Increasing National Undergrounding Trends

ARPA-E GOPHURRS Kickoff Meeting

Charlotte, NC

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The **mission** of **PDi2** is to increase awareness about options for underground power infrastructure. We will use data to provide objective means to evaluate when and where undergrounding makes sense.

Objectives

- Help utilities justify investment decisions based on data-driven lifecycle cost analysis
- Educate stakeholders on all technology and construction options to determine the most viable, reliable and cost-effective solution for the installation of transmission and distribution systems when evaluated via lifecycle cost analysis
- Convey qualitative and quantitative value of underground to all stakeholders
- Develop common methods by which cable systems can be evaluated from both a utility and public value perspective
- Communicate the methodology to utilities, individual state utility commissions and other influencers
- Actively promote developed models as an enabler for grid extension in North America with all members of the value chain – including utilities
- Influence more actively as part of the North America power industry

Scope

- Geography: priority is North America
- Modeling data will help drive focus areas
- Initially focus on new infrastructure, then existing/rehabilitation projects
- Initiate modeling projects that consider:
  - Population density
  - Areas prone to storms/repeated outages
  - Land values
  - Growing economic regions
  - Political climate

Overhead & Underground System Comparisons

Overhead

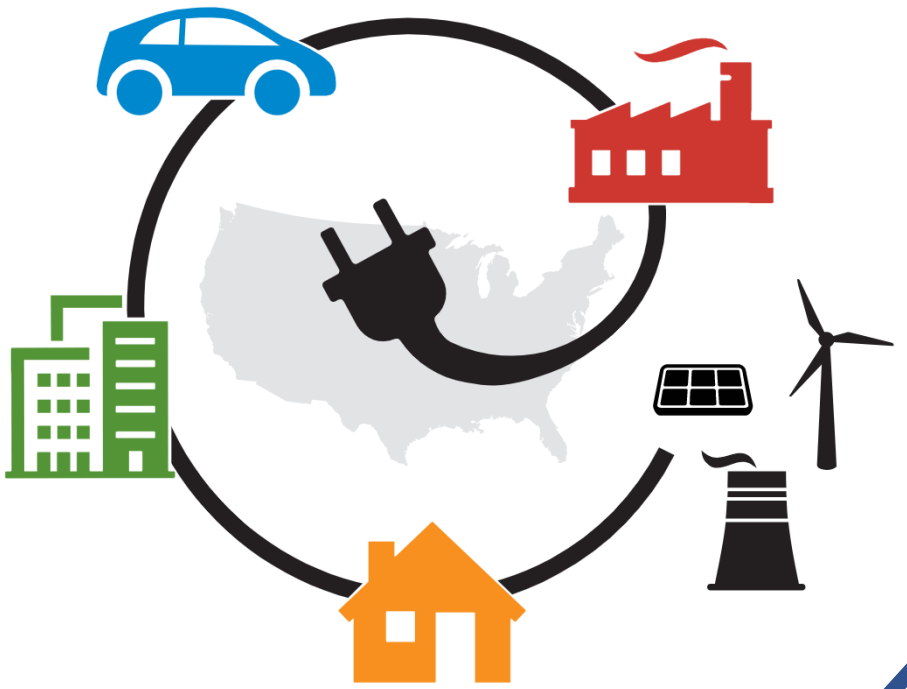
- Initial cost typically lower*
- Easy to inspect
- Higher power capacity for longer distances
- Wider right-of-way
- Quicker to upgrade
- Best option in challenging locations such as mountains

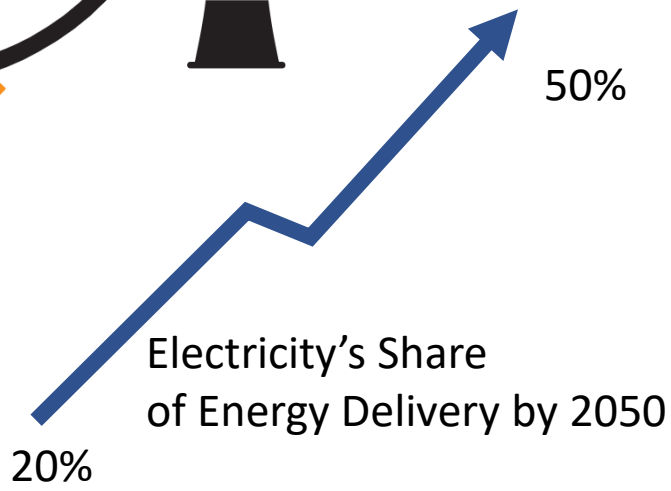
Underground

- Commissioning & protection enable longer service life
- More reliable, safer, & lower maintenance cost
- Better usage & value of real estate
- Technology provides detailed inspections
- Lower lifecycle cost
- Permitting is easier & faster with quicker return

