships-grip-program-projects.

Federal Smart Grid Grants from DOE are aimed at making electricity systems flexible, efficient, and reliable. For example, PPL Electric's Grid of the Future project recommended by the DOE will:[130]

- Prevent and shorten power outages through the addition of intelligent grid devices, sensors and automation on single-phase and underground networks.
- Improve system reliability and reduce maintenance costs through predictive failure monitoring technology.
- Provide real-time visibility into the grid to identify outages, changes in customer demand and fluctuations in distributed energy resources to automatically reroute power and safely balance the flow of power on the grid.
- Enable increased connections of distributed energy resources and electric vehicle adoption on the grid through IT enhancements using artificial intelligence and machine learning.

Applications for this round of the grant program closed in May of 2026 and undergrounding power lines was not explicitly listed in hardening updates.[131] Underground may be eligible; however, much of the focus is on the expansion of transmission infrastructure. While topic area 3 of the "grid innovation program" may be eligible, undergrounding projects are likely not viable due to the 50 percent cost share and 48-month project period. There is $862 million being distributed as part of this program in fiscal year 2026.[132]

Maintaining Reliability in Pennsylvania

There can be significant variation in the reliability of electrical service from year to year depending on weather events occurring across the country. For example, in 2019 Pennsylvania ranked 31st in reliability among the states, but by 2020 Pennsylvania ranked 23rd.[133] How reliability is measured is important. When major weather events are excluded, Pennsylvania's electricity service is a reliable approximation for outage times for both mid-Atlantic region and

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[130] "US Dept of Energy selects PPL Electric Utilities for grid modernization projects in Central and Eastern PA," PPL Electric Utilities, Oct. 19th, 2023, https://news.pplweb.com/U-S-Department-of-Energy-selects-PPL-Electric-Utilities-for-grid-modernization-projects-in-Central-and-Eastern-Pennsylvania.

[131] "Financial Assistance Notice of Funding Opportunity Part 1," US Dept of Energy, Feb. 4, 2026, https://files.simpler.grants.gov/opportunities/6ce21142-b06c-40c7-86ab-76735a317a42/attachments/d5bafbac-f7cd-499b-8dda-3c008f3f36f9/DE-FOA-0003580_SPARK_NOFO_Part_1_MOD_1.pdf.

[132] Taite McDonald, Katherine Hantson, Joseph Greenberg, et al, "DOE Releases $1.9 Billion Funding Opportunity for Grid Upgrades and Expansion." Mar. 2026, https://www.hklaw.com/en/insights/publications/2026/03/doe-releases-1-9-billion-funding-opportunity-for-grid-upgrades.

[133] Citizens Utility Board of Illinois, "Electric Utility Performance: A State-By-State Data Review," December 22, 2022, https://www.citizensutilityboard.org/wp-content/uploads/2022/09/Electric-Utility-Performance-Report-Second-Edition-final.pdf.

the nation as a whole.[134] Including major weather events, Pennsylvania customers spend an average of 4.5 hours without power each year, and this outage period has been growing at a rate of 16 minutes annually.[135]

One important factor in reliability woes is related to the age of the Pennsylvania energy infrastructure. Much of the infrastructure in the US was built more than 50-75 years ago which exceeds the 40 to 60 year expected lifespan for above ground poles and lines.[136] To combat the aging infrastructure, the last 15 years have seen a push to increased investment in electric companies to be more proactive with replacing outdated equipment through the Distribution System Improvement Charge (DSIC).[137] Data collection about the grid is easier since adoption of smart meters. Further advancements in technology have changed the design of the grids over time. Examples of this include radial loops to quickly reroute power to improve reliability, and a less centralized, two-way design to better accommodate distributed energy sources such as wind and solar. However, issues with reliable electrical service extend beyond the need to update equipment; increasingly it is becoming a struggle to protect what has been already built.

PA Grid Resilience Utility and Industry Grant

Recently, the Pennsylvania Department of Environmental Protection (DEP) awarded more than $15 million in grants to electric distribution companies to improve electric grid reliability and resilience through Pennsylvania Grid Resilience Grants (PA GRG) funding."[138] The goal of this funding was to shorten the duration of power outages for 60,000 Pennsylvanians living in rural areas. See Table 6.

In March 2026, DEP announced funding of $10 million to six cooperative and municipal recipients aimed at improving energy reliability through the installation of smart-grid equipment.[139] The grants were aimed primarily at increasing the reliability of electric service in rural Pennsylvania. Recipients paid $3 million in cost sharing from its awardees.

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[134] JSGC Staff Analysis of "Annual Electric Power Industry Report, Form EIA-861 detailed data files," Years 2013-2024, Data provided by US Energy Information Admin, https://www.eia.gov/electricity/data/eia861/.
[135] JSGC Staff Analysis of "Annual Electric Power Industry Report, Form EIA-861 detailed data files," Years 2013-2024, Data provided by US Energy Information Administration, https://www.eia.gov/electricity/data/eia861/; 2014 and 2018 excluded to create statistically significant result.
[136] Shalini Bhat, "Aging Electric Infrastructure in the United States | Interdisciplinary Professional Programs," Interdisciplinary Professional Programs, May 14, 2025, https://interpro.wisc.edu/aging-electric-infrastructure-in-the-united-states/.
[137] "Defining System Improvement Charges," PA Public Utility Commission, February 1, 2013, https://www.puc.pa.gov/general/consumer_ed/pdf/DSIC_FS.pdf.
[138] "Shapiro Administration Awards over $15 Million to Strengthen Rural Electric Grid and Prevent and Shorten Power Outages for Nearly 60,000 Pennsylvanians." PA Depot of Environmental Protection, Jul. 30, 2024, https://www.pa.gov/agencies/dep/newsroom/shapiro-administration-awards-over-15-million-to-strengthen-rural-electric-grid-and-prevent-and-shorten-power-outages-for-nearly-60000-pennsylvanians.
[139] "Shapiro Administration Invests $10 Million to Strengthen Electric Grid Infrastructure and Help Prevent Power Outages," PA DEP, March 16, 2026, https://www.pa.gov/agencies/dep/newsroom/2026-03-16-shapiro-administration-invests-over-10-million-to-strengthen-electrric-grid-infrastructure.

Table 6
Pennsylvania Grid Resilience Grant Recipients
2026

Organization	Award Amount	Program	County
Borough of Hatfield	$355,945	56 old utility poles replaced.	Montgomery
Borough of Duncannon	507,840	Smart grid allows isolation and looped distribution allowing for a 25 percent reduction in outages.	Perry
Borough of Schuylkill Haven	994,746	Purchased a metering and data system to improve response times	Schuylkill
REA Energy Co-op	1,500,000	70 pieces of equipment to reduce outages to 9,000 rural customers	Cambia, Indiana, Westmoreland
Claverack Rural Electric Co-op	2,193,767	1.5MW battery system for a 9-1-1 center. Will reduce outages by 44 percent in worst performing areas.	Susquehanna
Northwestern Rural Electric Co-op	4,680,655	Connect two substations with high-voltage power lines. Reduce outages by 85 percent	Erie and Crawford
Total	10,232,953	--	Combined

Source: "Shapiro Administration Invests $10 Million to Strengthen Electric Grid Infrastructure and Help Prevent Power Outages," PA DEP Newsroom, March 16, 2026, https://www.pa.gov/agencies/dep/newsroom/2026-03-16-shapiro-administration-invests-over-10-million-to-strengthen-electrric-grid-infrastructure.

PA PUC Actions to Improve Reliability

The PUC is also working to enhance grid resilience within Pennsylvania by addressing aging infrastructure and improving emergency preparedness for extreme weather. According to the agency, improving grid reliability can be categorized into three key areas:

1. Infrastructure resilience – invest in grid modernization.
2. Emergency preparedness – coordinate between utilities and state agencies to prepare for severe weather.
3. Balance affordability and reliability – ensure that infrastructure improvements do not burden ratepayers. [140]

[140] Steven DeFrank "Prepared Testimony before the PA House," 9-10.

The PUC has testified that technologies such as automatic reclosers and self-healing systems which quickly reroute power or bring lines back online, reduce the number of consumers who have outages in a storm. However, those that do lose power may take longer to fix repairs due to complex systems being more difficult to bring back online.[141] The PUC also conducts Utility Audits and Financial Accountability audits. These audits assess the fiscal and operational efficiency of public utilities, ensuring that rates are justified and that companies are prudently managing consumer revenues.[142]

To accomplish this task, the PUC reviews the infrastructure plans of EDCs on a regular basis. Each EDC must submit a Long-Term Infrastructure Improvement Plans (LTIIP), every five years. Additionally, EDCs submit annual maintenance plans. The releases of the LTIIPs are staggered by EDCs. Nine out of eleven EDC have included upgrades in their LTIIPs. Upgrades involve replacing old equipment and installing new poles and transformers to increase system resilience in such storms. The PUC reviews the LTIIPs for cost efficiency to ensure that the work is appropriate and that the costs are not inflated. However, the agency does not instruct the EDCs on how to direct their infrastructure plans.[143] Based on period of time covered in each LTIIP, the PUC has been planning ahead five years.[144] However, it is possible that planning for infrastructure needs five years ahead is no longer adequate to address long-term infrastructure investments needed to manage increased weather disruptions to the grid.

PECO Example

PECO is known to be one of the Pennsylvania EDCs that traditionally invested more in reliability, and as such has maintained its reliability standards. However, "In the last five years, PECO experienced 101 significant storms impacting nearly 2.7 million customers."[145] In the latest LTIIP, PECO noted, "This plan is part of the company's overall system investment of approximately $6 billion during the next five years across our electric and natural gas systems to inspect equipment, complete targeted system enhancements and corrective maintenance, invest in new equipment, and perform vegetation management."[146] PECOs practices of investing in infrastructure provide an example of how companies are meeting these challenges.

PECO is undergoing four major initiatives to harden against storms and increase resiliency

1. Customers Experiences Multiple Interruptions (CEMI) Areas Program. Are areas with worst performance.
2. Air Programs – replacing aerial assets and equipment over 50 years old.
3. Building substation retirements.
4. Unit substation retirement program

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141 Steven DeFrank "Prepared Testimony before the PA House," 9.
142 Steven DeFrank "Prepared Testimony before the PA House," 21.
143 JSGC staff meeting with PUC, January 21, 2026.
144 Steven DeFrank "Prepared Testimony before the PA House."
145 PECO, "Response: Petition of PECO Energy Company for Approval of Its Electric Long-Term Infrastructure Improvement Plan for the Period January 1, 2026 through December 31, 2030," PA PUC Docket, Filed August 20, 2025, 14.
146 PECO, "PECO Electric Reliability Improvement Project," Falls Township, July 22, 2024, https://fallstwp.com/resources/news/article/?id=9188.

The CEMI is a catch all. Efforts in PECO's CEMI include replacing obsolete or degraded equipment, new primary wires that are more resistant to trees, smart switching equipment (reclosures) and selective aerial/underground primary wire relocation. How PECO measures the success of its CEMI program is based on reduction in frequency of interruption in improved areas and circuits. The long-term goal for this program is a 25 percent reduction in frequency of interruptions by 2031 in these areas. Performance of past CEMI projects by PECO led to a 41 percent improvement in SAFI score, for frequency of interruption. As detailed in later sections of this report, some approaches to hardening and undergrounding power lines focus on investing in areas facing the worst system performance. In a later chapter, this report examines efforts PECO and other major EDCs are taking to improve reliability through replacing existing underground wiring.

Pole Inspections and Vegetation Management

According to the PUC's reliability report, the single largest issue affecting electrical reliability is off-right of way trees and branches knocked into wires during storms. "Since 2015 and continuing throughout 2024, vegetation has been the number one cause of outages and lost customer-minutes in Pennsylvania," according to one report.[147] In the past, extensive hardening measures were not needed by utilities to ensure reliable electrical service. The confluence of system age and increasing storms is exerting pressure on the electrical infrastructure. Electric distribution companies are required to maintain vegetation and inspect poles on a regular basis.

- "*Vegetation management*. The Statewide minimum inspection and treatment cycle for vegetation management is between 4-8 years for distribution facilities. An EDC shall submit a condition-based plan for vegetation management for its distribution system facilities explaining its treatment cycle."[148]
- "*Pole inspections*. Distribution poles shall be inspected at least as often as every 10—12 years except for the new southern yellow pine creosoted utility poles which shall be initially inspected within 25 years, then within 12 years annually after the initial inspection."[149]

Currently state law requires that poles that fail inspection must be replaced within 30 days. To ensure this process is transparent, the PUC hosts Inspection and Maintenance reports on its website.[150]

As previously noted, there have been concerns with EDC performance during storms for about a decade. In effort to fulfill its reliability responsibilities, the PUC began a more active role in overseeing vegetation management among EDCs. A management order sent out in 2017 led to ongoing meetings between the PUC and EDCS throughout 2017-2018.[151] Findings from these

[147] Paul Diskin, "2024 Pennsylvania Electric Reliability Report," v.
[148] 52 Pa. Code § 57.198(n)(1).
[149] 52 Pa. Code § 57.198(n)(1).
[150] "M-2009-2094773, Implementation – Inspection & Maintenance Standards," PA PUC Docket, filed March 19, 2009, https://www.puc.pa.gov/docket/M-2009-2094773/#docket-documents.
[151] Shelby Linton-Keddie, "Vegetation Management Collaborative Report," Harrisburg: PA PUC, February 20, 2019, 3.

meetings were then collected in a Vegetation Management Collaborative Report released in 2019.[152] The report had several findings:

- PUC decided that vegetation management reports filed by EDCs needed more details, provide greater justifications, and help education customers.
- The report covered general best practices but emphasized the importance of not being proscriptive. EDCs claimed they needed flexibility to address vegetation management as there are many circumstances to account for.

However, "the Commission has noted that vegetation management is not currently an eligible category under LTIIP funding, creating hurdles for utilities working to mitigate tree-related outages." Further, PUC Commissioner DeFrank testified that "weakened and dead trees – particularly those affected by infestations like the Emerald Ash Borer – continue to pose a major threat to grid reliability."[153] Accordingly, the PUC has recommended that EDCs increase the amount of vegetation management by shortening cycles so trees are pruned more frequently. Further, the PUC has encouraged companies to try to use innovative technologies such as AI, drones, and satellites to improve aspects of their maintenance programs.

In response to recent reliability concerns, EDCs have been increasing their vegetation management cycles. For example, FirstEnergy companies have reportedly increased both tree trimming and pole inspections beyond the statutory requirements. In 2025 they dropped from a 5-year distribution overhead line inspection cycle to a two-year cycle.[154] Their 2027 plan lists this cycle: Every 4 to 5 years for vegetation management (with some sections being done more often).[155]

While EDCs have lobbied for the inclusion of vegetation management in their LTIIPs, currently it is ineligible and intended to be part of a company's rate case. If vegetation were to be allowed, this activity would likely deter investment in longer term hardening solutions to improve reliability.

The PUC created an Electric Reliability Collaborative (ERC) in 2021 after informal meetings held the previous year. The ERC's goal is to improve reliability by having meetings with EDC's and the Energy Association of PA. This group, the ERC, reviewed how the reliability performance metrics were calculated and looked at possible changes such as adoption of performance-based rates tied to reliability, gathering stakeholders collaborate on ways to reduce the impact of off-right of way trees, and adopting new methods of calculating major event days based on standard deviations from the Institute of Electrical and Electric Engineers.

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[152] Shelby Linton-Keddie, "Vegetation Management Collaborative Report,"3.
[153] Steven DeFrank "Prepared Testimony before the PA House," 9-10.
[154] FirstEnergy, "Response: Biennial Inspection, Maintenance, Repair and FirstEnergy Electric Company for the period of January 1, 2027 – December 31, 2028," PA PUC Docket, October 1, 2025, https://www.puc.pa.gov/pcdocs/1897159.pdf.
[155] FirstEnergy, "Response: Biennial Inspection, Maintenance, Repair and FirstEnergy Electric Company," 2025.

The PUC recommended strategic undergrounding in its recent reliability report.[156] Part of strategic undergrounding planning is to identify which lines are most prone to outages and then bury them to improve reliability and reduce repair time. Undergrounding can also improve wildfire resilience. The PUC has suggested that EDCs look into not only undergrounding but also "Optimized Construction Practices" which have demonstrated that advanced wires and poles to harden infrastructure can resist downed trees in simulated tests.[157] However, the uses described by Electric Power Research Institute are primarily evaluated through the lens of fire reduction, not hardening against storms. The PUC has encouraged EDCs to look to other states to learn storm related hardening strategies.

[156] "Strategic Undergrounding," Electric Power Research Institute, 2026, https://distribution.epri.com/wildfire/public/wildfire-tech-database/fault-count-freq-reduction/strategic-undergrounding/.
[157] "Optimized Construction Practices," Electric Power Research Institute, 2023, https://distribution.epri.com/wildfire/public/wildfire-tech-database/fault-count-freq-reduction/optimized-construction-practices/.

DETAILED OVERVIEW OF UNDERGROUNDING ELECTRICAL POWER AND OTHER UTILITY LINES

Discussion surrounding the practice of moving overhead power lines underground (undergrounding) has been cyclical over the last quarter century. Infrastructure is damaged in storms and customers facing outages demand answers as to why wires were not better protected from tree branches tossed by storm winds. The thinking goes that these vulnerable wires would be safer underground where they would be protected from the elements. In answer to this pressure, public officials, regulators, and power distributors conduct studies. These investigations show that undergrounding power lines would improve reliability of electricity service but at an exorbitant cost that few would be willing to pass on to consumers who would shoulder that burden. Faced with extremely high costs of burying wires it is usually determined to be preferable to continue to rebuild instead. Consequently, new technologies, stronger poles, and increased trimming are embraced. The reliability improves until a larger storm hits, takes down the wires, and the cycle begins again. This report questions some of these assumptions comparing the expense of undergrounding to lifecycle costs.

Based on a review of the available research, it is neither prudent nor practical to underground all electrical wires within Pennsylvania. In some instances, it may not even be best practice to underground even the most vulnerable of power lines if the correct conditions are not met. Where undergrounding does occur, it must be emphasized that, like any other type of infrastructure, it eventually needs repair or replacement. Underground wires age and need to be replaced, and while such wires are vastly more resilient against storms, they too are sometimes damaged and washed away by flood waters. When this occurs, they must be dug up, replaced, back filled, and buried again. Transmission lines are particularly expensive to underground and accordingly, it is done less frequently. Estimates are that only 0.5 percent of transmission lines have been undergrounded in the US.[158] A later chapter of this report will focus on the obstacles to undergrounding transmission lines.

Because of the expense involved, how often undergrounding occurs depends on the frequency and ferocity of the storms. Southern states on the Atlantic coast facing annual hurricane winds were the first to embrace undergrounding because, no matter how high the cost, the alternative of replacing poles and rebuilding lines after each hurricane season was even more unfathomable. Ultimately the question of whether to underground is decided by how much pressure is applied to utilities that will only convert overhead wires to underground when they have exhausted more convenient options. Increasingly some utilities are exploring the benefits of

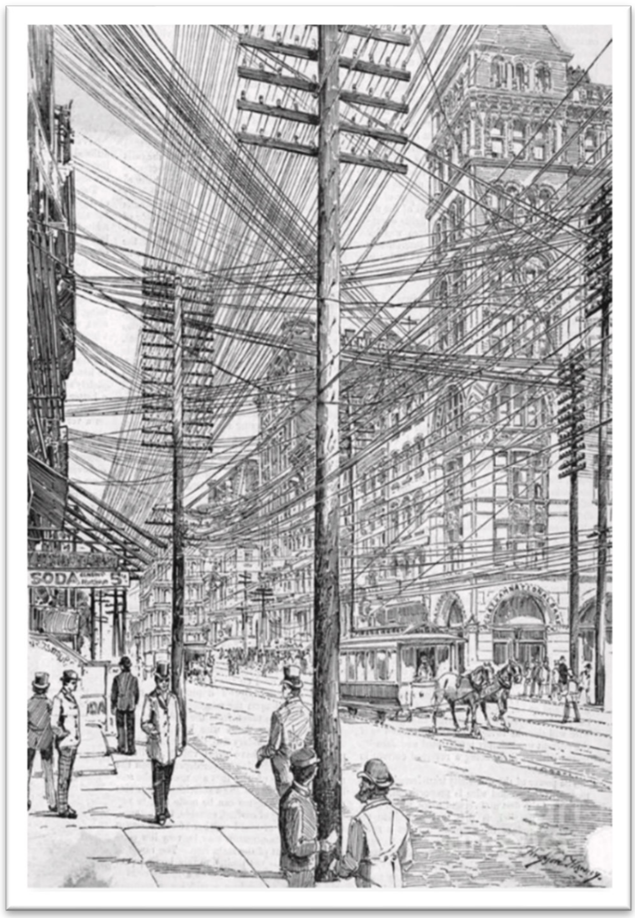
[158] "Power Outages Often Spur Questions around Burying Power Lines," US Energy Information Admin., July 25, 2012, https://www.eia.gov/todayinenergy/detail.php?id=7250.

undergrounding in context beyond storms: animals, vehicle crashes, reduced maintenance costs, and reduced tree trimming.[159]

Timeline of Underground Electric Power Lines in the United States

Undergrounding has been practiced almost since the inception of electrical service with Thomas Edison burying lines in New York City.[160] At the turn of the 20th century, when AC (alternating current) prevailed over DC (direct current) as the default method of electrical service, power lines were constructed en masse and they choked the airspace of major cities as utilities did not have service areas as they do now. Consequently, each power and telecommunication company had its own set of wires spider webbing cities. See Figure 6. These conditions eventually led to power lines being buried underground in urban areas. See Figure 7.

Figure 6
Historical Illustrations of Aerial Wire Overcrowding in New York City
1890

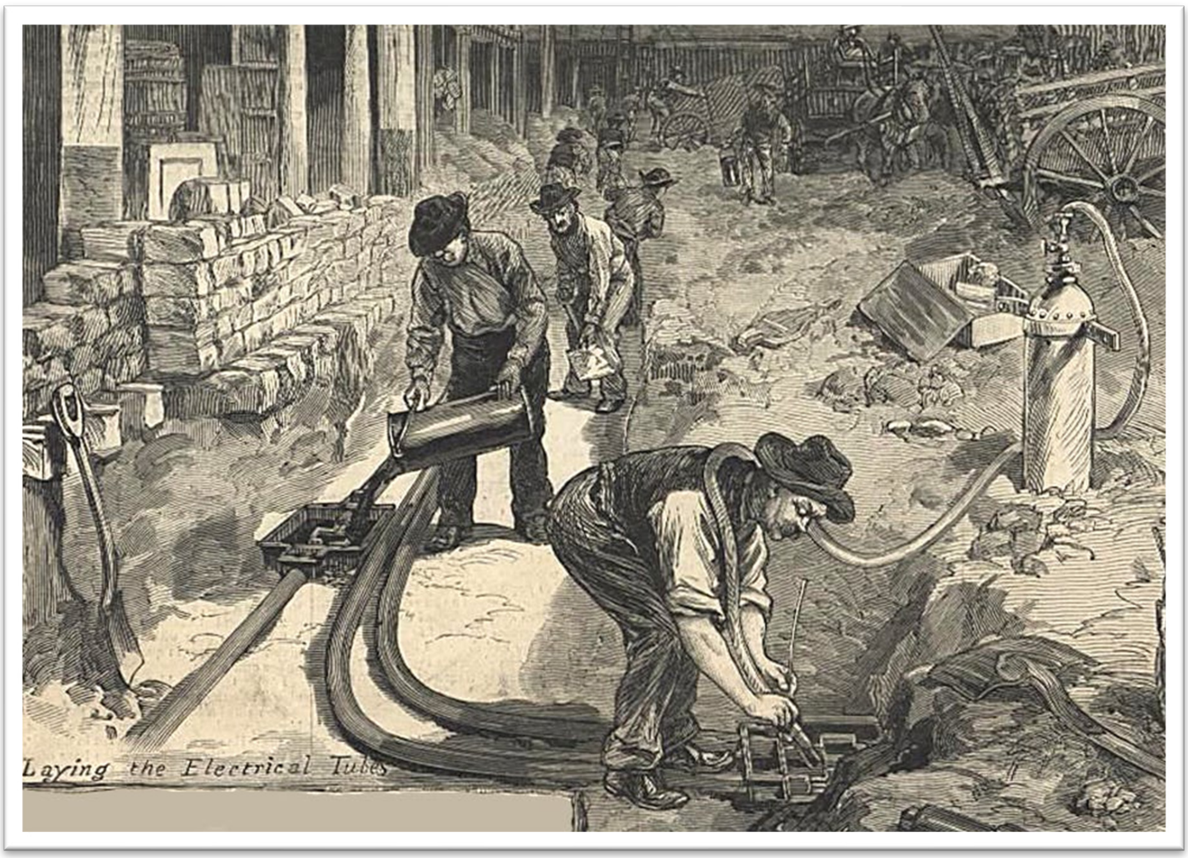


Source: Virtual New York "Book of Old New York," 2001, https://virtualny.ashp.cuny.edu/blizzard/introduction/intro_set.html.

[159] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," Sept. 29, 2022. https://www.fortnightly.com/sites/default/files/whitepapers/PUF_Undergrounding_Report.pdf
[160] Power Delivery Intelligence Initiative, "Utility Undergrounding Life-Cycle Cost Guide," 2024, https://assets.super.so/bca43356-8906-4248-b8ab-3005437278f2/files/6a7a2dce-ba01-48e5-837c-36ff5dd7d722/UAZ-12_PDI2_Undergrounding_Lifecycle_Guide.pdf

While a desire to place power lines underground has existed for almost as long as there have been power lines, so have many of the barriers that make this decision logistically challenging. Although early-adopting cities experienced significant visual clutter from the proliferation of overhead lines, the essential obstacles to placing power lines underground also existed. To wit, "Even the best armored cables are liable to be ruined by a single stroke of the pickaxe."[161] Water seepage damaged power lines, and their proximity to iron city gas lines, which leaked into the conduits, presented danger.

Figure 7
Historical Illustration of Burying Electrical Lines
1882



Source: Virtual New York, "When Edison Lit Up Manhattan," 2001, The New York Historical, https://virtualny.ashp.cuny.edu/blizzard/introduction/intro_set.html.

[161] Robert Colburn, "Over and Under: A Brief History of Why Electric Power Lines Can't Easily Be Placed Underground," IEEE-USA, August 2, 2024, https://insight.ieeeusa.org/articles/over-and-under-a-brief-history-of-why-electric-power-lines-cant-easily-be-placed-underground/.

There are two general types of distribution lines that can be undergrounded: main and lateral. Main power lines have larger wires with more insulation, which conflicts with aims to keep underground conduits as narrow as possible. However, additional insulation is needed to stop the alternating current from arcing underground to nearby metallic structures. While the costs of many types of labor are more expensive today, even a century ago digging up roads to place power lines was costly. The downsides of aerial power lines, however, were also noted: "aerial circuits, unusual snow or sleet loads, high winds, the abrasion of tree branches, etc., are constantly tending to destroy the conductors."[162] Since that time, various technologies have improved the practicality of undergrounding; the relative expense of undergrounding, however, is still a frequent obstacle.

Power lines were seldom buried in rural areas, timber for poles was plentiful, and electrifying America needed to be done as cheaply and quickly as possible during the 1930s to spread electrical service to the largest number of customers. Decades later, as the country prospered after WWII and new housing developments flourished, undergrounding became a popular option for housing developers seeking to improve the aesthetic appeal of their communities. By 1962, approximately half of the utilities in the US were beginning to underground new housing developments.[163] These measures proved popular enough that by the 1970s undergrounding became required for new housing developments in Pennsylvania.[164]

For a long time, the price of electricity and the growing need to replace older infrastructure was at the forefront of EDCs' priorities. Reliability was not a chief concern of energy companies except in isolated cases. Undergrounding has been considered a policy solution for electrical disruption from extreme weather events since the "Great Blizzard of 1888," after which New York City made significant progress in burying its underground power lines, despite the objections of some businesses and power companies.[165] Over a century later, the benefits of burying power lines after inclement weather were still being weighed. In the late 1990s, non-profit Dakota Energy Cooperative used FEMA Hazard Mitigation funding to bury a 5.5 mile line segment following an ice storm in locations where crews were unable to restore power due to snow. The project cost $57,850.[166] It was later determined that the expense of undergrounding would pay for itself after two major storms, compared to replacing above ground lines every time.[167] Since that time, Dakota Energy budgets each year for undergrounding sections of the lines.

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[162] Robert Colburn, "Over and Under," 2024.
[163] Historic PAS Report 163, "Underground Wiring in New Residential Area," American Planning Association, October 1962, https://www.planning.org/pas/reports/report163/.
[164] 52 Pa. Code § 57.81-88.
[165] Virtual New York City, "The NY Blizzard Of 1888," Accessed July 8, 2026, https://virtualny.ashp.cuny.edu/blizzard/introduction/intro_set.html.
[166] Federal Emergency Management Agency, "From Overhead to Underground: It Pays to Bury Power Lines," Feb. 11, 2021, https://www.fema.gov/case-study/overhead-underground-it-pays-bury-power-lines.
[167] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 11

Undergrounding remained mostly a desirable feature of new housing developments until the new millennium brought with it an increasing number of hurricanes damaging the distribution networks of southeast states, prompting power companies to explore alternatives. One of the first such efforts was a 2004 undergrounding report conducted by the Edison Electric Institute (EEI) which helped establish undergrounding's reputation of being impractical. The findings of the report were inconclusive, including unknown tradeoffs and questionable reliability benefits, but guaranteed a high cost. The study considered aesthetics to be one of the chief benefits of undergrounding but its merits were not quantified. In 2007 Virginia's State Corporation Commission estimated that undergrounding all electric utility distribution lines within the state would cost $80 billion.[168] A 2009 Virginia legislative report confirmed these findings, and studies in North Carolina and Maryland also found undergrounding to be costly.[169] Overall, during these early studies there was not enough information on what the reliability benefits of undergrounding might be.

Attitudes surrounding undergrounding began to shift as the practice was reevaluated to improve system resilience against storms in 2014 with the Massachusetts Department of Energy Resources report. This report was conducted after nor'easters in October 2011 and February 2013 and it noted that "the cost of converting the entire existing overhead electric distribution system underground would likely be borne by the ratepayers and could be prohibitively expensive… However, converting a targeted selection of circuits may be part of a successful storm resiliency program and worth the investment."[170] This report helped legitimize the idea of selective or targeted undergrounding.

Around that time, undergrounding was also being investigated in Washington, D.C. as the city looked for ways to improve its chronic reliability problems. In May 2014, a report concluded that a billion dollar project focused on moving sixty of the city's worst performing feeder distribution lines, i.e. the lines that are the final stage of delivery, where electricity reaches the end user.[171] While the full amount was not approved by the federal government, Potomac Electricity Company (PEPCO) operates what would become DC Plug, a $500 million partnership with the city to reduce outages in the D.C. area through the targeted undergrounding of feeder power lines.[172]

In 2017, Hurricane Irma caused a massive amount of damage to Florida's electrical infrastructure. The storm resulted in a ten-day restoration period for all electrical service, with the average time being two days during which customers were out of power. One of the factors delaying the repair was difficulty getting utility repair vehicles into neighborhoods through downed trees. After the storm, analysis indicated that hardening overhead lines would be impractical in these communities. In response, Florida Power & Light (FPL) devised a plan to

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168 PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 8.
169 PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 8.
170 MA Dept. of Energy Resources, "Feasibility Study for Undergrounding Electric Distribution Lines in Massachusetts," December 2014, https://www.mass.gov/doc/feasibility-study-for-undergrounding-electric-distribution-lines-in-massachusetts/download.
171 PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 8.
172 Pepco, "First Biennial Underground Infrastructure Improvement Projects Plan," July 3, 2017, https://edocket.dcpsc.org/apis/api/Filing/download?attachId=18746&guidFileName=7f6c8eb5-6879-488f-ab75-52dca76bc988.pdf.

underground neighborhood lines over a period of 20 to 25 years where technically feasible.[173] Florida Public Service Commission requires IOUs to include undergrounding in their storm protection plans. It is estimated that programs to make the grid more resilient, although enormously costly, can be less expensive than the cost of storms. It will take $700 million to $1 billion for FPL to make its system more resilient. The cost of restoring electricity after a "20 year storm" is estimated at $1.4 billion.[174] So far, FPL has invested over $1 billion to harden its system against storms.[175]

Dominion Energy, an EDC in Virginia, has led an increased acceptance of undergrounding, although only 10 years prior, two reports had noted the total impracticality of undergrounding within the state. As of 2022, Dominion had buried 1,900 miles of overhead lines underground.[176] More on Dominion's program can be found within this report's chapter on case studies. Seeing Dominion Energy's example, Florida and Wisconsin IOUs were undergrounding by 2020.[177]

Perhaps the most publicized instance of undergrounding within the last decade was when Pacific Gas & Electric (PG&E), one of the largest energy companies in the country, announced in 2021 the largest commitment to date of $15 billion to $30 billion to bury 10 percent of its most risk prone service lines at a rate of 1,000 miles a year.[178] This California based utility noted that this initiate was largely motivated by the infrastructure owned by the company being linked to wildfires and efforts to hold the company accountable for these risks.

In summer of 2022, Hawaiian Electric, the state's largest energy company, requested state utility regulators for $190 million for five years of resilience investments including strategic undergrounding.[179]

Underground Construction

The most important aspect to understand about undergrounding is that it is a more involved process than merely taking down existing wires from their poles and burying them. The primary distinction between above and underground lines revolves around insulating materials used to cover the wires and construction techniques.

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[173]PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 9.
[174]Sarah Brody, Matt Rogers, Giulia Siccardo, "Why, and How, utilities should start to manage climate-change risk," McKinesey & Company, April 2019, ttps://www.mckinsey.com/~/media/McKinsey/Industries/Electric%20Power%20and%20Natural%20Gas/Our%20Insights/Why%20and%20how%20utilities%20should%20start%20to%20manage%20climate%20change%20risk/Why-and-how-utilities-should-start-to-manage-climate-change-risk-vF.pdf, 3-4.
[175] Brody, Rogers, Siccardo, "Why, and How, utilities should start to manage climate-change risk," 2019, 4.
[176] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 10.
[177] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 10.
[178] Michael Liedtke, "PG&E Will Spend at Least $15 Billion Burying Power Lines," AP News, July 22, 2021, https://apnews.com/article/business-government-and-politics-527e93e58c6ac7736488d8cd60003f86.
[179] Kavya Balaraman. "Hawaiian Electric Proposes $190M of Resiliency Spending in First Phase of Climate Adaption Push." Utility Dive, July 20, 2022. https://www.utilitydive.com/news/hawaiian-electric-climate-grid-puc-proposal-resilience/627655/.

