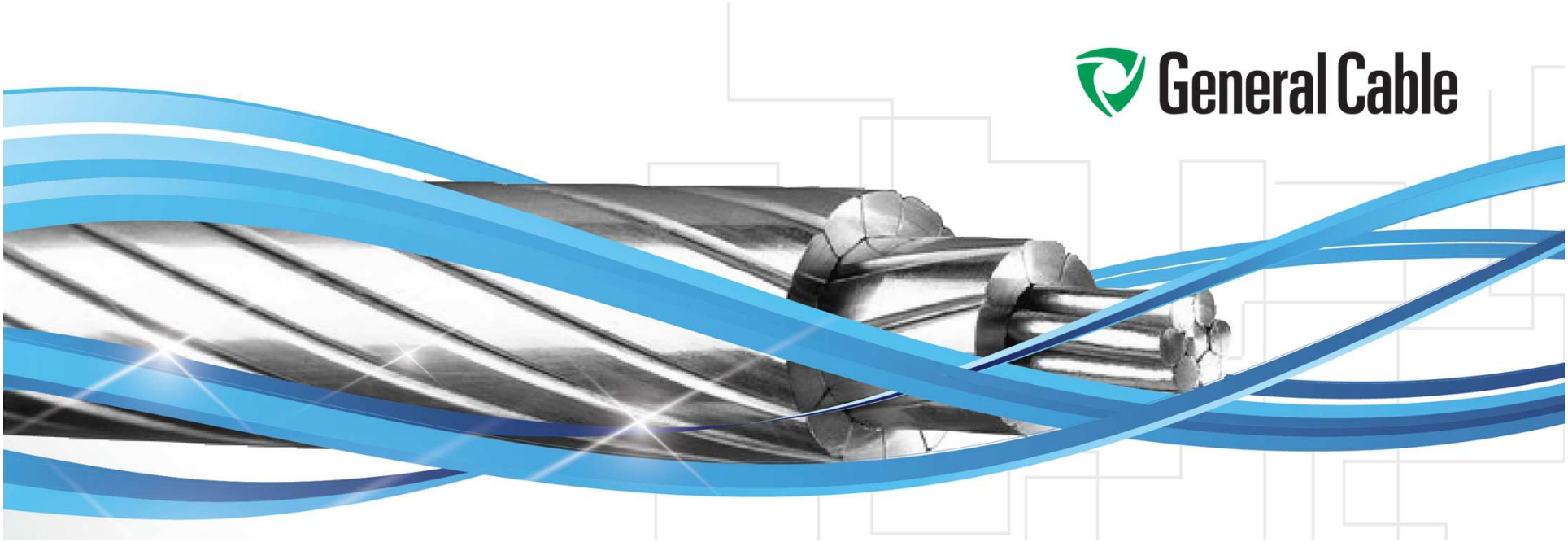
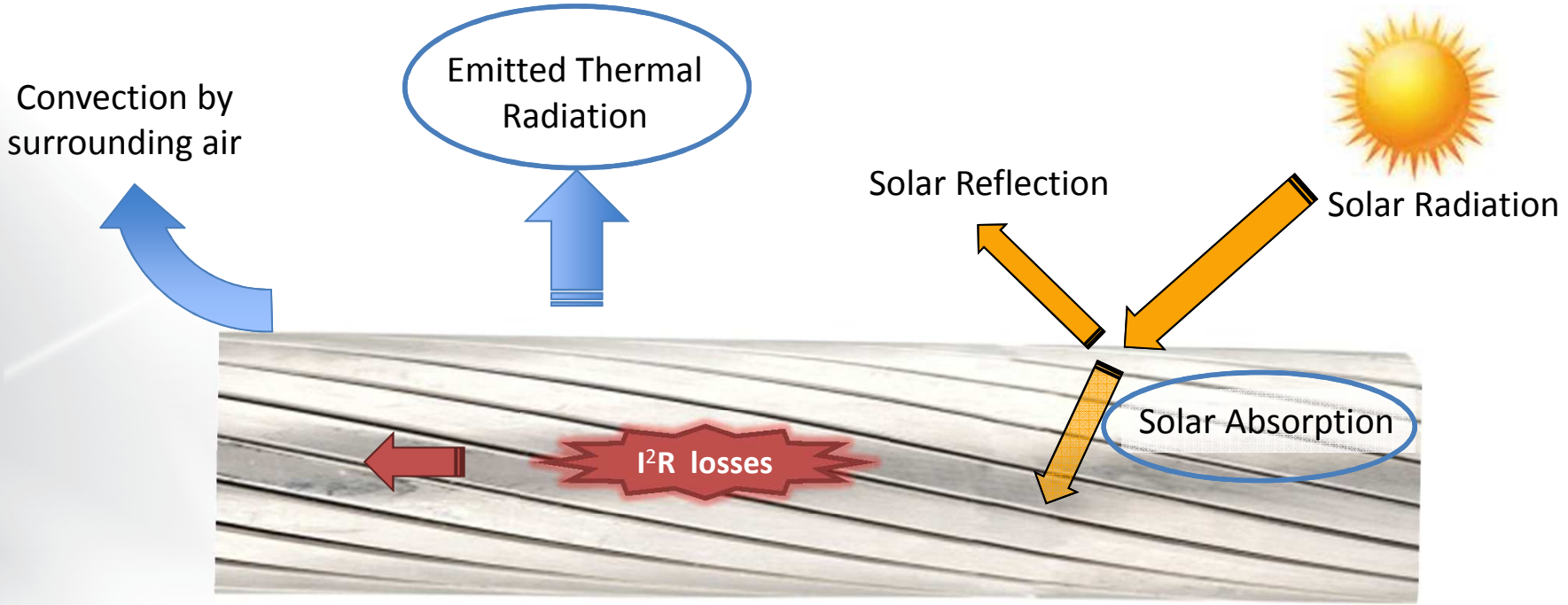


