Utility Vegetation Management: Industry Overview

SUMMER 2022

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Sector Overview: Utility Services and T&D Infrastructure

Utility Services Whitepaper (View Article Here)

- The Current State of Electric & Gas Infrastructure
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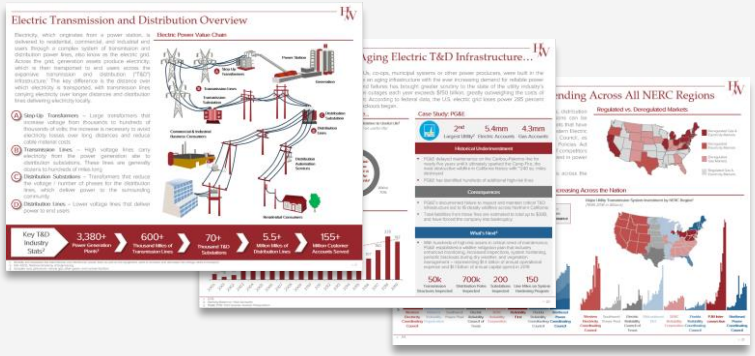
- Public and Private Companies in Market Landscape
- Services Overview & Descriptions
- Key Considerations for Investors



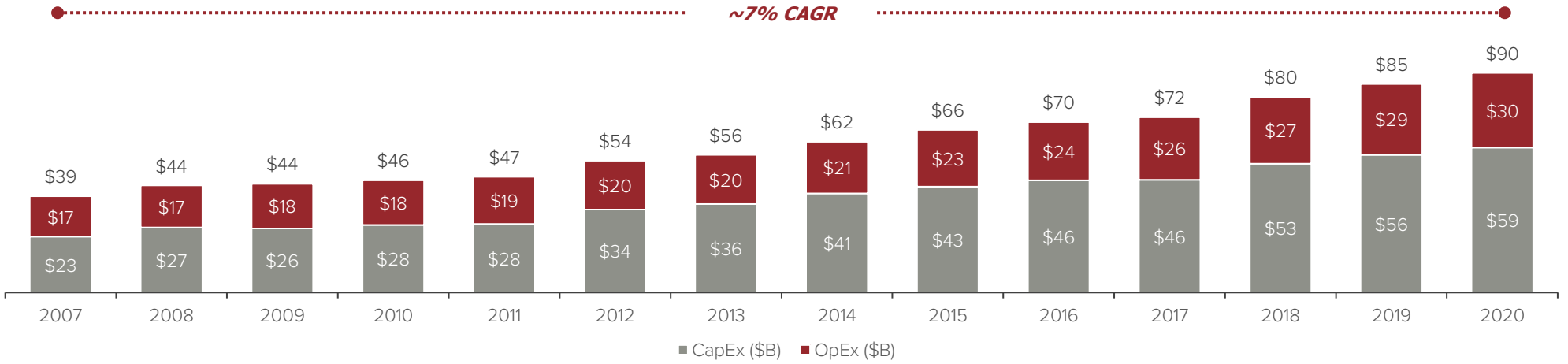
Date Published: June 2020

Maintaining the Existing Transmission & Distribution Infrastructure

The North American Transmission & Distribution ("T&D") industry is the backbone of the power system and is characterized by significant recurring investment in infrastructure. Fueled by the need to improve the reliability and capacity of the North American T&D network and by long-term regulatory requirements and secular tailwinds, utilities are making substantial investments to replace, upgrade, and expand new and existing T&D infrastructure. Outsourced utility service providers stand to benefit from the significant planned investment in electric and gas infrastructure. In 2020 alone, utilities spent approximately $90 billion on T&D infrastructure, representing a 2.3x increase since 2007.[1] One major facet of ensuring the reliable operation of T&D infrastructure is preventing trees and other vegetation from falling into or contacting powerlines. Vegetation management is frequently the single largest line item in annual operating budgets, exceeding $100 million annually in many larger utilities, and is almost entirely spent on third party suppliers who perform various aspects of the program.[2]

Continued Spend in the Sector is Driving Growth

U.S. Electrical Power T&D Spend by Utilities[3]
($ in billions)



Subsector Overview: Utilities Spend ~$8B Annually on UVM

Utility Vegetation Management is a Non-Discretionary Service that Continues to Grow Through Economic Cycles

- Utility Vegetation Management ("UVM") is the process of executing planned chemical and mechanical treatments to protect transmission and distribution ("T&D") infrastructure from trees and other vegetation that could generate a power outage by falling into or contacting power lines. Vegetation fall-ins and contacts have historically been a leading cause of power outages, causing or contributing to over 55% of outages on transmission lines alone, in addition to increased fire risk.[4]

- Following the heels of major national power outages, including the 2003 Midwest and Northeast Blackout, the Federal government implemented a new regulatory framework layered with penalties to ensure utilities appropriately protect their T&D assets from encroaching vegetation. This regulatory framework and penalties for failure to comply have made spending to protect and ensure the reliability of T&D infrastructure from vegetation and other potential hazards non-discretionary and independent from economic cycles.