Material Requirements

Underground power lines must be fabricated of specific materials. While historically there have been multiple types of underground cable, such as those filled with fluids or gases to keep wires cool, today the most common type of underground power lines is Cross-Linked Polyethylene Cables. These wires are named after the type of insulation used to cover the copper that lies at the center of the cable. See Figure 8.

Figure 8
Cross Section of Cross-Linked Polyethylene Cable
2026

Source: GUDA Cable Group, "XLPE Cable Guide: Insulation Properties, Temp Ratings & PVC Comparison," January 2026, https://www.gudacable.com/xlpe-cable-guide/.

Some of the materials and techniques needed to bury power lines:

- **Conduit**: In the context of cable installation, a conduit refers to a tube or pipe used to protect and route electrical wires or cables. It shields the cables from external elements and provides a safe passage for them, commonly placed underground or within buildings.[180]
- **Lubricants**: Lubricants are designed to limit friction between cables and walls of conduit during installation make it safer to pull cables through during install. Less tension and friction on the cables makes for safer installs. Modern lubricants leave less residue behind, create less friction, and allow for easier removal.[181]
- **Vaults**: Underground chambers or structures used for accessing and maintaining cables or electrical equipment in an underground system.[182]
- **Pulling**: The process of drawing cables through conduits during installation, which necessitates reducing friction to prevent damage to cables and conduit walls. [183]
- **Splices**: Joints or connections made between two cable segments to facilitate continuous cable runs. Minimizing splices enhances the reliability of the cable system.[184]

Many of the underground power lines in service today are installation from the 1970s or older and may not meet today's standards. Overall, there is an expectation that modern underground assets will perform better and may be repaired faster.[185] For example, the technique of direct burying of power lines is no longer recommended in most instances and instead, the wires are sheathed in a protective conduit. While in the past utilities performed direct bury, today underground wires are typically shielded from corrosion caused by soil and water by PVC conduit which encases it.[186] Conduit shielded lines are easier for line crews to repair which can shorten the length of outage interruptions to service.[187]

It should be no surprise that underground power lines are harder to access than overhead lines. The purpose of vaults is to create portals to access underground wires, as seen in Figure 9. These vaults are typically where sections of cables are spliced together. The distance that cable can be safely pulled without damaging the power line dictates the number of vaults and splices needed.

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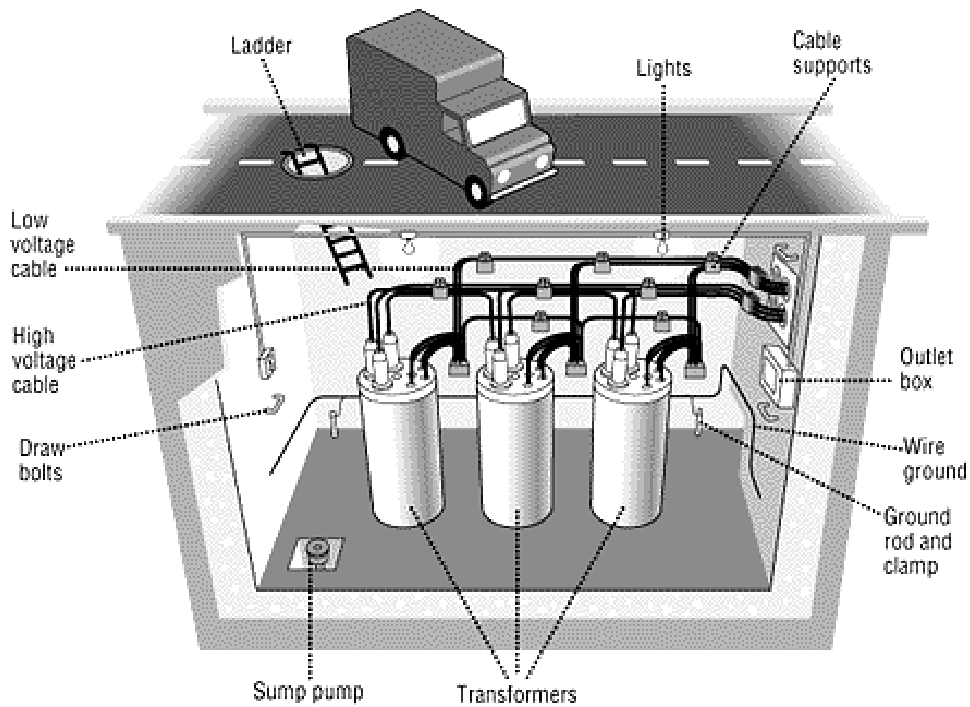
[180] Scenic America, "Undergrounding Case Study: Underground Cable Installation and Conduit Design," December 6, 2024, https://www.scenic.org/take-action/resources/undergrounding-resources/undergrounding-resources-and-white-papers/underground-cable-installation-and-conduit-design/.
[181] Scenic America, "Undergrounding Case Study: Underground Cable Installation and Conduit Design," 2024.
[182] Scenic America, "Undergrounding Case Study: Underground Cable Installation and Conduit Design," 2024.
[183] Scenic America, "Undergrounding Case Study: Underground Cable Installation and Conduit Design," 2024.
[184] Scenic America, "Undergrounding Case Study: Underground Cable Installation and Conduit Design," 2024.
[185] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience."
[186] Jeff Gavin, "Going Underground: Power Line Burial Is on the Rise." Electrical Contractor Magazine, March 13, 2026, https://www.ecmag.com/magazine/articles/article-detail/going-underground--power-line-burial-is-on-the-rise.
[187] Jeff Gavin, "Going Underground: Power Line Burial Is on the Rise." Electrical Contractor Magazine, 2026.

Figure 9
Underground Vault
2011



Source: PDQ Electric Corp, "Transformer Vaults, Substations," accessed June 5, 2026, https://www.pdqindustrialelectric.com/Transformer-Vaults,-Substations.html.

Physical Installation of Lines

There are two common approaches for underground construction: trenching or tunneling (alternatively called drilling or boring). In the first practice, trenches are dug power lines are placed within and then the trench is covered back up. Other companies are turning to the practice of Horizonal Directional Drilling (HDD) "in which cables are installed in a predetermined underground path."[188] The two methods can have differences in cost, times, and risk. One is not necessarily better; whichever method fits the current situation is used.

When trenching, crews dig a specified distance and width underground. For example, PPL requires a minimum of 12 inches wide by 39 inches deep.[189] After trenching, the floor is created with either sand or cement. The line is buried directly or covered with a conduit that provides physical protection and thermal insulation. The trench is then covered with backfill. Trenching can be done in either short or long sections. See Figure 10, which illustrates this construction method. In some places, shallow trenching a few inches deep, also known as micro trenching, is viable but the process is a poor fit for Pennsylvania due to the seasonal freeze and thaw.

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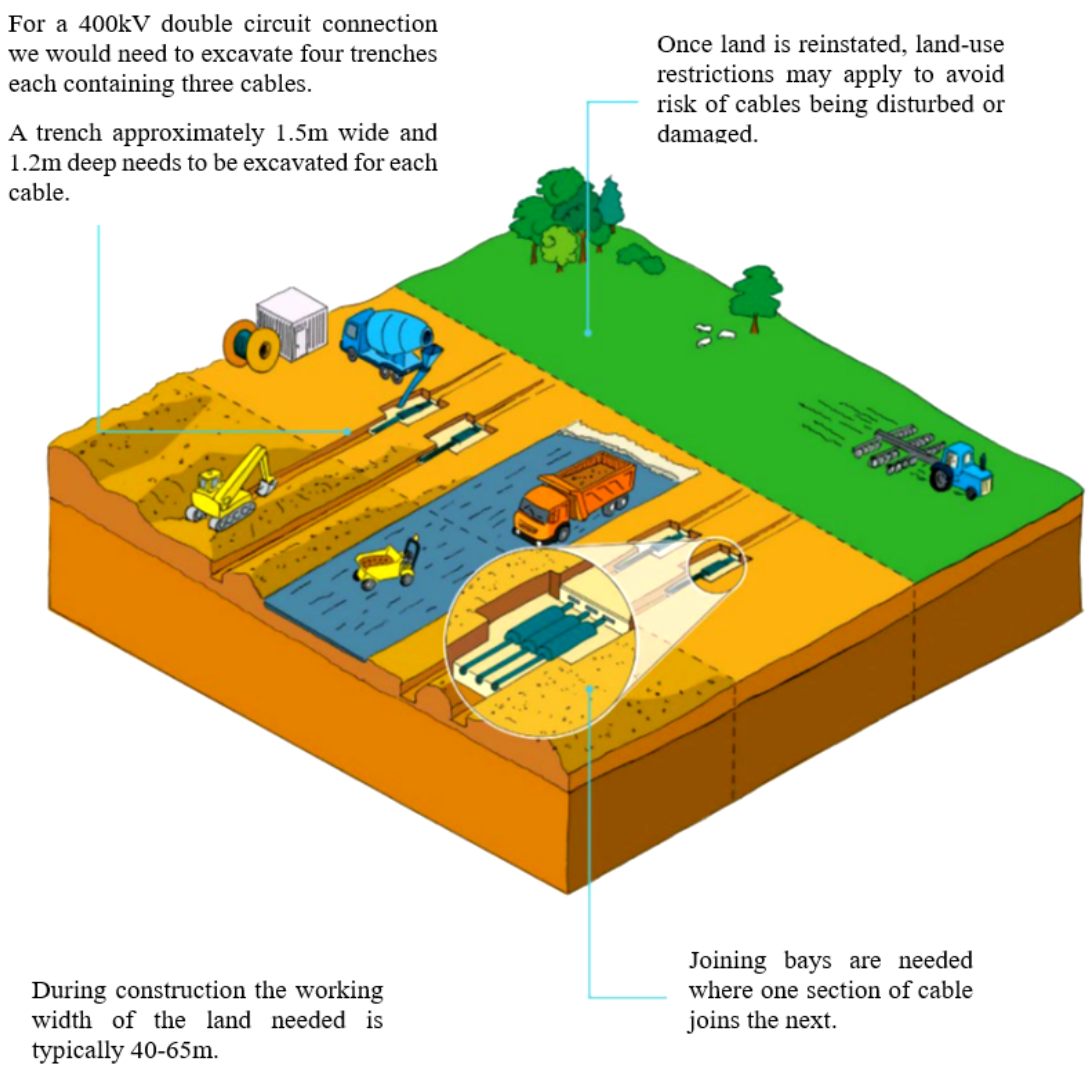
[188] Scenic America, "Undergrounding Case Study: Dominion Energy," December 2024, 3.
[189] PPL Electric Utilities, *Underground - General Specifications Trenching & Backfilling by Customer, November 21, 2024, Customer Reference Specification 6-14-121, November 21, 2024*, https://www.pplelectric.com/-/media/PPLElectric/At-Your-Service/Docs/REMSI/CRS/crs-6-14-121.pdf.

Tunneling, sometimes called directional boring, is a newer method of underground power lines and gaining popularity. It utilizes horizontal drilling to bore through a target, then wire is pulled through. Compared to trenching, this process is minimally disruptive to the surface. With this method a thorough understanding of what utility infrastructure and other obstacles may already be underground is necessary to avoid damage. The method is demonstrated in Dominion's targeted undergrounding program and Pepco's DC Plug program.

The exact process used in construction depends on whether main feeder power lines, which are larger than smaller lateral service lines, are being undergrounded. Further, the process depends on what needs to be dug up: a street, sidewalk, or a residential yard.

Figure 10
Trenching Construction
2024



Source: Berkeley Lab, "Undergrounding Transmission and Distribution Lines Resilience Investment Guide," 2.

PEPCO operating in the Maryland area, (the same owner as PECO) has a procedure for undergrounding power lines in roadways.[190] There are five phases for its projects including surveying, engineering, traffic control, permitting, and project construction. PEPCO typically break projects into three stages: trenching, maintenance vaults, and cable pulling covered below.

During the construction of a midblock trench the first step is clearing roadway so that the work can be conducted. In the traffic control stage, cones are set out and road lanes are closed, though typically one in each direction is open. An asphalt saw then cuts through the road, and pavement is removed. A backhoe excavates approximately 20 feet of trench per day, which is then shored up with metal plating. Either fiberglass or steel pipe conduits are then placed in the trench (which is determined in the engineering phase). Construction crews use reinforcement bars to stabilize the trench.

The conduits are then covered as concrete or thermal backfill (a mix of concrete, sand and grout designed to disperse heat) is poured into the trench to encase and to secure the conduit. Several hours later a slurry mix is poured over, and steel plates are put on top to protect the roadway from elements, and the road is opened to traffic. Once dry, the plates are removed and the road gradually repaved, section by section. Some projects require power lines to cross intersections. Traffic control plans are needed for each intersection where this will occur.

Construction of a maintenance vault also needs traffic control. The opening where the vault will be located is excavated and then reinforced with shoring and cross beams. A crane lowers precast sections of vault underground to be assembled, the shoring is removed, and area around the vault filled with slurry concrete mix. At the end, vaults have two access manholes with cast-iron covers.

Cable pulling requires the use of two lanes of traffic, which are closed off. A cable reel truck is parked at one end and a winch truck is needed on the other at each of the underground vaults. Next, pull tape is attached to the wire within the conduit and placed near reel truck. The tape is used to pull the cables through each conduit. In the final step the power lines are energized.

Environmental Factors

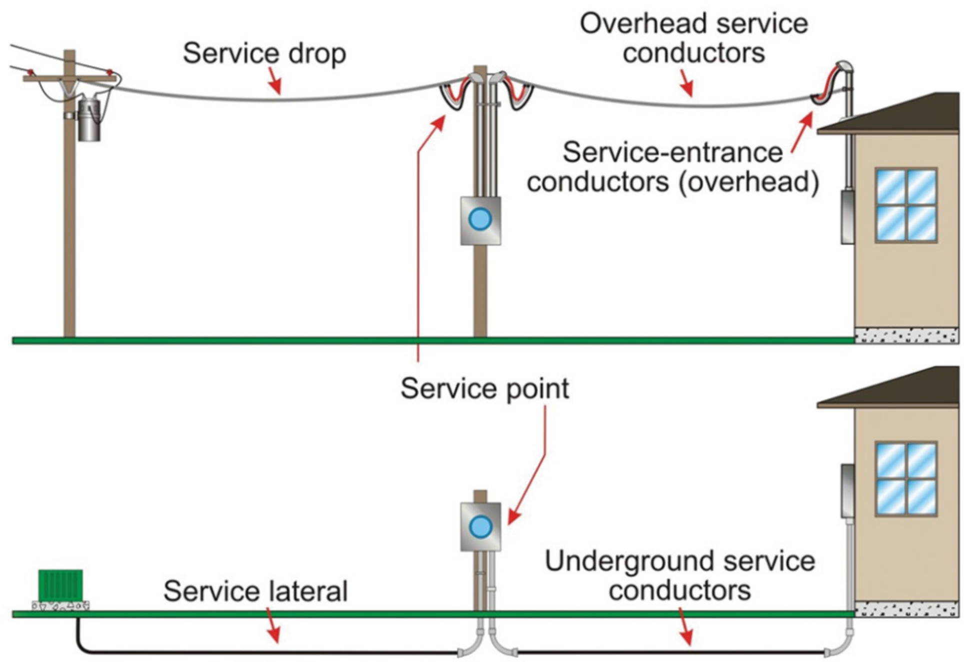
Undergrounding requires the appropriate environment and subsurface conditions. Environmental factors, for example those around wetlands and former wetlands, increase the complexity of the projects because of the need to prevent inundations. Geological factors can restrict some wires from being undergrounded: wires cannot be pulled through mountains.

In some cases, undergrounding is going to be more disruptive to the environment. Part of this depends on the whether trenched or directional bore is used. As noted in a report by Peter Larson, "…the process of installing underground power delivery infrastructure could significantly

[190] PepcoTV, "Understanding Underground Transmission Line Construction," YouTube, October 23, 2014, https://www.youtube.com/watch?v=RVWM59UqmnU.

disturb sensitive wetlands, forests, or other valuable ecosystems within the T&D corridor."[191] Overall, digging up space for a line is more intrusive than sticking a pole in the ground.

Figure 11
Overhead and Underground Service
2019



Source: Joseph Wages, "How Well Do You Know Your Electrical Service Point?" IAEI Magazine, December 20, 2019, https://iaeimagazine.org/2019/2019november/how-well-do-you-know-your-electrical-service-point/.

In residential areas, once the lines are buried, they make less of a visual presence but are not entirely invisible. Fee figure 11. Square footage of the yard may be lost to underground power lines due to the necessity to place pad-mounted transformers along the length of the underground lines. In the US, appearing as green boxes mounted on a concrete pad. See Figure 12. After conversion is done, new connection boxes to houses may need to be installed.

[191] Peter H. Larsen, and Lawrence Berkeley National Laboratory, "Estimating the Costs and Benefits of Undergrounding Power Lines," IEEE DRWG Meeting, July 19, 2016, https://cmte.ieee.org/pes-drwg/wp-content/uploads/sites/61/2016-09-03-LBNL-Estimating-the-Costs-and-Benefits-of-Undergrounding-Power-Lines-Peter-Larsen.pdf.

Figure 12
Underground Pad-Mounted Transformers
2026

Source: Daelim Belefic, "Transformer Solutions for Utilities" 2026, https://daelim-electric.com/transformer-solutions-for-utilities/.

Benefits

Undergrounding has many possible benefits: low operating costs, aesthetics, decreased maintenance, vegetation management reduction, reliability, resiliency, and customer satisfaction. In the past, the focus of reliability investment was to keep outages as brief and infrequent as possible within established limits, however there is an increased focus on lessening damage of large outages through preventive measures. In the past, state-conducted research generally agreed that undergrounding was too cost prohibitive to improve reliability. For some utilities this proved incorrect as the costs of successive repairs within their service areas quickly exceeded the cost of undergrounding. Since those early studies the frequency of storms has shifted; further the benefits of undergrounding are now better understood.

While public demand for undergrounding was high 20 years ago, it increased since.[192] In an effort to understand utility responses to an increase in the number of undergrounding projects being undertaken, PUF Energy Research created a survey of companies with underground power lines. This survey noted a paradigm shift occurring within electricity industry. The PUF survey of a dozen investor-owned utilities and two independent experts.[193] There were three main conclusions from this survey:

1. undergrounding is gaining popularity among utility providers because of direct reduction in outage incidents and indirectly shortening the period of outages. Previously undergrounding was considered a non-optimal or specialized solution for improving system performance.

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[192] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," Sep. 29, 2022, https://www.fortnightly.com/sites/default/files/whitepapers/PUF_Undergrounding_Report.pdf;
[193] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience."

2. Technological improvements, installation methods, and processes of undergrounding have driven down the relative costs of undergrounding and made the wires placed underground stronger and last longer.
3. Underground is happening in part because of more extreme weather and in part because society is becoming more reliant on electricity linked to health and safety.

However, it should be noted that underground networks are not invulnerable, for example lightning can damage these systems. Also, if an undergrounded neighborhood also has power carried to it by aerial power lines, power may still be lost during storms.

Reliability Improvements

One of undergrounding's main benefits is preventing initial outages in the first place. This is tied to the concept of resilience is how well a grid handles itself under applied stress.[194] Today there are increasing expectations of electrical reliability from the public. Schools are increasingly requiring online access to complete assignments and since the Covid-19 pandemic hybrid and work from home schedules have grown more commonplace. This has lowered customer tolerance levels for outages and expect resiliency in their electrical service. "It is now apparently well understood that, putting aside cost and some technical considerations, undergrounding can be a potent tool in making electricity systems more resilient. Particularly for lines most susceptible to environmental conditions."[195]

As noted in the chapter on climate and reliability, overhead lines are vulnerable to tornadoes, ice storms, and severe winter weather. Vibrations caused by wind and weight can pressure the lines. When the two are present in an ice storm, damage is even more likely. Underground wires are less prone to damage and disruption and less expensive maintenance.[196]

> "Underground cables are sheltered from environmental and other hazards on both clear and inclement weather days, so they benefit both grid reliability (as measured by the System Average Interruption Duration Index [SAIDI] and System Average Interruption Frequency Index [SAIFI] excluding major events days) and resilience to major storms (as measured by SAIDI and SAIFI including major event days)."[197]

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194 Pacific Northwest National Laboratory, "Electric Grid Resilience and Reliability for Grid Architecture," Mar. 2018.
195 PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," Sept. 29, 2022. https://www.fortnightly.com/sites/default/files/whitepapers/PUF_Undergrounding_Report.pdf
196 William Atkinson, "Organizations Debate Underground and Overground Power Lines," Electrical Contractor Magazine, May 19, 2022, https://www.ecmag.com/magazine/articles/article-detail/your-business-organizations-debate-underground-and-overground-power-lines.
197 Chris Watts, "The Changing Economics of Utility Investment in Undergrounding," 2.

Undergrounding power lines has been proven to reduce disruptions from extreme weather and wildfires, making grids more reliable and resilient. [198] Underground distribution lines protect against falling vegetation, and animal, vehicle, tornado, thunderstorm, hurricane, and derecho damage.[199] One older source estimated that a 10 percent increase in a system's underground line miles correlated with 14 percent reduction in annual service interruptions.[200] Studies cited in this report note that an increase in the percentage of transmission and distribution lines underground see greater reliability. One example with WEC Energy saw a 16 percent decrease in the amount of customer minutes interrupted that they attributed to undergrounding.[201]

The Wisconsin Public Service Commission found that overhead-to-underground distribution lines conducted between 2012 and 2021 led to a 95 percent performance improvement in SAIDI. This reduced system down time by 137 minutes during storms.[202] Reliability benefits were noted by EDCs operating within the state as well. The WEC Energy Group which operates across Wisconsin and the upper Peninsula of Michigan have completed 2,000 miles of undergrounding which had increased their system reliability by 93 percent.[203]

After conducting undergrounding projects, Florida's underground lines failed at a rate of 4 percent compared to 24 percent outages for regular lines in 2017's Hurricane Irma.[204] Virginia Electric and Power Company conducted undergrounding and as a result, it had improved SAIFI 99 percent once the project was finished. It had a 27 percent reduction in system restoration times following a snowstorm and by one analysis potentially millions of dollars in thunderstorms. Dominion Energy Company has noted that they find many more faults in overhead infrastructure, by a 95-99 percent. They have indicated that many of the underground faults involved interactions with terminal poles for underground facilities.

Of particular interest to rural Pennsylvania may be an example by Northwestern Energy. This company faced numerous dead trees from beetles that could not be handled by vegetation management. Ultimately it was determined that burying single-phase lines would be cheaper than constant repairs. A representative from the company noted:

> "What we're seeing was just a lot more vegetation contact. And it is vegetation contact issues that we have little or no control over. Our historical legal rights to trim trees are limited to ten feet on either side of the wires. The trees that are falling are thirty, forty feet outside our right of way. These are sixty, seventy-foot tall trees

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[198] Lawrence Berkeley Lab, "Undergrounding Transmission and Distribution Lines Resilience Investment Guide."
[199] Lawrence Berkeley Lab, "Undergrounding Transmission and Distribution Lines Resilience Investment Guide," 2.
[200] Peter H. Larsen, "Severe Weather, Power Outages, and a Decision to Improve Electric Utility Reliability," Stanford University Department of Management Science and Engineering, (2016), https://purl.stanford.edu/sc466vy9575.
[201] Smalley, Michael Smalley, Steven Schott, and Ross Barret, *System Modernization and Reliability Project (SMRP)*, Institute of Electrical and Electronics Engineers (IEEE) Education Session, October 23, 2019.
[202] Richard Stasik & Wisconsin Public Service Corp., "Re: PSCW Docket #6690-CE-198 Wisconsin Public Service Corporation Application for Certificate of Authority System Modernization and Reliability Project (SMRP) – 2021 Post Construction Report," February 2022, https://apps.psc.wi.gov/ERF/ERFview/viewdoc.aspx?docid=430842 5.
[203] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 10.
[204] Florida Power & Light Co., "Direct testimony of Michael Jarro, in Petition for Approval of the Florida Power & Light Company 2023-2032 Storm Protection Plan," Submitted to Florida Public Service Commission in Docket 2022-0051-EI, https://www.floridapsc.com/pscfiles/library/filings/2022/02358-2022/02358-2022.pdf.

> that are within the strike zone of our facilities. Other than encouraging the customers to be proactive in removing these dead trees, there is just absolutely nothing we can do as a utility."[205]

From the perspective of an EDC, those that excel at undergrounding have voiced the necessity to understand the capabilities of underground wires and have clear objectives for their projects. For example, they must understand whether cheaper alternatives could provide similar increases in reliability. Underground is very effective against ice and snowstorms, however if the issues are tree and wind related it may be able to be addressed through better vegetation management. Understanding the causes for system reliability issues inform the most effective way to address them**.**[206]

Challenges

Despite the potential reliability benefits associated with undergrounding there can also be tradeoffs as well.

- Traditionally the underground wires have a shorter lifespan of 20-40 years compared to 30-50.[207] The life span is reported because of heat degrading insulation and corrosion from underground moisture.
- System monitoring becomes important to locate underground faults. Repairs can take longer if a fault cannot be located quickly.
- Duke Energy in Florida noted that time to restore service to underground lines was five percent to 46 percent higher compared to overhead during three hurricanes.

Flooding

While storms and the outages they cause strengthen the argument for undergrounding, floods are one of the primary challenges they face. Though flooding results in a relatively small cost compared to storms, climate change and consequent increase in precipitation is likely to increase the frequency and the severity of flooding.[208] If undergrounding efforts are expanded in Pennsylvania, they will have to be designed with an understanding that flooding is likely to be frequent in many areas of the Commonwealth.

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[205] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 13.
[206] Power Delivery Intelligence Initiative, "Your Mileage May Vary-Undergrounding Distribution Lines." YouTube, 2024, September 28, 2024, https://www.youtube.com/watch?v=LEoCh_cV7nc.
[207] Lawrence Berkeley Lab, "Undergrounding Transmission and Distribution Lines Resilience Investment Guide,"
[208] Smith, "U.S. Billion-Dollar Weather and Climate Disasters, 1980 - Present (NCEI Accession 0209268)"; Clarke et al., "Extreme Weather Impacts of Climate Change," 6–9.

Flooding is a major reason to be hesitant to adopt underground wires, but appropriate materials can incorporate this risk into project design as standard crosslinked polyethylene (XLPE) can be replaced by Water resistant XLPE and Ethylene propylene rubber.[209] Florida continues to underground despite the amount of water their lines encounter from storms and floods. During Hurricane Irma, the underground grid performed 85 percent better than the overhead one. Florida utilities emphasized that some areas with underground infrastructure do become impacted by floods. [210] In addition to power lines other types of underground electrical equipment can be made to be insulated and submersible.

Fault Detection and Speed of Repair

For decades, another of undergrounding with noticeable disadvantages was difficulty locating an underground point of failure, when compared to the ease of detecting a downed wire above ground.[211] This is why historically, it takes longer to locate faults that are undergrounded. Additionally, underground lines may be harder to access and require digging up and replacing the line which is more expensive and increases outage times and may require special equipment or skills.[212]

Outages still occur underground due to equipment and cable failures. If undergrounding is to be a worthwhile investment faults must be located and isolated. There are numerous reasons for failure of underground cables, which can happen as cable insulation becomes weakened, or spliced or elbow connection points fail.[213] To find faults a crew of electrical workers are sent in a truck and they travel from transformer to transformer performing manual tests until a fault is found. This is not only a time-consuming process but also carries risks of working with medium voltage and turning a defective transformer back on which can damage equipment, injure workers, and even cause additional outages.[214] After the fault is confirmed, a second crew must be deployed to repair the fault. While the repair of underground wires is difficult even in good weather, it may be more so during a storm. Further, this process is costly.[215]

One obstacle to increasing the proportion of underground power lines is that the ways of protecting overhead power lines compared to underground lines are different and it would necessitate utility companies changing their strategies. Further, the equipment to do so is different.[216] In recent years, automatic reclosers and fusers interrupt faults at points along overhead feeder lines to minimize the amount of area facing an outage.[217] In comparison, underground power lines have pad-mounted transformers which are focused on power distribution, which can

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209 PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 11.
210 PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 11.
211 Power Delivery Intelligence Initiative, "Utility Undergrounding Life-Cycle Cost Guide," 13.
212 Watts, "The Changing Economics of Utility Investment in Undergrounding," 6.
213 Wood Mackenzie, "Going Underground: Reinventing Resilience," S&C Electric Co., June 5, 2024, https://www.sandc.com/globalassets/sac-electric/documents/technical-paper-wood-mackenzie.pdf?dt=639128149560827881, 4.
214 Scenic America, "Undergrounding Case Study: S&C Electric Company," Accessed May 5, 2026, https://www.scenic.org/take-action/resources/undergrounding-resources/undergrounding-resources-and-white-papers/case-study-sc-electric-company/.
215 Wood Mackenzie, "Going Underground: Reinventing Resilience," S&C Electric Co., 2024, 4.
216 Watts, "The Changing Economics of Utility Investment in Undergrounding," 7.
217 Watts, "The Changing Economics of Utility Investment in Undergrounding," 7.

sectionalize a line but not prevent fault interruptions on the main line. A later section examines how certain designs and technologies may overcome this limitation.

However, even accounting for these variables such as vulnerability to flood and difficulty to repair, the main deterrent for burying power lines is the costs.

Costs

Cost, more than any other factor, is the primary deterrent to the expansion of undergrounding. Reportedly, costs of undergrounding wires vary widely but are typically several times more than installing new overhead lines.[218]

Various studies have focused on the factors that impact the costs.[219] Greater voltages require more insulation, which in turn increases the amount of space wires take up underground, both of which increase the cost. There are also differences in cost whether an underground electrical line is new or converted. Studies have found that it is 3 to 10 times more for new construction while typically only 1.5 to 5 times as much for a conversion.[220] Part of the difference in price for the type of construction lies in selling scrap of above ground materials. One study found that undergrounding conversion costs are approximately the same as new build, once salvaging existing overhead lines are accounted for.[221]

The technical details of the power line and the terrain it is being installed in are also important as the type of cable, amount of insulation needed, and other engineering details affect the costs of the project:

- High pressure fluid filled power lines cost more than cross-linked polyethylene.[222]
- 3-phases power lines cost more than single phase lines.[223]
- Rocky terrain and customer density are perhaps one of the main drivers in underground costs. Places where you can trench easily and create right of way agreements are ideal.[224]

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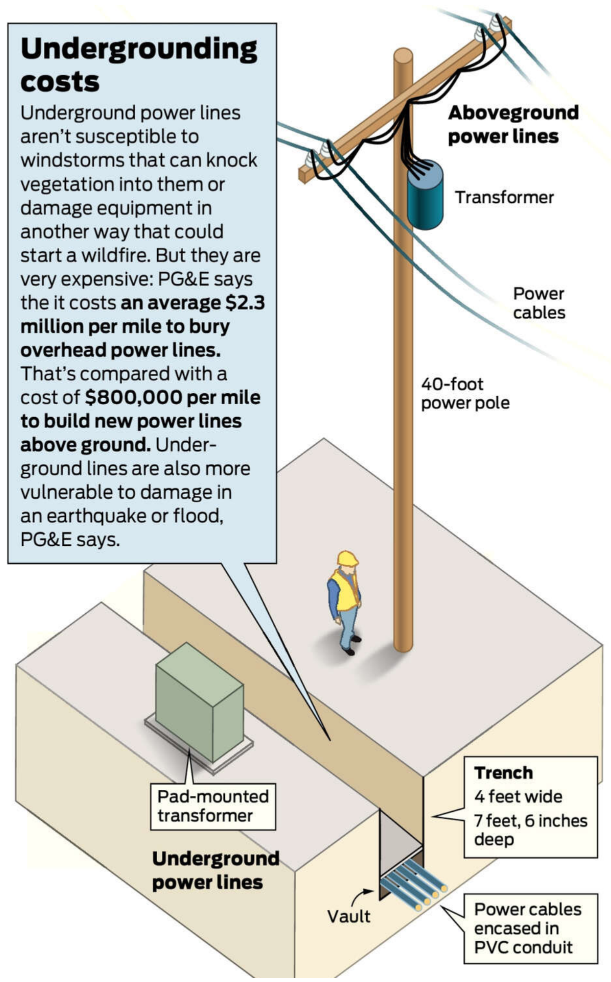
[218] Kenneth Hall, "Out of Sight, out of Mind 2012 an Updated Study on the Undergrounding of Overhead Power Lines," 2013, https://www.eei.org/-/media/Project/EEI/Documents/Issues-and-Policy/Reliability-and-Emergency-Response/UndergroundReport.pdf?la=en&hash=7E2DB1E527AA94410D64121EE340AF3D8BD07694
[219] Angelena Bohman, "Investing in Power System Resilience: A Mixed Methods Approach to Assessing the Tradeoffs of Resilience Strategies," PhD dissertation, 2022, https://www.cmu.edu/ceic/research-publications/angelena-bohman-phd-thesis-2022.pdf.
[220] Lawrence Berkeley Lab., "Undergrounding Transmission and Distribution Lines Resilience Investment Guide,"
[221] Kenneth Hall, "Out of Sight, out of Mind 2012 an Updated Study," 2013.
[222] Lawrence Berkeley Lab., "Undergrounding Transmission and Distribution Lines Resilience Investment Guide."
[223] Lawrence Berkeley Lab., "Undergrounding Transmission and Distribution Lines Resilience Investment Guide."
[224] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 17.

On the lower end of case studies reviewed was Virginia's Dominion: $500,000 per mile and an additional $250,000-$500,000 in sites with rocky terrain.[225] As noted elsewhere, Dominion's program focuses on lateral lines that are lower voltage and comparatively less costly to construct. The cost was calculated as $2.50 per customer for 650,000 customers. There were about 60 customers per mile.

On the other end of the cost spectrum is California's PG&E, which has cited an average of $3.75 million per mile of underground wire. Reportedly, this project has a different design from Dominion's and focuses on main lines, which involves burying power lines of higher voltages. The utility has a goal of lowering the costs to $2.5 million per mile by 2026. It is expected that this will be accomplished through building up a workforce with the necessary construction equipment such as rock wheels, ploughs, and chainsaw trenchers. Even if technology is not advanced it must be acquired by utility companies and worked into their plans. See Figure 13 for more information.

Figure 13
PG&E Installation of Underground wires 2019



Source: San Fransico Chronicle, "Put PG&E's Power Lines Underground? It can be done," October 25, 2019, https://www.sfchronicle.com/california-wildfires/article/Put-PG-E-s-power-lines-underground-It-can-be-14565060.php.

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[225] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience."

While traditional comparisons examine the cost of miles of overhead compared to new miles of underground. All new construction of power lines for new housing developments are placed underground where feasible. But there are still a significant number of homes built prior to this time that would be expensive and difficult to underground. A later chapter of this report notes instead decision to underground should be based on total life-cycle cost of a particular technology whenever possible.