**** This is dependent on many factors. Greenfield URD & secondary UG costs are often lower.***

Increased Electrification





Princeton University Study Prediction

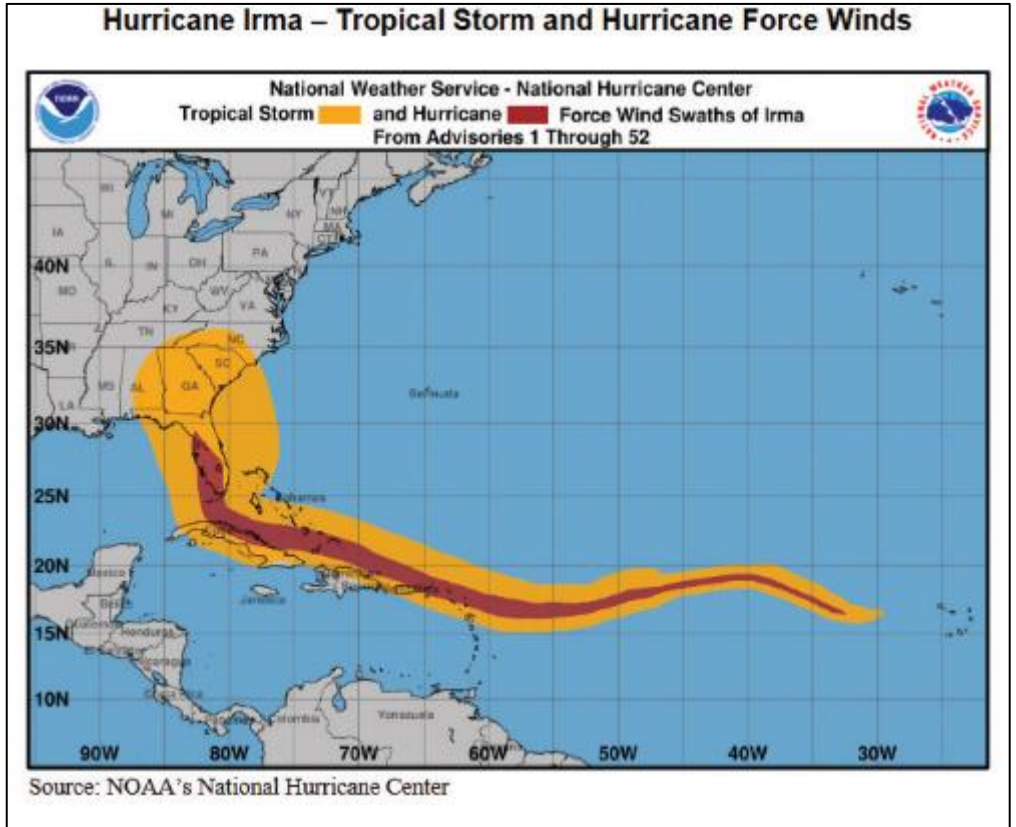
State GDP Impact

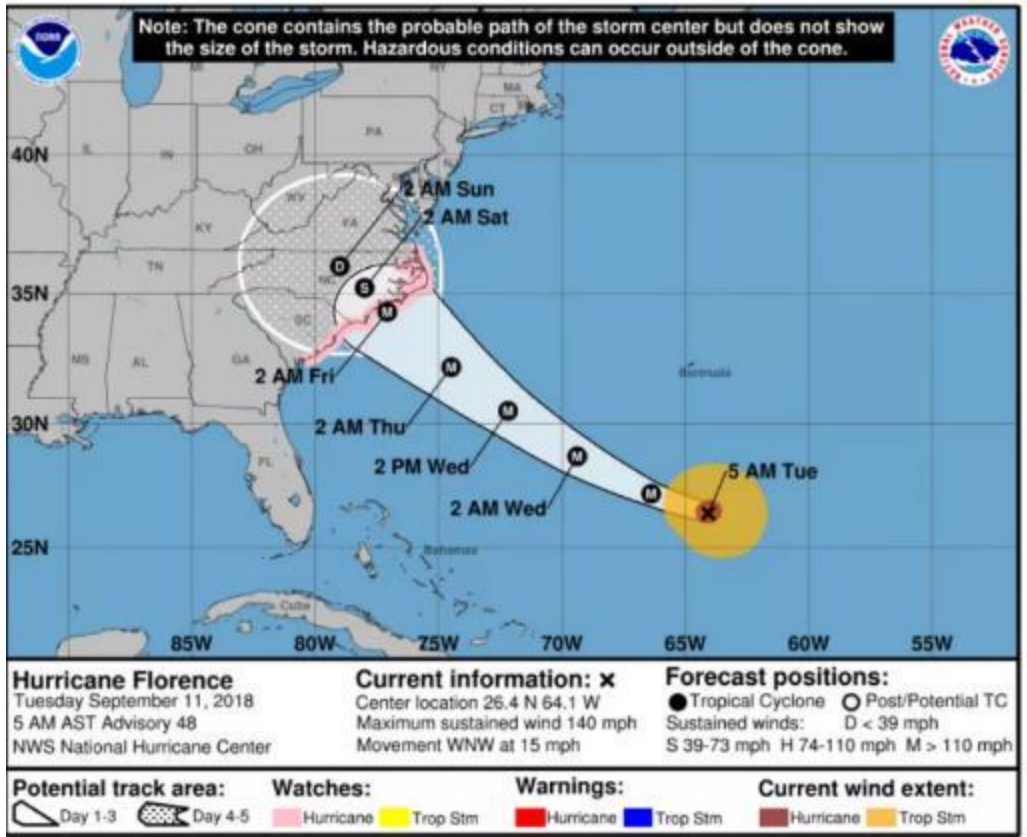
Florida GDP $3.7B/day

Virginia GDP $1.8B/day

https://usafacts.org/metrics/gross-domestic-product-gdp-by-state-florida/

https://usafacts.org/metrics/gross-domestic-product-gdp-by-state-virginia/





Weather vs. Aged Infrastructure

Utilities generally agree:

