Technical Conference

March 22, 2023

Today's Agenda

- **Conference kickoff (15 min)**
- Context and background
  - Overview of DTE's 4.8kV distribution system (45 min)
  - 4.8/13.2kV distribution systems and the integration of EVs and DERs (15 min)
  - The Detroit 4.8kV System and PLD arc wire (15 min with Hardening)
- 4.8kV Hardening Program (45 min)
- 4.8kV Hardening program and alternative solutions (1 hr)
- Open table discussion/conference feedback (30 min)

Conference Kickoff

- DTE kickoff and welcome

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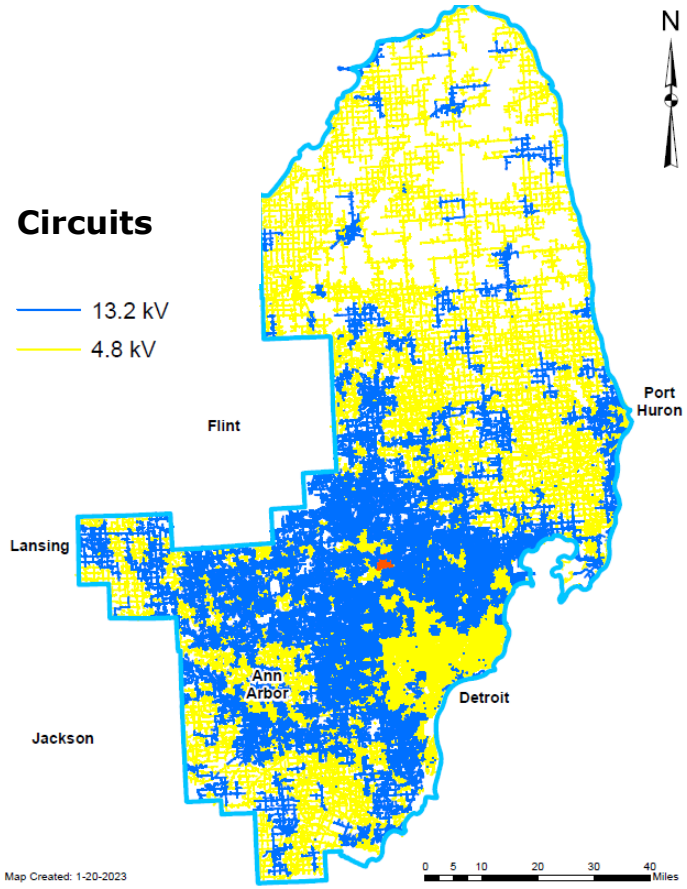
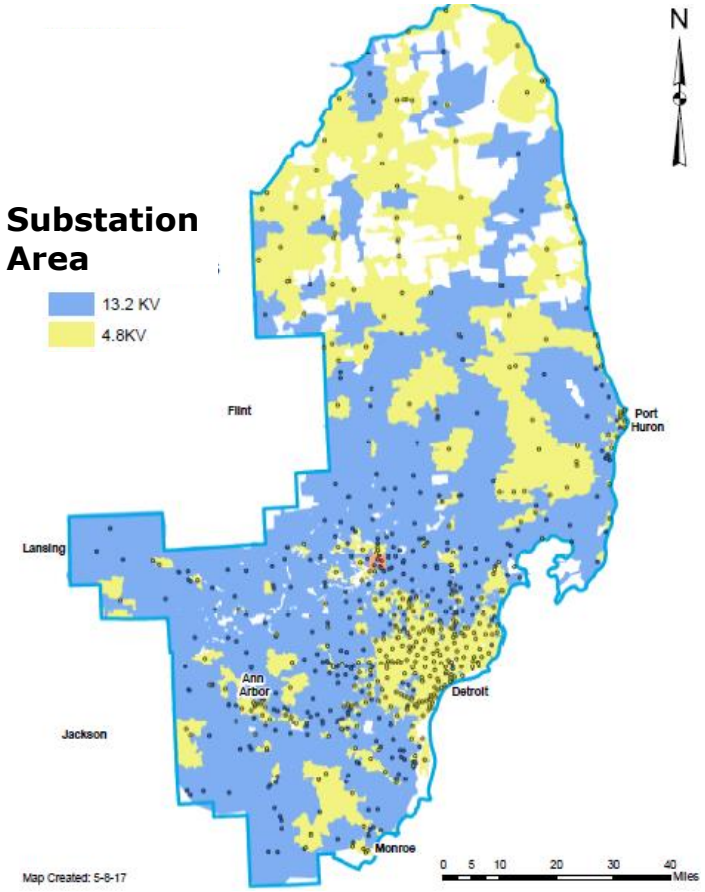
DTE's distribution system consists primarily of two voltages – 13.2kV and 4.8kV

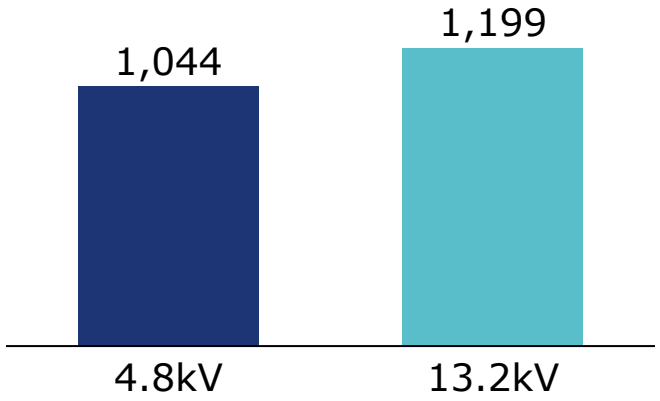
System Map (Circuit voltage)



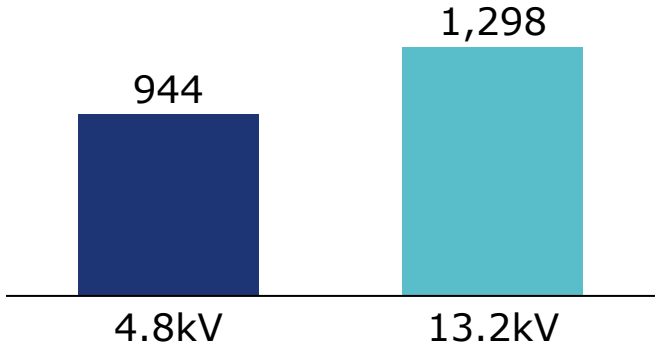
System Map (Substation Voltage)



Customer Count
(Circuit Voltage, 000's)



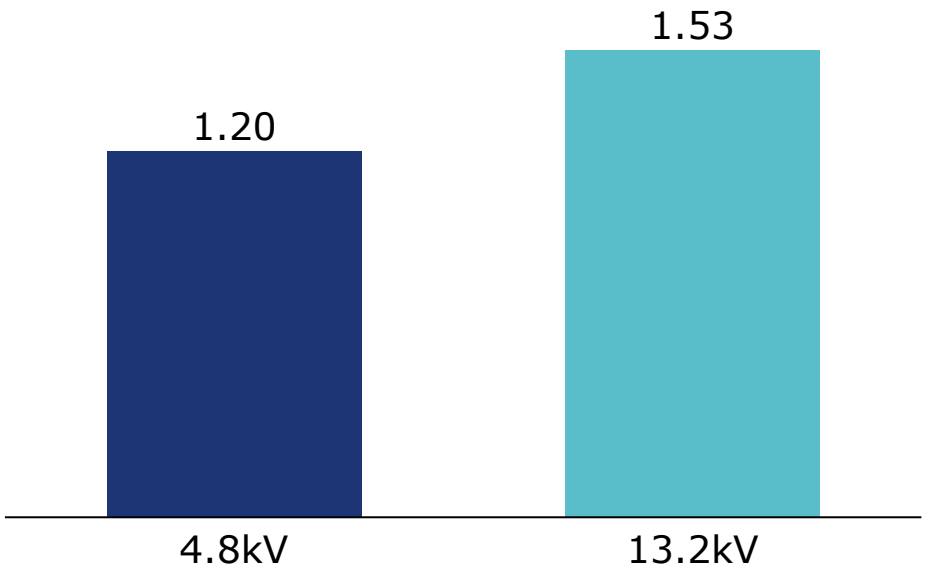
Customer Count
(Substation Voltage, 000's)



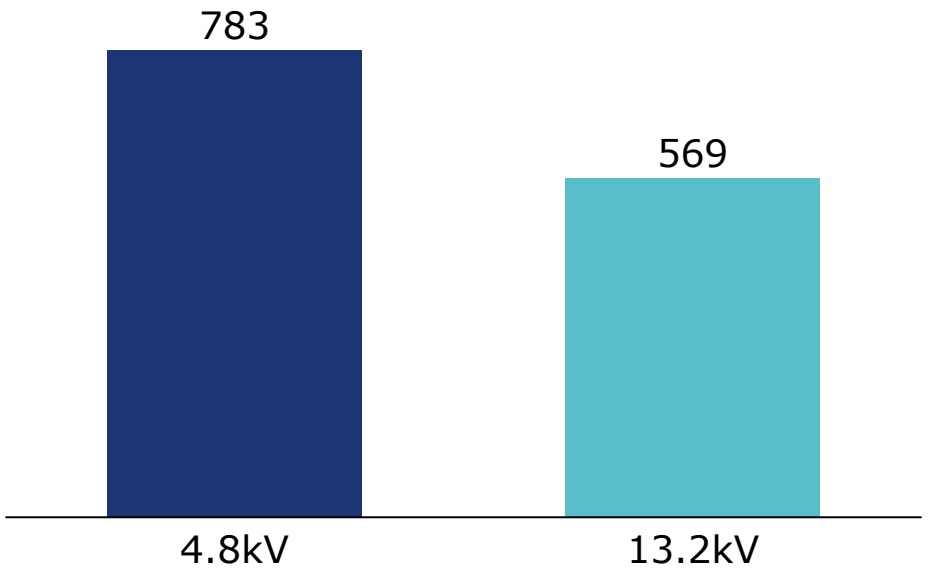
Some circuits on the system contain ISO down areas, which begin at a 13.2kV substation but voltage is stepped down to 4.8kV through isolation transformers serving ~100k customers across 5,500 line miles