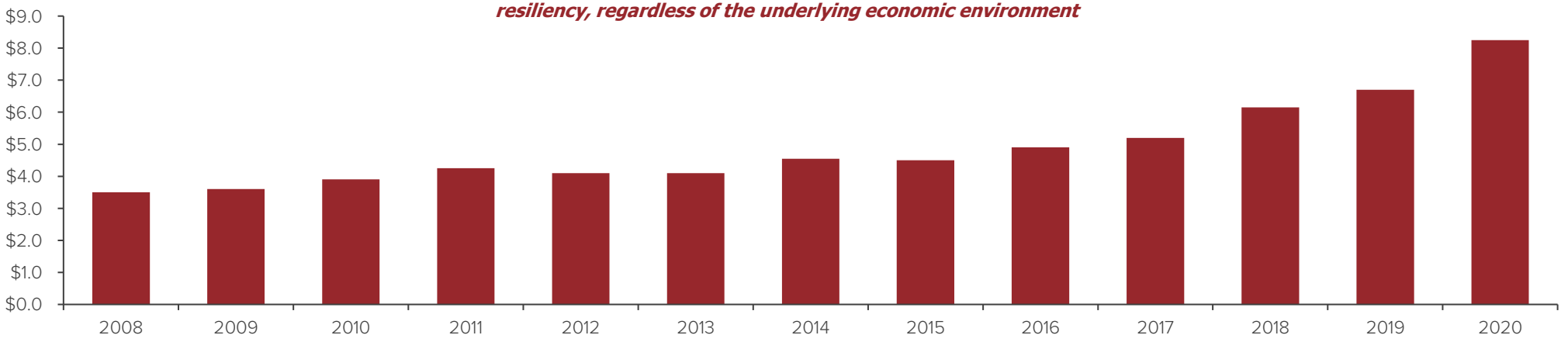
- A multitude of factors, including a tightening regulatory framework, the need for additional T&D mileage, and a changing, more extreme climate are driving an increase in spend on T&D infrastructure. As T&D infrastructure expands, so too must spend on UVM to properly protect the new infrastructure from vegetation encroachment. From 2015 to 2020, utilities' T&D capital expenditures and operating expenses increased from $66 billion to approximately $90 billion.[5] According to The C Three Group, across all utilities, the percentage of operating expenses going to UVM has similarly grown from 55% of utility's overhead maintenance budgets to approximately 75%.[6] In 2020, utility spend on UVM reached ~$7.6 billion, not including $700 to $900 million of spend on hazard tree removal and right-of-way ("ROW")* clearing (costs that are capitalized).[7]

- That increasing spend has largely gone to outsourced UVM providers hired to plan, monitor, and execute treatments for utilities, commercial clients, and residential areas. The competitive landscape includes a handful of larger providers who compete against numerous smaller local or regional operators offering more niche services for long-time local clients. Utility customers maintain stringent reliability and safety standards that require significant training and expertise from technicians and project managers.

Annual U.S. Investor-Owned Utility ("IOU") Spend on Overhead Maintenance of Distribution Lines Continues to Expand**

Total U.S. IOU Distribution Overhead Maintenance Costs[8]
($ in billions)

Spending for IOUs has increased at a CAGR of ~7% since 2008, highlighting the stability and resiliency, regardless of the underlying economic environment



Source: The C Three Group

*"Right-of-Way" is a type of easement or agreement that grants a utility the right to use, access, or transit a piece of property according to the terms of the easement. The easement is typically granted by property owners to an electric utility for the purpose of constructing, operating, and maintaining power lines and other equipment.
**Spending excludes overhead maintenance from cooperatives and municipalities, which represent another 20% to the total spend.

Introduction to Utility Vegetation Management

Utility Vegetation Management Overview

- UVM is the process of managing the growth of trees and other vegetation to mitigate interference with electric power lines in a way that could threaten the reliable operation of the T&D system. Electric power outages and wildfires can occur when trees grow or fall onto overhead electric power lines or grow close enough to spark arc flashes. Many of these interferences can be mitigated by managing the vegetation before it becomes a problem.
- UVM activities and services can be grouped into three categories: pre-planning and monitoring; treatment; and reactive repair.
  - **Pre-Planning and Monitoring**: Treatment through evaluating, mapping, and tracking vegetation growth, and proactively planning how best to treat identified hazardous vegetation as it grows. Mapping and monitoring can include aerial surveillance via satellite, unmanned aerial vehicles, and light detection and ranging (LiDAR),* combined with ground patrols to spot any hazardous tree encroachments. Expert arborists are often engaged to help identify problematic species of vegetation within the control areas, advise on best treatment methods, and develop a plan and schedule to apply those treatments. This plan is what T&D owners and operators submit to regulatory officials for approval.
  - **Treatment**: Includes mechanical treatments (i.e., mowing, trimming of branches, and pruning), and chemical application (i.e., using herbicides to eliminate certain aggressive species of vegetation, applying pruning retardants to tree stubs, or injecting chemicals into tree roots to stunt growth) to actively remove and maintain vegetation. Combined application of both mechanical and chemical treatments, also referred to as Integrated Vegetation Management ("IVM"), can be more cost effective than mechanical-only treatments. When done with the guidance of professional UVM service providers, IVM is shown to be less disruptive and more protective to the ecosystems treated. These activities are executed on a planned frequency depending on the growth rate of the species of vegetation managed, but generally occur every four to six years.
  - **Reactive Repair**: Primarily reactions to unplanned events that cause trees to fall into and trip power lines, including debris removal following extreme weather events and emergency trimmings of encroaching vegetation causing power line contacts.

Key Causes of Outages

Arc Flashes

When light loading on a system (i.e., lower customer demand) causes an excess of power, high voltage wires can exceed the insulation capabilities of equipment and cause dangerous electric arcs between the power lines and nearby vegetation, sparking wildfires or tripping the power line. To mitigate, UVM service providers trim trees to maintain a minimum prescribed distance from the nearest power lines.

