

*Operations Support &
Distribution Engineering*

Focused on Our Future

Distribution Asset Analytics

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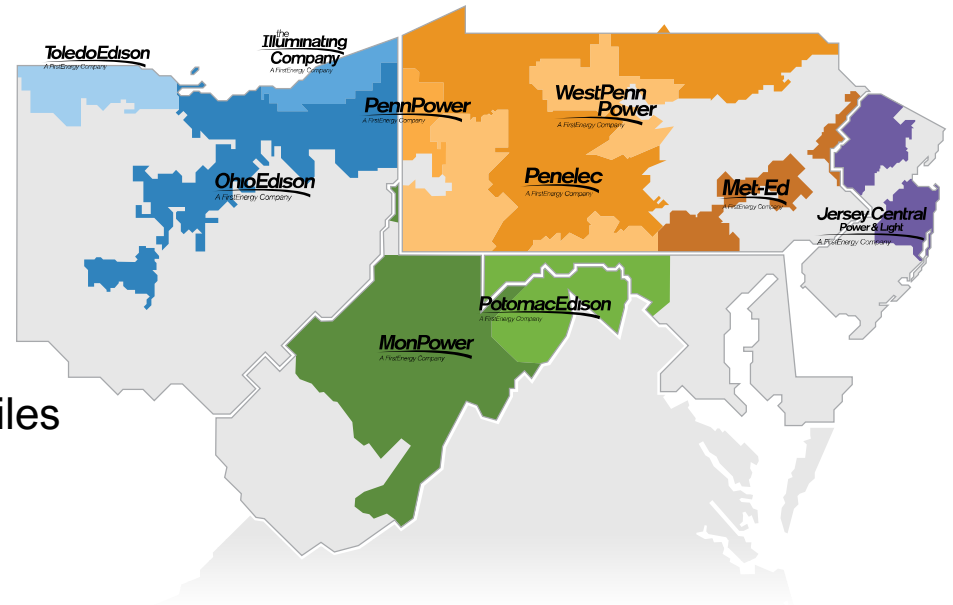
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About FirstEnergy

- Among the largest investor-owned electric systems in the U.S. based on 6 million customers served
- Approximately 12,000 employees
- 10 electric utility operating companies in 6 states
- 65,000-square-mile service territory
- 24,000 miles of transmission lines and 272,000 miles of distribution lines
- Energize 365
 - Robust Investment Plan \$26B
 - CapEx from \$4.3B in 2024 to \$6.2B in 2028
 - 16% increase vs. '23 Spend



Advanced Analytics: Using Data and Machine Learning to make more informed decisions in Capital Planning

From



Current data utilized for planning is limited to age and failure history



Budget allocated mostly based on simple historical rules



No ability to test quality of the rules or actual ability to predict failures



Static visibility on reliability outcomes



To



150+ features to build a model predicting probability of failure



Optimized budget to focus on risk mitigation

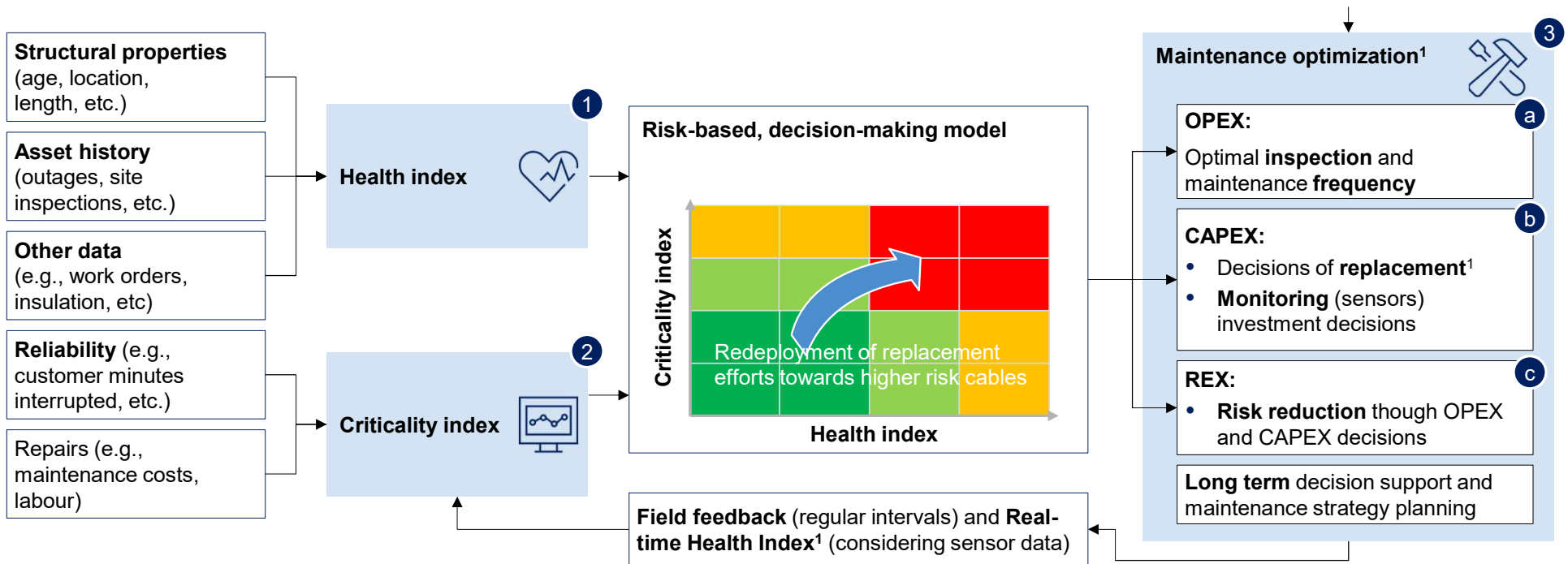


Models are back-tested against actual failures and will improve every year



Dynamic visibility on reliability outcomes

Health (probability of outage) and Criticality (cost of outage) drive an optimized replacement and inspection plan