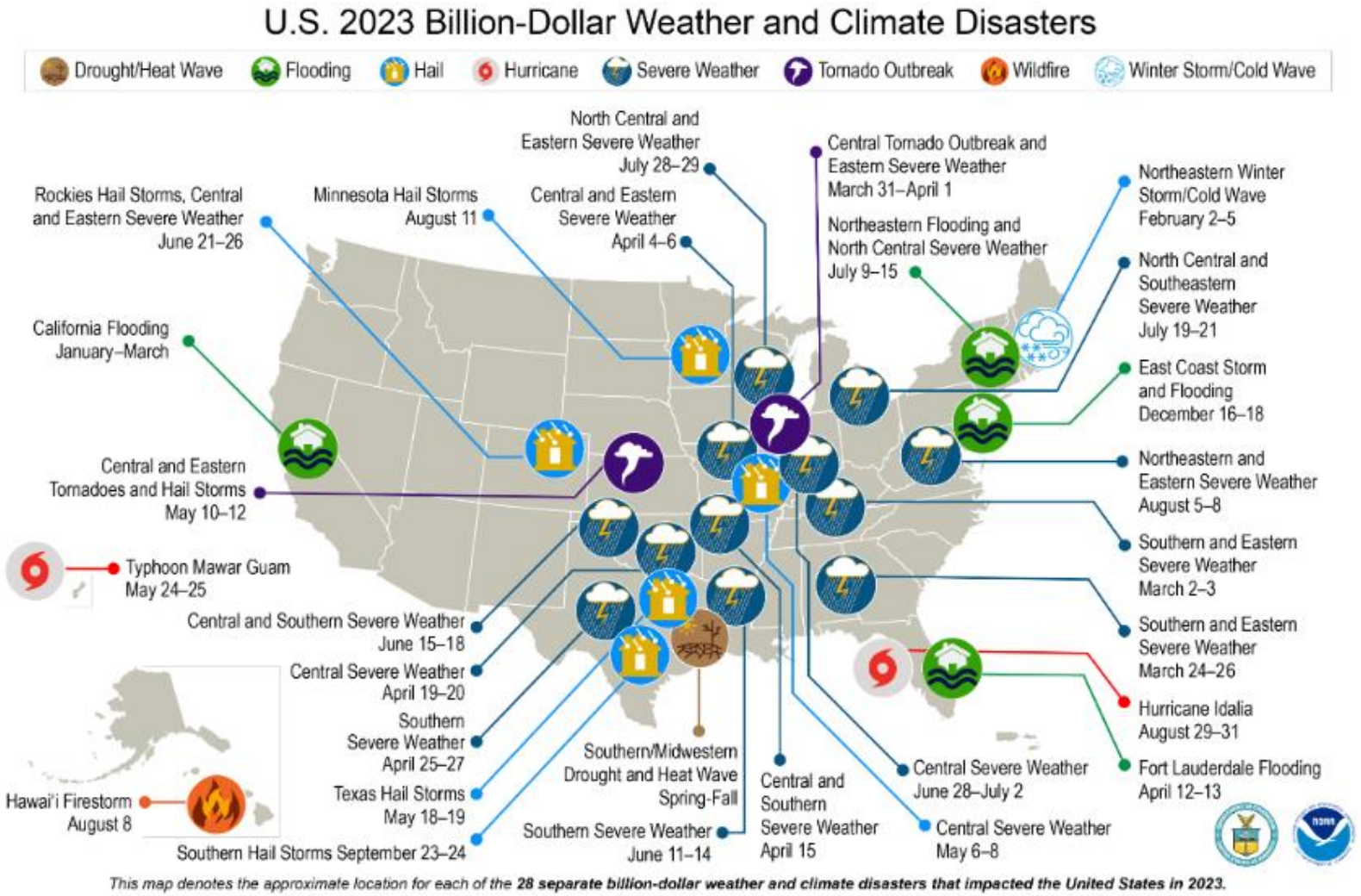
Utility 1: 76% of outages are attributed to weather, fallen trees & aging equipment

Utility 2:

- Hurricane: ~90% of 1.4 million customers out: “power lines and poles downed by wind-blown trees and broken transformers”
- Severe weather is the leading cause: lightning, strong winds, ice and snow, floods, coastal salt contamination, and trees.

Utility 3: Weather is the leading cause of power outages. High winds, lightning, ice and snow, and trees.

Billion-Dollar Events: 20 per Year

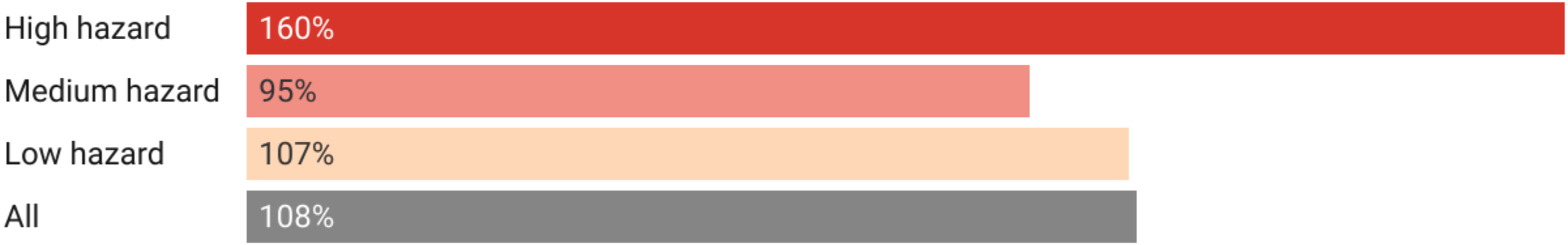


NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Severe Weather Events https://www.ncdc.noaa.gov/billions/

Population Safety/Movement

Population growth in the wildland-urban interface

The number of people in the wildland-urban interface, where development and wilderness meet, expanded disproportionately in areas facing the highest wildfire risk from 1990 to 2010.