# Advancements in Overhead Conductor technology:
# Engineered Emissivity

# Conductor Temperature/Line Ratings

**Ratings can be increased with higher emisivity and lower absorptivity**




TransPowr® with E3X TECHNOLOGY

General Cable

# Explanation of Emissivity and Absorptivity

**From a utility's facility rating methodology***

The *Infrared Emissivity* coefficient represents the ratio of radiant energy emitted by the conductor surface to the infrared radiant energy emitted by a blackbody at the same temperature, and can vary between about 0.2 to about 0.9. As a conductor ages, the infrared emissivity, or ability of the conductor to radiate heat energy to its surroundings increases, which increases the MVA rating of the conductor.

The *Solar Absorptivity* coefficient represents the fraction of incident solar radiant energy that is absorbed by the conductor surface. The solar absorptivity coefficient varies between about 0.2 to about 0.9, with higher values indicating that more solar energy is being absorbed by the conductor. As a conductor ages, the solar absorptivity, or the amount of solar energy absorbed by the conductor increases, which decreases the MVA rating of the conductor.

selection of these two variables can be highly subjective.

*E3X changes these **variables** to **fixed values**, eliminating uncertainty*

TransPowr® with E3X TECHNOLOGY

*downloaded from OATI webOASIS℠

General Cable

# New vs. Aged Conductors

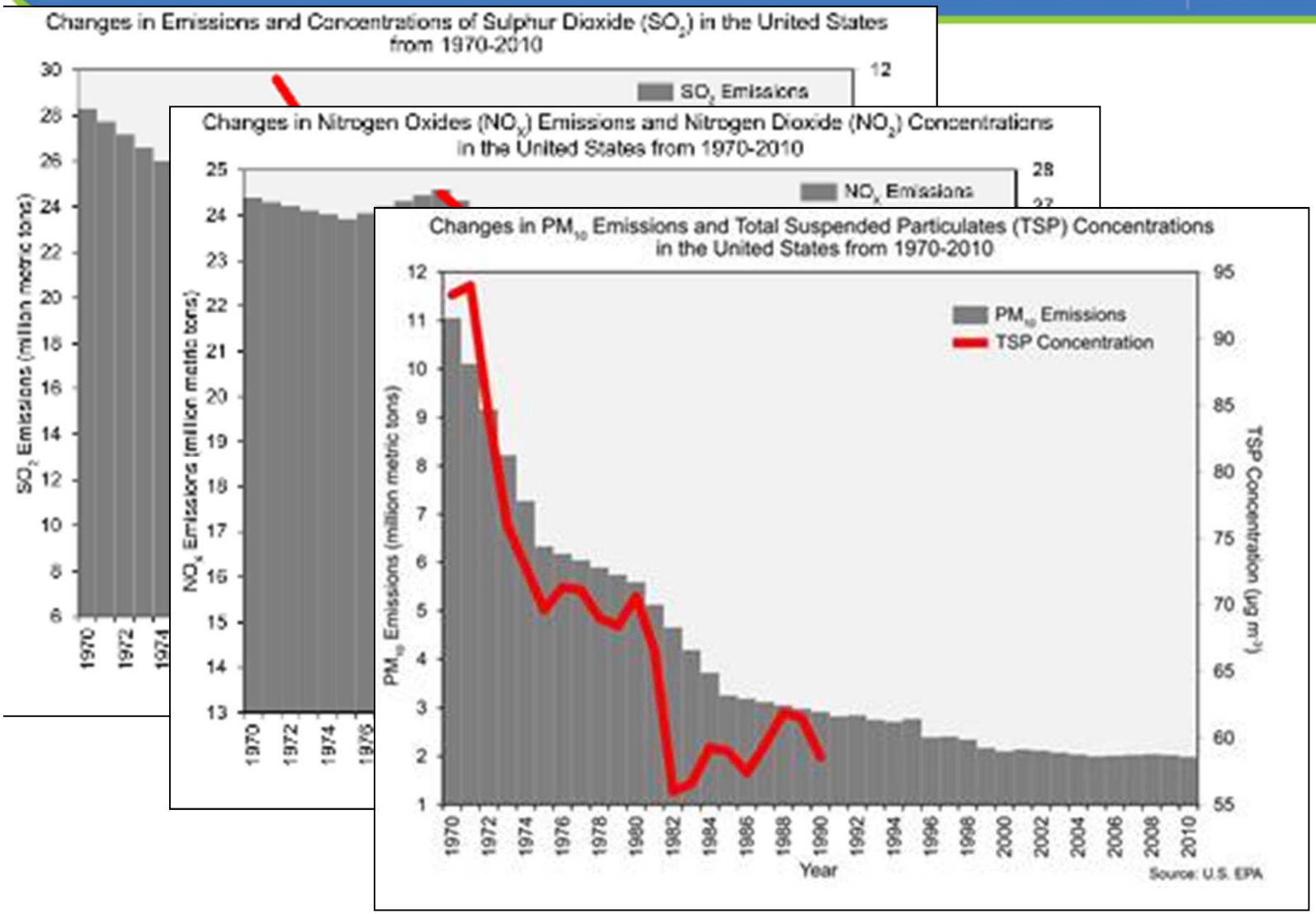
New aluminum conductor

Aged aluminum conductor