Customers served by our 4.8kV systems, on average, experience fewer outages (SAIFI), but longer total duration (SAIDI)

All-weather SAIFI[1]
by substation voltage



All-weather SAIDI[1]
by substation voltage



DTE invests in reliability improvements on both 4.8kV and 13.2kV systems to improve safety and reliability

1. 5-year average 2017-21

While our 4.8kV and 13.2kV systems have some unique differences, the basic components of the circuit remain the same

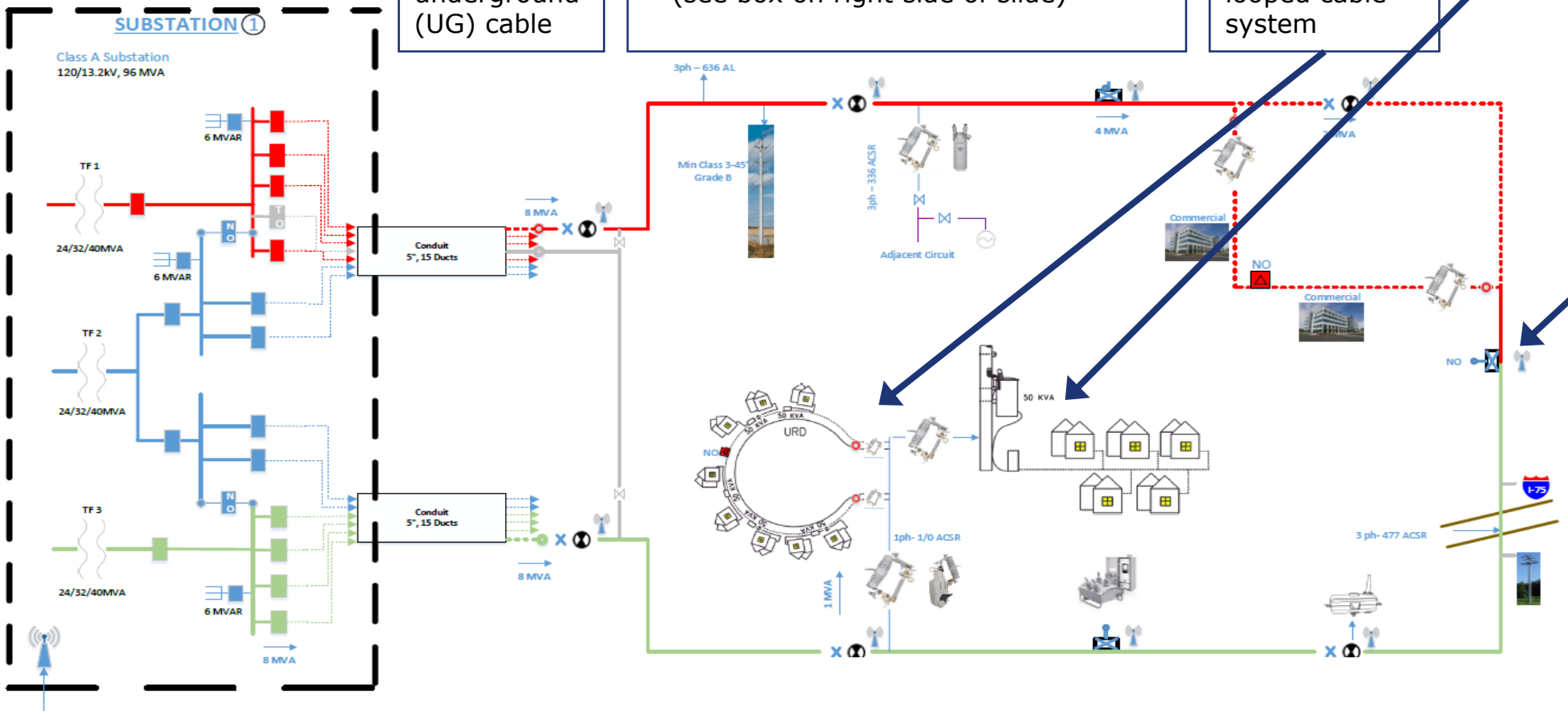
Substation
Step down from transmission or subtransmission voltage to primary voltage (4.8kV, 13.2kV)

Cable
Circuits leave substation through conduit and underground (UG) cable

Circuits
- Often come overhead at a pole
- 3-phase backbone, and laterals (primary voltage)
- May be tied together for loop schemes (see box on right side of slide)

URD
Underground residential distribution (URD) – buried looped cable system

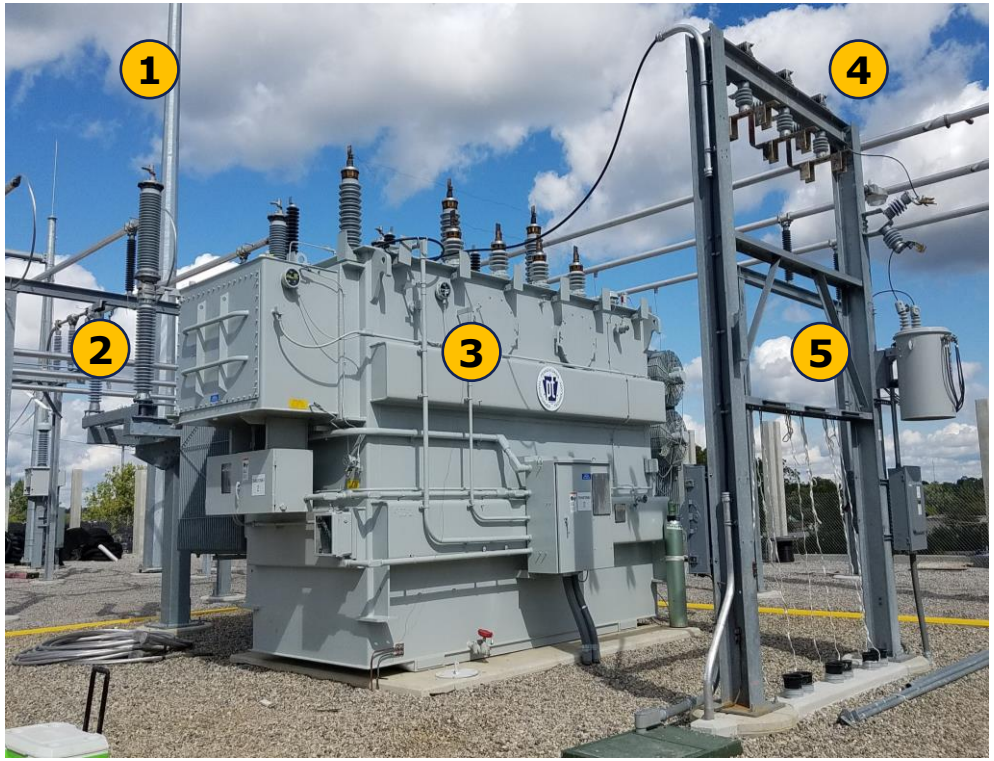
Secondary
Lower voltage system on low side of distribution transformers



Loop scheme
The two circuits (red and green) have a point of connection here creating a 'loop'

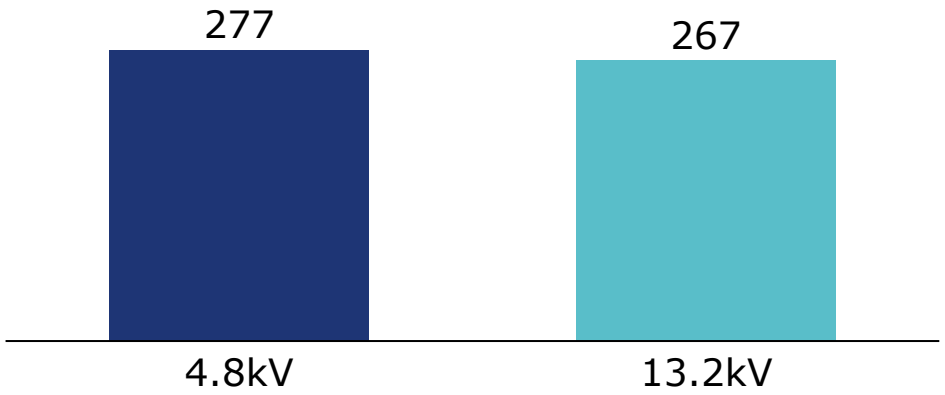
The purpose of a substation is to step down transmission or subtransmisison voltages to distribution voltages to serve residential, commercial or industrial loads

Typical Substation Configuration

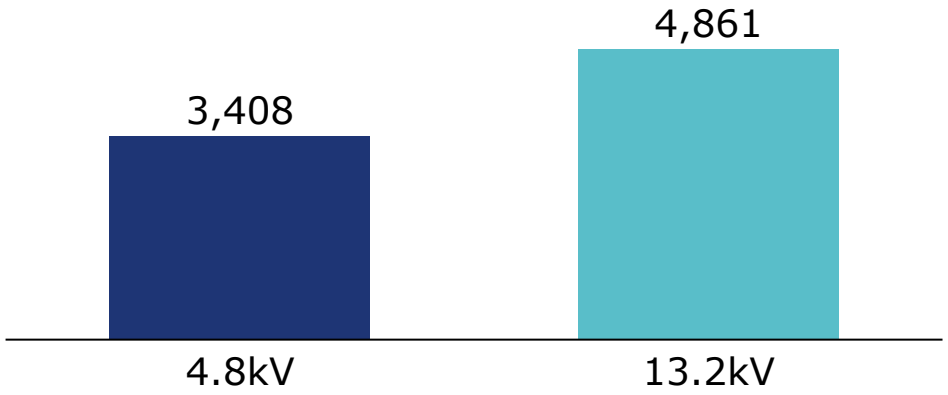


1. 120kV Input
2. Circuit Switcher
3. Power Transformer
4. 13.2kV Output
5. Secondary Tower