1. Includes several scenarios based on risk perception and appetite
2. The optimization engine can prioritize for savings on CAPEX, reliability, etc. We need to align with the business

Asset Analytics leverages cross-functional sub-teams

Data Scientists

- Dedicated Digital factory resource in a sub team and responsible for an asset's initial model as well as scaling it
- In steady state¹, DS will handle multiple assets. Will continuously improve models and monitor model outcomes

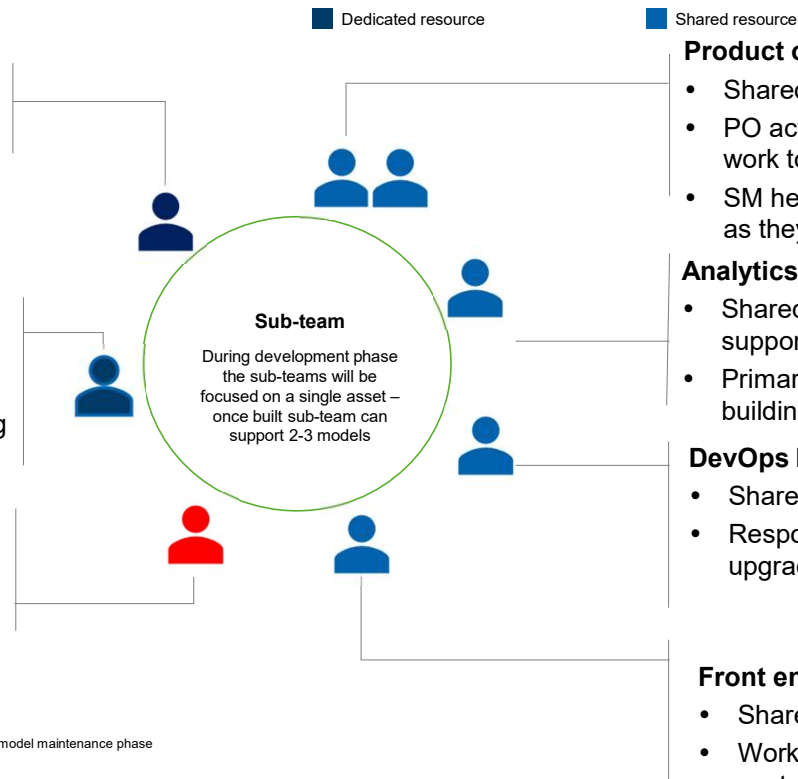
Data Engineer

- Dedicated Digital factory resource in a sub team.
- Will be involved in Data collection and cleaning efforts and then move onto next asset.

Asset Management SME

- Dedicated business resource in a sub team and will support modeling efforts through initial model and scaling
- Will act as a consultant for the asset in steady state and own Asset Management going forward

1. Steady state is the model maintenance phase



Product owner & scrum master

- Shared across full Dx portfolio
- PO acts as the voice of the customer – helping team prioritize work to provide value
- SM helps team manage velocity – and removes roadblocks as they arise

Analytics Translator

- Shared business resource across sub teams who can support 2-3 of them in parallel
- Primarily involved in incorporating business needs into model building