How many years will it take for conductor to “darken” to assumed value?
Will today’s conductors ever reach this level?

# Atmospheric Pollution Reduction 1970-2010

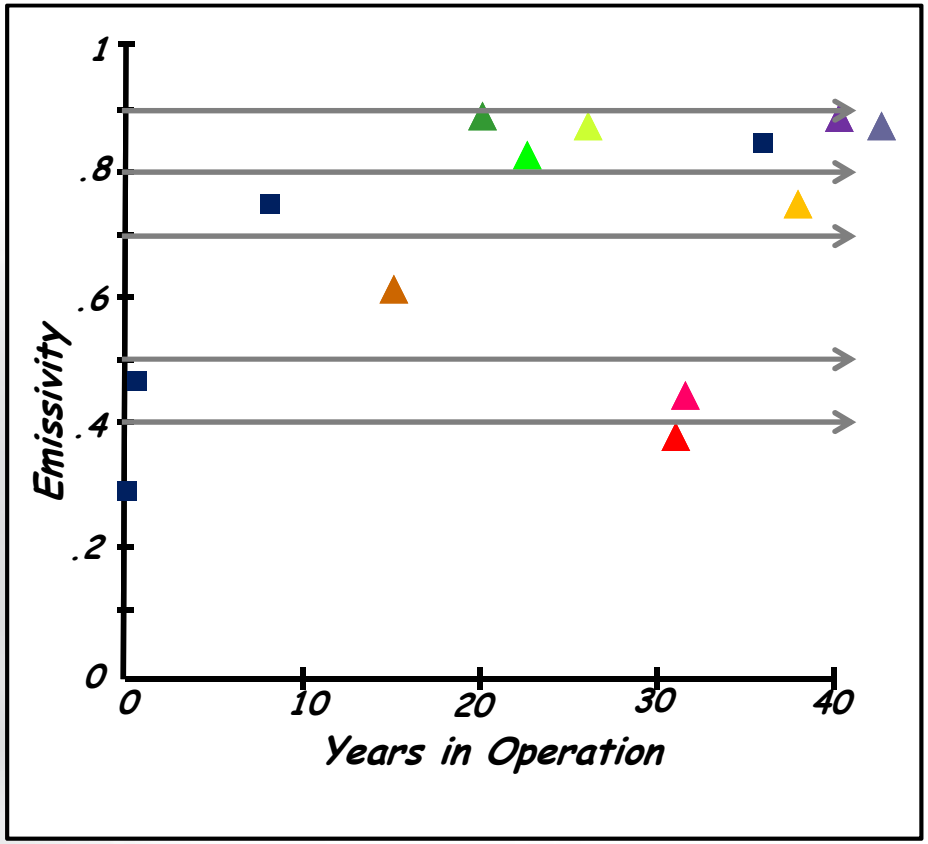
## Conductors from existing studies were installed pre-1970




Limited number of more recent conductors tested show lower emissivity

General Cable

# What value of Emissivity is used today? (For standard lines not using E3X conductors)




| Location | Years in service | approx. year installed | Reference | Emissivity |
|---|---|---|---|---|
| Washington, DC | 0.8 | 1971 | PJM/NASA | 0.46 |
| Washington, DC | 8 | 1964 | PJM/NASA | 0.74 |
| Washington, DC | 36 | 1936 | PJM/NASA | 0.85 |
| San Francisco | 40 | 1916 | Taylor, House | **0.91** |
| Philadelphia | 21 | 1935 | Taylor, House | **0.89** |
| Chicago | 25 | 1931 | Taylor, House | **0.89** |
| San Francisco | 43 | 1913 | Taylor, House | **0.88** |
| New York | 23 | 1933 | Taylor, House | **0.80** |
| Tennessee | 38 | 1918 | Taylor, House | **0.77** |
| New Jersey | 15 | 1993 | EPRI | **0.63** |
| Austin, TX | 32 | 1982 | EPRI | **0.45** |
| San Bernadino | 32 | 1924 | Taylor, House | **0.38** |

*A sample of emissivity values used for line rating by EEI members:*
***0.4,0.5,0.7,0.8,0.9***
***Which value is Correct?***

*Values derived by Aluminum Company of America in study cited in IEEE 738 and by EPRI using their Emissivity Testing Instrument and by NASA in for 1973 PJM conductor rating task force Shape of aging curves are estimates for illustration purposes only*