Despite the high cost of underground cables they also have the potential to save money in other areas as research indicates that they may last longer and can eliminate expenses relating to vegetation management and pole inspections.[226] For example, one way underground powerlines save money compared to overhead lines is maintenance expenses decrease due to their reliability, which have been estimated to be three to seven times less than overhead lines.[227] Accordingly fewer "truck rolls" are needed, where a crew of utility repair specialists are sent out to repair a site.

Geographic Factors Influencing Cost

Apart from technical specifications of underground power lines, one of the main reasons there is so much variability in the cost of underground is that geography plays a large role in determining the viability and the cost with an undergrounding project. For example, "Rocky soil or heavily urbanized areas may substantially increase installation costs. To properly ascertain the benefits of placing lines underground, geographically dissimilar areas need to be measured separately. Ultimately, the cost-benefit analysis should be done individually by each company with separate analyses done for different types of geography."[228] This is one reason why national estimates from undergrounding should not be used to determine its feasibility throughout the United States.

The digging itself constitutes much of the time and expense of the undergrounding process. Overall, there are many site-specific criteria that determine how undergrounding is conducted. Preferred methods of burying lines may vary based on geology and type of line being buried. While digging trenches was the standard practice for undergrounding, there has been a growth in the use of horizontal directional drilling (HDD) in undergrounding projects which in some situations can be less expensive than digging or trenching and may disturb the surface less.[229] HDD has the benefit in that it better avoids other underground obstacles (by going under them). HDD can save money in certain situations as it allows for smaller work crews and might avoid road closures. With HDD, it becomes possible to install cable under rivers, driveways, and roads.[230]

Meanwhile, trenching is often cheaper in cost, but it causes ecological and visual disruptions as the ground is torn up. Depending on the area, different trenching needs may vary from 24" to 36". Digging smaller trenches saves money because crews can spend less time and resources on construction. While HDD unlocks many underground-related possibilities, it will

[226] Watts, "The Changing Economics of Utility Investment in Undergrounding." *S&C Electric Co.,* 2023, 10.
[227] Power Delivery Intelligence Initiative. "Utility Undergrounding Life-Cycle Cost Guide." 5
[228] Ephram Glass, and Victor Glass, "Underground Power Lines Can Be the Least Cost Option When Study Biases Are Corrected," The Electricity Journal 32, no. 2 (March 2019): 7–12, https://doi.org/10.1016/j.tej.2019.01.015, 9.
[229] Power Delivery Intelligence Initiative, "Utility Undergrounding Life-Cycle Cost Guide."
[230] Watts, "The Changing Economics of Utility Investment in Undergrounding," 9.

not be the preferred solution for every project. [231] In some instances, it is still cheaper to trench on a cost per foot basis. However, some types of terrain allow for shallower trenches (microtrenching) and direct burying of cables. This saves money on conduit and expenses of pulling cable; however, such measures would likely be inappropriate in Pennsylvania due to its climate and geography that involves seasonal thawing and freezing.

Increased use of prefabricated components can lower installation costs. Precast Concrete structures like manholes, equipment pads and duct banks can be created in a factory and shipped to the project site. This saves time and money and reduces the amount of highly skilled labor necessary to complete undergrounding projects.[232] Even if a company is enthusiastic to begin undergrounding projects, supply chain issues can slow down the rollout of undergrounding and cause some companies to do it more incrementally. Some companies noted that during the COVID-19 pandemic shortages of components like pad-mounted transformers meant such projects could not be completed.[233]

Proper planning and becoming informed on potential risks is critical to success of an undergrounding project. The costs are often incredibly specific to the conditions at a project such as the terrain, so that labor and materials can make generalized assumptions inaccurate. Improper public records about existing underground resources must be overcome. In the design and planning phase companies must have engineering and construction guidelines that further their goals and cooperation and coordination across departments as well as buy in from necessary stakeholders. For example, construction and operator input should be factored into the undergrounding designs, and those who service them should ask for concessions on operating clearances, or landscaping. Those who design underground systems may have different struggles to those that operate and maintain systems.

Scale of an undergrounding program also affects undergrounding price. Undergrounding multiple lines in succession by grouping nearby circuits into larger initiatives can result in cost savings. "Bigger projects and long-term visibility into project portfolio provide clarity and certainty."[234] A contractor with resources for engineering design, construction, and customer management means this would not have to be duplicated each time. EDCs may reduce costs by moving undergrounding design and construction capabilities in-house.

The duration of undergrounding projects can vary between months to one-to-two years and require much upfront planning.[235] Those with experience have noted that an approach with focus can accomplish an achievable set of goals in a realistic period and have the greatest success. It is important to decide on key elements early in project lifecycle to avoid costs ballooning later. During the initial phases of a project's design, 3D design and GIS mapping software make it easier

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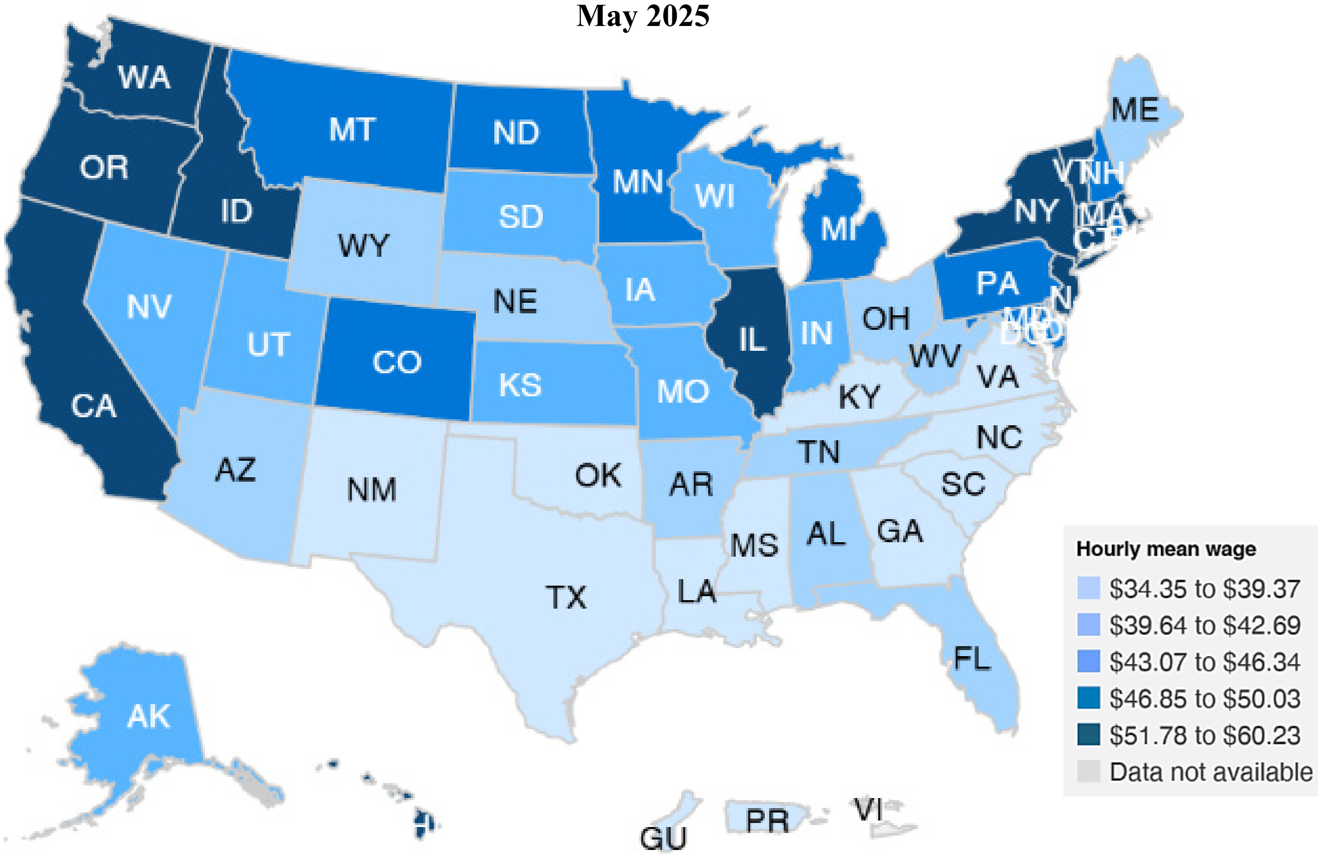
[231] Jeff Griffin, "Trenching Is Still King: 2023 Underground Report," Electrical Contractor Magazine, March 15, 2023, https://www.ecmag.com/magazine/articles/article-detail/trenching-is-still-king-2023-underground-report.
[232]Power Delivery Intelligence Initiative, "Utility Undergrounding Life-Cycle Cost Guide,"
[233] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience."
[234] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience."
[235]Power Delivery Intelligence Initiative, "Your Mileage May Vary-Undergrounding Distribution Lines," YouTube, Sep. 28, 2024, https://www.youtube.com/watch?v=LEoCh_cV7nc.

to visualization the underground project. This can increase the accuracy between plans and the actual conditions on the site which, in term, lowers installation costs.[236]

Labor Costs

Labor costs in the area where work is being performed are also a factor in the overall cost of undergrounding projects. In Pennsylvania this can involve well-trained professionals that cost up to $49.02 an hour. This value is fairly in the middle compared to some states used in the case studies. Virginia's labor costs are $37.71 per hour per person; Florida's is approximately $40.82. Other states have higher costs, such as New York's $51.94. California has one of the highest hourly rates at $60.23. See Map 12.

Map 12
Hourly Mean Wage of
Electrical Power Line Installers and Repairers
by State
May 2025



Source: US Bureau of Labor Statistics, "Occupational Employment and Wage Statistics Maps," May 2025, https://data.bls.gov/oesmap/.

[236]Power Delivery Intelligence Initiative, "Utility Undergrounding Life-Cycle Cost Guide."

There are also differences in the cost of hourly wages across Pennsylvania which would affect undergrounding work in various parts of the state. Table 7 shows an overview of rates paid by federal construction projects for work relating to electrical line installation across Pennsylvania. Rates were typically highest in the southeastern region, with fringe benefits being proportional to the hourly rate. Northern Pennsylvania had higher advertised rates but proportionally fewer benefits.

Table 7
Davis-Bacon Act Wage Determination of Line Installers in Pennsylvania
May 2026

Position	**Region**							
	Western PA[237]		**Southeastern PA**[238]		**Central PA**[239]		**Northern PA**[240]	
	Rates	*Fringes*	*Rates*	*Fringes*	*Rates*	*Fringes*	*Rates*	*Fringes*
Cable Splicer	\$54.38	34.25% +\$11.50	\$62.54	34.25% +\$11.50	\$53.2	34.25% +\$11.50	NA	NA
Groundman	32.63	34.25% +11.50	37.52	34.25% +11.50	31.92	34.25% +11.50	\$42.2	\$16.02
Lineman	54.38	34.25% +11.50	62.54	34.25% +11.50	53.2	34.25% +11.50	68.06	31.43
Truck Driver	35.35	34.25% +11.50	40.65	34.25% +11.50	34.58	34.25% +11.50	44.24	16.21
Winch Truck Operator	38.07	34.25% +11.50	43.78	34.25% +11.50	37.24	34.25% +11.50	NA	NA
Equipment Operator	NA	NA	NA	NA	NA	NA	68.06	31.43

Source: US Dept. of Labor, Davis-Bacon Act Wager Determinations, 2026. See table footnotes.

While the expense of undergrounding is a major deterrent, if EDCs adopted undergrounding initiatives, it would likely create addition construction jobs throughout the state.

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[237] US Dept of Labor, Davis-Bacon Act Wage Determination #PA20260002, May 17, 2026, https://sam.gov/wage-determination/PA20260002/3.
[238] US Dept of Labor, Davis-Bacon Act Wage Determination #PA20260004, May 17, 2026, https://sam.gov/wage-determination/PA20260004/3.
[239] US Dept of Labor, Davis-Bacon Act Wage Determination # PA20260006, May 18, 2026, https://sam.gov/wage-determination/PA20260006/1.
[240] US Dept of Labor, Davis-Bacon Act Wage Determination # PA20260006, May 18, 2026, https://sam.gov/wage-determination/PA20260006/1.

Emerging Technologies

As noted above, price is the most relevant factor limiting the adoption of underground power lines within the Commonwealth. However, other limitations of the technology are often cited as reasons to avoid the practice. Such claims are often repeated either in industry reports or are cited by energy companies as why undergrounding may be an impractical solution. Table 8 reviews these common limitations. However, these issues have reportedly been solved by technological advancements provided a utility has the financial resources along with the engineering and construction expertise, and a sufficient supply chain.

Table 8
Limitations of Underground Wires
May 2026

Problem	Solution
Locating underground faults cannot be seen without physical inspection.	Electronic sensors can be installed to detect faults.
Underground cables have not lasted as long as overhead wires.	New cable materials can reportedly last up to a hundred years.
Underground wires can degrade from water and moisture damage.	Improvements in design all for better water proofing of materials.

Source: PUF Energy Research, “The Role of Undergrounding in Electricity System Resilience.”

With the correct investments underground power lines may not be bound by the same limitations today as the wires buried in the 1970s. However, verifying manufacturing claims can be difficult for electric companies that are not incentivized to experiment with new materials. It is expected that better manufacturing, construction, and installation techniques will increase the longevity of underground wires compared to past wires. For example, stronger cables on bigger reels (spools) means that fewer vaults are needed, which in turn means there are fewer pieces of wires to splice together.[241] Similarly, improved quality control tests used at project sites during installation can help ensure power lines are performing as intended and can lower the chances that faulty materials will break further in the future.

Quality control measures can find the weakest segments of cable so when serviced, shorter segments need to be replaced. [242] Improvements made to semiconducting shields within the wires, specifically designed for underground applications, can reportedly reduce the stress caused on wires from grounding and dissipating high voltages. Similarly, reducing copper content in XLPE

[241] Power Delivery Intelligence Initiative, “Utility Undergrounding Life-Cycle Cost Guide.”
[242] Power Delivery Intelligence Initiative, “Utility Undergrounding Life-Cycle Cost Guide.”

power lines can decrease its vulnerability to overheating during a fault.[243] Cable joints and separatable connectors with fully submersible components perform better in storms and floods.[244]

Better insulation materials in a test environment allows cables to last a simulated 100 years, double the lifespan of a wooden pole.[245] If these results were reproduceable in the field, this would be a great reduction in expenses if EDCs could avoid the need to re-bury underground lines every 40 years.

Improving Reliability of Underground Power Lines

As noted previously, the difficulty of fixing underground power lines has long been regarded as one of its primary disadvantages. Overhead power lines have relied on automatic recloser to interruption faults and restore power quickly, however this strategy has traditionally been unusable underground. This limitation appears to be changing as "some protection devices now use low-energy fault-testing on underground and hybrid feeders and automated switching on single-phase underground residential distribution (URD) loops, resulting in fewer customers being affected by faults on these parts of the grid and achieving faster restoration."[246]

One example of a product that can offer underground powerlines similar flexibility to above ground power lines is EdgeRestore a so called 'smart switch' by S&C that can aid in fault detection and power rerouting.[247] When EdgeRestore is installed in a underground system it can reportedly find a fault, isolate it, and reroute power in 60 seconds.[248] "When a voltage loss happens, circuit interrupters are triggered to open. The nearest interrupter to the electrical fault remains open, while the rest of the downstream interrupters engage in an automated communication process via power line carrier technology."[249] This is a possible solution for residential neighborhoods with obstructions, as 'powerline communication' does not need line of sight. Once the signal is sent the interrupter closes and power to customers is sent by another source. While a repair crew is still needed to fix the fault, this avoids having the first crew come out and test and saves time.[250]

While some traditional methods of locating faults underground can damage underground power lines, S&C noted that "Fault Interrupter that uses 5% or less fault energy to test for faults, meaning a softer version of conventional reclosing can confidently be applied on three-phase underground or hybrid underground and overhead feeders with much less risk of further damage to the system."[251] This technology allows for segmentation of the power lines which can lower the number of customers affected by faults.

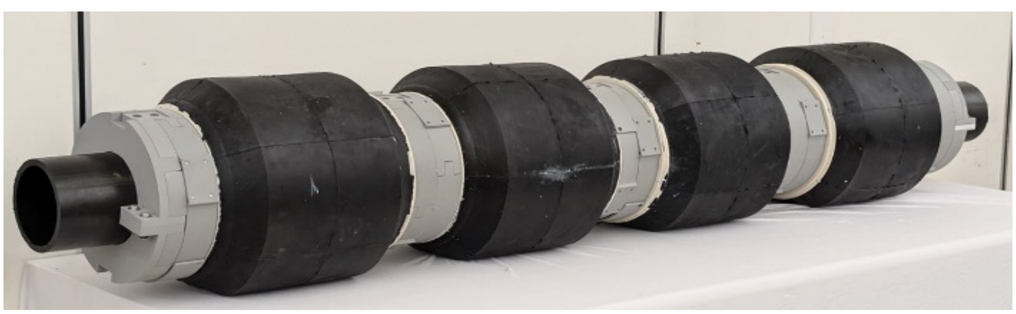
243 Power Delivery Intelligence Initiative, "Utility Undergrounding Life-Cycle Cost Guide."
244 Power Delivery Intelligence Initiative, "Utility Undergrounding Life-Cycle Cost Guide."
245 Power Delivery Intelligence Initiative, "Utility Undergrounding Life-Cycle Cost Guide."
246 Watts, "The Changing Economics of Utility Investment in Undergrounding," 1.
247 Scenic America, "Undergrounding Case Study: S&C Electric Company," June 2025, https://www.scenic.org/take-action/resources/undergrounding-resources/undergrounding-resources-and-white-papers/case-study-sc-electric-company/.
248 Wood Mackenzie, "Going Underground: Reinventing Resilience," *S&C Electric Co.*, 2024, 5.
249 Scenic America, "Undergrounding Case Study: S&C Electric Company," June 2025.
250 Scenic America, "Undergrounding Case Study: S&C Electric Company," June 2025.
251 Watts, "The Changing Economics of Utility Investment in Undergrounding," 9.

One example of a Pennsylvania EDC which has worked to improve the monitoring and fault detection capabilities of its underground network is Duquesne Light Co. (DLC), based in the Pittsburgh area. In recent years, DLC sought innovative solutions to increase its reliability. In December of 2021 DLC held a contest on a crowdsourcing platform to determine who could make better underground electrical system.[252] DLC spent two years reviewing entries until a chosen technology "Smart Cable Guard" by a company known as DNV was awarded. This AI powered monitoring system performs real time data collection to identify faults and claims it helps reduce distribution cable failures by 70 percent.[253] "DLC plans to install the underground cable monitoring system on more than 500 miles of infrastructure during the 5-year period from 2025 to 2030."[254] DLC will be the third utility to have this system installed on it. It is expected that this system will improve worker safety by giving better understanding of conditions underground while predicting future failures.

Innovations in Digging Technology

The US DOE is pioneering new technologies with the goal of lowering the cost of burying underground power lines. Within its Advanced Research Projects Agency-Energy (ARPA-E) there is a program called "Grid Overhaul with Proactive, High-speed Undergrounding for Reliability, Resilience, and Security."[255] Reportedly, "GOPHURRS" is focused on ways to simplify the construction of underground medium-voltage (5–46 kV) power distribution grids in urban and suburban areas. Automation, damage prevention and error elimination are key tenets to reduce costs, increase speed and improve safety. This project aims to make directional drilling less risky by combining sensors on a drill bit with ground penetrating radar. (Elsewhere the report notes that poorly documented underground infrastructure, detritus, etc. is a risk of using directional drilling). See Figure 14.

Figure 14
GOPHURRS Robotic Undergrounding Tool
2026



Source: Jeff Gavin, "Going Underground: Power line burial is on the Rise," Electrical Contractor, Mar 13, 2026, https://www.ecmag.com/magazine/articles/article-detail/going-underground--power-line-burial-is-on-the-rise.

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252 Emergency Preparedness Partnerships, "Duquesne Light Deploys Underground Cable Monitoring System," February 8, 2024, https://emergencypreparednesspartnerships.com/duquesne-light-deploys-underground-cable-monitoring-system/.
253 Emergency Preparedness Partnerships, "Duquesne Light Deploys Underground Cable Monitoring System."
254 Emergency Preparedness Partnerships, "Duquesne Light Deploys Underground Cable Monitoring System."
255 Jeff Gavin, "Going Underground: Power Line Burial Is on the Rise," 2026.

Case Western Reserve University has created a prototype of this project with a robotic digging tool inspired by earthworms that lay down conduit as it goes to reduce costs in urban and suburban environments.[256] Since an estimated 75 percent to 90 percent of the cost of underground is civil works, GOPHURRS hopes to halve this cost.[257] Another potential innovation could be Plasma Tunnel Boring which can cut through hard rocks while staying in a narrow path.[258]

Underground Telecommunication Lines

While this report primarily focuses on reliability improvement pertaining to power lines, there are also associated benefits and expenses to burying telecommunications lines. Within Pennsylvania, the FCC and the PUC regulate telecommunication utilities. "The FCC regulates interstate and long-distance telephone service, cellular service, and internet-based telecommunications. The FCC also establishes national telecommunications standards and helps promote best practices for resiliency."[259] In Pennsylvania there are many more telecom providers than EDCs. Some use their own facilities for service while others pay other telecom companies to use their service. This adds complexity and logistical difficulty to potential collaborations between telecom providers and EDCs as significant coordination may be needed to underground all wires.

There are important telecom components to provide telephone and cell, cable tv, and internet services. These include critical facilities (central switching offices, head ends), cabling, outside-plant equipment (remote switching offices, cable hubs, cell sites), and end user equipment.

> Critical facilities are larger distribution and switching centers that provide connectivity across all major services. Cabling provides the connections from the critical facilities to end-users; cables are either strung overhead via utility poles or run underground through a conduit. Outside-plant equipment helps connect the cables to the larger telecommunications network. Lastly, equipment in homes, offices, and other buildings such as electronic multiplexers or terminals distribute the signal transmitted via cabling from critical facilities to the customer.[260]

NY's report noted that telecom equipment is vulnerable to storm events like wind damaging aerial cables and poles, as well as flooding.[261] Some telecom equipment also needs electric to operate. "For instance, some wireless services rely on batteries charged by the electric system to

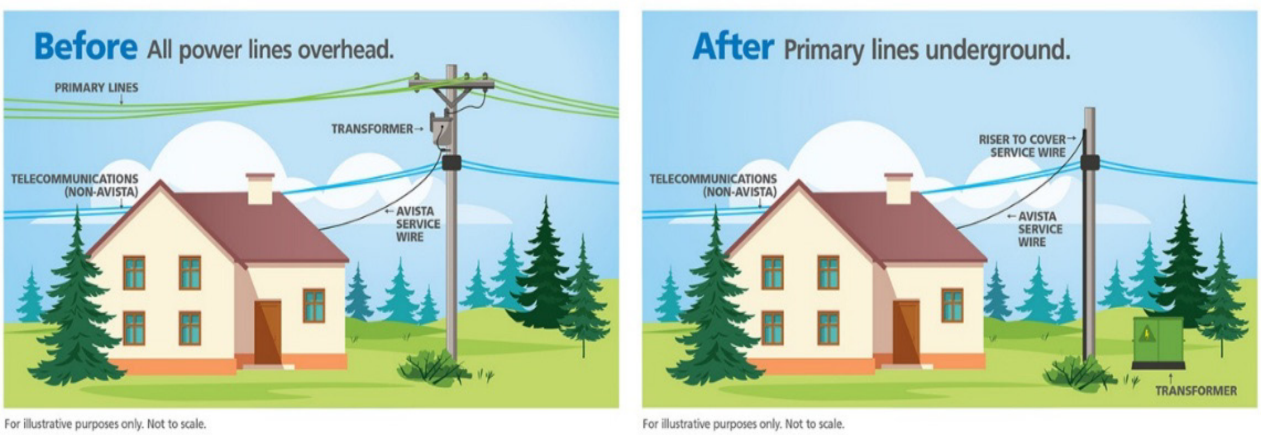
[256] Jeff Gavin, "Going Underground: Power Line Burial Is on the Rise," 2026.
[257] Jeff Gavin, "Going Underground: Power Line Burial Is on the Rise," 2026.
[258] Scenic America, "Undergrounding Case Study: EarthGridTM Plasma Tunnel-Boring," December 6, 2024, https://www.scenic.org/take-action/resources/undergrounding-resources/undergrounding-resources-and-white-papers/earthgrid-plasma-tunnel-boring-technology/.
[259] Industrial Economics, "The Benefits, Costs, and Economic Impacts of Undergrounding New York's Electric Grid," New York State Dept. of Public Service, May 27, 2023, 10.
[260] Industrial Economics, "The Benefits, Costs, and Economic Impacts of Undergrounding New York's Electric Grid," New York State Dept. of Public Service, May 27, 2023, 10.
[261] Industrial Economics, "The Benefits, Costs, and Economic Impacts of Undergrounding New York's Electric Grid," New York State Dept. of Public Service, May 27, 2023, 10.

power cell sites; cable and internet services in homes also use commercial electric power provided by the customer."[262] Telecommunications outages during hurricanes are not uncommon.

Similarly, a Massachusetts DOE report from 2014 found that burying telecom lines along with electric will reduce outage risks from wind, downed poles and tree damage. Overall greater degrees of cooperation between EDCs and telecommunications companies could lead to the coordination of buried infrastructure and possible cost sharing. However, it is both costly and very difficult to coordinate fiber and coaxial burial of undergrounding power lines. Getting large organizations to work together on a series of small incremental goals on time and on budget can be a herculean task. Also, an element of luck is needed in terms of timing as utility companies may have already made key investments. Telling potential partners about intentions far in advance may help increase the chances of cooperation down the line.

One of the reasons coordination of undergrounding projects is so important is telecommunications poles can only be entirely removed if all utilities that reside on those poles are buried.[263] Otherwise there will still be a telephone poll outside a house (albeit a 3-4 foot shortened one).[264] See Figure 15.

Figure 15
Telecommunication Line Illustration
2025



Source: Avista, "Strategic Undergrounding," 2025, https://www.myavista.com/about-us/construction-services/strategic-undergrounding.

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[262] Industrial Economics, "The Benefits, Costs, and Economic Impacts of Undergrounding New York's Electric Grid," New York State Dept. of Public Service, May 27, 2023, 10.
[263] Scenic America, "Undergrounding Case Study: Dominion Energy," December 2024, https://www.scenic.org/take-action/resources/undergrounding-resources/undergrounding-resources-and-white-papers/case-study-dominion-energy/, 4.
[264]Dominion Energy, *Understanding What Happens to the Poles?* 2021, https://cdn-dominionenergy-prd-001.azureedge.net/-/media/content/about/delivering-energy/electric-projects/strategic-underground-program/faqs/what-happens-to-poles.pdf.

Strategies to encourage this behavior may be necessary. Dig once policies also present an opportunity for stakeholders to make the most of their infrastructure investments. Each time undergrounding is planned for a power line, this is communicated to telecommunication providers to give notice so that broadband, power, and other utilities may coordinate their actions. In some instances, EDCs have been able to share the costs with telecommunications companies which helps to spread out the costs and bury more infrastructure underground.[265]

[265] Pat Hoffman, "Resilient Power Grids: Strategically Undergrounding Powerlines," March 22, 2022, https://www.energy.gov/oe/resilient-power-grids-strategically-undergrounding-powerlines.

LEGAL IMPLICATIONS OF UNDERGROUND POWER LINES IN PENNSYLVANIA

This chapter examines legal implications relevant to the adoption of underground power lines. Pertinent issues revolve around current undergrounding requirements for new construction, how EDCs acquire the land they use to bury wires, navigating the relationship between the authority of the PUC and local governments when siting power lines, and existing laws dedicated to protecting underground power lines.

Existing Pennsylvania Undergrounding Requirements

Underground electric service has been required in subdivisions of newly constructed housing developments with five or more buildings (or apartment buildings with five or more units) in Pennsylvania since the mid-1970s.[266] Additional requirements and exceptions are listed in Title 52, Chapter 57 of the Pennsylvania Code. In the typical process, a developer readies the lots for the installation of underground cables and the utility (or designee) which installs them. The expense of this process is on the developers, which is typically passed on to buyers as part of the property sale price. The utility company sets the construction standards.

Pennsylvania's laws recognize that undergrounding will not always be possible. Section 57.86 allows applicants for electrical service to file exemptions with the PUC when these requirements would be inappropriate, create undue hardship or be physically impossible.

- For example, one exemption granted in a development in 2015 was due to an area being too rocky to support the installation at Hazleton PA.[267]
- In 2013 an exception was granted due to large lot size, rocky geology, and to minimize the disturbance of natural forest in Pike County.[268]

So that power lines do not terminate directly at housing developments, Section 57.84, requires that the 100 feet of distribution line closest to the property should be undergrounded at the utility's expense.

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[266] 52 Pa. Code § 57.81-88

[267] Sean & Maura K. Finan Shohola Township Pike County "E-2013-2372436," PA PUC Docket, filed July 1, 2013, https://www.puc.pa.gov/docket/E-2015-2487043

[268]Eagle Rock Resort Corporation, "E-2015-2487043," PA PUC Docket, filed May 11, 2015 https://www.puc.pa.gov/docket/E-2013-2372436

Municipal Electric Distribution companies are not regulated by the PUC and may choose to underground their electric lines at their own discretion. For example, Kutztown required undergrounding of power lines as well as utility wires within its borough.[269]

Land Acquisition

Most electric distribution companies do not outright acquire the land that they use to install power lines. Instead, they purchase a right to use property, usually in the form of an easement or right-of-way. In Pennsylvania property law, while the terms "easement" and "right-of-way" are frequently utilized interchangeably, they possess distinct legal definitions and consequences when applied to public utilities. Where a landowner and an EDC can not reach an agreement, an eminent domain proceedings may be filed.

Easement

An easement is a nonpossessory interest in the land of another that confers a right upon the easement holder to use the land for a specific, limited purpose.[270] EDCs typically secure express easements "in gross," which benefit a specific entity rather than a dominant parcel of land.[271]

Right-of-Way

A right-of-way (ROW) is a specific type or public dedication that grants the right to pass through or occupy a defined corridor of land.[272] Pennsylvania courts have confirmed this relationship directly, holding that a right of way is an easement.[273] The term right-of-way generally signifies an easement in the absence of special circumstances, and it is usually the term used to describe the easement itself or the strip of land which is occupied for the easement.[274] Public rights-of-way typically encompass municipal streets, highways, and adjacent sidewalks, regulated by sovereign or delegated municipal authority under the state's police powers.[275]

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[269] Borough of Kutztown, PA, "Chapter 195 Subdivision and Land Development, Article vi Design Standards," 195-29 §, accessed June 21, 2026, https://ecode360.com/11191686.

[270] *Allegheny Valley R. Co. v. City of Pittsburgh*, 95 A.3d 938 (Pa. Commw. Ct. 2014)*; Riverwatch Condo. Owners Ass'n v. Restoration Dev. Corp.,* 980 A.2d 674 (Pa. Commw. Ct. 2009).

[271] *Ephrata Area School Dist. v. County of Lancaster*, 886 A.2d 1169, 204 Ed. Law Rep. 323 (Pa. Commw. Ct. 2005), decision rev'd on other grounds, 595 Pa. 111, 938 A.2d 264, 228 Ed. Law Rep. 362 (2007).

[272] *United States v. Town of Lac du Flambeau,* 797 F. Supp. 3d 894 (W.D. Wis. 2025), *appeal dismissed sub nom. United States v. Town of Lac Du Flambeau, Wisconsin,* No. 25-3058, 2026 WL 1334947 (7th Cir. Jan. 30, 2026).

[273] *Berwick Twp. v. O'Brien*, 148 A.3d 872 (Pa. Commw. Ct. 2016).

[274] *Berwick..*

[275] *Scranton Gas & Water Co. v. City of Scranton*, 214 Pa. 586, 64 A. 84 (1906).

Overhead to Underground Relocation

A primary legal impediment to a widespread undergrounding mandate is whether an existing express easement granted for overhead utility lines authorizes the EDC to trench and bury those lines underground without seeking a renegotiation or modification of the easement from the servient estate owner.

Under long-standing Pennsylvania jurisprudence, the scope of an express easement is governed strictly by the intention of the parties as manifested by the clear, unambiguous language of the written grant.[276] If the original easement deed explicitly specifies the right to construct and maintain "poles, wires, crossarms, and overhead fixtures," any unilateral attempt by the utility to excavate, trench, and install underground conduits constitutes an impermissible expansion of the easement's scope.[277]

Such actions fundamentally alter the physical burden on the servient estate and exceed the scope of the rights granted, such as: disrupting soil, interfering with subterranean root structures, and restricting future underground use by the private landowner.[278]

Consequently, unless the original granting language is broad enough to include any method of transmitting electricity, overhead access agreements must generally be renegotiated, and new or amended easements must be executed.[279] This re-negotiation requirement introduces substantial land acquisition costs, administrative delays, and potential eminent domain litigation.[280]

A further complication arises when the rights to the various levels of the property have been split or severed. The owner of a parcel of land is considered to own the air above, the surface, and the subsurface to the Earth's core. The landowner may divide the property vertically and sell or lease various resources in the subsurface property. This can also be limited to specific veins or ranges of depth. Subsurface rights can be sold or leased in whole or in part. They can be delineated into smaller portions and can further be divided into types of resources. Further, it is a common law rule in all 50 states that the owner of mineral rights has the dominant property interest over the surface property.[281]

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276 *Zettlemoyer v. Transcontinental Gas Pipe Line Corp.*, 540 Pa. 337, 657 A.2d 920 (1995).
277 *Zettlemoyer* at 924.
278 *Lease v. Doll*, 485 Pa. 615, 403 A.2d 558 (1979).
279 In *Enon Valley Telephone Co. v. Market*, the Commonwealth Court held that a telephone company's act of abandoning underground cable and placing aerial telephone poles and lines on a landowner's property without an easement constituted a trespass and recognizing that overhead and underground installations are legally distinct uses, each requiring independent authorization. *Enon Valley Telephone Co. v. Market*, 90 Pa.Cmwlth. 53 (1985); Similarly, in *Fretz v. Pennsylvania Public Utility Commission,* the easement at issue expressly conveyed the right to construct electric lines including poles, towers, cables, and wires above and under the surface of the ground. *Fretz v. Pennsylvania Public Utility Com'n*, 666 A.2d 372 (1995). The presence of the phrase "under the surface of the ground" in the grant was treated as essential to the grant's scope, underscoring that without such language, underground use would not be authorized.
280 *In re PPL Elec. Utilities Corp. of Real Est. Situate in Schuylkill Cnty*., 68 A.3d 15 (Pa. Commw. Ct. 2013).
281 Hannah Wiseman, "Underground Property Rights in Pennsylvania: Understanding Surface Ownership, Mineral Ownership and Pore Space," *Penn State Center for Energy Law and Policy*, December 2022,

Additionally, the number of properties that have been split into multiple estates by subsurface mineral rights leases and sales in Pennsylvania is unknown. Since these are generally private agreements, no central database exists. One project to identify and map oil and gas leases in Allegheny County has identified 269,370 agreements, covering about 32 percent of the county's landmass.[282]

Moving existing power lines from the surface to the underground will require legal research and possible contests as to who has the greater right to the use of the underground portion of the property. New underground lines designed to run under land previously not subject to an easement or ROW will also require substantial legal research and assistance to determine what rights can be sold or made subject to eminent domain.

