Day 1: Undergrounding Technical Workshop

What is Happening Now?

September 17, 2025

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Introduction – U-21388

Late-March 2025

Storm
Ice Storm Hits Northern Michigan

May 21, 2025

Public Forum
Town hall in Gaylord where undergrounding emerged as a key theme

June 12, 2025

Order
Staff to 1) conduct undergrounding workshop and 2) issue report with recommendations

Sept. 2025

Workshops
Staff lead workshops on September 17 and 19

Oct. 31, 2025

Staff Report
Staff to file a report with recommended next steps

Note: Staff explored undergrounding in U-15279 (2007) and issued a report indicating that the reliability benefits of undergrounding are uncertain and did not compare favorably to the costs.

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Agenda

What Is Happening Now?		
12:30-12:45	Welcome & Introduction	Katherine Peretick, MPSC Commissioner
12:45-1:00	Michigan's Electric Grid: Reliability, Spending, & Utility Audit Overview	MPSC
1:00-1:15	Storm Activity & Commission Efforts in Michigan	MPSC
1:15-2:00	Extreme Weather Data	Tom Wall, Argonne National Laboratory
2:00-2:30	Reliability Improvements from Undergrounding	Luke Dennin, MPSC
2:30-2:45	Break	
2:45-4:15	Hybrid Panel Undergrounding in Michigan: Utility Perspective & Efforts Underway Moderator: Olivia (Li) Szilagyi, MPSC	Michael Kelly, Consumers Aaron Balch, DTE Ken Dragiewicz, Alpena
4:15-5:00	Undergrounding Transmission: Community Engagement, Permitting Considerations, & Economics	Josh Rogers, GPI Raj Rajan, SOO Green HVDC Link
	Closing	MPSC

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Housekeeping

- Meeting is Recorded

- Workshop Format
  - Questions and discussion at the end of presentations
  - Raise hand feature through Teams in the order received (primary)
  - Questions in the chat (secondary)
  - Presenters may follow up with questions not answered

- Please Mute Unless You Are Speaking

Michigan's Electric Grid: Reliability, Utility Audit, & Spending Overview

MPSC Case U-21388:
Undergrounding Workshop

Tayler Becker
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September 17, 2025

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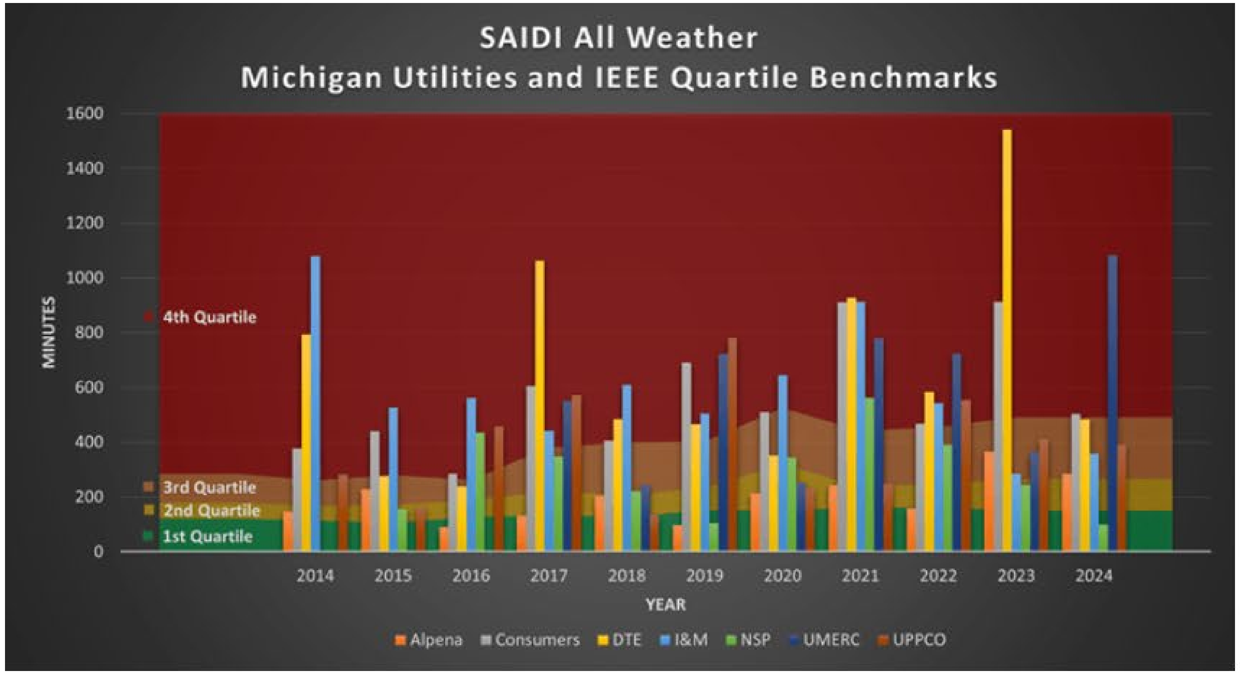
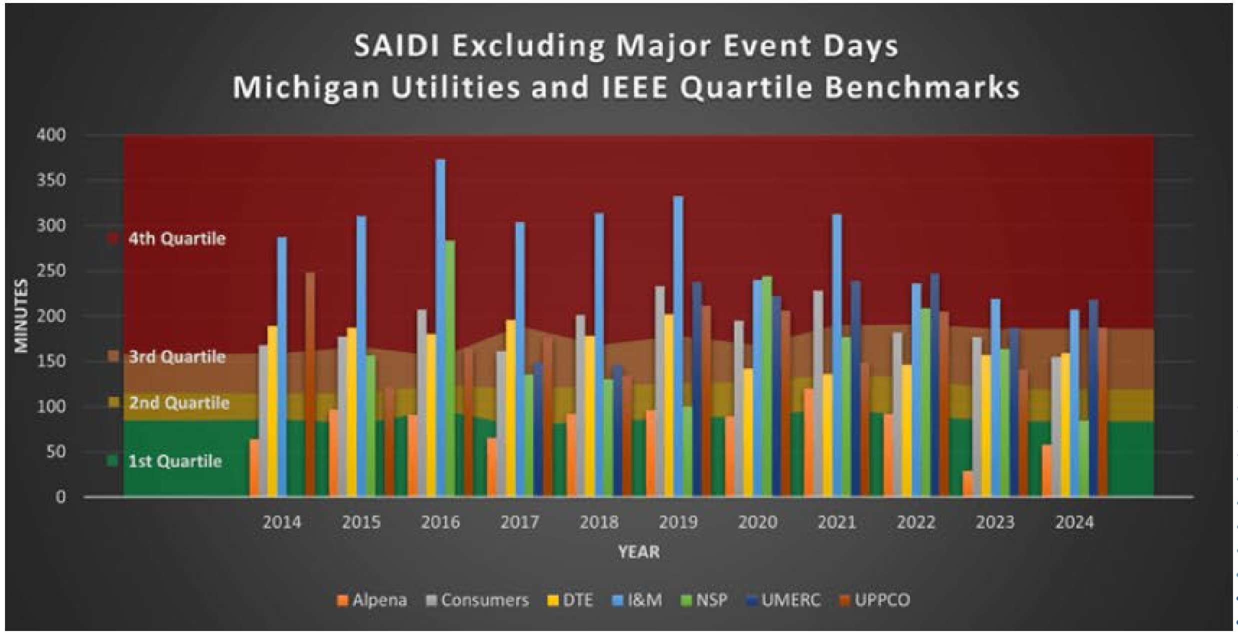
MPSC Distribution Reliability Webpage

- MPSC Case No. U-21122 - Accessibility and Transparency Through Monthly Data Submissions
- MPSC Reliability Metrics and Data Webpage
  - Review data
  - Request data
  - Download data
- Applies IEEE Distribution Reliability Working Group Benchmarking

Reliability - SAIDI

- **System Average Interruption Duration Index (SAIDI)** – represents the total number of minutes of interruption the average customer experiences
- Most Michigan Customers Experience 3rd – 4th Quartile SAIDI





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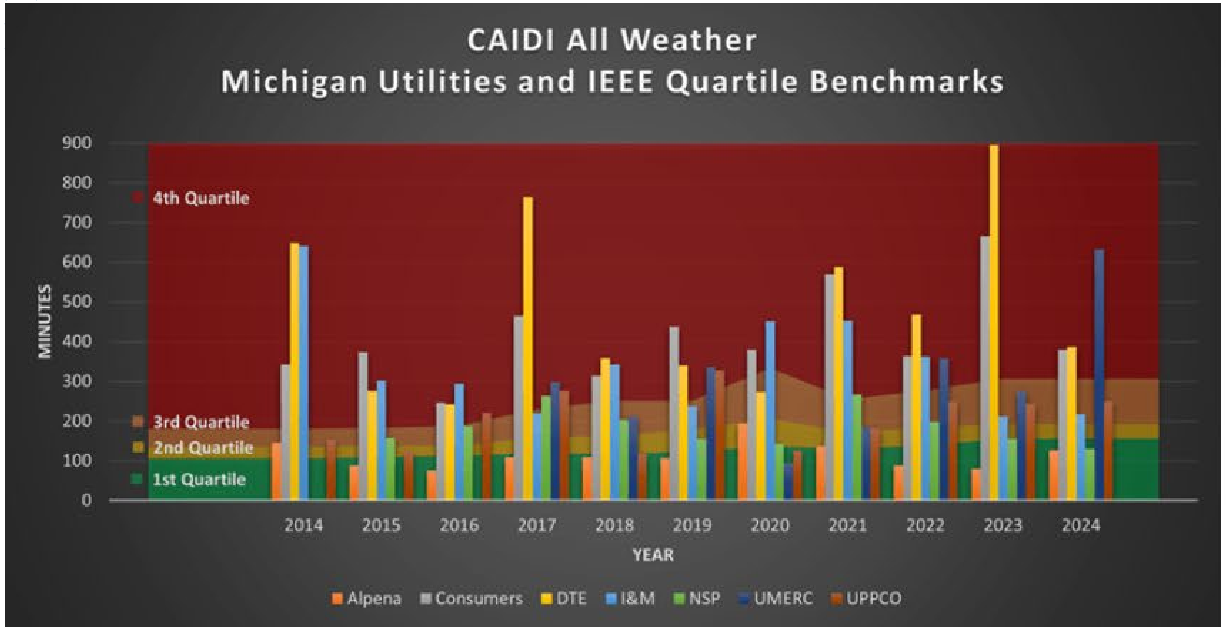
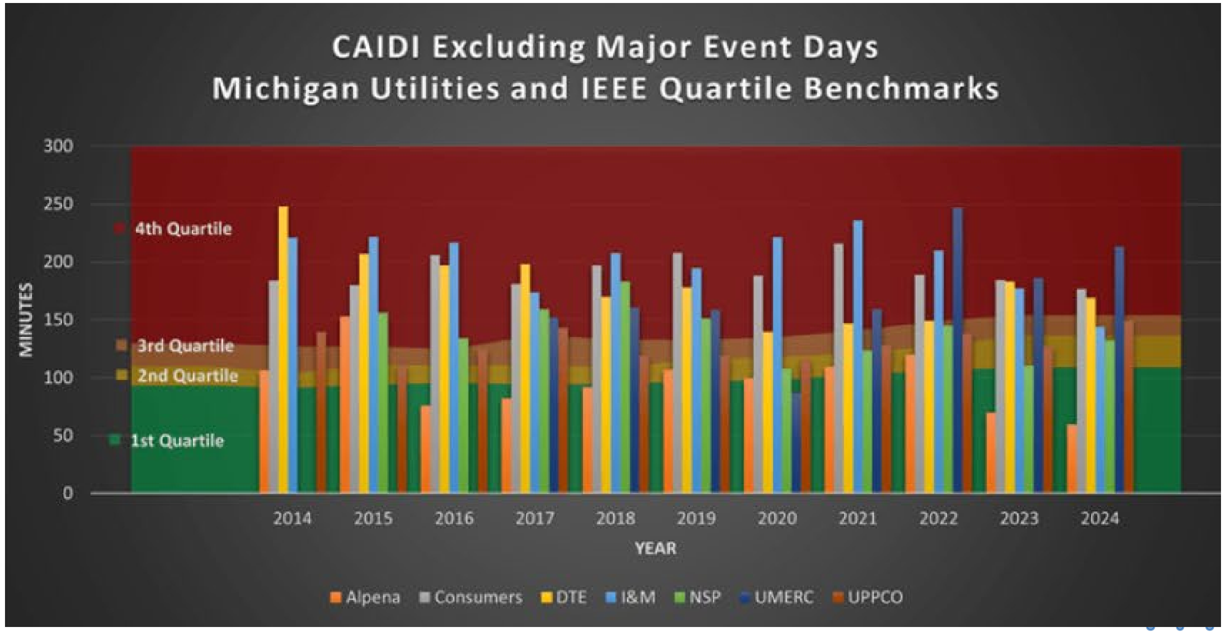
Reliability - CAIDI

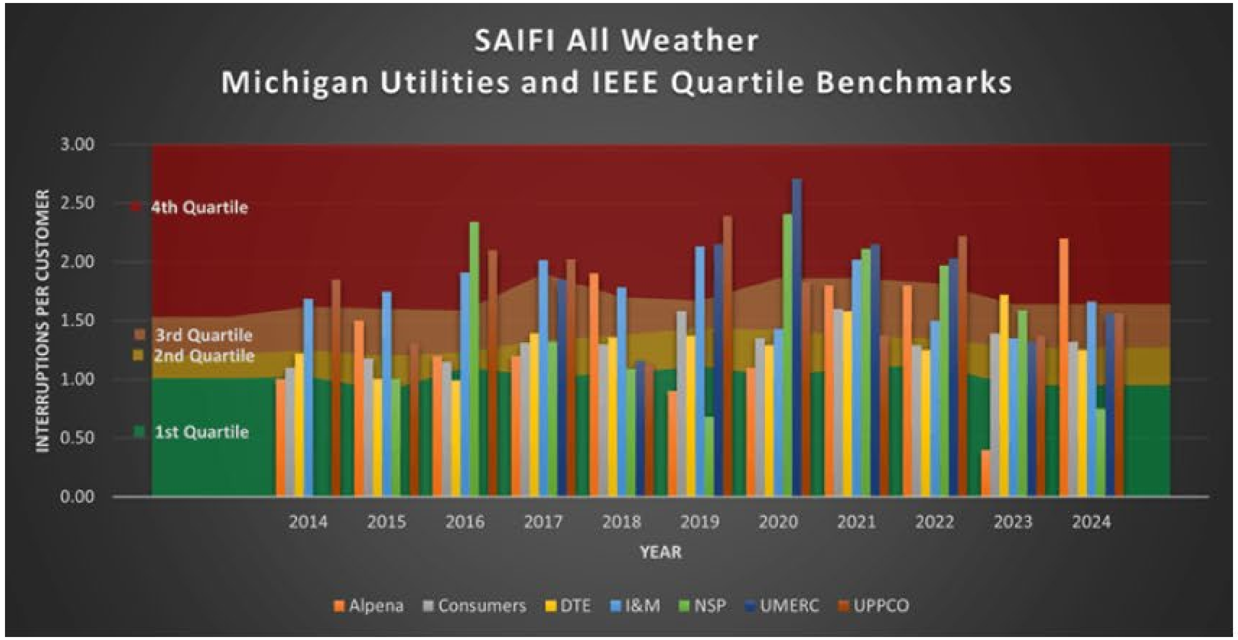
- **Customer Average Interruption Duration Index (CAIDI)** – represents the average time required to restore service
- Most Michigan Customers Experience 3rd - 4rd Quartile CAIDI

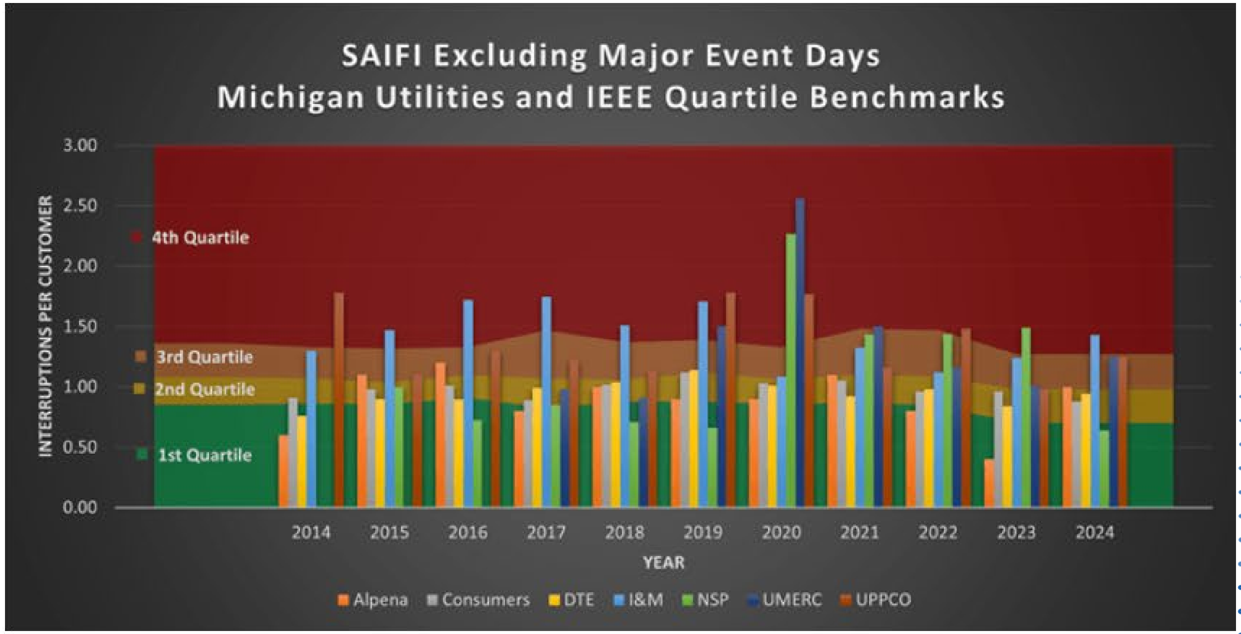




Reliability - SAIFI

- **System Average Interruption Frequency Index (SAIFI)** – represents the average number of times a customer experiences an outage
- Most Michigan Customers Experience 2nd – 3rd Quartile SAIFI





Utility Audit – U-21305

- October 5, 2022 Commission Order in MPSC Case No. U-21305
  - August 29, 2022 Wind Storm
  - Fatal and critical injuries
  - 3rd party review of DTE and Consumers electric distribution systems.
    - Part 1 – physical audit
    - Part 2 – program and process audit
- September 23, 2024 Liberty Reports Issued
- June 12, 2025 Commission Orders (DTE and Consumers)

Reports

DTE Part 1, Part 2

Consumers Energy Part 1, Part 2

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Utility Audit – Undergrounding

Comparison of Circuit Miles in Service Territory

Circuit Miles	Consumers	DTE	AIC	ComEd	LBWL
Overhead Distribution Miles	51,574	28,548	32,048	34,648	2,126
Overhead Distribution %	84%	687%	82%	52%	70%
Underground Distribution Miles	9,630	13,357	7,311	31,982	919
Underground Distribution %	16%	32%	19%	48%	30%
Total	**61,204**	**41,905**	**39,359**	**66,630**	**3,045**
Service Territory (square miles)	28,300	7,600	67,700	11,428	97

DTE Part 1, page 55 & Consumers Part 1, page 47

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Utility Audit – Undergrounding Quotes

- “DTE has **twice** the overhead distribution circuit miles compared to underground circuit miles. However, the operations and maintenance costs for overhead circuit operations and maintenance proved **12 times** that for underground circuits. DTE’s O&M spending for distribution overhead lines has increased significantly over the last four to five years while underground line O&M has remained constant.” (DTE Part 1, page 3)
- “Benchmarking also indicates that large scale programs produce cost efficiencies and that undergrounding **single phase laterals proves less costly**, given the standards required for three-phase and backbone circuits.” (DTE Part 2, page 82)

- “Consumers spends approximately **5 percent** of its electric LVD maintenance spending on underground facilities which comprise approximately **13 percent** of the LVD system. Consumers spends approximately **98 percent** of service restoration costs on overhead facilities which comprise **87 percent** of its LVD system.” (Consumers Part 1, page 3)
- “Consumers O&M spending for distribution overhead lines has **increased significantly** over the last four to five years while underground line O&M has remained constant”. (Consumers Part 1, page 3)
- “Historic cost differences between overhead and underground construction have traditionally militated strongly against undergrounding, except in special circumstances, although, undergrounding use is expanding as a resiliency measure.” Consumers Part 2, page 70)

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Utility Audit – Line Clearing and Storm Spend

Changes in DTE O&M *(millions)*

Category	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Regional Customer Operations	$50.4	$54.9	$57.8	$57.4	$50.4	$50.8	$50.8	$52.4	$70.7	$65.5
Substations	$30.1	$34.1	$31.7	$30.8	$29.5	$27.4	$24.5	$20.6	$24.2	$17.5
System Operations	$18.6	$20.0	$9.3	$9.3	$10.7	$9.6	$12.0	$8.1	$8.3	$6.8
Storm & Storm Functions*	$107.5	$44.8	$44.4	$69.8	$51.5	$50.2	$46.5	$79.7	$59.9	$183.8
Engineering	$16.2	$15.6	$13.4	$13.8	$15.5	$14.3	$11.7	$11.1	$12.7	$8.7
Customer Excellence Tree Trim**	$0.0	$0.0	$0.0	$0.0	$0.0	$0.8	$6.0	$0.2	$0.1	$0.1
Scheduling & Coordination/Miss Dig	$5.2	$4.6	$4.6	$4.6	$5.9	$6.2	$6.0	$8.1	$7.2	$8.8
Operational Technology	$0.0	$0.5	$0.8	$2.1	$3.3	$3.3	$3.4	$2.8	$1.9	$3.6
Customer Trans/Automation***	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$7.4	$3.3
VP Staff	$2.1	$4.0	$3.5	$2.8	$3.9	$3.1	$3.7	$3.7	$6.0	$2.8
Inventory Reserve	$0.5	$0.7	$5.6	$0.5	$2.2	-$1.1	$2.9	$5.0	$4.1	$1.9
Canceled Capital Projects	$0.0	$0.0	$3.5	$2.8	$2.8	$1.1	$3.0	$2.0	$1.3	$3.2
Telecom	$6.4	$5.3	$4.5	$4.9	$5.6	$6.0	$7.1	$7.6	$7.8	$7.6
Accounting Transactions	-$4.1	$3.4	$5.4	-$0.2	-$0.2	$0.0	$0.0	$0.0	$0.0	$0.0
Tree Trim	$35.4	$57.0	$74.2	$84.3	$89.1	$152.6	$178.7	$180.4	$250.9	$174.5
Total	**$268.3**	**$244.8**	**$258.8**	**$282.7**	**$270.1**	**$324.5**	**$356.3**	**$381.8**	**$462.6**	**$488.1**

Changes in Consumers O&M *(millions)*

Category	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
O&M Assoc w/Construction	-$2.0	-$1.8	$1.1	-$2.5	$0.9	-$1.7	$0.0	-$0.3	$0.0	$0.0
Non-Forestry Reliability	$4.5	$3.1	$3.1	$3.2	$3.8	$3.4	$4.2	$5.4	$6.4	$6.2
Forestry Reliability	$40.4	$37.3	$50.9	$50.3	$52.4	$53.6	$55.9	$86.6	$102.0	$109.1
Ops, Mtc & Mtr w/o Svc Rest	$49.0	$42.7	$33.6	$32.9	$35.6	$33.2	$28.8	$35.8	$35.7	$34.7
Service Restoration	$47.0	$38.2	$35.5	$50.2	$53.9	$92.1	$71.3	$159.7	$113.3	$188.0
Field Operations	$22.6	$25.6	$22.5	$27.1	$29.7	$26.9	$22.7	$31.2	$36.4	$31.1
Compliance and Controls	$0.0	$0.0	$0.0	$0.0	$0.0	$0.5	$1.4	$1.7	$1.7	$1.2
Operations Performance	$5.7	$3.8	$4.8	$7.9	$8.0	$7.0	$5.7	$4.0	$6.8	$3.9
Operations Management	$9.5	$7.4	$7.6	$6.5	$6.8	$5.7	$6.1	$7.3	$9.5	$7.4
Unallocated	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Total	**$176.7**	**$156.3**	**$159.2**	**$175.5**	**$191.2**	**$220.8**	**$196.1**	**$331.4**	**$311.7**	**$381.6**

Data indicates two key drivers in the growth of O&M expenditures in last five-years

1) Tree Trimming
2) Storm Restoration

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Utility Audit – Recommendations Summary

- **Undergrounding**- pilot undergrounding and expand, as necessary, after careful evaluation of costs and benefits
- **Line Clearing** – move to a 4-5 year line clearing cycle for LVD
- **Storm Restoration** – re-baseline restoration budgeting to produce estimates that consider expected needs and balance company and customer interests in addressing volatile restoration costs

- June 12, 2025 Commission Orders largely supported Liberty's recommendations in these areas

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Projected Spending – Distribution Plans

- **DTE 2023 Plan**
  - Undergrounding conversions: 2024-2025 pilots totaling $20 million
  - Tree trimming: ramp up to $140 million per year in 2025
  - Storm response
    - Emergent replacements: 2024-2025 average of ~$375 million per year
- **Consumers Amended 2023 Plan filed in 2025**
  - Underground conversions: ramp up from 2026-2029 to $160 million (400 miles) per year
  - Line clearing: ramp up from 2026-2030 to $236 million per year to achieve 5-year clearing cycle
  - Storm response:
    - Demand failures: level off from 2025-2029 to ~$200 million per year
    - Storm restoration: ramp up for 2025-2029 to $160 million per year

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Summary

- Opportunity to Improve Distribution System Reliability Performance
- Potential Opportunity to Expand Undergrounding
- Changing Landscape Which May Strengthen Business Case for Undergrounding
  - Increasing line clearing spend for overhead
  - Increasing storm response spend for overhead

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Storm Activity & Commission Efforts in Michigan

MPSC Case U-21388:
Undergrounding Workshop

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September 17, 2025

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Storms

When	Type	Characteristics	Customer Outages (~)
Dec. 2013	Ice	0.75" ice with 10-20 mph wind	>640,000
March 2017	Wind	30 mph sustained with 60+ mph gusts	1,108,000
May 2018	Wind	70 mph gusts	300,000
Jan. 2019	Polar Vortex	-25° F temps	>400,000
Aug. 2021	Wind	70+ mph wind gusts	892,000
Aug. 2022	Wind	70+ mph winds	462,000
Feb-March 2023	Ice	0.25-0.65" ice, 6" snow, 35-45 mph wind	>1,400,000
March-April 2025	Ice, Wind	0.5-1.5" ice and tornadoes	>756,000

Commission Actions

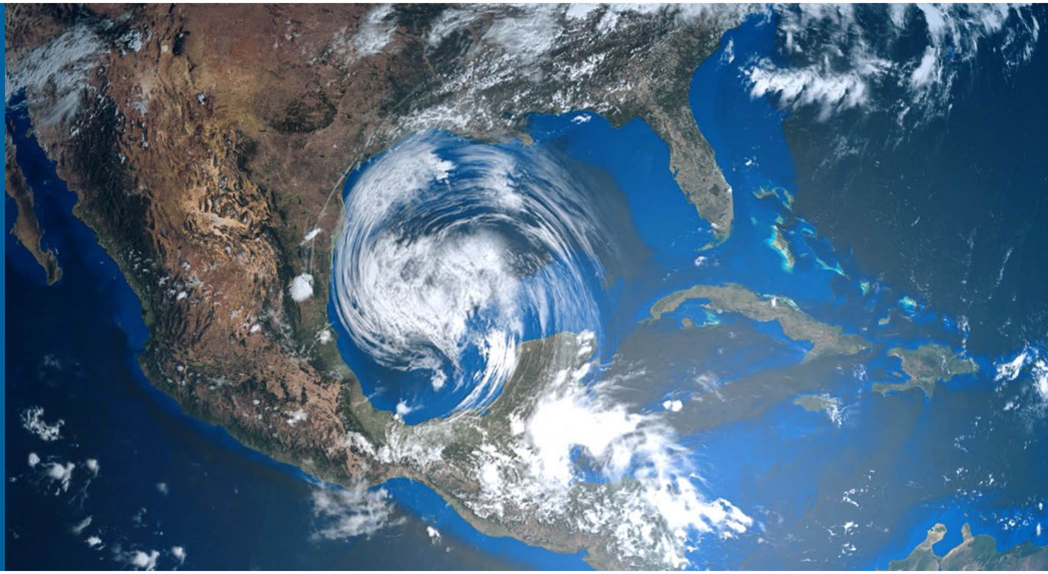
- U-17542 (2014): December 2013 Ice Storm Investigation
  - Outcomes: hazardous tree removal, power quality reports, and transparent outage credit information
- U-18346 (2017): March 2017 Wind Storm Investigation
  - Outcomes: increased tree trimming, cont. smart meter integration, and infrastructure improvements
- U-20169 (2018): May 2018 Wind Storm
  - Outcomes: increased wire down personnel, track down wire causes, youth education, and reporting
- U-20464 (2019): Polar Vortex Investigation & SEA Report
  - Outcomes: several dockets initiated on rule changes, DR, mutual aid, curtailment, distribution planning, etc.