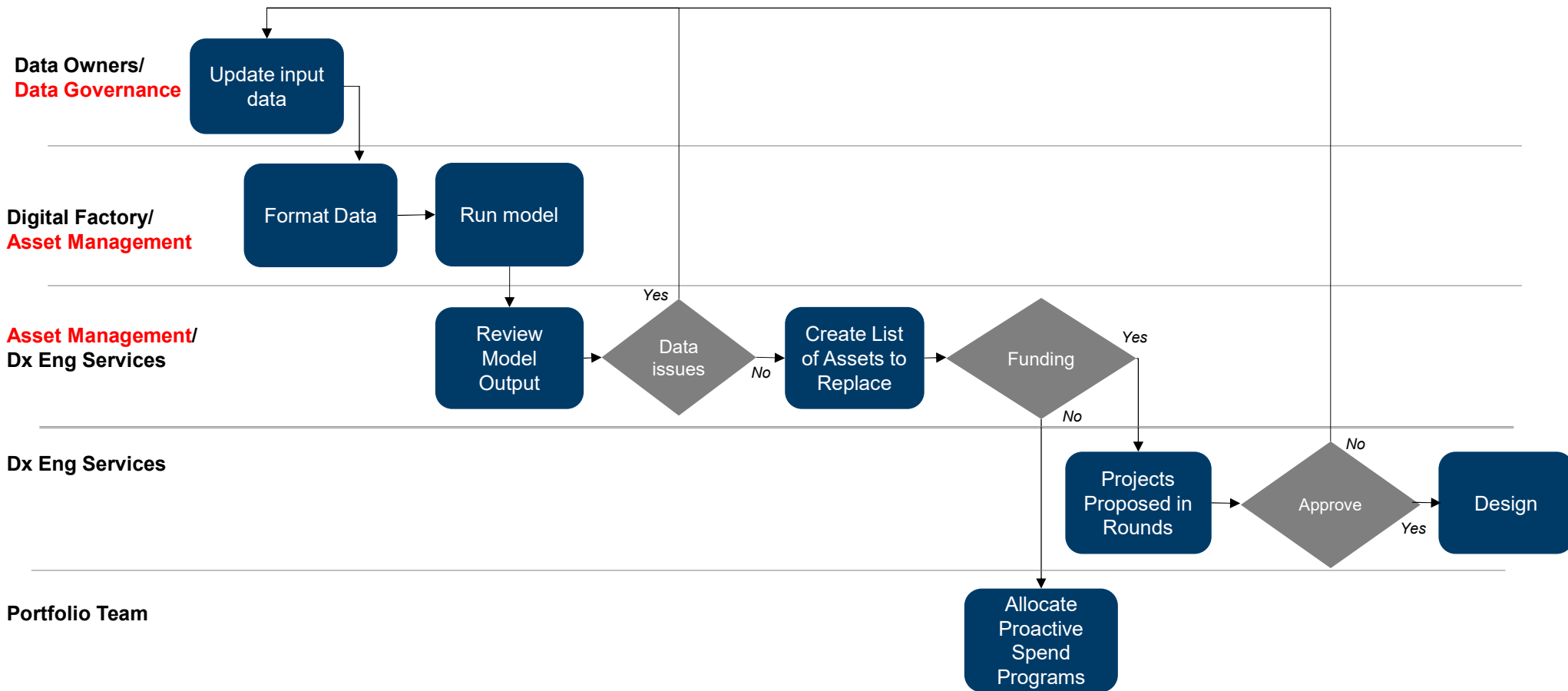
DevOps Engineer

- Shared resource across sub teams in steady state
- Responsible for ensuring continuity with Data pipeline upgrades. Also, fixes and communicates pipeline failures

Front end UI

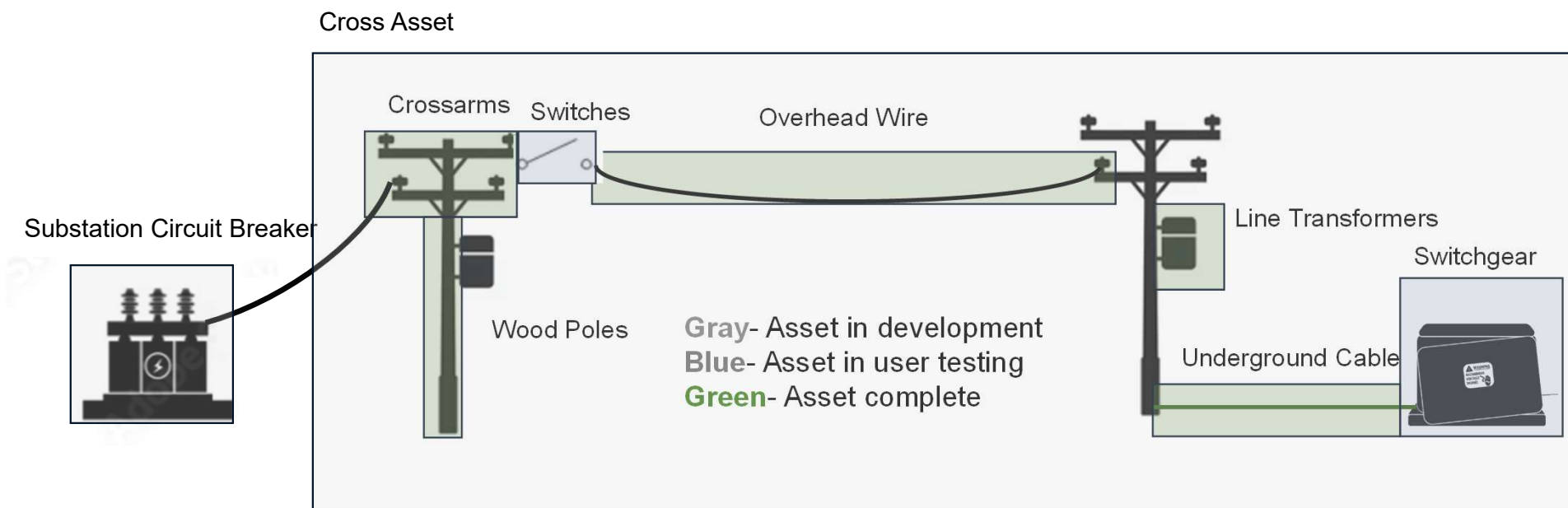
- Shared business resource across sub teams
- Works with team during development phase, with some customer informed iteration after