General Cable

# Video Demonstration

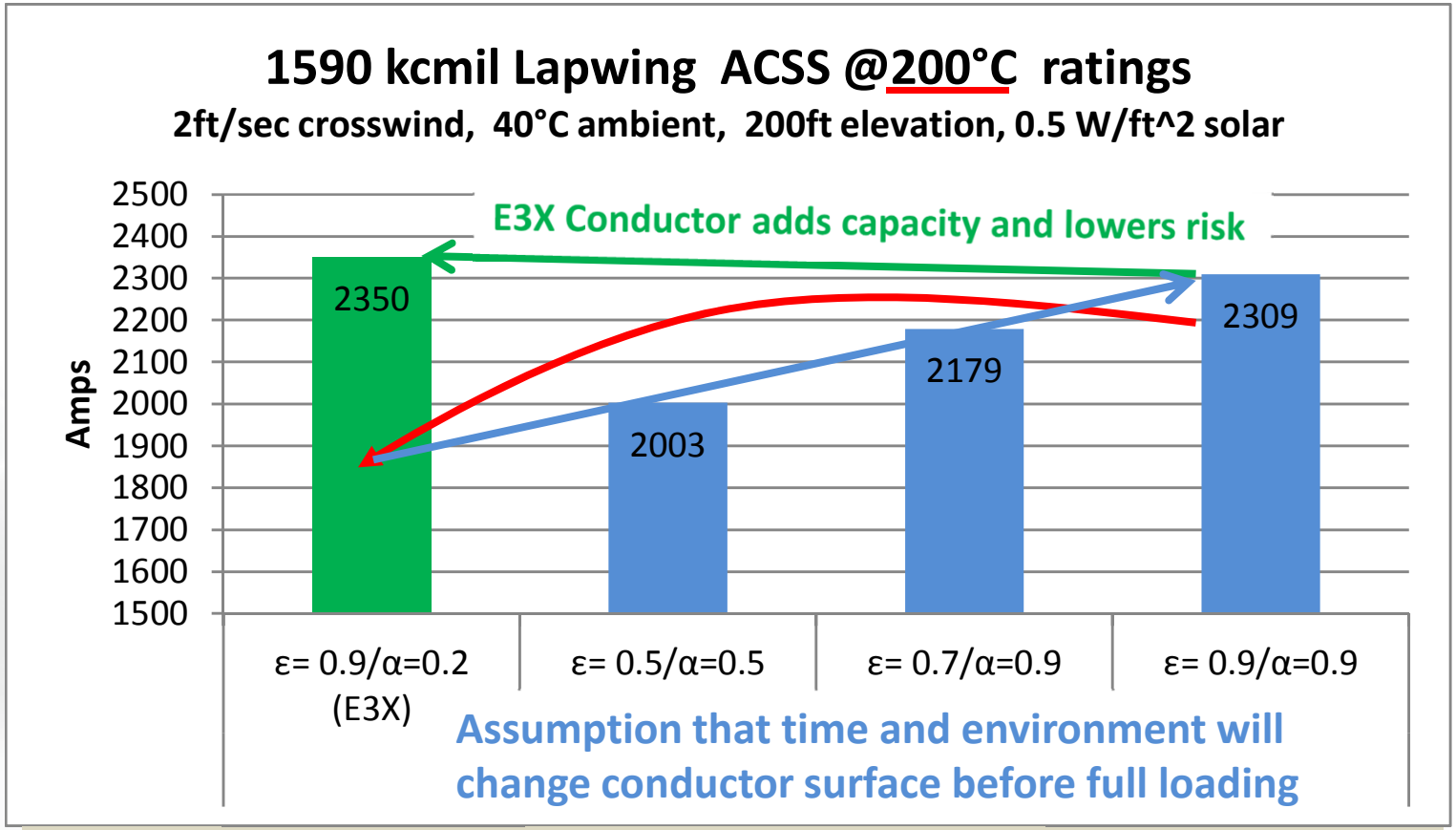
General Cable

**Surface Modified**
**Overhead Conductor**
**Temperature Rise Test**

TransPowr® with E3X TECHNOLOGY

General Cable

# Impact of different surface conditions on ratings



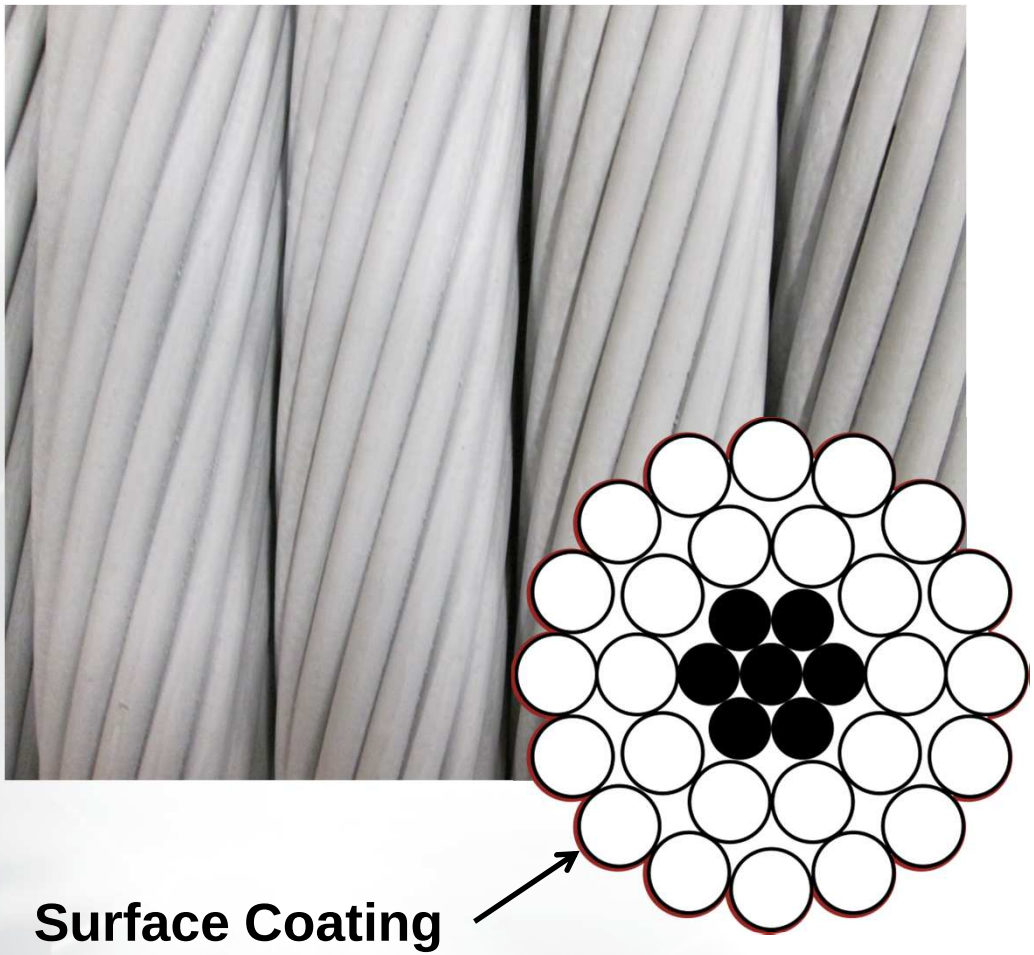

What if full "0.9" load put on new conductor? 2309 amps = 320 °C

**What if 2309 amps put onto E3X Conductor? 195 °C**

TransPowr® with E3X TECHNOLOGY

General Cable

# Introducing E3X™ TECHNOLOGY



Surface Coating

**High Emissivity (0.9), Low Absorptivity (0.2)**

**Results in cooler operating conductor for given load**

**Applied in the factory to the outside of the conductor**

**Thin (½ mil) coating**

**Environmentally stable**

**Hard, Durable, Abrasion and Heat Resistant, Flexible**

**Can only be removed by removing underlying aluminum**

TransPowr® with E3X™ TECHNOLOGY

General Cable

# Commonly Used ERCOT conductors

| | | | |
|---|---|---|---|
| **Frequency:** | 60 Hz | **Ambient Temperature:** | 40 °C |
| **Total Solar Radiated Heat:** | 95.4 W/ft² | **Crosswind Velocity:** | 2.00 ft/s |
| **Azimuth of Line:** | 0 ° | **Wind Angle:** | 90 ° |
