THE CHANGING ECONOMICS OF UTILITY INVESTMENT IN UNDERGROUNDING

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INTRODUCTION

A key trend in U.S. investor-owned utility investments in reliability and resilience is targeted or larger-scale undergrounding that includes a mix of work on main feeder lines and laterals. There are also similar developments internationally in countries such as Australia, Finland, and Sweden. The key drivers are addressing reliability and resilience issues and improving aesthetics (visual amenity).

While it's typical for new feeder lines and laterals in urban areas to be installed underground, converting existing overhead main feeder lines and laterals to be underground has traditionally been viewed as a high-cost option for improving reliability and resilience relative to the benefits created. However, the economics are changing, and undergrounding is becoming much more common.

Climate change is increasing the frequency and severity of major events, such as severe storms, hurricanes, ice storms, and wildfires, meaning there are greater benefits from undergrounding. At the same, time the electrification of transport and the electrification of space heating underway as part of the energy transition means the importance of reliable and resilient electricity distribution grids is growing.

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).

Innovation in technologies for underground and hybrid networks means the reliability performance of underground networks can be improved further, addressing historical challenges that previously had no reasonable solution. For example, 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.

Some policymakers and regulators are taking action to allow for additional funding for resilience measures, either through general rate cases or separate funding mechanisms, based on benefit-cost analysis and other forms of justification. However, to enable more widespread improvements in performance through undergrounding, others importantly must undertake similar initiatives.

This paper considers the drivers for the increase in undergrounding and potential challenges; the changing economics of undergrounding, including the role of innovative technical solutions that can further improve the performance of underground networks; key examples of undergrounding programs; and policy or regulatory levers that can help such developments.

KEY DRIVERS OF UNDERGROUNDING

Several key factors support the trend toward increased undergrounding.

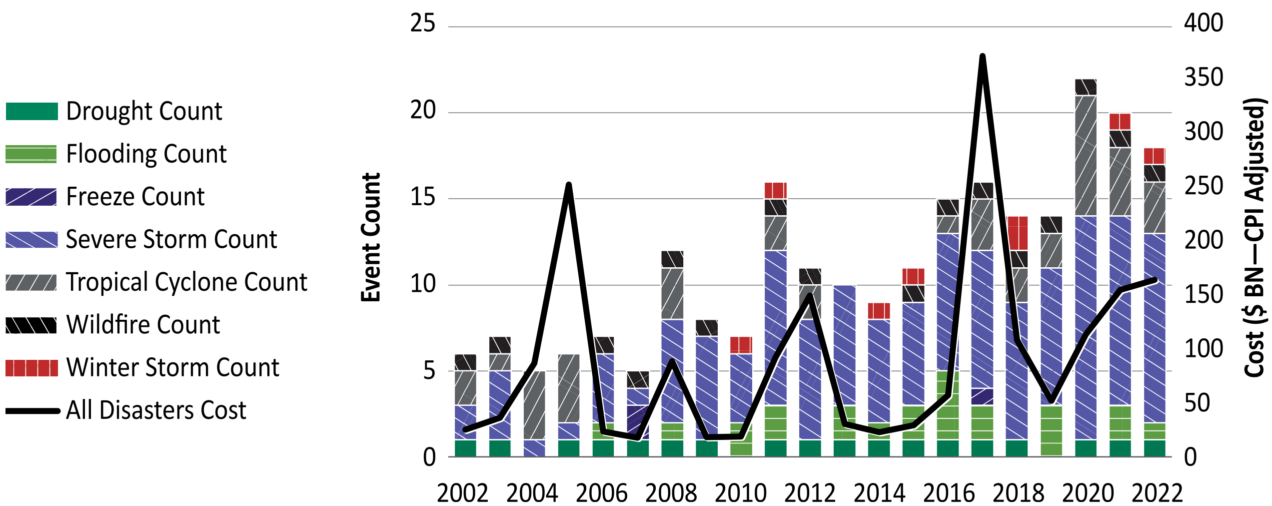
1. Increasing frequency and severity of major events

The most important driver is the increasing frequency and severity of major events associated with climate change, which can lead to widespread, prolonged electricity outages and have a profound effect on customers and the local economy. Florida Power and Light (FPL) has estimated one day of improved storm recovery in its service territory is worth up to $2 billion in avoided damage to economic output.[1]

Frequent and severe weather events include severe winds and hurricanes, but they also include a greater risk of extremely high temperatures and wildfires and greater risk of extreme cold weather, such as ice and snow events.