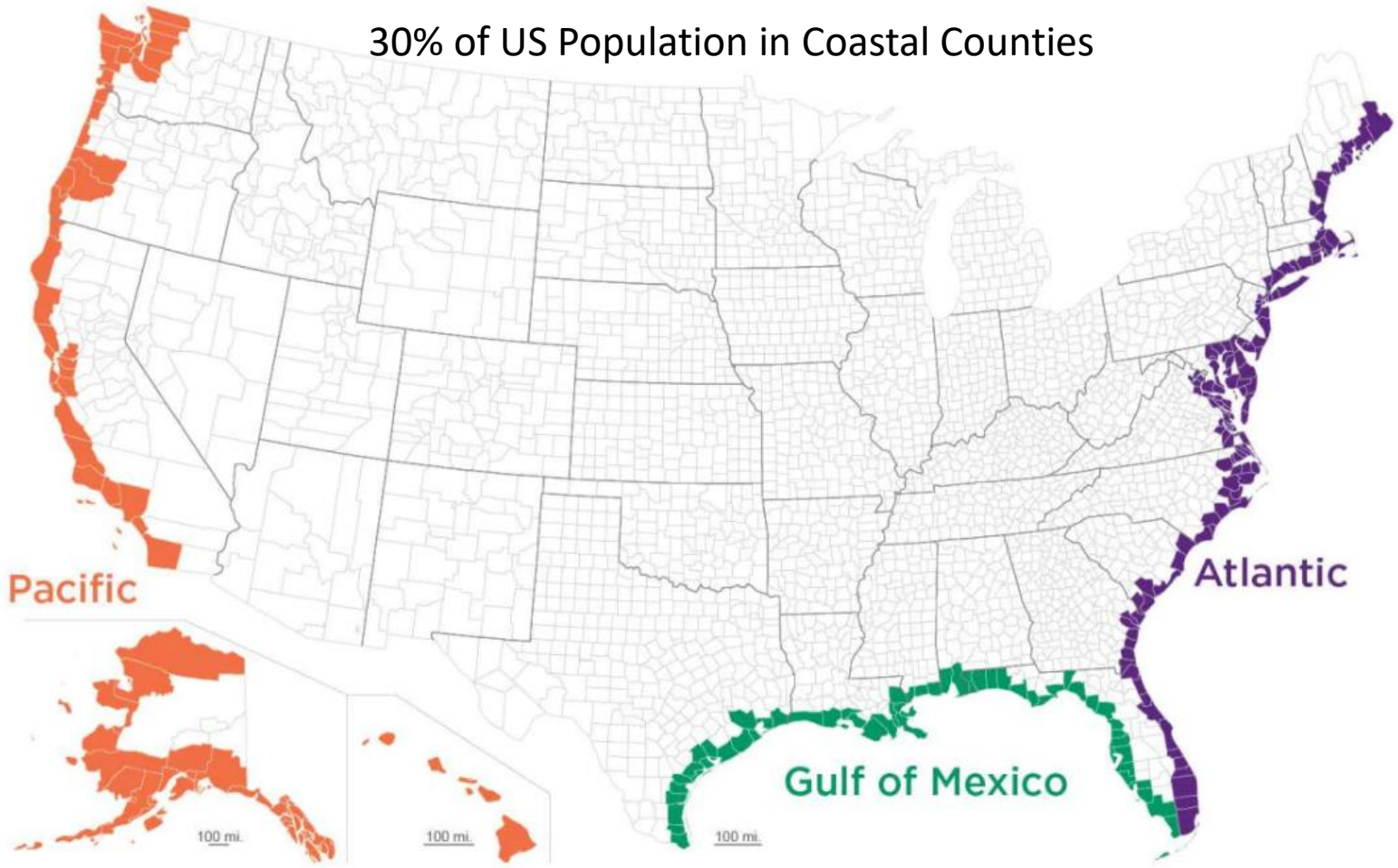
Data shows population growth from 1990-2010.

Chart: The Conversation/CC-BY-ND • Source: Krisha Rao, 2021

https://theconversation.com/the-fastest-population-growth-in-the-wests-wildland-urban-interface-is-in-areas-most-vulnerable-to-wildfires-173410#:~:text=The%20wildland%2Durban%20interface%20population,hazard%20regions%20grew%20by%20160%25.