Municipal Authority vs. Utility Rights (PUC Preemption)

Municipalities have limited ability to compel EDCs to run lines underground. Conflict frequently arises when a local government attempts to compel an EDC to adopt undergrounding policies through local ordinances, subdivision regulations, or permit conditions. In Pennsylvania, the resolution of these conflicts leans heavily in favor of statewide regulatory uniformity via the Pennsylvania Public Utility Commission (PUC).

In the seminal case of *Pennsylvania Power Co. v. Township of Pine*, the Commonwealth Court addressed a situation where a developer and a township sought to force an EDC to install its distribution lines underground along a public road right-of-way, denying a permit for overhead poles. The Court reaffirmed that the Public Utility Code occupies the entire field of public utility regulation within the Commonwealth.[283] Under the doctrine of field preemption, local municipalities lack the legislative authority to regulate or dictate the standard of service, safety, practices, or facilities of a public utility.[284] This absolute preemption means that local ordinances, subdivision rules, or historical preservation restrictions attempting to mandate underground lines are legally void. The choice between overhead and underground distribution lines is fundamentally a question of utility service design and economic cost allocation, which falls under the exclusive jurisdiction of the PUC, not local townships.[285] Therefore, a local municipality cannot compel an EDC to adopt undergrounding policies, regardless of their local ordinances, subdivision regulations, or permit conditions.

Environmental Rights Amendment and Historic Preservation Exceptions

Municipalities have increasingly sought to bypass field preemption by invoking Article I, Section 27 of the Pennsylvania Constitution, known as the Environmental Rights Amendment

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https://celp.psu.edu/wp-content/uploads/2022/12/Summary-of-Underground-Property-Rights-in-Pennsylvania_CELP-for-posting.pdf.

282 The Allegheny Lease Mapping Project, *FracTracker Alliance*, https://www.fractracker.org/resources/lease-mapping/analysis/accessed June 22, 2026.

283 *Pennsylvania Power Co. v. Township of Pine*, 926 A.2d 1241 (Pa. Cmwlth. 2007) at 1252-53.

284 *Pine* at 1252; see also *PECO Energy Co. v. Township of Upper Dublin*, 922 A.2d 996 (Pa. Cmwlth. 2007).

285 *Pine* at 1252; 52 Pa. Code § 57.84

(ERA). The ERA guarantees citizens the right to clean air, pure water, and the "preservation of the natural, scenic, historic and esthetic values of the environment."[286]

This intersection was deeply analyzed in the litigation surrounding utility infrastructure placements and historic aesthetics, notably in *City of Lancaster v. Pennsylvania Public Utility Commission* and subsequent developments regarding municipal environmental/historical zoning.[287] While the Commonwealth Court reaffirmed that the PUC holds exclusive field preemption over utility operations, it emphasized that the PUC itself is a Commonwealth agency bound as a trustee under the ERA.[288] Therefore, the PUC must actively consider and protect environmental and historic values when promulgating regulations or approving utility practices. However, this does not grant municipalities individual veto or regulatory power over utility infrastructure; rather, it requires that any aesthetic or environmental challenges to utility facilities be raised directly before the PUC via formal complaints or rulemaking petitions, maintaining centralized regulatory control.[289] So, the PUC indeed has field preemption, but it must act in accordance with environmental concerns and is subject to environmental challenges when made through the proper channels.

The Pennsylvania Underground Utility Line Protection Law

The Pennsylvania Underground Utility Line Protection Law establishes a comprehensive framework requiring excavators and facility owners to coordinate through the Pennsylvania One Call System before excavation work begins to prevent damage to underground utilities. [290] The Act protects public safety, prevents property damage to utility infrastructure, and establishes duties for excavators, facility owners, project owners, and the One Call System itself, with enforcement authority vested in the Pennsylvania Public Utility Commission.

Definitions

- The Act defines "line" or "facility" to include "an underground conductor or underground pipe or structure used in providing electric or communication service, or an underground pipe used in carrying, gathering, transporting or providing natural or artificial gas, petroleum, propane, oil or petroleum and production product, sewage, water or other service.
- A "facility owner" is defined as "the public utility or agency, political subdivision, municipality, authority, rural electric cooperative or other person or entity who or which owns or operates a line."

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[286] Pa. Const. art. I, § 27.
[287] *City of Lancaster v. Pennsylvania Public Utility Commission*, 650 A.2d 477 (Pa. Cmwlth. 1994) See also *UGI Utilities, Inc. v. City of Reading*, 200 A.3d 116 (Pa. Cmwlth. 2018).
[288] *UGI Utilities* at 126; *Robinson Twp., Washington Cnty. v. Com.*, 623 Pa. 564, 83 A.3d 901 (2013).
[289] *City of Lancaster,* at 486.
[290] The act of December 10, 1974 (P.L.852, No.287), referred to as the Underground Utility Line Protection Law (UULPL); 73 P.S. §§ 176-186.

- The "Commission" refers to the Pennsylvania Public Utility Commission.[291]

Purpose and Practical Application

Undergrounding does lead to an increased risk to third parties (utilities, contractors, and homeowners). As with any underground work, digging near utilities can quickly lead to expensive repairs. Pennsylvania has already taken steps to protect its underground utilities as well as its workers and homeowners by putting policies in place to mitigate the risks. In one legal case, before performing excavation work for a waterline extension project, the appellant had requested that the appellee mark the locations of gas lines around the work sites pursuant to the One Call Act (Act).[292]

The Act's purpose is "not to protect against economic losses, but to protect against physical harm to individuals working on construction sites and to avoid property damage to utility equipment and surrounding structures."[293]

The One Call System serves as "a communication system established within this Commonwealth to provide a single toll-free telephone number for contractors or designers or any other person covered by this act to call facility owners and notify them of their intent to perform excavation, demolition or similar work."[294]

Duties and Enforcement

Excavators have extensive duties under the act. They must "report immediately to the facility owner any break or leak on its lines, or any dent, gouge, groove or other damage to such lines or to their coating or cathodic protection, made or discovered in the course of the excavation or demolition work."[295] Similarly, facility owners must respond to location requests by marking their underground lines "not later than the business day prior to the lawful start date of excavation."[296]

The Pennsylvania Public Utility Commission has enforcement authority under the act. Both excavators and facility owners must "comply with all requests for information by the commission relating to the commission's enforcement authority under this act within thirty days of the receipt of the request."[297] When utility companies seek to install electric lines, the act's requirements apply equally to them as facility owners. In the context of underground versus overhead lines, municipalities have limited authority to require undergrounding. The PUC retains "the ultimate authority to determine the particulars of implementation, including timing, feasibility and cost of the project."[298] This means that while a municipality can designate underground utility districts, the PUC has sole jurisdiction.

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[291] UULPL §1; 73 P.S. § 176.
[292] *Excavation Technologies., Inc. v. Columbia Gas Co. of Pennsylvania*, 604 Pa. 50, 52, 985 A.2d 840, 841 (2009).
[293] *Excavation Tech.,* 604 Pa. 50, 56-57 (2009); 73 P.S. §§ 178(7), 180(8).
[294] *Le Nature's, Inc. v. Latrobe Mun. Authority*, 913 A.2d 988 (2006), citing 73 P.S. § 176.
[295] UULPL § 5(6); 73 P.S. § 180(6).
[296] UULPL § 2(5); 73 P.S. § 177(5).
[297] UULPL §§ 2(11) and 5(17);73 P. S. § 177(11) and 180(17).
[298] *Duquesne Light Co. v. Borough of Monroeville*, 449 Pa. 573 (1972).

EXTENT OF US AND PA UNDERGROUNDING OF POWER LINES

Despite long held beliefs that undergrounding was too expensive, utility companies are starting to embrace the practice as the costs of maintaining, protecting, and replacing above ground wires have increased.[299] As of 2023, approximately 20 percent of the US electric distribution lines were underground.[300] This number has increased only nominally over the last 20 years, due to the sheer number of wires comprising the electric grid and the expense of burying them.[301] According to the US Department of Energy (DOE), the total percentage of power lines underground has increased, albeit only slightly, from 18 percent in 2009 to roughly 20 percent in 2023.[302] Approximately 90 percent of new housing subdivisions are undergrounded; older housing stock, however, remains costly to convert.[303]

Research by S&C Electric Company shows both underground and overhead capital expenses from investor-owned utilities (IOUs) increased from 2010 to 2019.[304] Underground expenses increased from 21.4 percent of total capital expenses in 2010 to 22.2 percent in 2019. Study authors believe this increase is driven by investment improvements to existing infrastructure and targeted and large scale undergrounding projects. The given reasons this is happening now are storms and scientific and engineering developments in undergrounding.[305] As noted in the climate and reliability section of this report, people are more reliant on electricity and are looking for solutions.

Research in a Stanford University paper called "Mapping the Depths," has identified where undergrounding is taking place across the country and characteristics of the places adopting it. Nationwide, most undergrounding projects occurred along the east and west coasts as well as in northern states, while the interior of the country noted lower rates of undergrounding. The report found that areas with high populations are more likely to have underground infrastructure.[306] See Map 13.

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[299] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience."
[300] Mike Beehler, "Distribution Goal: 50% Underground by 2040," T&D World, May 25, 2023, https://www.tdworld.com/smart-utility/article/21253499/distribution-goal-50-underground-by-2040.
[301] Lawrence Berkeley Lab., "Undergrounding Transmission and Distribution Lines Resilience Investment Guide," US Grid Deployment Office, Sept. 2024, https://www.energy.gov/sites/default/files/2024-11/111524_Undergrounding_Transmission_and_Distribution_Lines.pdf.
[302] U.S. Dept of Energy. "Infrastructure Funding Progress Update Winter 2025." Energy.gov, April 30, 2026. https://www.energy.gov/infrastructure/progress.
[303] Power Delivery Intelligence Initiative, "Utility Undergrounding Life-Cycle Cost Guide," 17.
[304] Watts, "The Changing Economics of Utility Investment in Undergrounding." *S&c Electric Co.,* 2023, 10.
[305] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 11.
[306] Tao Sun et al., "Mapping the Depths: A Stocktake of Underground Power Distribution in United States," (Seattle, WA: IEEE Power & Energy Society General Meeting, 2024), https://ieeexplore.ieee.org/document/10688935, 3.

Washington D.C., Nevada, and Maryland were areas that had the highest underground distribution rate. While the number of total distribution miles within a state certainly plays a part (as there is more to bury), there was significant variation between the underground rates of New York, California, and Texas, all of which were at the higher end of total number of distribution miles.[307] Pennsylvania has a number of power lines similar to Virginia's but fewer underground wires.

Related to research conducted by Stanford was a web portal showing the progress the country has made at undergrounding power lines since the 1990s. States surrounding New Jersey, Maryland, and Delaware had higher proportions of undergrounding. Overall, the figures corresponded with dense metropolitan areas along the coasts. New Jersey, Maryland, and Delaware along with New York City had the highest proportion of underground near Pennsylvania. The portal showed there was expansion of undergrounding along the sunbelt in the early 2000s largely due to new housing construction. While the Stanford report studied burial of power lines over a 30-year period, Pennsylvania's degree of undergrounding has hardly changed over this duration.[308] In fact, in some counties there has been a decrease, likely due to more overhead power lines being built lowering the overall percentage.

As of 2020, the portal shows that undergrounding was relatively limited across the country and that relatively few counties chose to underground more than a quarter of their power lines and that hitting 50 or higher was a rarity nationwide.[309] In the states surrounding Pennsylvania, Maryland had the highest proportion of undergrounded power lines.

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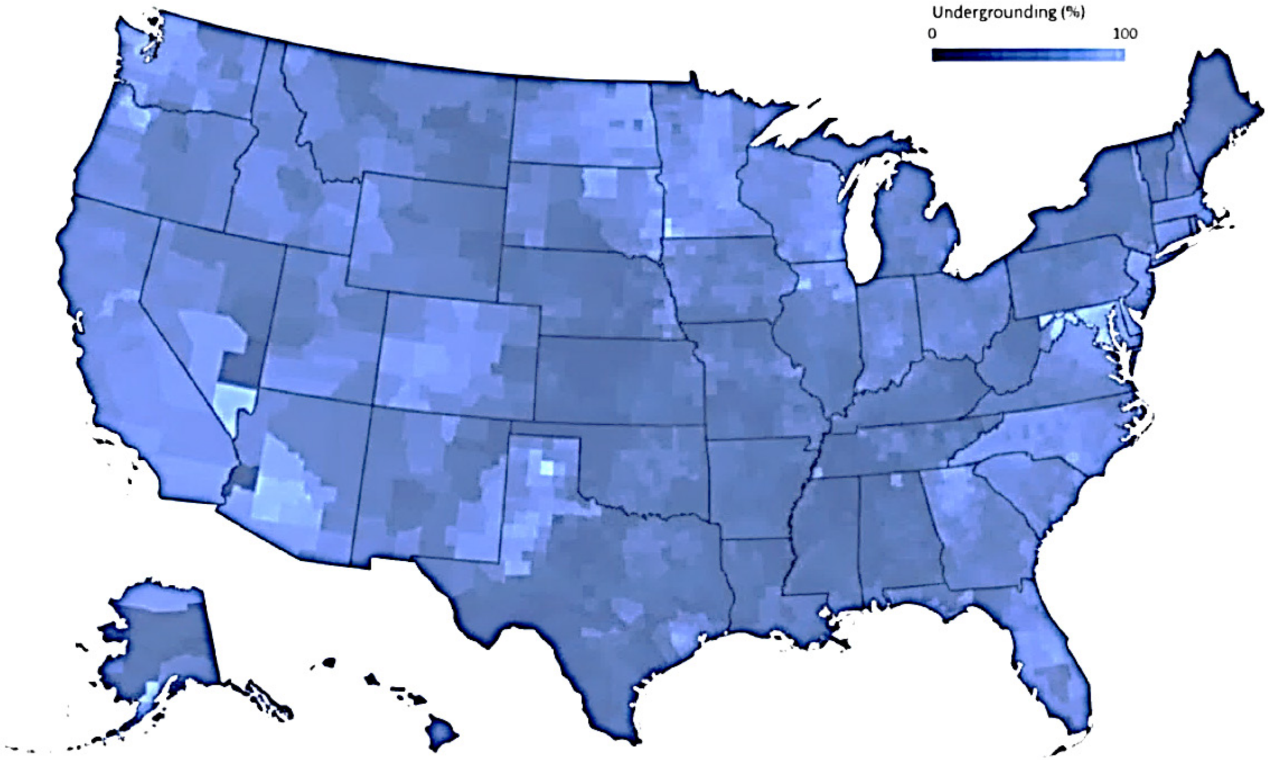
[307] Tao Sun et al., "Mapping the Depths," 4.
[308] Doerr School of Sustainability and Stanford University, "Undergrounding Power, Extreme Weather, and Grid Resilience," 2026, https://underground.datacommons.stanford.edu/.
[309] Doerr School of Sustainability and Stanford University, "Undergrounding Power, Extreme Weather, and Grid Resilience," 2026.

Map 13
Distribution of Underground Power Lines throughout the United States
2020-2025

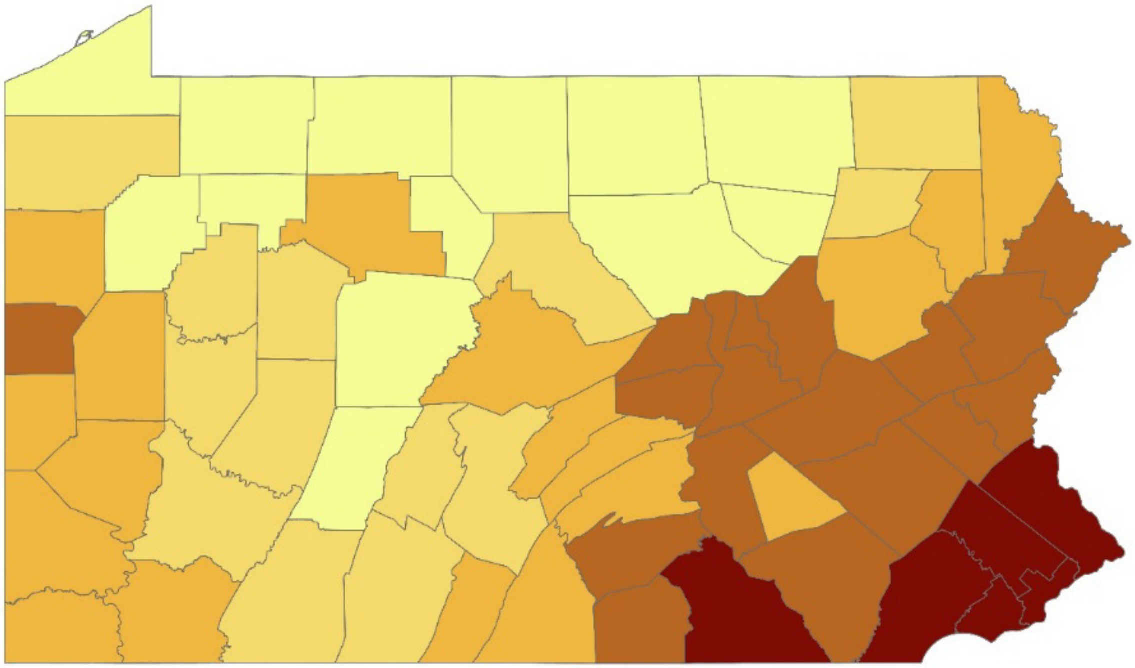


Source: Doerr School of Sustainability and Stanford University, "Undergrounding Power, Extreme Weather, and Grid Resilience," Stanford.edu, 2026, https://underground.datacommons.stanford.edu/.

As of 2020, Pennsylvania lacked the extensive undergrounding found in some states and most of the underground power lines are concentrated in the southeast. See Map 14, While all Pennsylvania counties have at least five percent of the wires buried, only 23 have more than 15 percent.[310] The state's highest rate is Philadelphia's 40 percent. Even the most urbanized areas contain a lower percentage of buried wires than metropolitan cities facing the sea. For example, Baltimore County in Maryland had 66 percent of its distribution lines underground. The map roughly aligns with the service territory of various EDCs, with PECO and PPL's service areas showing the highest levels of undergrounding present.

[310] Doerr School of Sustainability and Stanford University, "Undergrounding Power, Extreme Weather, and Grid Resilience," 2026.

Map 14
Percent of Power Lines Underground in Pennsylvania Counties
2020



Source: Doerr School of Sustainability and Stanford University, "Undergrounding Power, Extreme Weather, and Grid Resilience," Stanford.edu, 2026, https://underground.datacommons.stanford.edu/.

The Stanford study also examined the possibility of increasing the number of underground wires present in each county and estimated its impact on the longest outage reduction throughout the state. This analysis highlights that the location, weather risk, population density, and currently existing levels of undergrounding all play a part in the effectiveness of the technique.[311] For example an additional 5 percent increase in undergrounding was determined to have no effect on shortening outage times in 23 counties. Lycoming, Bradford, and Sullivan could all reduce outage times by an hour by burying only an additional 5 percent of the power lines counties.

An increase of an additional 15 percent undergrounding was calculated to have minimal effect on outages in 12 counties but would reduce outage by least an hour in 19 counties. An increase of an additional 25 percent of power lines underground would have impacted all counties. See Map 15.[312]

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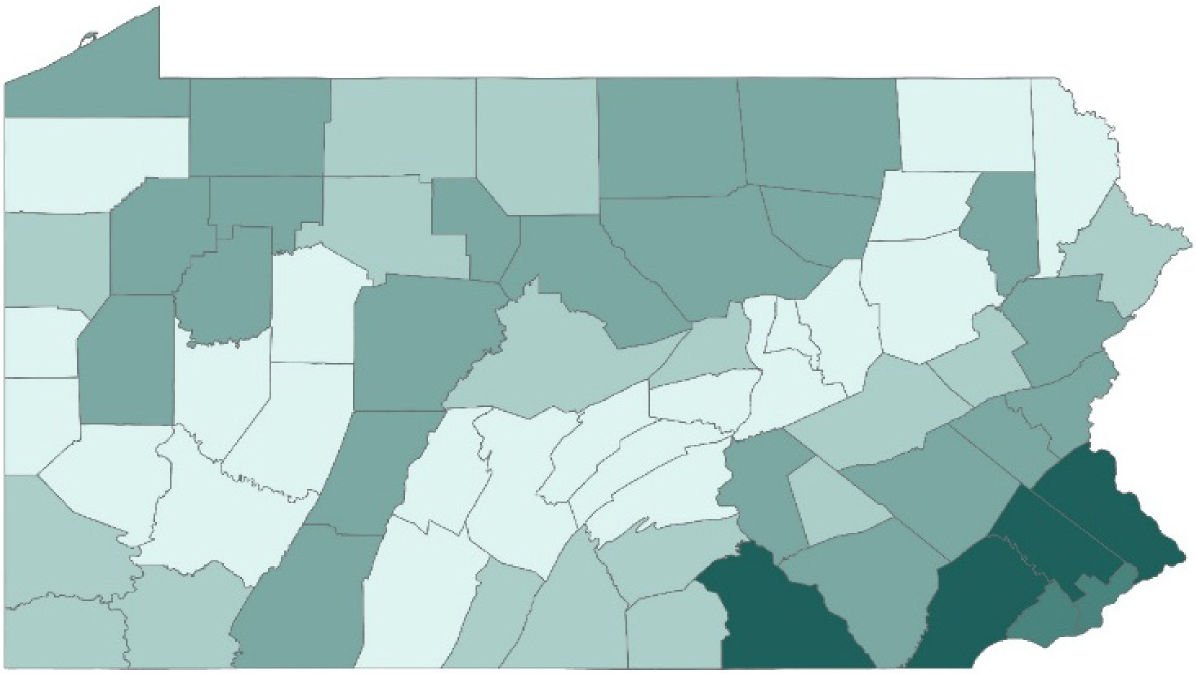
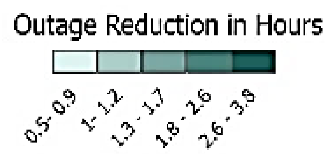
[311] Doerr School of Sustainability and Stanford University, "Undergrounding Power, Extreme Weather, and Grid Resilience," 2026.
[312] Doerr School of Sustainability and Stanford University, "Undergrounding Power, Extreme Weather, and Grid Resilience," 2026.

Map 15
Effect on Outage Times by Increasing Underground Wires by 25 Percent
Pennsylvania
2026



Source: Doerr School of Sustainability & Stanford University, "Undergrounding Power, Extreme Weather, and Grid Resilience" 2026, Map created by JSGC Staff.



Overall, the portal indicates that some of the areas with the highest existing levels of undergrounding in the southeast of the state would see the greatest reduction in outages. York, Montgomery, Bucks, Chester, and Philadelphia would all see a 2.5 hour reduction in longest outage times from an additional 25 percent increase.[313]

While this research could serve as a starting place to identify areas to underground, it should be noted that this study did not examine any physical barriers that could hamper undergrounding efforts, or the relative difference in cost between undergrounding in large rural areas and densely populated urban areas.

A review of existing undergrounding activities within the state has determined that overhead-to-underground conversion of power lines is a type of investment that is virtually nonexistent within Pennsylvania at this time. However, that is not to say that the electric companies do not own and are not investing in underground power lines.

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[313] Doerr School of Sustainability and Stanford University, "Undergrounding Power, Extreme Weather, and Grid Resilience," 2026.

Based on available information from the federal government, utility companies' filings, and PUC reports, Commission staff tried to capture the essential characteristics of the fragmented distribution system. The EDCs regulated by the PUC serve nearly six million customers spread out over 135,890 square miles.[314] Based on staff estimates, there are likely at least 110,000 miles of overhead distribution lines within the state.[315] From these sources, staff identified 17,600 miles of underground distribution power lines within the state, see Table 9. Using academic research from Stanford University, Commission staff estimated an additional 7,200 miles of underground power lines were likely to exist within the footprint of the First Energy and UGI service areas.[316] This brings the estimated number of underground lines to 24,800 and total distribution lines to 134,800 miles.

Table 9
Approximate Overhead and Underground Distribution Power Line (Circuit Miles)
Pennsylvania
2026

Utility Name	Overhead Distribution Mile (Circuit)	Underground Mile (Circuit)	Underground %
Citizens' Electric Co[317]	161	53	24.8
Duquesne Light Co[318]	6,500	500	7.1
PPL Electric Utilities Corp[319]	28,144	8,017	22.2
PECO Energy Co[320]	13,000	9,000	40.9
Pike County Light & Power Co[321]	100	40	28.5

[314] US Energy Information Admin., "Table 10: 2024 Utility Bundled Retail Sales – Total." 2025, https://www.eia.gov/electricity/sales_revenue_price/pdf/table_10.pdf, Analysis by JSGC Staff.

[315] This is intended to capture the length of all distribution circuits within the state found, not the total length of all power lines which sometimes run two or three wires between poles. However, it is possible that due to fragmented sources this information was complied from that in some instances, conductor miles could be included instead in this count.

[316] JSGC Staff Analysis. These companies are known to have underground power lines, but do not separate them in filings to the PUC.

[317] John Kelchner & Citizens' Electric Co., "Biennial Inspection, Maintenance, repair and replacement Plan of Citizens' Electric Company of Lewisburg, PA, For the Period of January 1, 2018- December 31, 2019," PUC Docket No. M-2009-2094773, September 8, 2016, https://www.puc.pa.gov/pcdocs/1474882.pdf, 3.

[318] Duquesne Light Co., "Corporate Responsibility: 2024 Report," https://duquesnelight.com/docs/default-source/default-document-library/dlc-corporate-responsibility-report.pdf?sfvrsn=db1aed44_36; AND Clarion Energy Content Team, "Duquesne Light Company to install underground cable monitoring devices," Factor This, January 29, 2024, https://www.renewableenergyworld.com/power-grid/grid-modernization/duquesne-light-company-to-install-underground-cable-monitoring-devices/.

[319] Pennsylvania Public Utility Commission, "Petition of PPL Electric Utilities Corporation for a Waiver of the Distribution System Improvement Charge Cap of 5% of Billed Revenues," PUC Docket No. P-2024-3048732, https://www.puc.pa.gov/pcdocs/1856966.pdf/.

[320] Kenneth Kulak, "RE: Letter of Notification of PECO Energy Company Filed Pursuant to 52 Pa. Code § 57.71 et seq. for Approval of the Siting and Construction of the Conowingo 220-47 Line Project Located in Plymouth Township and Upper Merion Township, Montgomery County, Pennsylvania," Dec. 19, 20214, https://www.puc.pa.gov/pcdocs/1860122.pdf

[321] Pike County Light & Power Co., *Home Page*, accessed July 2026, https://pclpeg.com/.

Table 9
Approximate Overhead and Underground Distribution Power Line (Circuit Miles) Pennsylvania 2026

Utility Name	Overhead Distribution Mile (Circuit)	Underground Mile (Circuit)	Underground %
UGI Utilities, Inc[322]	1,056	144	12.0
Wellsboro Electric Co[323]	570	29	4.8
FirstEnergy[324]	57,301	7,082	11.0
Total	113,832	24,865	17.9

Source: See table footnotes.

The lack of accurate publicly available data for the number of circuit miles owned by each EDC makes it difficult to determine the number of miles of power lines that would need to be buried for a hypothetical scenario where all distribution lines were buried. Based on estimates created by Commission Staff, such total undergrounding scenarios would likely necessitate burying over 110,000 miles of lines. Undergrounding all electrical distribution lines within the state would be an astronomical expense, costing at minimum between one to two times as much as the $50.1 billion state budget of Pennsylvania.[325] For this reason, it is preferable to approach undergrounding strategically, embracing it where other hardening measures have been ineffective, and where it will be most beneficial to the Commonwealth.

While publicly available data of underground line miles may be inconsistent, there are other ways to approximate the number of power lines owned by each EDC. For example, the value of each power company's physical assets listed in their Schedule 205 filings with the PUC lists the value of both overhead and underground assets owned by each electric company. A review of these assets found that there were significant differences in the percent of total distribution assets listed as underground for each EDC. PECO was highest with 46 percent of the valued distribution infrastructure being associated with underground lines. In comparison, FirstEnergy had 17 percent of its total asset value associated with infrastructure underground.[326] Generally, EDCs in more suburban and urban areas such as PECO, PPL, and UGI grew their share of underground

[322] UGI, "Vision and Values," accessed July 2026, www.ugi.com/about-us/vision-values/; Commission staff estimated Miles underground power lines were likely to exist within the footprint of UGI service areas at a rate of 12 percent.
[323] Wellsboro Electric Co., "Frequently Asked Questions," Accessed July 2026, https://wellsboroelectric.com/customer-service/faq/.
[324] FirstEnergy, "2024 Base Rate Case Filing," PA PUC DOCKET NO. R-2024-3047068, Filed April 2, 2024, https://www.firstenergycorp.com/content/dam/customer/Customer%20Choice/Files/PA/tariffs/VOLUME; Commission staff estimated underground miles approximated based on 11 percent of service area.
[325] PA State budget from Fiscal Year 2025-2026, at an assumed undergrounding rate of $1 to 2 million dollars per mile.
[326] Staff Analysis of Pennsylvania Electric Distribution Annual Reports for years 2019 and 2024 submitted by PECO and FirstEnergy Companies. Original Reports available at PUC.

distribution line assets faster than overhead lines.[327] Duquesne Light (located in another urban/suburban area) already had a higher share of underground assets.

Using these sources, there is some evidence that undergrounding may affect reliability rates in Pennsylvania. The electric companies with the largest share of distribution line assets underground (Duquesne and PECO) have two of the best SAIFI (measures frequency of power interruptions). UGI also had a good SAIFI score. As expected, the companies with more underground assets tend to have fewer power outages.

Both CAIDI and SAIDI, measure how long it takes to repair outages. Higher numbers indicate that it took longer to restore power. Of the larger companies (PPL, PECO, Duquesne, and FirstEnergy), PECO and Duquesne had the lowest/best CAIDI scores while also having the largest share of the wires underground. It is unclear if the quickness of the restoration of power is due to having more underground lines or because their service areas are more compact (more urban) and they can reach damaged areas faster (less travel time).

The data show that underground lines can lessen the number of power outages, but it really cannot answer the question of how long average power outages are with underground versus above ground power lines.

Existing Underground Wire Replacement Through Distribution Charges

A review of LTIIPs filed by EDCs within the state has demonstrated that these companies devote millions of dollars of funding each year replacing 40-year-old underground wires that are projected to be near the end of their useful lives. Overall, the money is being spent to maintain current reliability levels. Each company that participates typically has two different underground replacement programs, one for main stem and one for urban residential distribution. While this will reduce the number of underground faults and make existing wires safer and reliable, focusing on older wires means it will not expand system resilience during storms.

FirstEnergy

Despite maintaining separate rates for their customer bases, FirstEnergy Companies now share rate cases and improvement plans such as LTIIPs. In FirstEnergy's LTIIP III, the company's most recent Long-Term Infrastructure Improve Plan, project categories included \$19.6 million to improve locations where "Customers Experiencing Multiple Interruption" which is also known as CEMI. Of particular interest to this report is that selective underground is proposed as a possible solution, however the plan is far from a firm commitment. FirstEnergy also boasts a \$397.99 million circuit improvement that lists selective undergrounding as possibility.

[327] Staff Analysis of Pennsylvania Electric Distribution Annual Reports for years 2019 and 2024 submitted by PECO, PPL, UGI, and DLC and FirstEnergy Companies. Original Reports available at PUC.

For existing underground infrastructure, FirstEnergy has committed to invest over $45 million on network and underground ducted systems and over $58.7 million on underground cable and equipment replacement focusing on the 829,000 feet of older cables which have a chance of failure. See Tables 10 and 11.

Table 10
Schedule of Planned Projects
Underground Cable Replacement (cable feet)
Pennsylvania
2025

Rate District	2025	2026	2027	2028	2029	Total
Met-Ed	50,130	98,724	86,341	83,792	62,791	378,778
Penelec	24,305	26,837	22,993	22,314	16,769	113,218
Penn Power	37,844	55,342	37,840	36,723	35,639	203,388
West Penn	16,908	30,589	29,686	28,810	27,959	133,952
Total	129,187	211,492	176,860	171,639	143,158	829,336

Source: Darsh Singh and First Energy Electric Co., "Regarding Petition of FirstEnergy Pennsylvania Electric Company for Approval of its Long-Term Infrastructure Improvement Plan," PUC Docket No. P-2024-, July 22, 2024, 40.

Between 2025 and 2029, FirstEnergy plans to replace over 157 miles of aging cables. The company noted that its cost to replace underground cable is approximately $374,101 per mile.[328] The highest proportion of these cables are located in the Met-Ed district which extends throughout sections of southeastern Pennsylvania.

Table 11
Planned Annual Expenditures
(in Millions)
Pennsylvania
2024

Rate District	2025	2026	2027	2028	2029	Total
Met-Ed	$2.16	$4.25	$3.95	$3.95	$3.05	$17.36
Penelec	2.25	2.56	2.26	2.26	1.75	11.08
Penn Power	2.92	4.40	3.10	3.10	3.10	16.62
West Penn	1.62	3.02	3.02	3.02	3.02	13.70
Total	8.95	14.23	12.33	12.33	10.92	58.76

Source: Darsh Singh and First Energy Electric Co. "Regarding Petition of FirstEnergy Pennsylvania Electric Company for Approval of its Long-Term Infrastructure Improvement Plan," July 22, 2024, 41.