Number of substations

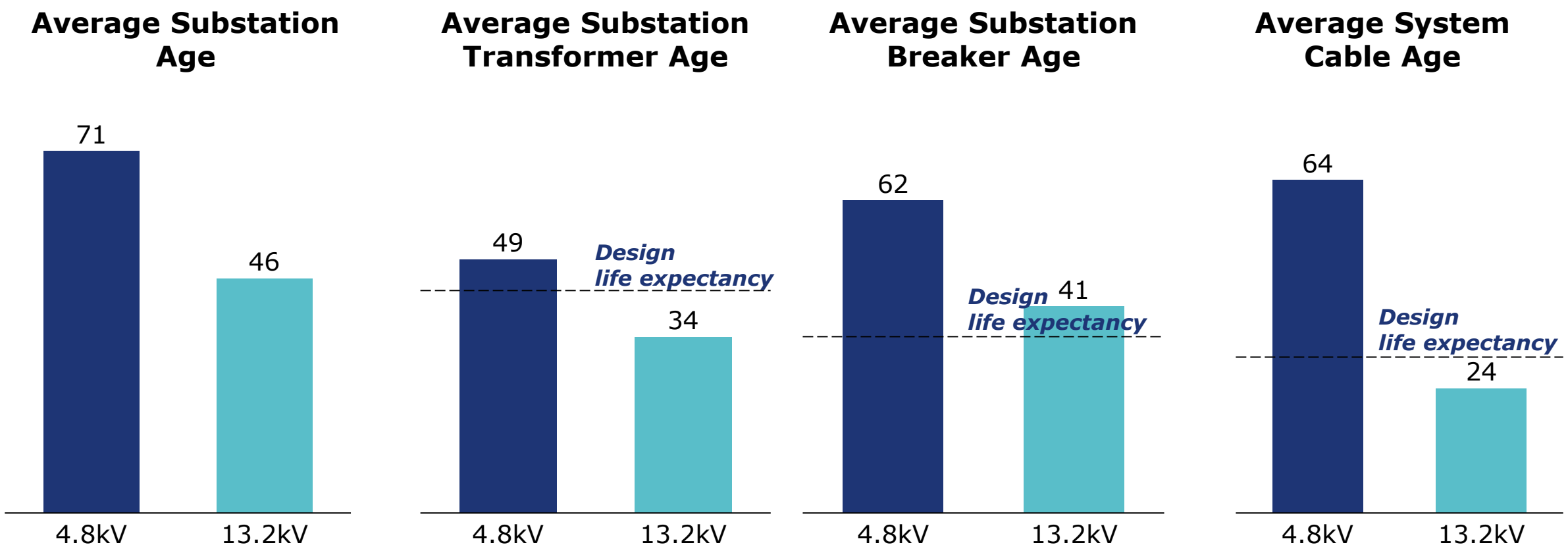


Customers per substation



DTE

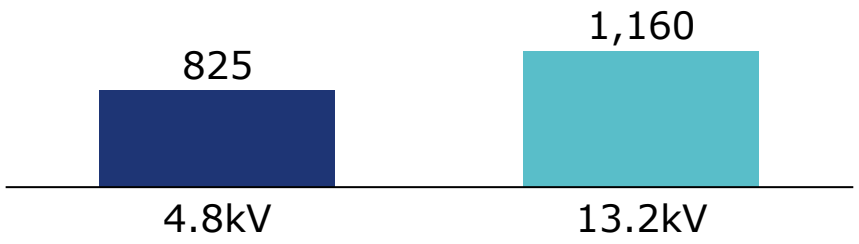
While age is only one factor influencing system performance, our 4.8kV equipment is significantly older on average than equipment on the 13.2kV system



Note: Life expectancy uses median of expected age range

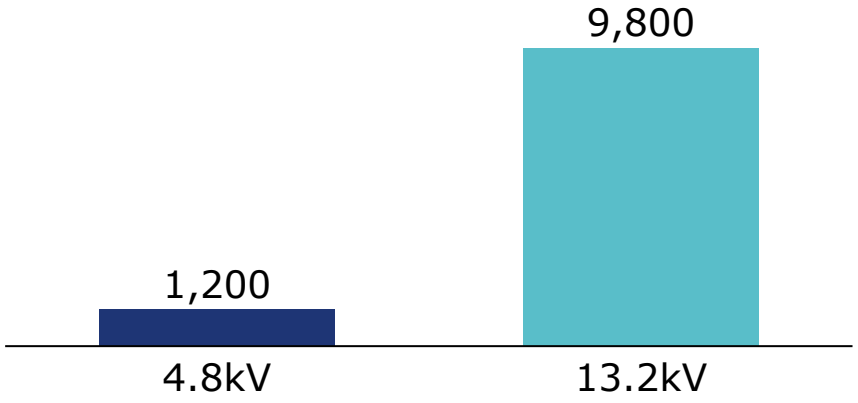
About 35% of our system is underground and primarily uses two main types of cable – System Cable and Underground Residential Distribution (URD) cable

System Cable miles by voltage class



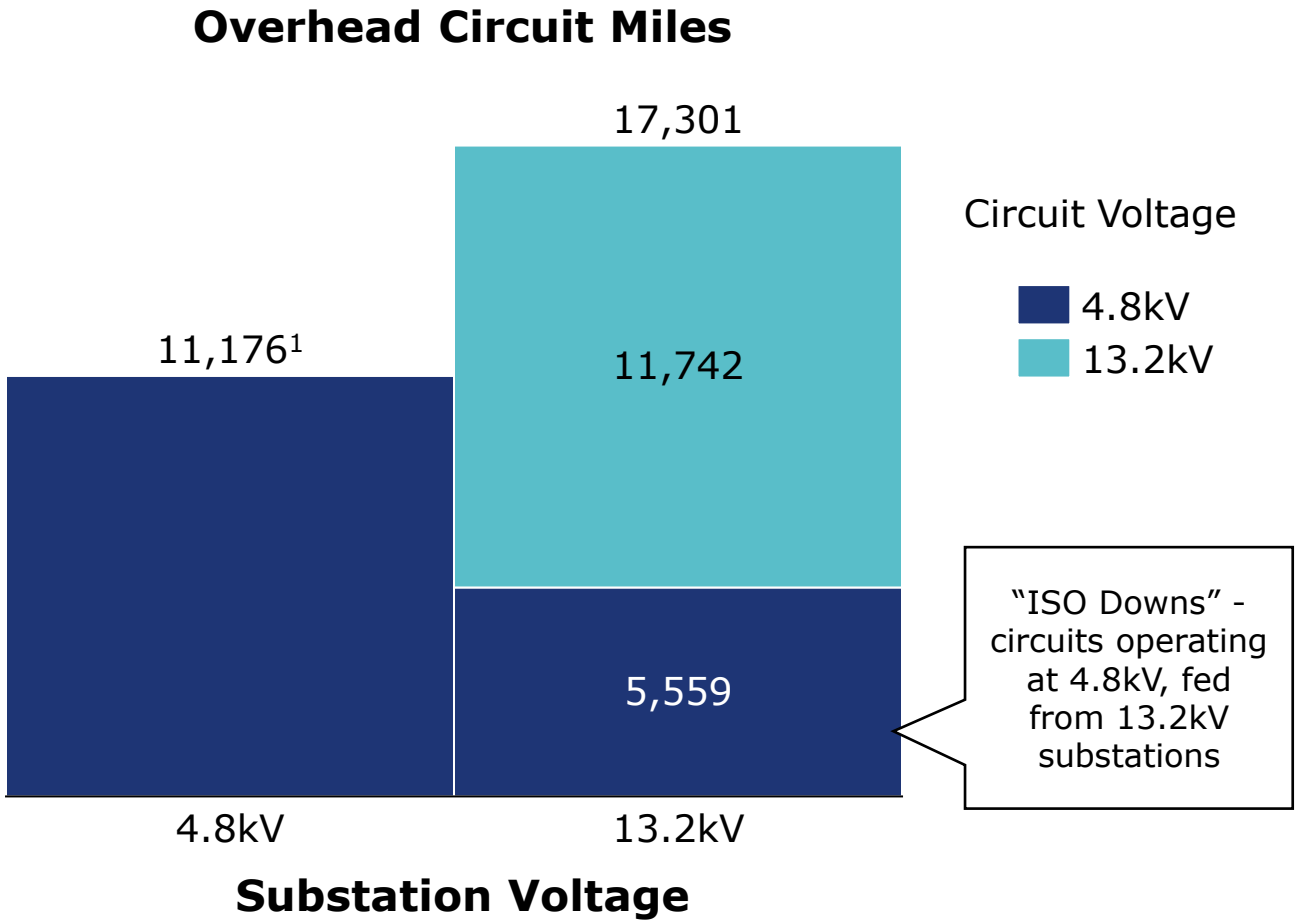
- Most frequently used leaving substation underground regardless of voltage
- Pulled through conduit (duct banks)

URD miles by voltage class



- Direct buried cable in residential subdivisions between transformers
- All new subdivisions since 1970s are fed by URD
- Even when served from a URD, often part of the circuit is fed from the overhead

The most visible part of the distribution system has ~28,500 miles of overhead circuits with, 16,700 miles operating at 4.8kV

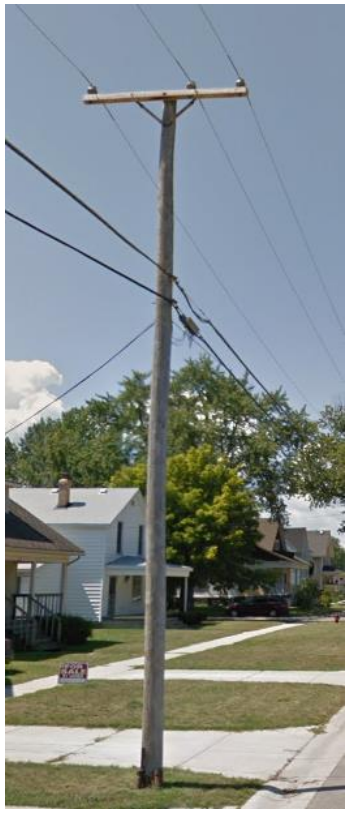


1. 32 miles of 13.2kV standard overhead is being operated at 4.8kV

Construction of the three phase leads are similar across voltage type, and may be either in the rear lot or near road right of way; 4.8kV poles are often shorter and require less clearance