Commission Actions Cont.

- U-21122 (2021): August 2021 Storms
  - Outcomes: MPSC Reliability Webpage and outage reporting template
- U-21305 (2022): August 2022 Storms
  - Outcomes: 3rd party audit with several conclusions and recommendations
- U-21388 (2023): February 2023 Storms
  - Outcomes: resilience technical conferences and Staff resilience report
- U-21388 (2025): March 2025 Ice and April 2025 Wind
  - Outcomes: undergrounding technical workshop

CENTER FOR
RESILIENCE AND DECISION SCIENCE
Argonne National Laboratory

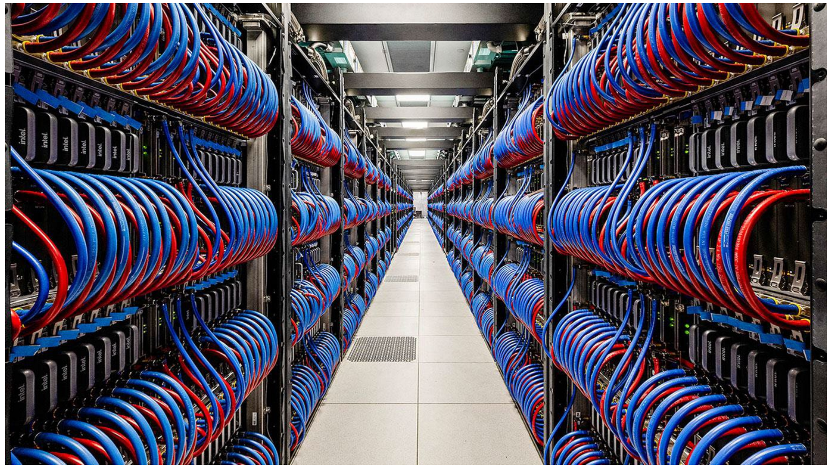
INTRODUCTION TO EXTREME WEATHER DATA FOR POWER UTILITY DECISION MAKERS



TOM WALL, PH.D.
Director, Center for Resilience and Decision Science
Department Manager, Infrastructure Security and Resilience

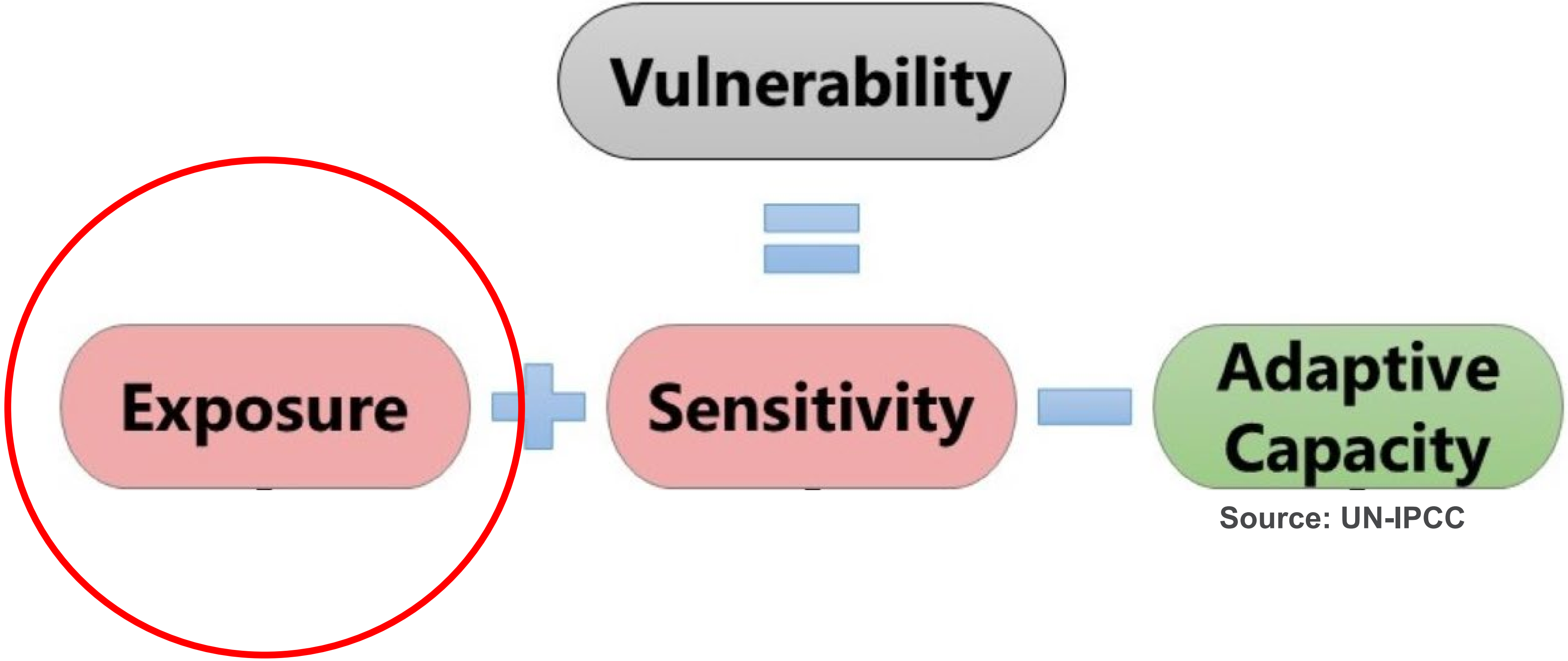
CENTER FOR RESILIENCE AND DECISION SCIENCE

- The Center for Resilience and Decision Science (CRDS) conducts research and analysis to enable unmatched future weather-risk-informed decision-making and risk mitigation planning for public and private stakeholders facing a variety of challenges around the world.
- The CRDS is comprised of a multidisciplinary scientific team that collaborates with research partners to ensure that weather risk-informed decision-making is contextualized in socio-economic, infrastructure, environmental, and fiscal realities so that mitigation actions are grounded in science and practicable for immediate implementation.
- **Relevant expertise include**: artificial intelligence, advanced computing, atmospheric science, decision science, engineering and infrastructure analysis



WEATHER MODELING AND DATA 101

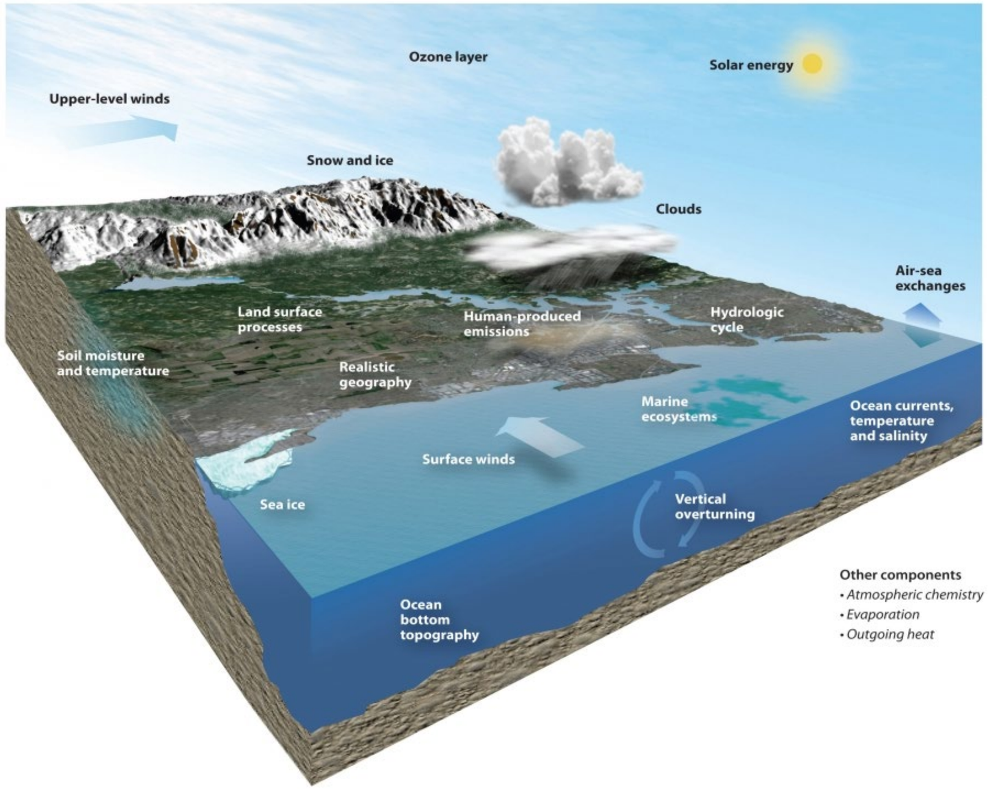
Importance of Place-Based Data in Assessing Asset Vulnerability

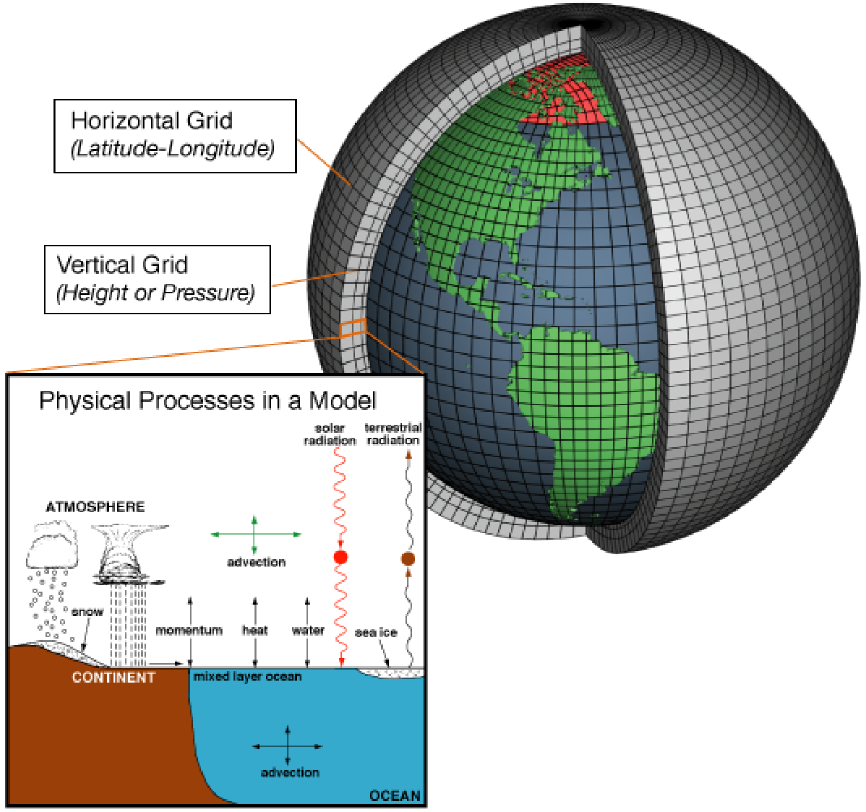


Source: UN-IPCC

WEATHER MODELING AND DATA 101

Mathematical representations of the weather systems are based on physical laws and understanding of processes



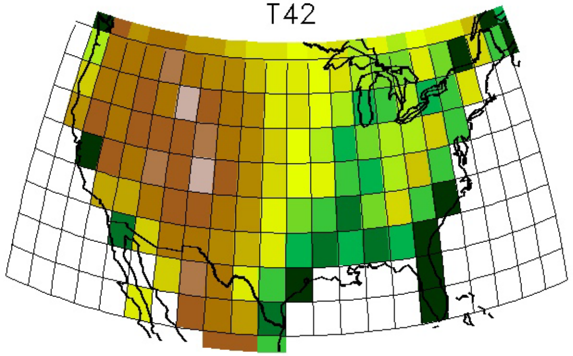


Source: UCAR and NOAA

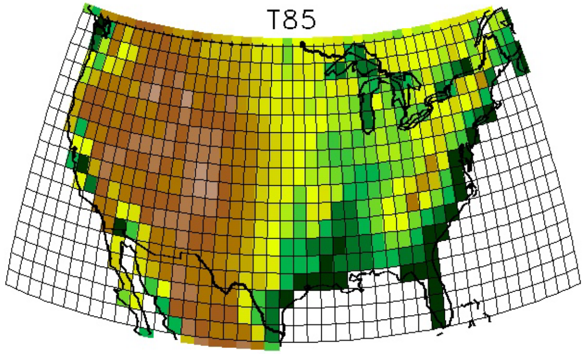
WEATHER MODELING AND DATA 101

Model Resolution is Dependent on Computing

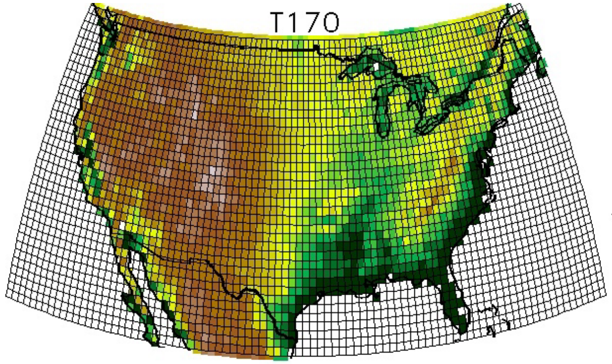
- As computing resources have improved over time, models have become increasingly complex and more detailed
- Smaller grid squares or “pixel sizes” enable more place-specific and detailed projections of locally relevant weather
- But hang on, because artificial intelligence (AI) and machine learning (ML) is accelerating…



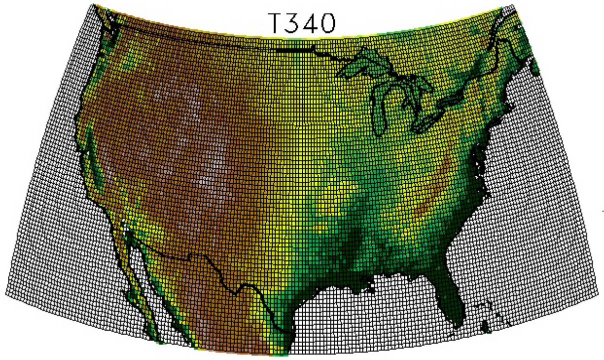
Mid-1990s 200~300 kms



2000s 100~150 kms



Current 50~100 kms



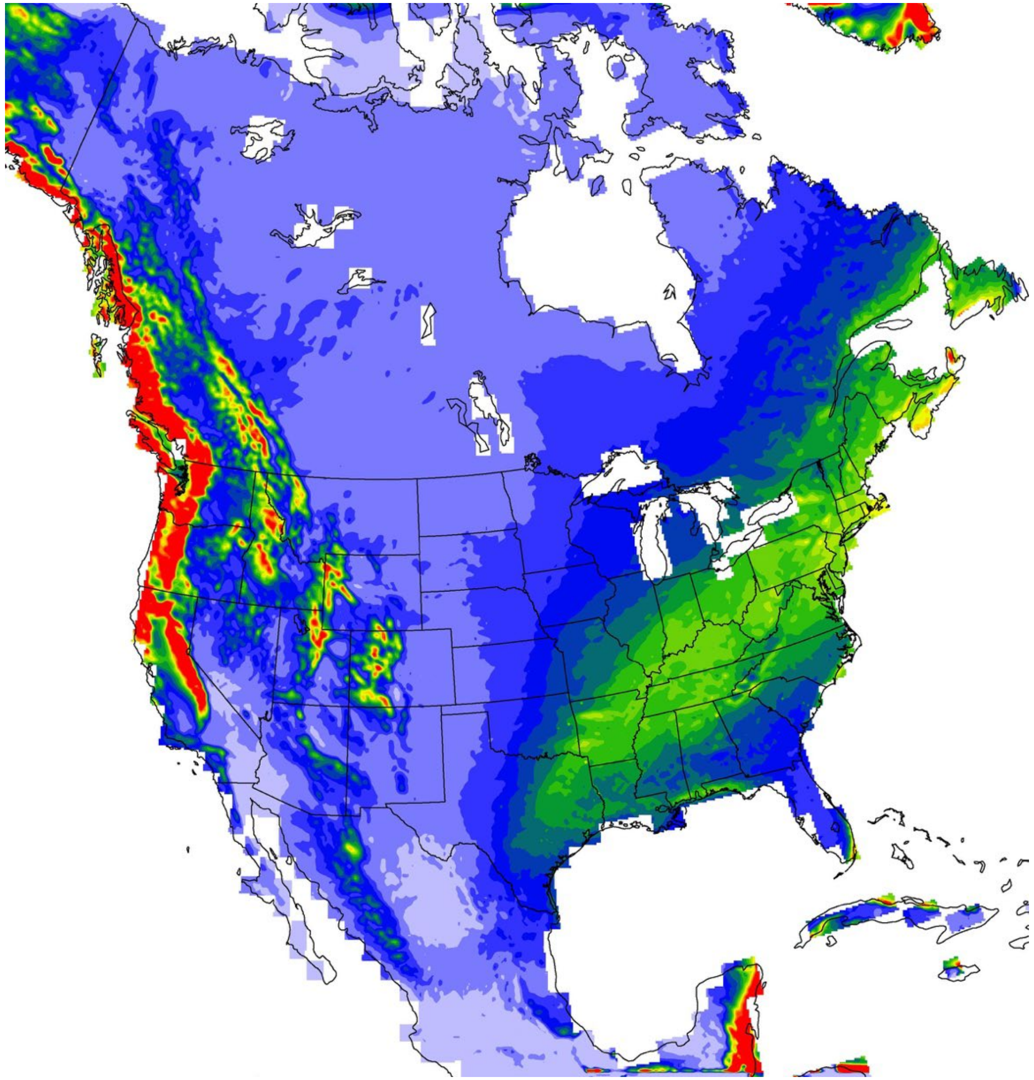
Future. 25~40 kms

Source: UCAR

LOCAL WEATHER PROJECTIONS THROUGH DYNAMIC DOWNSCALING

ARGONNE'S DYNAMICALLY DOWNSCALED, REGIONAL WEATHER MODELING IS A UNIQUE NATIONAL RESOURCE

- High resolution, neighborhood level (12km)
- Scientific transparency: widely published and scientifically peer reviewed modeling and outcomes
- Dynamical downscaling offers improvements over statistical downscaling
  - Physics-based, addresses non-stationarity
  - Produces 60+ unique variables
- RCP8.5 (upper limit) + RCP4.5 (mid-century peak)
- Three member ensemble of general circulation models
- Three timeframes: historical, mid-century, end-of-century



LOCAL WEATHER PROJECTIONS THROUGH DYNAMIC DOWNSCALING

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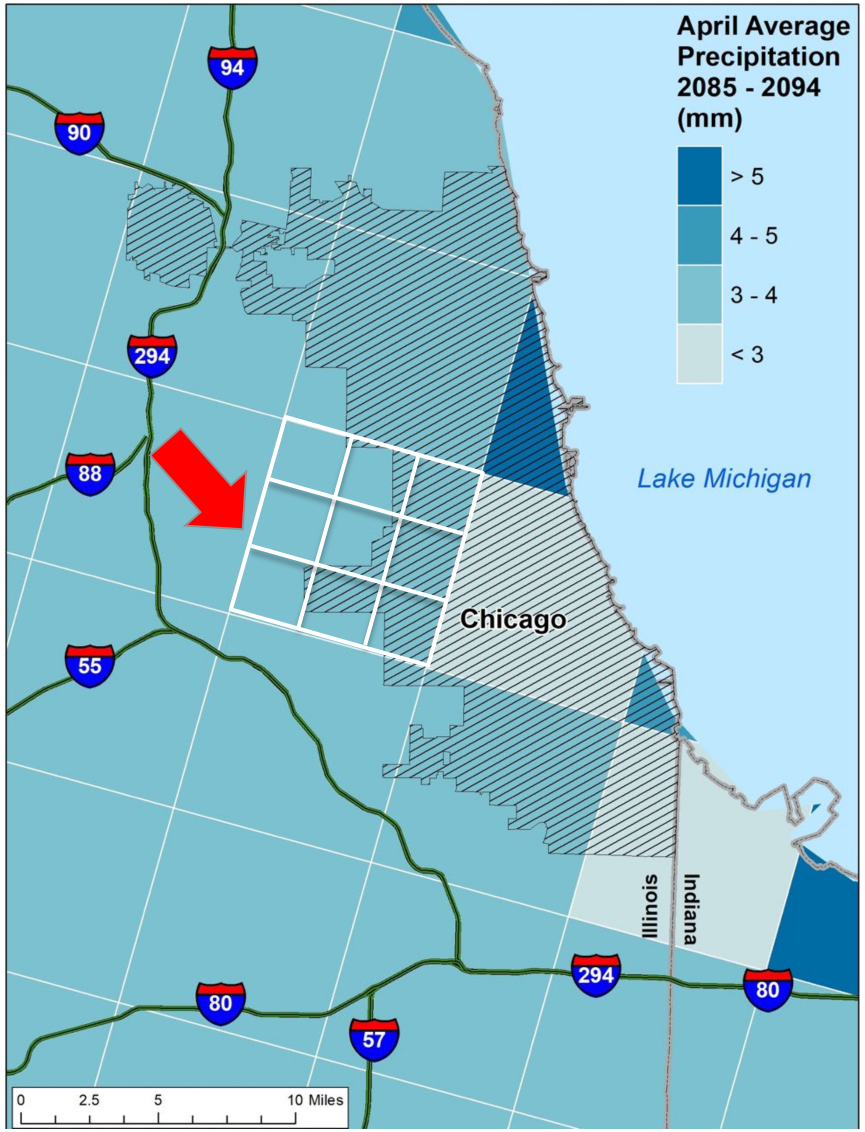

COLLABORATORS IN APPLIED WEATHER RESEARCH

U.S. DEPARTMENT OF ENERGY | Office of Science

U.S. DEPARTMENT OF ENERGY | OFFICE OF Cybersecurity, Energy Security, and Emergency Response

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

GDO GRID DEPLOYMENT OFFICE

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comed AN EXELON COMPANY

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EAGLE ROCK ANALYTICS

Baringa

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

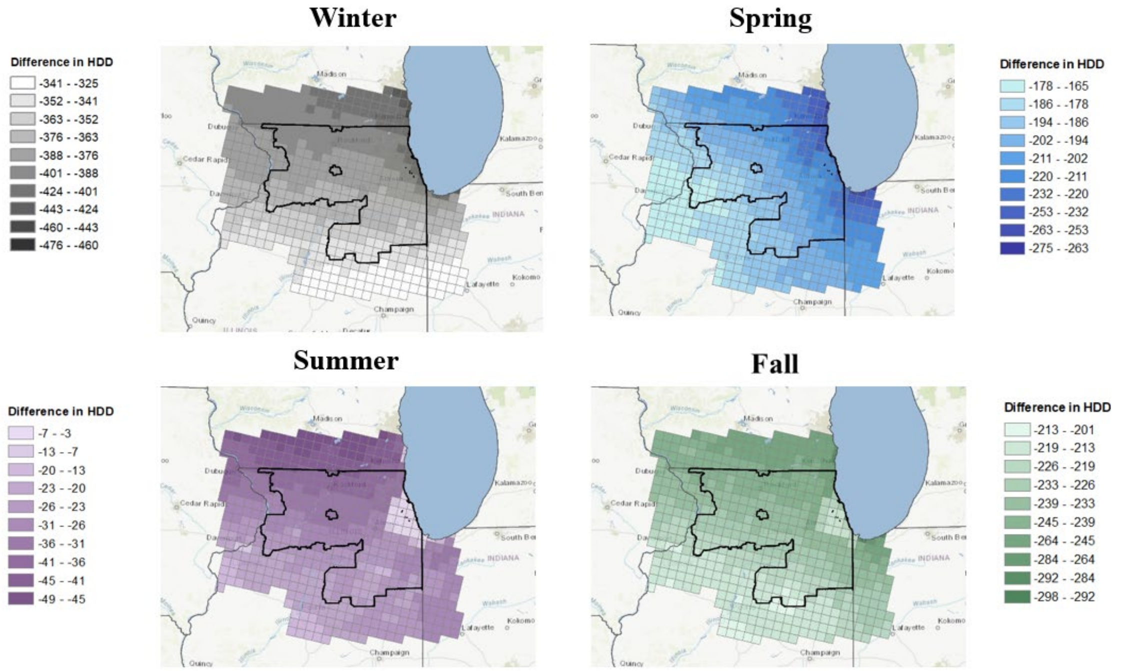
IBM

asean

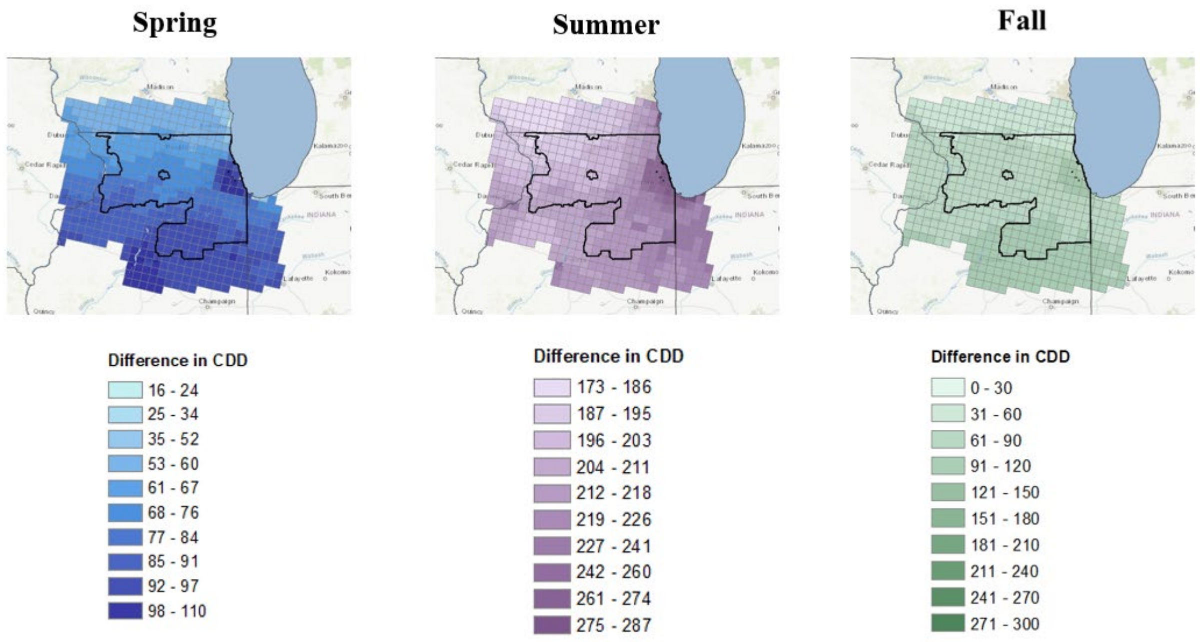
EXAMPLE APPLICATION TO INFORM DECISIONS

Argonne, ComEd assess future weather impacts in Northern Illinois

- **Heating Degree Days:** Annual decrease between 761 to 1060 territory-wide (Winter average decrease ~408)