Distribution Asset Analytics Model Implementation Process



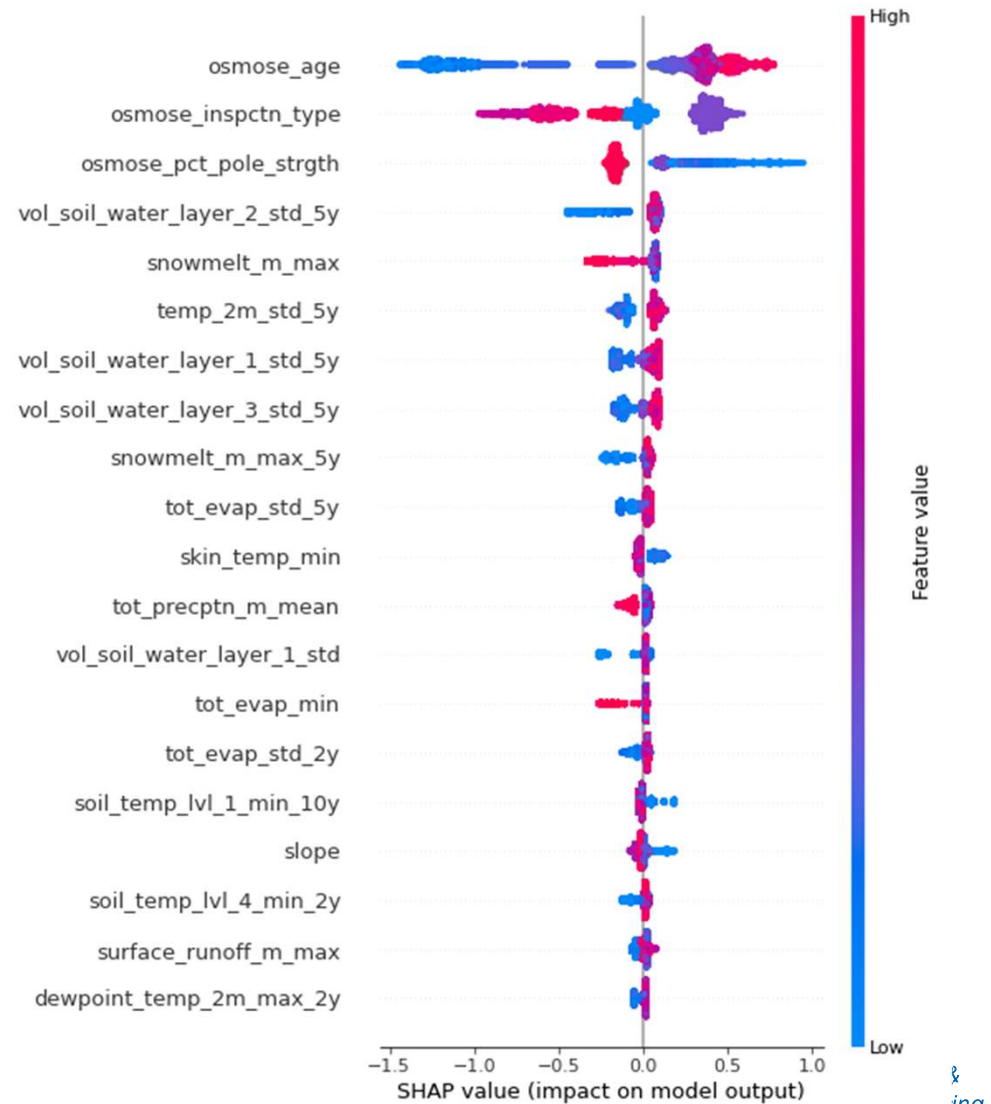
Distribution Asset Analytics – What we completed

Goal: Provide a data-driven, asset-specific predictive health score for each component on the distribution system, as well as the impact a failure of that component would have on customers.