Cascading

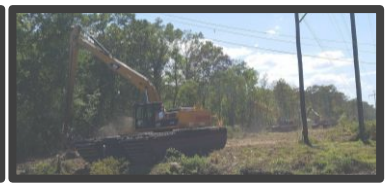
Transmission lines are built with multiple lines for redundancy, so that when one line goes out, another carries the load to avoid an outage. This can lead to quick load escalations among remaining lines should multiple others trip. Power lines automatically shut down if the load exceeds carrying capacity to avoid physical damage. This feature of the interconnected system is what can lead to inter-regional blackouts.

Typical Services Provided

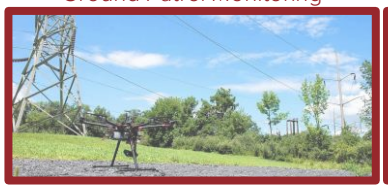

Ground Patrol Monitoring

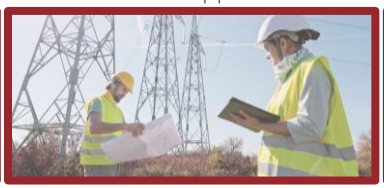

Herbicide Application


Right-of-Way Maintenance

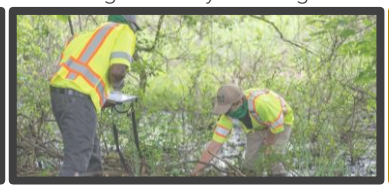

Right-of-Way Clearing

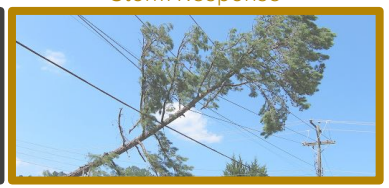

Storm Response


Aerial Mapping


VM Planning & Scheduling


Tree Pruning & Trimming


Ecosystem Management


Line Clearing

Pre-Planning and Monitoring

Treatment

Reactive Repair

*LiDAR is a land surveying technology that uses pulsed laser light from helicopters and fixed-wing airplanes to create 3D presentations of vegetation. See generally IBM Transforming Predictive Vegetation Management for additional insights into how UVM service providers on the leading edge are leveraging data analytics to improve UVM efficiency and effectiveness.

A Leading Cause of Outages is Tree Interference with T&D Lines

Investigations of Historic National Blackouts has Routinely Identified Tree Interference as a Root Cause of Otherwise Preventable Outages

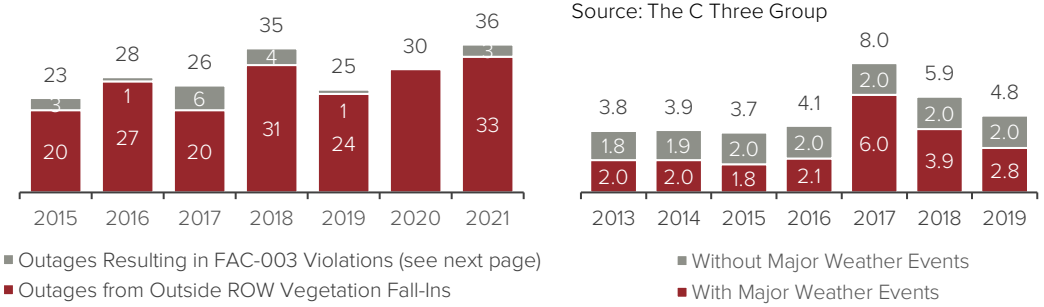
- Power outages are estimated to cost the U.S. economy between $28 and $169 billion annually.[9] Vegetation interference has been, and continues to be, a significant source of power outages in the U.S. Several major national outages have been traced back to power-line interference with trees, including two blackouts in 1996 in Idaho and California, the 2003 outage that drove blackouts across the Midwest and Northeast, and the 2011 blackout in the Northeast driven by winter storms, to name a few. Each of these blackouts involved preventable power line interference with trees that caused power outages for millions of people, cost billions of dollars, and resulted in millions of lost work hours, materially impacting regional GDP.[10]
- While standards and regulations have helped decrease the number of tree-related outages, particularly for transmission lines, vegetation is still responsible for over 55% of U.S. power outages, and has caused catastrophic wildfires in Sonoma, CA (2017) and Paradise, CA (2018).[11]

Vegetation-Related Transmission Outages[12]
(Number of Outages)

Average Duration of Total Annual Interruptions[13]
(Hours per Customer)

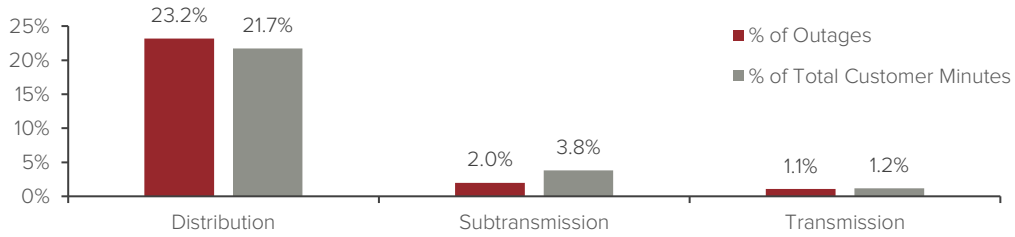
The average amount of outages is increasing as the number and severity of major weather-related events increases

Source: The C Three Group



Outages Attributable to Vegetation per Line Type[14]