4.8kV System

Rear Lot



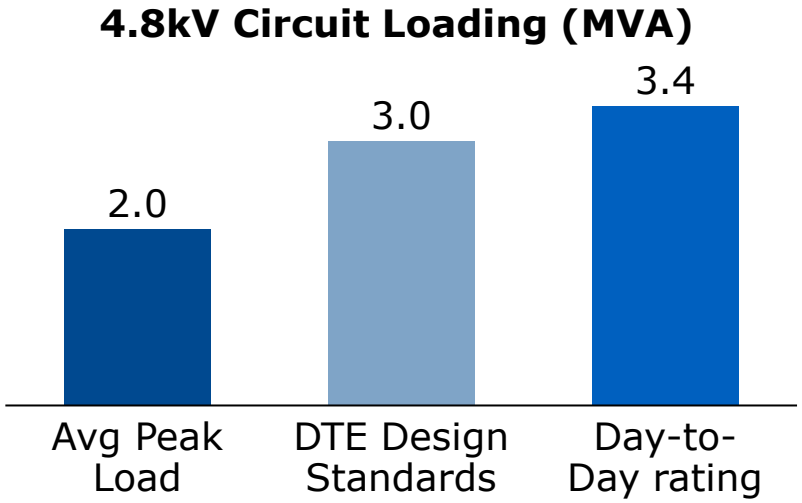
Road
right-of-way

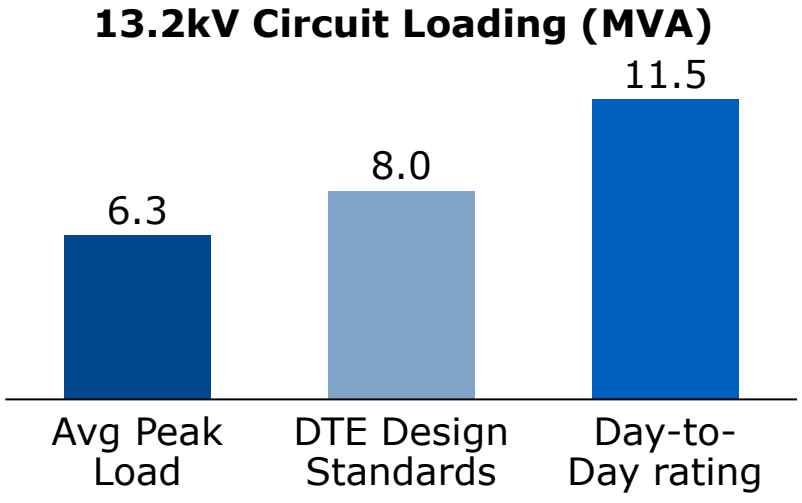
13.2kV System

Rear Lot

Road
right-of-way

13.2kV circuits can serve up to three times the load of a comparable 4.8kV circuit; DTE Design Standards limit load on a circuit to maintain system capacity and operational flexibility





- The day-to-day rating is the load that equipment can operate at without impacting lifespan
- The DTE Design standards limit of 8 MVA is intended to provide capacity to support ~1/2 of an adjacent circuit and remain within the day-to-day rating of the equipment
- Approximately 20% of 4.8kV circuits and 30% of 13.2kV circuits operate above the DTE Design Standards limit

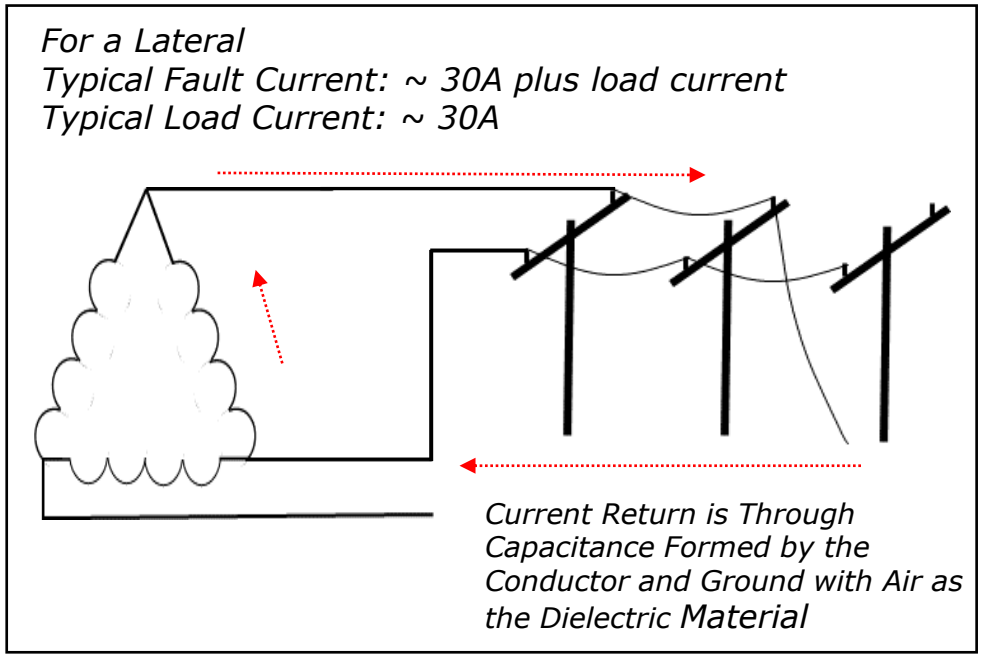
DTE

Despite the 4.8kV's superior SAIFI performance, the nature of our 4.8kV system introduces challenges impacting Safety, Reliability, Capacity, Outage Duration, and the ability to add Automation

Safety	**The 4.8kV system is an ungrounded delta configuration, making detection of wire downs challenging**
Reliability	**Has most of the conductor which is weaker in strength compared to current wire standards**
Capacity	**Inherent to the design, the 4.8kV substations and circuits have lower capacity**
Outage Duration	**Ringed circuit & banked secondary make maintenance & fault locating more difficult**
Automation	**The 4.8kV system has limited remote monitoring & control capabilities**

The 4.8kV ungrounded delta configuration leads to low fault currents from wiredowns that don't result in a protective device operating and makes wiredown detection challenging

Ground Fault on 4.8kV Ungrounded Delta



- There is no direct ground path on a delta configuration – and downed wires may only create a fault current that is not much larger than typical loads
- Due to lower fault currents, down wires are typically live
- 80% of the faults are phase-to-ground, which include wire downs
- The remaining 20% are phase-to-phase faults, which create significantly more fault current and trip protective devices typically
- Because protective devices don't operate as frequently, SAIFI performance is superior to a grounded system (13.2kV)

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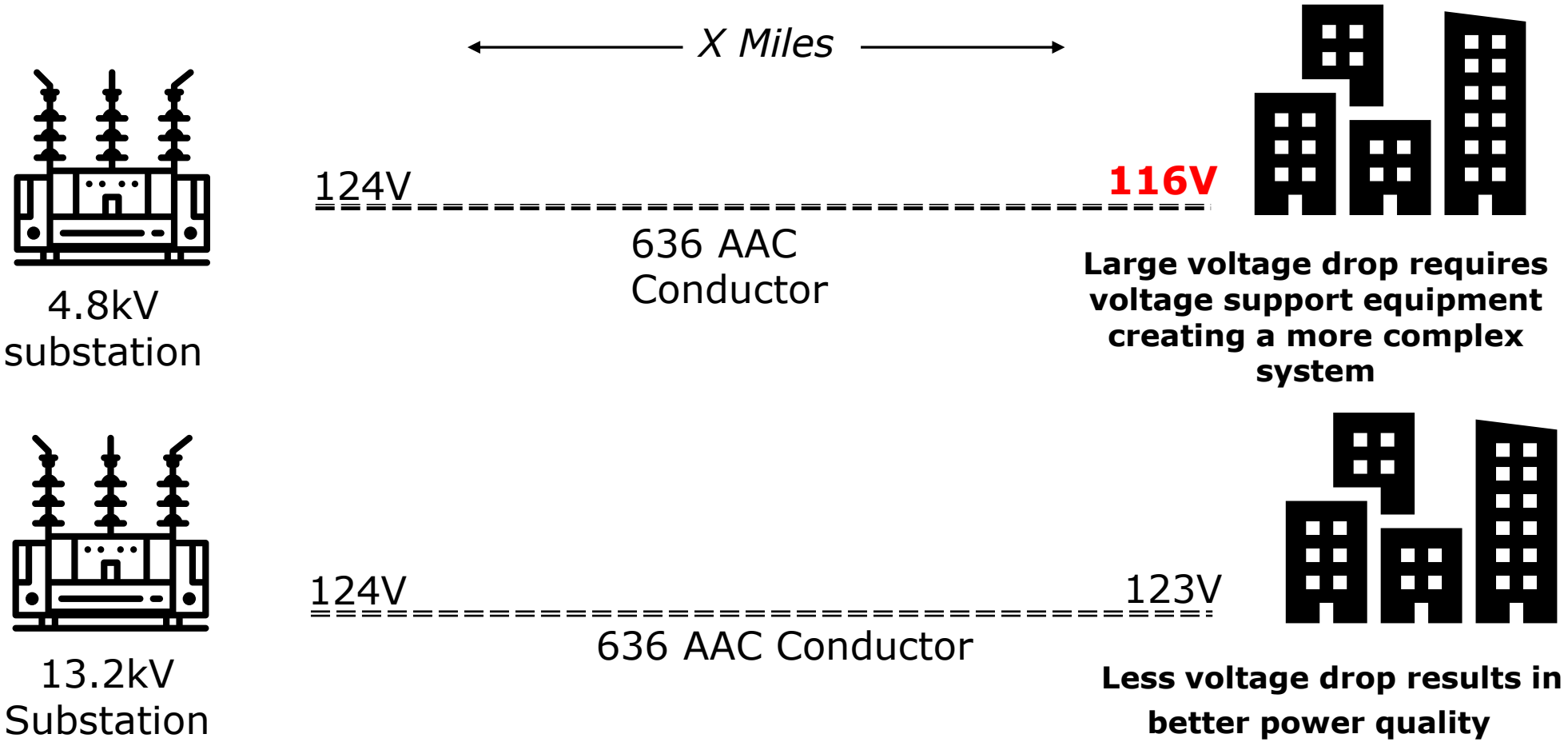
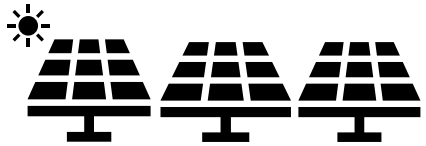
4.8kV is more susceptible to voltage fluctuations from large electric loads coming on and off the system; future EV and DER additions are expected to exacerbate this issue