Consider the National Oceanic and Atmospheric Administration (NOAA) data on severe weather events that cost more than $1 billion for the U.S. economy. See **Figure 1**. Over the past two decades, there has been a significant rise in the frequency and severity of events, thereby increasing the cost impact. The number of events has tripled between 2002 and 2022. Similar trends are also being experienced in other countries, including Canada, the United Kingdom, Australia, and New Zealand.

FIGURE 1. Severe Weather Events Costing More Than US$1 billion



Source: *NOAA National Centers for Environmental Information (NCEI), "Billion-Dollar Weather and Climate Disasters (2022)."*[1]

1 https://www.ncei.noaa.gov/access/billions/

1 https://seekingalpha.com/article/4552241-nextera-energy-and-nextera-energy-partners-winning-together

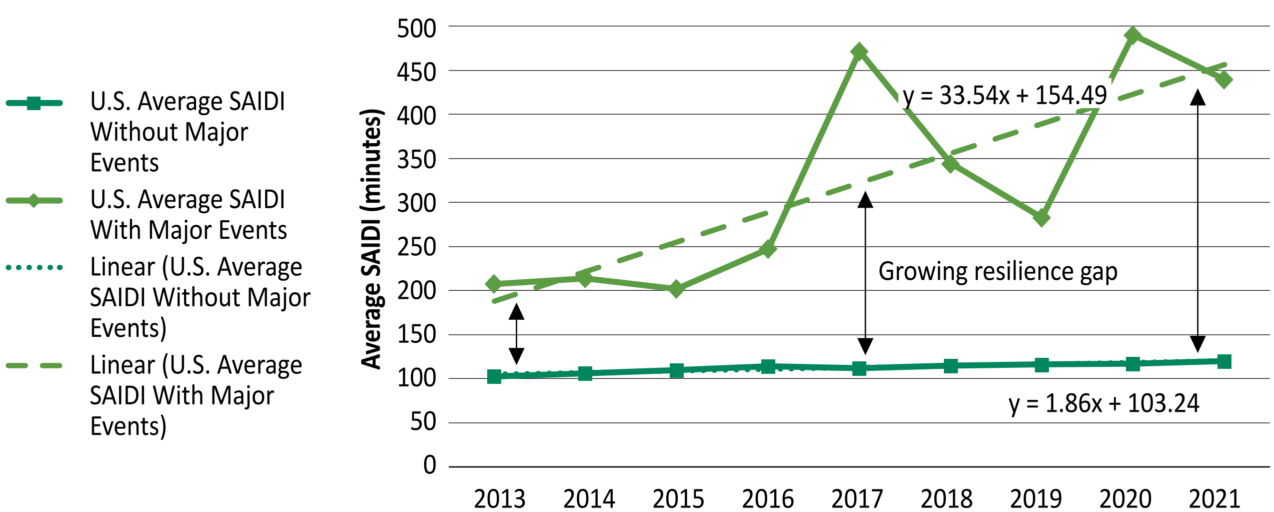
A number of utilities have named a major event period as a driver for establishing an undergrounding program, such as Dominion Energy, which experienced major storms in 2010-11 with prolonged restoration periods, and FPL following Hurricane Irma in 2017.

As we highlighted in our paper, "Trends in Reliability and Resilience–The Growing Resilience Gap,"[2] and illustrated in **Figure 2**, we see a growing gap between the U.S. SAIDI performance when both including and excluding major event days. This U.S. resilience gap is increasing by more than 30 minutes per year, and this must be addressed through a range of options to improve performance.[3] This trend is not unique to the U.S. and can be seen in several other countries, including Canada and Ireland.

When considering planned reliability and resilience investment, utilities must consider not only present weather patterns, but also the likely much greater frequency and severity of weather events in 2030, 2040, and 2050.