328 Staff calculation of total of planned annual expenditure divided by total planned cable, feet converted to miles.

Of all the power companies in the state, FirstEnergy has the most documented instances of discussing targeted undergrounding without having performed such projects. In 2017, the company experienced a high number of reportable events and tree-related outages. Vegetation management expenses are not part of DSIC, but are instead considered part of base rates. In a public meeting held September 2018, the PUC had determined that FirstEnergy companies "LTIIPs are not designed to adequately maintain and improve the efficiency, safety, adequacy and reliability of the EDCs' distribution systems, and have not adequately met its obligations in terms of improving storm hardening, system resiliency, and reliability."[329] In an Opinion and Order the PUC recommended that among other measures to improve its reliability, First Energy should "Consider selective undergrounding for areas with continuing storm-related reliability issues" in future LTIIPs.[330]

In August of 2019 Met-Ed applied for LTIIP II. In response to the prior year's order, it included information about undergrounding.[331]

> "Selective undergrounding is an available option and is pursued where it supports effective implementation of infrastructure improvement initiatives and will be used in conjunction with those initiatives, as appropriate. In residential zones, undergrounding is seldom used due to concerns about customer costs when upgrades to internal and external structures and facilities are necessary to meet code requirements. Rocky and mountainous terrain throughout much of Met-Ed's territory also pose barriers for undergrounding. Undergrounding inherently reduces operational flexibility with failures resulting in longer outages due to longer troubleshooting and repair times."

West Penn and other FirstEnergy power companies included an LTIIP 2 Petition.[332] In response to this, the PUC's Office of Consumer Advocate wanted more details.[333] In September the Office of Consumer Advocate noted that "FirstEnergy should provide additional detail regarding the FirstEnergy Companies' proposed use of selective undergrounding."[334]

In January of 2020 the PUC stated "We also note that selective undergrounding may be a part of an effective program to improve reliability. However, we recognize that such a program should be carefully monitored for effectiveness, given the potential cost. As such, we direct FirstEnergy in its subsequent Annual Asset Optimization Plans (AAOPs) to specifically identify

[329] Opinion and Order, Public Meeting held Sept 20, 2018, PUC Docket Numbers M-2018-3000943; M-2018-3000947; M-2018-3000948; M-2018-3000949, 18.
[330] Opinion and Order, Public Meeting held Sept 20, 2018, PUC Docket Numbers M-2018-3000943; M-2018-3000947; M-2018-3000948; M-2018-3000949, 19.
[331] Petition of Metropolitan Edison Company for Approval of its Long-Term Infrastructure Improvement Plan; Docket No. P-19-3012618, 15.
[332] John Munsh and WestPenn Power, "Response: Petition of West Penn Power Company for Approval of its Long-Term Infrastructure Improvement Plan," PA PUC, https://www.puc.pa.gov/pcdocs/1634662.pdf.
[333] Erin Gannon, "Regarding: Petition of West Penn Power Company for Approval of its Long-Term Infrastructure Improvement Plan," PA PUC Docket No. P-2019-3012617, September 30, 2019, https://www.puc.pa.gov/pcdocs/1638306.pdf, 5.
[334] PA PUC Public Meeting January 16 2020; docket numbers P-2019-3012618;P-2019-3012617; P-2019-3012615; P-2019-3012614, 3.

and provide detailed information regarding the cost and expected benefits for any selective undergrounding projects that are undertaken in the course of LTIIP-II."[335]

Review of FirstEnergy undergrounding projects in its Annual Asset Optimization Plan of the Met-Ed, Penelec, Penn Power, and West Penn Power companies indicates that no selective underground projects were completed between 2016-2022.[336] After the companies were merged and filing consolidated plans, there were still no selective underground projects undertaken.[337] While many of the reports after 2019 lists undergrounding as possible solution in Customers Experience Multiple Interruptions, Circuit Improvement, Remote Sectionalizing. "Selective undergrounding of facilities will be considered during these programs where conditions are feasible from both geographic and future load perspectives."[338]

As of 2024 FirstEnergy stated in a petition to the PUC, "CEMI projects are identified in a reactive manner after review of year-end reliability data and throughout the LTIIP program. FE PA rarely conceptualizes CEMI projects proactively as the initiative responds to present day outages. In theory, CEMI projects would likely be more prevalent within worst performing circuits, however, the number and name of the circuits have not been identified at this time."[339] Energy companies cannot be proactive about undergrounding if worst performing circuits are not identified and tracked over the course of multiple storms.

Currently, 2026 is the first year an undergrounding project has been planned, but current documents provided no information about the extent or project. FirstEnergy's Annual Asset Optimization Plan reviewing the 2025 year noted that "Met-Ed, Penelec, Penn Power, and West Penn did not undertake any selective undergrounding projects in 2025 but will have some selective undergrounding projects in 2026."[340]

FirstEnergy Companies have been dealing with system performance issues for over a decade, likely due to their rural service areas which covers some of the most forested areas of the state. This case demonstrates how under the current regulatory structure there are limited actions that can be taken on part of the PUC to encourage utilities to adopt measures that would improve system resilience. As the example above illustrates, merely suggesting that undergrounding may improve an EDCs reliability is not compelling enough of a reason for them to do so given its expense. FirstEnergy has noted in other states that it estimates the cost of underground

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[335] PA PUC Public Meeting January 16 2020; docket numbers P-2019-3012618; P-2019-3012617; P-2019-3012615; P-2019-3012614, 3.
[336] Review of Met Ed Annual Asset Optimization Plans year 2016-2021; Review of West Penn Power Annual Asset Optimization Plans 2017-2023; Review of Pennelec Annual Asset Optimization Plans years 2016-2023.
[337] Review of FirstEnergy Annual Asset Optimization Plans year 2023-2025.
[338] Darsh Singh and FirstEnergy Electric Co. "Re: Petition of FirstEnergy Pennsylvania Electric Company for Approval of its Long-Term Infrastructure Improvement Plan," PA Public Utility Commission, July 22, 2024, 16.
[339] Darsh Singh and FirstEnergy Electric Co., "Re: Petition of FirstEnergy Pennsylvania Electric Company for its Approval of its Long-Term Infrastructure Improvement Plan," PA PUC Docket No. P-2024-3050269, October 18, 2024, https://www.puc.pa.gov/pcdocs/1853307.pdf.
[340] Angelina Umstead and FirstEnergy Electric Co., "Annual Asset Optimization Plan of FirstEnergy Pennsylvania Company," March 2, 2026, Available at Puc.pa.gov, 32.

conversation at a rate of $1 million per mile.[341] While the PUC recommended reforms in 2018, it has taken them over eight years to consider acting on them.

PPL

Like other Pennsylvania utilities, as of 2026 PPL is not pursuing overhead-to-underground conversion to any significant degree. Reviewing its LTIIP over the last decade, underground cable replacement centered on replacing outdated infrastructure more prone to failure and the reports note the average age of these assets. See Table 12 for current underground wire replacement information from PPL.

PPL has blamed its increasing reliability concerns with worsening weather conditions within the state. In its annual asset plans, PPL has argued that there should be different storm criteria compared to the baseline period:

> "Each quarter, distribution planners and regional reliability supervisors meet to propose projects to improve WPCs. Projects are approved by distribution planning supervisors and vetted against other projects for scheduling based on historical reliability, potential benefit, and cost. Projects may span multiple years and are listed in the years they are planned to go in service. Scope is expected to increase in outer years as circuits and projects are identified. Examples include, but are not limited to, circuit reconfiguration"[342]

Such reliability projects include "circuit reconfigurations and relocations, device installations, new ties, new lines and terminals, or the installation of substations for reliability improvement."[343] Selective undergrounding did not appear to be a priority of PPL at this time.

Table 12
Summary of PPL LTIIP
Underground Wire Replacements
2023

PPL Spending Plan	2023	2024	2025	2026	2027	Total
Cost (in Millions)	$.42	$1.11	$1.67	$1.59	$1.59	$6.37
Project Scope (cable segments)	25-100	75-150	135-225	100-200	100-200	435-875

Source: Devin Ryan, "Re: Petition of PPL Electric Utilities Corp. for Approval of its Long-Term Infrastructure Improvement Plan for the Period January 1, 2023 through December 31, 2027," Sept. 2022.

[341] FirstEnergy, "EnergizeNJ Proposal Makes for a Brighter Future Faster in New Jersey," April 23, 2024, https://www.firstenergycorp.com/newsroom/featured_stories/energizenj-proposal-for-brighter-future-faster-in-nj.html
[342] Kimberly Klock & PPL, "Regarding: PPL Electric Utilities Corporation Annual Asset Optimization Plan," March 2, 2026, 23.
[343] Kimberly Klock & PPL, "Regarding: PPL Electric Utilities Corporation Annual Asset Optimization Plan," March 2, 2026, 24.

PECO

Even as far back as 2002, PECO was reinvesting in its underground system to replace old components.[344] More recently, in 2014 PECO invested $444,000 in upgrades to underground residential distribution work in Ashton Township in Delaware County.[345] In 2025 a $150,000 infrastructure investment was used along several streets to harden the system against storms in Falls Township in Bucks County.[346]

Table 13
Summary of PECO LTIIP III
Underground Wire Expenditures
(in millions)
2025

PECO Spending Plan	2026	2027	2028	2029	2030	Five-year Total
Main Stem	$33.1	$61.1	$57.0	$58.4	$57.0	$266.6
URD Cable	106.3	79.8	70.8	76.5	85.5	418.9
Total	139.4	140.9	127.8	134.9	142.5	685.5

Source: PECO, "Response: Petition of PECO Energy Company for Approval of Its Electric Long-Term Infrastructure Improvement Plan for the Period January 1, 2026 through December 31, 2030," PA PUC Docket, Filed August 20, 2025.

PECO has 17,100 conductor miles underground. [347] Based on available data it appears that PECO has both the most underground miles and highest percentage of underground wires within the state at 37 percent of its distribution system. While it does not appear to be converting overhead service to underground, it is aggressively replacing old underground wires to improve reliability.

For Main Stem Underground Cable replacements PECO budgets between $1.1-$2.2 million per mile. LTIIP 3 estimates that over the course of five years it will replace between 135 and 230 miles of cable for a total cost of $266.6 million. See Table 13. In previous LTIIPS between 2021-2024, it replaced 99 miles of main stem underground at a cost of $1.05 to $20.5 million per mile for a total $136.5 million. The average cost is per $1.38 million per mile. Supply chain shortages and municipal permitting delays led to decreases in the total cost of undergrounding per

[344] Clarion Energy, "PECO Energy Completes Major Underground Electric Improvement Project," Power Engineering, May 28, 2003, https://www.power-eng.com/coal/peco-energy-eompletes-major-underground-electric-improvement-project/.
[345] Kelly Pippin, "Upcoming PECO URD (Underground Residential Distribution) Work," Official Aston Township Website, July 29, 2024, https://astontownship.net/upcoming-peco-urd-underground-residential-distribution-work/.
[346] PECO, "PECO Update," Falls Township, March 10, 2025, https://fallstwp.com/resources/news/article/?id=9785.
[347] Richard Webster & PECO, "Regarding: Petition of PECO Company for Approval of Its Electric Long-Term Infrastructure Improvement Plan for the Period January 1, 2026 through December 31, 2030," PA PUC Docket No. filed August 20, 2025, 321.

year, as fewer undergrounding projects were completed. At this level of investment, targeted main stem cables will be replaced within five and ten years. More information

Other than main stem, Underground Residential Distribution (URD) cable replacement is the second part of PECO's underground replacement program. According to the plan,

> A URD looped supply to a development allows service to be restored to all customers quickly by arranging the cable supply to transformers in a continuous loop fed from two directions. In the event of a cable failure, the failed cable can be removed from service, and all transformers returned to supply using the other cables in the loop. In addition to reducing the average time to restore service, the looped supply eliminates the need to install a temporary cable to bypass a failed cable.[348]

PECO has invested $448.9 million to replace between 780 and 1,140 miles of URD cables across southeast Pennsylvania. It is prioritizing the replacement of cables manufactured prior to 1985. Rather than doing it exactly as it was previously, radial URD cable will be looped as part of this program. The program "may include additional infrastructure improvements, including, but not limited to, looping of developments, voltage conversions, upgrading from submersible to pad-mounted transformers."[349] The ultimate goal is to reduce URD cable failures per mile. In the previous LTIIP II Between 2021-2024, 565.3 miles of URD were replaced for $260.6 million. The project was affected by a shortage of transformers due to supply chain issues. Not counting LTIIP 3 it is estimated that 1,700 miles of pre-1985 URD cable will remain.

PECO currently views its underground assets as an area to maintain lest aging materials lower its current standards. It is not actively pursuing undergrounding as a solution relating to increasing resiliency. However, given the rate at which the company is replacing pre-1985 wires, PECO should consider piloting an overhead to underground conversion project once it has completed burying the wires most likely to fail.

Duquesne Light Company

DLC is actively working on projects that involve underground distribution lines; these projects are largely focused on replacing lines within the city that include cable most likely to fail.[350] Table 14 shows all underground program related projects under DLC's latest LTIIP. One such underground project focused on electric duct banks along a bus line.[351] DLC replaced 2.5 miles of electric duct bank and 86,000 feet of outdated underground cables as part of the effort to improve electric reliability in several Pittsburgh neighborhoods.

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348 Richard Webster & PECO, "Regarding: Petition of PECO Company for Approval of Its Electric Long-Term Infrastructure Improvement Plan for the Period January 1, 2026 through December 31, 2030," PA PUC Docket filed August 20, 2025, 33.

349 Richard Webster & PECO, Re: Petition of PECO for Approval of LTIIP 2026-2030, PA PUC Docket filed August 20, 2025, A-8.

350 Duquesne Light Company, "Reliability Projects," https://duquesnelight.com/service-reliability/infrastructure-projects.

351 Duquesne Light Company, "Duquesne Light Bus Rapid Transit Project," 2021, https://www.duquesnelight.com/service-reliability/infrastructure-projects/bus-rapid-transit-project.

A 2024 report about DLC noted is involved in an underground power line project in a major urban center such as Pittsburgh.[352] Back in 2021, 51,000 feet of cable and 216,000 feet of conduit were installed to meet growing demand in the Uptown neighborhood of Pittsburgh, while minimizing traffic disruptions. The project was coordinated with other utility improvements (gas, water, sewer). Data collection involved developing a utility atlas, topographic and subsurface utility surveys, manhole inspections, and reconciling observations with records. This information allowed for a better engineering design plan. Then, a preliminary path could be established. "Extensive test hole work" was then performed to confirm exact locations and depths of utilities. Project Risk Identification involved having team members with the skills necessary to minimize the risks. A full-time utility coordination manager was hired to improve safety.

It can be challenging to integrate new cables into existing underground systems because of branching and the number of different types of cables. According to reports on the project,

> In some areas, existing underground utility congestion made new cable distribution and manhole installation impossible, such that dozens of existing brick manholes had to be carefully demolished and rebuilt larger in place in order to accommodate the new cables. Engineering and construction teams closely coordinated this effort and others, with safety top of mind at all times.[353]

Further, planned outages had to be managed.

Table 14
Summary of DLC LTIIP
Underground Wire Expenditures
(in millions)
2024

DLC Spending Plan	2023	2024	2025	2026	2027	2028	Total
Cable Replacement	$12.8	$9.3	$6.7	$8.4	$4.2	$4.6	$45.9
URD Rehabilitation	1.6	3.2	4.2	4.4	5.4	4.9	23.7
Underground Infrastructure Rehabilitations	4.9	5.2	2.9	3.4	2.7	2.9	21.9
Network Transformer Replacement	1.3	1.4	1.4	1.5	1.5	1.5	8.6
Underground Repairs and Restoration	9.6	9.8	10	10.3	10.5	11.4	61.6
Other Underground Work	6.4	1.4	4.5	3.7	4.1	11.9	32.1
Total Underground Programs	36.6	30.3	29.7	31.6	28.4	37.2	193.8

Source: Public Meeting, "Petition of Duquesne Light Co. for Approval of its Second Long-Term Infrastructure Improvement Plan," PUC Docket No. P-2022-3032805, Filed November 10, 2022.

[352] Burns & McDonnell, "Duquesne Light Company Prepares for the Future in Pittsburgh's Urban Core," March 24, 2024, https://info.burnsmcd.com/hubfs/Collateral/Case%20Studies/TND_CHI_DuquesneLightCompany_788346/Duquesne-Light-Company-Prepares-for-Future-in-Pittsburghs-Urban-Core-case-study-burns-mcdonnell-788346.pdf.

[353] Burns & McDonnell, "Duquesne Light Company Prepares for the Future in Pittsburgh's Urban Core," March 24, 2024, https://info.burnsmcd.com/hubfs/Collateral/Case%20Studies/TND_CHI_DuquesneLightCompany_788346/Duquesne-Light-Company-Prepares-for-Future-in-Pittsburghs-Urban-Core-case-study-burns-mcdonnell-788346.pdf.

UNDERGROUNDING CASE STUDIES

While other sections of this report provide detail about undergrounding projects occurring throughout the US, this chapter focuses primarily on three case studies. Dominion Energy's strategic undergrounding program in Virginia documents how planning ahead and being intentional and data driven regarding infrastructure investments can yield system improvements during storms. The New Jersey case study examines system reliability in another state which shares some of the same distribution companies as Pennsylvania, and how despite more extreme weather, thus far they have not broadly adopted undergrounding. Finally, the Japan case study shows the results of long-term undergrounding investments in a country facing extreme weather.

Dominion Case Study

Areas that seem most likely to adopt undergrounding as a measure to improve system resilience appear to make the decision after experiencing multiple infrastructure damaging storms in short succession. One example is Virginia, which experienced Hurricane Irene in August of 2011 followed by a derecho event which caused extensive thunderstorms in 2012. In each event one million customers were left without power, due to downed trees.[354] After several years of study, Dominion created a strategic underground program in 2014 with the goal to burying 4,000 miles of power line within Virginia.[355] A decade later in 2024, the company announced that 2,000 miles of overhead lines had been buried.[356]

Dominion's UG strategy involved a focus on areas that were the most outage prone

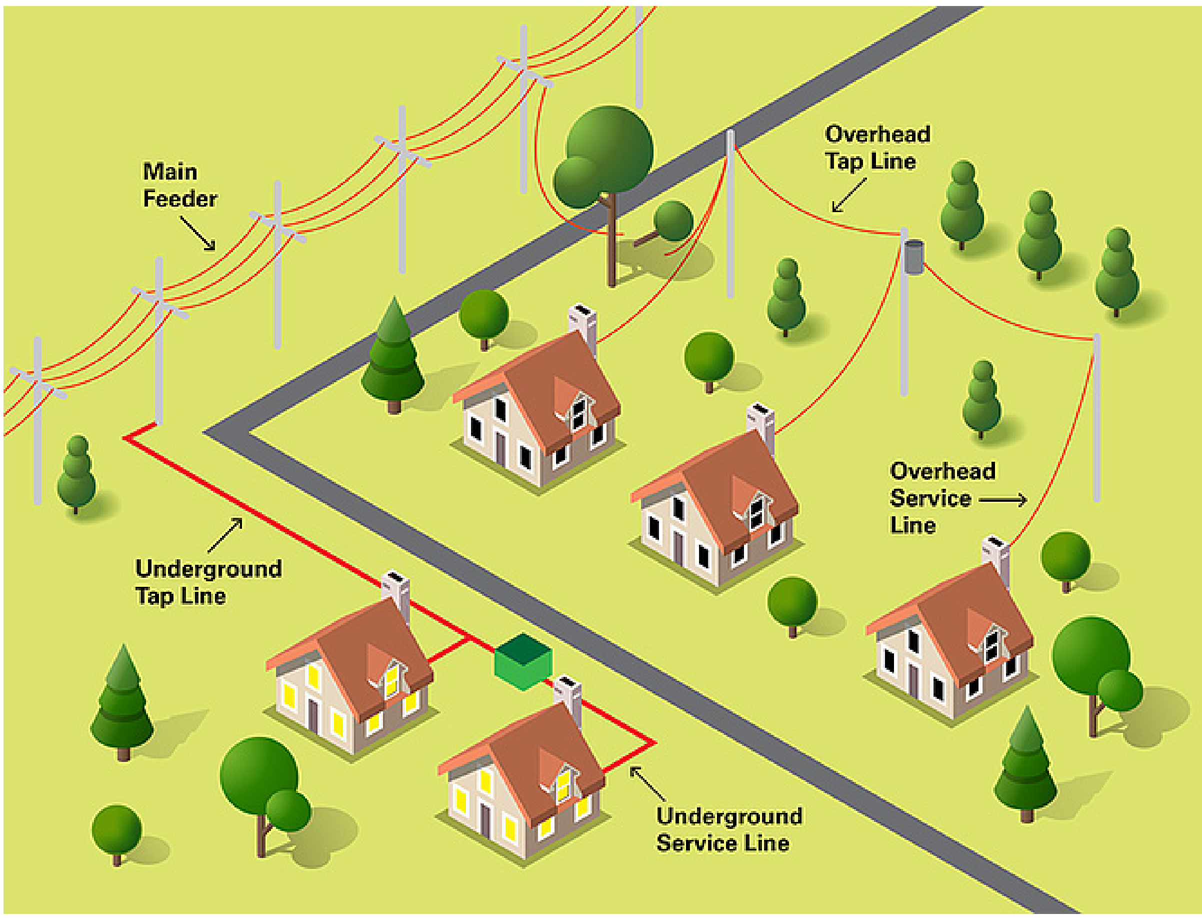
1. Reduce the number of customers without power (increases safety).
2. Reduces the economic cost of the storm (fewer areas would need to restore power).
3. Faster restoration of power in other areas.

Dominion's research concluded that the most cost-effective strategy for them was to underground lateral (here called tap) lines which run alongside streets or cross back yards to connect homes to power. See Figure 16. These lateral lines were frequently close to trees that fell on them and disrupted power. It was determined that 20 percent of tap lines were responsible for two-thirds of their power outages.[357] The 4,000-mile goal of undergrounding by the energy

[354] Scenic America, "Undergrounding Case Study: Dominion Energy." Scenic America, December 2024, https://www.scenic.org/take-action/resources/undergrounding-resources/undergrounding-resources-and-white-papers/case-study-dominion-energy/, 1.
[355] Scenic America, "Undergrounding Case Study: Dominion Energy," Dec. 2024, 1.
[356] Max Duchaine, "Scenic America Applauds Dominion Energy's Successful Undergrounding Project," Scenic America, June 24, 2024, https://www.scenic.org/2024/06/24/scenic-america-applauds-dominion-energys-successful-undergrounding-project/.
[357] Scenic America, "Undergrounding Case Study: Dominion Energy," Dec. 2024, 2.

company focuses primarily on these lines.[358] Conversely, Dominion found that three-phase distribution lines cost five times more to underground and resultingly has not made them a focus of their undergrounding efforts.[359] Other hardening strategies are employed such as stronger pole replacements to protect such lines.

Figure 16
Dominion Underground Power Line Example
2021



Source: Mike Salmon, Strategic Underground throughout Fairfax County, July 2021, https://www.viennaconnection.com/news/2021/jul/29/strategic-underground-throughout-fairfax-county.

[358] Scenic America, "Undergrounding Case Study: Dominion Energy," Dec. 2024, 2.
[359] Scenic America, "Undergrounding Case Study: Dominion Energy," Dec. 2024, 2.

Dominion's Undergrounding program has occasionally faced setbacks. For example, the Covid 19 pandemic led to many supply chain issues that slowed underground at the beginning of the decade. After holes are dug and wires buried, energy companies waiting for backordered parts, such as transformers, can see a project delayed.[360] To minimize delays Dominion restores land in half-finished projects while waiting to retain customer approval of the project.[361]

In 2014, amendments to Virginia Code § 56-585.1 changed the means of financing undergrounding. Now, Dominion can recover expenditures relating to their underground programs through a rider. This is the first instance of distribution investments receiving a power bill rider in Virginia.[362] In 2018 the law was further amended to add guidelines by which undergrounding program expenses would be eligible for reimbursement. Specifically, per customer and per mile thresholds on underground spending were established.

Section 56-466.2 (201&) of the VA Electric Utility Regulatory Act created some additions relating to undergrounding rules:[363]

- Power companies must notify cable operators when relocating overhead distribution lines underground.
- Cable operators are given a choice between relocating facilities underground or having them stay overhead.
- Law clarified ownership and maintenance of utility poles by providing provided a legal framework for continued use of overhead facilities.

The overall goal of this law was to increase cooperation and create a clear set of rules and duties for each actor. This law provides an overall framework for how the undergrounding process works, and the Virginia State Corporation Commission (SCC) regulates this program and oversees its implementation. Under this framework, Dominion seeks permission from SCC to add a charge to customer bills allowing it to recover approved underground expenses.[364]

Dominion cooperates with SCC in rate cases to prove that it is meeting the legislative threshold for how much its underground costs cab be passed on, on a customer and mile basis. The process of working with the SCC is likely similar to PA PUC involving interrogatories, hearings, and final rulings held approximately nine months after rate cases are filed. Having legislative guidance for the companies to follow has helped these rate cases be approved.[365]

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360 Scenic America, "Undergrounding Case Study: Dominion Energy," Dec. 2024, 4.
361 Scenic America, "Undergrounding Case Study: Dominion Energy," Dec. 2024, 4.
362 Scenic America, "Undergrounding Case Study: Dominion Energy," Dec. 2024, 5.
363 Scenic America, "Undergrounding Case Study: Dominion Energy," Dec. 2024, 6.
364 Scenic America, "Undergrounding Case Study: Dominion Energy," Dec. 2024, 6.
365 Scenic America, "Undergrounding Case Study: Dominion Energy," Dec. 2024, 6.

Measuring Impact of Dominion's Undergrounding Program

Dominion reflects on the difficulty of measuring the success of underground programs because they involve averted costs. For example, given if a tree falls after a wire has been undergrounded, it calculates the likelihood that a power outage has been averted and the associated cost of such an event. There has been some positive anecdotal feedback from customers and service workers in areas that had vulnerabilities in frequent storms.[366] There is also a more analytical approach that evaluates system performance after major storm events compared to historical outages: Dominion examines grid performance after severe storm events that require a "total length of restoration" period that is at least 72 hours.

Dominion uses its data on transformer failure rates to determine the path of the storm. "If 3 or more surrounding grids did have transformer outages, then it is assumed that the storm did pass through those areas but did not result in transformer damage".[367] After the path of storm is found they look at how many transformers that are candidates for Dominions UG program along the storm path failed per mile.

The rate of failure is then applied to miles of lines that are already undergrounded lines to approximate how many miles of these lines would have failed had they not been undergrounded. Based on the rate of time it would crews to restore a fuse after a storm, this amount of time is added to the total length of restoration time to estimate how the total outage time the undergrounded lines prevented. It can also estimate how many hours they would have saved had all the candidates been undergrounded.[368]

Dominion has cited a 2022 example of winter storm as one instance where the undergrounding program showed success. High winds and wet snow on trees led to higher level of outages and left 250,000 customers without power. Total Length of Restoration for service was 5.13 days. Overall, 1, 764 miles of uncovered tap lines were affected by the storm. There were 284 outage events in the area. Dividing the two numbers created a failure rate of .16 events per mile of exposed line.[369] The .16 failure rate was multiplied by the 1005 miles of lines already undergrounded that were in the path of the storm. This resulted in approximately 162 avoided outages. Based on the length of fuse restoration jobs the company avoided, undergrounding was estimated to have reduced the TLR by 13 hours.

Work from Dominions program is conducted by a mix of Dominion Energy and qualified contractors. Areas covered include project management, right of way, communications, installation and removal.[370] Dominion is undergrounding select tap lines in residential areas that are most prone to outages.[371] Because the company is aware of customers sensitive to changes made to their properties, Dominion uses Horizontal Directional Drilling (HDD) in its strategic underground

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366 Scenic America, "Undergrounding Case Study: Dominion Energy," Dec. 2024, 7.
367 Scenic America, "Undergrounding Case Study: Dominion Energy," Dec. 2024, 7.
368 Scenic America, "Undergrounding Case Study: Dominion Energy," Dec. 2024, 7.
369 Scenic America, "Undergrounding Case Study: Dominion Energy," Dec. 2024, 7.
370 Dominion Energy, "Undergrounding FAQs," accessed May 4, 2026, https://www.dominionenergy.com/about/delivering-energy/electric-projects/strategic-underground-program/undergrounding-faqs.
371 Dominion Energy, "Undergrounding FAQs," accessed May 4, 2026.

program. When directional drilling is infeasible at a particular site, Dominion employs an additional hand dug hole, known as the process of “potholing” and ensures the buried electrical cable avoids other underground objects.[372]

Apart from access needed for the initial project, the plan must also contain permission for maintenance and repair of these lines. A significant amount of company resources must be spent on communication and marketing. Dominion estimated that between 20 to 25 percent of their undergrounding projects could not be completed due to being unable to obtain easements. [373]

Dominion’s goal is to try and improve customer service and customer acceptance of their strategic undergrounding program through four steps: avoiding infrastructure and utility damage, communication, augmented reality, property restoration:

1. One way is to earn the good will of customers and is avoiding municipal infrastructure like water or gas lines when undergrounding. Homeowners may also bury things in the yard such as septic systems, sprinklers or even electric fencing for pets.[374]
2. Dominion communicates with customers every 60-90 days from when the underground process starts through a variety of means such as letters, postcards, door hangers, phone calls, and visiting the house. The goal is to educate homeowners on how underground works and easements. Another part is gauging homeowner satisfaction with the process. Types of information include the status of the underground project: project updates, estimated timelines, meetings, and notifying homeowners about any damage to their property or planned outages[375]
3. Dominion uses augmented reality software to help homeowners understand the visual impact of the undergrounding on their property and where the “green box” may be located.
4. Dominion often uses a horizontal drilling process that minimizes damage to a lawn, and the company notes it restores grasses.

Community outreach is vital for undergrounding. This should start early in the planning phase, to learn what people care about and to dispel misconceptions. As a result the company goal is to communicate through multiple channels such as social media, town halls, and newsletters. Dominion emphasized the importance of leveraging new and old technology from postcards to VR headsets which show the final visual impact on a homeowners property. Overall, they must demonstrate how beneficial it is for the community by demonstrating its improvements to the reliability, safety, aesthetics, and property value. Part of managing the expectations is sharing with people what the final results of the project will look like such as what a pad mounted transformer will look like in their yards. Despite its high cost, undergrounding electric wires has proven

[372] Scenic America, “Undergrounding Case Study: Dominion Energy,” Dec. 2024, https://www.scenic.org/take-action/resources/undergrounding-resources/undergrounding-resources-and-white-papers/case-study-dominion-energy/, 3.
[373] Scenic America, “Undergrounding Case Study: Dominion Energy,” Dec. 2024, 2.
[374] Scenic America, “Undergrounding Case Study: Dominion Energy,” Dec. 2024, 2.
[375] Scenic America, “Undergrounding Case Study: Dominion Energy,” Dec. 2024, 2.

popular with Dominion's customers due to associated aesthetic benefits in a way that is unique compared with other hardening strategies.[376]

New Jersey

As neighboring states, Pennsylvania and New Jersey share similarities pertinent to undergrounding power lines. Both states are set to experience increasing precipitation and extreme weather events in the future, and PJM Interconnection services all parts of the states. At the same time, New Jersey borders the Atlantic Ocean, and the state experiences a heightened threat from tropical cyclones. It is also the nation's most densely populated state at 1,300 residents per square mile, over four times that of Pennsylvania.[377]

Figure 17 illustrates the difference between Pennsylvania and New Jersey in hurricane risk. The Federal Emergency Management Agency (FEMA) calculates the National Risk Index (NRI) quantifies the level of risk for 18 natural hazards for each census tract or county.[378] NRI is an aggregate rating based on "data for Expected Annual Loss due to natural hazards, Social Vulnerability, and Community Resilience."[379] The figure shows that most of New Jersey is expected to shoulder a relatively high or moderately high level of risk from hurricanes, whereas on Pennsylvania only Lancaster and Philadelphia Counties are subjected to a relatively high level of risk.

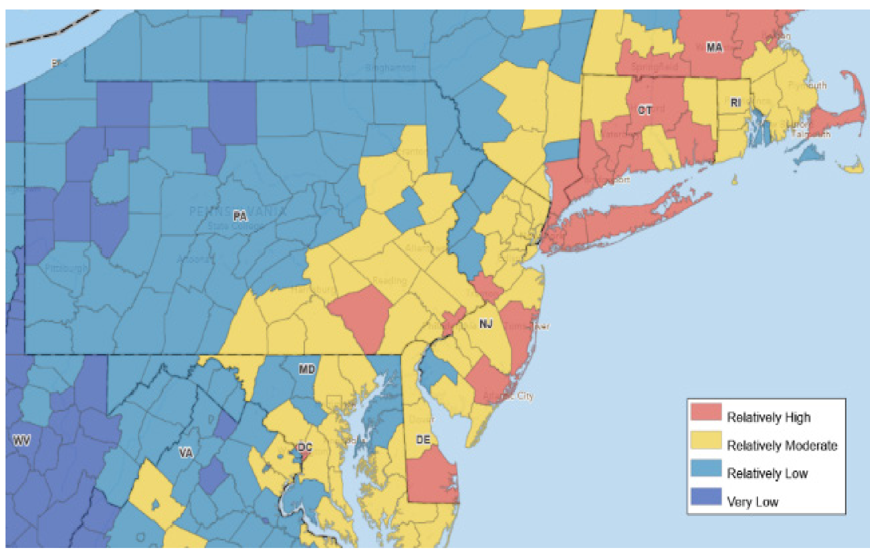

Figure 17
National Risk Index (NRI)
Hurricane by Counties
2026

Source: "Resilience Analysis and Planning Tool (RAPT)," *Federal Emergency Management Agency*, accessed March 20, 2026, https://experience.arcgis.com/experience/0a317e8998534c30a9b2d3861c814d42.

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[376] Scenic America, "Undergrounding Case Study: Dominion Energy," Dec. 2024, 6.
[377] "New Jersey - Analysis," *Energy Information Administration*, February 19, 2026, https://www.eia.gov/states/NJ/analysis.
[378] "National Risk Index Data," *Federal Emergency Management Agency*, January 6, 2026, https://www.fema.gov/about/openfema/data-sets/national-risk-index-data.
[379] "Hurricane Risk Index Rating, County, National Risk Index - Overview," *Federal Emergency Management Agency*, accessed March 20, 2026, https://www.arcgis.com/home/item.html?id=c3698da4e0c945009eb5b722b0a95b8f.