Population Safety/Location

30% of US Population in Coastal Counties

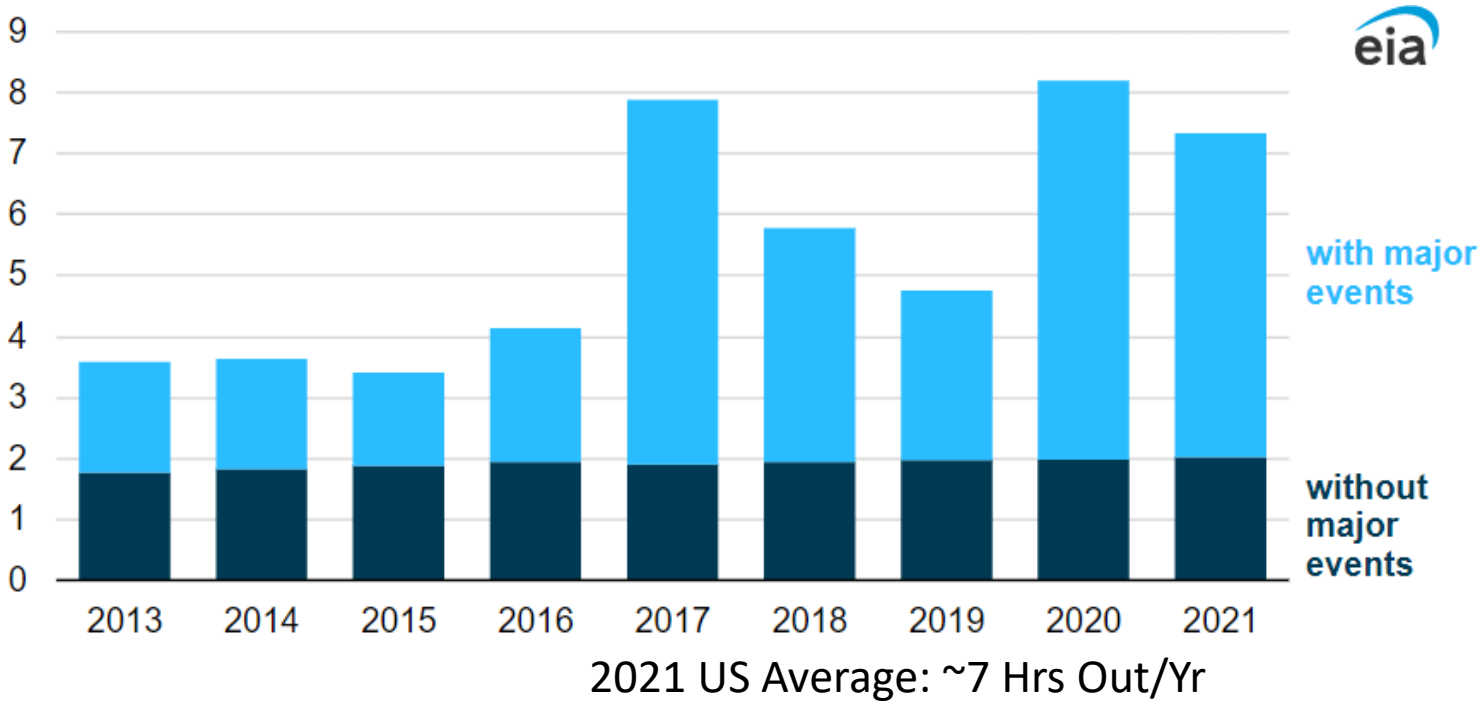


List of coastline counties: <www2.census.gov/library/stories/2018/08/coastline-counties-list.xlsx>.
Source: U.S. Census Bureau.

https://www.census.gov/content/dam/Census/library/visualizations/2019/demo/coastline-america.pdf

Reliability vs. Resiliency

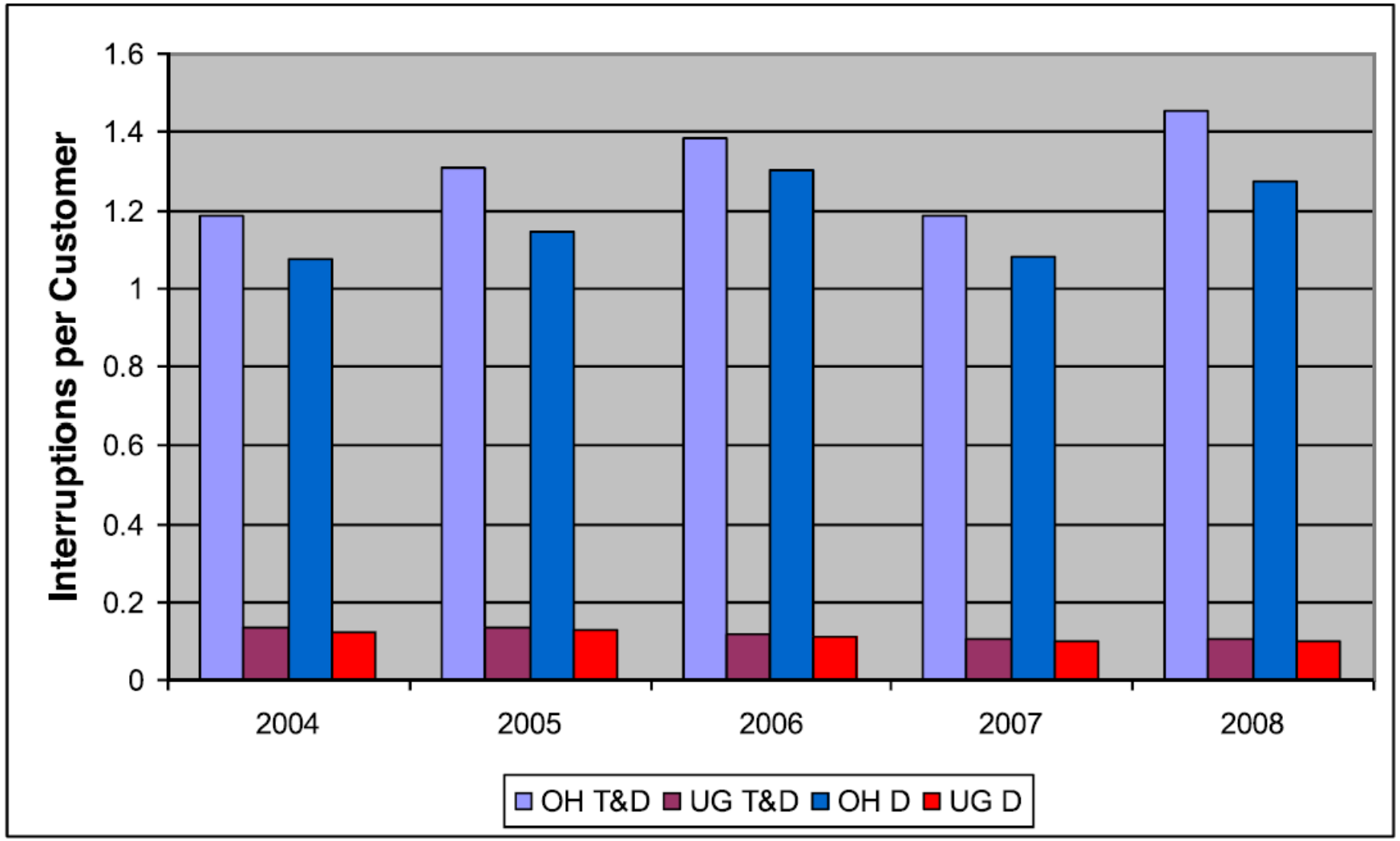
- Reliability 99.97% per Galvin Electricity Initiative
- Resiliency Withstand High Impact Low Probability (HILP) event with little or no customer outage
  Total Time of Line Restoration (TLR)