Undergrounding main feeder lines and laterals increases the robustness of the distribution grid to most weather events, such as high winds and storms, lightning, snow and ice, and wildfires. It also reduces the risk of tree contact. However, undergrounding does not eliminate resilience risks completely. For example, underground networks may be vulnerable to events such as flooding and some lightning impacts. Leibowicz (2023) notes that Hurricane Sandy in October 2012 caused large storm surges in and around New York City. Nearly 20% of the city's land area was flooded, shutting down numerous substations and networks, and 2 million customers lost power.[4]

FIGURE 2. U.S. SAIDI With and Without Major Event Days



Source: *Annual Electricity Power Industry Report, EIA Form 861 data.*[1]

1 https://www.eia.gov/electricity/data/eia861/

2 https://www.sandc.com/globalassets/sac-electric/documents/public---documents/sales-manual-library---external-view/technical-paper-100-t135.pdf?dt=637961663037312086

3 The equations for the trend lines show the estimated intercept and slope of the trend lines. The estimated slopes show the rates at which average SAIDI excluding and including major events are increasing per year.

4 https://www.tandfonline.com/doi/full/10.1080/23789689.2022.2138163

2. Growing importance of reliability and resilience

The need for reliable and resilient electricity distribution grids is also increasing as electricity users become more reliant on electricity for digital services, transportation, and heat. Customers increasingly expect to never be interrupted. This was highlighted during the COVID-19 pandemic as people sheltering and working from home began placing a higher value on the reliability and resilience of electricity supplies. The electrification of transport and heat also reinforces this trend because distribution system reliability and resilience will now be important for the transportation sector and a greater proportion of heating requirements. This means the economic benefits of undergrounding are increasing.

Larsen (2016) highlights a strong statistical correlation between the share of underground lines on transmission and distribution grids and reliability and resilience.[5] Larsen notes an increase of 10% in the share of the transmission and distribution miles that are underground corresponds with a 14% reduction in SAIDI including major events.

3. Resilience strategies

Historically, major events affecting the distribution grid tended to be relatively infrequent, allowing for a reactive approach to managing them. However, resilience challenges are becoming increasingly common, and utilities are having to develop proactive resilience strategies that consider a range of options for increasing resilience, such as grid hardening, distribution automation and reclosing, and undergrounding. These plans are typically supported by a qualitative assessment of options or benefit-cost analysis.

Leibowicz et al. (2023) notes that “since 2006, FPL and the other Florida utilities have been required to develop and submit detailed storm-hardening plans for the (Florida Public Service Commission [FPSC]) review on a 3-year cycle.” Since 2019, the Florida utilities have been required to consider “the estimated costs and benefits to the utility and its customers of making the improvements proposed in the (storm protection) plan”.[6]

Similarly, as part of the British energy regulator Ofgem’s performance-based regulations—the RIIO framework—utilities are required to develop climate-resilience strategies, including carrying out a risk assessment of key climate threats for their grids and a benefit-cost assessment of options to address them. Selected options have then been included as part of their investment plans.

4. Increasing environmental concerns and aesthetic benefits

Another important driver of greater levels of undergrounding is environmental concerns, particularly related to aesthetic or visual amenity benefits. EEI (2013) notes customers prefer underground construction, and one of the major benefits is to help create positive community relations by mitigating visual

5 https://eta-publications.lbl.gov/sites/default/files/lbnl-1006394_pre-publication.pdf

6 https://www.tandfonline.com/doi/full/10.1080/23789689.2022.2138163

impact.[7] For example, San Diego is focused on enhancing aesthetics and improving reliability in local neighborhoods.[8] San Diego Gas and Electric was tasked with avoiding or removing high concentrations of overhead conductors and devices along streets, roads, and rights of way, particularly where they are close to civic, public-recreation, or scenic areas. The program, funded through a surcharge on bills approved by the California Public Utilities Commission, will eventually convert all of the city's residential overhead lines to underground.

Ofgem has a visual amenity scheme as part of its latest rate cases for 2023-2028. It allows for the undergrounding of existing overhead distribution lines in "areas of outstanding natural beauty and national parks." This is the continuation of a scheme in place since 2010 that has been refined over time. There is a £68 million expenditure cap over five years based on customer willingness to pay for these improvements.