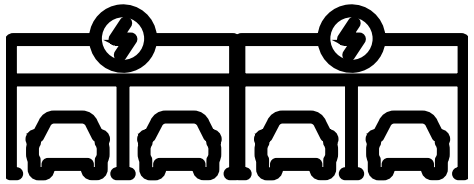


In addition to the voltage concerns, the 4.8kV system will be more challenged to serve future commercial DER and EV's due to limited capacity

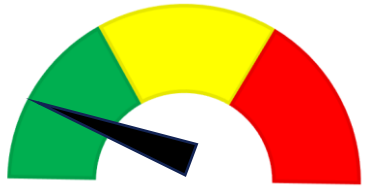
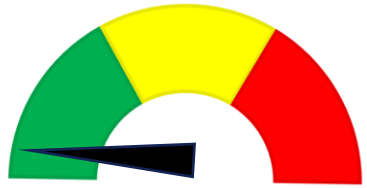
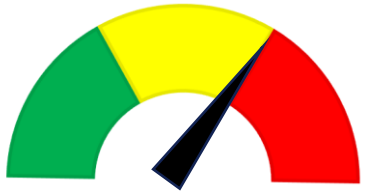
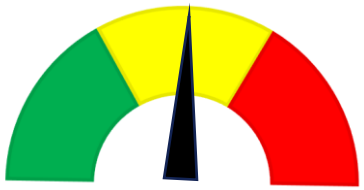
100 EV's
~0.6 MVA



Small Commercial Solar
~0.5 – ~2 MVA



EV Charging Station
~1.5 MVA

	4.8kV Circuit 3.0MVA	**13.2kV Circuit 8 MVA**
100 EV's ~0.6 MVA	 20%	 8%
Small Commercial Solar ~0.5 – ~2 MVA	 66%	 25%
EV Charging Station ~1.5 MVA	 50%	 19%

EV and DER on their own can require a majority of circuit capacity on a 4.8kV circuit making it a challenge to serve

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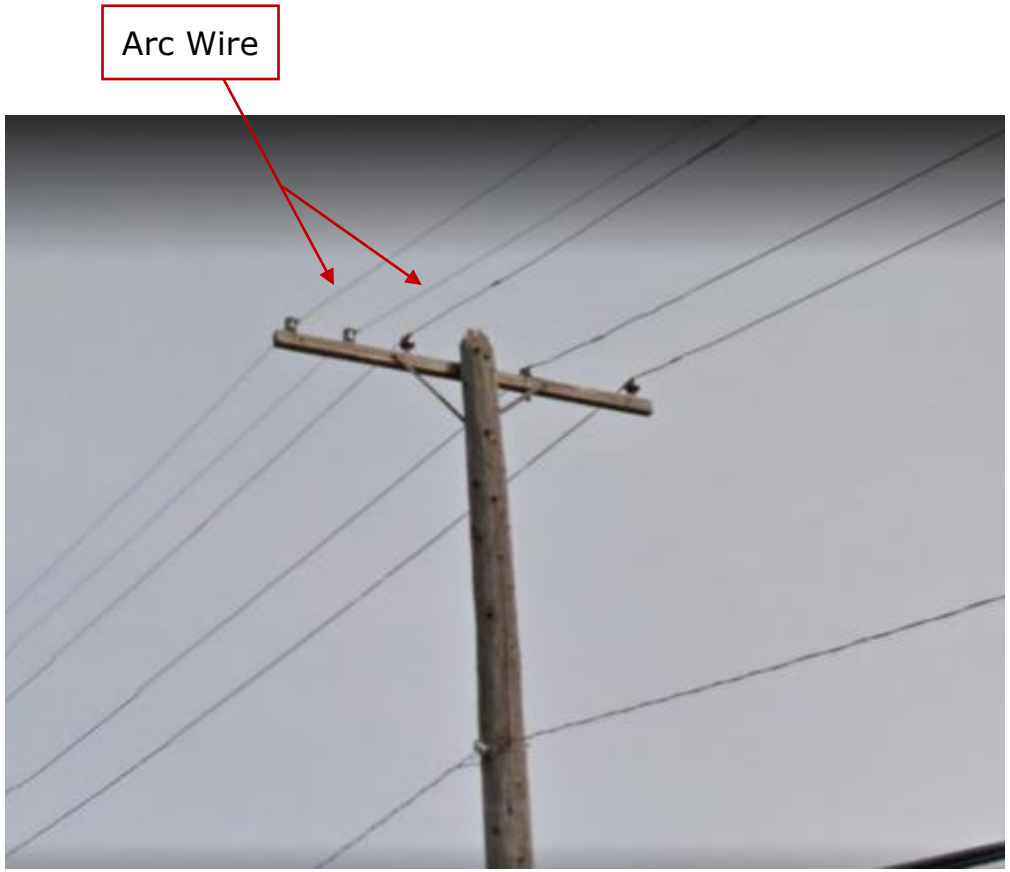
The age of and access to the 4.8kV infrastructure in the City of Detroit provides significant challenges to maintenance and reliability programs

- The 4.8kV system in the City of Detroit has approximately 2,400 primary overhead line miles
- The electrical system in much of Detroit is the original distribution built and many sections were constructed in the early 1900s
- When installed, back lot construction was prudent
  - Access for DTE construction, maintenance, and tree trimming was through the city-maintained alleyway
  - Over time, the city abandoned alleys and their maintenance which became inaccessible by truck as trees were overgrown or property owners relocated their fence lines
- While much of this construction provided safe and reliable service for decades, the age of the infrastructure, as well as the construction type (size and strength of wire and poles, etc.), no longer provides the level of service the community needs

DTE

The Public Lighting Department (PLD) Arc Wire System was used to supply electricity to arc-type streetlamps and share utility poles with DTE Electric distribution



- Those streetlamps are no longer used, but large amounts of arc wires are still attached to utility poles
- The abandoned wire poses a risk if it becomes energized by making contact with DTE facilities
- In 2017, we estimated that there were approximately 1,300 miles of DPLD arc wire that was intermittently co-located among DTE Electric's 2,400 miles
- An average DTE Electric circuit in the City of Detroit is expected to have arc wire co-located on about 50% of the poles

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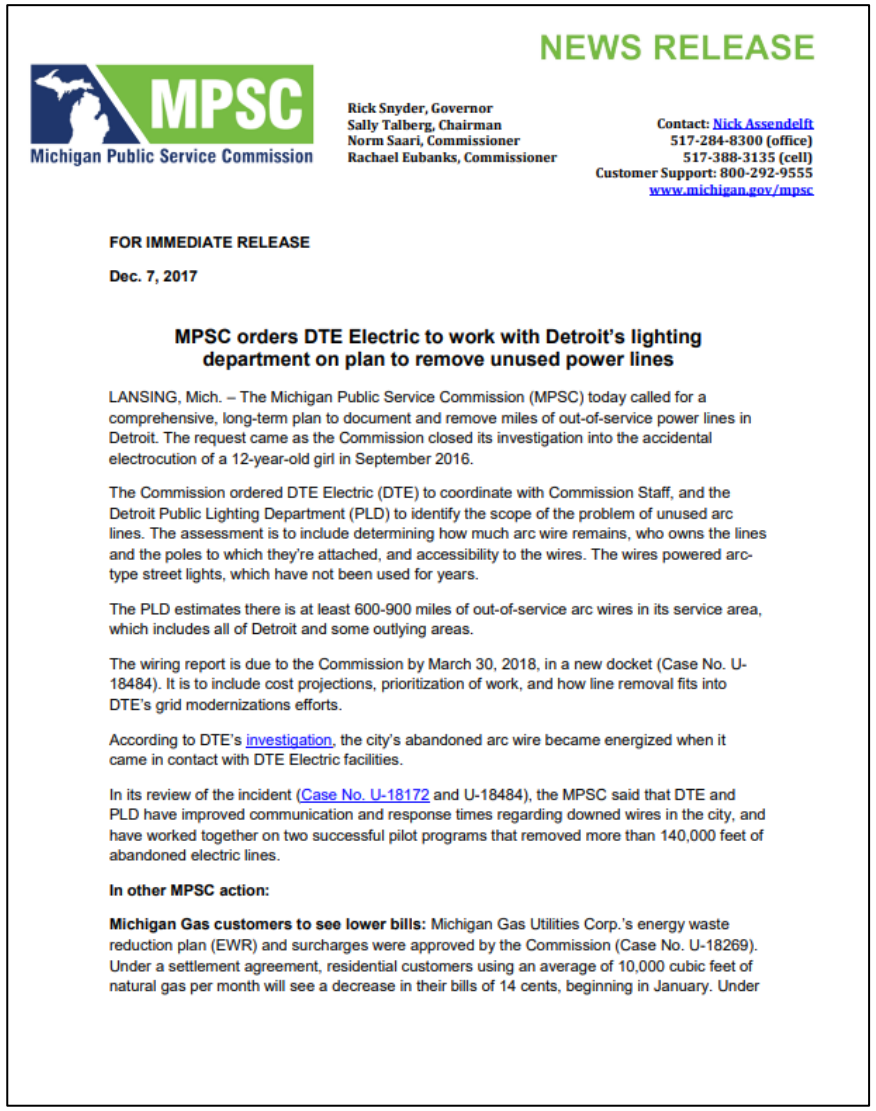
In December 2017, the Commission issued an order for DTE to work with Detroit Public Lighting to remove unused arc wire co-located on its infrastructure

- The Order in Case No. U-18484, required DTE to work with relevant entities to accomplish a long-term comprehensive plan to address out-of-service Detroit Public Lighting Department owned arc wire
- The Company closely examined the options to best address the issue and concluded that addressing the DPLD arc wire as a standalone program was not the option that best addressed the safety and reliability needs of the grid
- In response, the 4.8kV Hardening program was developed that balanced safety, cost, and reliability improvements



NEWS RELEASE

MPSC
Michigan Public Service Commission

Rick Snyder, Governor
Sally Talberg, Chairman
Norm Saari, Commissioner
Rachael Eubanks, Commissioner

Contact: Nick Assendelft
517-284-8300 (office)
517-388-3135 (cell)
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FOR IMMEDIATE RELEASE

Dec. 7, 2017

MPSC orders DTE Electric to work with Detroit's lighting department on plan to remove unused power lines

LANSING, Mich. – The Michigan Public Service Commission (MPSC) today called for a comprehensive, long-term plan to document and remove miles of out-of-service power lines in Detroit. The request came as the Commission closed its investigation into the accidental electrocution of a 12-year-old girl in September 2016.