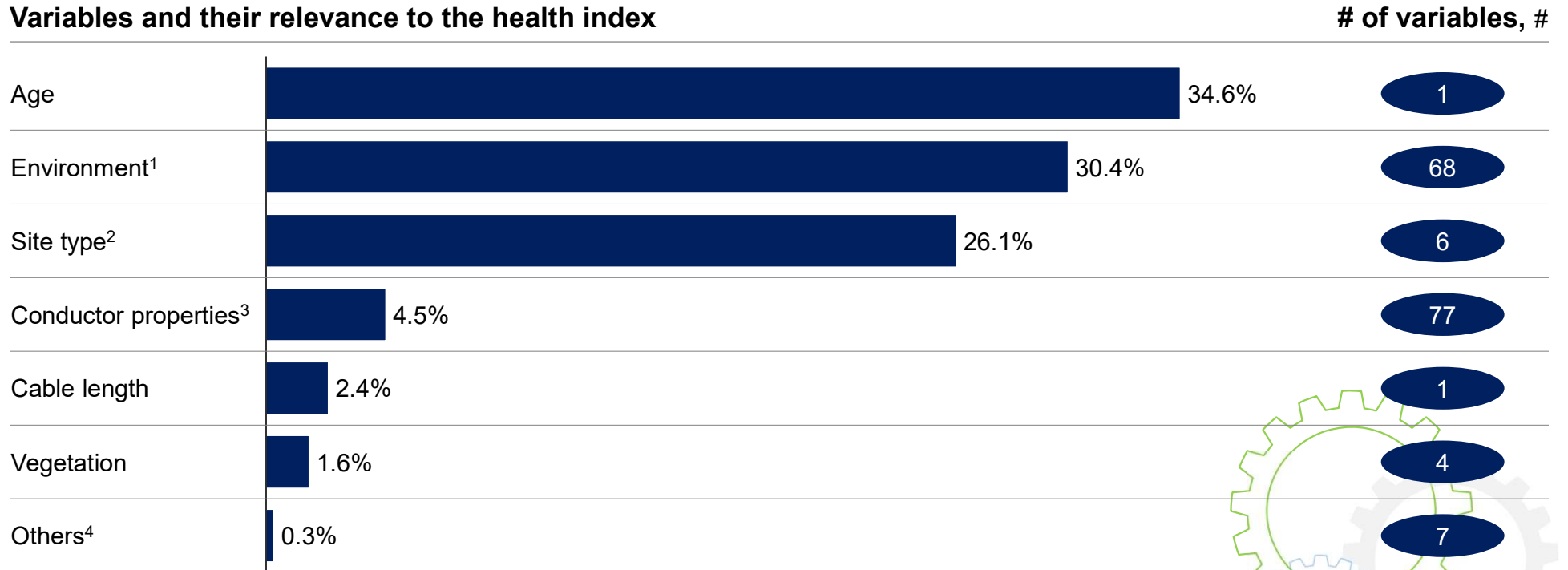
Model inputs - health

- Dots to the right of the vertical line indicate this value *adds* to the probability of a pole being a priority pole, to the left *subtracts*
- Red dots are a *high* value, blue dots are a *low* value
- The model finds the age of the pole, the type of inspection performed last cycle, and the strength remaining of that last inspection the best indicators



Age, Environment, and Site type are important variables in determining the health of underground cables

Variables and their relevance to the health index

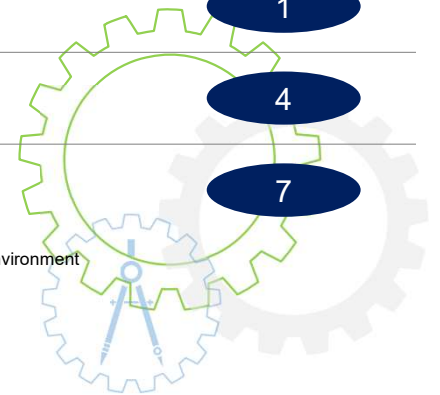


1. 68 Environment variables include Soil temperature, soil water volume, temperature, dewpoint temperature, evaporation, surface runoff. Mean, min, max and std of 17 environment variables

2. 6 Site type variables includes both from and to site types – Overhead, Padmount and Underground

3. 77 conductor properties variables Includes conductor size, quantity, phasing, phase configuration, type, primary voltage and rated kV

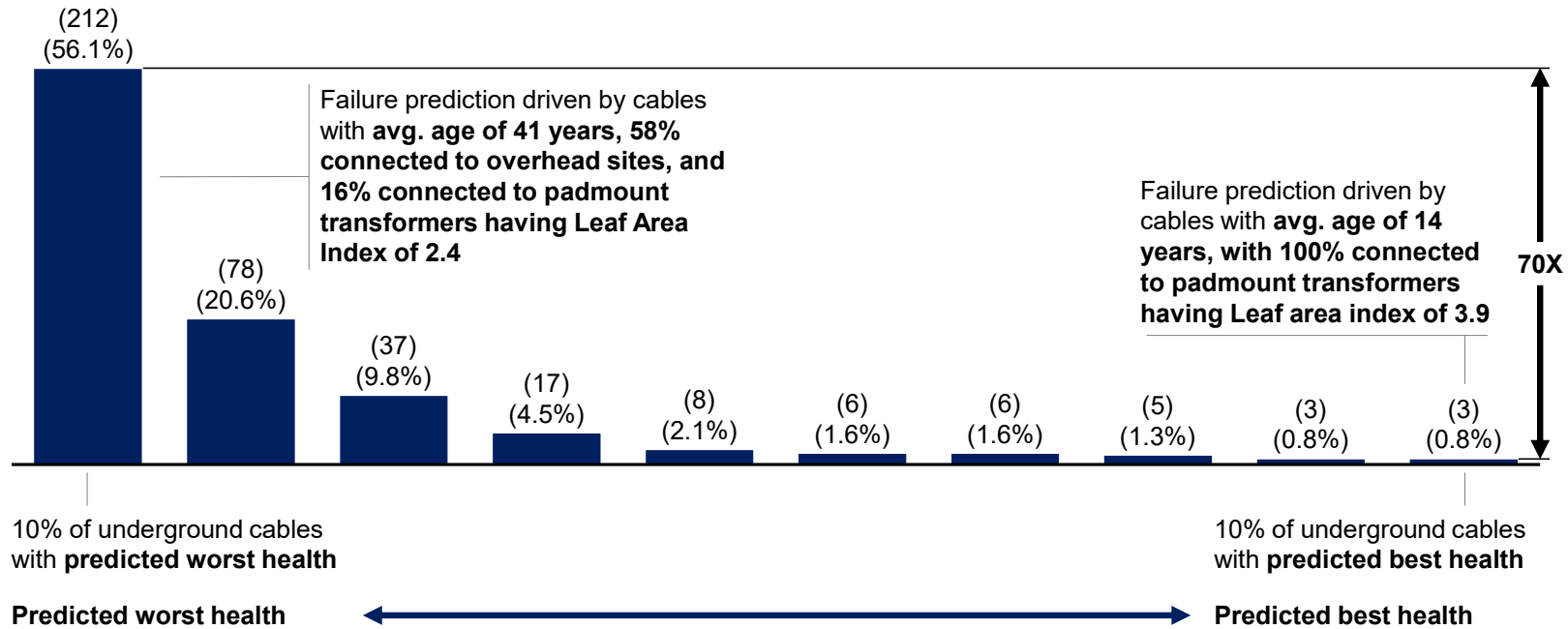
4. 7 variables includes insulation, inspection and outages information wherever available and elbow or endpoint flag