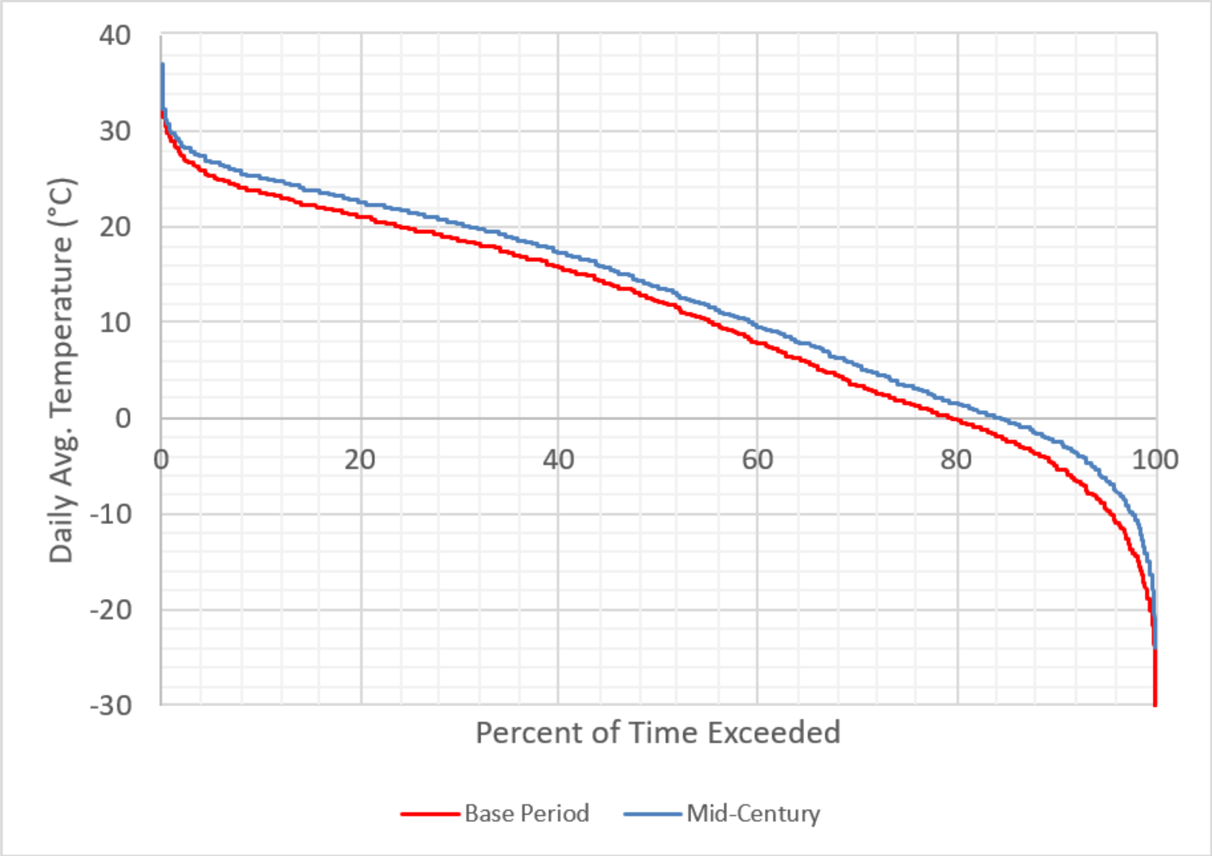
- **Cooling Degree Days:** Annual increase between 258 to 399 territory-wide (Summer average increase ~230)



EXAMPLE APPLICATION TO INFORM DECISIONS

Argonne, ComEd assess future weather impacts in Northern Illinois

- Temperature extremes are critical for
  - Reliable operations of existing assets
  - Design and investment in future assets
  - Load forecasting
- Different **daily average** temperature thresholds are needed for different applications
- In northern Illinois:
  - Baseline: 35°C (95°F) exceeded ~1 days/decade
  - Mid-century: 35°C (95°F) exceeded ~4 days/decade

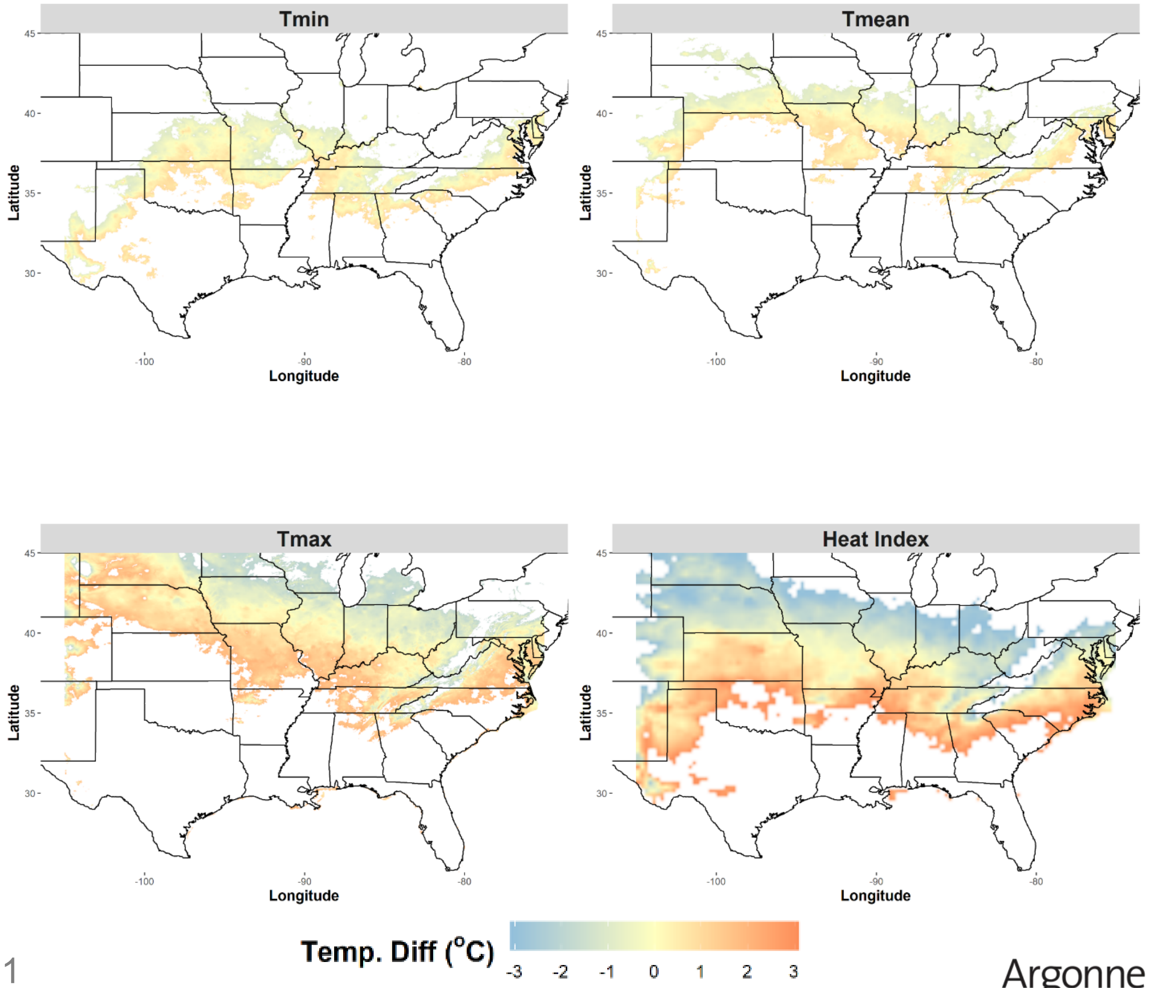


Percentage of time (days/year) that daily average temperatures exceed a given threshold for the baseline and mid-century periods

EXAMPLE APPLICATION TO INFORM DECISIONS

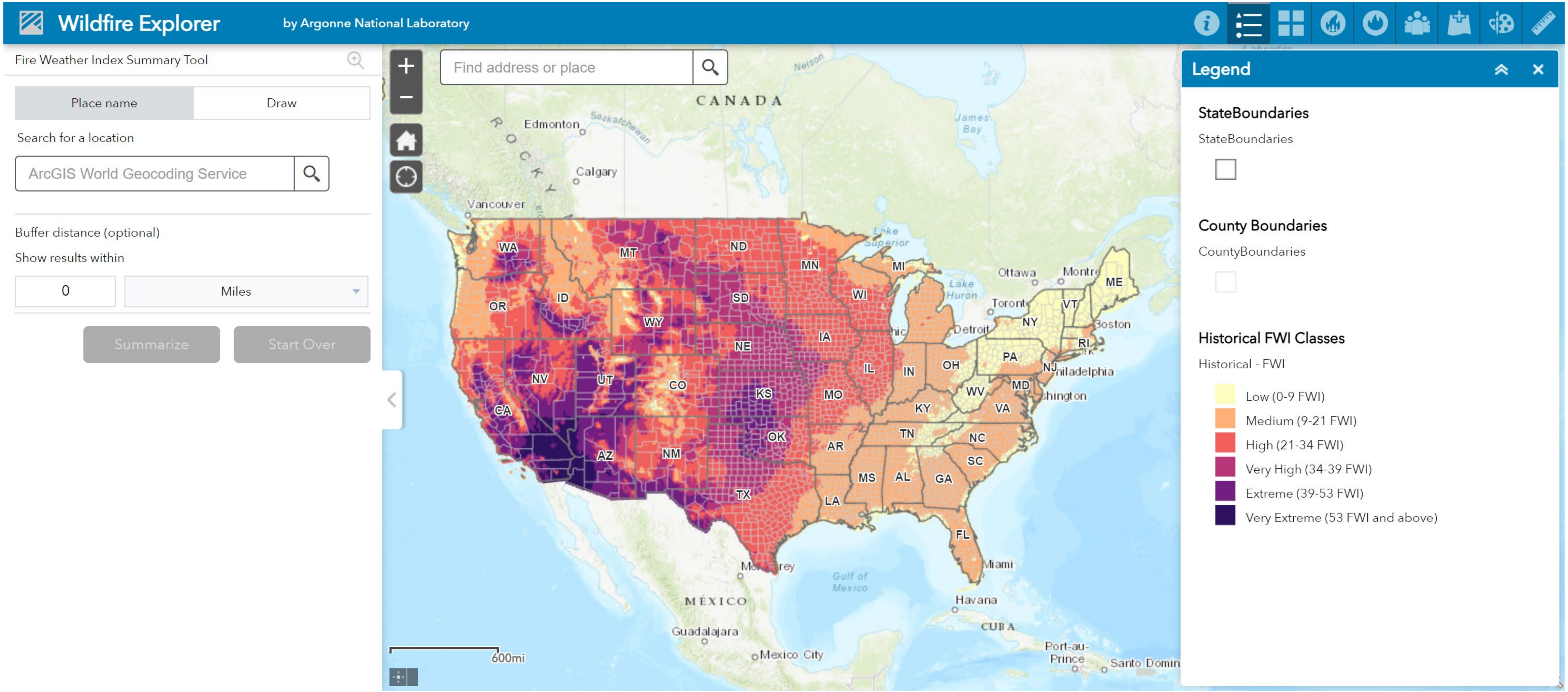
Argonne, ComEd assess future weather impacts in Northern Illinois

- Enables ComEd to better assess how future weather will affect regional communities, grid assets, future loads, and decarbonization efforts.
- High-resolution model outcomes tailored to ComEd's planning and analysis needs, and community and industry engagement activities.



INFORM LOCAL DECISIONS AT NATIONAL SCALE

ClimRR Portal



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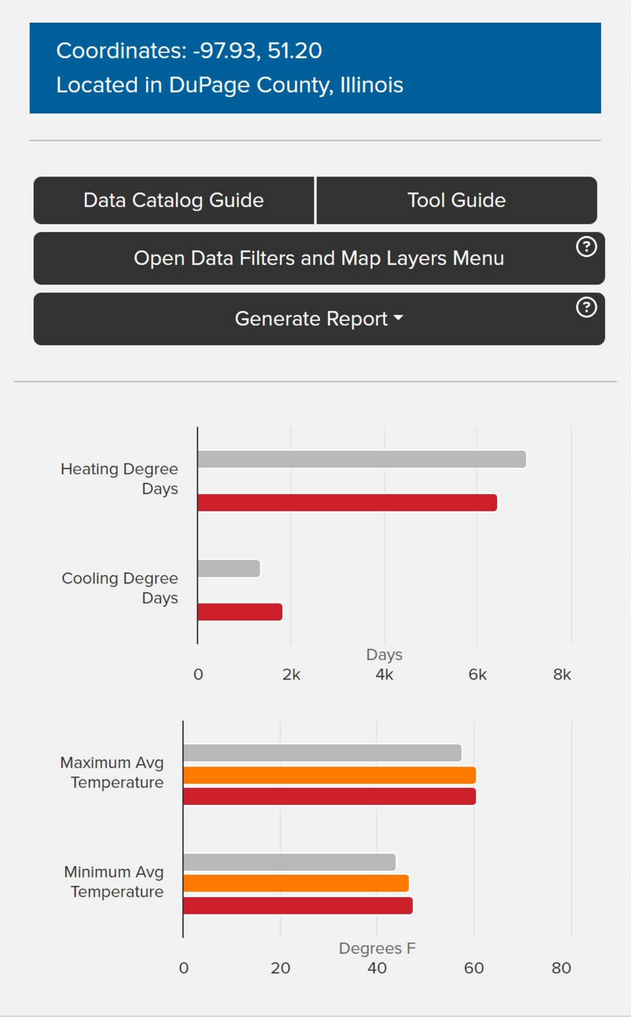
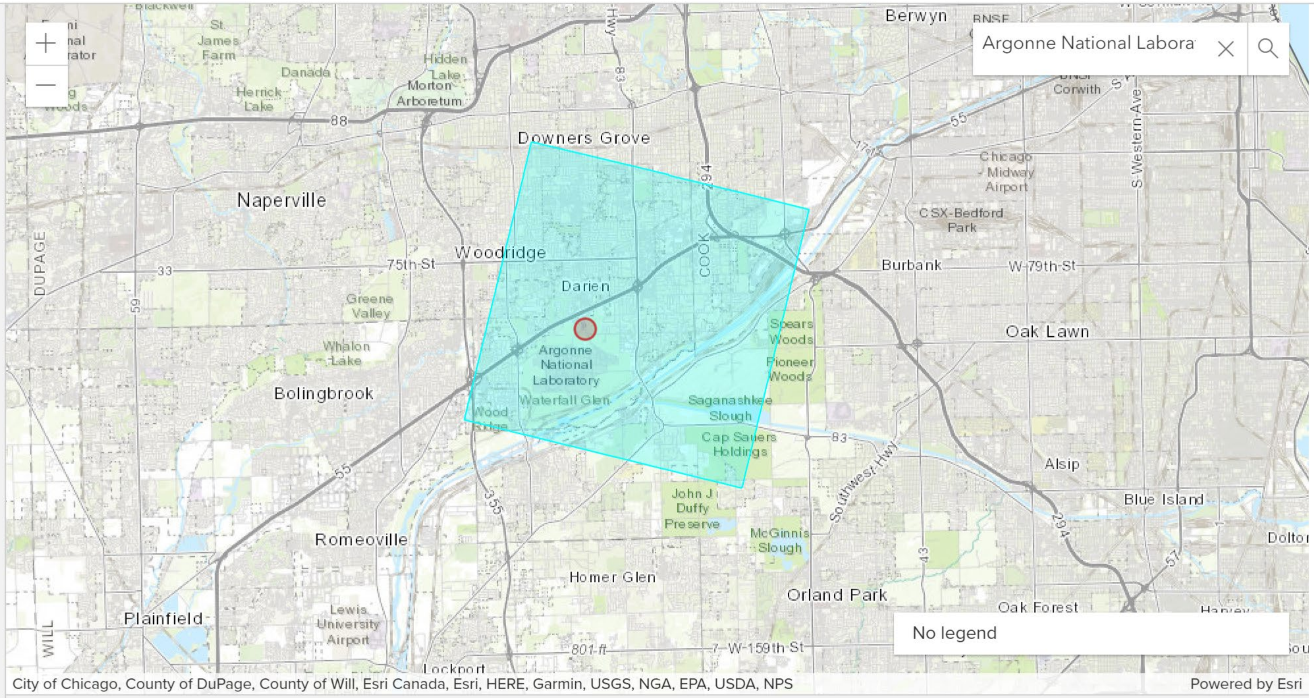
INFORM LOCAL DECISIONS AT NATIONAL SCALE

ClimRR Portal





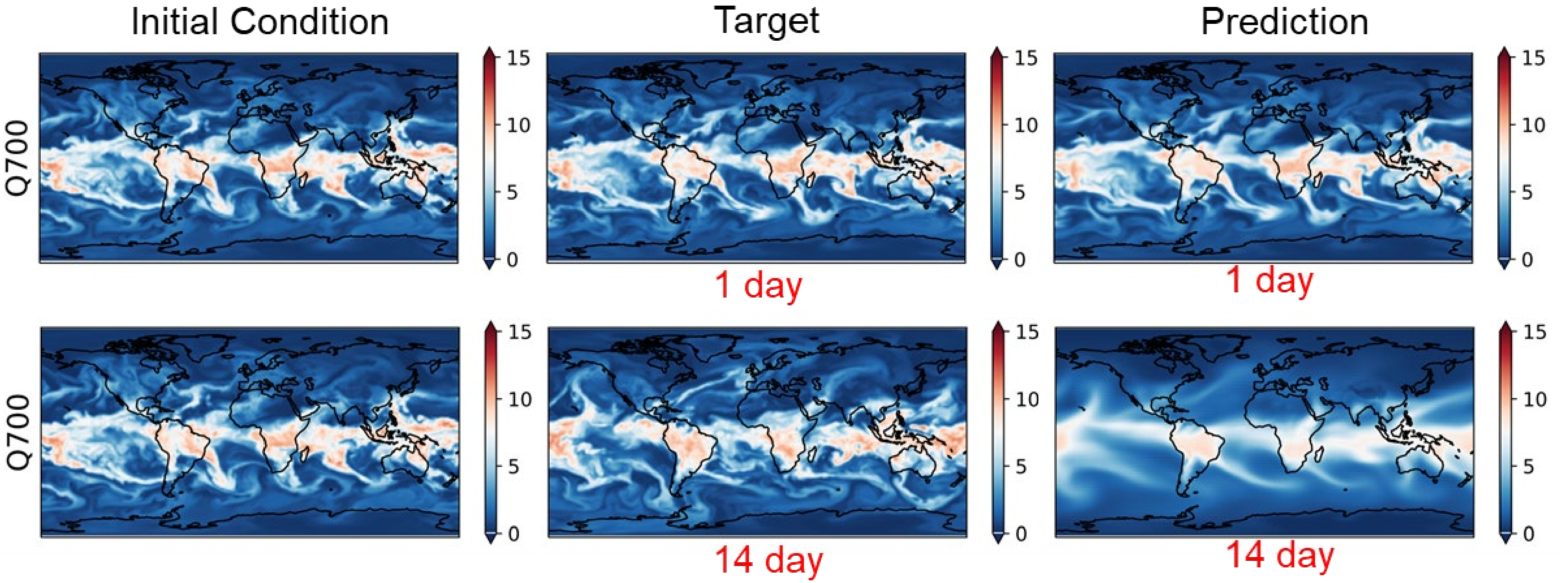
Climate Projection	Historical	Mid Century RCP 4.5		Mid Century RCP 8.5	
Heating Degree Days (Days)	7,059.01	-		6,441.85	vs Historical: -617.16
Cooling Degree Days (Days)	1,349.38	-		1,833.21	vs Historical: +483.83
Maximum Avg Temperature (Degrees F)	57.59	60.68	vs Historical: +3.09	60.54	vs Historical: +2.95 vs RCP 4.5: -0.13
Minimum Avg Temperature (Degrees F)	44.18	46.93	vs Historical: +2.75	47.74	vs Historical: +3.56 vs RCP 4.5: +0.82

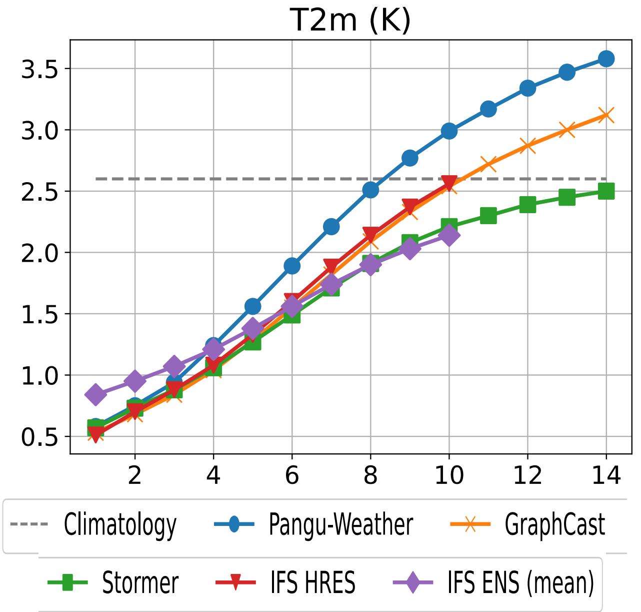
https://climrr.anl.gov

AI/ML FOUNDATION MODELS FOR WEATHER

STORMER & AERIS Subseasonal-to-Seasonal Weather Models

- Our state-of-the-art machine learning weather forecast models, Stormer and AERIS, run at ~30km resolution and can make 14-day global weather forecasts in 2 seconds
- Funded by DOE-CESER to provide near-real-time awareness of weather hazards to utilities for emergency planning and response





AI/ML FOUNDATION MODELS FOR WEATHER

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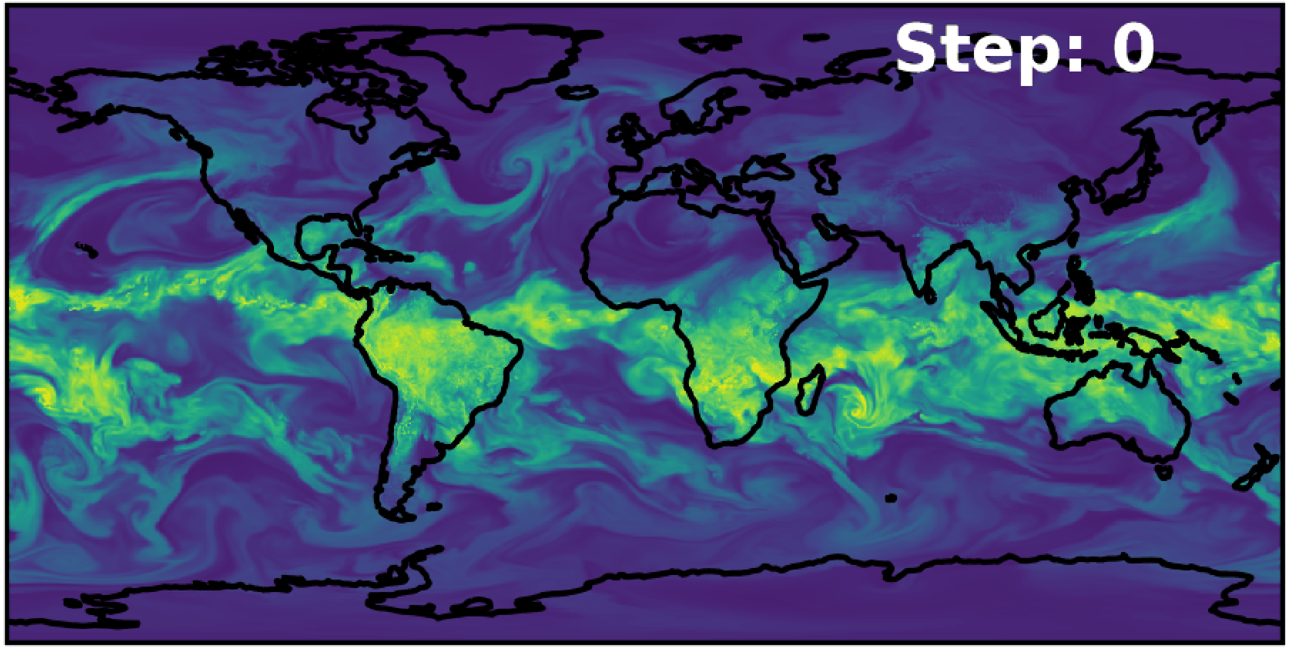
- Funded by DOE-CESER to provide near-real-time awareness of weather hazards to utilities for emergency planning and response

Achievements of scaling to **37B parameters**:

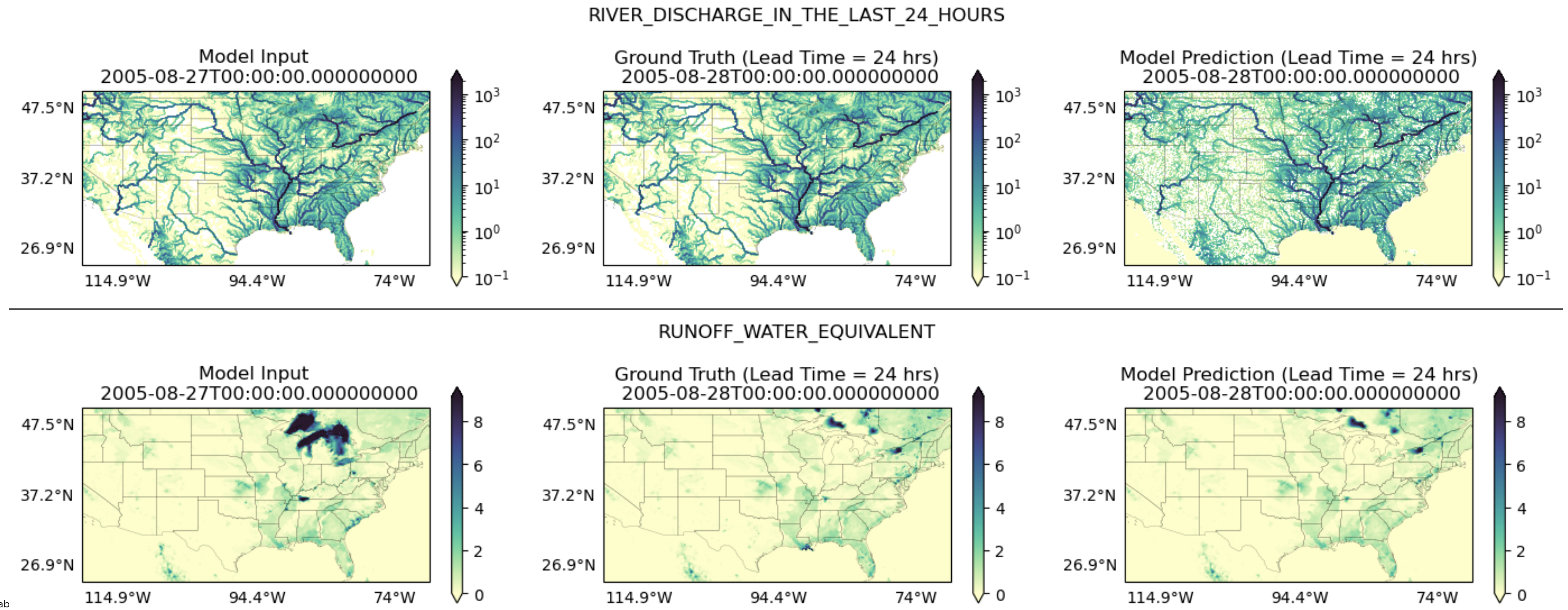
- One of the largest AI weather models
- Perfect linear scaling (log-log) across model sizes
- 9000 nodes (100,000 GPUs) – 90% of Aurora (currently 3rd fastest supercomputer globally)