The Commission ordered DTE Electric (DTE) to coordinate with Commission Staff, and the Detroit Public Lighting Department (PLD) to identify the scope of the problem of unused arc lines. The assessment is to include determining how much arc wire remains, who owns the lines and the poles to which they're attached, and accessibility to the wires. The wires powered arc-type street lights, which have not been used for years.

The PLD estimates there is at least 600-900 miles of out-of-service arc wires in its service area, which includes all of Detroit and some outlying areas.

The wiring report is due to the Commission by March 30, 2018, in a new docket (Case No. U-18484). It is to include cost projections, prioritization of work, and how line removal fits into DTE's grid modernizations efforts.

According to DTE's investigation, the city's abandoned arc wire became energized when it came in contact with DTE Electric facilities.

In its review of the incident (Case No. U-18172 and U-18484), the MPSC said that DTE and PLD have improved communication and response times regarding downed wires in the city, and have worked together on two successful pilot programs that removed more than 140,000 feet of abandoned electric lines.

In other MPSC action:

Michigan Gas customers to see lower bills: Michigan Gas Utilities Corp.'s energy waste reduction plan (EWR) and surcharges were approved by the Commission (Case No. U-18269). Under a settlement agreement, residential customers using an average of 10,000 cubic feet of natural gas per month will see a decrease in their bills of 14 cents, beginning in January. Under

The 4.8kV Hardening Program was created to complete a long-term comprehensive plan to address the removal of arc wire while at the same time providing additional safety and reliability benefits

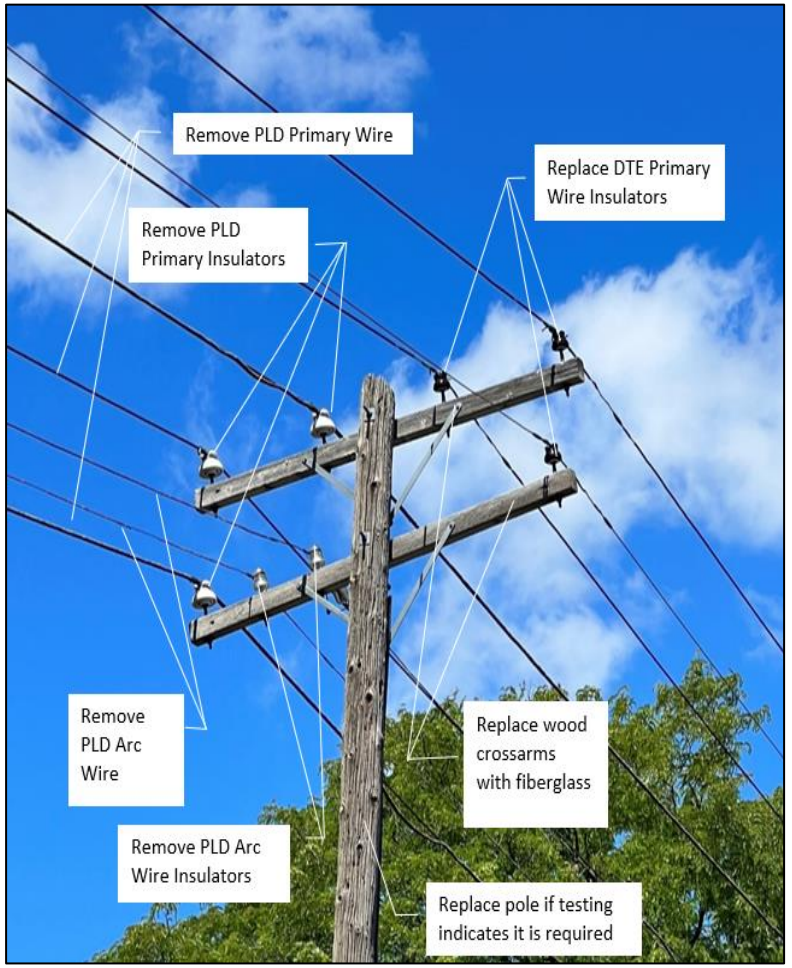
Objectives

- Remove Detroit Public Lighting Department (PLD) arc wire and distribution wire
- Harden and stabilize the 4.8 kV distribution circuits to improve safety, reliability, and storm resiliency
- Extend the life of the 4.8 kV circuits until DTE completes conversion

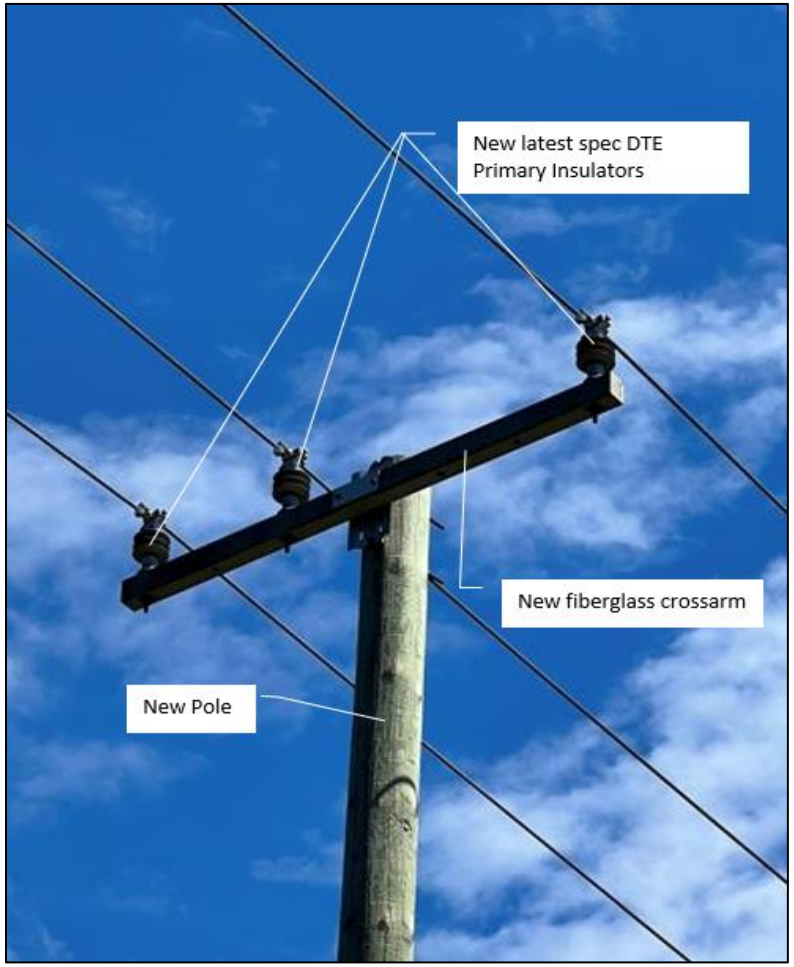
Scope of Work

- Replace or reinforce condemned poles
- Replace wood crossarms with fiber glass
- Remove Detroit PLD arc wires and distribution wires that are co-located with DTE assets
- Remove service lines to abandoned properties
- Trim the trees to construction specifications

Before Hardening



After Hardening



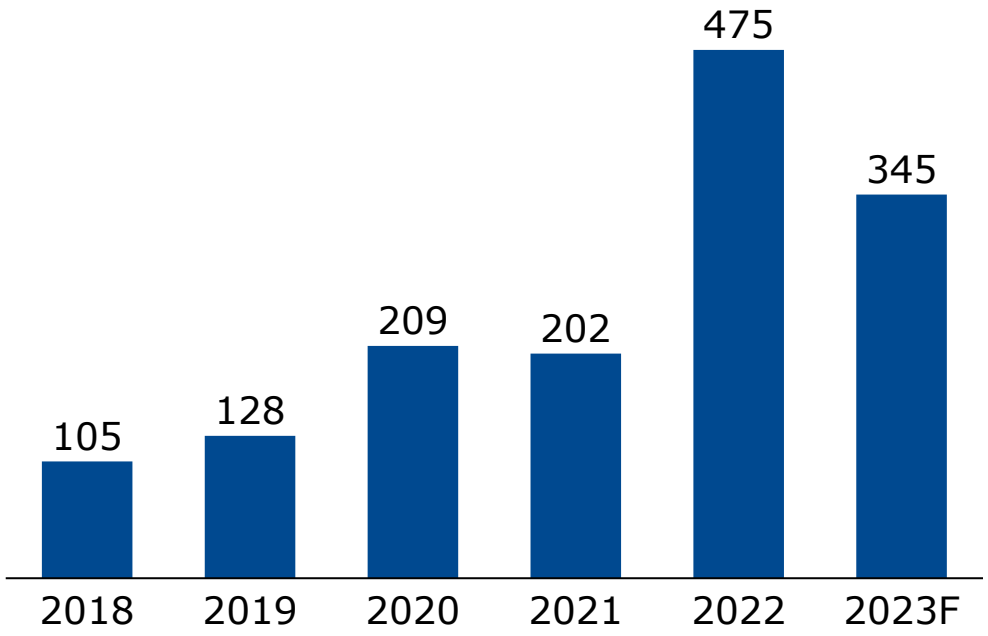
DTE

Before and after photos are from different pole locations

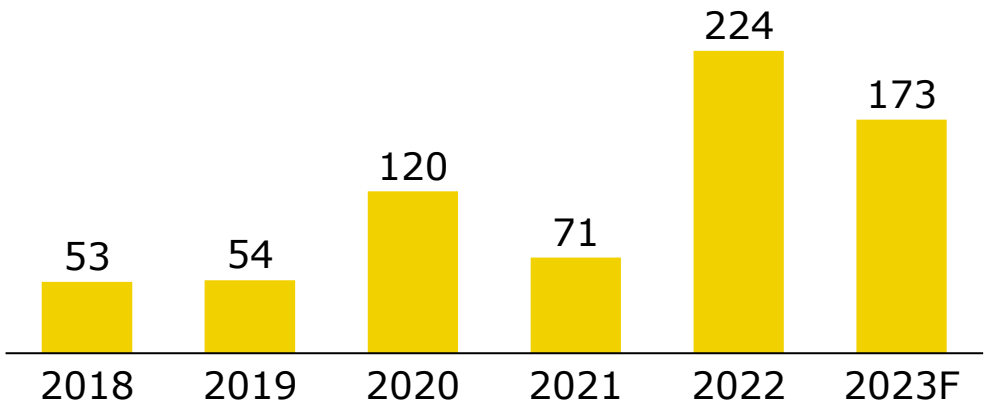
4.8kV Hardening Program Overview - Video