2021 US Average: ~7 Hrs Out/Yr

US EIA Annual Electric Power Industry Report

OH vs. UG Failure Data



OH 1.2+

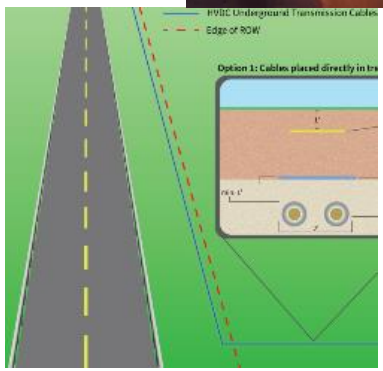
12X

UG 0.1

Edison Electric Institute (EEI) Out of Sight, Out of Mind Revisited 2009 Survey of Investor-Owned Utilities (IOU) Figure 3.3 System Average Interruption Frequency Index (SAIFI), page 13

Technology & Method Options Are Good

- 100-year+ cable life with proper duty management
- Robust standards & testing: design, manufacturing, interchangeability, installer training, tools & field QC methods
- GIS databases & ROW mapping (Theray.org/PDI2 collaboration)
- Continuously improving & new trenchless technologies
- Precise underground mapping, 3D CAD & augmented reality (AR)
- Increasing voltage class “oil free” designs for both AC & DC cable systems: cable, equipment & accessories; green dielectric oils & new designs such as XLPE HPFF replacement cables
- Longer pulling lengths, improved direct burial methods & component designs, and more conduit choices
- Monitoring: DTS, DAS, AI line sensing & line scanning condition assessment



Reliable Renewables?

- Connect renewables to the grid in general
- Connect these new generation sources to load across long distances
- Synergize solar & wind intermittency with long duration storage, dispatchable options – dams, pump storage, BESS, hydrogen, etc.
- Neptune RTS – 65 miles subsea
- Champlain Hudson Power Express – 339 miles
- SOO Green HVDC Link – 350 miles
- Cascade Renewable – 100 miles

https://www.rechargenews.com/wind/monumental-step-construction-starts-on-giga-scale-canada-to-us-clean-power-trunk-line/2-1-1364158

https://www.rtoinsider.com/29310-new-york-start-building-big-2022/

https://www.27east.com/east-hampton-press/27speaks-turn-turn-turn-south-fork-wind-activates-first-turbine-2222780/