| **Atmosphere:** | Clear | **Northern Latitude:** | 32 ° |
| | | **Elevation:** | 600 ft |
| | | **Month and Day of Year:** | July 1 |
| | | **Time of Day:** | 2:00 PM |

| | 795.0 kcmil 20/7 Drake/ACSS/TW/MA2 | | | | 959.6 kcmil 22/7 Suwannee/ACSS/TW/MA2 | | | |
|---|---|---|---|---|---|---|---|---|
| Temp | Resistance | Ampacity | | | Resistance | Ampacity | | |
| C | Ω/kft | New (shiny) | E=0.5/A=0.5 | E3X | Ω/kft | New (shiny) | E=0.5/A=0.5 | E3X |
| 200 | 0.03622 | 1415 | 1550 | 1759 | 0.03006 | 1595 | 1753 | 1996 |

| | 1590.0 kcmil 42/19 Falcon/ACSS/TW/MA2 | | | | 1926.9 kcmil 42/19 Cumberland/ACSS/TW/MA2 | | | |
|---|---|---|---|---|---|---|---|---|
| Temp | Resistance | Ampacity | | | Resistance | Ampacity | | |
| C | Ω/kft | New (shiny) | E=0.5/A=0.5 | E3X | Ω/kft | New (shiny) | E=0.5/A=0.5 | E3X |
| 200 | 0.01955 | 2125 | 2352 | 2695 | 0.01620 | 2398 | 2664 | 3065 |

TransPowr® with E3X TECHNOLOGY

General Cable

# E3X Technology improves any aluminum conductor

## Added Capability

- E3X adds capacity to standard bare aluminum conductors such as ACSR and ACSS, increasing operational flexibility and reducing the need for one-off solutions