POTENTIAL CHALLENGES OF UNDERGROUNDING

Several important challenges of undergrounding require consideration.

1. Costs of undergrounding

Historical cost differentials between underground and overhead distribution networks have varied from a factor of 2 times to 10 times the cost for electricity distribution. EEI (2013) notes the conversion costs often do not differ much from the cost of new underground distribution construction. However, the salvage value of the overhead system that would be removed during a conversion can offset some of the costs.[9] Such cost differences are a key consideration for utilities and regulators at a time when there is pressure on customer bills. However, there is an important efficiency debate in terms of higher upfront costs from undergrounding being offset by avoided longer-term costs associated with improved reliability and resilience to major storms.

2. Outage restoration

Because visual inspections are typically not possible, it may be more difficult to locate and repair faults. This means it can take longer to repair faults and restore customers' electrical service. Repairs may require specialized equipment and crews, which can take longer to mobilize.

Underground circuit failures increase with operating temperatures, and during prolonged periods of high temperatures underground circuits may experience large numbers of failures. Outage restoration can be hastened by technology that assists with fault location, such as increased visibility by sensors or more granular segmentation by automatic switching equipment.

7 https://www.eei.org/-/media/Project/EEI/Documents/Issues-and-Policy/Reliability-and-Emergency-Response/UndergroundReport.pdf?la=en&hash=7E2DB1E527AA94410D64121EE340AF3D8BD07694

8 https://www.sandiego.gov/undergrounding/overview

9 EEI (2013) as above

3. Protection challenges caused by underground or hybrid overhead and underground feeders

Underground lines present both new challenges and opportunities. Protection devices and philosophies for overhead distribution systems do not translate to underground systems. In fact, the equipment used and the main purposes of the equipment are almost mutually exclusive.

Reclosers and fuses interrupt faults at many points along overhead feeders to minimize the outage area. Pad-mounted gear's main purpose is to distribute power. It is often used for sectionalizing but not for fault interruption on the main line. So, new technology using low-energy fault-testing should be considered as protection schemes are adapted to accommodate underground sections.

4. Environmental remediation

Placing lines underground can also result in greater environmental disturbance and costs associated with remediation. For example, Larsen (2016) notes "the process of installing underground power delivery infrastructure could significantly disturb sensitive wetlands, forests, or other valuable ecosystems within the T&D corridor." It also likely will increase the area of environmental disturbance compared to traditional overhead line replacement.[10]

5. Third party cable strikes

There are risks of cable strikes by third parties, such as other utilities or contractors, carrying out work, which can lead to lengthy outages.

So how do the key drivers and potential drawbacks of undergrounding impact the overall case for undergrounding?

CHANGING ECONOMICS OF UNDERGROUNDING

At a high level, 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. These include incremental costs to lay underground cables versus overhead conductors or to convert existing overhead conductors to underground, impacts on safety and environmental restoration, and benefits such as reduced outages on blue-sky days and during major events.

Table 1 on page 8 provides a high-level illustrative view of the costs and benefits of undergrounding and how they are changing over time given environmental trends such as weather impacts, customer expectations for improved reliability and resilience, and changing technology.

10 https://eta-publications.lbl.gov/sites/default/files/lbnl-1006394_pre-publication.pdf

TABLE 1. An Illustrative View of Undergrounding Cost-Benefit Analysis

Costs

Costs of undergrounding	Trend
Utilities & Ratepayers	
Higher installation costs for new underground cables **OR** Costs associated with conversion from overhead cables to underground lines	Differential decreasing with new technology, economies of scale from carrying out more work
Risks of cable strikes	Improved mapping of underground utility networks
All Residents	
Faults that do occur may take longer to restore on U/G networks because visual inspection isn't possible and it's hard to locate and repair faults	New technology allowing low energy fault testing on underground/hybrid feeder and switching on underground URD loops reduces number of customers affected and restoration times
Increased environmental restoration	Differential likely to be relatively constant