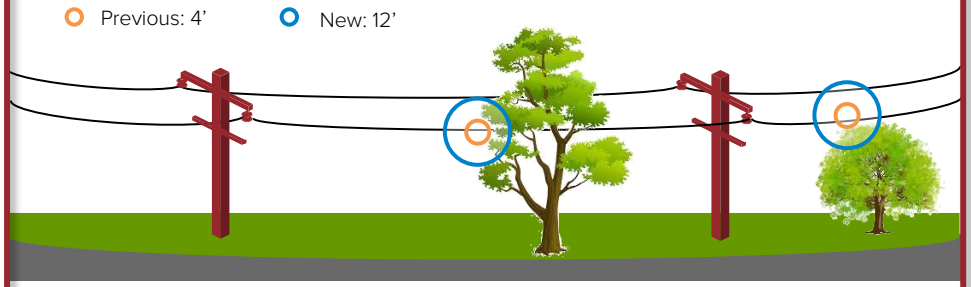
Most outages occur on distribution lines given the scale of the distribution system, while the most consequential outages occur on transmission lines



Case Study: California Wildfire Safety Requirements

- 2,000+ California wildfires from 2017 and 2019 were the result of 'utility ignitions,' including instances when vegetation contacted electric power lines[15]
- New California regulation PRC 4293 increases required clearance of vegetation from utility lines from 4' to 12', which will take over 10 years to satisfy[16]
- Contractors are typically responsible for pre-determined milage or a territory, with a single mile roughly comprising a day's worth of work
- To address the increased clearance requirements, contractors are buying larger and more efficient equipment, or adding additional labor to meet the change in regulatory demand

Radial Clearance Requirements



Wildfire Protection, Management, and Prevention Spend[17]

$800M	»	$3.3B	$15B+
State of California, 2005-2006		State of California, 2020-2021	PG&E Liability Damages

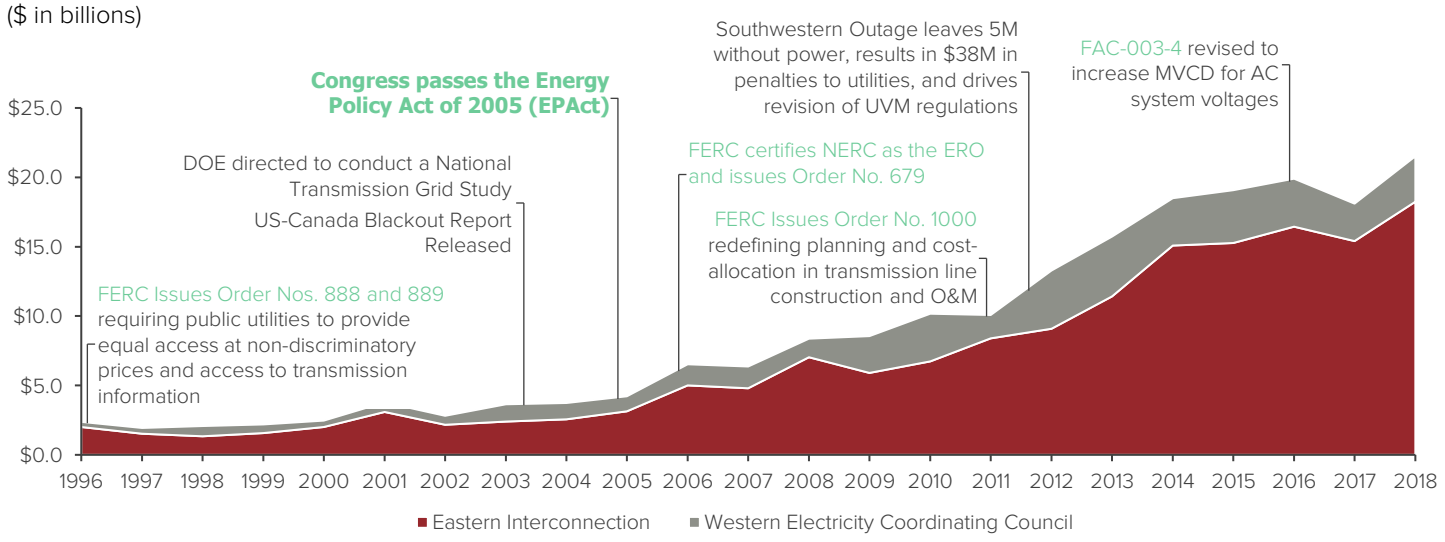
4x+ increase in spend in less than 20 years

Evolution of the Regulatory Framework for Electric Grid and UVM

UVM has Evolved into a Highly Regulated Industry and Penalizes T&D Operators and Owners for Tree-Related Outages

- The serious consequences of the several major blackout events, particularly the 2003 Midwest and Northeast Blackout, drove state and federal governments to implement legislation subjecting utilities to penalties for failing to take reasonable actions to ensure the reliable operation of the electric power lines within their control.
- The Federal government amended the Federal Power Act with the Energy Policy Act ("EPAct 2005") to empower the Federal Energy Regulatory Commission ("FERC") to create an independent "electric reliability organization" ("ERO") mandated to develop and enforce mandatory reliability standards* to ensure the "reliable operation" of the nation's transmission facilities and the bulk power system ("BPS"). The National Electric Reliability Company ("NERC") was subsequently certified as the national ERO and instructed to create mandatory reliability standards for utilities, audit transmission owners and operators to ensure compliance with those standards, and assess and enforce penalties for violation of those standards.
- FAC-003-4 is the reliability standard applicable to vegetation management and outlines six key requirements, including: (1) maintaining a minimum vegetation clearance distance ("MVCD") between power lines and vegetation; (2) documenting maintenance strategies and procedures; (3) notifying appropriate control centers of conditions that could cause flash-over events; (4) taking corrective action to eliminate potential flash-over events; (5) inspecting vegetation conditions annually; and (6) completing annual work to prevent flash-over events. Non-compliance with any of these can result in fines of up to $1 million for each day that the utility is out of compliance.
- Distribution lines are subject to state jurisdiction given the local nature of distribution lines. Utilities are largely allowed to determine their own strategy to ensure vegetation does not encroach on distribution assets, although these plans must be submitted to state regulators for approval. NESC Rule 218 has been adopted by most Public/State Utility Commissions. While NESC Rule 218 does require utilities to submit a utility UVM plan for approval, it does not mandate active management (but instead asserts that trees should be trimmed or removed to avoid interference).