## More Ratings Certainty

- E3X lowers risk of clearance violations and damage to lines from overheating by converting uncertain ratings variables to fixed values
  - –Changes assumed emissivity values to fixed emissivity values
  - –Changes assumed absorptivity values to fixed absorptivity values

TransPowr® with E3X TECHNOLOGY

General Cable

# E3X Testing:
# from the lab to field trials to utility deployment

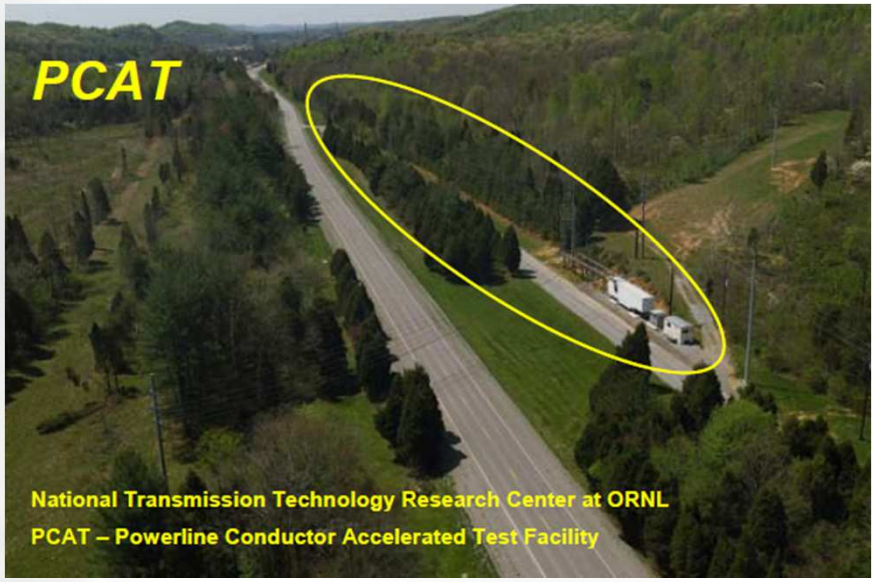
| | |
|---|---|
| Performance | • Temperature Reduction (vs. New, Non-Specular, and Aged )<br>• Ampacity<br>• Oak Ridge National Laboratory<br>• Temperature Reduction vs. Coating Coverage |
| Physical Durability | • Adhesion<br>• Thermal Stability<br>• Sheave Roller<br>• Galloping<br>• Aeolian Vibration<br>• Tension Cycling |
| Environmental Durability | • Weatherometer<br>• 85/85 Heat/Humidity<br>• Water Immersion<br>• Low pH<br>• High pH<br>• Salt Water |
| Electrical Performance | • Corona / Wet Corona |
| Field Testing | • Utility Installations |

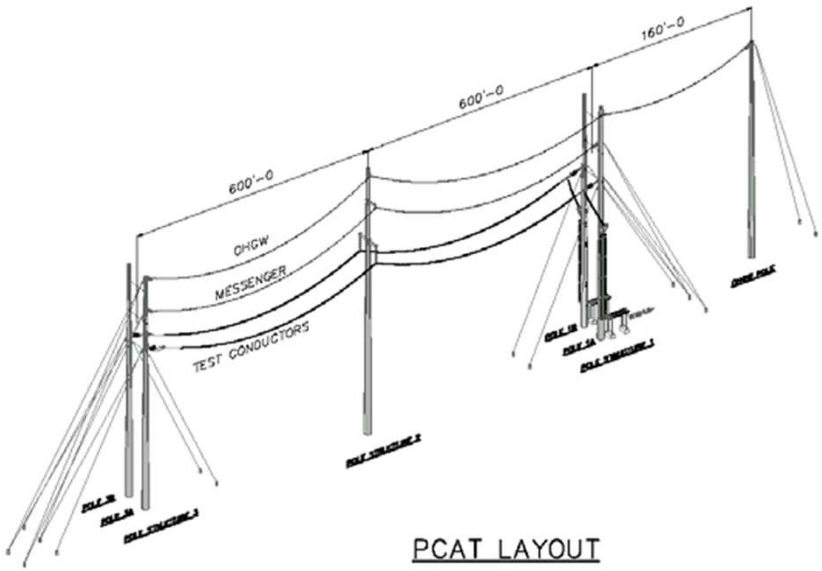
TransPowr® with E3X TECHNOLOGY

General Cable

# Sample of testing performed: Oak Ridge National Laboratory

- **Conductor was installed at Oak Ridge National Laboratory's PCAT (Powerline Conductor Accelerated Test Facility) in October 2014**