AI/ML FOUNDATION MODELS FOR FLOODING

Near-Real-Time Prediction of Flooding from Current Meteorology

- Leverage multiple AI/ML approaches (Fourier Neural Operator & Shifting Windows Transformer) to project local-scale flooding up to 72-hours in advance of initiating meteorology and storm systems
- Also funded by DOE-CESER to provide near-real-time awareness of flood hazards to utilities and communities for emergency planning and response



THANK YOU

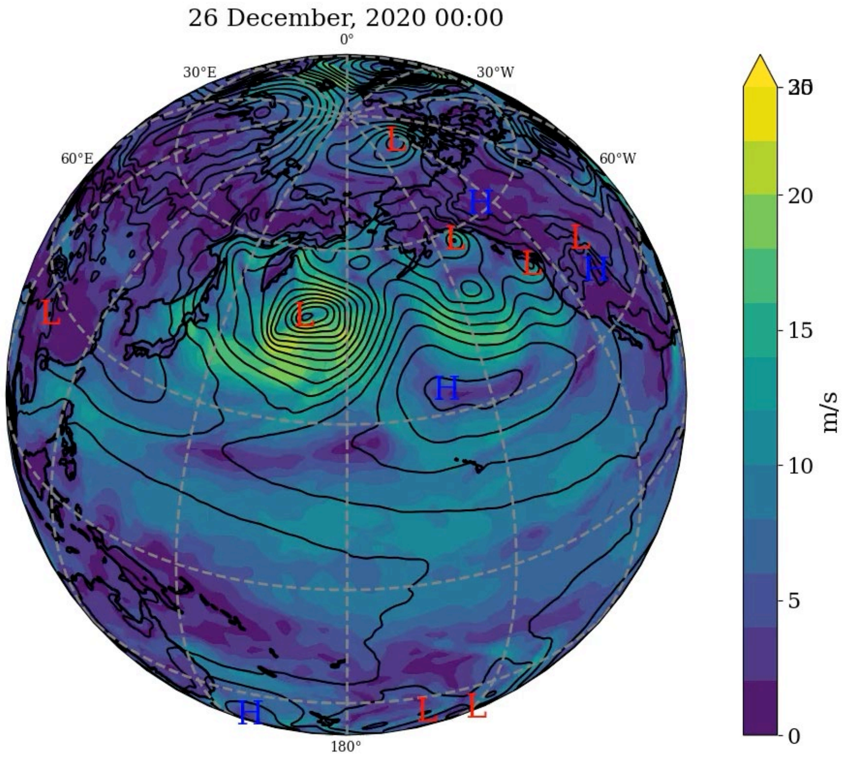
CENTER FOR
RESILIENCE AND
DECISION SCIENCE
Argonne National Laboratory

Argonne NATIONAL LABORATORY

CRDS ONGOING RESEARCH EFFORTS

- **STORMER AI/ML Weather Model:** Argonne launched STORMER, an AI/ML-based weather model, and is updating for enhanced sub-seasonal to seasonal forecasting and long-term weather modeling
- **Generative AI-Based Regional Flood Model:** AI/ML based flood models to provide near-real-time awareness of future flooding from impending storm or typhoon events
- **Enhanced Local-Scale Physical Flood Modeling:** Applying lessons learned from national-scale WRF-Hydro modeling to project future flooding at 10m-50m, and incorporating urban stormwater systems
- **Capital Investment Decision Support Tool for Resilience:** Collaboration with LBNL, ComEd and other utilities, to evaluate power system weather vulnerabilities and conduct BCA of capital investments to increase resilience
- **Technical Assistance – Power Utilities and Emergency Managers:** Ongoing efforts with municipal and cooperative utilities, and emergency managers, to apply weather data in resilience planning

STORMER: Training using observation-based reanalysis (ERA5)



Reliability Improvements from Undergrounding Distribution Power Lines

MPSC Case U-21388:
Undergrounding Workshop

Luke Dennin, Ph.D.

U.S. Department of Energy Fellow
Michigan Public Service Commission

September 17, 2025

MPSC
MICHIGAN PUBLIC SERVICE COMMISSION

Agenda for the Talk

1. **Literature review**
   – What do we know from existing information?

2. **Data from Consumers Energy**
   – What does Michigan-specific data tell us?

3. **Statistical analysis**
   – Can we extract usable information for analysis?

1. Literature review

What do we know from existing information?

Critical to this talk are IEEE reliability metrics

1. **SAIFI**
   - **S**ystem **A**verage **I**nterruption **F**requency **I**ndex
   - A measure of outage frequency

2. **CAIDI**
   - **C**ustomer **A**verage **I**nterruption **D**uration **I**ndex
   - A measure of outage duration

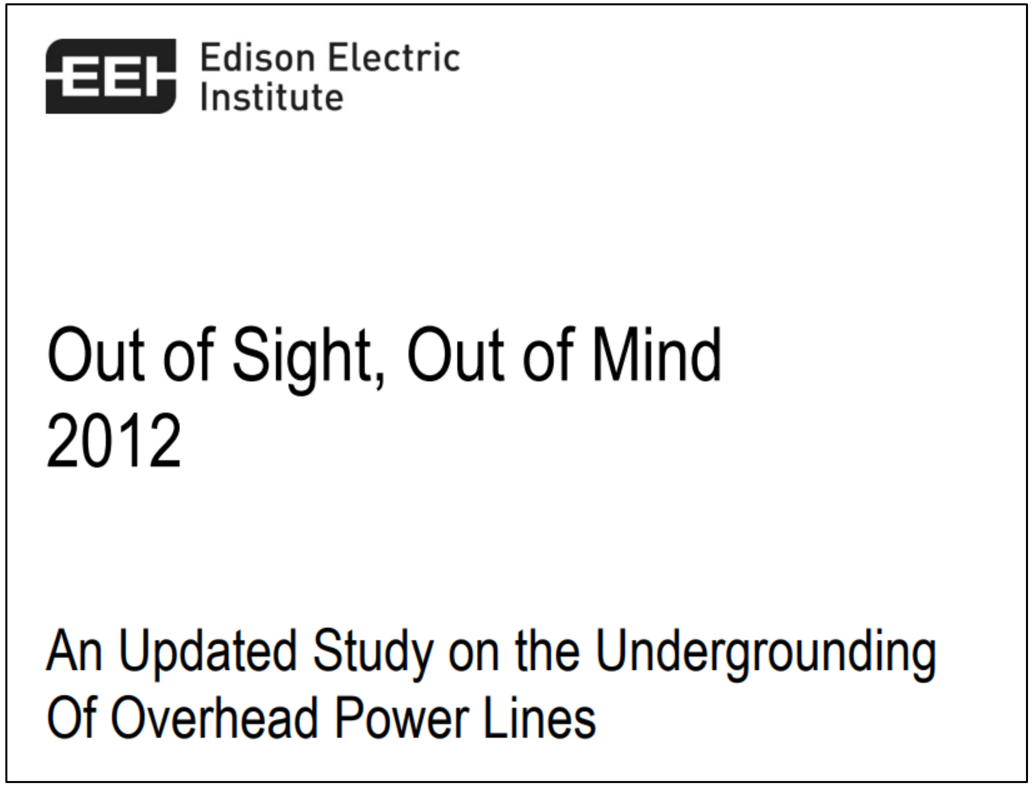
3. **SAIDI**
   - **S**ystem **A**verage **I**nterruption **D**uration **I**ndex
   - A combined measure, total time without power

Studies suggest undergrounding decreases outage frequency and slightly increases outage duration

Study 1 of 5:

Hall (2013): Edison Electric Institute [Study]

- ☑ Overhead lines had much higher SAIFI than underground.
- ☑ CAIDI was only slightly higher for overhead.
- ☑ Combined effect meant SAIDI strongly favored undergrounding.


Edison Electric Institute

Out of Sight, Out of Mind
2012

An Updated Study on the Undergrounding Of Overhead Power Lines

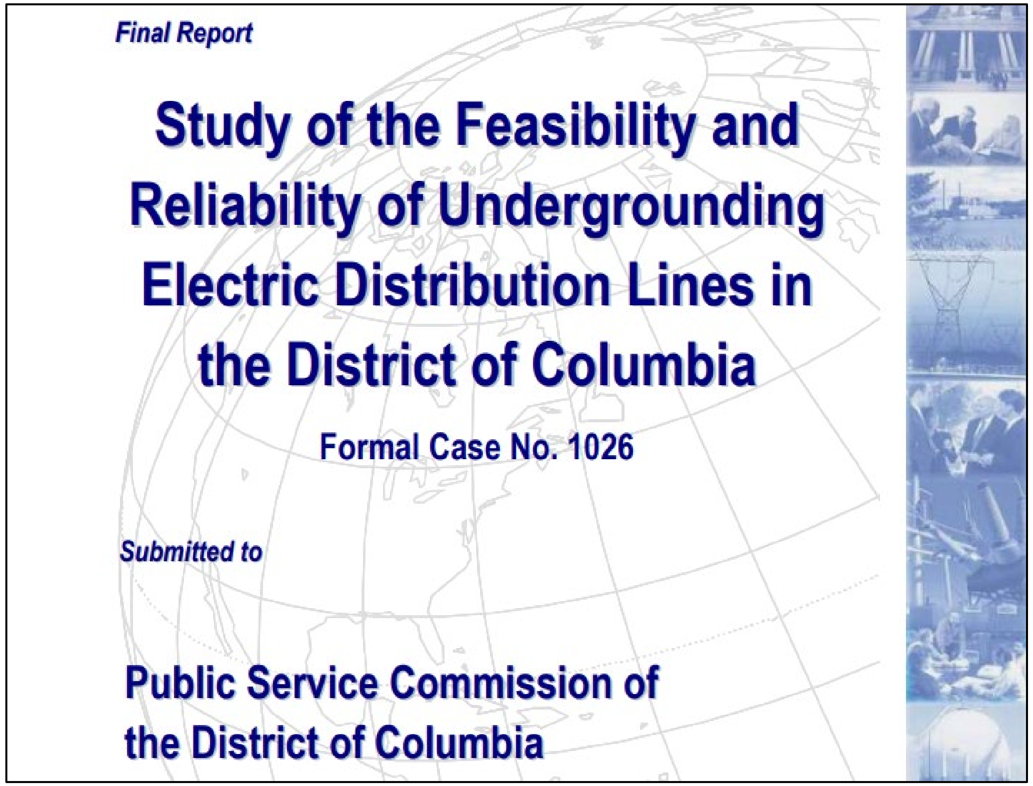
Source: *Hall (2013) – Link*

Studies suggest undergrounding decreases outage frequency and slightly increases outage duration

Study 2 of 5:

Shaw Consultants (2010): Washington D.C. Study

- Undergrounding reduced SAIFI.
- But increased CAIDI for non-storm events.
- During storms, overhead CAIDI nearly tripled, while underground lines were protected.



Final Report

Study of the Feasibility and Reliability of Undergrounding Electric Distribution Lines in the District of Columbia

Formal Case No. 1026

Submitted to

Public Service Commission of the District of Columbia

Source: *Shaw Consultants (2010) – Link*

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Studies suggest undergrounding decreases outage frequency and slightly increases outage duration

Study 3 of 5:

NEI Electric (2009): New Hampshire Study

- Estimated an up to 10x reduction in SAIFI with undergrounding.
- But also an up to 10x increase in CAIDI.

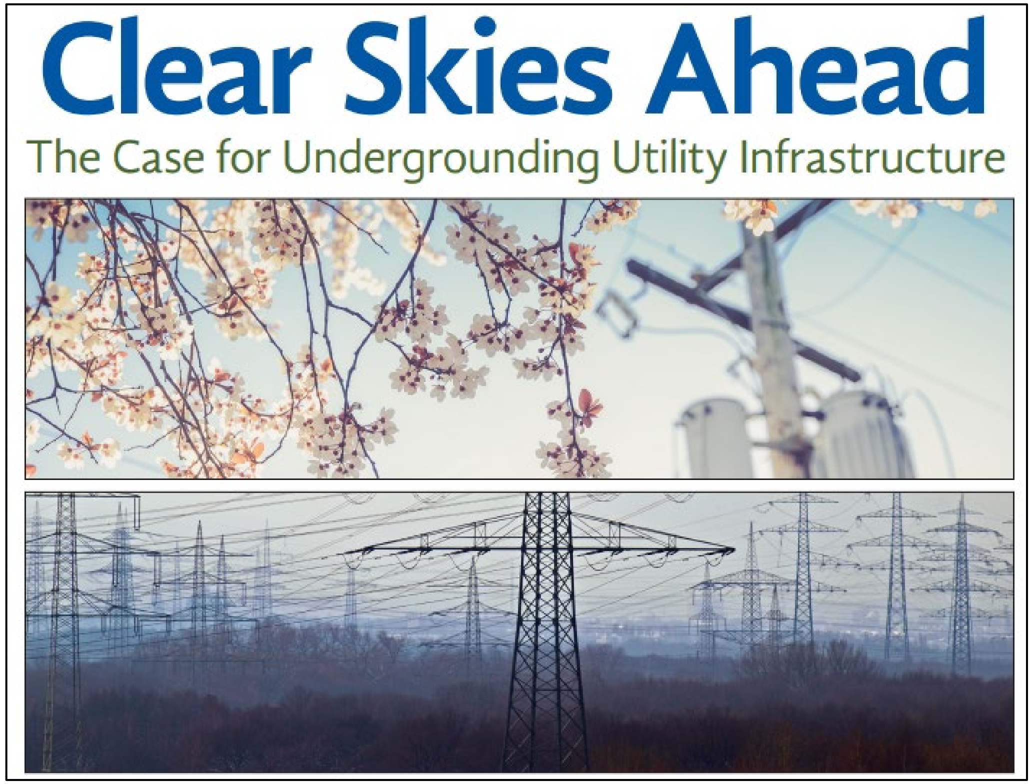
Source: *NEI Electric (2009) – Link*

Studies suggest undergrounding decreases outage frequency and slightly increases outage duration

Study 4 of 5:

twentytwenty LLP (2019): 7-State Meta-Analysis

- ✅ 94% reduction in storm-related outages.
- ✅ 74% reduction in overall outages
- ⚠️ 52% increase in outage durations
- ✅ 61% net reduction in total outage time



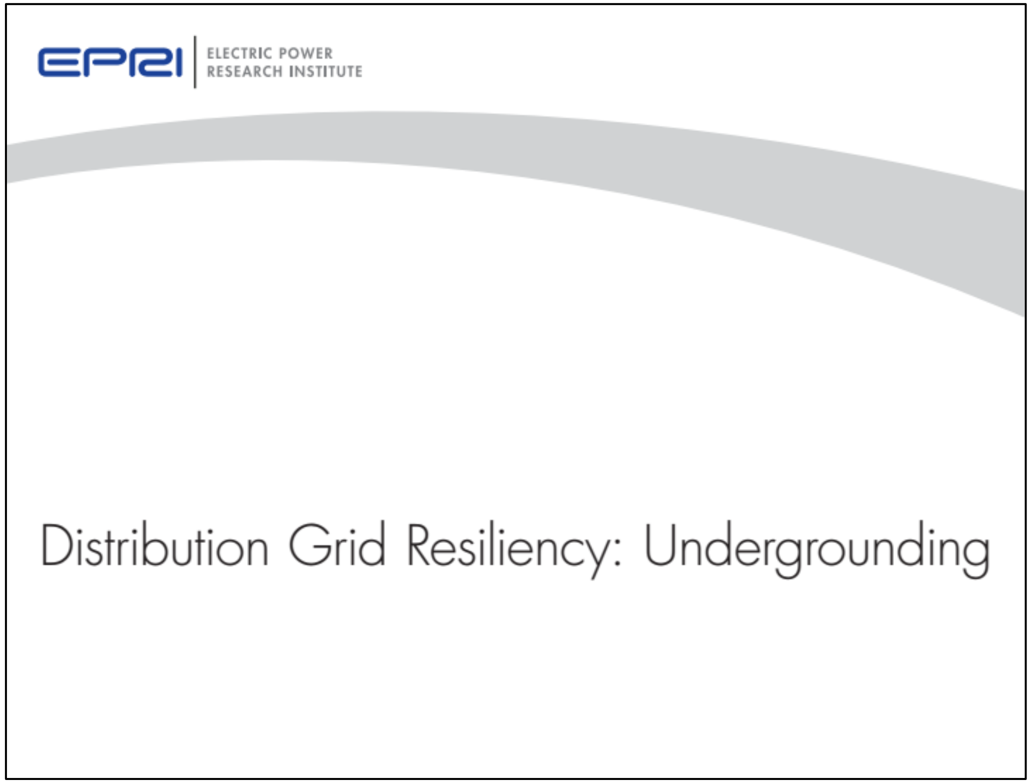
Source: *twentytwenty LLP (2019) – Link*

Studies suggest undergrounding decreases outage frequency and slightly increases outage duration

Study 5 of 5:

Tripolitis et al. (2015): Electric Power Research Institute Study

- "[Undergrounding] is different from other options in that by removing aerial infrastructure from exposure, damage from wind, ice, and trees is 100% prevented from affecting that infrastructure."


ELECTRIC POWER RESEARCH INSTITUTE

Distribution Grid Resiliency: Undergrounding

Source: *Tripolitis (2015) – Link*

2. Data from Consumers Energy

What does Michigan-specific data tell us?

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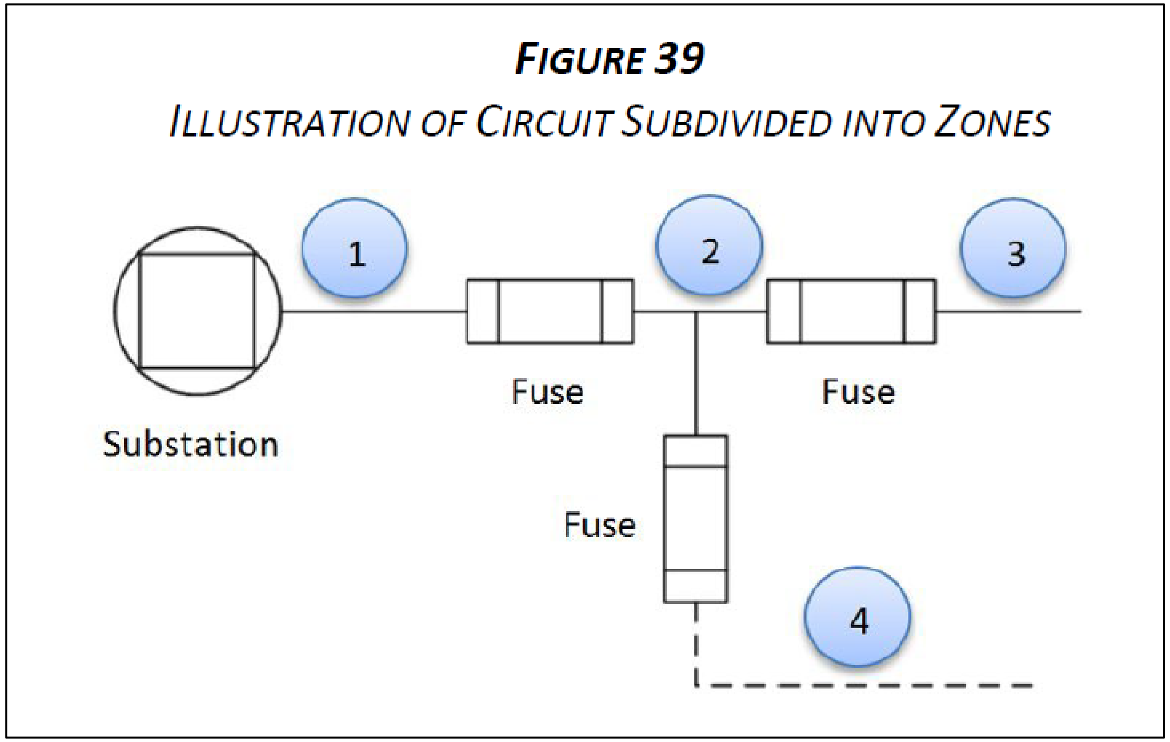
Here, we'll look at two groups of protective zones

- **Group 1: Overhead**
  - 108,541 (71%) protective zones
  - More than 50% overhead
  - Average stats:
    - 12 customers & 0.48 miles
    - 26 customers per mile

- **Group 2: Underground**
  - 44,937 (29%) protective zones
  - 50% or more underground
  - Average stats:
    - 14 customers & 0.21 miles
    - 64 customers per mile



Source: *Consumers Energy Company (2023) – Link*

Critical to this talk are outage conditions

Definitions from MPSC's service quality and reliability standards – Link:

1. **Blue sky**
   - ≤1% of customers out

2. **Gray sky**
   - >1% and <10% of customers out

3. **Catastrophic**
   - ≥10% of customers out

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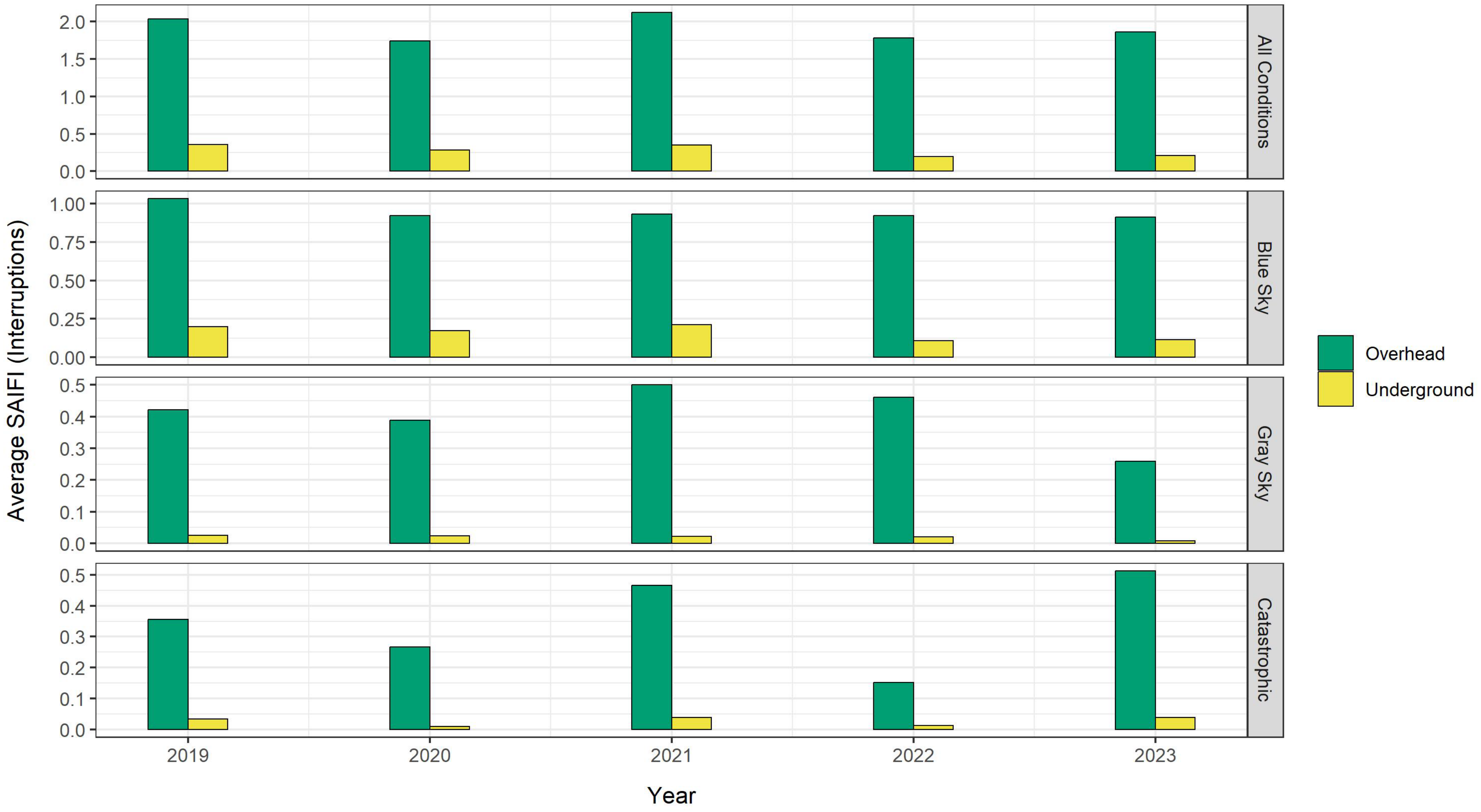
Undergrounding suggests SAIFI gains