Transmission Infrastructure Investment in Eastern and Western Interconnections Following Regulatory Action[18]
($ in billions)



Regulatory Evolution Highlights

2003 Midwest & Northeast U.S.-Canada Blackout[19]

- The largest North American blackout on record impacting 50 million people and costing $4 to $10 billion and 18.9 million lost work hours
- Caused by combination of human error, equipment failures, and transmission lines tripping by sagging into overgrown trees
- An appointed Task Force generated 46 recommendations, which inspired passage of the EPAct 2005

EPAct 2005

- Amends the Federal Power Act to include a mandatory electric reliability regime
- Creates an independent ERO to develop and enforce mandatory reliability standards

NERC

- Certified as the national ERO, and delegates oversight responsibility into 8 regions and 20 assessment areas

FAC-003-4

- NERC's proposed vegetation management reliability standard, through which NERC establishes UVM best practices, audits and enforces compliance with those practices, and assesses penalties for their violation

*Reliability Standards are requirements created by NERC and approved by FERC to provide for reliable operation of the bulk power system.

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UVM Market and Industry Dynamics

Utilities Now Spend ~$8 Billion Annually on Routine UVM

- Spend on UVM exceeded $7.6 billion in 2020 (not including $700 to $900 million in hazardous tree removal and ROW clearing), with the budget of any single utility ranging from $50,000 to hundreds of millions annually.[20] For utilities, UVM programming spend represented approximately 75% of total spend on overhead maintenance operations, up from 50-55% historically.[21]
- This increased spending in UVM is driven by and tied directly to investments in T&D infrastructure, which have steadily increased over time. Transmission lines particularly have benefited from an increase of investment across more than 600,000 miles of existing infrastructure.[22] The ongoing investment is intended to provide access to clean energy, increase the grid's reliability, security, and resilience, decrease congestion, and replace aging transmission infrastructure. Distribution lines, which total more than 5.5M miles, have similarly received significant investment boosts over the past two decades to link new wind and solar generation to transmission lines and customers, upgrade aging equipment, and "harden" the grid to reduce the frequency and duration of outages.[23]
- As power line mileage increases, so too must UVM budgets to manage the increased mileage of vegetation. T&D owners and operators have therefore expanded their UVM programming to protect these new and upgraded T&D assets.

Drivers of Increasing Spend on UVM Programming for T&D Lines

Power Line Mileage Growth

Mileage of power lines requiring vegetation management has grown to accommodate increasing electrification demands by connecting distributed energy resources ("DERs") to expand universal access to electric power.

Adapting to Regulatory Modifications

Changes to UVM practices at the state and federal levels, including through the evolution of FAC-003 requirements from 2003 to 2016, have resulted in mandated increases in MVCDs, ROW spans, and reporting requirements, each of which have driven increased spend to ensure compliance.

Price and Unit Volume Increases

Increased insurance premiums, per diem requirements, and increases in minimum wages for clearance tree trimmers and electrical utility linemen have driven unit rate increases for trimming and removals.

Adoption of Advanced Pruning Methods

Developing more environmentally friendly UVM programming to ensure minimal impact to managed ecosystems requires employing expert arborist, utilizing more advanced tracking, monitoring, and mapping technologies, and more wholistically managing vegetation.

Increasing Temperatures

Increasing temperatures and prolonged seasons of warm weather increase vegetation growth rates, thereby shrinking pruning cycles and increasing the frequency of vegetation treatment.

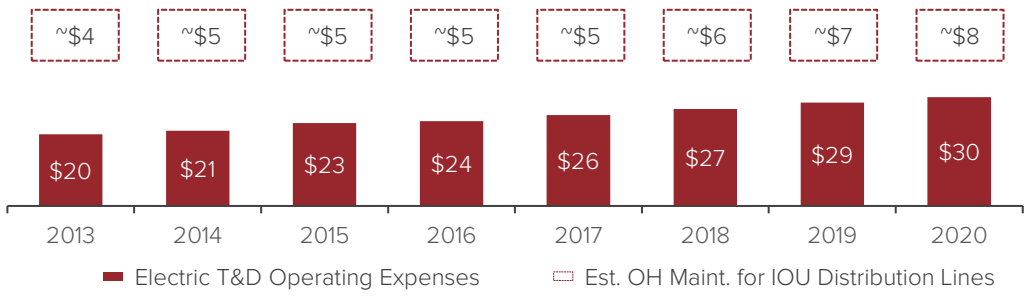
Extreme Weather Events

Increasing frequency and severity of extreme weather events increases the probability of trees outside the right-of-way falling into and tripping electric power lines.