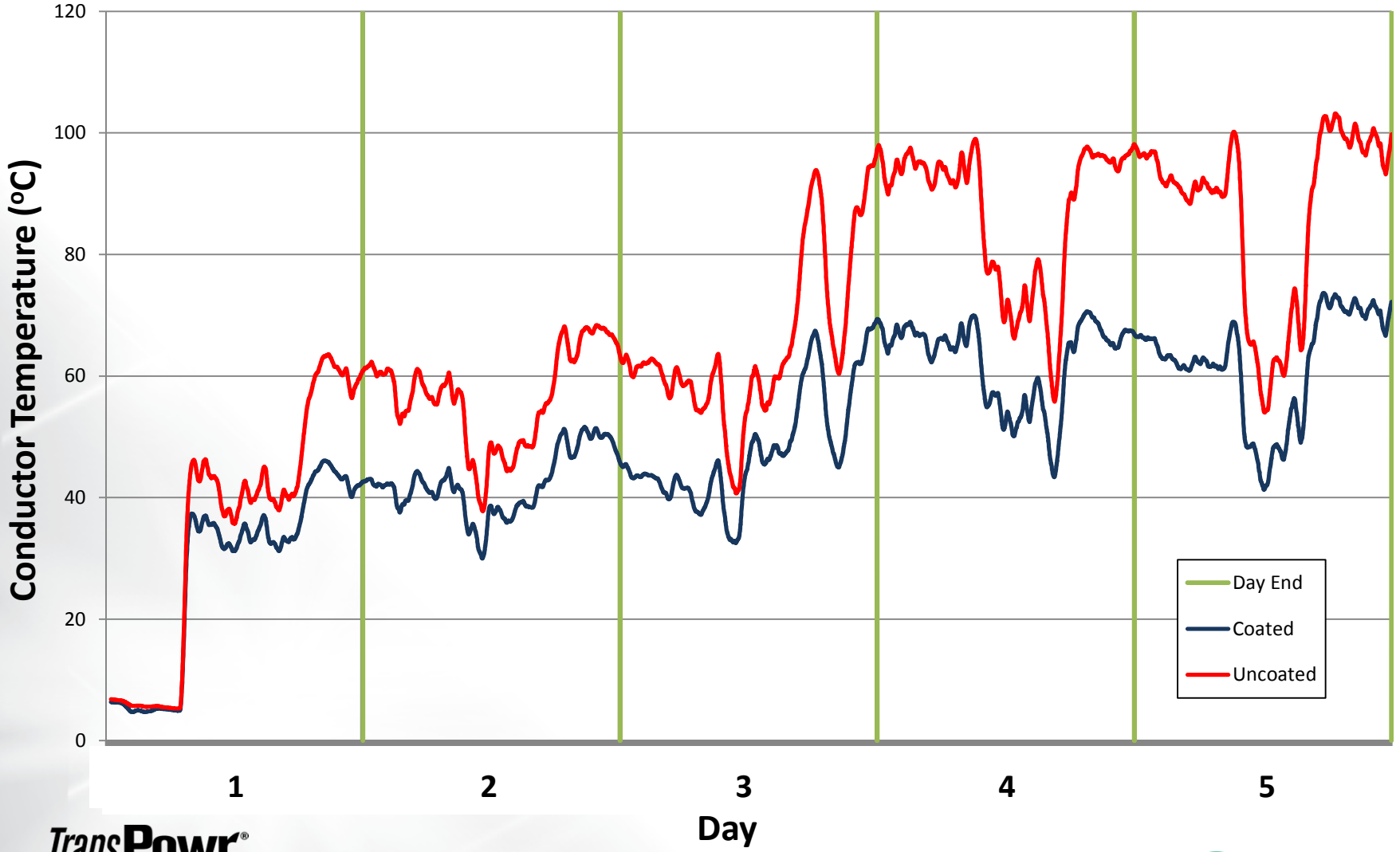



TransPowr® with E3X TECHNOLOGY

General Cable

# Sample Test Results at Oak Ridge National Laboratory



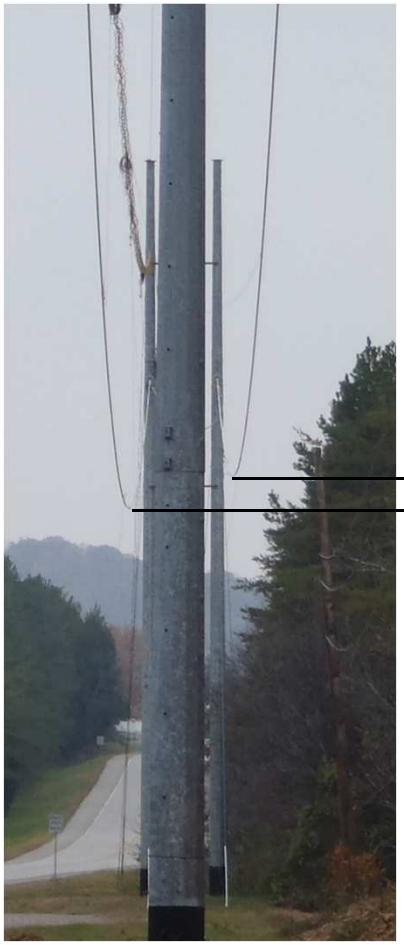

TransPowr® with E3X TECHNOLOGY

General Cable

# Sample Test Results at Oak Ridge National Laboratory

| Ambient Temp (°C) | Wind Velocity (ft/s) | Drake ACSS/MA2 (°C) | Drake ACSS/MA2/E3X (°C) | Temperature Reduction (°C) | Sag Differential (ft)* |
|---|---|---|---|---|---|
| 9 | 1.1 - 3.6 | 90 | 72 | 18 | 0.5 |
| 8 | 0 - 4.7 | 119 | 90 | 29 | 0.7 |
| 8 | 4.4 - 5.7 | 125 | 94 | 31 | 0.9 |
| 6 | 0.2 - 3.2 | 166 | 125 | 41 | 1.5 |
| 6 | 0.4 - 4.8 | 200 | 150 | 50 | 1.6 |
| 4 | N/A | 240 | 174 | 66 | 2.25 |
| 2 | 2.1 - 2.2 | 275 | 190 | 85 | 2.85 |