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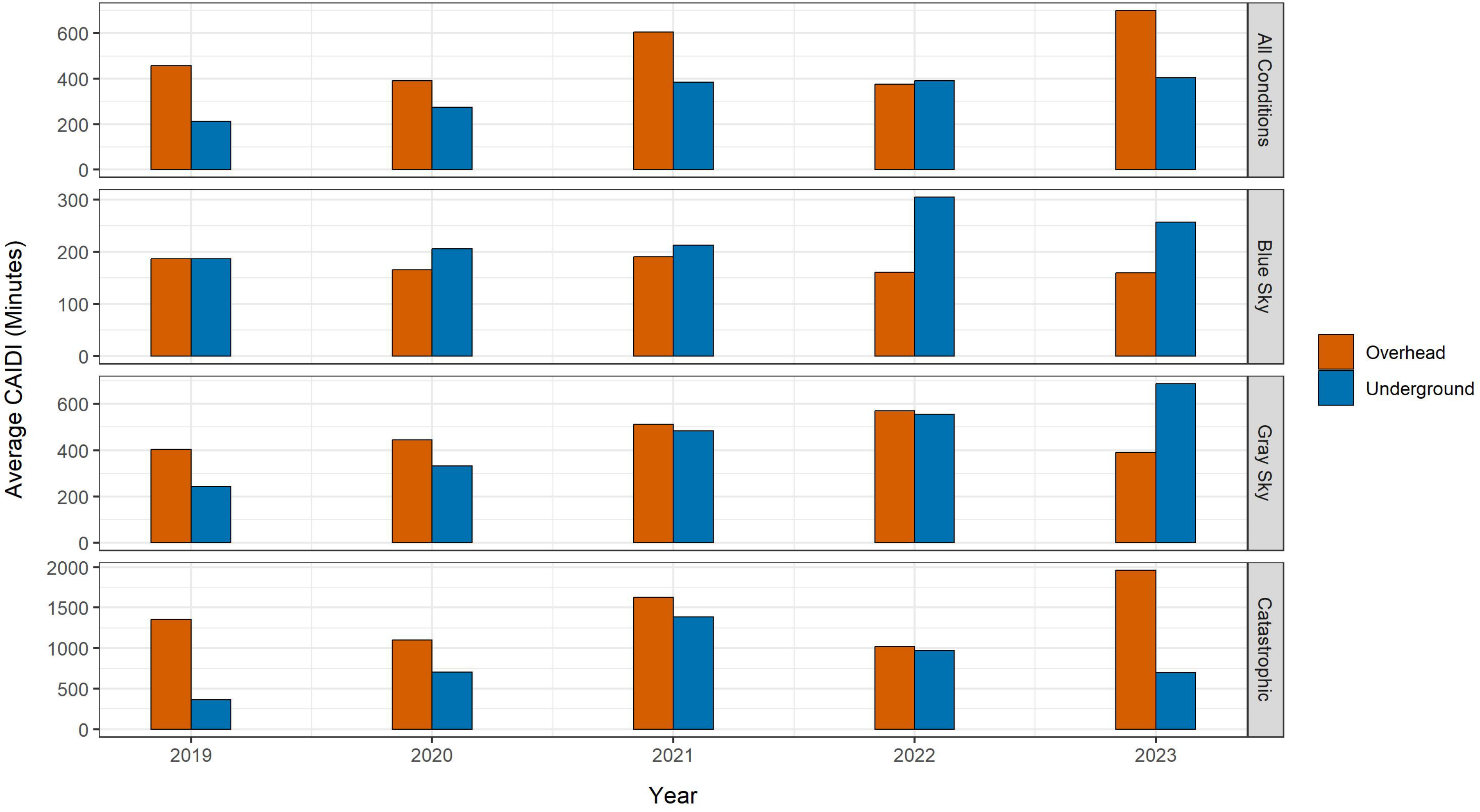
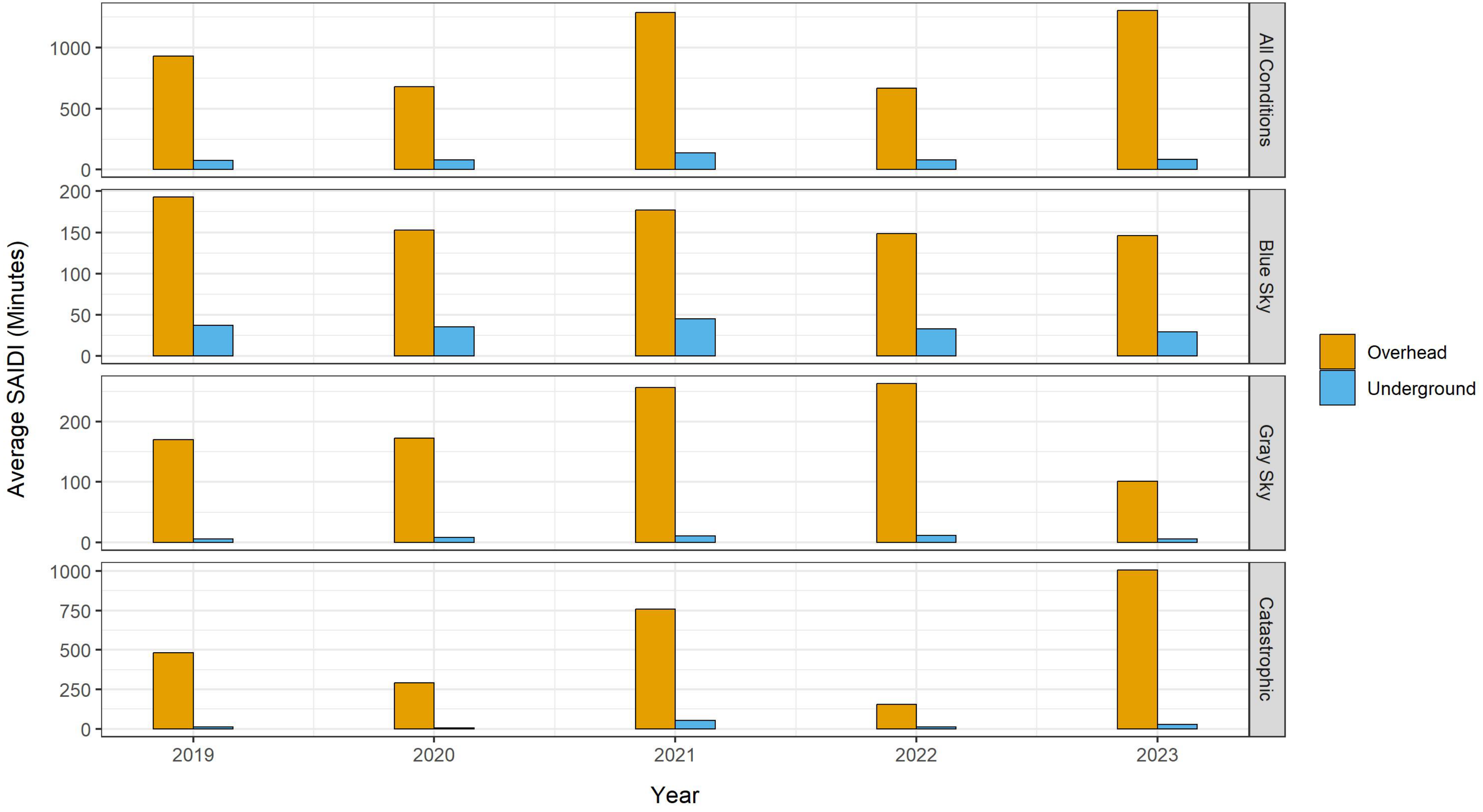
CAIDI is more outage condition-dependent



Undergrounding suggests SAIDI gains



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Let's again look at our two groups of zones

- **Group 1: Overhead**
  - 108,541 (71%) protective zones
  - 50% or more overhead
  - Average stats:
    - 12 customers & 0.48 miles
    - 26 customers per mile
- **Group 2: Underground**
  - 44,937 (29%) protective zones
  - 50% or more underground
  - Average stats:
    - 14 customers & 0.21 miles
    - 64 customers per mile

Are there other reasons for the differences in the reliability metrics?

Is there omitted variable bias?

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3. Statistical analysis

Can we extract usable information for analysis?

As the share of underground increases, what is the expected change in the reliability metrics?

Larsen et al. (2020) – LBNL Study

- **Approach:** Regression analysis of reliability metrics vs. underground line share.
- **Data:** >80 utilities, up to 16 years, annual (temporal) and service territory (spatial) granularity.
- **Objective:** Assess effect of undergrounding on SAIFI and SAIDI, controlling for other variables (e.g., high-wind days, distribution expenditures).

Beta coefficients informing reliability impacts

Result	SAIFI	SAIDI
β Coefficient	-4.26E-03	-5.74E-03
Significance	** ($p < 0.05$)	N/A ($p > 0.10$)
1%-pt ↑ in UG	-0.426% ↓	-0.574% ↓

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What do these reliability improvements look like in Michigan under different outage conditions?

Dennin (2025) – MPSC Study

- **Approach:** Regression analysis of reliability metrics vs. underground line share.
- **Data:** >1,900 circuits, 5 years, 3 outage conditions + an all-condition model:
  - Blue Sky: <1% of customers out
  - Gray Sky: <10% of customers out
  - Catastrophic: >10% of customers out
- **Objective:** Assess effect of undergrounding on SAIFI and SAIDI, controlling for other variables (e.g., tree density, customer counts).

Beta coefficients informing reliability impacts

Condition	SAIFI	SAIDI
All Condition	-4.87E-03***	-8.02E-03***
Blue Sky	-2.48E-03*	-5.61E-04
Gray Sky	-6.51E-03**	-9.24E-03***
Catastrophic	-7.36-03**	-8.51E-03***

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$; ‘ ’ $p \geq 0.10$

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What do these reliability improvements look like in Michigan under different outage conditions?

Dennin (2025) – MPSC Study

CAIDI β Coefficient Derivation:

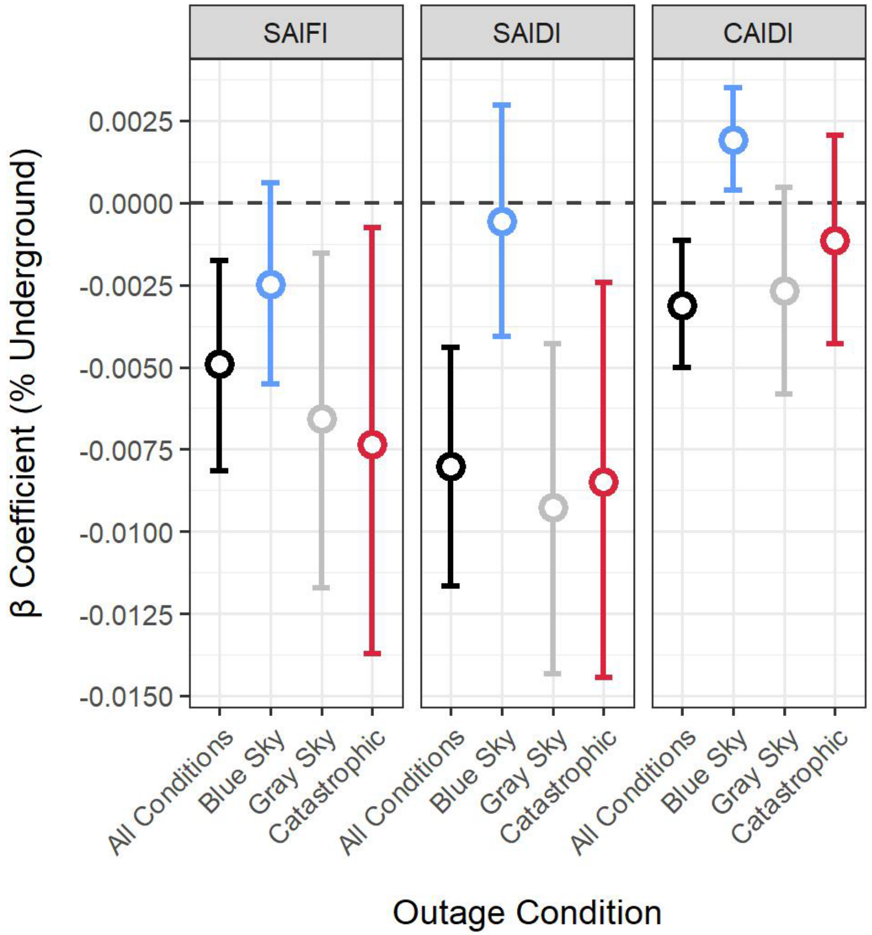
$$SAIDI_t = SAIFI_t \times CAIDI_t$$

$$ln(SAIDI_t) = ln(SAIFI_t) + ln(CAIDI_t)$$

$$\Delta ln(SAIDI_o) = \Delta ln(SAIFI_o) + \Delta ln(CAIDI_o)$$

$$\beta^{(u)}_{SAIDI_o} x_u = \beta^{(u)}_{SAIFI_o} x_u + \beta^{(u)}_{CAIDI_o} x_u$$

$$\beta^{(u)}_{CAIDI_o} = \beta^{(u)}_{SAIDI_o} - \beta^{(u)}_{SAIFI_o}$$



This approach enables modeling experiments, like one-mile conversion project benefit-cost analyses…

Dennin (2025) – MPSC Study

- **Example:** Theoretical Circuit
  - **Mileage:** 50 miles
    - 49 overhead (98%)
    - 1 underground (2%)
  - **One-mile conversion project:** 1 overhead mile to underground → +2%-point increase
    - The β coefficient informs the percentage change in reliability metrics per 1%-point increase in undergrounding (interpretation: β x 100 % change per 1%-point ↑)

Gray Sky Metric	Baseline Metric Value	Beta Coefficient	% Change in Metric Value	Post-UG Metric Value
SAIFI	1.03	-6.51E-03	-1.302%	1.016
SAIDI	383	-9.24E-03	-1.848%	375.6
CAIDI	373	-2.73E-03	-0.546%	371.0

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Thank you! Questions?

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U.S. Department of Energy Fellow (Energy Innovator Fellowship)

Washington, D.C.

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DTE Undergrounding Pilot Learnings

MPSC Undergrounding Technical Workshop

September 17, 2025

DTE identified tangible benefits from undergrounding by addressing challenges of increasingly unfavorable weather, decreasing customer sentiment, and financial challenges

Why Undergrounding is important

- We are seeing increasingly adverse weather, with the number of high wind days growing by nearly 5% each year
- Customer and stakeholder sentiment associated with electric reliability is becoming much less tolerant of long duration outages
- In addition, DTE continues to face challenges with rising reactive costs driven by storm and emergent trouble that impact customer affordability

Benefits of Undergrounding

- Relocating overhead distribution underground eliminates interference from trees and the risk of downed wires, improving safety and reliability
- Reducing or eliminating truck rolls to address trouble on small or single outages
- Eliminating significant reactive costs associated with Tree Trim maintenance on high-cost segments
- Shortening or eliminating the long-tail of storms by preventing small outages on completed projects

The benefit and cost of undergrounding is dependent on the segments of the circuit to be undergrounded

Greater SAIDI Benefits ⟷ **Greater Outage Events Reduction**

Backbone

- SAIDI improvement of 50 to 60%
- Small resiliency improvement ~ 7% of outage events
- Cost to underground
- $2M - $4.2M/mile versus OH $1.1M to $1.7M/mile

Laterals

- SAIDI improvement of 20 to 25%
- Better resiliency improvement – ~20 to 25% outage events
- Cost to underground
  - 3 phase - $1M to $2M/Mile versus OH $0.5M to $1M/Mile
  - 1 phase - $0.8M to $1.5M/Mile versus OH $0.5 to $1.0M/Mile

Secondary & Services

- SAIDI improvement of less than 1%
- Best resiliency improvement ~ 40 to 50% outage events
- Cost to underground
  - Secondary ~ $70/K per mile versus OH ~ 50/K per mile
  - Services - $4K to $7K per customer versus OH $1K per customer

DTE has completed two urban strategic undergrounding pilots and captured learned from each one to apply to potential future projects

Appoline – Detroit

- Urban environment with medium customer density
- Scope to convert rear-lot overhead to rear-lot underground
- **Learnings:**
  - Additional cost to clean up the rear lot alleys in an urban setting
  - Importance of upfront customer communications
  - Challenges of undergrounding of services from the rear lot

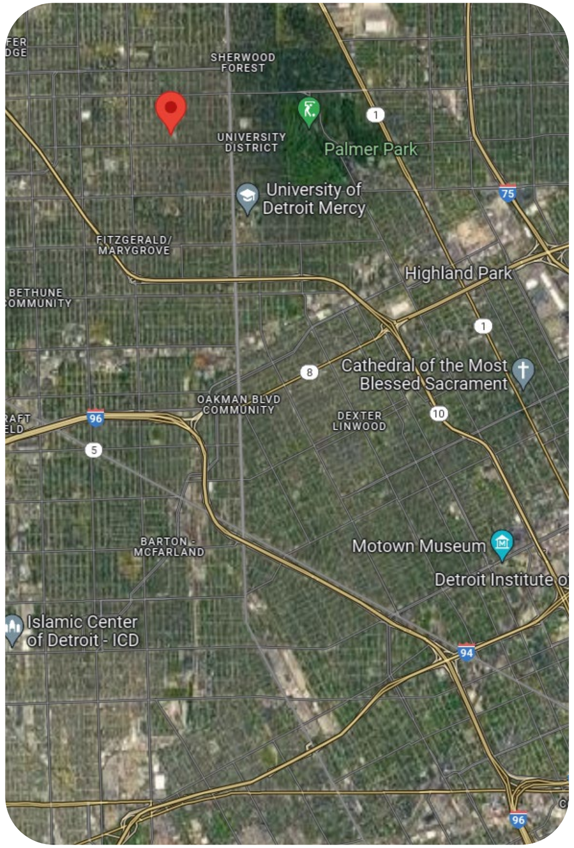
Buffalo-Charles - Detroit

- Urban environment with low customer density
- Scope to convert rear-lot overhead to front-lot underground
- Work with DTE Gas to reduce implementation cost
- **Learnings:**
  - Importance of all easements/agreements procured prior to construction
  - Optimized Customer UG service agreement process with DTE Legal (notice letters)

The first underground distribution pilot was the Appoline project in Detroit, it was completed in 2023

- The Appoline project’s scope was to rear-lot underground ~1,300 feet of rear-lot overhead, impacting 61 customers
- The primary goal of the project was to identify safety benefits by relocating the overhead distribution lines to underground
- The conversion was completed for all customers in the Appoline project in November 2023

Appoline Project – Bagley Neighborhood



DTE

The second underground distribution pilot was the Buffalo-Charles project in Detroit, it was completed in 2024

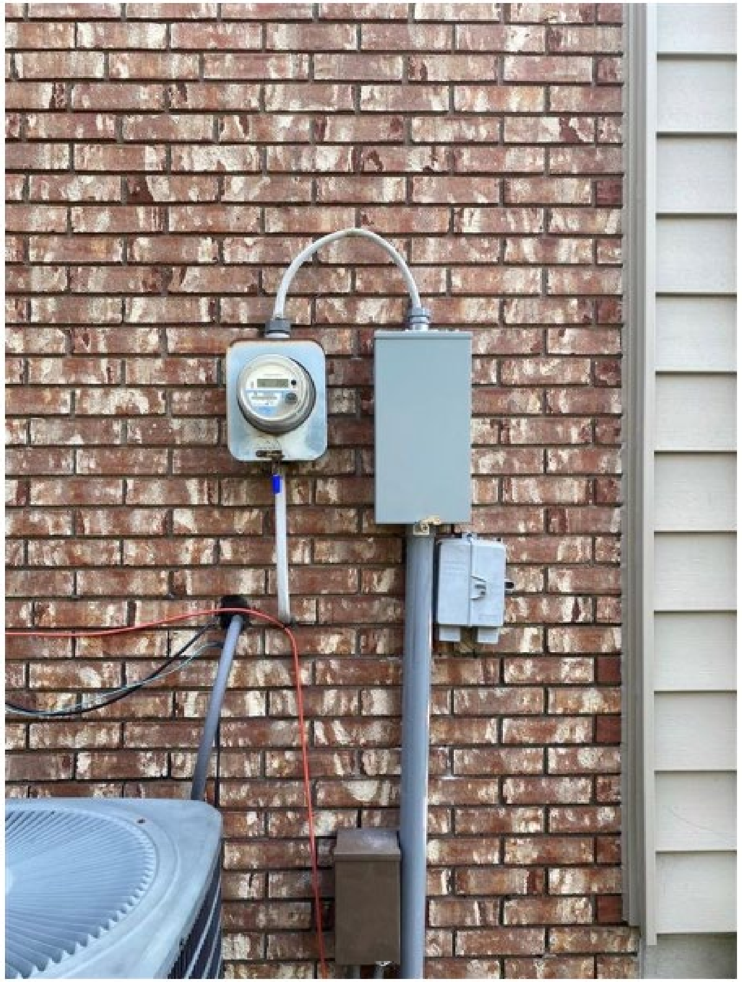
- 16 cable pole locations for 8 new primary feeders and approximately 2,500' of new overhead conductor to facilitate primary feeders were installed per block to enable scalable construction based on easement procurement

- 17,500' of new URD cable, 77 pad-mounted transformers, 260 pedestals, and 455 underground residential services were installed

- Approximately 2.4 miles of rear-lot overhead lines were removed from the area (marked in red)

Buffalo-Charles Neighborhood Project

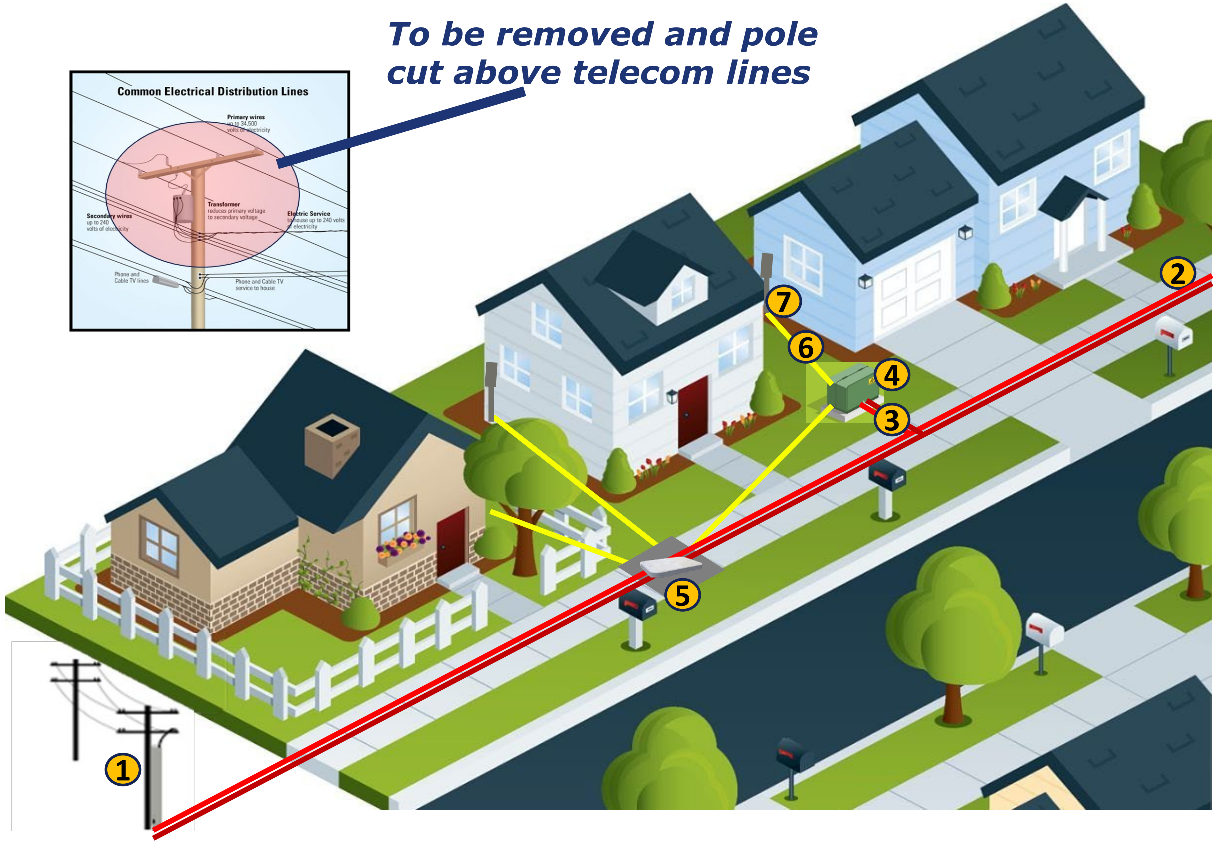
Overhead to underground service conversions were performed using junction boxes to limit scope of work to utility side of meter



- Services were undergrounded by boring to the location that was feasibly nearest the meter and brought into a junction box mounted on the customer’s home. Service entrance cable was brought out of the top of the junction box and routed back to the meter.
- Installing the junction box minimized the impact to the customer by removing the need for them to spend time and money to upgrade their service equipment
- Each junction box requires a signed agreement from the customer.
- Typical service size is 2/0 Aluminum cable

The actual costs of pilots have lateral undergrounding costs at approximately three to five times the cost of an overhead rebuild. Both pilots took approximately two years to complete.

	Appoline	Buffalo Charles
Project Type	Rear OH to Rear UG (Services Only)	Rear OH to Front Lot UG (primary, Secondary & Services)
Project Status	Complete	Complete
# of Customers	+/- 61	+/- 455
Actual Cost per mile	2.9 M	3.2 M



DTE

Through the pilot projects DTE Electric identified construction synergies that may improve cost and further quantify benefits

Lessons the Company has learned from these pilots

- Obtaining easements and properties rights to construct new assets above and underground requires extensive planning
- Field construction is more complicated and longer in duration to safely avoid conflicts with other utilities and mature trees
- Structures (such as sheds, pools, patios, etc.) and other obstacles can prohibit or prevent construction in established areas
- Homes with rear-lot overhead typically have their meters located on the rear of the home, providing for longer and more challenging service runs

Strategic Undergrounding next steps

- Incorporate the less tangible benefits of safety and resiliency into the BCA model by utilizing a risk valuation framework (Probability x Consequence) to gain broader regulatory support and identify future projects with forecasted benefits that exceed the cost

- Continue to learn from our UG pilots and industry peers to further drive productivity and cost efficiency improvements

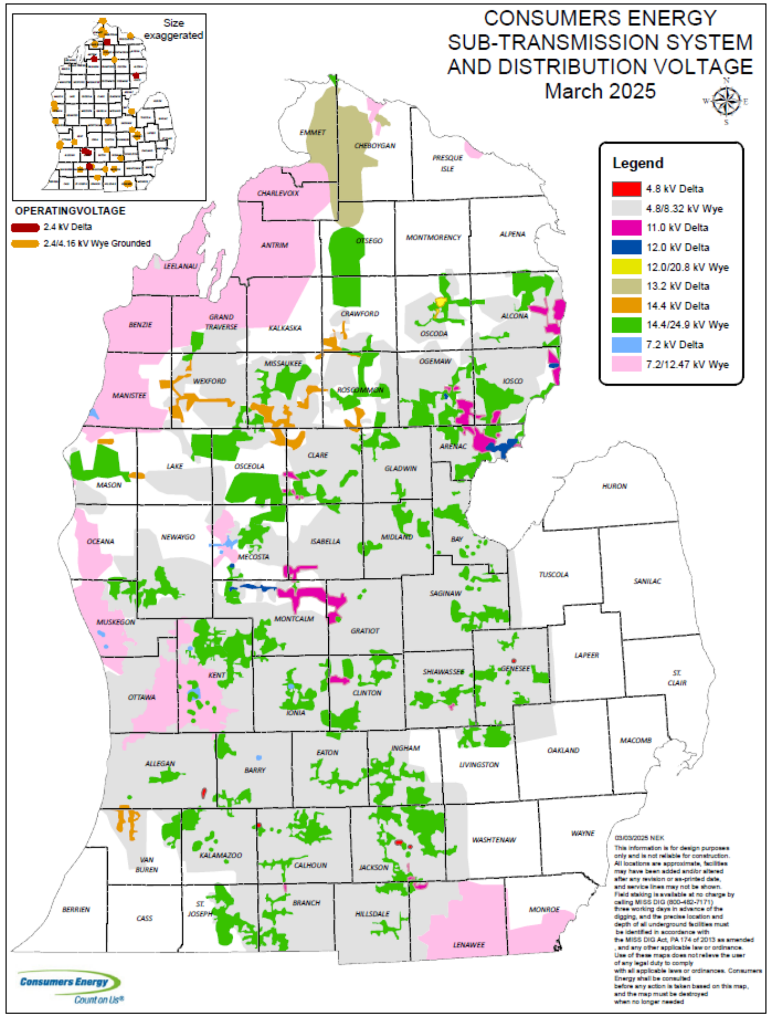
- Continue to evaluate new technologies, standards, and construction methods to reduce undergrounding costs relative to OH rebuild