The model is able to predict ~80% of failures from 20% of underground cables

Anomalies (378) during the blind test of 2020 against the full population of 54931 cables

~80% of failures predicted from 20% of cables

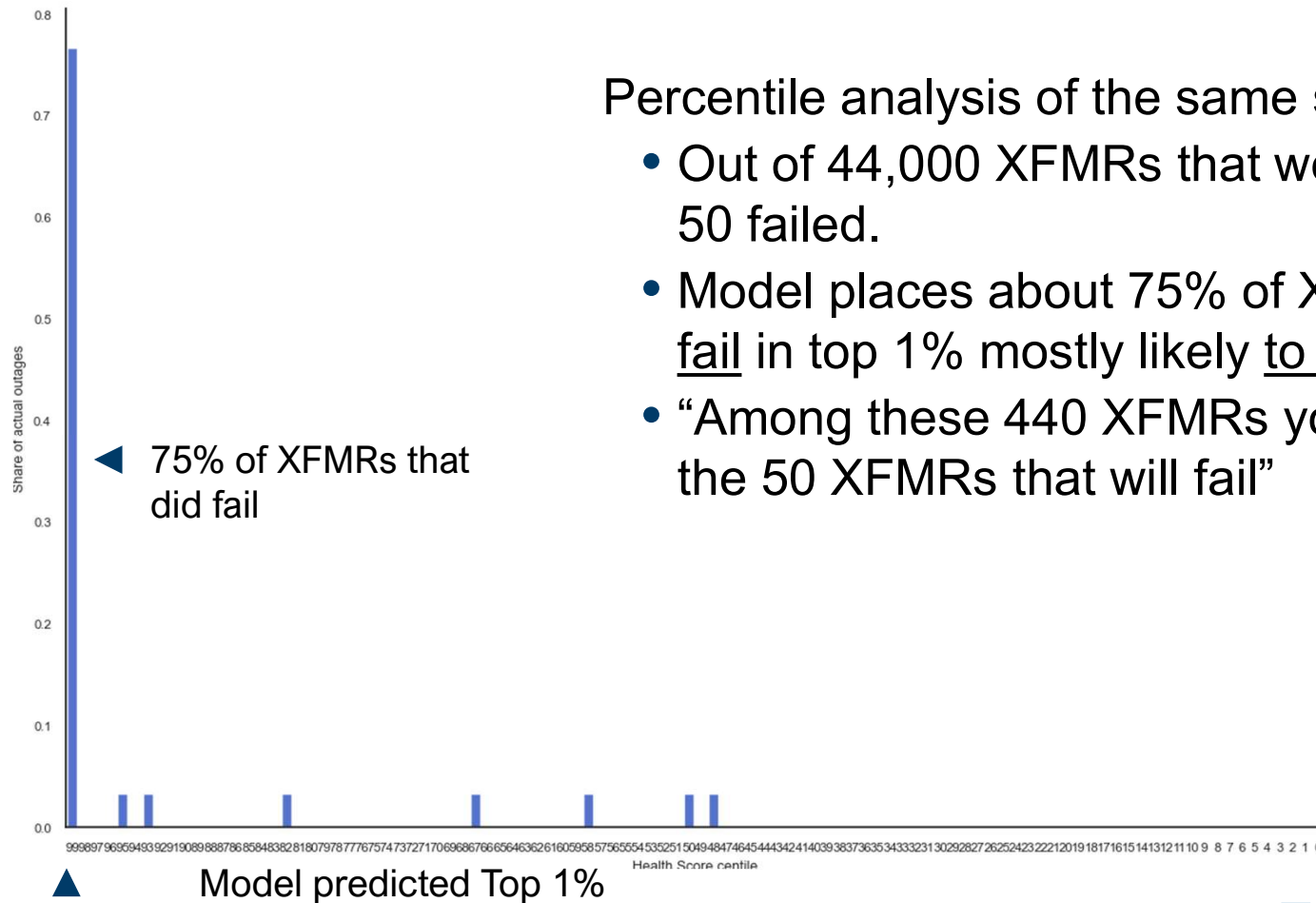


By only targeting the **top 20%** of underground cables, we would be able to capture **around 80%** of the failures