Table 15
Comparison of Pennsylvania and New Jersey Electric Distribution Companies (EDCs) by Reliability Metrics
2024

State	Company	SAIFI (outages/year/ customer)	CAIDI (minutes/year/ customer)
PA (2024)	PECO	0.78	96 (Lowest)
	PPL	1.22	371 (Highest)
	Citizen's Electric Company	0.45 (Lowest)	144
	Metropolitan Edison	2.06 (Highest)	242
NJ (2025)	Atlantic City Electric	0.71	84
	Jersey Central Power & Light	1.44	119
	PSE&G	0.53	62

Source: Kyle Mason and Robert Freudenberg, "The State of the Grid in New Jersey (2025)," *Regional Plan Association*, December 22, 2025, https://rpa.org/news/lab/the-state-of-the-grid-in-new-jersey; Paul T. Diskin, *Pennsylvania Electric Reliability Report 2024* (Pennsylvania Public Utility Commission, 2025), https://www.puc.pa.gov/media/3782/24_-electric-rel

In all, 11 electric distribution companies (EDCs) service Pennsylvania, whereas only four exist in New Jersey: Atlantic City Electric, Jersey Central Power & Light, PSE&G, and Rockland Electric Company.[380] Table 15 shows that New Jersey EDCs tend to be more reliable than Pennsylvania EDCs by the two metrics used by the Pennsylvania Public Utility Commission (PUC): System Average Interruption Frequency Index (SAIFI) measured in outages per year per customer and Customer Average Interruption Duration Index (CAIDI) measured in minutes per year per customer. The range of performance is larger in Pennsylvania as well. SAIFI spread is 1.61 outages per year per customer in Pennsylvania and 0.91 in New Jersey. CAIDI spread is 275 minutes per year per customer in Pennsylvania and 57 in New Jersey. In 2024, the overall System Average Interruption Duration Index (SAIDI, measured in IEEE method) was 353.1 minutes per year per customer for Pennsylvania and 173.3 for New Jersey.[381]

Compared to Pennsylvania, however, New Jersey has been more prone to widespread power outage events from hurricanes. For example, Hurricane Irene in 2011 caused a disruption affecting 1.9 million customers across the entire state, and Hurricane Sandy in 2012 resulted in an outage affecting 2.5 million customers.[382] There were eight statewide outage events between 2010 and 2017, with some years experiencing multiple major events.[383] The heightened vulnerability to hurricanes and other types of storms may be conducive for undergrounding power lines.

[380] Diskin, *Pennsylvania Electric Reliability Report 2024*; 5.22-2.
[381] *Electric Power Annual,* "Table 11.4," (Energy Information Administration, 2025), https://www.eia.gov/electricity/annual/pdf/epa.pdf;
[382] *New Jersey State Hazard Mitigation Plan 2019*, 5.22-6.
[383] *New Jersey State Hazard Mitigation Plan 2019*, 5.22-7–5.22-11.

Yet, New Jersey Board of Public Utilities (NJBPU) and the state government do not appear to prioritize undergrounding power lines. In the past decade, there have been two Energy Master Plans published by New Jersey agencies including NJBPU, with one in 2019 and the most recent in 2025.[384] Though grid modernization is extensively discussed, neither document mentions undergrounding power lines.[385]

Likewise, while undergrounding is a salient issue for the New Jersey Legislature, it has not garnered much support. All bills at the New Jersey Legislature related to undergrounding would require distribution lines to be undergrounded in areas affected by natural disasters have been introduced with the same language by the same group of legislators and none have advanced beyond respective committees. A bill that would establish a taskforce on underground utility lines was introduced in two separate legislative sessions: 2012-2013 and 2014-2015.[386] Neither bill was advanced from the Assembly Telecommunications and Utilities Committee.

A search of bills introduced during the 2024-2025 session highlights the perceived importance of grid modernization through securing more electricity generation capacities, renewable energy, and microgrid instead of undergrounding power lines. A search using the keyword, "grid," yields 16 bills, of which two advocate for enhanced power generation, four advocate for renewables, and eight advocate for creating or supporting microgrid.[387]

Jersey Central Power & Light (JCP&L), covering northern and central parts of the state, is currently pursuing undergrounding as part of its grid modernization strategy. In November 2023, JCP&L filed a proposal for major infrastructure improvement with NJBPU.[388] Named EnergizeNJ, the five-year plan would require $930.5 million investment and achieve three goals: grid modernization, system resiliency, and substation modernization.[389]

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[384] By Rambo Talabong, "New Jersey Has A New Map For Its Energy Future. The Ground Under It Is Already Shifting.," *Inside Climate News*, December 7, 2025, https://insideclimatenews.org/news/07122025/new-jersey-energy-grid-plan/.

[385] *2019 New Jersey Energy Master Plan: Pathway to 2050* (New Jersey Board of Public Utilities, 2020), https://www.nj.gov/emp/pdf/2020_NJBPU_EMP.pdf; *New Jersey Energy Master Plan 2024* (New Jersey Board of Public Utilities, The New Jersey Governor's Office of Climate Action and the Green Economy, 2025), https://www.nj.gov/emp/pdf/2024NJEMP.pdf.

[386] Establishes NJ Task Force on Underground Utility Lines, A3483, New Jersey Legislature 2012–2013 (2012), https://www.njleg.state.nj.us/bill-search/2012/A3483; Establishes NJ Task Force on Underground Utility Lines, A2711, New Jersey Legislature 2014–2015 (2014), https://www.njleg.state.nj.us/bill-search/2014/A2711.

[387] New Jersey Legislature, "Bill Search."

[388] "JCP&L EnergizeNJ," *Jersey Central Power & Light*, accessed March 20, 2026, https://www.firstenergycorp.com/jersey_central_power_light/jcpl-energizenj-iip.html.

[389] "New Jersey to Replace 46 Miles of Underground Electrical Lines with $935 Million Infrastructure Proposal," *Underground Infrastructure*, November 13, 2023, https://undergroundinfrastructure.com/news/2023/november/new-jersey-to-replace-46-miles-of-underground-electrical-lines-with-935-million-infrastructure-proposal.

The breakdown of the plan includes:

- Grid Modernization: $271.2 million
    - Upgrading 410 miles of overhead lines
    - Replacing 46 miles of underground lines with more robust, protected cables
    - Installing 2,069 automated reclosers to detect anomalies in the grid
    - Burying seven miles of lines and installing more circuit protections

- System Resiliency: $559.3 million
    - Standardizing voltage across JCP&L distribution grid
    - Upgrading 18 substations
    - Interconnecting existing circuits for more redundancies
    - Building new circuits

- Substation Modernization: $100 million
    - Installing switchgears
    - Purchasing additional mobile substations

While FirstEnergy has seemed reluctant to undertake undergrounding projects in PA, in New Jersey one of its subsidiaries will bury 1,500 feet of transmission lines at a cost of $1.75 million in a tree lined area in NJ's Somerset County.[390] The project was scheduled for 2024.[391]

There are policy actions that could be leveraged to encourage undergrounding. However, all of them may not be well suited to Pennsylvania. For example, in neighboring New Jersey SB 2607 required municipalities to address utility vulnerability to extreme weather and climate change in their land use master plans.[392] The goal of this plan was to encourage local governments to apply for federal moneys such as Hazard Mitigation Grant Program (HMGP) or Building Resilient Infrastructure and Communities (BRIC) to harden their infrastructure.

[390] Gavin, Jeff. "Going Underground: Power Line Burial Is on the Rise." Electrical Contractor Magazine, March 13, 2026. https://www.ecmag.com/magazine/articles/article-detail/going-underground--power-line-burial-is-on-the-rise.
[391] Gavin, Jeff. "Going Underground: Power Line Burial Is on the Rise." Electrical Contractor Magazine, March 13, 2026. https://www.ecmag.com/magazine/articles/article-detail/going-underground--power-line-burial-is-on-the-rise.
[392] NCSL. "FEMA Funding for Energy Resilience: Highlighting the Role of State Legislatures." Ncsl.org, July 7, 2022. https://www.ncsl.org/energy/fema-funding-for-energy-resilience.

Japan

Pennsylvania's climate shares many similarities with that of Japan, and the country's approach to undergrounding power lines, especially in its urban cores, can serve as an example for the Commonwealth. Though Japan is an island nation with long coastlines unlike the Commonwealth, Japan also experiences humid summers with frequent cyclones (typhoons) and cold winters with heavy snow in the north that correspond to seasonal changes in Pennsylvania. Moreover, its mountainous terrain and concentrated urban agglomeration in two major metropolitan areas makes Japan an adequate comparison case.[393]

The climate profile of Greater Philadelphia matches that of Tokyo and the neighboring prefectures, and the climate profile of Pittsburgh, Harrisburg, and Allentown is similar to that of Sapporo.[394] Given that severe weather events cause most of power outages, Japan's policy response to undergrounding power lines may provide edifying insights.

Japan's central government has actively pursued undergrounding utility lines, including power transmission and distribution lines, since the 1980s. It devised and implemented a series of undergrounding policy initiatives for different zones. The first (1986), the second (1991), and the third (1995) were aimed at undergrounding distribution lines in urban commercial zones along major thoroughfares, resulting in 2,100 miles of cables moved by 1994.[395] The fourth (1999) expanded the target to major thoroughfares in residential zones or mid-level commercial zones.[396] The fifth initiative, from 2004 to 2008, shifted the focus from a utilitarian approach to one that emphasizes beautification and historical preservation.[397] The sixth initiative, beginning 2009, added tourism promotion and road accessibility for the disabled as additional justifications.[398]

Following these initiatives, Japan reaffirmed undergrounding power lines and eliminating utility poles as a national priority. A public statute promulgated in December 2016 stipulates that the national government is responsible for discouraging new utility poles and promoting undergrounding alongside municipalities and relevant stakeholders.[399] The responsibility includes fiscal support as well as strategic planning.[400] The law cites "prevention of disaster, safe and uninterrupted transit access, [and] scenery beautification" as the three primary reasons.[401]

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393 Information contained within Brackets appearing in this section has been translated from Japanese by JSGC Staff.
394 "Köppen-Geiger Climate Classification System," *National Geographic MapMaker*, accessed March 12, 2026, https://www.arcgis.com/apps/instant/atlas/index.html?appid=0cd1cdee853c413a84bfe4b9a6931f0d&webmap=9966020554ae4b468c5ca9b62739e2a2.
395 *[Plan for Undergrounding New Electric Cable Type (Phase 4)]* (The Ministry of Land, Infrastructure, Transport and Tourism, n.d.), accessed March 13, 2026, https://www.mlit.go.jp/road/road/traffic/chicyuka/toukei/ref_04.pdf, 1.
396 *[Plan for Undergrounding New Electric Cable Type (Phase 4)]*, 1–2.
397 *[Plan for Promoting Utility Pole Elimination (Phase 5)]* (The Ministry of Land, Infrastructure, Transport and Tourism, n.d.), accessed March 13, 2026, https://www.mlit.go.jp/road/road/traffic/chicyuka/toukei/ref_05.pdf, 2.
398 *[Guideline on Utility Pole Elimination]* (The Ministry of Land, Infrastructure, Transport and Tourism, n.d.), accessed March 13, 2026, https://www.mlit.go.jp/road/road/traffic/chicyuka/toukei/ref_06.pdf, 1.
399 [Act on the Promotion of Utility Pole Elimination], Pub. L. No. 49 (2022), https://laws.e-gov.go.jp/law/428AC1000000112.
400 [Act on the Promotion of Utility Pole Elimination]; see Article 13, Supplementary Article 2.
401 [Act on the Promotion of Utility Pole Elimination]; see Article 1; translated from Japanese by JSGC staff.

The public awareness campaign poster created by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) expands upon the reasons thusly:

- Disaster Prevention: In times of large-scale disasters such as earthquake or typhoon, we can avoid traffic obstruction from toppling utility poles.
- Scenery and Tourism: By eliminating utility poles and power lines obstructing the scenery, we can beautify the area.
- Safety and Comfort: By eliminating utility poles and widening sidewalk, we can secure safety and comfort for pedestrians.[402]

Additionally, the statute designates November 10th as the National Day of Transmission Pole Elimination.

Between the fourth and the fifth initiatives, MLIT shifted the standard measurement metric of undergrounding from the length of cables moved to the length of roads without utility poles.[403] This shift reflects the changing priority as well, with MLIT and other government agencies employing *utility pole elimination* as the default policy goal rather than undergrounding.[404] This has resulted in significant statistical discrepancies between MLIT and utility companies like Tokyo Electric Power Company (TEPCO). TEPCO is responsible for generating, transmitting, and distributing electricity in and around Tokyo, covering a territory one-third the land area and three times the population of Pennsylvania.

According to MLIT, only eight percent of roads in Tokyo's 23 urban wards had utility poles either undergrounded or eliminated by 2017.[405] This compares unfavorably to major cities that have completed undergrounding such as London, Paris, Hong Kong, and Singapore.[406] The low rate of undergrounding is due to smaller roadways maintained by urban wards with overhead power lines and utility poles.

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[402] [*If There Weren't Utility Poles... If The Ambulance Could Reach... Let's Think About Utility Pole Elimination.]* (The Ministry of Land, Infrastructure, Transport and Tourism, 2022), https://www.mlit.go.jp/road/road/traffic/chicyuka/pdf/chi_24_05.pdf.

[403] *[Plan for Undergrounding New Electric Cable Type (Phase 4)]*, 1; *[Plan for Promoting Utility Pole Elimination (Phase 5)]*, 1.

[404] *[Toward Promoting the Undergrounding of Roadside Utility Poles]* (The Ministry of Land, Infrastructure, Transport and Tourism, n.d.), accessed March 13, 2026, https://www.mlit.go.jp/road/road/traffic/chicyuka/pdf/chi_24_04.pdf, 5;*[Tokyo Metropolis Utility Pole Elimination Plan (Amended)]* (Tokyo Metropolitan Government, 2021), https://www.kensetsu.metro.tokyo.lg.jp/documents/d/kensetsu/000052901, 7; to maintain consistency, the rest of this section uses the term "undergrounding" as a catch-all term for both undergrounding power lines and utility pole elimination.

[405] *[Toward Promoting the Undergrounding of Roadside Utility Poles]*, 3. A ward is similar to a municipal government in Pennsylvania.

[406] *[Toward Promoting the Undergrounding of Roadside Utility Poles]*, 3.

The national Road Act classifies roads by authorities responsible for their maintenance. The three classes include national expressways and highways; metropolitan and prefectural roads; and, local roads under the jurisdiction of ward, city, town, or village.[407] In Tokyo, smaller roadways maintained by urban wards occupy close to 90 percent of the roadways, which is over 14,000 miles.[408] These roads either do not have sidewalks or border narrow sidewalks, with 94 percent abutting sidewalks with the width smaller than eight feet.[409] This renders undergrounding and placement of overground equipment difficult. Combining the portion of national, metropolitan, and local roads with undergrounded power lines results in the figure of eight percent.

In terms of cable length, however, Tokyo has most of its power lines undergrounded. TEPCO notes that 4,364 of 4,716 miles of transmission lines and 10,498 of 22,198 miles of distribution lines in Tokyo's urban wards had been undergrounded by 2017. Respectively, this amounts to 92.5 percent of transmission lines and 47.3 percent of distribution lines.[410] Further, throughout the six initiatives starting from 1986, the national government has shifted the focus from undergrounding by major thoroughfares to local roads in residential neighborhoods, and technological advances allow for more compact and inexpensive multipurpose conduits as well.[411] Thus, the statistic on distribution lines adjacent to local roads may change significantly in the coming years.

The ten regional electric distributors such as TEPCO and authorities responsible for maintaining roadways are involved in undergrounding procedures. As Figure 18 shows, electric distributors must purchase cables and other auxiliary equipment, install them, and then remove existing overhead power lines and utility poles. National, prefectural, and local government entities that oversee affected roadways must excavate, purchase sheaths and pipes to contain new cables, install them, and then bury and pave over them. In this case, the space registered and designated by controlling agencies as roadways includes such structures as sidewalks and drainages.[412] The law restricts property rights in spaces that accommodate traffic and are understood to be of public use, meaning private landowners cannot ask the agencies for rent or compensation.[413]

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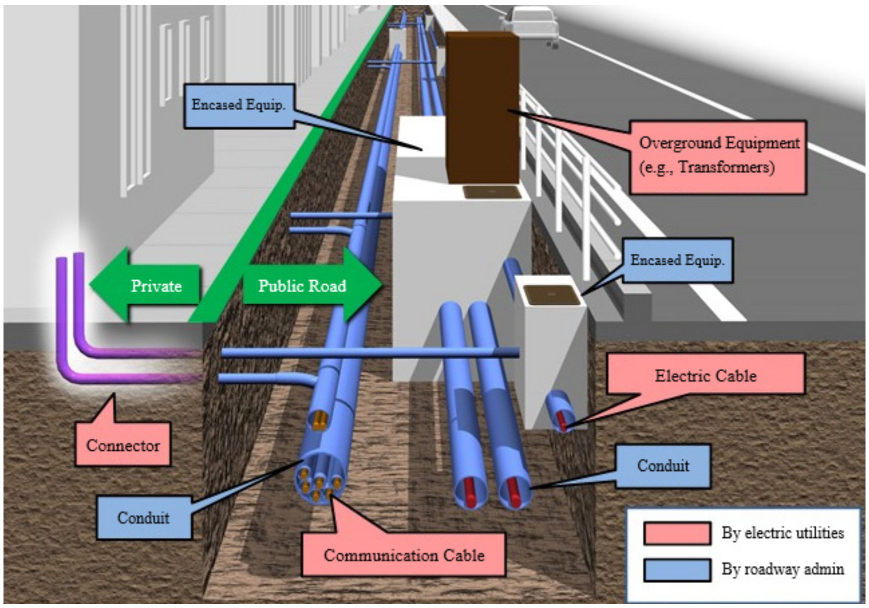
[407] [The Road Act], Pub. L. No. 22 (2025), https://laws.e-gov.go.jp/law/327AC1000000180; Chapter 1, Article 3; *Roads in Japan, 2024* (Road Bureau - The Ministry of Land, Infrastructure, Transport and Tourism, 2024), https://www.mlit.go.jp/road/road_e/pdf/ROAD2024web.pdf, 3–4.
[408] *[Tokyo Metropolis Utility Pole Elimination Plan (Amended)]*, 11.
[409] *[Tokyo Metropolis Utility Pole Elimination Plan (Amended)]*, 11.
[410] "[Rate of Undergrounding Transmission Lines]," *Tokyo Electric Power Company Holdings, Incorporated*, accessed March 12, 2026, https://www.tepco.co.jp/corporateinfo/illustrated/electricity-supply/transmission-underground-j.html; "[Rate of Undergrounding Distribution Lines]," *Tokyo Electric Power Company Holdings, Incorporated*, accessed March 12, 2026, https://www.tepco.co.jp/corporateinfo/illustrated/electricity-supply/distribution-underground-j.html.
[411] *[Guide to Reducing the Cost of Utility Pole Elimination]* (The Ministry of Land, Infrastructure, Transport and Tourism, 2024), https://www.mlit.go.jp/road/road/traffic/chicyuka/pdf/tebiki-doc03.pdf, 2–79.
[412] "[Road Site and Restriction of Property Rights]," *WEB*, accessed March 13, 2026, https://www.douroweb.jp/315handling/land_restriction.html.
[413] "[Road Site and Restriction of Property Rights]"; per [The Road Act], Article 4.

The government entities are also responsible for supporting new technological development that may lead to less expensive undergrounding strategies.[414] Any cost incurred during undergrounding is therefore split among the responsible parties.[415] In general, it takes $3 million per mile to underground utility lines.[416]

Figure 18
Undergrounding Cost Division for Multipurpose Utility Conduit
Japan, 2026



Source: "The Cost Allocation of Underground Multipurpose Conduits," *The Ministry of Land, Infrastructure, Transport and Tourism*, accessed March 12, 2026, https://www.mlit.go.jp/road/road/traffic/chicyuka/chi_19.html; translated from Japanese and modified by JSGC staff.

The governmental authorities responsible for maintaining roadways shoulder two-thirds of the undergrounding cost, with the national government and the local governments sharing it equally.[417] Meanwhile, utility companies shoulder the remaining one-third.[418] Undergrounding in designated *Center Core Areas*, i.e. downtown or central business district areas, within the 23 urban wards of Tokyo is eligible for a national subsidy up to 55 percent of the total cost and the Tokyo Metropolitan Government subsidy up to 22.5 percent, which leaves 22.5 percent to be shouldered by the wards themselves.[419]

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[414] [Act on the Promotion of Utility Pole Elimination], Article 13.
[415] "[Cost-Sharing for Multipurpose Utility Conduits]," *The Ministry of Land, Infrastructure, Transport and Tourism*, accessed March 13, 2026, https://www.mlit.go.jp/road/road/traffic/chicyuka/chi_19.html.
[416] *[Tokyo Metropolis Utility Pole Elimination Plan (Amended)]*, 10; U.S. dollar figure calculated based on June 2021 exchange rate (1 Japanese yen = 0.009 U.S. dollar); "Japanese Yen to U.S. Dollar Spot Exchange Rate," FRED, *Federal Reserve Bank of St. Louis*, accessed March 13, 2026, https://fred.stlouisfed.org/data/EXJPUS.
[417] *[Status of Utility Pole Elimination Initiatives]*, nos. 2–1 (The Ministry of Land, Infrastructure, Transport and Tourism, 2020), https://www.mlit.go.jp/road/ir/ir-council/chicyuka/pdf10/04.pdf, 4.
[418] *[Tokyo Metropolis Utility Pole Elimination Plan (Amended)]*, 10.
[419] *[Tokyo Metropolis Utility Pole Elimination Plan (Amended)]*; the policy may have changed since March 31, 2025.

Between 2016 and 2018, the Japanese national government spent ¥400 billion ($3.6 billion) per year for undergrounding.[420] In 2019, this increased to ¥1.1 trillion ($9.8 billion), with an additional appropriation of ¥205 billion ($1.9 billion) in the supplementary budget.[421] This represented approximately one percent of the overall government expenditure, or one-fifth of the national defense or education expenditures.[422] This can be construed as onerous for the central, prefectural, and municipal governments, which altogether maintain long-term debt obligations amounting to double the Japanese economy (211 percent) and use a quarter of the national budget for debt service.[423] In comparison, the debt obligations by all US government entities amounted to 131 percent in the second quarter of 2025.[424]

To advance undergrounding, the Japanese government has pursued a number of different fiscal incentives and taxes. For instance, in addition to subsidies to local governments pursuing undergrounding power lines, the national government dedicates a portion of international tourist taxes to beautification projects in historic and tourist districts.[425]

In 2023, the national government instituted a new revenue cap system for EDCs, which requires each company to submit an operation plan every five years for governmental evaluation and to set rate caps based on the approved plan.[426] The primary goals of this system are to encourage EDCs to replace aging grid infrastructure in Japan, much of which was built between 1970 and 1985, and to achieve net-zero emissions by 2050.[427] This system is similar to long-term infrastructure improvement plans (LTIIPs) Pennsylvania EDCs must submit to PUC for review.[428] The new system stipulates that Japanese EDCs may account for the cost of undergrounding in operation plans.[429]

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[420] *[Status of Utility Pole Elimination Initiatives]*, 22; average exchange rate between 2016 and 2018 calculated from the Federal Reserve data; Federal Reserve Bank of St. Louis, "Japanese Yen to U.S. Dollar Spot Exchange Rate."
[421] *[Status of Utility Pole Elimination Initiatives]*, 22
[422] *Japanese Public Finance Fact Sheet* (The Ministry of Finance, 2020), https://www.mof.go.jp/english/policy/budget/budget/fy2020/04.pdf., 3; , 35-38.35–38.
[423] *Japanese Public Finance Fact Sheet* (The Ministry of Finance, 2025), https://www.mof.go.jp/english/policy/budget/budget/fy2025/02.pdf, 1, 6.
[424] "State and Local Governments; Debt Securities and Loans; Liability, Level (SLGSDODNS)," FRED, *Federal Reserve Bank of St. Louis*, accessed March 13, 2026, https://fred.stlouisfed.org/graph/?g=Wycp;
[425] *[Status of Utility Pole Elimination Initiatives]*, 16, 23.
[426] " [Transmission Charges and the Revenue Cap System]," *Electricity and Gas Market Surveillance Commission - The Ministry of Economy, Trade and Industry*, accessed March 13, 2026, https://www.egc.meti.go.jp/info/revenue_cap/.
[427] *[Overview of the Revenue Cap System and Summary of the System Review Due to Inflation and Other Developments]* (Transmission and Distribution Grid Council, 2026), https://www.tdgc.jp/information/docs/%E3%83%AC%E3%83%99%E3%83%8B%E3%83%A5%E3%83%BC%E3%82%AD%E3%83%A3%E3%83%83%E3%83%97%E5%88%B6%E5%BA%A6%E3%81%AE%E6%A6%82%E8%A6%81%E3%81%8A%E3%82%88%E3%81%B3%E6%83%85%E5%8B%A2%E5%A4%89%E5%8C%96%E3%82%92%E8%B8%8F%E3%81%BE%E3%81%88%E3%81%9F%E5%88%B6%E5%BA%A6%E8%A6%8B%E7%9B%B4%E3%81%97%E3%81%AE%E6%A6%82%E8%A6%81%E3%81%AB%E3%81%A4%E3%81%84%E3%81%A6_r0.pdf, 4, 6–7.
[428] Diskin, *Pennsylvania Electric Reliability Report 2024*, iv.
[429] *[Regarding the Revenue Cap System]*, no. 3 (The Agency for Natural Resources and Energy - The Ministry of Economy, Trade and Industry, 2025), https://www.mlit.go.jp/road/ir/ir-council/chicyuka/pdf20/03.pdf, 11.

MLIT also publishes a detailed guide on technologies, materials, and methods used for undergrounding power lines that may aid any interested entity to conduct a cost-benefit analysis.[430] Additionally, bureaucratic procedures associated with undergrounding are multifold and complex, which necessitates interested governments to maintain a flow chart with all relevant stakeholders included.[431]

Despite four decades of continuous push by the central government, undergrounding or utility pole elimination continues to be a protracted process in Japan, as Table 16 demonstrates. In the years following the passage of the public statute for utility pole elimination, Japan increased its underground transmission lines by 440 kilometers (273.4 miles) or 31.3 percent of the expanded transmission line length and its underground distribution lines by 4,261 kilometers (2,648 miles) or 29.7 percent of the expanded distribution line length. The average pace of undergrounding per year is 62.9 kilometers, or 39.1 miles, of transmission lines and 608.7 kilometers, or 378.2 miles, of distribution lines. However, the overall increase of the undergrounded lines versus overhead lines is slow. The underground percentage for transmission lines increased by 0.1 percent and for distribution lines by 0.3 percent between 2017 and 2024.

Table 16
Electric Transmission and Distribution Line Status in Japan
2024

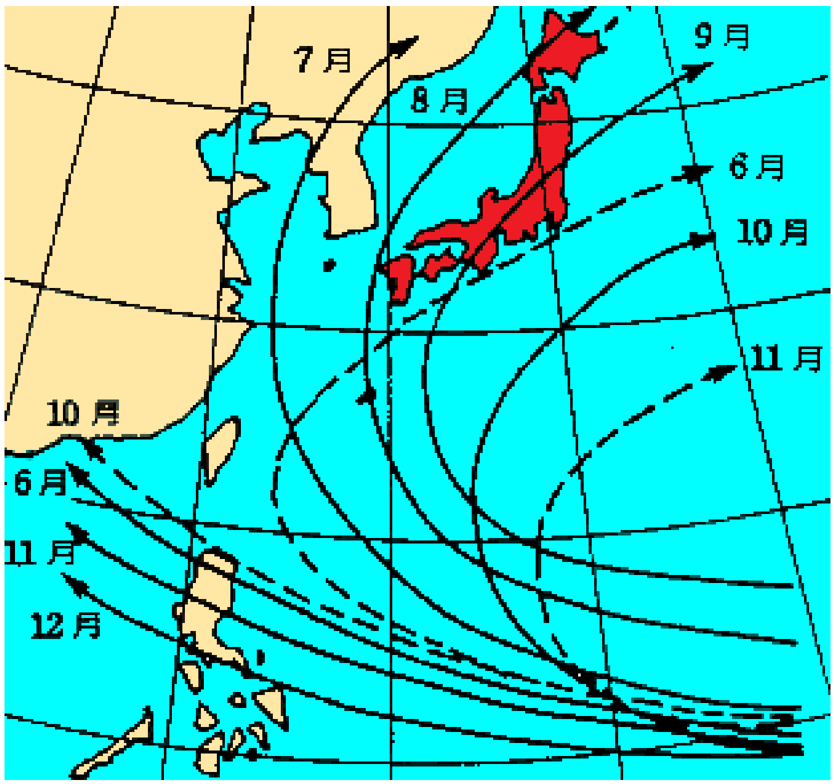
Year	Transmission, Overhead (km)	Transmission, Underground (km)	Underground Transmission Percent	Distribution, Overhead (km)	Distribution, Underground (km)	Underground Distribution Percent
2015	151,637	27,064	15.1	1,285,486	78,310	5.7
2016	154,706	27,205	15.0	1,289,752	78,957	5.8
2017	151,513	27,150	15.2	1,293,745	79,740	5.8
2018	151,625	27,243	15.2	1,297,414	80,368	5.8
2019	151,862	27,385	15.3	1,290,139	81,106	5.9
2020	152,298	27,434	15.3	1,293,591	81,716	5.9
2021	152,387	27,535	15.3	1,296,408	82,230	6.0
2022	152,573	27,593	15.3	1,299,434	82,810	6.0
2023	152,475	27,589	15.3	1,301,903	83,430	6.0
2024	152,479	27,590	15.3	1,303,850	84,001	6.1
Change	842	526	0.2	18,364	5,691	0.4

Source: Tokyo Electric Power Company Holdings, Incorporated, "Rate of Undergrounding Transmission Lines," Tokyo Electric Power Company Holdings, Incorporated, "Rate of Undergrounding Distribution Lines."

[430] *[Guide to Reducing the Cost of Utility Pole Elimination]*.
[431] For example, the Tokyo Metropolitan Government has published a comprehensive manual on undergrounding powerlines in April 2023 that includes one; *[Tokyo Metropolis Electric Cable Multipurpose Conduit Manual]* (Bureau of Construction - Tokyo Metropolitan Government, 2025), https://www.kensetsu.metro.tokyo.lg.jp/documents/d/kensetsu/000048552, 2-2.

Utility pole elimination is proceeding at a slow pace as well. According to a MLIT factsheet, Japan added 157,000 new electric poles in 2021 and 151,000 in 2022. At the same time, it took down 98,000 existing ones in 2021 and 94,000 in 2022. This resulted in the overall increase of electric poles by 59,000 in 2021 and 57,000 in 2022.[432] However, it is notable that only a quarter of the new poles are located in public lands, and only 17 percent of the new poles are in land designated for roadways.[433]

Figure 19
Month-by-Month Average Typhoon Path
by the Japan Meteorological Agency
2026



Source: “ [Typhoon’s Occurrence, Approach, Landfall, and Path],” *Japan Meteorological Agency*, accessed March 12, 2026, https://www.jma.go.jp/jma/kishou/know/typhoon/1-4.html; modified by JSGC staff to indicate Japan as the area in red.

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[432] *[Summary of Survey Results for Newly Installed Utility Poles, 2022]* (Road Bureau - The Ministry of Land, Infrastructure, Transport and Tourism, n.d.), accessed March 13, 2026, https://www.mlit.go.jp/road/road/traffic/chicyuka/pdf/22-03.pdf.
[433] “Press Release: [Countermeasures to Curb New Utility Poles Based on Analysis of Pertinent Factors],” *The Ministry of Land, Infrastructure, Transport and Tourism*, April 20, 2022, https://www.mlit.go.jp/road/road/traffic/chicyuka/pdf/22-01.pdf, 2.

Table 17
Comparative Population Density of Regions of Interest
2026

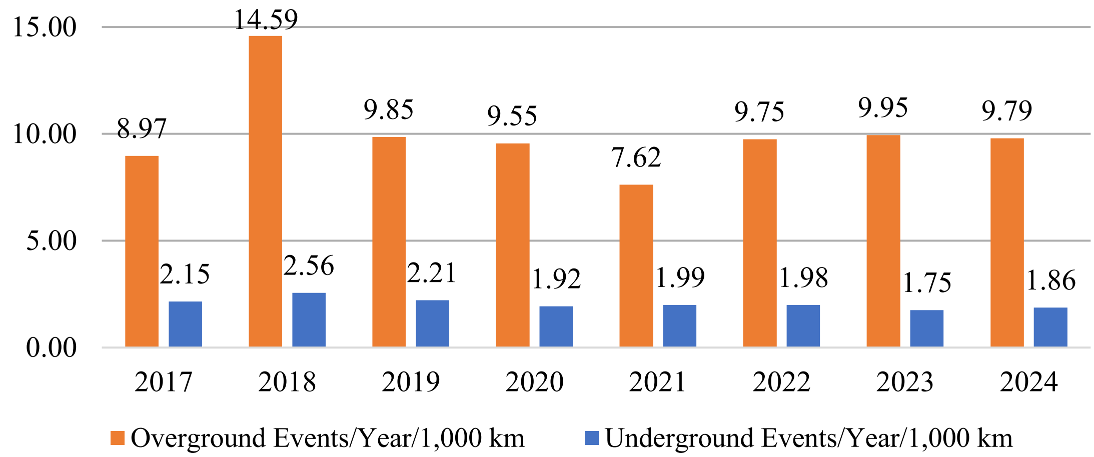
State, Prefecture, or Region	Population Density per Square Mile
Pennsylvania	292
Hokkaido Prefecture	161
Tohoku Region	348
Kanto Region (Greater Tokyo)	2781
Kansai Region (Kyoto-Osaka-Kobe)	1935

Sources:*[2025 National Survey of Land Area by Prefecture, City, Ward, Town, and Village]*, Geospatial Information Authority of Japan Technical Data nos. E2-No. 90 (Geospatial Information Authority of Japan, 2025), https://www.gsi.go.jp/KOKUJYOHO/MENCHO/backnumber/GSI-menseki20251001.pdf; "[Population Estimates: Population as of 1 October of Each Year, 2020 Census Standard, Statistical Table]," [Portal Site of Official Statistics of Japan], *National Statistics Center, Japan*, accessed March 12, 2026, https://www.e-stat.go.jp/dbview?sid=0003448231; "QuickFacts: Pennsylvania," *US Census Bureau*, accessed March 12, 2026, https://www.census.gov/quickfacts/fact/table/PA/PST045224.

The Japanese data demonstrate that the government views urbanization and beautification as more salient reasons for undergrounding than weather and climate. Figure 19 illustrates that all of Japan is in the range of typhoons in August and September when they are the most frequent and most destructive, meaning all electric companies are equally vulnerable to damages related to tropical cyclones.[434] Undergrounding is comparatively rare in Hokkaido and Tohoku, northern regions that see the most significant snowfalls in Japan.[435] In fact, Tohoku, which receives the most overall snowfall, has the lowest undergrounding rate among the four regions of the country. Table 17 indicates that population density of these regions is similar to that of Pennsylvania.[436] In contrast, heavily urbanized areas around Tokyo (Kanto) and Kansai (Kyoto-Osaka-Kobe) have far more undergrounded power lines.