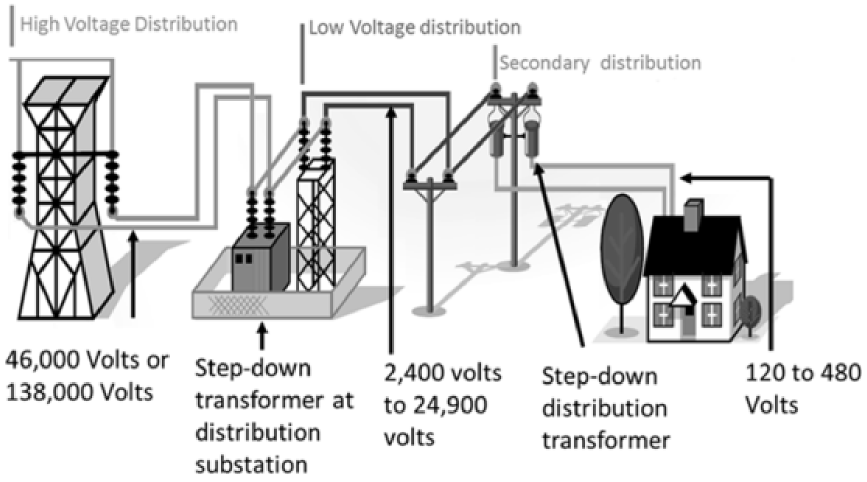
Underground Pilots & Performance

September 17, 2025

Consumers Energy
Count on Us®

Consumers Energy's distribution system serves 1.9 million customers over 1.6 million poles, almost 116,000 line miles, and 1,135 substations





28,600 Sq. Miles

- 20% larger than peer average
- Each overhead line worker covers 25 sq. miles and 45 line miles

1.6 Million Poles

- 0.1MM HVD
- 1.1MM Primary
- 0.4MM Secondary

1,135 Substations

- 144 HVD
- 163 Dedicated Customer
- 828 General Distribution
- 30 Serving Municipalities and Co-ops

115,905 Line Miles

- 4,600 miles of HVD
- 51,735 miles of primary overhead,
- 9,885 miles of primary underground,
- 31,210 miles of secondary overhead,
- 18,475 miles of secondary underground

Agenda

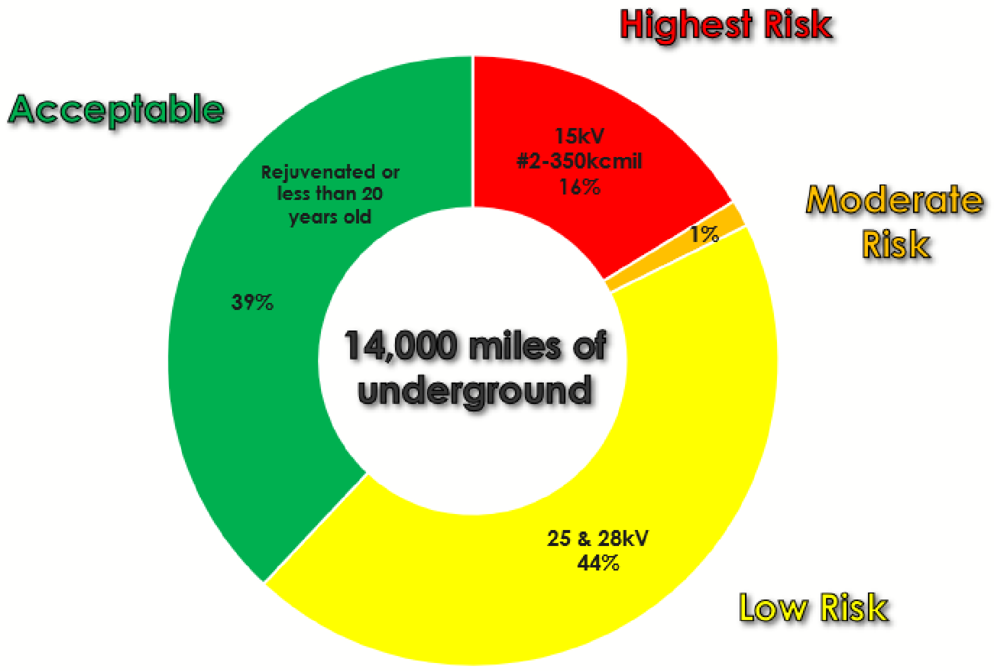
- Historic Undergrounding and Cable Rejuvenation
- Overhead to Underground Conversion Pilot

Approximately 16% of the Company primary distribution system is underground, nearly 10,000 system line miles, or 14,000 miles of cable

Underground History:

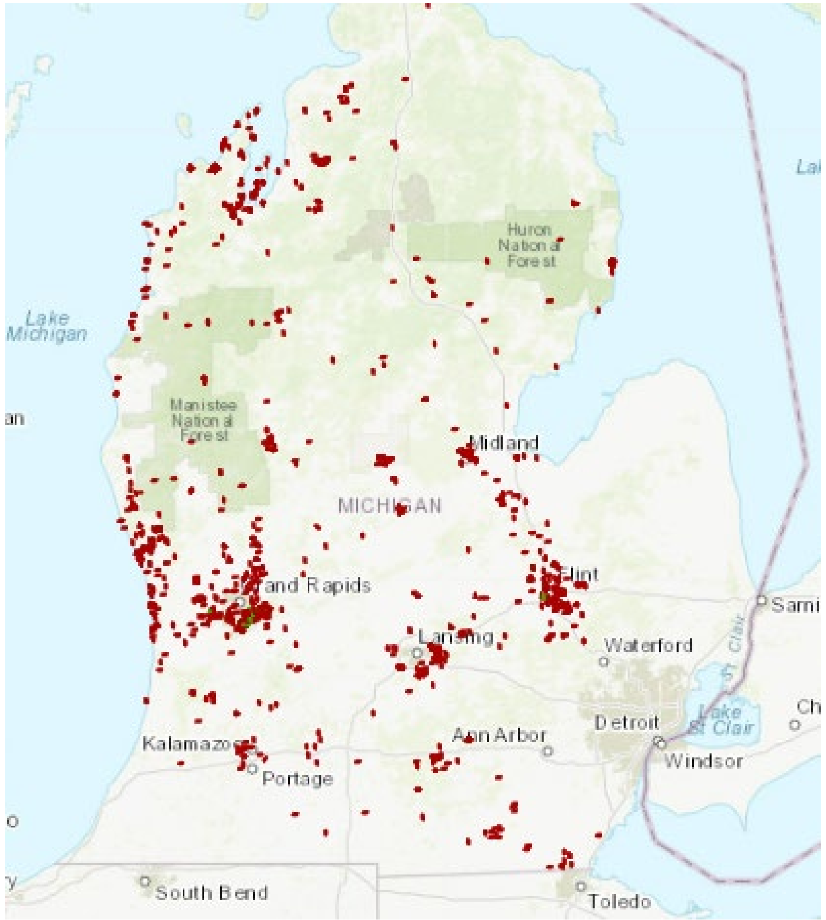
1960s	First installations of Underground (Bare Neutral, 15 kV)
Early 1970s	Transitioned to installing all 28 kV cable – Strand filled
Early 1990s	Changed to Jacketed cable (Covered Neutral)
Late 1990s	Changed to 25 kV rated and tree retardant insulation providing better and more durable insulation
Now	Cable rejuvenation of smaller 15 kV cable installations feeding residential and small commercial areas

Underground Cable Risk



The Company plan to rejuvenate approximately 2,300 miles of the smaller cable that is serving subdivisions and small business

Vintage Cable Locations

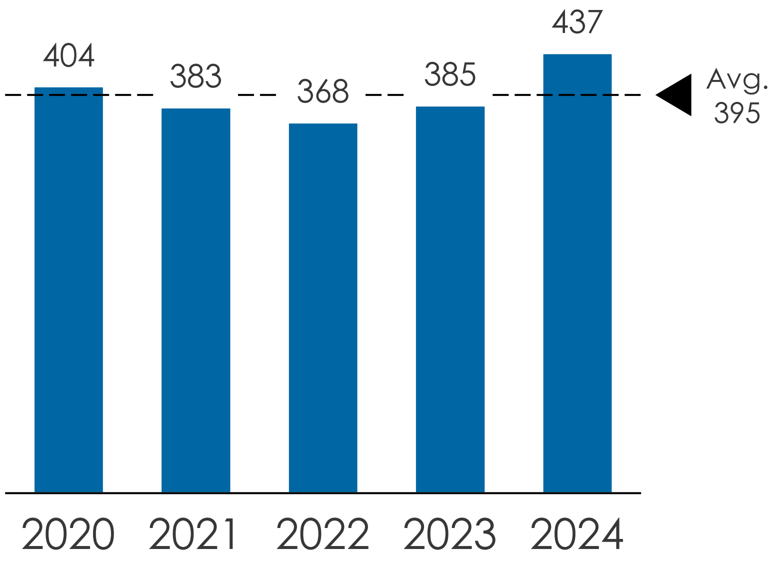


The Company has targeted only two communities at this point—Grand Rapids and Flint, with projects planned additionally in the Traverse City area in 2026

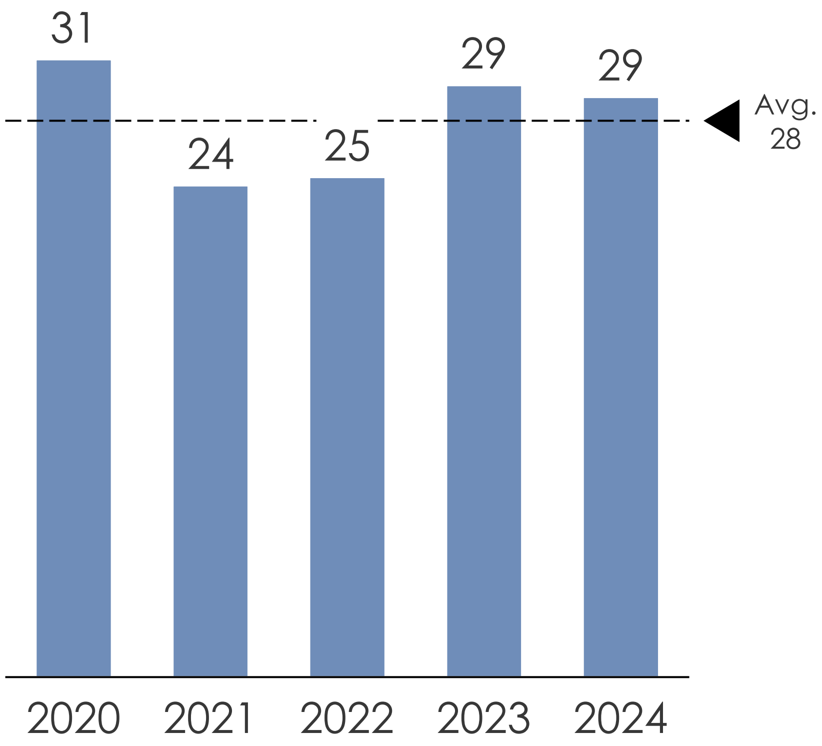
The Company plans to rejuvenate the highest risk 15kV cable at a rate of approximately 250 miles per year through 2033

Underground cable faults accounts for 395 incidents per year, impacting 28,000 customers, on average

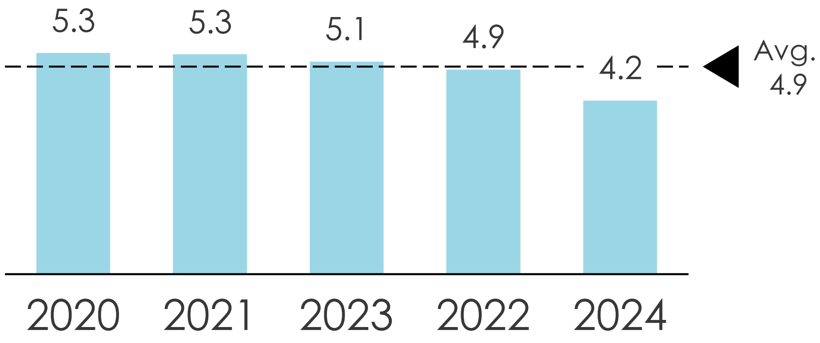
Underground Incidents
(# of Incidents)



Outages
(thousands # of Customers)

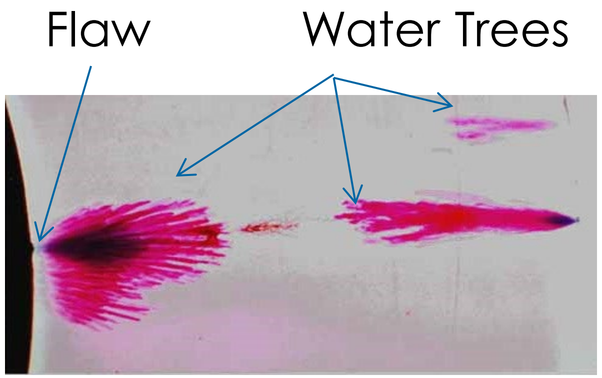


All-weather SAIDI
(minutes)

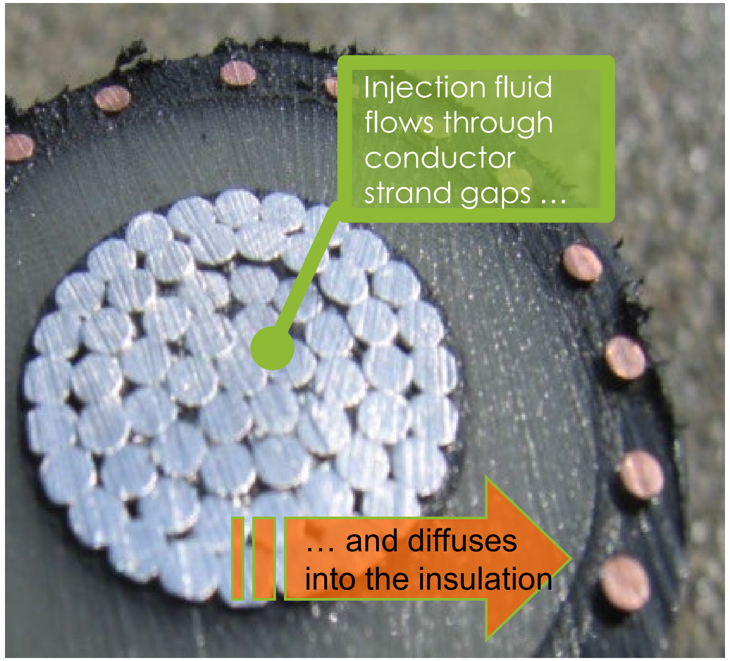


Cable rejuvenation is lower cost than replacing with new cable

Testing and Rejuvenating



Flawed cable insulation



Rejuvenating at $32/foot compared to Replacement at $80/foot

Cable Rejuvenation Process

1. Take a cable out of service
2. Perform neutral and air flow testing
3. Inject a fluid like insulation that solidifies over time,
4. Put cable back into service all at a lower cost than replacing the cable with new

Any cable that fails the testing portion of the process gets replaced with new, jacketed cable

No injected cable failures to date

Agenda

- Historic Undergrounding and Cable Rejuvenation
- Overhead to Underground Conversion Pilot

In 2023, Consumers proposed converting ~10 miles of overhead to underground to test cost effectiveness to traditional hardening

Circuit Segments originally proposed for Undergrounding

Community	Substation	Circuit	LCP	Overhead Miles	Customers	CAIDI	Project Cost	Other
Saugatuck	Saugatuck	Douglas	063	0.6	54	665	$240,000	
Fennville	Blue Star	Pier Cove	622	1.2	39	604	$480,000	
Parshalville	Dean Road	Hogan	951	2.0	73	868	$800,000	
Tawas	Tawas	Tawas	482	0.8	67	641	$300,000	Federal Disadvantage Community
Hudsonville	Hager Park	Wellington	536	0.6	12	1834	$240,000	
Greenville	Peck Road	M-91	473	2.1	72	640	$840,000	
Trowbridge	Merson	Merson	412	2.0	66	1119	$800,000	Federal Disadvantage Community
Genesee	Geneseeville	Rogers	100	1.0	48	949	$420,000	MI Environmental Justice
Total				**10.3**			**$4,120,000**	

The segments were identified based on nine selection criteria where undergrounding could be considered to improve resiliency

Selection Criteria:

1. will be single-phase,
2. have had at least one outage in the last 24 months,
3. serve between 10 and 100 customers[1],
4. be operated at one of the three standard wye voltages,
5. not be considered for another reliability project,
6. have an average CAIDI of 600 minutes or more[1],
7. have a load after installation of 36% or less of the ampacity of the newly installed facilities,
8. be located in an area of dense trees[1], and
9. not supply an overhead system

The criteria were designed to target areas that would benefit most from undergrounding, particularly those prone to outages due to environmental factors like dense tree cover

1. Criteria has been updated in latest case U-21870

Ultimately, the Company landed slightly shy of its 10 miles goal in completing approximately 9 miles in the test year

Status of Projects

	Community	Substation	Circuit	OH Miles	Customers	Status
Originally Proposed	Saugatuck	Saugatuck	Douglas	0.6	54	Complete
	Fennville	Blue Star	Pier Cove	1.2	39	Halted
	Parshalville	Dean Road	Hogan	2.0	73	Halted
	Tawas	Tawas	Tawas	0.8	67	Late
	Hudsonville	Hager Park	Wellington	0.6	12	Complete
	Greenville	Peck Road	M-91	2.1	72	Halted
	Trowbridge	Merson	Merson	2.0	66	Halted
	Genesee	Geneseeville	Rogers	1.1	48	Complete
Subsequently Added	Port Sheldon	Pigeon Lake	Olive	1.2	37	Complete
	Hillsdale	Carleton Road	Beck Road	1.0	15	Complete
	Standish	Duquite	Saganing	1.5	20	Complete
	Newaygo	Conklin Park	Holly	1.4	10	Complete
	Honor	Honor	Indian Hill	1.5	43	Complete

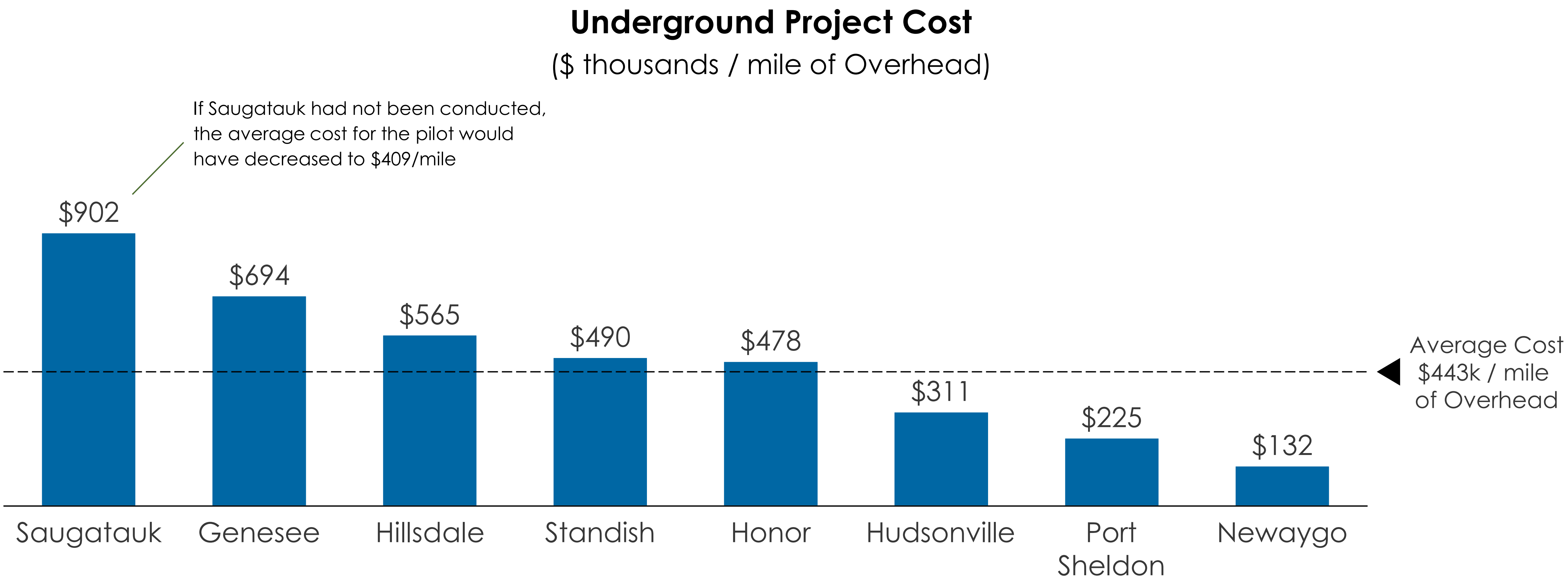
Lessons Learned

- Need to keep momentum going on undergrounding as project planning and design needs to happen well in advance of plan year
- All projects in delayed status were due to issues in acquiring easements
- Utilizing the road right-of-way should reduce easement difficulties and vegetation removal and allow for faster and less costly construction through plowing as opposed to boring

Customer Feedback

- Several customers expressed excitement for better reliability
- Customer alignment is needed on equipment locations, even with existing easements
- Better understanding of forestry activities is needed for undergrounding construction

The Company experienced a large range of project costs with an average pilot cost of approximately $443k / mile of overhead converted



Average cost based on underground conductor installed was $422k/mile, or $398k/mile excluding the costliest project, lower than the $626k/mile cost the Company first expected the process to cost in the early half of the decade[1]

1. U-21122 filed in 2021 had an expected cost of undergrounding averaging $626k for Rural Feeder

The conditions present at the undergrounding locations affected the project costs

High End Conversion Cost

Saugatuck at $902k per Overhead Mile

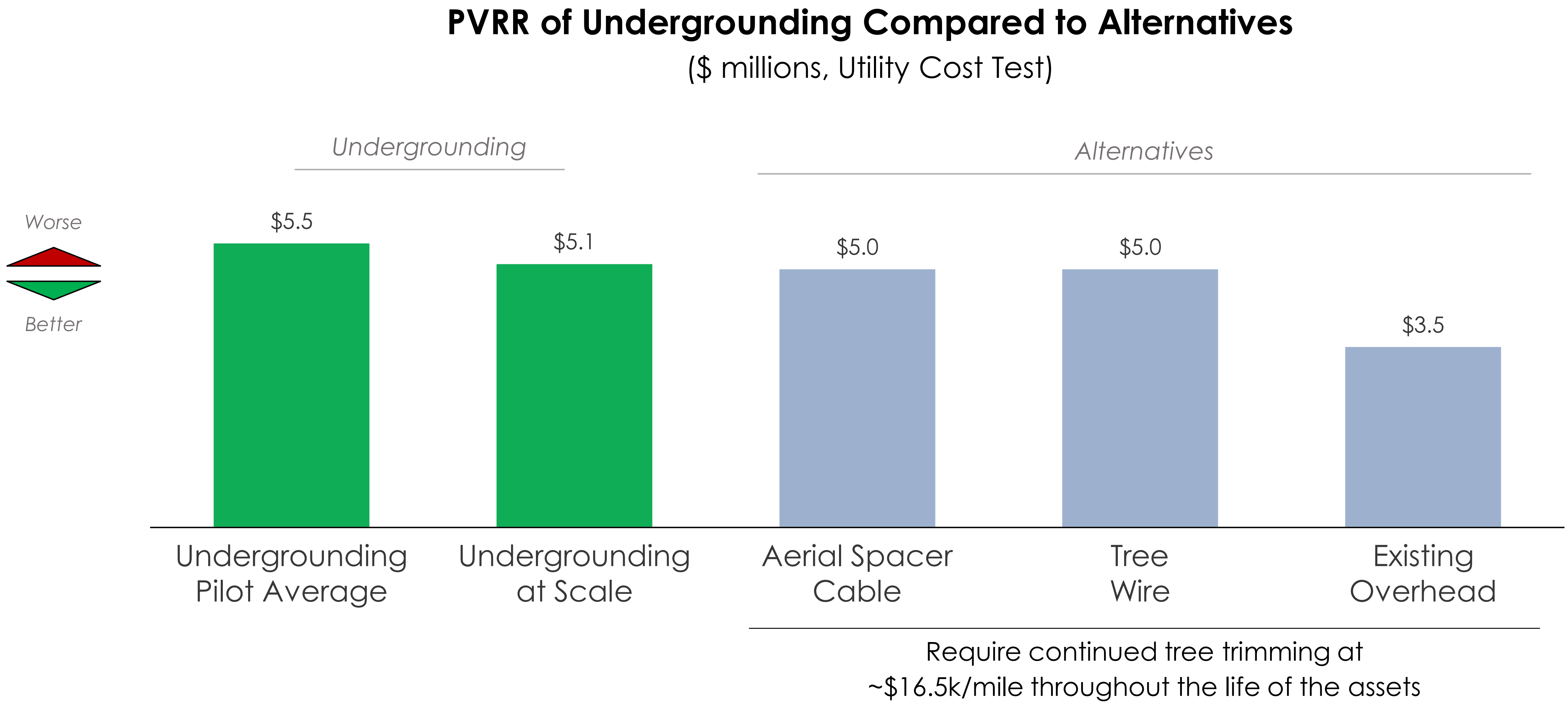
Almost 100% bore
Narrow right of way
High customer density
Busy road with popular local park

Low End Conversion Cost

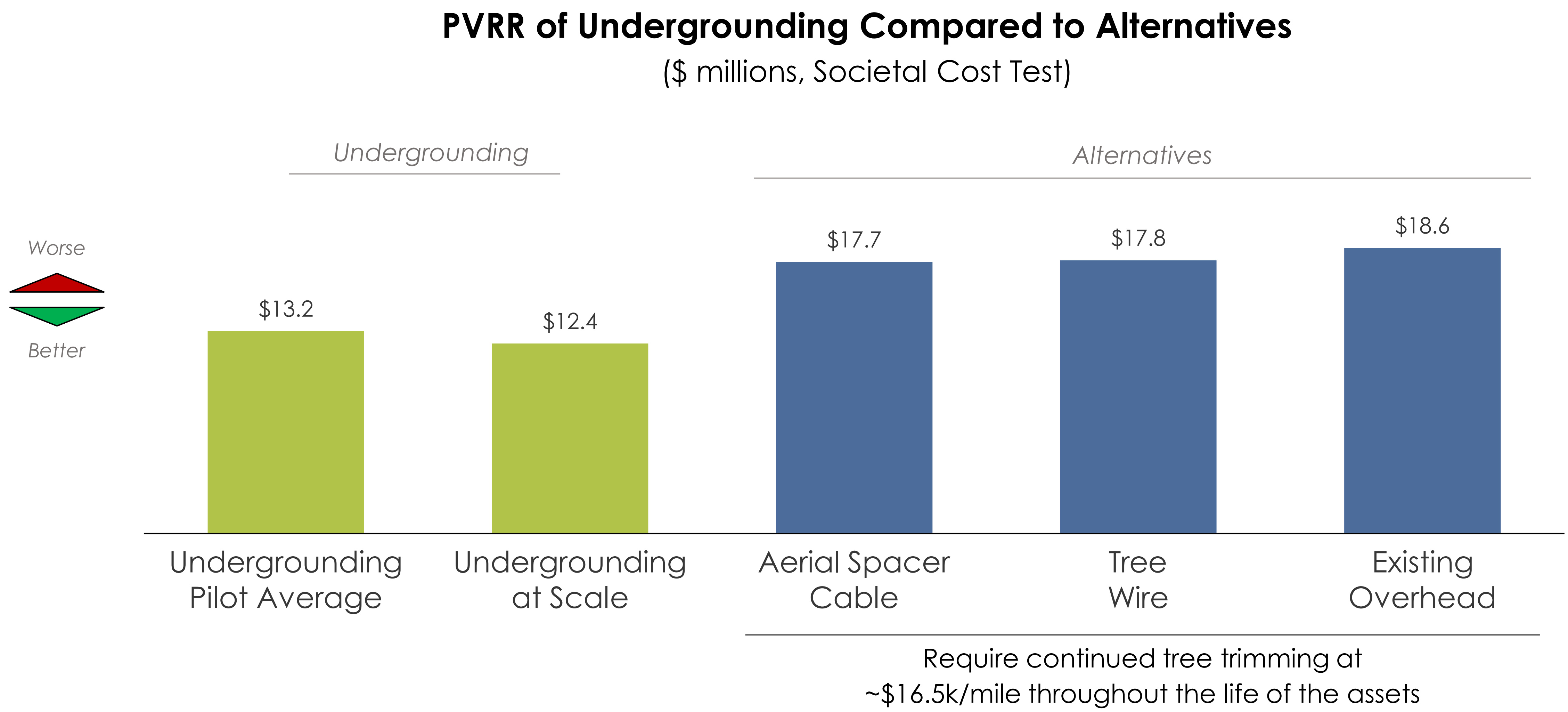
Newaygo at $132k per Overhead Mile

100% plowing, no boring
Rural with good right of way
Lower customer density
Away from busy roads