70X higher risk in top decile compared to lowest decile

1. P = padmount site, O = overhead site

AMI Transformers – Percentile Health Scores



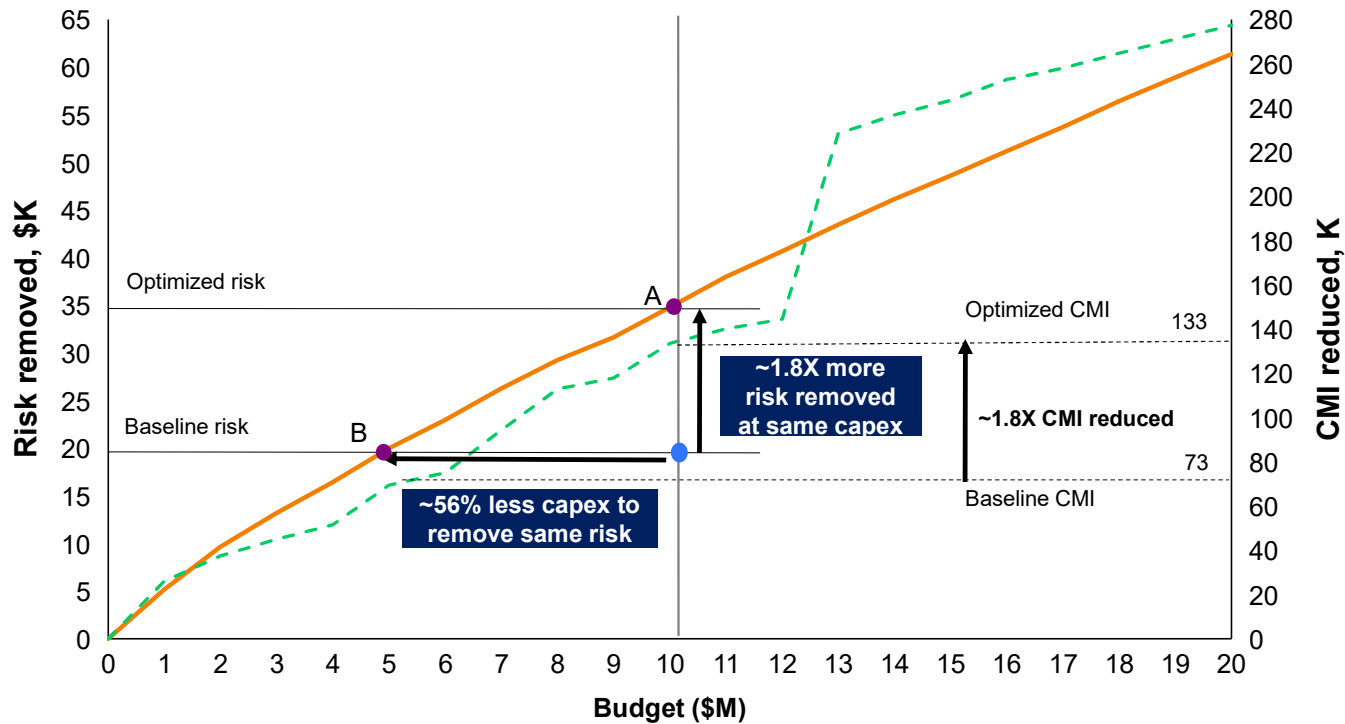
Percentile analysis of the same sample:

- Out of 44,000 XFMRs that were in this test, 50 failed.
- Model places about 75% of XFMRs that did fail in top 1% mostly likely to fail
- “Among these 440 XFMRs you’ll find 37 of the 50 XFMRs that will fail”

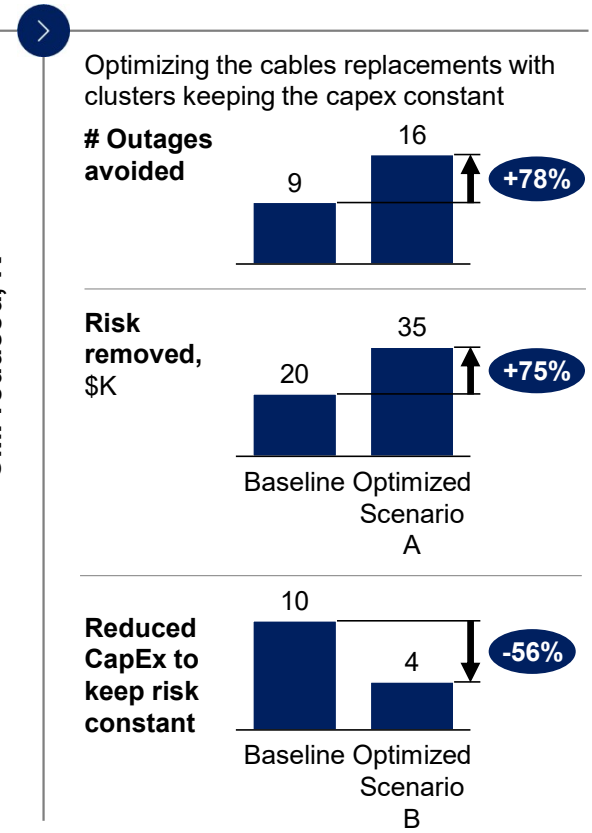
PotEd UG Cable Optimized Investment Strategy

— FE Optimized Risk removed - - - FE Optimized CMI avoided ● FE Baseline ● Scenario

Optimizing for risk² removed



1. CMI is calculated as probability of failure * number of downstream customers * average duration of outage (184 min) over last 3 years
 2. Risk is calculated as probability of failure * cost of failure



Why Asset Analytics?