Scoping Increased Spend on UVM of T&D Assets

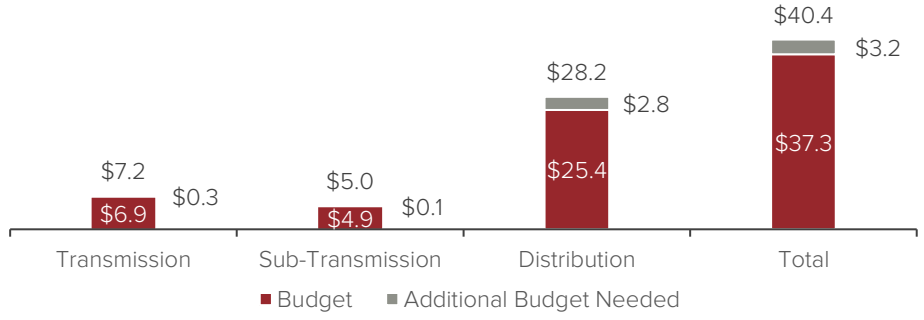
U.S. Utility T&D Electrical Spend on OpEx[24]
($ in billions)

Operating expenses for electric utilities has grown by ~5% p.a. since 2013, with overhead maintenance serving as the catalyst, growing ~10% p.a. since 2013



Mean UVM Budget per Line Type[25]
($ in millions)

Recent survey shows utility owners believe their vegetation management budgets are routinely 10.6% below needed levels



UVM Market Projections and Drivers

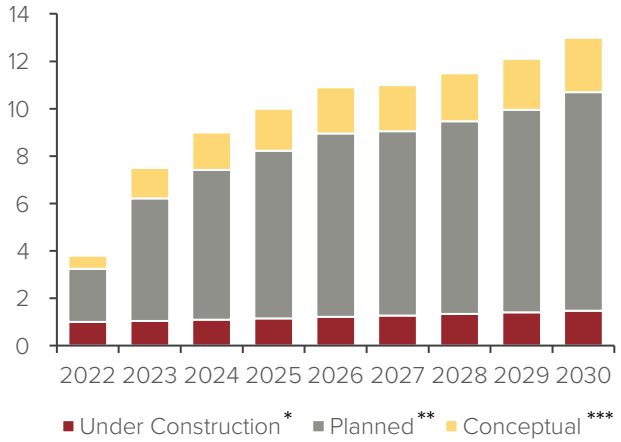
UVM Programming Spend on New Transmission Lines Alone Projected to Generate Approximately $1.2 Billion of Additional Annual Spend by 2027

- The nation's electricity grid will require significant changes and expansion to accommodate the various clean energy and carbon-reduction goals established across state and federal governments. Studies suggest that the capacity of the nation's transmission system alone may have to be doubled to meet the Biden Administration's goals. As a result, capex investments in T&D infrastructure are projected to exceed $63 billion in 2022 and 2023, including the construction of some 13,000 miles of new transmission lines.[26] Consequently, T&D power line mileage expansion is expected to drive growth in annual T&D O&M budgets beyond current spending levels, composed largely of increased spend on UVM programming.

Projected Transmission Expansion by Project Status[27] (000s of Miles)

- The projected 13,000 miles of new transmission lines include lines that are generally shorter in length, primarily to enhance reliability of specific segments of transmission. Area planning processes may, however, identify needs for longer length transmission projects to capture and transmit renewable energy from areas distant from load centers.

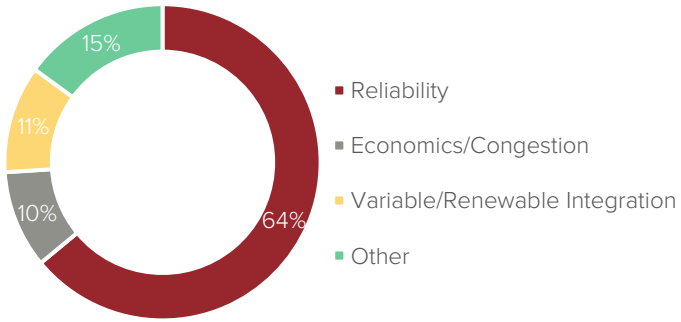
New transmission lines projected to generate more than $1.0 billion of additional annual spend by 2027 [28]



Percentage of New Transmission Circuit Miles Through 2030 by Primary Driver[29]

- The majority of new transmission lines are being created to support new generation and enhance reliability. Alleviating congestion and replacing aging assets are also key drivers of the need for new lines.

64% of future transmission lines needed for reliability improvements, up from 57% in 2020



U.S. IOU Projected Distribution Line Capex Spend[30] ($ in billions)

- States historically slow to react to hardening initiatives will find themselves in cycles of emergency rebuilding following extreme weather events, thereby accelerating growth of storm hardening programs and increasing the average capex spend per customer served.

Despite difficulties in projecting storm recovery costs and state regulator attempts to halt spending, conservative estimates project 5%+ of distribution capex growth through 2025

Utility Type	CAGR (2014-2020)	Projected CAGR (2021-2025)
IOUs	~10%	~6%
Co-ops	6%	4%
Munis	6%	~4%

Source: The C Three Group

*Under Construction – Construction on the line has begun.
**Planned – Permits have been approved, design is complete, and the new lines are needed to meet a regulatory requirement, but construction has not yet begun.
***Conceptual – Projected in the transmission plans and is required to meet NERC standards or power-flow models but does not yet qualify as "Under Construction" or "Planned."