Benefits

Costs of undergrounding	Trend
Utilities & Ratepayers	
Lower ongoing operations and maintenance costs	More frequent and severe storms will mean more O&M avoided
Lower risk of contact with overhead cables	Differential likely to be relatively constant
All Residents	
Avoided interruptions and interruption duration due to less frequent outages on blue sky days and in severe weather. Greater value of reliability and resilience because of electrification	The frequency and severity of Major Events is increasing at the same time as the value of reliability and resilience is increasing
Improved visual amenity/ aesthetics, increased property values	Increased focus on environmental issues

Net Benefits

Trend
Overall increases over time driven by reducing costs of undergrounding, benefits of addressing climate-change impacts, growing value of reliability and resilience, and new technology

Source: *Based on a review of Larsen (2016), EEI (2013), plus own additions.*[1]

1 https://eta-publications.lbl.gov/sites/default/files/lbnl-1006394_pre-publication.pdf, https://www.eei.org/-/media/Project/EEI/Documents/Issues-and-Policy/Reliability-and-Emergency-Response/UndergroundReport.pdf?la=en&hash=7E2DB1E527AA94410D64121EE340AF3D8BD07694

Generally, the trends favor increased undergrounding. For example, new technologies are addressing the historical challenge of longer outage durations associated with underground faults. There are opportunities to use modern automation equipment, such as S&C's IntelliRupter® PulseCloser® 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. This allows for further improvements in performance through segmentation and minimizing the number of customers affected by a fault, essentially making traditional overhead feeder protection philosophies a practical reality on underground lines.

Automated switching using S&C's EdgeRestore® Underground Distribution Restoration System on single-phase URD loops (laterals) means customers' supplies can be restored quickly following a fault without a sustained outage.

Newer techniques for undergrounding, such as horizontal directional drilling, reduce the need for costly digging, large crews, and road closures, and they make it easier to install cables under rivers, driveways, etc. New standards for the design and construction of underground lines optimize the type of materials, equipment, and construction approaches, depending on the local environment. Economies of scale for larger programs can also significantly reduce the costs through bundling work geographically (for example, targeting all laterals on a feeder) and having a single contractor carry out a broad scope of work, including the engineering design, construction, and customer interaction.

Larsen (2016) highlights that policymakers should consider requiring undergrounding where most of the following conditions are present:[11]

- There is a large number of customers per line mile.
- There is an expected vulnerability to frequent and intense storms.
- There is the potential for underground line installation economies of scale.
- Overhead line utility easements are larger than underground T&D utility easements.

Overall, the combined impact of lower costs associated with undergrounding, addressing key challenges, and greater benefits means targeted or larger-scale undergrounding initiatives are becoming more attractive.

11 https://eta-publications.lbl.gov/sites/default/files/lbnl-1006394_pre-publication.pdf

UTILITY INVESTMENT STRATEGIES AND TRENDS

United States

Some key examples of undergrounding investment with strong justifications are the programs being carried out by FPL, Dominion Energy, Pacific Gas and Electric Company (PG&E), and Potomac Electricity Company (Pepco).

FPL is carrying out a $4 billion undergrounding initiative. Its undergrounding activity includes its Storm Secure Underground Program (SSUP), which focuses on laterals, and its municipality/community-initiated underground conversions, which include main feeder lines as well as laterals.

FPL's SSUP is justified based on reductions in O&M costs and the avoided costs associated with a major hurricane every three to five years. In addition, there are major GDP benefits for the local economy from avoiding power outages following a hurricane. Lateral undergrounding allows for faster outage restoration following hurricanes because often the overhead laterals are most affected by such events, and by necessity lateral repairs are completed after the main feeder lines have been restored.

Dominion Energy is undertaking a $2 billion, 4,000-mile strategic undergrounding program, which began in 2014 and will run until 2028.[12] The aim of this program is to shorten restoration times following major storms by targeting the most outage-prone laterals.

The justification for the program identified a reduction in Virginia's Gross Domestic Product (GDP) per customer outage hour of $35,458, and shortening outage durations yielded $1.76 in saved GDP per $1 spent on the program. Dominion Energy has already seen its storm-restoration time drop by 50% in areas with undergrounding.