[434] Japan Meteorological Agency, "[Typhoon's Occurrence, Approach, Landfall, and Path]."
[435] "[All-Time National Rankings]," *Japan Meteorological Agency*, accessed March 13, 2026, https://www.data.jma.go.jp/stats/etrn/view/rankall.php; see the maximum depth of snow cover ranking .
[436] The definition of each region followed the division of ten electric distributor companies as indicated in the following citation; " [Implementation of the Legal Separation of Transmission and Distribution (Unbundling): April 2020 Marks the Dawn of a New Era for the Electricity Industry]," Enelog, *The Federation of Electric Power Companies of Japan*, June 2020, http://www.fepc.or.jp/enelog/focus/vol_42.html.

Graph 10
Average Frequency of Service Interruption
per 1,000 kilometers of Power Lines in Japan by Source
2017-2024



Source: *[Report on the Quality of Electrical Supply -2024 Performance Records-]*; *[Report on the Quality of Electrical Supply -2021 Performance Records-]*.

The Organization for Cross-regional Coordination of Transmission Operators, a governmental trade association, publishes data on outage events separated by their sources every year: substation, overhead and underground transmission lines, overhead and underground distribution lines, consumer-end equipment, and other equipment or facilities related.[437] JSGC staff used these data to calculate new measures, which are standardized by accounting for the length of overhead and underground power lines in Japan, i.e. the frequency of outage events per year per 1,000 kilometers of either overhead or underground lines.

Graph 10 demonstrates the difference between the two standardized measures, which remain relatively consistent between 2020 and 2024. In general, 1,000 kilometers of overhead power lines cause approximately 10 outage events per year. In contrast, 1,000 kilometers of underground power lines cause approximately two outages per year, with the record trending toward a decrease over time.

A counterfactual scenario may be estimated using the differential ratio between the average frequency of service interruption between underground and overhead lines. If none of the power lines had been undergrounded, Japan would have experienced 869 more outages per year on average between 2017 and 2024, which amounts to a 5.7 percent increase. The increase would range from 728 (2017 amount, 5.4 percent increase) to 1,295 additional outages (2018 amount, 5.9 percent increase).

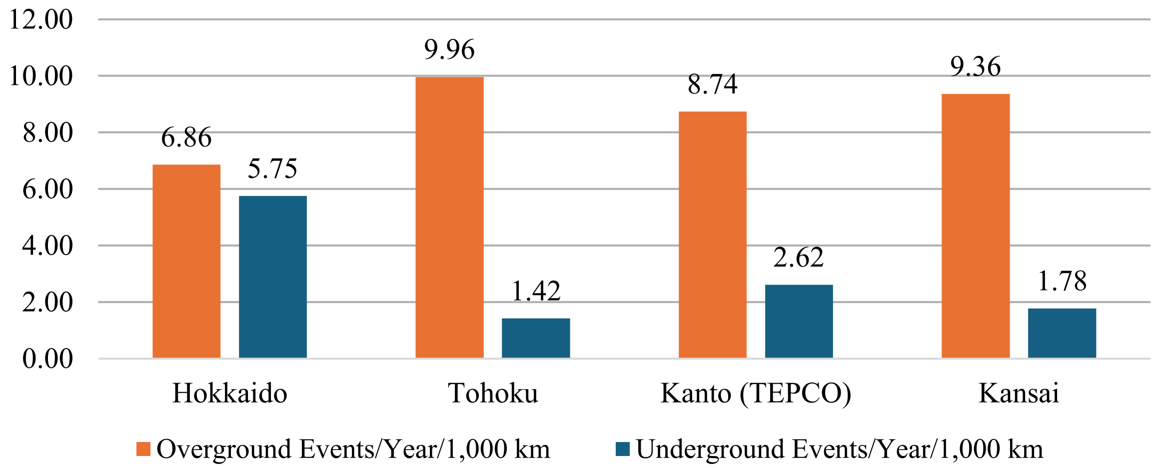
[437] *[Report on the Quality of Electrical Supply -2024 Performance Records-]*, 4–6.

Table 18
Count of Service Interruption Events
by EDC and Source
2024

Source	Hokkaido	Tohoku	Kanto (TEPCO)	Kansai
Substation	1	7	15	4
All Overhead Power Lines	645	2065	3284	1410
All Underground Power Lines	15	7	86	26

Source: *[Report on the Quality of Electrical Supply -2024 Performance Records-]*.

Graph 11
Average Frequency of Service Interruption
per 1,000 kilometers of Power Lines by EDC and Source
2024



Source: *[Report on the Quality of Electrical Supply -2024 Performance Records-]*.

The pattern holds at the regional level as well. Table 18 shows that across Hokkaido, Tohoku, TEPCO, and Kansai grids, fewer service interruptions occur along underground power lines compared to overhead lines. Standardizing the measures for comparability reveals a pattern that is similar to what Graph 10 illustrates. Graph 11 shows that underground interruptions ranged from only 14 percent (Tohoku) to 84 percent (Hokkaido) of overground interruptions in 2024. It is unclear why underground events were comparatively more frequent in Hokkaido, as Tohoku and Kanto experienced more seismic activities and cyclones than Hokkaido did.[438] Still, investment in undergrounding power lines, infrastructure upkeep, and tracking progress via detailed metrics, i.e. annual statistical reports by a regulatory agency, appear to have improved grid resilience in Japan overall, though efforts continue.

[438] Found in the records at the Japan Meteorological Agency (JMA); " [Seismic Activity and Magnitude Database Search]," *Japan Meteorological Agency*, accessed March 13, 2026, https://www.data.jma.go.jp/eqdb/data/shindo/; 3, 5.

Experiences in Other Countries

Comparing the United States to European countries with successful undergrounding strategies is difficult due to differing compositions of the countries' infrastructure. Germany, for example, has successful undergrounding in urban areas that are densely populated without much sprawl.[439] Its transmission and distribution system is laid out differently and crews can make repairs quickly.

In Sweden undergrounding was pursued after large storms in 2005 damaged 30,000 kilometers of distribution lines that led to power outages for 730,000 customers. These storms caused rural areas to lose power for up to 20 days.[440] From 2004-2018, Sweden increased the amount of medium and high voltage lines underground from 39 percent underground to 57 percent. Similarly, the country went from 70 percent low voltage undergrounded to 82 percent. As result of infrastructure improvements, SAIFI fell by 37 percent between 2011 and 2020; SAIDI fell by 63 percent.[441]

Neighboring Nordic counties have also adopted undergrounding measures in response to storms. In Finland, the 2011 Cyclone Tapani caused extensive damage to its infrastructure.[442] In response it created a plan to harden the grid by 2036 with a goal that storm outages would not exceed six hours in cities and 36 hours in rural parts of the country. The second largest distribution operator in Finland, Elenia, began to invest in undergrounding. The stated goal of this project was to increase from 41 percent underground in 2019 to 75 percent in 2028. This study reported that interruptions decreased by half and temporary outages have been reduced.

In the United Kingdom, energy regulator Ofgem has adopted performance-based regulations called the RIIO framework. As part of RIIO, utilities must develop climate-resilience strategies including risk assessments of the climate and lay out costs of how these will be addressed.[443] The intention of this requirement was to increase the level of transparency in how the country invested in its future. Ofgem included undergrounding for visual appeal as part of its rate case for 2023-2028.[444] Evidently, customers are willing to pay £68 million over these five years for visual improvements. Various versions of this program have existed since 2010.

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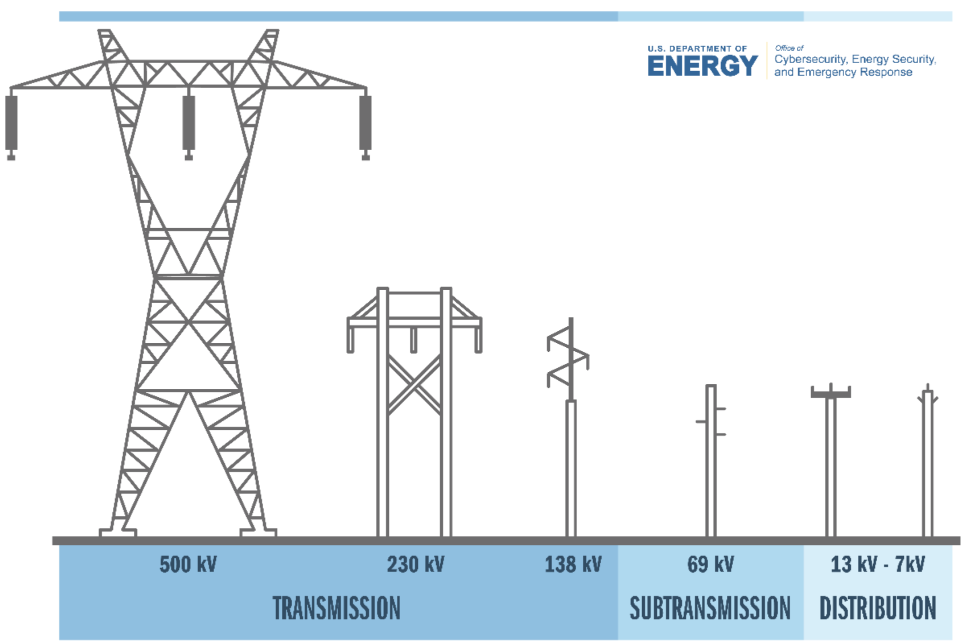
[439] Ephram Glass and Victor Glass, "Underground Power Lines Can Be the Least Cost Option When Study Biases Are Corrected," The Electricity Journal 32, no. 2 (March 2019): 7–12, https://doi.org/10.1016/j.tej.2019.01.015.
[440] Chris Watts, "The Changing Economics of Utility Investment in Undergrounding," S&C Electric Co., May 22, 2023, https://www.sandc.com/globalassets/sac-electric/documents/public---documents/sales-manual-library---external-view/technical-paper-100-t144.pdf, 12.
[441] Watts, "The Changing Economics of Utility Investment in Undergrounding," S&C Electric Co., 2023.
[442] Watts, "The Changing Economics of Utility Investment in Undergrounding," S&C Electric Co., 2023.
[443] Watts, "The Changing Economics of Utility Investment in Undergrounding," S&C Electric Co., 2023, 5.
[444] Watts, "The Changing Economics of Utility Investment in Undergrounding," S&C Electric Co., 2023, 12.

The differences between transmission and distribution lines can be thought of as similar to the different sizes of roads. Smaller roads like single lane and city streets have less traffic and carry fewer cars than larger multi-lane highways. Similarly, high voltage transmission lines have larger infrastructure and more electricity travels along its wires. As previously noted, transmission lines contain higher voltages so that they may carry electricity over great distances, not directly to customers. There are fewer overall miles of transmission lines in the US, however they cover great distances stretching across the country connecting generation sources and population centers. [445] As of 2025 there were an estimated 600,000 miles of transmission lines across the United States.[446]

Figure 20
Designs of Electric Poles and Tower Based on Voltage
2023



Source: US Dept. of Energy, "Exhibit 2. Electric Power Line Structure by Type," Nov. 2023, https://www.energy.gov/sites/default/files/2023-11/FINAL_CESER%20Electricity%20Grid%20 Backgrounder_508.pdf, 3.

[445] Sara Hoff, "US Electric System Is Made up of Interconnections and Balancing Authorities," US Energy Information Admin., July 20, 2016, https://www.eia.gov/todayinenergy/detail.php?id=27152.
[446] American Society of Civil Engineers, "2025 Infrastructure Report Card: Energy," infrastructurereportcard.org, March 17, 2025, https://infrastructurereportcard.org/wp-content/uploads/2025/03/Energy.pdf.

These transmission lines regularly pass between state lines and are subject to various reliability standards established by NERC and overseen by FERC as well as state-level regulations.[447] This, along with their greater voltages leads to different structural requirements for transmission towers. For example, higher voltages typically require higher clearance from objects for safety reasons. To achieve this clearance, taller towers were built, which necessitated stronger structures to protect wires from the elements.[448] See Figure 20. Typically transmission lines also have larger right of way requirements (100 to 200ft) which requires greater degrees of vegetation management.[449] In areas under the critical wire zone, no tree species are allowed and height must be kept below six feet. As a result of these precautions, transmission lines are much less likely to be impacted by storms knocking trees into them and do not suffer the same reliability issues that distribution lines do. Ninety percent of interruptions of service are from the distribution power lines.[450]

As demand for electricity rises new transmission lines may be needed to move electricity from generation sources to the grid. In recent years a substantial amount of funding has been spent to improve the transmission system within the US. In 2023, utilities spent $11.8 billion upgrading these power lines.[451] Unlike distribution lines, which have seen a steady increases in the total number buried lines due to new housing developments, or EDCs burying power lines to improve reliability, resultingly very few Transmission lines are buried.

Transmission Lines within Pennsylvania

Due to their fragmented ownership and propensity to cross state lines, there is no official count of the number of transmission lines within the Commonwealth. Files within the Homeland Infrastructure Foundation-Level Data (HIFLD) estimates that there are 2,480 line segments that comprise a total of 13,452 miles of transmission lines in Pennsylvania.[452] Approximately 20 percent of those miles are high voltage (345kV or more), which can be thought of as the backbone of the transmission system. PPL Electric is the company with the most transmission line miles at 3,598 miles. However, when combined, FirstEnergy power companies total 8,044 miles, or 60 percent, of the transmission lines within Pennsylvania.[453]

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447 Ashley Lawson, "Introduction to Electricity Transmission," US Congress, 2025, https://www.congress.gov/crs-product/IF12253.
448 Transmission Agency of Northern California, "The Transmission System and How It Works," accessed June 22, 2026, https://www.tanc.us/understanding-transmission/the-transmission-system-and-how-it-works/.
449 PA Game Commission, "Electric Utility Right-Of-Way Management," August 2013, https://www.pa.gov/content/dam/copapwp-pagov/en/pgc/documents/habitat-management/habitat-management-/row%20utility%20row%20management.pdf.
450 National Renewable Energy Laboratory, "Explained: Reliability of the Current Power Grid," January 2024, https://docs.nrel.gov/docs/fy24osti/87297.pdf, 1.
451 American Society of Civil Engineers, "2025 Infrastructure Report Card: Energy."
452 Daniel O'Donohue, "Pennsylvania Electric Power Transmission Lines: Interactive Map and Operator Data," mapscaping.com, April 27, 2026, https://mapscaping.com/pennsylvania-transmission-lines/#lat=45.7215&lng=-66.1267&z=7; The limited nature of the data means that some line segments that touch Pennsylvania owned by FirstEnergy company that extend from PA to neighboring states are also included.
453 Daniel O'Donohue, "Pennsylvania Electric Power Transmission Lines: Interactive Map and Operator Data."

As of 2025, transmission line projects are increasing to serve rising energy demand, especially from new high load customers like data centers.[454] PPL expects demand to triple, which has led to consumer backlash over larger towers.[455]

Searching the HIFLD database revealed that underground transmission lines are very uncommon within Pennsylvania. PPL, PECO, DLC each own underground transmission lines and together these total approximately 16.4 miles.[456] Underground transmission lines account for less than one percent in the state. Those lines that were underground were typically either 69kV, which is considered "sub transmission," or 138 kV. These underground lines were chiefly located in Pennsylvania cities, with the greatest concentrations being in Philadelphia and Pittsburgh. No transmission lines higher than 200kV transmission lines were detected underground.[457]

History of Burying Transmission Lines

Above ground transmission lines disperse excess heat into the air and wide amount of space is kept between wires for safety. When buried underground, these lines require a greater degree of insulation than lower voltage distribution lines. The Wisconsin Public Service Commission (PSC) notes the first underground 132kV transmission lines were buried in 1927, however they proved difficult to maintain and there were design challenges associated with insulating high voltage cables due to their proximity to grounding wires and being filled with fluids to stop them from overheating.[458] While new designs eventually produced solid cross-linked polyethene cables (XLPC), these type of solid power lines were not filled fluids or gas, and as a result required less maintenance.

The undergrounding of higher voltage transmission lines began becoming more common in 1980s, and today thousands of miles of underground cables have been buried all over the world. In the United States there are fewer buried transmission lines, and in 2012 only .5 percent of transmission lines 200kV or higher were buried in the US.[459]

Internationally, diverting high voltage transmission lines underground in urban and industrial settings have been driven by environmental and resiliency concerns. New materials,

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[454] Associated Press, "AI Is Spurring a Big Expansion of High-Voltage Power Lines. Landowners and Locals Are Fighting Back," US News & World Report, 2026, https://www.usnews.com/news/business/articles/2026-03-08/ai-is-spurring-a-big-expansion-of-high-voltage-power-lines-landowners-and-locals-are-fighting-back.

[455] Associated Press, "AI Is Spurring a Big Expansion of High-Voltage Power Lines," US News & World Report, 2026.

[456] Daniel O'Donohue, "Pennsylvania Electric Power Transmission Lines: Interactive Map and Operator Data," mapscaping.com, April 27, 2026.

[457] It is possible that this database is incomplete and there may be more transmission lines which were not reported, their voltages were not listed, or they were not identified by software designed to document transmission lines from analyzing aerial photographs.

[458] Public Service Commission of Wisconsin, "Underground Electric Transmission Lines," May 2011, https://psc.wi.gov/Documents/Brochures/Under%20Ground%20Transmission.pdf.

[459] "Power Outages Often Spur Questions around Burying Power Lines," US Energy Information Admin., July 25, 2012, https://www.eia.gov/todayinenergy/detail.php?id=7250.

processing technology, installation techniques and steady reduction in relative costs have contributed to the rise in underground abroad. In some cases, there are advantages to reliability and life expectancy as well as maintenance and operating costs.

There are design challenges involved with undergrounding transmission wires that must be considered, many of which are similar to undergrounding distribution wires. For example, underground transmissions lines frequently have lower current capacity than overhead lines. Heat dissipation is restricted in soil (unlike on overhead where it is released into the air). As noted in section on underground distribution challenges faults can be challenging to locate and repair. Environmental and regulatory constraints can add delays. While an improvement over past materials, it was discovered that XLPE cables can become brittle with age, and there are no fluid or gas leaks to aid in detection faults like older cables.

The rapid development of new technology over the last few decades has meant that underground transmission lines can be longer and buried at higher voltages than previously was the case, however planning scenarios do not always keep up with new technology.[460] Extra high voltage (EHV) underground cable systems have been available for some time, although their use has been restricted to providing interconnections between overhead transmission lines and specified locations within urban and industrial areas. EHV cables have also been used where environmental factors take precedence in expanding or improving transmission networks. Although most of these lines' segments are comparatively shorter, longer ones also exist, and there are cases of 400-500 kV lines buried across Asia and Europe. The typical length of undergrounded high voltage cables is only 1.25-12 miles.[461]

Even in the countries most dedicated to undergrounding, at some point above ground wires must be transferred underground and these places require special consideration. "High-voltage underground transmission lines require small transition stations wherever the underground cable connects to overhead transmission. Transition stations require grading, access roads, storm water management facilities and fencing."[462] For example, at 400-500kV the size and weight terminations and necessary clearances dictate the use of separate high security transition compounds on the ground. The compound can require an area of 2,500 square meters depending on power level and amount of equipment installed.

Transmission lines can impact property values, and communities are conscious of this cost and is one of the pressures for transitions lines to be moved underground internationally. The reason transmission lines are sometimes considered unwanted features in proximity to housing is due to blocking views, noise, heat and other factors such consumer concern over electromagnetic fields. Undergrounding transmission lines conducted in UK at the turn of the 21st century found that it avoided a five to 20 percent loss in property values.[463]

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460 Engineering Institute of Technology, and Akhtar Kalam, "The Unexpected Complexity of Converting Overhead Lines to Underground Cables: Part 2," YouTube, January 23, 2026, https://www.youtube.com/watch?v=SkBBgMBuxlA.

461 Kalam, "The Unexpected Complexity of Converting Overhead Lines to Underground Cables: Part 2,"

462 Xcel Energy, "Overhead vs. Underground," February 10, 2023, https://cdn.xcelenergytransmission.com/blobvizxe609304b0a5/wp-content/uploads/2024/07/WWTConnection-Underground-Oct-2023.pdf.

463 Lawrence Berkeley Lab, "Undergrounding Transmission and Distribution Lines Resilience Investment Guide."

There are also several drivers for undergrounding transmission beyond aesthetics.[464] Internationally, the necessity to move power lines underground due to increasing urban density requires compact corridors. As with other underground power lines, undergrounding transmission lines offers improved resistance against storms and wildfires. In some instances community driven beautification policies may be the cause for adoption or due to safety reasons such as airports who pay for transmission lines to be undergrounded.[465]

Australia Transmission Line Case Study

In Australia, power lines are buried in newer developments and slowly undergrounded in old ones. While undergrounding transmission infrastructure may have support from the public, in some instances they may face significant opposition from companies unwilling to undertake a project. In one instance, a housing developer outside of Waverly Park Estate in Mulgrave Victoria made agreements as part of 2002 building permits that it would underground a segment of transmission lines. advertised to the purchasers of the future housing development. The company in question later determined that the expense of burying a third of a mile segment of a 220 kV transmission lines would be cost prohibitive at $60 million Australian.[466] Additionally a transition enclosure at either end of the project connecting to overhead lines were estimated to be space inefficient and contain visual obstructions.

Subsequently, a government consultant reviewed this project to determine if there were any feasible alternatives such as a tower mounted terminations or practical transition enclosures that would provide the least visual impact and be a cost effective way to underground a 220kV high-voltage power line. Despite the consultant identifying a project in New Zealand with a design that meet the needed criteria, be two-thirds of the cost, and have a smaller profile that would decrease visual obstructions, this alternative proposal was also rejected by the developer.[467]

In 2015, it was agreed by a tribunal that the company would not need to underground this infrastructure, and it replaced transition towers with slimmer steel mono-structure poles in 2018 as well as agreed to pay to install a pond project to improve the community.[468] It is hard to force companies to underground a power line if they do not view it as a necessary and will spend many millions of dollars to avoid the expense of tens of millions of dollars.

Analysis of this project and other underground transmission projects has shown that geotechnical studies are necessary before committing to a project, and that civil expenses should

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464 Engineering Institute of Technology, and Akhtar Kalam. “From Sky to Earth – Unexpected Complexity of Converting Overhead Lines to Underground Cables: Part I.” YouTube, January 20, 2026. https://www.youtube.com/watch?v=jgfjLWzudus.
465 SRP, “Humphrey-Turpen 69 KV Transmission Project,”, 2026, https://www.srpnet.com/grid-water-management/grid-management/improvement-projects/humphrey-turpen-transmission.
466 Converted from metric.
467 Kalam, “The Unexpected Complexity of Converting Overhead Lines to Underground Cables: Part 2.” YouTube, 2026.
468 Kalam, “The Unexpected Complexity of Converting Overhead Lines to Underground Cables: Part 2.” YouTube, 2026.

not be underestimated.[469] This study found that quality of the joints (where transmission lines are connected to each other) are one of the most critical ways these projects can fail.

Underground transmission cables can pose complex multidisciplinary design challenges. While they are often safer and more reliable, they can also be vastly more expensive. To do this they necessitate engineering solutions that require advanced modeling and materials. There may also be significant constraints not evident to the public. Engineers working on such projects must balance performance cost, safety, and regulations.

Brief Survey of Underground Transmission Line Costs

Costs have remained the primary factor that has kept transmission networks overhead. In a 2011 report by Wisconsin PSC that reviewed underground transmission lines found that many factors affected its price such as the local environment, length of wire between splices and termination points, and a number of related facilities needed such as underground vaults.

While materials, design, and general cost of digging can be estimated to plan a project there are also unknown variables that only present themselves once a project is already in development that can escalate the cost of undergrounding. Some of these factors include right of way access, start-up complications, construction limitation in urban areas, conflicts with other utility infrastructure, trenching difficulties, and crossing natural or manmade barriers. While many of these factors for burying high voltage transmission lines are similar to that of undergrounding distribution lines, transmission lines may also need forced cooling.[470]

While it is generally agreed that undergrounding distribution power lines is more expensive than building new overhead lines, burying transmission lines is more expensive still. The Wisconsin PSC found that:

> Underground transmission construction can be very site-specific, especially for higher voltage lines. Components of underground transmission are often not interchangeable as they are for overhead. A complete in-depth study and characterization of the subsurface and electrical environment is necessary in order to get an accurate estimate for undergrounding a specific section of transmission.[471]

Some commonly quoted older studies have placed the cost at five to 10 times the cost of the construction of new overhead lines.[472]

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469 Kalam, "The Unexpected Complexity of Converting Overhead Lines to Underground Cables: Part 2." YouTube, 2026.

470 Public Service Commission of Wisconsin, "Underground Electric Transmission Lines," May 2011, https://psc.wi.gov/Documents/Brochures/Under%20Ground%20Transmission.pdf.

471 Public Service Commission of Wisconsin, "Underground Electric Transmission Lines," 17.

472 Kenneth Hall, "Out of Sight, out of Mind 2012 an Updated Study on the Undergrounding of Overhead Power Lines," 2013, https://www.eei.org/-/media/Project/EEI/Documents/Issues-and-Policy/Reliability-and-Emergency-Response/UndergroundReport.pdf?la=en&hash=7E2DB1E527AA94410D64121EE340AF3D8BD07694.

Due to such variation in project design and conditions, it is not surprising that each undergrounding study provides a different answer for the cost to underground transmission lines. A Edison Electric Institute (EEI) study estimates $1.5 million to $33 million for undergrounding transmission lines.[473] Wisconsin's PSC noted that conversion per mile costs of 69kV and 138kV may cost $2.2 and $2.9 million, respectively.[474] Arizona's Salt River Project power company found 69kV power line costs $3.5 million to underground each circuit in a mile.[475] California's Public Utilities Commission provided the highest cost of undergrounding estimates and noted that for its three energy companies, the conversion of overhead to underground transmission lines takes a minimum of $6 million per mile while difficult segments up to $100 million per mile.[476] The overall trend is the higher voltage a power line is, the more expensive it will be to underground. See Table 19 for a breakdown on the among of each type of voltage for transmission lines within Pennsylvania.

Table 19
Voltage Class Breakdown for Pennsylvania
2026

Voltage Class	Miles	Segments	Percent Share
500 kV	1,673	65	12.4%
345 kV	977	35	7.3
220 – 287 kV	2,944	351	21.9
100 – 161 kV	4,432	799	32.9
Under 100 kV	2,056	800	15.3
Voltage not reported	1,370	425	10.2

Source: Pennsylvania Electric Power Transmission Lines: Interactive Map and Operator Data, April 27, 2026, https://mapscaping.com/pennsylvania-transmission-lines/#lat=40.9882&lng=-78.1128&z=7.

473 Kenneth Hall, "Out of Sight, out of Mind 2012," 2013.
474 Underground Electric Transmission Lines, Wisconsin PSC, p 17; adjusted for inflation.
475 SRP, "Humphrey-Turpen 69 KV Transmission Project," Srpnet.com, 2026, https://www.srpnet.com/grid-water-management/grid-management/improvement-projects/humphrey-turpen-transmission.
476 Sean Wolfe, "What Would It Cost to Bury All of California's Power Lines?," Factor This™, January 27, 2025, https://www.renewableenergyworld.com/power-grid/outage-management/what-would-it-cost-to-bury-all-of-californias-power-lines/.

One of the reasons that costs for underground transmission prices appear to be increasing in recent years is that undergrounding projects are sensitive to increases in the cost of oil and copper, both of which have increased in recent years. The costs for copper, of which the wires are made, has risen by 194 percent and the price of crude oil, used to create insulating plastics, has risen by 88 percent in the last decade.[477]

Hypothetical Undergrounding Scenario

While a more thorough investigation based on the material requirements and geographic conditions of each proposed site would be needed to create a broad estimate, figures from the Wisconsin PSC updated for inflation indicate it may cost up to $16 billion to underground 6,500 miles of transmission lines under 200kV within Pennsylvania. This would still leave an additional 5,600 miles of transmission lines to bury at a higher dollar per mile value. Using California's $6 million per mile as an approximation this could be over $33.6 billion. Overall, it would take approximately the entire annual state budget of Pennsylvania to bury transmission lines.

Map 16
Location of Transmission Lines in Pennsylvania Over 200kV
2026

Source: Pennsylvania Electric Power Transmission Lines: Interactive Map and Operator Data, April 27, 2026, https://mapscaping.com/pennsylvania-transmission-lines/#lat=40.9882&lng=-78.1128&z=7.

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[477] Macrotrends, "Crude Oil Prices - 70 Year Historical Chart," Macrotrends.net, 2029, https://www.macrotrends.net/1369/crude-oil-price-history-chart And, Macrotrends, "Copper Prices - 45 Year Historical Chart," Macrotrends.net, 2026, https://www.macrotrends.net/1476/copper-prices-historical-chart-data.

Aside from this monumental expense, certain transmission lines could also be onerous to bury due to crossing geographical barriers with the state such as the Allegheny and Pocono Mountains. Many voltage transmission lines also cross through state forests and game lands. See Map 16. Burying these lines would have a comparatively higher environmental impact than the current poles as the rights of ways and easements would still need to be cleared of vegetation so the lines could be accessed.[478]

To summarize the impact of burying transmission lines:

> Burying a 230 kV double circuit transmission line at a minimum would require a continuous trench or duct bank at least 3.5 feet wide at the bottom and 7 feet deep." AND "Considerable clearing and grading would be necessary, and dust and noise from construction would last three to six times longer than it would for overhead construction. Large concrete splice vaults or access structures… are needed at 2,000 to 2,500-foot intervals. Permanent access to the vaults is required to make repairs when needed.[479]
>
> After construction there is also remediating the disturbed area.
>
> Site restoration for underground construction is a much larger endeavor than it is for overhead construction because soil is disturbed along the entire route. Topsoil have to be restored and returned to vegetated areas, and all hard surface areas must be reestablished to meet local codes. Vegetated areas may require up to two years to return to preconstruction conditions.[480]

If buried lines were to follow the path of existing transmission lines, they would need to be drilled under Pennsylvania's many rivers adding greater expense and technical difficulties. JSGC staff observed approximately 60 transmission lines over 200kV which cross the length of the Susquehanna River. Assuming that the wires closest to each other could be buried in the same tunnels it may still require approximately 30 tunnels.[481] While it is the longest waterway in the state, it is far from the only river. Transmission lines were also observed crossing the following rivers:

- Allegheny: 7
- Ohio: 7
- Monongahela: 4
- Youghiogheny: 1
- Delaware: 13

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[478] PPL Electric Utilities, "Chanceford 500 KV Project," Feb. 5, 2024, https://hdp-us-prod-app-wspusa-collinsville-files.s3.us-west-2.amazonaws.com/5717/1468/3609/Transmission_-_Chanceford_500_kV_Project_FAQs_-_5-2-2024.pdf.

[479] Xcel Energy, "Overhead vs. Underground," Feb. 10, 2023, https://cdn.xcelenergytransmission.com/blobvizxe609304b0a5/wp-content/uploads/2024/07/WWTConnection-Underground-Oct-2023.pdf.
https://www.xcelenergy.com/staticfiles/xe/Corporate/Corporate%20PDFs/OverheadVsUnderground_FactSheet.pdf.

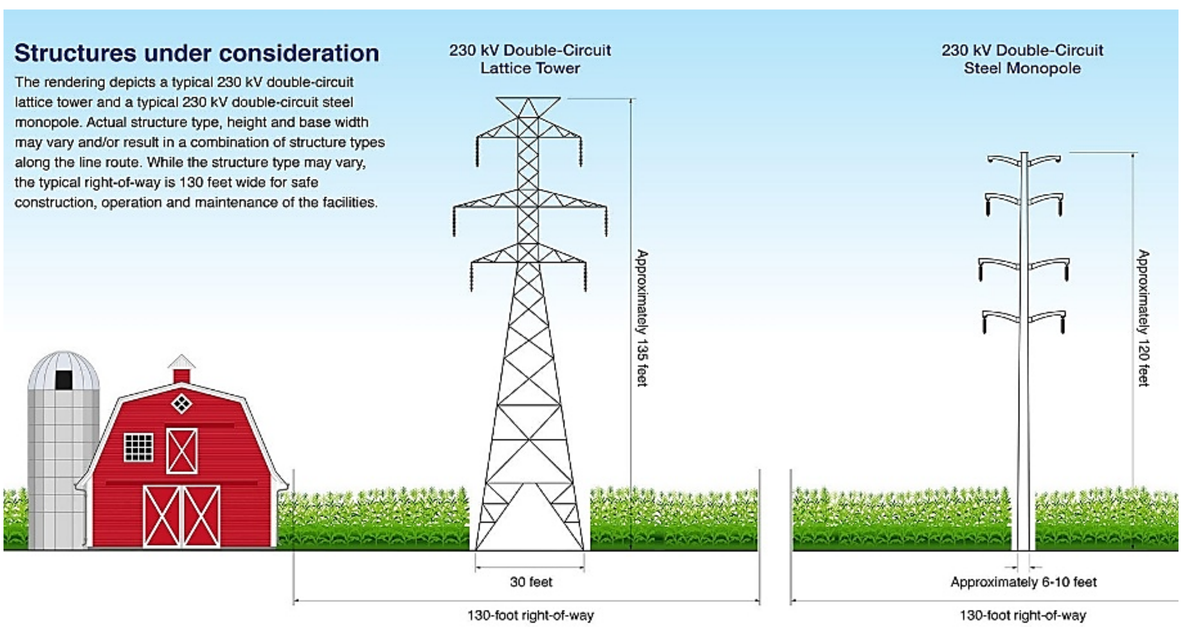
[480] Xcel Energy, "Overhead vs. Underground: Information about Burying High-Voltage Transmission Lines," May 2014, https://www.xcelenergy.com/staticfiles/xe/Corporate/Corporate%20PDFs/OverheadVsUnderground_FactSheet.pdf.

[481] "US Electric Power Transmission Lines," Felt.com, accessed May 18, 2026, https://felt.com/map/US-Electric-Power-Transmission-Lines; Analysis by JSGC Staff.

Overall, there are significant geographic barriers in the form of mountains, waterways, and forests along the current route of transmission lines within the Commonwealth and these would increase the expense and difficulty of burying these lines.

To focus on an individual example of why companies may choose not to underground is the Brunot Island-Crescent Transmission Reliability project outside of Pittsburgh undertaken by Duquesne Light Company (DLC). This project cost a total of $40 million for 14.5 miles at a cost of $2.7 million per mile to replace transmission towers with a larger, slimmer, sturdier monopole designs.[482] See Figure 21 for a comparison between lattice tower and monopole designs. DLC noted that this project was not selected for underground for the following reasons: longer underground outages, steep rocky terrain that would be difficult to dig up or bore through, and significantly higher costs.[483] In other instances, DLC has chosen to underground transmission lines. During the Universal-Plum-Cheswick reliability project, the company installed three miles of underground transmission lines.[484]

Figure 21
Comparison of Transmission Tower Designs
2017



Source: Transource Energy, "Proposed Structures," September 2017, https://www.ydr.com/story/news/politics/2017/09/13/york-county-planners-concerned-transource-power-line-project/642395001/.