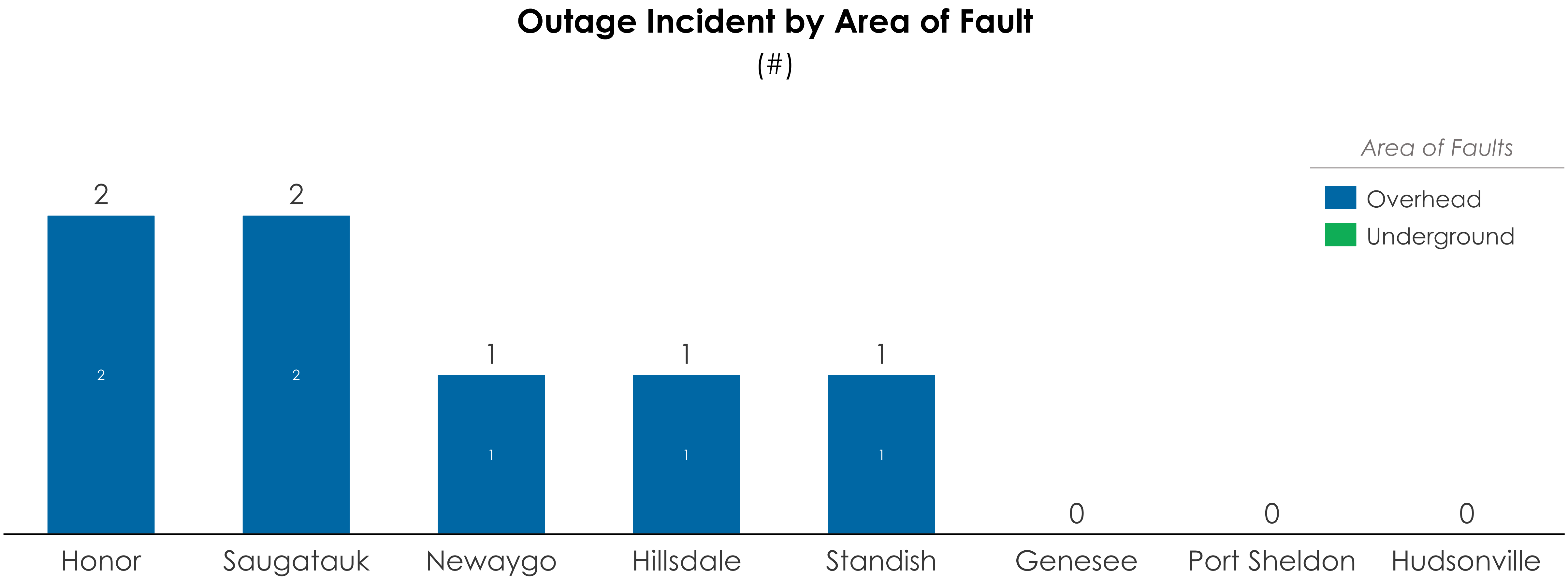
When programmatically converting overhead to underground, avoid high-cost areas to yield a comparable cost to customers



Undergrounding provides better value to customers when utilizing an alternate valuation methodology to consider the societal costs of outages



Since the completion of the pilot, customers have experienced outages, but they are due to faults on the overhead system powering their feeders



Customers experience outages because the undergrounded segments of the system are still fed by an overhead system and exposed to severe weather and trees

ALPENA POWER COMPANY

Undergrounding in Michigan

Utility Perspective & Efforts Underway

September 17, 2025

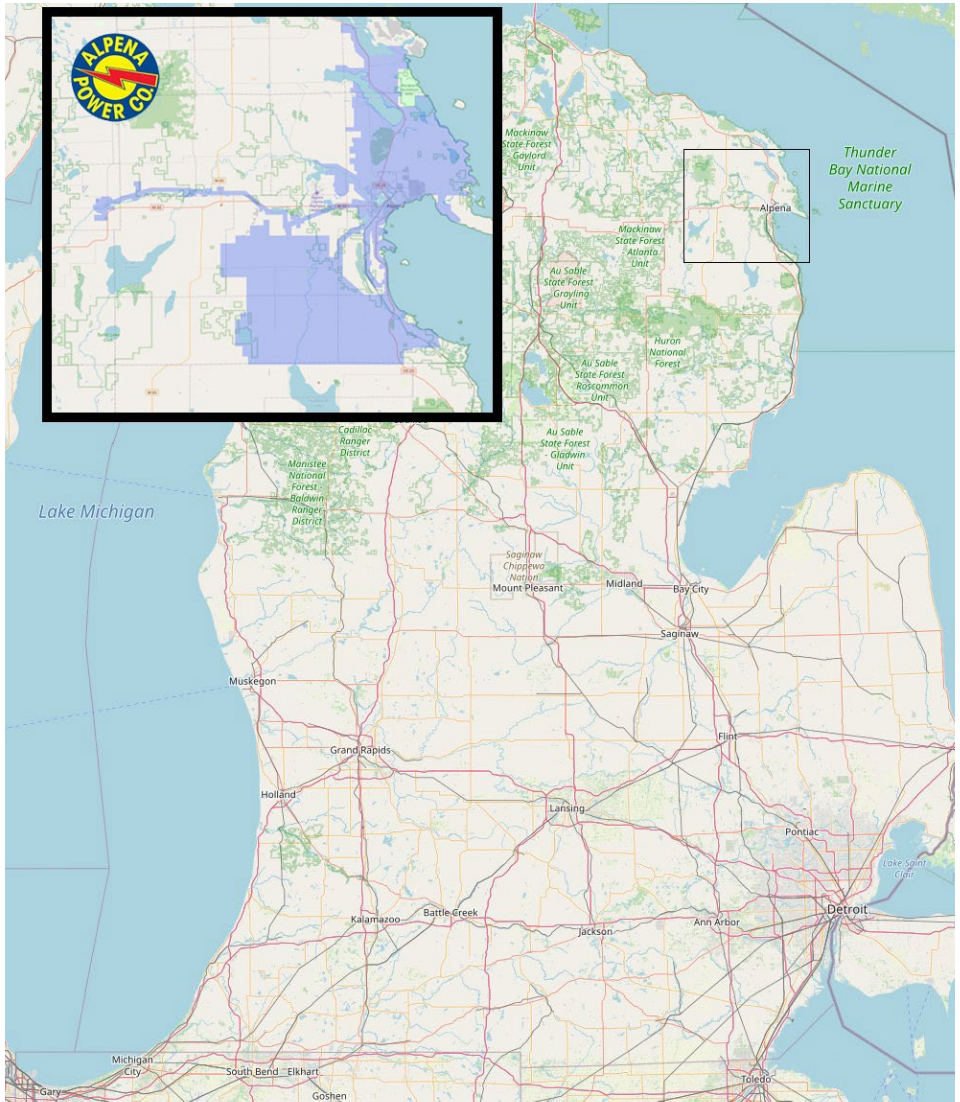
ALPENA POWER COMPANY

Company Overview

- Serve approximately 16,750 customers in NE lower MI
- Service territory includes portions of Alpena, Alcona, Montmorency and Presque Isle counties
- Territory includes approximately 61 miles of Lake Huron shoreline and 250 square miles
- 656 Miles of Overhead Primary Line
- 75 Miles of Underground Primary Line
- 33 Full Time Employees

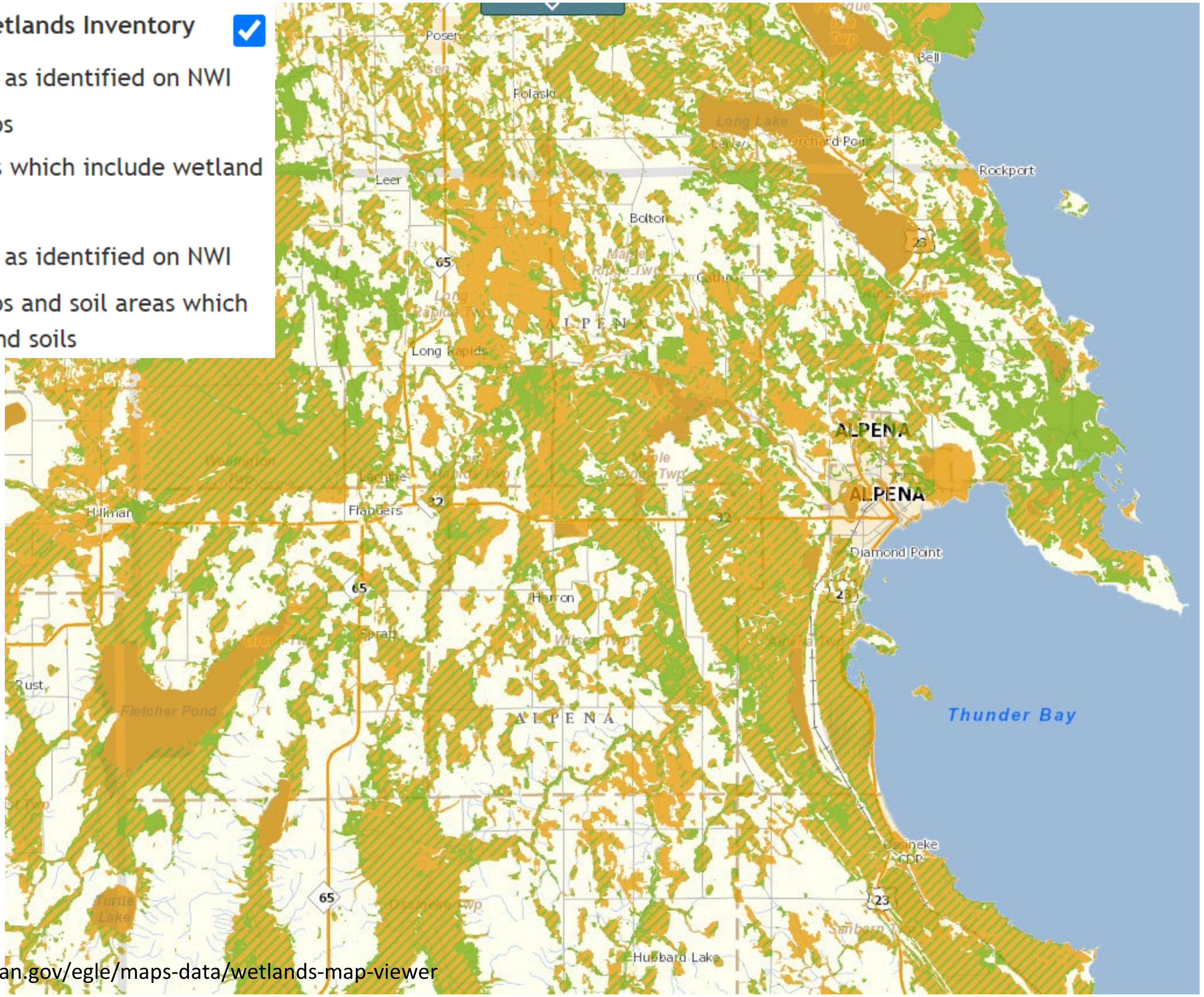
ALPENA POWER COMPANY

Service Territory



ALPENA POWER COMPANY

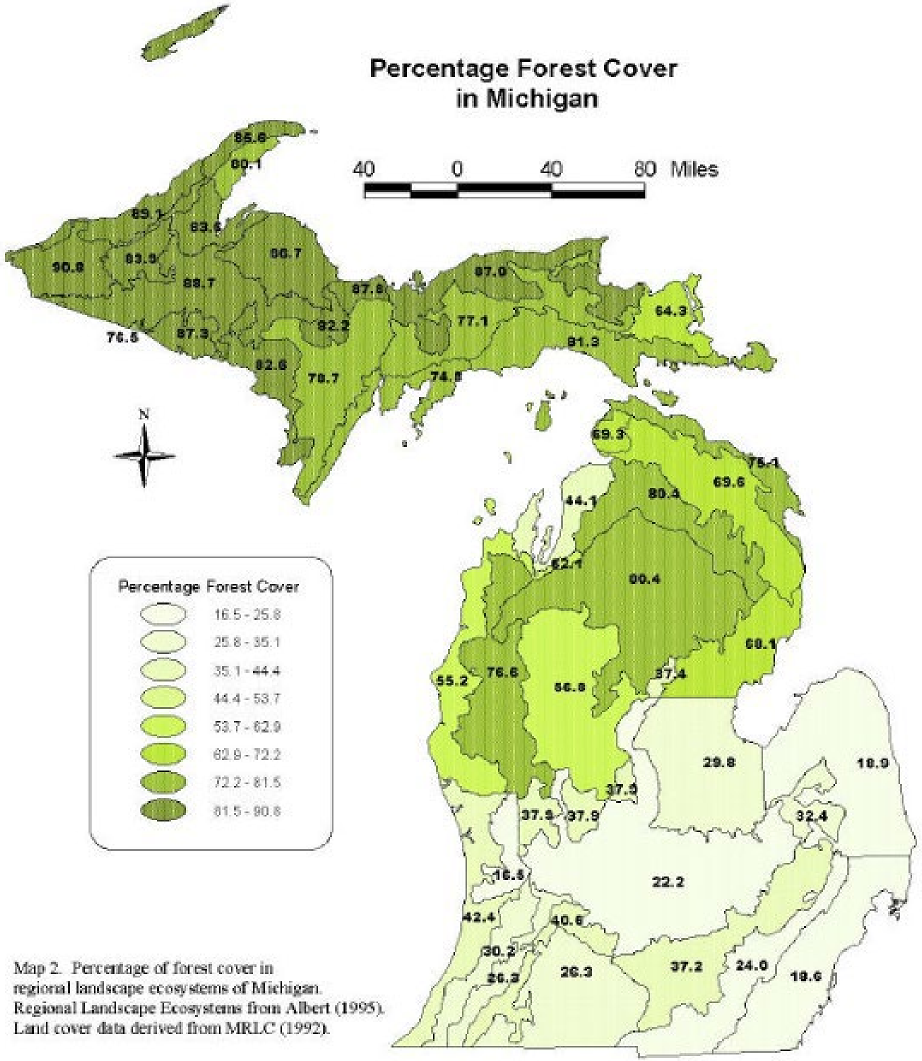
Service Territory Challenges – Wetlands [1]



[1] https://www.michigan.gov/egle/maps-data/wetlands-map-viewer

ALPENA POWER COMPANY

Service Territory Challenges – Forest Cover [2]



Map 2. Percentage of forest cover in regional landscape ecosystems of Michigan. Regional Landscape Ecosystems from Albert (1995). Land cover data derived from MRLC (1992).

[2] https://www.michigan.gov/- /media/Project/Websites/dnr/Documents/FRD/SFMP/13overview.pdf?rev=44d9b8f272cb439ca62540b650ba 5ba9

ALPENA POWER COMPANY

Reliability Challenges

- Repetitive outage issues in rural areas with low customer density
- Results in non-compliance with reliability standards for some customers
- Majority of outage causes are tree related
- Wet, rocky terrain leads to shallow tree root bases subject to uprooting
- Many trees causing outages come from outside the right-of-way

ALPENA POWER COMPANY

Undergrounding Projects – Bloom Road Circuit

- Rural circuit serving about 330 customers
- Over 36 miles of primary, most of which was overhead construction prior to 2011
- Over 12 miles of Lake Huron shoreline
- Heavily wooded wetland with rocky soils
- Customers experienced significant outage minutes due to repetitive outages
- Full easement tree clearing, ground to sky did not have significant impact on outages
- Solution selected to address repetitive outages – targeted undergrounding

ALPENA POWER COMPANY

Undergrounding Projects – Bloom Road Circuit

- From 2011 to 2023 converted 6.5 miles of overhead primary to primary underground
- 7 separate projects to address targeted areas causing large amount of tree related outages
- Focus was undergrounding of primary but also engaged customers in undergrounding of service drops
- Challenges
  - Soil Conditions, some areas with bedrock at or near the surface
  - Right-of-way access
  - Customer density

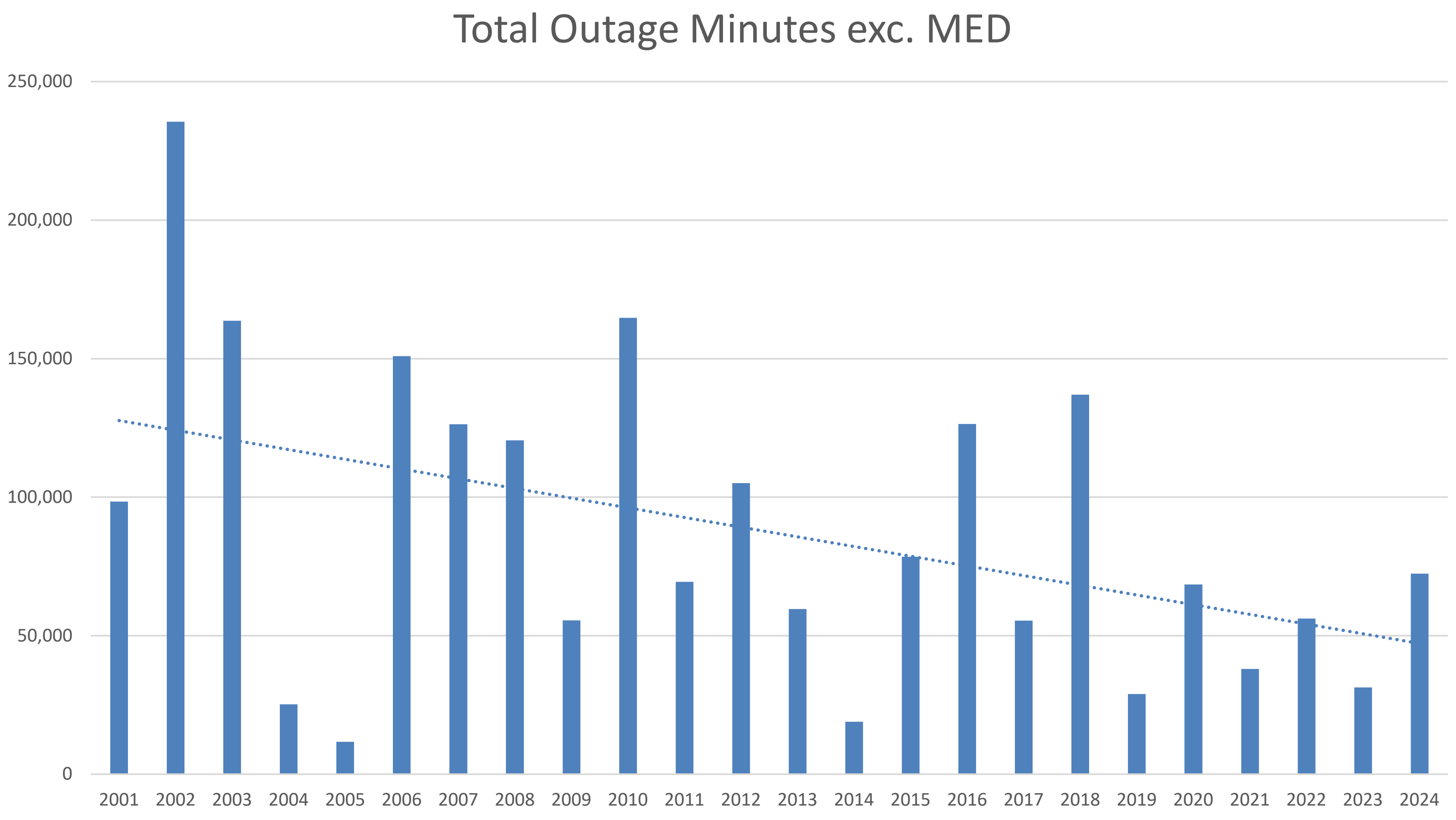
ALPENA POWER COMPANY

Undergrounding Projects – Bloom Road Circuit

Year	Conversion Distance (miles)	Total Cost	Cost/Foot
2011	1.09	$40,627	$7.09
2012	2.39	$178,187	$14.13
2012	0.38	$60,164	$30.04
2013	0.66	$56,048	$15.98
2015	0.93	$132,408	$26.91
2021	0.40	$59,329	$28.33
2023	0.57	$87,889	$29.07
TOTAL	**6.42**	**$614,655**	**$18.14**

ALPENA POWER COMPANY

Undergrounding Projects – Bloom Road Circuit



ALPENA POWER COMPANY

Undergrounding Projects – Path Forward

- Targeted undergrounding has proved to be valuable tool to address repetitive outages
- Project cost largely dependent on soil conditions
- Better data drives better decisions
  - Outage reporting based on IEEE standards
  - More detailed outage cause data
  - Investigating reporting outage cause location

Lessons Along the Road to Transmission Deployment

Josh Rogers, Policy Specialist at the Great Plains Institute

GREAT PLAINS INSTITUTE

Better Energy. Better World.

Maine transmission line is stalled despite court victories

By Benjamin Storrow | 04/27/2023 06:38 AM EDT

Legal fights and permitting problems have delayed a project that is supposed to help New England lower its emissions. It might mark a national trend.

DEPT. OF ENERGY

THE HOLDOUTS IN THE QUEST FOR A BETTER POWER GRID

Farmers in Missouri are opposing the Grain Belt Express, a transmission line that will connect wind farms in Kansas with cities in the East.

Conservation groups sue to stop a transmission line from crossing a Mississippi River refuge

102-mile line linking WI, IA projected to cost more than half a billion dollars

Associated Press

Environmentalists continue fight against planned power line crossing the Mississippi River

Power companies say the transmission project would improve reliability and hook more clean energy to the electricity grid.

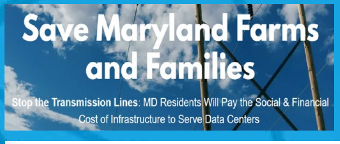
Now You Know: Our push to stop new high-voltage electric lines

Ryan Nawrocki and Kathy Szeliga   Mar 19, 2025   0

High Voltage, Higher Stakes: Residents Protest Dominion Energy's Power Expansion

Residents of the Loudoun Valley community fight against Dominion Energy's proposal to build power lines on the campuses of Rosa Lee Carter and Rock Ridge High School.

Law will help wealthy Louisiana landowner in dispute with power line builder



Legal Challenges Continue for SunZia Transmission Line

Southern Arizona tribes and San Pedro Valley residents continue their legal challenges to halt construction of the largest renewable energy project in U.S. history.

A New York power line divided environmentalists. Here's what it says about the larger climate fight.

States waited too long to decarbonize, and now they have to make tough choices.

NORTH DAKOTA | Brief

Landowners, local governments lose power struggle over power lines

An Epic Battle Over 1 Mile of Land in Wisconsin Is Tearing Environmentalists Apart

Conservationists and green energy developers square off, with big consequences for the climate.

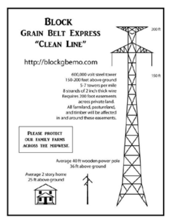
Tribes, environmental groups ask US court to block $10B energy transmission project in Arizona

Concerns grow over proposed power lines

By Betty Williamson and Ron Warnick Eastern New Mexico News   Feb 21, 2025

A Power Line Debate Pits Environmental Allies Against Each Other in the Upper Midwest

The transmission line project on the Iowa-Wisconsin border has been halted by the latest in a series of legal challenges.



Residents, Parents Protest Transmission Lines on School Grounds

State appeals court tosses proposal for new transmission line in central Illinois

Advocates say the controversial project is necessary to meet renewable energy needs

Montana transmission lines draw opposition from all sides

Eastern Oregon residents oppose energy transmission line project: 'Absolute disaster for ecosystem'

The Boardman-to-Hemingway line could move enough clean electricity to power 150,000 homes, but opponents say the environmental tradeoffs aren't worth it.

Battle Lines: Fighting the Power

Landowners Concerned About LCRA's Hill Country CREZ Lines

Angry Carroll County residents plan to fight proposed transmission line project

Maine Gov. Mills, 2 Environmental Groups Back Controversial $1 Billion Transmission Project

Need a power line? That'll be $3B and 18 years.

By ARIANNA SKIBELL | 06/21/2023 05:59 PM EDT

Stop R-Project powerline from traversing Sandhills

News | Feb 16, 2024

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Better Energy. Better World.

Why does local opposition matter?

1. Transmission capacity needs to increase by 2-5 times (~75,000 miles by 2035)
2. Maintaining a rapid pace of development for a decade requires a **SOCIAL LICENSE** to build
3. Absent local support, developers are facing
    1. Costly lawsuits and delays
    2. Protest
    3. Legislative action

GREAT PLAINS INSTITUTE

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Lessons Along the Road to Transmission Deployment

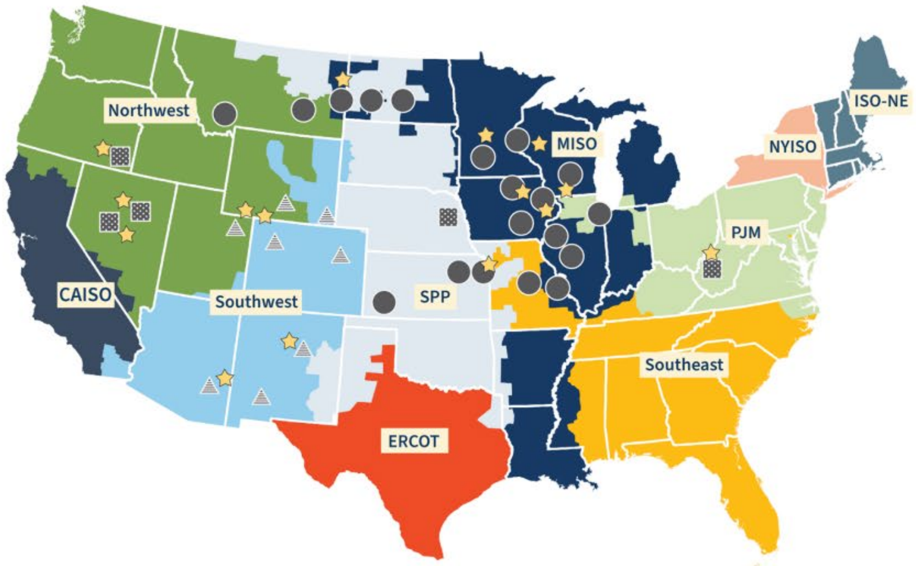


Figure 1. Geographic scope of GPI's grassroots research

- In-person interviewee
- Virtual interviewee
- Prior in-person research
- Transmission projects studied

Note: Multi-color regions on the map represent transmission planning regions.