PG&E in 2021 committed to undergrounding 10,000 miles of its power lines in high fire-threat areas. This represents approximately 40% of its overhead system in High Fire Threat Districts and 12% of its overall overhead power system. This program is concentrating on main feeder lines because PG&E has other solutions for fire mitigation on laterals.

The District of Columbia Power Line Undergrounding (DC PLUG) initiative is a $500 million partnership between the district and Pepco to improve the reliability and resilience of the most outage-prone power lines in Washington, D.C., by placing select feeders underground.[13]

At an aggregate level for the U.S., as shown in **Table 2** and **Table 3 on page 11**, investment in underground conductors, devices, and conduits increased significantly from 2010 to 2019, slightly exceeding the growth in total distribution capital expenditures, or capex. The increase in the proportion of capex from 21.4% to 22.2% over this period is likely driven by a combination of increasing work on existing underground circuits and new circuits, along with targeted and larger scale undergrounding.

12 https://www.dominionenergy.com/projects-and-facilities/electric-projects/strategic-underground-program
13 https://www.dcpluginfo.com/

TABLE 2. Capex ($ billion) for Investor-Owned Utilities

Capex ($BN) for IOUs	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Overhead Conductors and Devices	2.64	2.74	3.25	3.46	3.63	3.91	4.20	4.53	5.05	5.63
Underground Conductors, Devices and Underground Conduits	3.55	3.77	4.14	4.25	4.90	5.47	5.70	5.98	6.35	7.25
Station Equipment	2.19	2.34	2.88	2.58	2.88	3.17	3.46	3.84	4.41	4.78
Other	8.22	8.23	8.96	7.97	9.21	10.22	10.93	11.49	13.32	15.05
Total	***16.60***	***17.07***	***19.24***	***18.27***	***20.61***	***22.76***	***24.29***	***25.83***	***29.14***	***32.70***

Source: *Federal Energy Regulatory Commission (FERC) Form 1 data on regulated utility capex sourced using the Wood Mackenzie Grid Edge dashboard.*[1]

1 https://www.ferc.gov/general-information-0/electric-industry-forms/form-1-1-f-3-q-electric-historical-vfp-data

TABLE 3. Capex Percent of Total Investment

Capex (% of total)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Overhead Conductors and Devices	15.9%	16.0%	16.9%	19.0%	17.6%	17.2%	17.3%	17.5%	17.3%	17.2%
Underground Conductors, Devices and Underground Conduits	21.4%	22.1%	21.5%	23.3%	23.8%	24.0%	23.5%	23.1%	21.8%	22.2%
Station Equipment	13.2%	13.7%	15.0%	14.1%	14.0%	13.9%	14.2%	14.9%	15.1%	14.6%
Other	49.5%	48.2%	46.6%	43.6%	44.7%	44.9%	45.0%	44.5%	45.7%	46.0%
Total	***100%***	***100%***	***100%***	***100%***	***100%***	***100%***	***100%***	***100%***	***100%***	***100%***

Source: *Federal Energy Regulatory Commission (FERC) Form 1 data on regulated utility capex sourced using the Wood Mackenzie Grid Edge dashboard.*[1]

1 https://www.ferc.gov/general-information-0/electric-industry-forms/form-1-1-f-3-q-electric-historical-vfp-data

Sweden and Finland

In Northern Europe, both Sweden and Finland have been carrying out large undergrounding programs following very severe weather events that caused extensive damage and widespread, long-duration outages in each of the countries. In both cases, network-performance data suggest the greater focus on undergrounding has delivered significant benefits for customers.

Storm Gudrun caused significant destruction in parts of northern Europe in January 2005. In Sweden, 30,000 kilometers of distribution lines were damaged, leading to long-lasting power disruption for approximately 730,000 customers. In urban areas with underground cables, power was restored within a few hours, whereas rural areas experienced outages lasting up to 20 days.

As a result, there has been an ongoing program of extensive undergrounding in Sweden. In 2004, approximately 39% of Swedish medium-voltage/high-voltage (MV/HV) lines were underground and 70% of low-voltage (LV) lines. By 2018, 57% of MV/HV lines were underground, and 82% of LV lines.[14] This investment has coincided with a period of significant improvements in reliability performance in Sweden.