UVM Market Projections and Drivers (cont'd)

Projected Growth in T&D O&M Spend Driven Primarily by Agreement Across Key Stakeholders on the Need for Increased Resilience & Reliability of the Electric Grid

- The projected growth will be driven by several tailwinds that will require expansion of T&D mileage, along with repair, replacement, and upgrading of existing T&D infrastructure.
- More specifically, ongoing investment in T&D infrastructure is needed to harden and enhance resiliency and reliability of existing infrastructure against unplanned outages, to adjust to a changing energy mix amidst existing plant retirements, to integrate existing and new DERs into the wider grid to accommodate increasing demands for electrification, and to mitigate existing load congestion. These tailwinds similarly drive increases in UVM budgets, as T&D operators must ensure proper management of expanded T&D infrastructure.

Reliability Improvements[31]

Reliability focuses on assuring day-to-day sustained and efficient system operation. Investments here are intended to improve system reliability and mitigate outages.

The Infrastructure Investment Jobs Act ("IIJA") provides access to federal funding and expertise to "enhance resilience and reliability" of grid infrastructure. The Act includes specific provisions to help T&D owners and operators to research, develop, and execute UVM programming, including:

- Harden T&D Infrastructure:

(§'s 40101 and 40103) Provides funding for R&D and to help execute plans to harden T&D infrastructure, while ensuring the small generators producing less than 4 million MW/hrs receive at least 30% of available funding.

- Mitigate Wildfire's through UVM:

(§ 40803) Provides access to $100 million of direct federal funding to develop and execute wildfire mitigation through UVM, and another $200 million to hire labor to execute that plan.

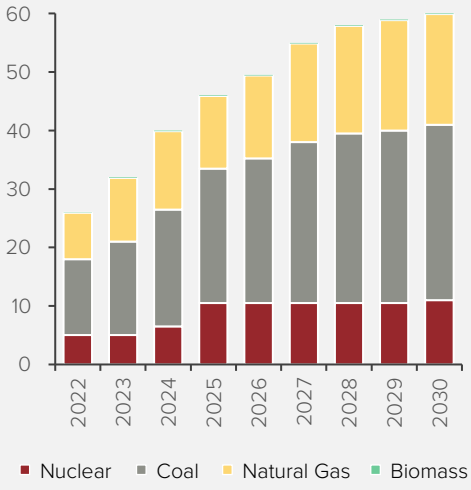
- Ecosystem Restoration:

(§ 40804) Provides $2.1 billion for ecological maintenance and restoration during utility UVM.

Changing Energy Mix

Projected retirements of aging or fossil-fuel-based generators are to be replaced by new or repurposed plants, which will drive expansion of transmission lines. Retiring plants will no longer be available for reliability services to other transmission systems, which will drive expansion of effected transmission systems to close the gap. Similarly, replacement generators in different locations will require new transmission lines to connect to the system.

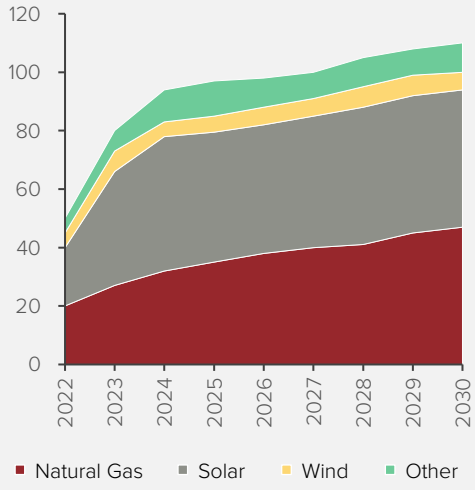
Planned Capacity Retirements by Plant Type[32]
(MW in thousands)



Integration of DERs to the Grid

Projected increasing demand for electricity as the nation's GDP grows and the increasing number of decentralized energy generation sources (including wind, solar, and battery storage) combined drive a need for increased transmission lines to connect these generation sources to the grid. Wind, solar, and natural-gas-fired generation are the overwhelmingly predominant generation types in the planning horizon.

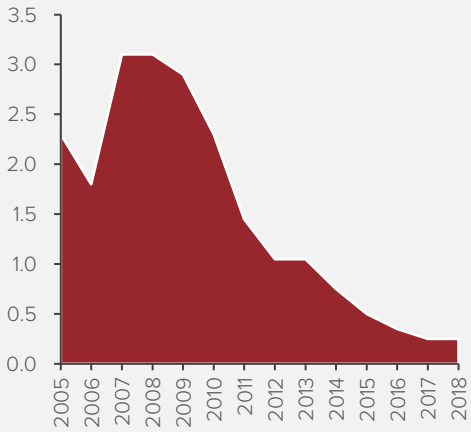
Planned DER Capacity Additions[33]
(000s of MWs)



Improving the Economics of Congestion[34]

Congestion costs are directly decreased by investments that minimize transmission constraints via additional transmission lines or improved capacity. It is estimated that 10% of new transmission line circuit miles are needed to further integrate transmission and distribution lines and alleviate congestion to improve operation economics.