Since 2018, the 4.8kV Hardening Program had addressed ~185 circuits impacting over 144K customers in the City of Detroit and surrounding areas and, by the end of 2023, will have removed over 700 miles of arc wire

4.8kV Miles Hardened
~1,465 miles total



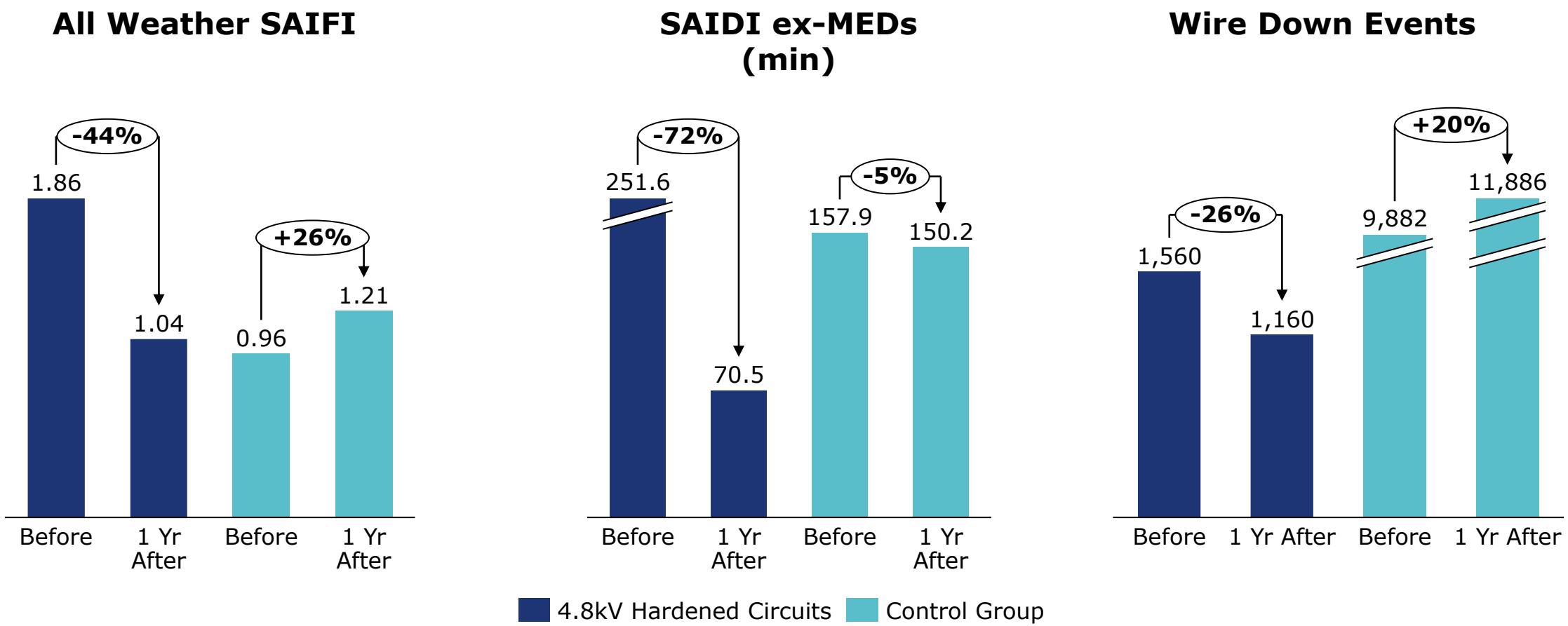
Miles of Arc Wire Removed
~700 miles total



Through 2023 we estimate that we will have removed over half of the arc wire that is co-located with DTE owned assets, and estimates that 400-600 miles of arc wire remain

DTE

Performance of circuits addressed by the 4.8kV Hardening program have seen significant improvements in SAIFI, SAIDI ex-MEDs, and wire down events



Note 1: Analysis based on aggregate numbers of 82 circuits hardened - 10 in 2018, 35 in 2019, and 37 in 2020 using three-year historic average (2015/16/17 – 2017/18/19) compared to one year after (2019/20/21)
Note 2: Performance deterioration for control group is largely driven by weather
Note 3: SAIDI during MEDs is heavily influenced by circuit restoration prioritization; hence SAIDI ex-MEDs is considered a better metric to reflect the program improvements

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As directed by the Commission in case U-20836, DTE has considered several alternatives to the 4.8kV Hardening program

Tree Trimming	• Trees trimmed to enhanced specification, no arc wire removal
PTMM	• Replace failed poles and pole top equipment, no arc wire removal
Arc Wire Removal	• Arc wire removal only, reduced scope tree trimming and equipment replacement
4.8kV Hardening	• Arc wire removed, crossarms replaced, tree trimming
Pre-conversion	• Arc wire removed, rebuild wires, poles, and pole tops to 13.2kV standards
Conversion	• Fully convert circuit and substation to 13.2kV, includes automation
Microgrids	• Arc wire removed with pre-conversion and microgrid for reliability
DERs	• Utility-scale or distributed solar and storage to improve capacity
Energy Efficiency	• Target residential, commercial, and industrial customers for waste reduction
Storage	• Utility-scale battery storage to improve capacity by shifting/decreasing peak

When comparing the effectiveness of the various alternatives, five approaches were appropriate for addressing the removal of the PLD arc wire

	Arc Wire Removal	Improved Reliability	Improved Safety/ Wire down	Improved Capacity	Cost Level	Execution Complexity
Tree Trimming	○	◒	◔	○	Low	Low
PTMM	○	◒	◔	○	Low	Low
Selected for Consideration 1 Arc Wire Removal	●	◔	◔	○	Medium	Low
2 4.8kV Hardening	●	◔	◒	○	Medium	Low
3 Pre-conversion	●	●	●	◔	High	Medium
4 Conversion	●	●	●	●	High	High
5 Microgrids	●	●	●	◒	Very High	Very High
DERs	○	○	○	◔	Medium	Medium
Energy Efficiency	○	○	○	◔	Low	Medium
Storage	○	◔	○	◒	High	Medium

Increasing difficulty ↓

① **Arc Wire Removal Only:** While there are benefits to only removing the arc wire, this option overlooks the opportunity to significantly improve the safety and reliability for the entire circuits that contain arc wire

Execution Speed: High

Scope – Arc Wire removal only
Cost per mile: $175K - $207K

- Remove Detroit Public Lighting Department (PLD) arc wire
- Trim the trees as needed to identify/remove the arc wire
- Balance the cross arms to make safe (for poles with arc wire, vast majority of cross arms will need to be replaced)
- Replace/reinforce pole if necessary
- Replace pole top if necessary

Benefits

- Remove Detroit Public Lighting Department (PLD) arc wire
- Improved reliability:
  - Wire down – 13% improvement
  - SAIFI – 22% improvement
  - SAIDI – 36% improvement
- Arc wire removal only is ~55% of the cost of Hardening per mile and best-case scenario results in half the reliability benefits

~50% of 4.8kV circuit miles will not receive reliability benefits under this program

② **4.8kV Hardening:** By conducting 4.8 kV Hardening on circuits that contain arc wire, customers experience significantly improved reliability and safety across the entirety of the circuit

Execution Speed: Medium-High

Scope – 4.8kV Hardening
Cost per mile: $333K - $373K

- Remove Detroit PLD arc wires and distribution wires that are co-located with DTE assets
- Trim the trees to construction specifications
- Perform pole testing and replace or reinforce condemned poles
- Replace wood crossarms with fiber glass crossarms
- Remove service lines to abandoned properties

Benefits

- Remove Detroit Public Lighting Department (PLD) arc wire
- Harden and stabilize the 4.8kV distribution circuits
- Extend the life of the 4.8kV circuits
- Improved reliability:
  - Wire down – 26% improvement
  - SAIFI – 44% improvement
  - SAIDI – 72% improvement

③ **Pre-conversion:** Brings the OH portion of the circuit up to new 13.2kV standards while leaving the UG and substation unchanged; this delivers tremendous reliability and safety benefits but does not add the additional capacity of full conversion

Execution Speed: Medium-Low

Scope – Pre-conversion
Cost per mile: $1.4M - $2.0M

- Remove Detroit PLD arc wires and distribution wires that are co-located with DTE assets
- Trim the trees to construction specifications
- Rebuild pole tops using fiberglass cross arms
- Replace poles and transformers as needed
- Reconductor overhead lines as needed, install neutral wire
- Rebuild underground infrastructure as needed

Benefits

- Replaced equipment meets latest upgraded standards
- Prepares the overhead infrastructure for conversion to 13.2kV
- Improved reliability
  - Wire down – 90% improvement
  - SAIFI – 85% improvement
  - SAIDI – 85% improvement

④ **Conversion:** Complete rebuild of the all parts of the substation and circuit yielding safety, reliability, and capacity benefits