As **Table 4** highlights, unannounced (unplanned) SAIFI fell by 37% between 2011 and 2020, while unannounced (unplanned) SAIDI fell by 63% over the same period. While this may reflect a range of drivers, the increased focus on undergrounding has clearly been a key contributing factor.

TABLE 4. An Annual SAIDI and SAIFI Comparison of Sweden's Announced and Unannounced Outages

Year	SAIFI, announced outages (outages/year)	SAIFI, unannounced outages (outages/year)	SAIDI, announced outages (minutes/year)	SAIDI, unannounced outages (minutes/year)
2011	0.19	1.31	16	174
2012	0.14	1.03	17	75
2013	0.14	1.02	18	139
2014	0.15	0.98	16	69
2015	0.14	0.96	16	107
2016	0.15	0.85	18	61
2017	0.14	0.82	16	52
2018	0.13	1.01	15	73
2019	0.15	0.96	17	120
2020	0.17	0.83	17	65

SOURCE: *Sweden's electricity and natural gas market 2021, Energimarknadsinspecktionen, p26*[1]

1 https://ei.se/download/18.31b721ca18388fe22ad2d3f/1664799315977/Sweden's-electricity-and-natural-gas-market-2021-Ei-R2022-07.pdf

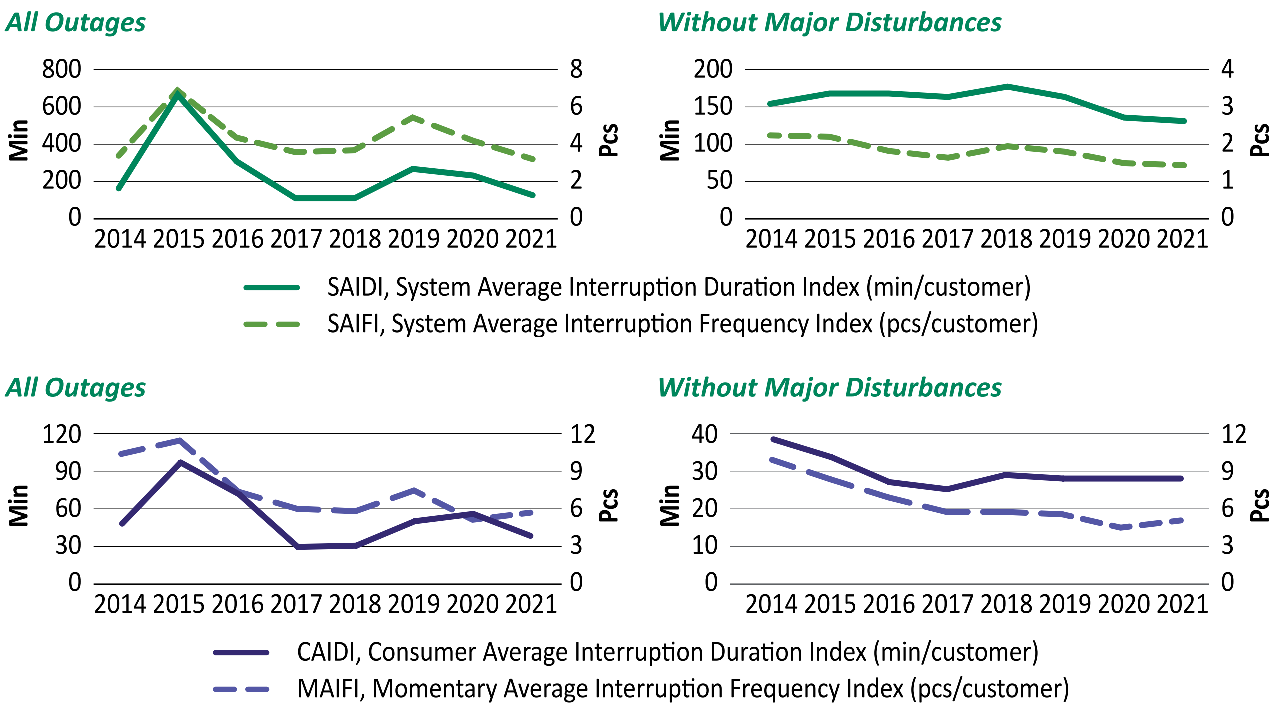
14 CEER 5th Benchmarking report on Quality of Supply (2011) - https://www.ceer.eu/documents/104400/-/-/0f8a1aca-9139-9bd4-e1f5-cdbdf10c4609 and CEER 7th Benchmarking report on Quality of Supply (2022) https://www.ceer.eu/documents/104400/7324389/7th+Benchmarking+Report/15277cb7-3ffe-8498-99bb-6f083e3ceecb