Benefits/Value Added

- Supports Business Strategy to improve health and reliability of the distribution system
- Improved & consistent risk and failure analysis (risk-based decision making)
- Agile Support of Proactive Long Range Investment Strategy (Substation Equipment)
- Process is adaptable to changing priorities including supply chain constraints (transformer harvesting)
- Validates project priorities to maximize investment benefits

Opportunities/Challenges

- Asset analytics tools still maturing and in early adoption phase
- Centralized **Distribution Asset Management** to drive consistency and adoption
- **Data Governance** adherence to improve asset health and performance
- Leverage Transmission APM System (Asset Health Center) for Distribution Assets
- Process gap identification and closure
- Program expansion across all assets



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Appendix

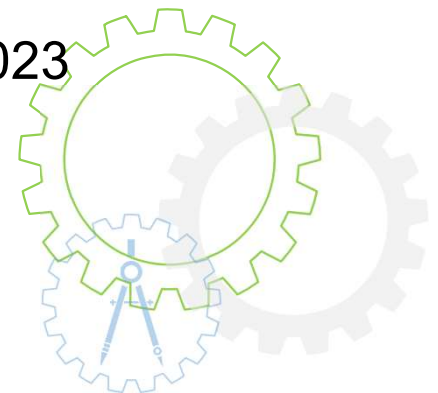
History and Roadmap of model development for asset analytics

Dx

Completed work

- Underground cable MVP: May 2022
- Poles MVP: September 2022
- Overhead wire MVP: October 2022
- Cross arms MVP: May 2023
- Cross Asset MVP: June 2023
- OVHD Switches MVP: May 2023
- Line Transformer AMI MVP: June 2023
- UG Switchgear MVP: November 2023

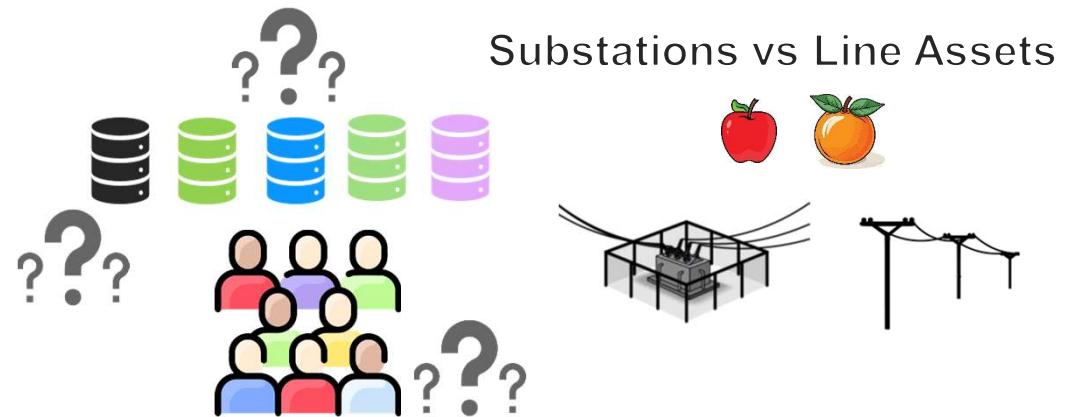
- Dx Sub OCBs MVP: April 2024
- Dx Sub Transformers MVP: May 2024



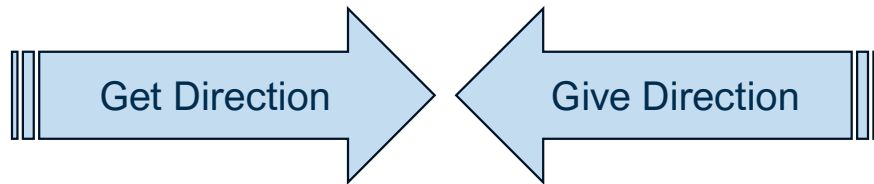
“Fail fast, fail often”



Challenges



Benefits



We are giving information back to the business for the data we will need in the future to provide better models

Adoption of the analytics model in Potomac Edison MD in 2022

Current 2022 Plan

(before using the model)

~37.5 miles out of the 50 miles of cables selected for replacement based on historical failures

The remaining 12.5 miles are held in reserve for emergent work⁴



Revised 2022 Plan (based on using the model)

~32¹ miles of cables selected for replacement based on the analytics model
~10.5³ miles have already been designed and will be replaced as currently planned; these additional miles will be optimized in 2023 onwards for additional impact

~40% reduction in miles held in reserve for emergent work (7.5 miles instead of 12.5 miles)



Takeaways

Adopting the model has potential to **reduce risk by 1.2X²**
Adopting the model can **potentially reduce number of CM events by up to ~50%²** compared to current plan

1. This is made up of 27 miles and an additional 5 miles from original 12.5 miles of reserve for emergent work
2. Assuming 64% of value from full model i.e. risk reduced = 64% of 75% and reduced CMs = 64% of 78%
3. Of the 10.5 miles, ~50% have a completed design, 15% is getting permits, and ~35% design is in progress
4. These are projects that arise mid-year, become a priority after plan has been developed, etc.