Why Underground?
Lifecycle Analysis Inclusion

10X Reliability & Resiliency

Capital Investment Consistent Rate of Return

Stable Rate Base Growth

Minimal Vegetation Management

10X O&M Elimination

10X Safety Improvement

Tech Improvement & Long Life

GDP/Tax Revenue Protection

Faster Permitting & $ Returns

Power Delivery Intelligence Initiative

2022 Public Utilities Fortnightly Research Report

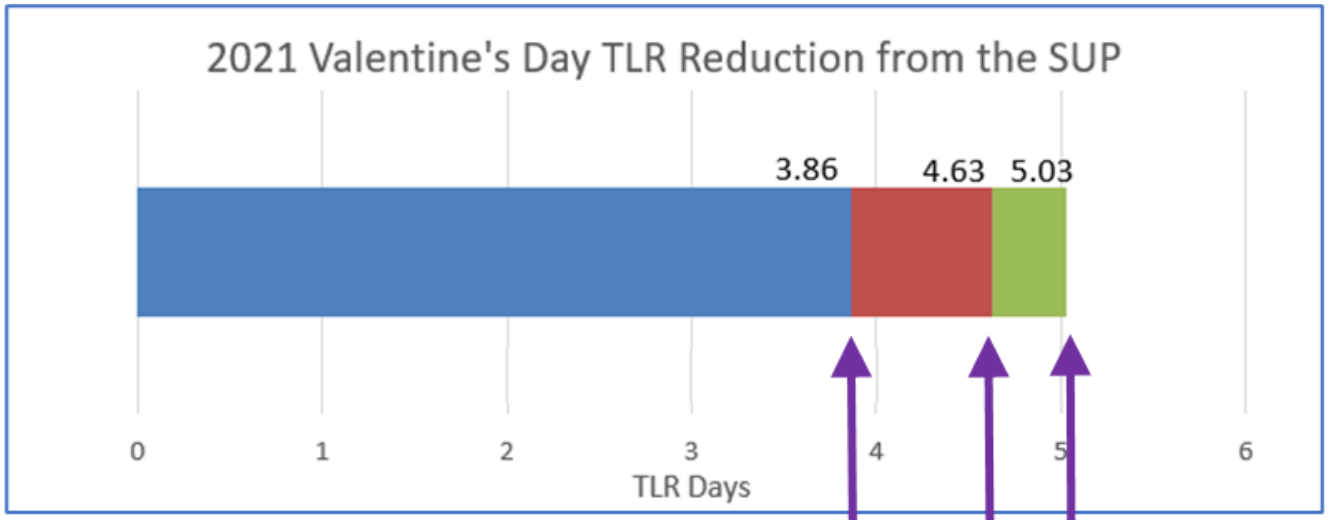
Large Strategic Undergrounding Programs

WEC Energy
Strategic Undergrounding Program

- Customer survey: Vast majority willing to pay more for underground
- 8 yr ~$500M, 2,200mile UG program
- Automation on 400 OH miles
- $4.30/month (5%) increase
- 2% CMI improvement with automation
- 97% reduction in CMI overall

Dominion Energy SUP Case Study

- Virginia GDP $1.6B/day - Legislative rider supporting cost
- ~$2B/4,000 mile strategic undergrounding program (SUP)
- Goal, 50% Total Line Restoration (TLR)



TLR=Total Length of Restoration

TLR if All SUP was Completed

Actual TLR

TLR with No SUP Program

FPL Undergrounding & Hardening Program

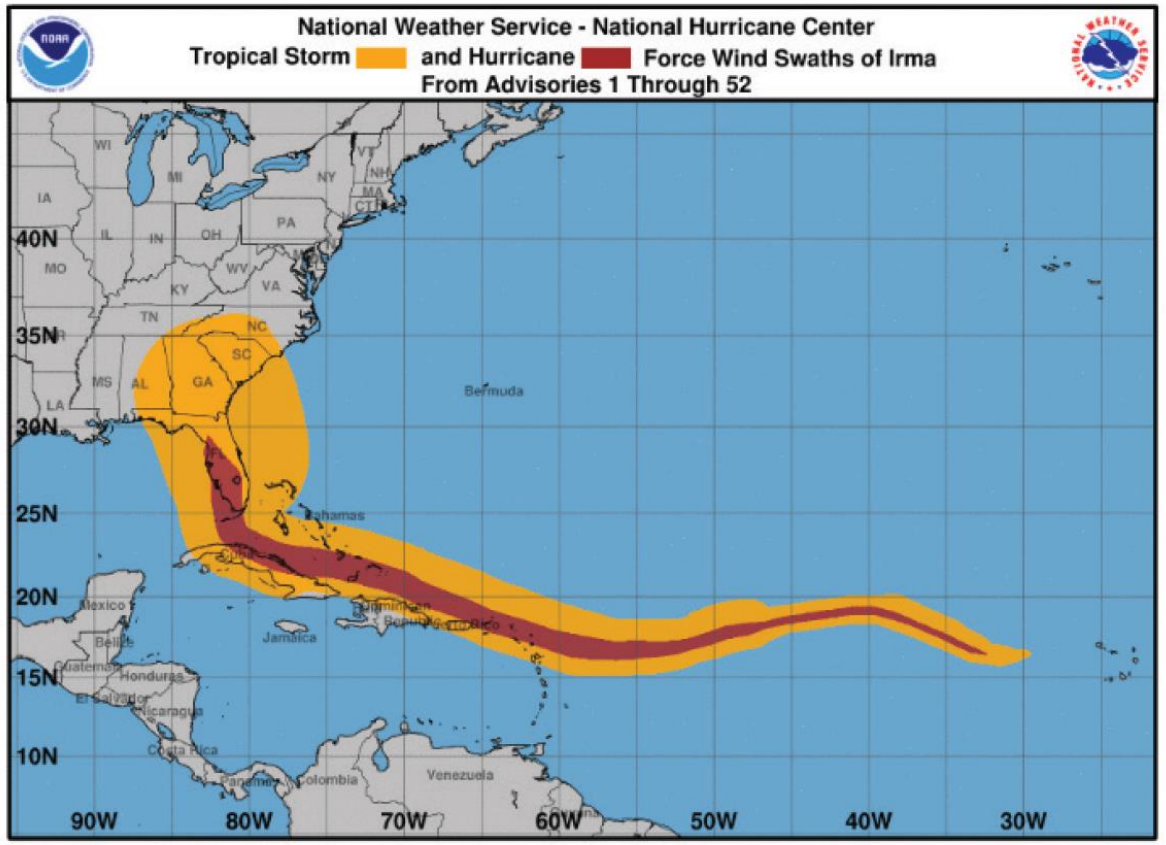
- State GDP $3.2 billion/day
- Feeders upgraded to concrete poles
- ~10yr/$20 billion URD program
- Undergrounding 5k miles by 2032
- Undergrounding all 27k miles of OH URD

Undergrounding Pilot Results

FPL Outage Rates for Facilities Impacted by Hurricane Irma

	Transmissions	Distribution feeders	Distribution Laterals
Overhead, Non-hardened	20%	82% ◀	24% ◀
Overhead, Hardened	16%	69% ◀	N/A
Underground	---[7]	18%	4% ◀
		16% ◀ Reduction	83% ◀ Reduction