On December 26, 2011, Cyclone Tapani hit Finland and reached gust speeds of up to 70.5 miles per hour. The storm caused some of the worst damage in more than 15 years, impacting overhead power lines and causing extensive power outages during the holiday period.[15] Following this storm, new legislation required Finnish utilities to develop their grids so that by the end of 2036, power outages caused by storms or snow would not exceed six hours in cities and 36 hours in rural areas.

As a result, Elenia, the second-largest distribution system operator in Finland, is continuing to invest substantially in undergrounding to increase in its proportion of underground lines from 41% in 2019 to 75% in 2028.[16] In its most recent sustainability report, Elenia highlighted that its security of supply was the best it has ever been. Average interruption time has halved in the last decade, and a similar improvement has been experienced in the number of temporary power outages.

These improvements are highlighted in the charts shown in **Figure 3**. Elenia attributed this improved performance to investments in undergrounding alongside network automation, the installation of advanced systems, and fault management contingency planning.

FIGURE 3. Charts showing Elenia's annual performance improvements.



SOURCE: *Elenia and Sustainability 2021, Elenia, p42.*[1]

1 https://www.elenia.fi/files/b3b6f78c430570353c12d1c20720a41f85f5973a/elenia-and-sustainability-2021.pdf

15 https://www.macquarie.com/au/en/impact/case-studies/underground-resilience-forfinlands-electricity-network.html

16 https://climate-adapt.eea.europa.eu/en/metadata/case-studies/replacing-overhead-lines-with-underground-cables-in-finland

POLICY MOVES TO ENSURE MEASURES ARE ENACTED

Further development of regulatory frameworks is the most direct route to altering utility incentives and empowering longer-term investment in reliability and resilience. Such development includes greater elements of performance-based regulation and mechanisms to support resilience investment, such as storms riders and reserve accounts. An important part of this is putting in place a robust framework for benefit-cost analysis that allows utilities to justify such investment by considering lifetime benefits and costs using both quantitative and qualitative analysis.

However, changes in legislation can also be an important driver of enhanced resilience. The U.S. Infrastructure Investment and Jobs Act contains several programs that focus explicitly on improving reliability and resilience and encouraging further innovation in these areas. Approximately $14 billion is directly allocated to resilience programs, and there are other funding streams that could also be used to drive such improvements. In providing this funding, two additional trends are evident in the U.S.:

- An increased focus on rural areas, recognizing these are often most at threat from climate change and have the most to benefit from targeted resilience investment
- The crucial link to “equity,” i.e., ensuring there is a focus on disadvantaged communities so all communities may benefit from a greater focus on resilience investment

As highlighted above, undergrounding is one of several solutions that may be used and, as the economics improve, may benefit from increased funding opportunities.

Overall, the most critical components of any regulatory or legislative approach are consistency and clarity. Ensuring utilities, regulators, and other stakeholders clearly understand the goals of any effort and the metrics by which reliability or resilience goals will be measured maximizes the chances of success for a particular initiative.

CONCLUSIONS

A range of factors make programs of targeted or larger-scale undergrounding more attractive. They include how climate change is increasing the frequency and severity of major events now and in the future, and the present changes in the energy sector to electrify transport and heat that will mean a greater reliance on reliable and resilient grids.

Innovative protection and automation technologies mean underground grids can now deliver even better performance for customers. We have already seen in some places that important enablers for this are new regulatory initiatives, such as performance-based regulation, funding mechanisms for resilience, and legislative programs that enable investment in reliability and resilience. To ensure customers get the most from undergrounding and other options for improving resilience, we expect these types of initiatives will become more widespread.

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