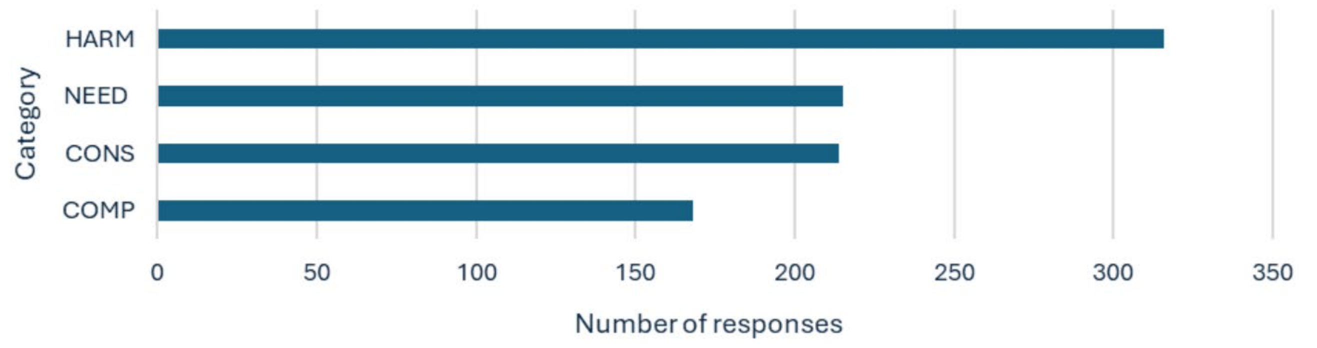
Sources: Figure by Aime Bita, Great Plains Institute, and Esther Ramsay, Horizon Climate Group, based on data from Joshua Rogers, Great Plains Institute, and transmission planning regions by Elizabeth Abramson, Horizon Climate Group, and Aparna Narang, Clean Grid Initiative, 2025, adapted from Federal Energy Regulatory Commission (FERC) Order 1000 Regions shapefile, December 2024.

- 150 Interviews
- 5 public meetings
- 6 months on the road
- 13 states in-person
- 15 HVTLs
- 37 distinct drivers
- 910 responses

Source: MISO, MTEP Futures White Paper, April 2020. https://cdn.misoenergy.org/20200427%20MTEP%20Futures%20Item%2002b%20Futures%20White%20Paper443656.pdf

How to understand opposition

Figure 2. Opposition framework: Interview responses



1. How will this negatively impact my life?
2. Why is this project even needed?
3. How will I be consulted on this project?
4. How will I be compensated for any potential harms caused by this project?

Undergrounding

1. **Significantly reduces perceived harm**
   - Transportation Corridors
   - Cultural & Aesthetic
   - Property Values
   - Safety*
2. Similar issues around need
   - Fear of novelty
   - Costs
3. Similar issues around consultation
4. Similar issues around compensation

Transportation Corridors

- **Most popular form of transmission development**
  - National opponents of transmission advocate this
  - Reduces impact on private property/Greenfields
  - Site control
- **Uncommon**
  - Increased uncertainty
  - Legal complexity: easement access

Cultural & Aesthetic

- **Cultural and aesthetic concerns drive ideological opposition to above ground high-voltage transmission**
  - Sense of place/community
  - Landowner motivations
- **Undergrounding dramatically reduces cultural & aesthetic harms**
  - No visual impact
  - Reduced land use
  - Reduced noise pollution

Property Values

- **Overhead**
  - Concerns: eye-sore, EMFs, & safety
  - Typically 0–10% depreciation in value
  - Some studies indicate depreciation can reach 17—45% for scenic areas
- **Underground**
  - Buring overhead lines can increase value by 5-20%
  - New lines have little to no negative effect on residential values

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Safety

- **Electromagnetic fields**
  - Uncertainty over whether this is a safety hazard
  - Overhead: present, can reach up to
  - Underground: metallic sheath + soil shields EMFs
- **Fire**
  - Overhead: wildfires
  - Underground: low risk
- **Repair**
  - Overhead: more frequent, but easier
  - Underground: less frequent, but more difficult

Costs

Underground

- Uncertain cost estimates (we don’t build these often)
- High upfront capital (2-10 times, depending on the study)
- High repair costs
- High replacement costs
  - Potentially lower lifetime

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THANK YOU

Josh Rogers

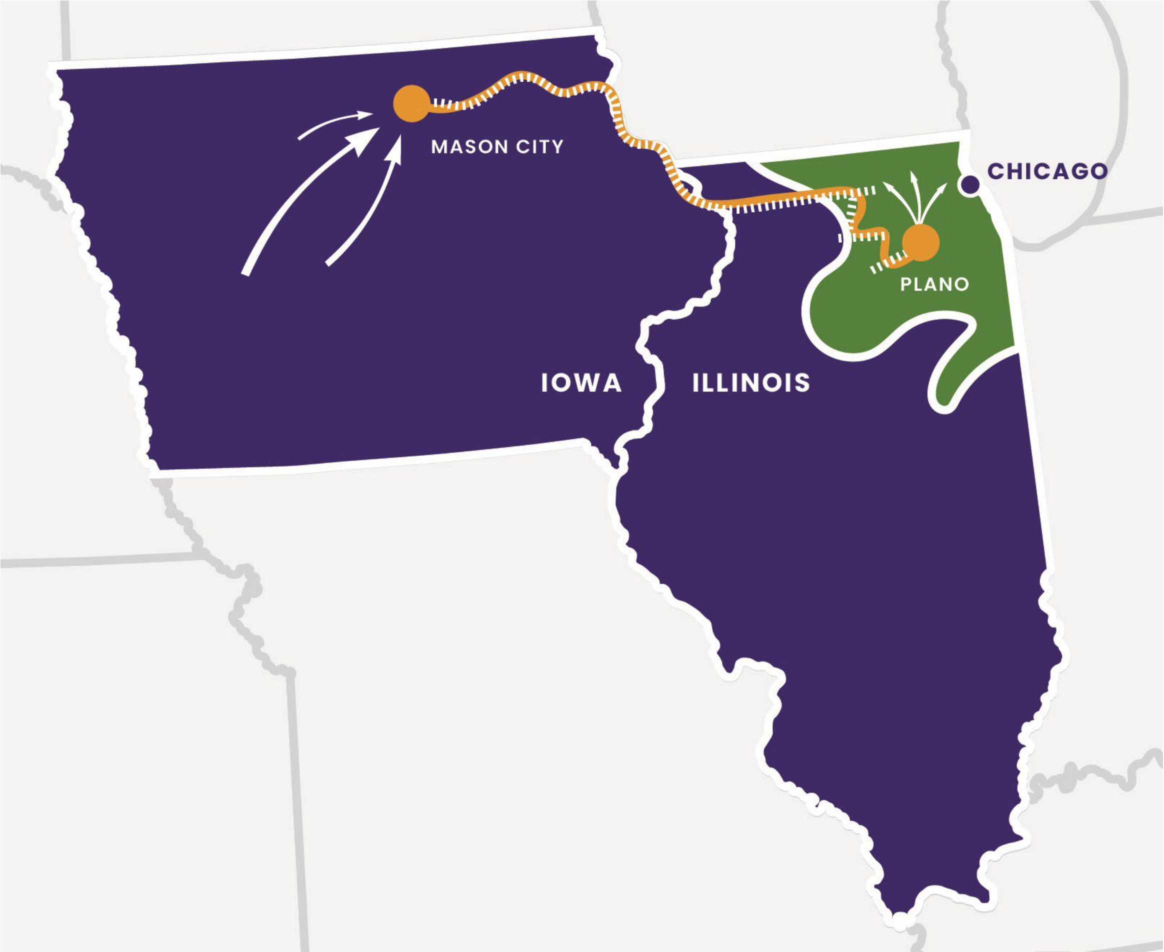
jrogers@gpisd.net

Undergrounding Transmission:
Permitting and Economics in the Grid Reliability and Resilience Context

Raj V. Rajan, PhD, PE [VP of Project Development, SOO Green HVDC Link ProjectCo LLC]

MPSC Undergrounding Workshop [17 September 2025]

SOO Green
HVDC LINK

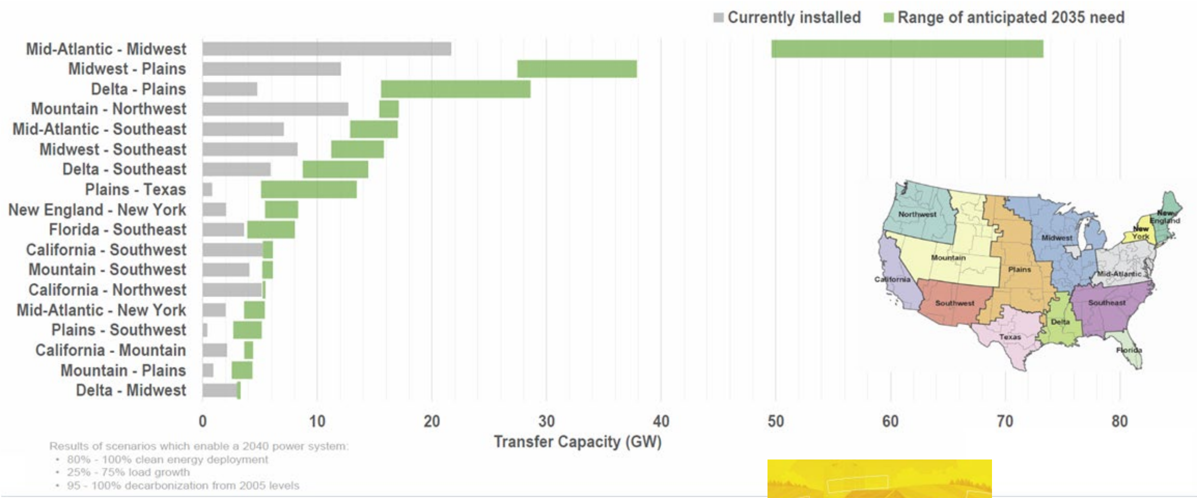


SOO Green
HVDC LINK

Location

Project

- Data from six capacity expansion studies analyzed, to identify future regional and interregional transmission needs.
- Biggest inter-regional 2035 Tx needs gap: Midwest <-> Mid-Atlantic (28-52 GW)



SOO Green
HVDC LINK

Driver

Project

Source: Draft National Transmission Needs Study, Dr. Adria Brooks, DOE/GDO [April 2023 @MIDGRID35 meeting]

Overview

Project

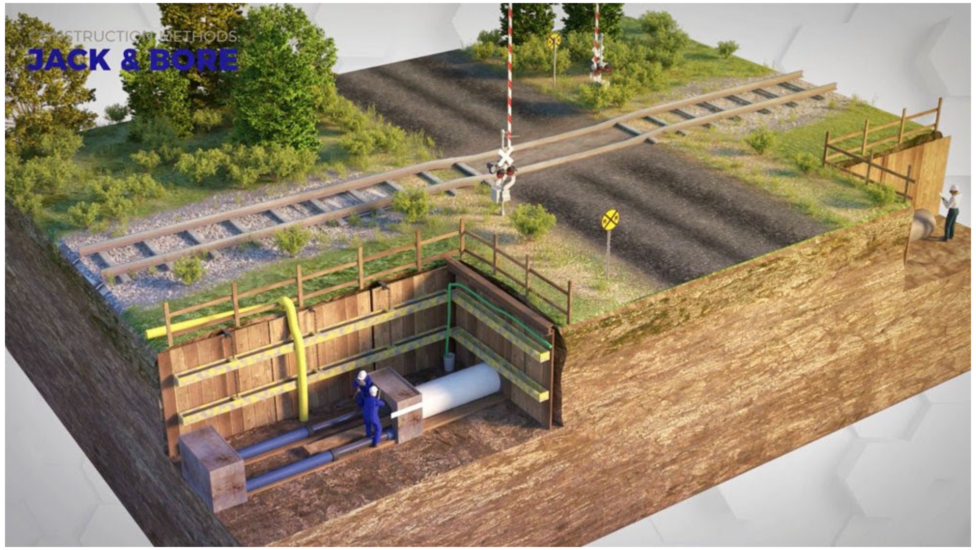
- Inter-State and Inter-RTO
- Underground Installation
- Transportation ROW Co-located
- In-Conduit Installation
- HVDC Transmission
- Symmetric Bipole configuration

SOO Green
HVDC LINK

Specifics

Project

- Insulated and Shielded Cables
- 350+ miles point to point
- 525 kV Voltage Class
- 2100 MW Nameplate Capacity
- 13+ TWh/yr transmitted
- MMC VSC Converters



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Development & Implementation Team

The Project

CIP COPENHAGEN INFRASTRUCTURE PARTNERS

energyRe

ppl PPL Electric Utilities

SIEMENS energy

Mortenson

JINGOLI POWER

PRYSMIAN CABLES & SYSTEMS

CPKC

CN

OmniTRAX

BNSF RAILWAY

wsp

POWER ENGINEERS

HATCH

SOO Green HVDC LINK

Development Phase Permits

Permitting

SOO Green HVDC LINK

Federal Water Quality
Clean Water Act (Section 404)
Ambient Water Quality Permit

Electric Franchise
Iowa Utilities Board
Permit To Construct and Operate
Transmission Lines in Rural Iowa

IA Environmental
IOWA DEPARTMENT OF NATURAL RESOURCES
Clean Water Act (Section 401)
Water Quality Certification,
Antidegradation and Outstanding State Waters,
Floodplain Development

Federal Navigable Waters
Rivers and Harbors Act (Section 10)
Permit for construction of any structure
in, over, or under navigable waters

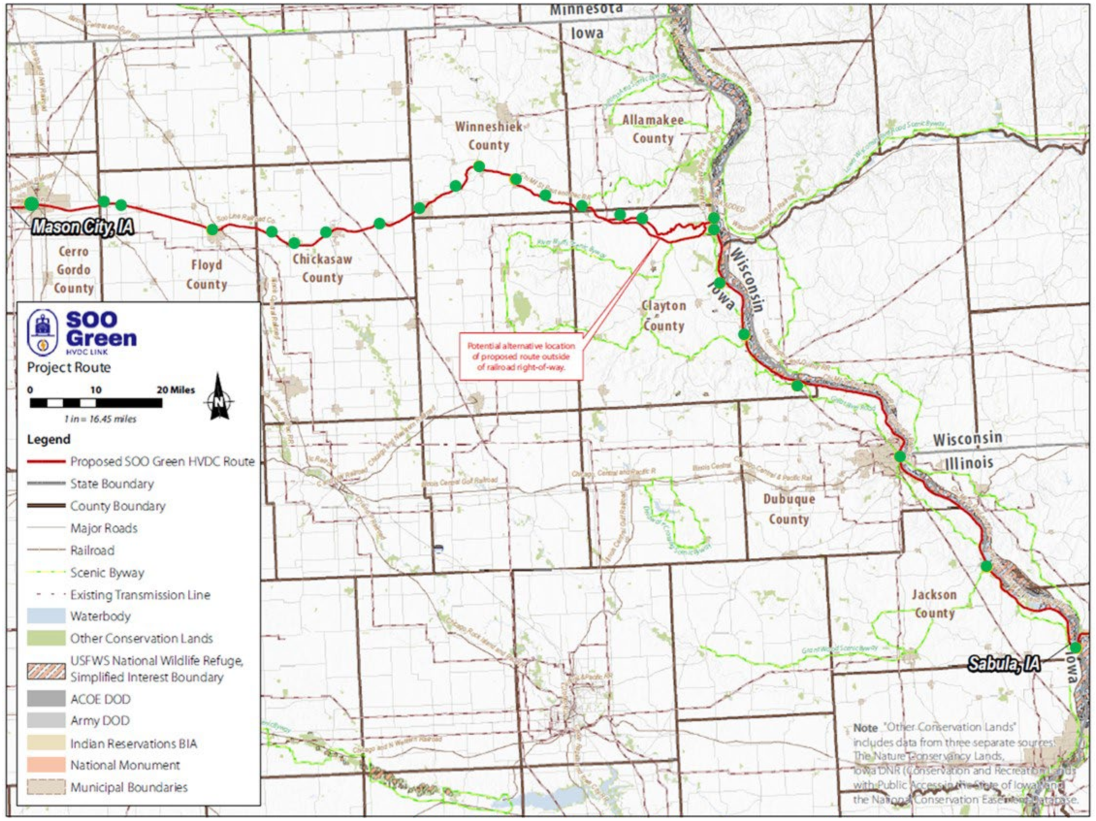
IOWA DOT
Utility Installation Permits
Illinois Department of Transportation

Federal Civil Works
Rivers and Harbors Act Section 14
Codified under 33 USC 408 (Section 408)
Permit to Alter Federal Civil Works

Municipal Franchises
Permits To Construct and Operate
Transmission Lines in IA Municipalities

IL Environmental
Illinois Environmental Protection Agency
ILLINOIS DEPARTMENT OF NATURAL RESOURCES
Clean Water Act (Section 401)
Water Quality Certification,
Public Water Permit,
Floodway Permit)

Iowa Utilities Commission



● Municipal Franchise Agreement Approved & Fully Executed

State and Local Franchises

Permitting

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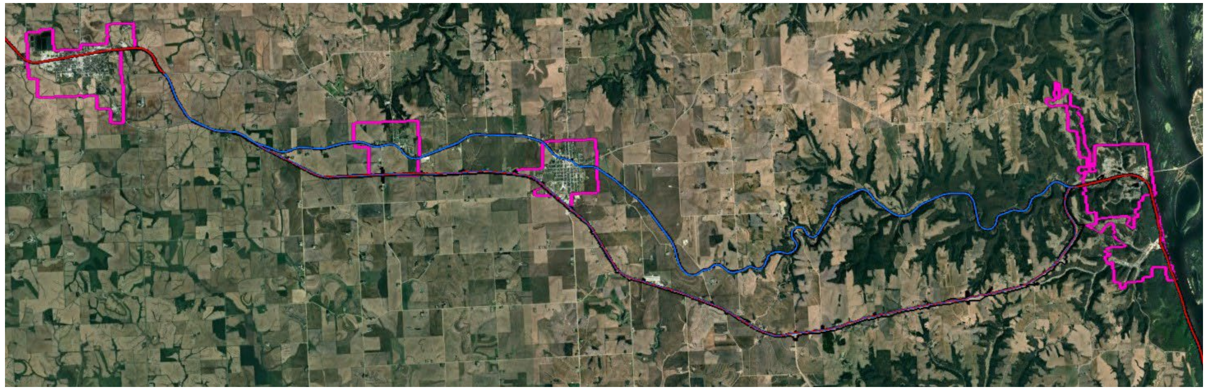
ILLINOIS COMMERCE COMMISSION ICC

IOWA DOT



Illinois Department of Transportation

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State DOT Utility Installation Permits

Permitting

Environmental Reviews

Permitting

Lead Federal Agency

(Waters of the United States Jurisdiction)
National Environmenental Protection Act (NEPA) documentation

Biological Resources

Endangered Species Act (Section 7)
Federal Agency Consultation

Biological Resources

Environmental Review for Natural Resources
Listed endangered or threatened species

IA Cultural Resources

National Historic Preservation Act (Section 106)
IA SHPO Consultation

IL Cultural Resources

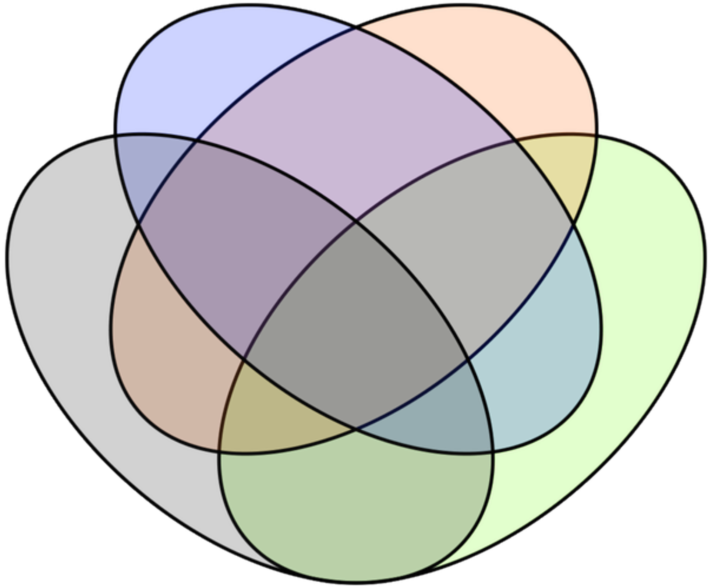
National Historic Preservation Act (Section 106)
Illinois State Agency Historic Resources Preservation Act (Section 707)
IHPA Consultation

IL Natural Resource Reviews

Illinois Endangered Species Protection Act
Illinois Natural Areas Preservation Act
Interagency Wetland Policy Act

Project to be submitted to and evaluated in Ecological Compliance Assessment Tool

- Financial Capital
- Human Capital
- Social Capital
- Natural Capital



Sustainable Multi Capital Accounting

Economics

SOO Green
HVDC LINK

Financial Capital

Economics

- Fixed and Variable Costs
- Spread in Wholesale Electric Prices +
- Spread in REC Values +
- Spread in Capacity Markets +
- Value of Ancillary Services (?)

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Human Capital- Qualitative Considerations

Economics

- Health Benefits from Reduced Emissions
- Commitment to Organized Labor [LiUNA, Operating Engineers, IBEW]
- Commitment to Workforce Development [Community Colleges and Local/Regional Economic Development Authorities]
- Train to Hire Programs Prioritizing Local Hiring from Disadvantaged segments of Community [Hire 360 in IL and Competitive Edge in IA]

SOO Green HVDC LINK

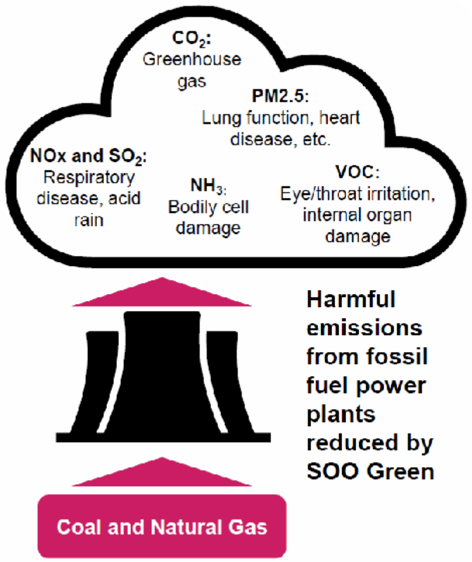
By displacing electricity generated by fossil fuel power plants, SOO Green will lower emission of greenhouse gases and other harmful pollutants, reducing damage caused by climate change, reducing healthcare costs, and saving lives.

$9.8Bn

Avoided Social Costs of GHG Emissions In Illinois

$9.7Bn

Illinois' Health Benefits, mainly in disadvantaged communities



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Human Capital- Quantified Impacts

Economics

Source: PA Consulting [Feb 2023]

Social Capital Summary

Economics

- Not relying on eminent domain authority for site control
- Economic Development [Jobs, Earnings, GDP] at Scale
- Grid Benefits from Reliability Enhancement
- Community Development Projects along project corridor
- State-of-the art Technology Transfer from Overseas w/ focus on Onshoring Manufacturing

$4Bn

Private Sector Investment to Boost Grid Resiliency

$1Bn

Avoided Daily Costs of Major Grid Interruption

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Source: PA Consulting [Feb 2023]

Social Capital- Economic Development

Economics

- Upstream Generation Impacts
- In-Stream Construction/Operation Impacts
- Downstream Economic Impacts

New Generation Construction + Component Manuf.
$9.9 Bn+ GDP output

New Generation Operations
$15 Bn+ GDP output

Tx Construction
$4.9 Bn+ GDP output

30-yr Tx Ops
$5.7 Bn+ GDP output

New Component Manufacturing
$560 MM+ state output

New Downstream Industrial Activities
$26 Bn state output

SOO Green HVDC LINK

Source: Strategic Economic Research, Dr. David Loomis [Feb 2023]

Key Takeaways from IPA Study:

- A significant portion of the energy delivered by SOO Green would contribute to generation and resource adequacy
- project would benefit ratepayers by impacting wholesale energy costs, lowering those costs for Illinois ratepayers by $5.85 billion over 20 yrs

0.01%

Estimated LOLE reduced from 0.1% in ComEd Territory with SOO Green

96%

ELCC for SOO Green in 2030 based on generation profiles submitted by the project

92%

ELCC for SOO Green in 2040 based on generation profiles submitted by the project

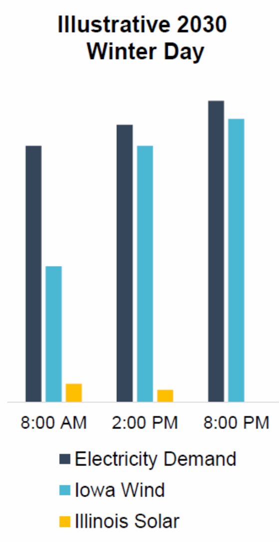
SOO Green HVDC LINK

Social Capital- Grid Benefits (Reliability)

Economics

Executive Summary, Illinois Power Agency 2024 Policy Study [March 1, 2024]

SOO Green's generation resource diversity will contribute to additional system reliability, as Illinois shifts towards a winter peaking demand, and step in to fill unserved demand in the instance of low-probability high-impact events.

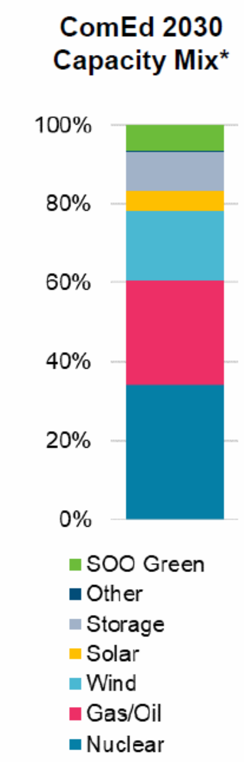


190GWh

Avoided Unserved Demand from Potential Summer 2030 Outage Scenario Without SOO Green

$6Bn

Value of Unserved Demand in Summer 2030 Generation Outage Scenario Without SOO Green



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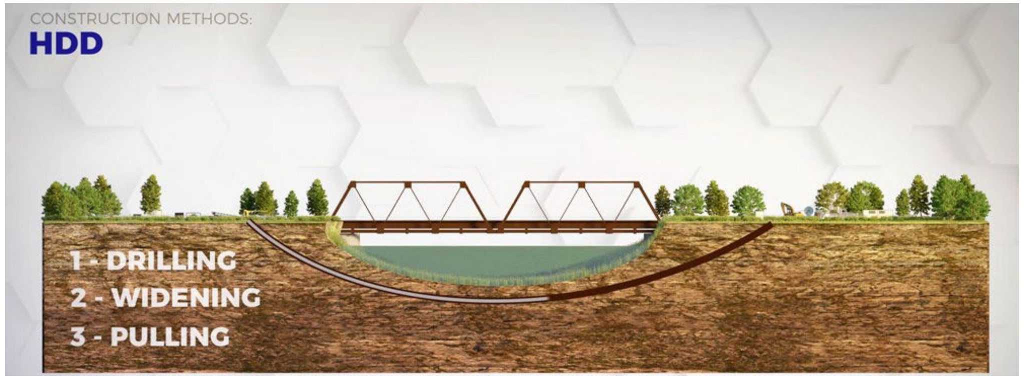
Social Capital- Grid Benefits (Resilience)

Economics

*Illinois Decarbonization Study: Climate and Equitable Jobs Act and Net Zero by 2050, Prepared for Commonwealth Edison (ComEd) by Energy and Environmental Economics, Inc. (E3), December 2022

Source: PA Consulting [Feb 2023]

- Delivers energy over long distances with low line loss
- Narrow Permanent Impact Corridor - Limited Environmental Impacts
- Extreme Weather Resilience through in-conduit Underground Installation
- Limiting Environmental Impacts to only construction and not during operations
- Low-impact Construction Methods in environmentally sensitive areas



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Natural Capital

Economics

Thank You!

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HVDC LINK

Next Steps

Day 2 – Solutions for the Future

- Friday, September 19th from 12:00-5:00 pm Eastern
- Topics: BCA, valuation, alternatives, community engagement, peer utility perspective, and resilience metrics

- Recordings and Presentations Posted to Event Pages

- Staff Report With Recommendations After Workshops

PowerPoint Template Instructions