Hurricane Irma – Tropical Storm and Hurricane Force Winds

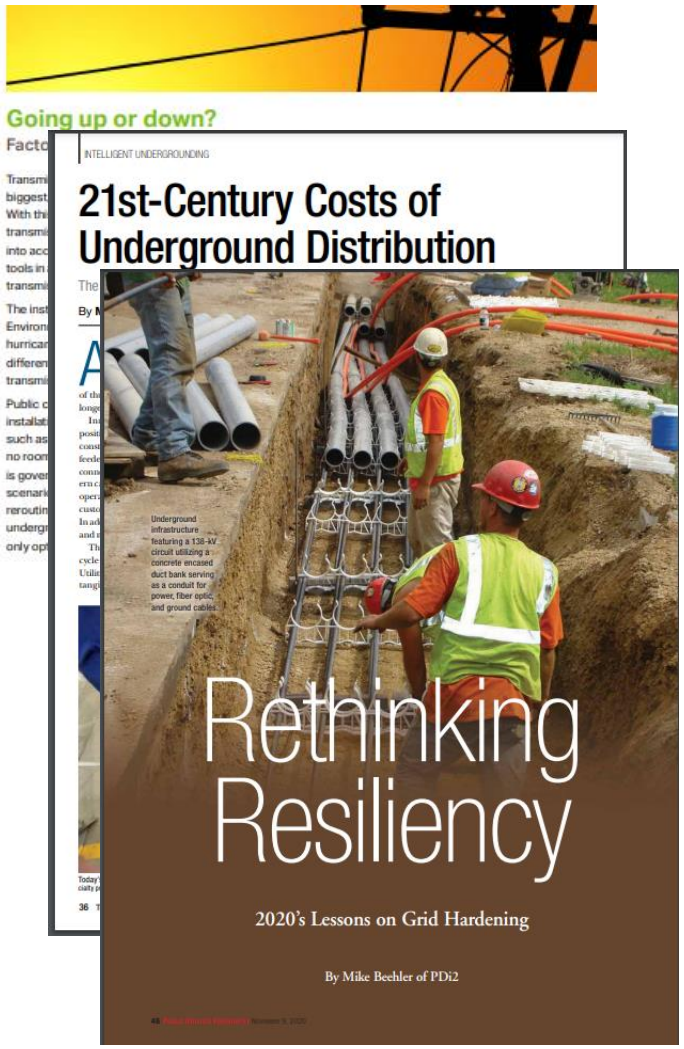


Source: NOAA's National Hurricane Center

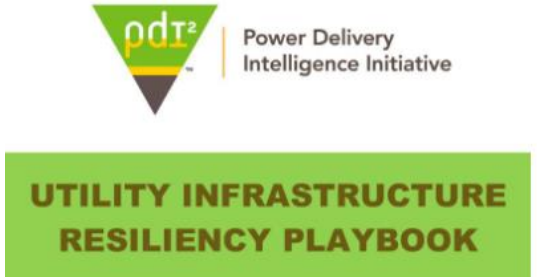
Summary: Why Undergrounding Is Trending Upward Nationally

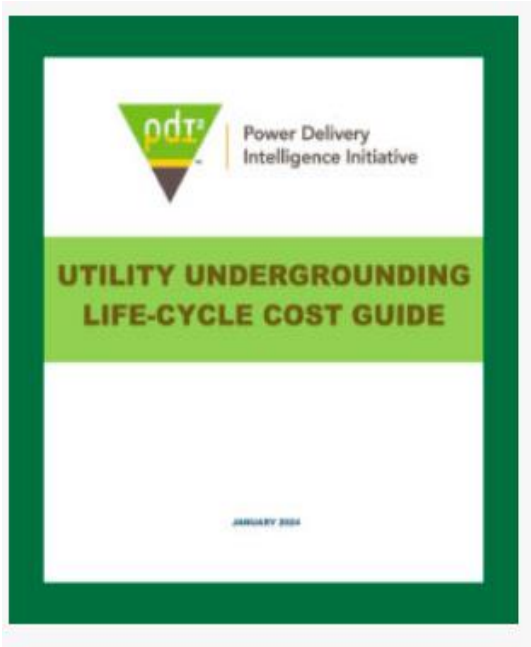
- Drivers: Electrification, Location, Safety, Weather, Total Owning Cost (TOC) & System Hardening
- Customers live in high-risk areas, want safer/more resilient grid & are willing to pay for it
- Regulatory bodies support equitable investments impacting GDP, total restoration time, and yielding stable rate increases
- Utility executives & Wall Street want opportunities to invest billions w/ guaranteed rate of return & eliminate O&M
- Technology and scale are driving UG costs down
- Materials, manufacturing, and factory comparable QC field testing are greatly improved allowing cable systems to live 2 to 3 times longer than wood pole supported assets
- Lifecycle total cost of ownership calculations are showing UG assets outperforming OH in more cases

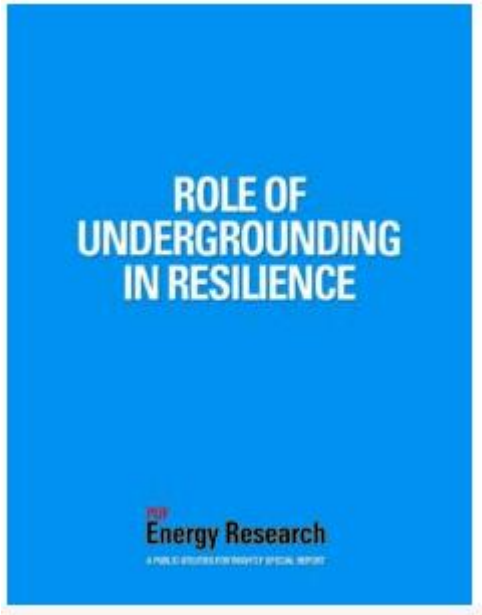
PDI2.org Complimentary Educational Resources



- Papers & Articles
- Research
- Network of Experts
- Videos Interviews
- Recorded Webinars







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