Execution Speed: Low

Scope – Conversion
Cost per mile: $2.4M - $3.0M

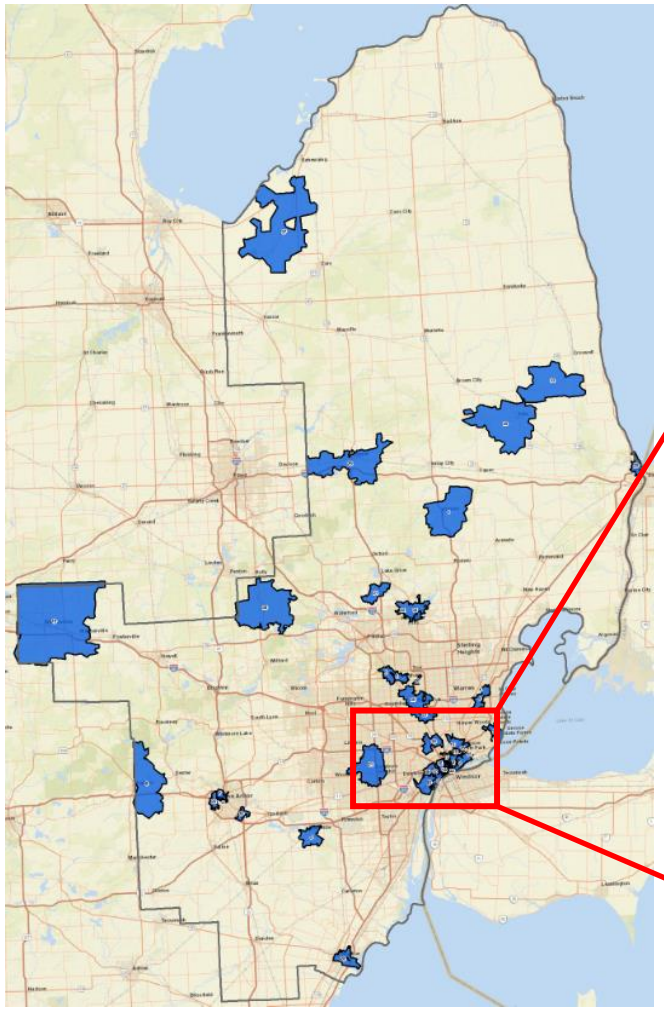
- All pre-conversion activities
- Build new 13.2kV sub/expand existing 13.2kV sub and install controls & automation in the substations/circuits to latest design standards
- Establish new DCs from new/upgraded 13.2kV substation
- Reconfigure circuits & establish jumpering points
- Convert and transfer load off the 4.8kV system to the 13.2kV system

Benefits

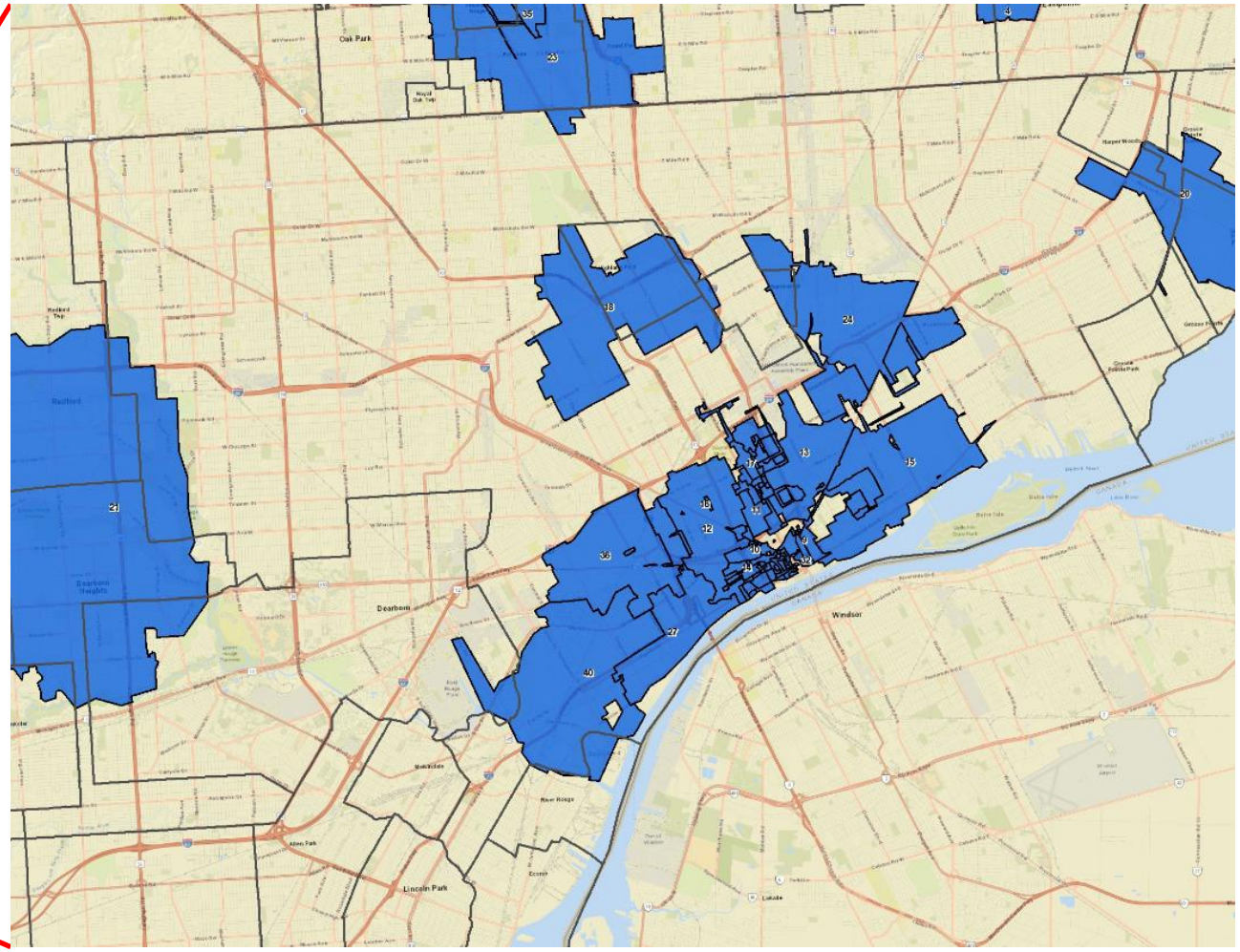
- Decommissioning of aging equipment
- Increased area capacity
- Reduced overload situations
- Improved jumpering capability
- Automated restoration
- Wye configuration is safer as wire downs are generally de-energized

DTE has several 4.8kV conversion projects underway throughout our service territory, many of which are concentrated in the City of Detroit

DTE Conversion Projects



City of Detroit Conversion Projects



In addition to all the construction work that conversion entails, there are a significant number of challenging activities that must occur to complete the rebuild and voltage conversion of a circuit

1. **Property acquisition** can be a long process to identify and purchase the location
2. **Permitting and approvals** for easements and environmental clearances for new circuits often have long time horizons
3. **Interconnection with ITC** can be lengthy requiring studies and approvals through MISO
4. **Customer Communication and Outreach** efforts can be extensive when new construction differs from existing facilities
5. **Establishing new circuits** requires significant underground work from the substation impacting adjacent public roads and property
6. **Weather constraints** impact the timing of customer shutdowns as they are typically performed in weather above 40 degrees
7. **Large scale coordination and overhead resources** are required to change each distribution transformer to the higher voltage simultaneously

5 **Microgrids:** Microgrid customers are likely to experience higher levels of reliability, but installation costs and execution complexity are very high

Execution Speed: Low

Scope –Microgrids
Cost per mile: $12.1M - $17.0M[1]

- All pre-conversion
- Install solar and battery storage as dictated by project along with associated equipment (inverters, switchboards, communication gateways, reclosers, etc.)
- Site prep as needed for battery storage (fence, driveway, below grade conduit etc.)

Benefits

- Islanding capability when main grid is not on-line
- Increased reliability from redundant source
- Improved jumpering capability
- Automated restoration
- Improved reliability within the Microgrid[2]
  - Wire down – 90% improvement
  - SAIFI – 90% improvement
  - SAIDI – 90% improvement

Microgrids can vary significantly based on use case; a key component to microgrids is energy storage[3] which is high cost and has a long lead time

1 Based on Port Austin example using 500kW solar and 1MW x 4MWh battery trailer
2 Based on expectations
3. DTE did not consider fossil generation as an energy source for microgrids

⑤ **Microgrids:** One microgrid project is currently in progress in Port Austin; the Company is pursuing additional microgrid projects at Port Austin and O'Shea as part of an IIJA grant

Port Austin Project (Pilot/IIJA Grant)

Current Project:
- Install (1) 500kW solar array
- Install (1) 1MW x 2-4MWh battery storage systems at two separate locations
- Install reclosers, communication and controls to create microgrid

Future Proposals:
- Install two additional microgrids
- All three microgrids will work together to provide optimized reliability for customers

O'Shea Project (Pilot/IIJA Grant)

Current Project:
- Install (1) 1MW x 2-4MWh battery storage system (already owned)

Future proposals:
- Install one more battery storage and other equipment to create two microgrids
- Install reclosers, communication and controls
- The two microgrids will work together to provide optimized reliability for customers

Expected outcomes from these pilots

- Influence the industry's development of the electrical system and advance the deployment of sophisticated and simpler microgrids
- Develop internal DTE Electric expertise with microgrids
- Enhance partnerships with other organizations such as EPRI and DOE National Laboratories
- Progress technology outside the NWA and microgrid space (i.e., fault locating, load forecasting, DER anomaly detection)

When comparing the alternative approaches, the 4.8kV Hardening program was selected originally because it strikes a balance between cost, reliability, and the timely removal of the arc wire from the DTE Electric system

	Cost per mile[1]	Wire down Reduction	SAIFI Reduction[2]	CAIDI Reduction[3]	Capacity Increase	Increase DER Usage	Execution Complexity	Potential Use Case
Arc Wire Removal	$191K	13%	22%	36%	No	No	Low	Lowest overall cost to remove arc wire
4.8kV Hardening	$353K	26%	44%	72%	No	No	Low	Highest benefit/cost for reliability improvement
Pre-conversion	$1.7M	90%	85%	85%	No	Yes	Medium	Provides step change in reliability performance
Conversion	$2.7M	90%	85%	85%	Yes	Yes	High	Best benefit/cost for significant capacity needs
Microgrids	$14.6M	90%	95%	95%	Yes	Yes	Very High	Potentially application for grid areas with critical reliability needs

1. Median of cost range
2. SAIFI measures the frequency of customer interruptions
3. CAIFI measures the duration of customer interruptions

Today's Agenda

- Conference kickoff (15 min)
- Context and background
  - Overview of DTE's 4.8kV distribution system (45 min)
  - 4.8/13.2kV distribution systems and the integration of EVs and DERs (15 min)
  - The Detroit 4.8kV System and PLD arc wire (15 min with Hardening)
- 4.8kV Hardening Program (45 min)
- 4.8kV Hardening program and alternative solutions (1 hr)
- **Open table discussion/conference feedback (30 min)**

Discussion / feedback

- Open table discussion
- Conference feedback