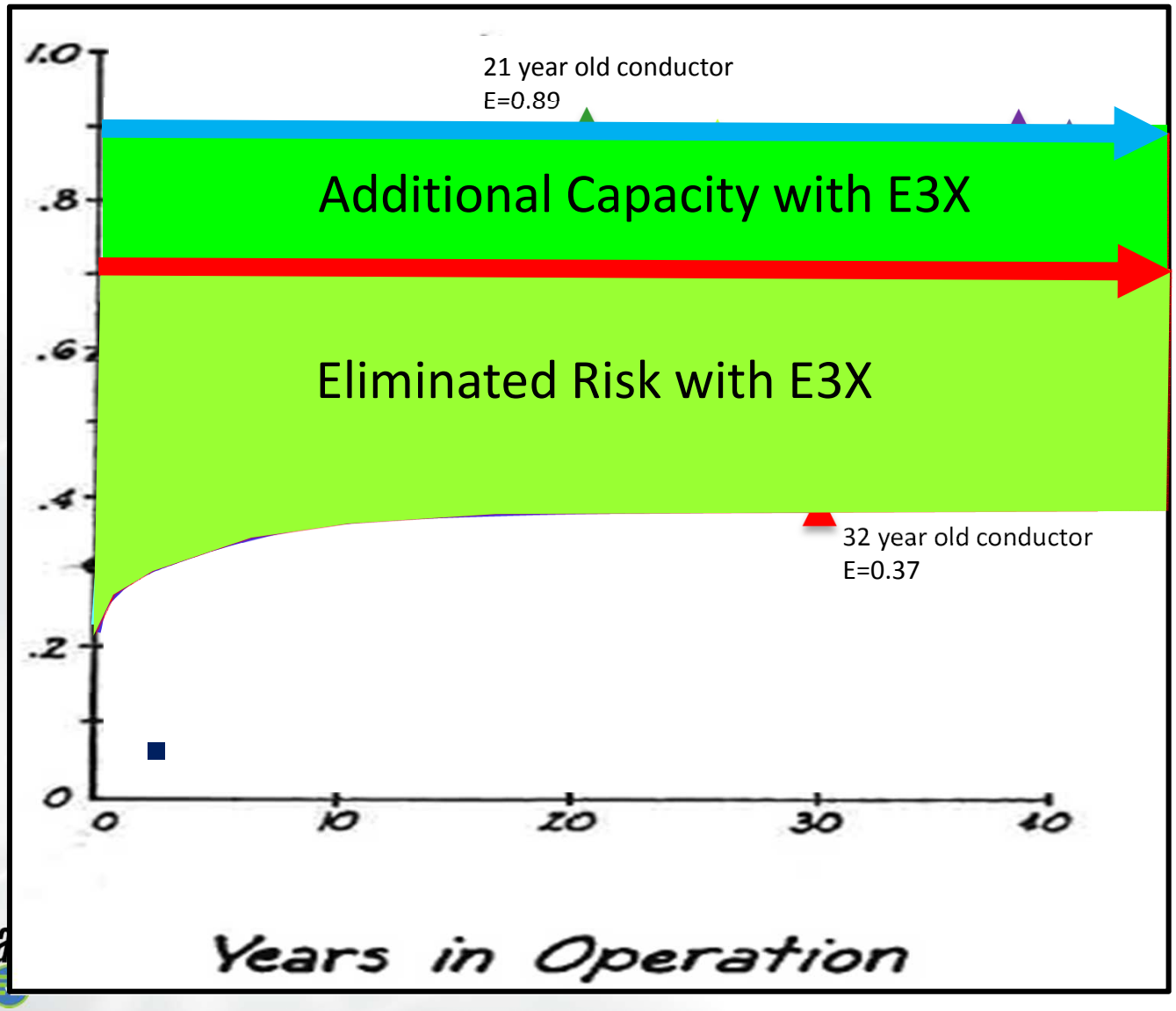
* 600 ft span




TransPowr® with E3X TECHNOLOGY

General Cable

# E3X Technology: Increased Capacity, Lower Risk




E3X E=0.9

Example:
E=0.7 estimate

General Cable

## Summary

- Adds capacity and flexibility to accommodate uncertainty in a fast changing transmission landscape
- Reduces risk in transmission line ratings by changing assumed variables to fixed values
- Lowers project costs by enabling conductors to operate safely at higher rated ampacities
- Reduces O&M costs by increasing capabilities of products already used everyday.
- Proven in the lab, the field, and with utility installations

# Thank You!

Joe Coffey
General Cable
Director Transmission
303 284 8025
jcoffey@generalcable.com

TransPowr® with E3X TECHNOLOGY

General Cable