Historical Transmission Load Relief Actions[35]
(No. of relief actions in 000s)



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UVM Service Provider Landscape

Provider	HQ	Sponsor Backed	Services Offered	Customer Base		
				Utilities	Commercial	Residential

Contact Harris Williams for Complete Detail

Service Offering Legend: Pre-Planning & Monitoring | Treatment | Reactive Repair

Key Considerations for Investors

Investment Considerations	Key Characteristics
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[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Contact Harris Williams for Complete Detail

Key Considerations for Investors (cont'd)

Investment Considerations	Key Characteristics
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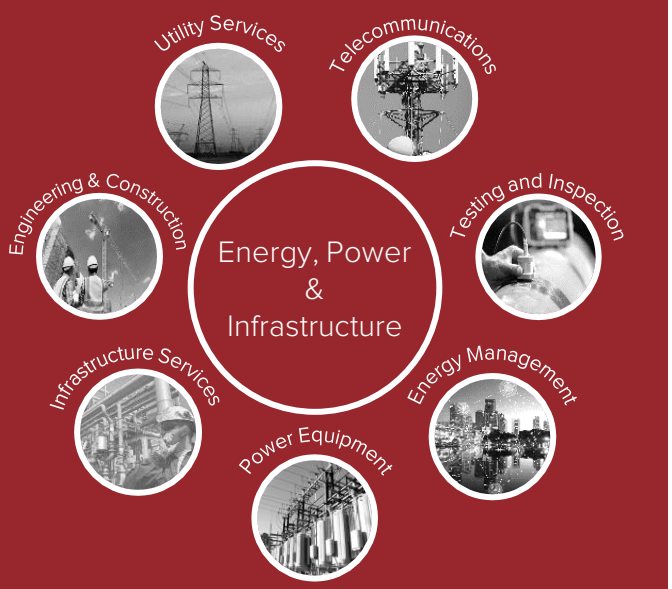
Harris Williams is an Industry Leader in the Utility Services Sector

Energy, Power & Infrastructure Group (EP&I)



Expertise Across the Utility Services Sector

Electric & Gas Infrastructure

- Line Planning & Construction
- Overhead Line Maintenance
- Underground Line Maintenance
- Vegetation Management
- Emergency Response
- Gas Distribution
- Renewables & Distributed Energy
- Electric Vehicle Infrastructure
- Protection & Control Substation Services
- Power Products

Telecommunications

- Installation & Fulfillment Services
- Wireless & Wireline Services
- Tower Design & Engineering
- Data Center Construction & Maintenance
- Tower testing, inspection, repair, and maintenance

Other Focus Areas

- Testing, Inspection, Certification, and Compliance (TICC) Services
- Power Products Manufacturing, Distribution, and Rehabilitation
- Energy Management Services
- Utility Software / Technology
- Environmental Services
- NETA certified electrical testing

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Sector Momentum Keeps Us at the Forefront of the Market

Relevant Experience

- Southwire has acquired Novinium
- Qualtek has merged with Rothchild Acquisition III Co.
- Investcorp has acquired Resa Power
- Owen Equipment has been acquired by Winnchurch Capital
- Riggs Distler has been acquired by Centuri
- Sparus has been acquired by Ridgemont Equity Partners
- tachyon has been acquired by NextEdge Networks
- Qualus Power Services has been acquired by New Mountain Capital LLC
- Artera has acquired [redacted]
- ArchKey Solutions has been acquired by One Rock Capital Partners
- Arcline has acquired NASS EPS
- ADB Companies has been acquired by Warren Equity Partners
- Powerteam Services has acquired Maverge
- Osmose (x2) has been acquired by EQT
- Solomon Corporation has been acquired by Sunbelt Transformer
- Artera (x2) has been acquired by Clayton, Dubilier & Rice
- SavaTree has been acquired by Apax
- Si Structural Industries has been acquired by Gryphon Investors
- USC (x3) has been acquired by Partners Group
- Resco Specialty Rentals (x2) has been acquired by ECP

Industry Content Pieces and Select Deal Snapshots

For M&A investors, 2021 will be a year to remember. How will 2022 stack up? As we head into the new year, Harris Williams Industry Group Heads share their views on which trends will drive growth, key investor considerations, and the opportunities to be found in each of the industries we cover. We look forward to pursuing these opportunities in partnership with our clients in the months to come.

ACCESS INSIGHTS

QUALUS POWER SERVICES
a portfolio company of
MASON WELLS
has been acquired by
NMC
New Mountain Capital LLC

Deal Snapshot: Qualus Power Services (March 2021)

In 2020, we advised a host of utility services companies, including Qualus Power Services, a leading provider of outsourced technical services for utility and power grid substations and infrastructure.

Here, Harris Williams Managing Directors Drew Spitzer and Matt White discuss buyer interest in utility services and what made Qualus a standout target.

The utility services sector remains highly sought after. Our resume across relevant transactions provides a unique perspective across the spectrum.

Our Firm

Harris Williams has a broad range of industry expertise, which creates powerful opportunities. Our clients benefit from our deep-sector experience, integrated industry intelligence and collaboration across the firm, and our commitment to learning what makes them unique. For more information, visit our website at www.harriswilliams.com.

Industry Group Expertise

Aerospace, Defense & Government Services	Business Services	Energy, Power & Infrastructure	Specialty Distribution	Transportation & Logistics
Building Products & Materials	Consumer	Healthcare & Life Sciences	Industrials	Technology

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Endnotes

34. Congestion occurs when transmission constraints (i.e., an element of the transmission system that limits power flows in order to avoid an overload that could cause one or more elements to fail and jeopardize reliability, or an operational limit imposed on a transmission line and its elements) limit the ability of system operators to transfer power in the amounts desired. When a transmission line is overloaded with electric power (i.e., experiences congestion), an IOU will pay power generators to re-dispatch power away from the affected line to maintain system integrity and avoid a line failure—the associated costs are passed on to the end users. The economic impact is the additional cost for generators to re-dispatch power away from the lowest cost dispatch (the original transmission line) in order to respect constraints in the transmission system.

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