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[482] Daniel Moore, "Seeing Growth, Duquesne Light Upgrades Transmission Lines," Pittsburgh Post-Gazette, February 21, 2017, https://www.post-gazette.com/powersource/companies/2017/02/21/seeing-growth-duquesne-light-upgrades-transmission-lines/stories/201702210003.
[483] Duquesne Light Co., "Brunot Island-Crescent Transmission Reliability Project," accessed May 4, 2026, https://duquesnelight.com/service-reliability/infrastructure-projects/brunot-island-crescent-transmission-reliability-project#undefined.
[484] Duquesne Light Co., "Cheswick-Plum Reconfiguration Project," 2024, https://duquesnelight.com/service-reliability/infrastructure-projects/cheswick-plum-reconfiguration-project.

Similarly, the upcoming Chanceford 500kV Project in York County by PPL involves upgrading transmission lines voltages and poles along an approximately 11 mile stretch of land.[485] The project is expected to cost $131 million. Reasons cited for this project not being underground include lower capacity of lines, greater earth disturbance, delayed repair times, and potential conflict with other underground utilities when crossing roads.[486] While this report shows that there are potential solutions to many of these obstacles, cost would be the greatest one. PPL stated that undergrounding this project could cost up to 10 times as much (a frequently cited industry estimate). Undergrounding would raise the total project cost to $1.3 billion. PPL notes that due to such factors that it only underground transmission lines where "there is no viable aboveground route."[487]

Overall, due to the size of the state and geographic features present, undergrounding transmission lines would appear to be a tremendous expense and, unlike distribution lines, would likely have a minimal impact on the state's reliability. Nonetheless, some environmental groups such as Scenic America and its Pennsylvania chapter have advocated for transmission lines to be placed underground primarily on the justification of restoring scenic views to natural areas.

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[485] PPL Electric Utilities, "Chanceford 500 KV Project," February 5, 2024, https://www.pplelectric.com/-/media/ppl-jss-app/assets/Home/Landing-Pages/Chanceford/Transmission---Chanceford-500-kV-Project-FAQs---12-21-2023.ashx
[486] PPL Electric Utilities, "Chanceford 500 KV Project," 2024.
[487] PPL Electric Utilities, "Chanceford 500 KV Project," 2024.

UNDERGROUNDING STRATEGIES AND JUSTIFICATIONS

Previous chapters of this report have established that undergrounding initiatives are expensive, however despite this cost, there are a growing number of instances throughout the country where EDCs have chosen to pursue the practice of undergrounding distribution lines, primarily to better system reliability.

Over the last decade, EDCs have worked to refine which lines are chosen and optimize their programs. Among IOUs surveyed there is a continuum from organizations beginning first steps or designing pilot projects to huge programs aggressively pursuing this policy. However, the companies adopting undergrounding do not view it as a short-term solution to reliability problems, but as a long-term strategy. A survey of IOUs who had adopted undergrounding noted the following conclusions:

1. Undergrounding has become a mainstream way to improve reliability of electricity systems.
2. Some utilities surveyed are undergrounding as much as possible while others are embracing a targeted approach. Both types are seeing improvements to system resiliency. [488]
3. Advancements in technology and methods have lowered undergrounding costs while improving the performance of underground cables… even in flood conditions. Service life of cables has been dramatically enhanced. Despite this it's still not cheap so utilities try and pick the lines to underground that will have the greatest benefit.[489]
4. Customers are a vital part of utility company underground strategies. Customers have strong support for underground programs, but undergrounding with them requires communication at multiple stages of the project's life.[490]

In some cases, utilities stated a desire to underground as much of their distribution lines system as they can … eventually. Others use modeling and data to determine on a line-by-line basis. Eversource Energy found that they were undergrounding due to the amount of trees in the northeast. They prioritize based on circuit performance, customers impacted, and where alternatives like vegetation management are most difficult.

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[488] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," Sept. 29, 2022, https://www.fortnightly.com/sites/default/files/whitepapers/PUF_Undergrounding_Report.pdf, 23.
[489] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 2022, 23.
[490] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 2022, 23.

When companies commit to regular undergrounding there can be need to change the skill set of their workforce because undergrounding uses different skills than overhead installation. Because of this, longer term objectives related to undergrounding allow companies to invest and commit resources, and this lowers undergrounding when compared to those who do it only occasionally.[491] More lines underground reduce costs across the system and there is a learning curve for companies conducting underground. At the start of underground initiatives, it is typical to outsource individual projects but those EDCs that commit to more will develop in house teams with their own equipment. This can be linked to career development of employees.[492] Utilities in states such as Georgia believe underground will remain a viable solution for improving reliability for decades to come, and among utilities that have pursued underground initiates there is an overall sense of optimism.

Total Undergrounding

Given the reliability benefits of undergrounding and the understanding that a system is only as strong as its weakest point, some analyses have attempted to examine scenarios where all wires are undergrounded. One of the most famous of these is a 2016 study of Texas which estimated that for a total undergrounding scenario involving the entire state the costs far exceeded the benefits; however, in specific areas the benefits exceeded these costs. Overall, the findings of this study were to consider the following factors which helped increase the viability of undergrounding power lines.[493]

1. Large number of customers per line mile such as more than 75 customers per transmission and distribution line mile.[494]
2. Expected vulnerability to frequent and intense storms.
3. Potential for economics of scale with underground line.
4. Overhead line utility easements are larger than underground transmission and distribution utility easements.

Building off Larsen's methodology, a recent study conducted by New York State was tasked with evaluating a broad mandate to underground electricity lines within the state. This report estimated a net loss of $261 billion in social welfare to bury all of New York's transmission and distribution lines.[495] The loss of benefits was noted in each of the states six investor-owned utility service areas, but the report found it would be most pronounced in less densely populated areas. The report noted a broad undergrounding mandate that would impact costumer bills varied

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[491] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 2022.
[492] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 2022, 20.
[493] Peter H. Larsen, and Lawrence Berkeley National Laboratory, "Estimating the Costs and Benefits of Undergrounding Power Lines," IEEE DRWG Meeting, July 19, 2016, https://cmte.ieee.org/pes-drwg/wp-content/uploads/sites/61/2016-09-03-LBNL-Estimating-the-Costs-and-Benefits-of-Undergrounding-Power-Lines-Peter-Larsen.pdf.
[494] Watts, "The Changing Economics of Utility Investment in Undergrounding," S&C Electric Co., 2023.
[495] Industrial Economics, "The Benefits, Costs, and Economic Impacts of Undergrounding New York's Electric Grid."

across the utilities greatly, with some experiencing only marginal increases while others would rise by over 50 percent. In the future, it projected that total undergrounding would cause the utility rate in one service area to triple.[496]

> From an economic perspective, undergrounding is likely to make more sense in the state's more densely populated areas, where the ratio of customers to line-miles – and thus benefits to costs – is generally higher. It is also likely to make more sense in areas that are susceptible to interruptions in service due to extreme weather events, particularly high-wind events such as hurricanes or tropical storms, to which overhead lines are especially vulnerable.[497]

Because the New York report examined a total undergrounding scenario, by necessity it relied on averages not specific areas where undergrounding costs could be even higher than those listed in the report, or resultingly lower where they could be of a benefit. Due to the similarities in geography and population between Pennsylvania and upstate New York, it is highly probable that any total undergrounding scenario in Pennsylvania would reach a similar conclusion about an overall loss of social benefit. For this reason, this report recommends practices related to strategic undergrounding of power lines that would be most beneficial, rather than a broad mandate to underground all wires.

Lifecycle Argument

Increasingly, some experts have argued that undergrounding power lines should take place when it offers the lowest cost "per life cycle" compared to either the status quo or other hardening measures and view undergrounding as one tool of many to meet resiliency and reliability targets.[498] Strategic undergrounding is the lowest long-term cost for these selected segments. While overall up-front cost may be two to three times the price, the industry claims that undergrounding is 10 to 15 times the cost of aerial wires.[499] Examination of the factors that lead to this study arguing that strategic undergrounding has the best cost performance was based on arguments that avoided costs (local GDP loss from outages), include annual tree trimming and outage truck rolls. Additionally, if claims of increased cable lifespan lasting a 100 years as well as three to seven times less maintenance costs are born out, it would be a large departure from the historical performance of underground wires cited by utilities.

By some analyses, older undergrounding reports present a false comparison: create a new overhead distribution line compared to constructing a new underground. In reality, most new power line construction in housing developments are underground. So the default scenario involves taking existing power lines and determining whether or not to move them underground

[496] Industrial Economics, "The Benefits, Costs, and Economic Impacts of Undergrounding New York's Electric Grid."
[497] Industrial Economics, "The Benefits, Costs, and Economic Impacts of Undergrounding New York's Electric Grid."
[498] Power Delivery Intelligence Initiative, "Utility Undergrounding Life-Cycle Cost Guide," Feb. 9, 2024, https://pdi2.org/resources/research, 4.
[499]Power Delivery Intelligence Initiative, "Utility Undergrounding Life-Cycle Cost Guide," Feb. 9, 2024, https://pdi2.org/resources/research, 4.

or deal with the associated costs with overhead lines as they are. As the costs to maintain overhead lines include outages, pole inspections, weather related repair increases and technology that makes undergrounding cheaper, the latter may start being economical in some cases.[500]

In some places the cost of undergrounding projects decreased over the last decade, which means that undergrounding a line may be comparable to the cost of hardening it. When the economics of hardening versus undergrounding are close, undergrounding is often the preferred solution to protect the lines. "The economics of undergrounding should be considered based on the net benefits or costs that will result for the utilities, end-customers and residents, and society more broadly."[501] The avoided cost on average was $95,472 per mile saved by undergrounding.[502]

There are generally two ways for energy companies to approach strategic undergrounding in the United States; either on a regional scale or addressing the poorest performing feeders. In some places regional action allows for work crews, permits, and other project elements to achieve an economy of scale. Others go after the lines that go down the most frequently to improve grid performance. For example, Pacific Gas & Electric (PG&E) in California states that it will underground 10 percent of its grid, in an effort to project its most vulnerable lines from wild fires.

With line rebuilds in rural areas some utilities perform a cost benefit analysis to determine whether its economical. When this is the case, leadership at EDCs is increasingly asking such companies to perform undergrounding. When large numbers of assets are at the end of their useful life it is a chance to assess the practicality of moving underground. One of the barriers to undergrounding is regulatory policies that require replacements to be in kind with original design standards.[503] Such policies reinforce existing inertia for EDCs to stick with the status quo, as replacing aerial wires is often the easiest option for power companies. Instead, this could be an opportunity to underground, in places where it's economically feasible. For example, Alliant Energy undergrounded a quarter of their system, spread between Iowa and Wisconsin. This company commences lines when life of overhead line has ended and they plan to underground one to two percent of their service area per year.[504]

Funding Justifications

Some policymakers and regulators fund underground programs through general rate cases. Other states have created separate ways of funding based on a cost-benefit analysis.[505] At the state level there are two typical approaches: regulatory action or legislated undergrounding.

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500 PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," Sep. 29, 2022, https://www.fortnightly.com/sites/default/files/whitepapers/PUF_Undergrounding_Report.pdf; and, Watts "the Changing Economics of Utility Investment in Undergrounding" S&C May 22, 2023.

501 Watts, "The Changing Economics of Utility Investment in Undergrounding," S&C Electric Co., 8.

502 Ephram Glass, and Victor Glass, "Underground Power Lines Can Be the Least Cost Option When Study Biases Are Corrected," The Electricity Journal 32, no. 2 (March 2019): 7–12, https://doi.org/10.1016/j.tej.2019.01.015, 9.

503 Power Delivery Intelligence Initiative, "Utility Undergrounding Life-Cycle Cost Guide," 13.

504 PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 2022.

505 Watts, "The Changing Economics of Utility Investment in Undergrounding," S&C Electric Co., 8.

Regulators can pay for undergrounding either through regular rate cases or by attaching riders to electric bills. Programs designed to last multiple decades can spread out the costs to customers. This concept has previously been applied to modernize electric distribution networks.[506] However, in some states undergrounding initiatives have met resistance from electric regulators simply due to conflicting objectives of keeping consumer costs low, against reliability improvements. Such regulators often recommend that less extreme actions like improving vegetation management be tried first.

Laws promoting underground power lines were passed in Florida, Indiana, and Virginia, when state regulators failed to address reliability issues to the satisfaction of state legislators.[507] In these instances these laws have mandated government and stakeholder supported funding. Governments can quantify these decisions through adopting lowest life-cycle cost, or by considering best ways to achieve resiliency and reliability targets.

Reduction of Outages

To encourage underground there must be benchmarks for underground programs which allow regulators to evaluate its effectiveness to ensure the undergrounding is having the intended benefits. For example, since 2006, Florida utilities must submit detailed storm-hardening plans on a three year cycle. As of 2019, the plans must include the cost and benefits to the utility and its customers as part of this storm protection plan.[508] Examples of metrics tracked include reduction in restoration standards post storms, reducing economic impact of outages, or focusing on improving system reliability metrics.

The central question is whether the high upfront cost of undergrounding will offset long-term costs associated with improved reliability and resilience to storms. Florida Power & Light began a $4 billion undergrounding initiative, known as the Storm Secure Underground Program (SSUP), which focuses on targeting specific lateral feeder lines that will have the most reliability benefit.[509] The cost of this program was justified based on costs of hurricane related repairs on a three- to five-year basis. The company has also noted avoided operational and maintenance expenses help to justify the program costs. Some municipal communities in Florida have opted to underground additional lines through raising money to pay for more extensive underground which includes both main feeder lines and laterals. Tampa Electric also conducts undergrounding.[510]

How storms affect Gross Domestic Product (GDP) is one way to evaluate the economic consequences for having system outages. For example, after Hurricane Irma outages were estimated $1 billion per day.[511] Where strategic undergrounding does not prevent outages, they

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[506] Power Delivery Intelligence Initiative, "Utility Undergrounding Life-Cycle Cost Guide." P13
[507] Power Delivery Intelligence Initiative, "Utility Undergrounding Life-Cycle Cost Guide."
[508] Leibowicz, Benjamin D., A. H. Sanstad, Q. Zhu, P. H. Larsen, and J. H. Eto. "Electric Utility Valuations of Investments to Reduce the Risks of Long-Duration, Widespread Power Interruptions, Part II: Case Studies." *Sustainable and Resilient Infrastructure* 8, no. sup1 (November 17, 2022): 203–22. https://doi.org/10.1080/23789689.2022.2138163.
[509] Watts, "The Changing Economics of Utility Investment in Undergrounding," S&C Electric Co., 10.
[510] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 2022.
[511] Power Delivery Intelligence Initiative, "Utility Undergrounding Life-Cycle Cost Guide," 17.

may decrease the total amount of time a system is down and being repaired, which lessens the total impact of the storm on economies.

As noted in the Case Study Chapter, Dominion Energy justified its underground program as shorting restoration times through targeting its most outage-prone laterals power lines. This had an impact on GDP per customer outage hour of $35,400. By shortening outages through undergrounding Dominion realized they saved $1.76 in GDP per $1 spent undergrounding. Current results show a 50 percent decrease in restoration times in areas with undergrounding. Similarly, Florida's overhead laterals enter property from the back which is hard to access. By undergrounding they can move facilities to the front, making repairs faster.[512]

Today sophisticated computer systems can use modeling based on type of vegetation, type of poles, and one or three phase wires, which can all influence reliability models. With this historic data, utilities can model the places where it is most advantageous to bury power lines. The age of infrastructure has frequently been regarded as a weakness, but where records have been kept well, there can be up to a hundred years of historical data on system performance in storms.

Public Acceptance of Undergrounding

Other than impacts on reliability, customers enjoy not having wires in their sightline and undergrounding can be used to improve community relations.[513] Aesthetics considerations can also be important to form alliances with the local community. These can also impact the schedule of the project, since homeowners would rather these be completed quickly if their property is going to be disturbed. It was noted that consistent power supply has the potential to enhance customer experience. In the age of social media this has become important, and goodwill may be the difference between an undergrounding project going forward or not. This has led companies to create positions for public relations. There are three ways which customers impact undergrounding projects.[514]

1. They hold utility companies responsible for fallen lines.
2. Their support is needed for undergrounding because undergrounding is so costly that it shouldn't be done if people in an area don't want it. Projects rely on their cooperation.
3. Public buy-in is necessary for undergrounding to be efficiently conducted and to be done to the fullest extent possible. Customers need to believe that undergrounding leads to an overall healthier system even if their specific lines are not being buried.

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512 PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 2022, 13.
513 Kenneth Hall, "Out of Sight, out of Mind 2012," (Edison Electric Institute, January 2013), Archived at https://web.archive.org/web/20220419204811/https://www.eei.org/-/media/Project/EEI/Documents/Issues-and-Policy/Reliability-and-Emergency-Response/UndergroundReport.pdf?la=en&hash=7E2DB1E527AA94410D64121EE340AF3D8BD07694
514 PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 2022, 14.

Utilities approach customer interactions differently. This seems partially on how well the public understands the benefits of undergrounding and what the disruptions entail. Those with prolonged outages are more likely to embrace undergrounding. Florida Power & Light tries to work with municipalities and cities to place underground wires within public right of ways. Again, use of digital visualizations can show people what locating a transformer or switching equipment will look like. Georgia Power has noted that since underground projects comes with disruption and challenges, local partners are necessary. For example, local partners process some of the work and traffic control. Additionally local partners may have insights that can help EDCs determine where undergrounding power lines will address root causes of outages and minimize the total costs.

WEC Energy Group surveyed customers and found 47 percent were willing to pay more for electric bills to underground, up to an additional $4.30 a month. Splitting the costs of undergrounding across EDC service areas is more popular if customers understand how it can make the whole grid healthier. When a major storm hits, repair crews can be spread across large service areas, as areas that are undergrounded do better in storms and repair crews can then focus on restoring service to smaller areas.[515]

Undergrounding can be a delicate balancing act, requiring strategic thought. For example, staggering projects which lead to intermittent improvements in system reliability can increase confidence in the program and show customers it's working. Also, it is important to manage expectations over the benefits results and timelines of undergrounding. For example, some lines will still go down in storms. These companies take the approach of doing one neighborhood makes the system better for the whole service area (lowering the number of places which need to be repaired after the storm).

Socioeconomic Inequities

It has been documented that areas with higher average incomes were more likely to be underground. Urban areas also had more undergrounding despite the number of obstacles which would be present to burying power lines in these places (conflicts with other infrastructure). Urban locations "may have a higher intention to implement underground distribution systems, potentially owing to land use restrictions, higher population densities, or the need to avoid overhead obstructions."[516] Finally, the study found that areas with higher residential electricity rates did not correspond to more underground infrastructure.

However, there is a risk of reliability programs rolling out unevenly across society. that wealthier neighborhoods are more likely to be undergrounded leaving historically marginalized, or poorer communities behind. It has been argued that strategic underground which focuses primarily on lowest preforming circuits may be more equitable. When only power outages are considered, it is more likely to result in the those that need improvements to their infrastructure the most will have improved reliable service.

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[515] PUF Energy Research, "The Role of Undergrounding in Electricity System Resilience," 2022, 14.
[516] Tao Sun et al., "Mapping the Depths,"

CONCLUSION

While the challenges posed to each state from increasingly inclement weather varies, many states are in a similar position to Pennsylvania where they are looking for reliability solutions as electricity becomes an ever more important part of American life. Increasingly, large utilities across the country are exploring undergrounding power lines as a method to improve system effectiveness against storms and high winds on the east coast, ice storms in the north, and wildfires in the west. In some instances, underground lines perform 90 percent better than those above ground in storm conditions.[517]

In the context of the Commonwealth's electrical grid, the increasing frequency of severe weather events matters insofar as those events cause outages and result in negative public health outcomes. Furthermore, as previous studies demonstrate, the unequal distribution of resources and infrastructure compounds the negative effects borne by the affected population. Given this, it may be helpful to include non-financial factors in the cost assessment of undergrounding power lines. In general, storms and wind add to the argument for undergrounding, as they affect overhead lines. Floods detract from the argument for undergrounding, as they impact undergrounded lines. Finally, public health impacts of outages provide a further context to the argument for undergrounding, as they are likely to be distributed unevenly due to existing socioeconomic disparities.

JSGC staff undertook a review of existing efforts within the state to harden the electrical infrastructure. While EDCs are replacing poles, strengthening wires, and replacing existing underground cables with newer models, efforts to convert overhead systems underground to improve reliability appear nonexistent. Due to the expected cost of undergrounding power lines, Pennsylvania's reliability system performance should continue to be evaluated. Stronger incentives and penalties for system performance during storms that are typically excluded as 'major event days,' which may encourage the adoption of lowest cost per lifecycle infrastructure investments.

In some areas, undergrounding is likely impractical due to low density of subscribers. In others, geographic conditions may make it disadvantageous. Geography frequently determines the methods of undergrounding. Areas in flood plains may need additional protection compared to those without. Based on a review of other states there are possible approaches to take with undergrounding distribution wires. Undergrounding main feeder lines can improve reliability in areas where other methods such as vegetation management are failing to improve reliability. Which power lines are chosen could potentially be based on worst performing circuits, preferably ones in close geographic proximity to each other. Urban areas have the highest subscribers per mile but face additional complications navigating around other underground infrastructure.

[517] Consumers Energy, "Consumers Energy Proposes New Program to Explore Burying Power Lines," Consumersenergy.com, 2023, https://www.consumersenergy.com/news-releases/news-release-details/2023/07/05/12/59/consumers-energy-proposes-new-program-to-explore-burying-power-lines.

Suburban areas with overhead power line service that routinely experience reliability issues due to vegetation interference may be the most suitable undergrounding candidates based on Dominion's experiences in Virginia. Areas within close proximity geographically may be able to reduce the costs of and difficulty of undergrounding by bundling the work, and undertaking community education initiatives. The benefits of improving a single community should not be underestimated, as when done strategically over time, it can strengthen entire systems. When a storm hits recovery efforts can be concentrated elsewhere and power restored faster. Undergrounding pilot programs in areas comparing performance in storms should be conducted. This cost and performance improvement should be compared against those of hardening initiatives to see how they are impacted during storms.

Reliability Findings

- PUC effectively tracks reliability of EDCs within the state and has indicated that eight out of 11 EDCs in Pennsylvania failed to meet PUC reliability benchmarks in both annual and three-year averages.[518]

- When data from major storms are excluded, Pennsylvania's electricity reliability SAIDI experience (131 minutes of outages) was in line with both regional (115 minutes) and national averages (126 minutes).[519]

- With storms included, Pennsylvania average minutes of downtime was 55 percent lower than national averages, but six percent higher than the region.[520]

- Current economic models suggest that outages in Pennsylvania residential customers lost average of $100 million a year (an average of $19 per residential customer). Interruptions can be much more costly to industries who lost an average of $6.4 billion over the last three years. [521]

- The average number of minutes Pennsylvanians face from power outages increases by 16 minutes each year. The so-called resiliency gap between regular system performance and that during storms continues to widen over time. In Pennsylvania this gap is six times higher than it was 11 years ago.[522]

- According to PUC, trees and branches from off right of way are a leading cause of outages for over a decade and are not easily addressed through traditional storm prevention methods.[523]

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[518] Diskin, *Pennsylvania Electric Reliability Report 2024*
[519] JSGC Staff Analysis of "Annual Electric Power Industry Report, Form EIA-861 detailed data files," Years 2013-2024, data provided by US, EIA, https://www.eia.gov/electricity/data/eia861/. Accessed June 5, 2026.
[520] JSGC Staff Analysis of "Annual Electric Power Industry Report, Form EIA-861 detailed data files," Years 2013-2024, data provided by US, EIA, https://www.eia.gov/electricity/data/eia861/. Accessed June 5, 2026.
[521] Staff use of ICE calculator
[522] JSGC Staff Analysis of "Annual Electric Power Industry Report, Form EIA-861 detailed data files," Years 2013-2024, data provided by US, EIA, https://www.eia.gov/electricity/data/eia861/. Accessed June 5, 2026.
[523] Diskin, *Pennsylvania Electric Reliability Report 2024*

Underground Effectiveness Findings

- Increasingly, electric utilities across the country facing severe weather disruptions such as hurricanes, ice storms and wildfires are embracing undergrounding as an infrastructure hardening strategy to improve reliability.

- One multi-study analysis suggested that underground powerlines were 94 percent less likely to fail during a storm and resulted in a 74 percent reduction of outages overall.[524]

- While resistant to weather-related outages, underground wires are not invulnerable, they can be disrupted by accidental digging, lightning, and floods. Additionally, all underground systems eventually connect to the above ground systems where they may be vulnerable.

- Floods may be an obstacle to undergrounding in Pennsylvania and must be accounted for using waterproof materials and submersible equipment.

- It can take longer to detect faults in underground power lines and repair them. Underground lines took on average 52 percent longer to repair.[525] New sensors may help alleviate this issue.

- While individual repairs may be expensive, existing studies show underground power lines have between a three to seven times reduction in maintenance costs, and increased safety due to fewer repair crew dispatches (truck rolls).[526]

- Strategic undergrounding programs can reduce total length of restoration of service following a storm by 40-50 percent.[527]

[524] Escoriza, M., & Robba, R. (2019). Clear Skies Ahead: The Case for Undergrounding Utility Infrastructure. In Scenic America. https://www.scenic.org/wp-content/uploads/2024/02/ClearSkiesAhead82580.pdf, 8.
[525] Escoriza, M., & Robba, R. (2019). Clear Skies Ahead: The Case for Undergrounding Utility Infrastructure. In Scenic America. https://www.scenic.org/wp-content/uploads/2024/02/ClearSkiesAhead82580.pdf, 8.
[526] Power Delivery Intelligence Initiative. "Utility Undergrounding Life-Cycle Cost Guide." 5
[527]Power Delivery Intelligence Initiative. "Utility Undergrounding Life-Cycle Cost Guide."

Underground Siting Findings

- The cost to underground is highly specific to the proposed site and project scope. Trees, rocky terrain, higher voltages, and the presence of underground obstacles or other buried infrastructure can drive up the cost of undergrounding.[528]

- It is estimated that strategic underground programs cost two to three times the upfront cost of an overhead replacement, not the 10-15 figures quoted by industry.[529] To minimize the higher cost undergrounding should be performed either in batches at lowest cost or when existing equipment nears the end of its expected life space. A five-year undergrounding program can take between 10-20 years to see a return on investment.[530]

- Areas with low subscriber density may be poorly suited to undergrounding unless the cost of vegetation management and repairs exceeds that of undergrounding.

Transmission Findings

- Undergrounding high-voltage transmission lines is more expensive and offers fewer benefits than distribution power lines.

- Transmission lines cross many natural barriers in Pennsylvania such as mountains, forests and rivers and undergrounding projects are likely to be disruptive and expensive in such areas.

- Underground transmission lines may increase scenic appeal in tourism areas, create more aerial space in dense urban areas, and avoid loss of property values within sight of the towers.

- Transmission lines are subject to federal regulation. Requirements for greater cutbacks and taller towers have face fewer disruption from falling vegetation during storms. Undergrounding these wires will not have the same reliability benefits.

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[528] Berkeley Lab. "Undergrounding Transmission and Distribution Lines Resilience Investment Guide." US Grid Deployment Office, September 2024. https://www.energy.gov/sites/default/files/2024-11/111524_Undergrounding_Transmission_and_Distribution_Lines.pdf.
[529] Power Delivery Intelligence Initiative. "Utility Undergrounding Life-Cycle Cost Guide." 15
[530] Power Delivery Intelligence Initiative. "Utility Undergrounding Life-Cycle Cost Guide." 16

Existing Underground Power Lines in Pennsylvania Findings

- The last 30 years have seen little progress overall in the percentage of power lines undergrounded within Pennsylvania.[531]

- Urban service areas of PECO and DLC service areas had the highest proportion of underground power lines, small EDCs rural areas had the fewest.[532]

    - Tioga County had the lowest percentage of power lines underground at five percent and Philadelphia and Delaware were tied for the highest at 40 percent.[533]

- As of 2020, 47 counties had between 10 to 20 percent of their power lines underground.[534]

- Expanding undergrounding in the southeast, where undergrounding is already most prevalent, would see the greatest benefits to reliability. One analysis suggests that Bucks, Chester, York, and Montgomery Counties could have reduced the longest power outage in 2018 by over 3.5 hours with an additional 25 percent of their system undergrounded.[535] These projects would need to occur within PECO, PPL, Met-Ed service areas.

Current Undergrounding Policy in Pennsylvania Findings

- EDCs within the Commonwealth are not pursuing overhead to underground power line conversion currently, likely due to high cost and lack of incentives.

- State law results in new housing developments having underground powerlines, however significant number of suburban areas were built prior to this law.

- EDCs are replacing already existing underground wires through Distribution System Improvement Charge.

- In conflicts between local governments and EDCs, the PUC is the arbiter. According to state precedent local governments cannot force an EDC to underground its power lines.

- Existing programs from the PUC are in place to protect underground infrastructure.

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531 Doerr School of Sustainability and Stanford University, "Undergrounding Power, Extreme Weather, and Grid Resilience," Stanford.edu, 2026, https://underground.datacommons.stanford.edu/.

532 Staff Analysis of Pennsylvania Electric Distribution Annual Reports for years 2019 and 2024 submitted by PECO, PPL, UGI, and DLC and FirstEnergy Companies. Original Reports available at PUC.

533 Doerr School of Sustainability and Stanford University, "Undergrounding Power, Extreme Weather, and Grid Resilience," Stanford.edu, 2026, https://underground.datacommons.stanford.edu/.

534 Doerr School of Sustainability and Stanford University, "Undergrounding Power, Extreme Weather, and Grid Resilience," Stanford.edu, 2026, https://underground.datacommons.stanford.edu/.

535 Doerr School of Sustainability and Stanford University, "Undergrounding Power, Extreme Weather, and Grid Resilience," Stanford.edu, 2026, https://underground.datacommons.stanford.edu/.

Recommendations

1. PUC should include EDC reliability statistics both with and without Major Event Days in its annual reliability reports to increase awareness of the detrimental effects of poor system reliability during storms.

2. PUC should encourage EDCs to have greater transparency regarding vegetation management costs, as undergrounding cannot be justified without understanding the cost and effectiveness of current vegetation management strategies.

3. PUC should create a framework and guidance for how undergrounding projects could become eligible through Distribution System Improvement Charges.

4. The legislature is advised against the creation of a broad undergrounding mandate that includes all power lines. Previous studies have found such initiatives to be impractical solutions to electrical reliability concerns given the cost. A possible alternative would be a system wherein aerial power lines nearing end-of-service life are replaced with underground lines if they are determined to have the lowest lifecycle cost.

5. To improve electrical reliability within the state, the Legislature could create a targeted underground pilot program modeled after Dominion Energy's that specializes in burying suburban power lines. Evaluated metrics for such a program should utilize data on shortening total outage times, and averted costs.

   Specifics relating to proposed pilot program:

   Funding of Grants – Grants will be provided through the Energy Programs Office within the Pennsylvania Department of Environmental Protection through a fixed appropriation. There should be a maximum limit on the amount per mile and require some percentage of matching funding from the electric distribution provider grantee.

   Eligibility – Proposed pilot areas should be those most prone to climate-related outages as well as represent multiple regions of the state and varied socio-economic demographics. Undergrounding should be limited to lateral lines, i.e., the lines that run along streets and on private property to reach homes and businesses. These lines have been found to be less expensive to convert and would allow limited funds to be stretched further to include more miles of line. Given the overall likely expense of the project, grants should be limited to two or three grantees overall.

Proposal Requirements –

- Public communication of plans to the public through multiple forms of media, with realistic estimates of beginning and end times for the project.
- Provide affected customers with options as to location of pad mount transformers.
- Require property restoration to the same condition is was in originally.
- Identification of areas where easements are needed and eminent domain may be used.
- Requiring a preference for horizontal directional drilling (HDD) and justifications for when trenching (which is more ecologically and visually intrusive, but less expensive) is to be used instead.
- Ensure compliance with the Pennsylvania One Call System.
- Provide a mechanism by which telecommunication and cable companies can participate in the undergrounding process, including cost-sharing and activity coordination.

Annual Report – Grantees to provide PUC information to be compiled into an annual report identifying number of residential and commercial customers included, as well as geographic, topographic, and demographic data on those customers, categories of expenditures, total expenditures per mile, and a breakdown of expenditures on the project.

PRINTER'S NO. 1866

THE GENERAL ASSEMBLY OF PENNSYLVANIA

HOUSE RESOLUTION

No. 254 Session of 2025

INTRODUCED BY STEELE, POWELL, SALISBURY, KHAN, PROBST, WEBSTER, SANCHEZ, MAYES, HADDOCK, HILL-EVANS, FRANKEL, RIVERA, BRENNAN, CEPEDA-FREYTIZ AND NEILSON, JUNE 6, 2025

REFERRED TO COMMITTEE ON CONSUMER PROTECTION, TECHNOLOGY AND UTILITIES, JUNE 9, 2025

A RESOLUTION

Directing the Joint State Government Commission to study the issue of underground electrical lines.

WHEREAS, Extreme weather events have been occurring more frequently in Pennsylvania; and

WHEREAS, These effects have had an increased negative financial impact to homeowners and utility customers across the State; and

WHEREAS, Pennsylvania has had multiple years with combined disaster costs of up to $5 billion, which had never occurred prior to the year 2000; and

WHEREAS, Since 2015, trees and vegetation have consistently been the leading cause of outages and lost customer minutes in Pennsylvania; and

WHEREAS, These storms routinely bring down trees and overhanging limbs from canopy trees, which is the primary threat to Pennsylvania's electric reliability; and

WHEREAS, Pennsylvania ranks fifth in the nation for weather-related outages, with over 82 outages from 2000 to 2022; and

WHEREAS, These storms may cause some residents to face power outages that last for more than a week; and

WHEREAS, Much of the United States electric grid was built in the 1960s and 1970s and our aging infrastructure is struggling to meet our modern electricity needs; and

WHEREAS, One way to prevent extreme weather from affecting our power grid is to explore the option of underground electrical lines; and

WHEREAS, Installing underground electrical lines costs more initially than overhead lines, but the underground lines are less prone to damage and disruptions; therefore be it

RESOLVED, That the House of Representatives directs the Joint State Government Commission to conduct a study and issue a report studying the efficacy of undertaking a Statewide project of placing electrical and other utility lines underground; and be it further

RESOLVED, That the study shall include the following: cost, viability, geographic and topographic limitations, right-of-way issues and land usage issues associated with underground electrical lines; and be it further

RESOLVED, That the Joint State Government Commission shall consult with the Pennsylvania Public Utility Commission when conducting their study; and be it further

RESOLVED, That the Joint State Government Commission submit the report to the Speaker of the House of Representatives and to members of the House Consumer Protection, Technology and Utilities Committee within one year after the adoption of this resolution.