Assessing Condition of Overhead Lines Using Best Asset Management Practices

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What is Asset Management?

- Appropriate for asset-intensive businesses
  (primarily physical assets with relatively long lives)
- Requires centralized decision making
- Maximized life-cycle based long-term effectiveness of investments
- Optimized balance between
  - Financial performance
  - Operating performance and
  - Business risk
- Asset Manager is responsible for assets performance
- Service Provider for workforce performance

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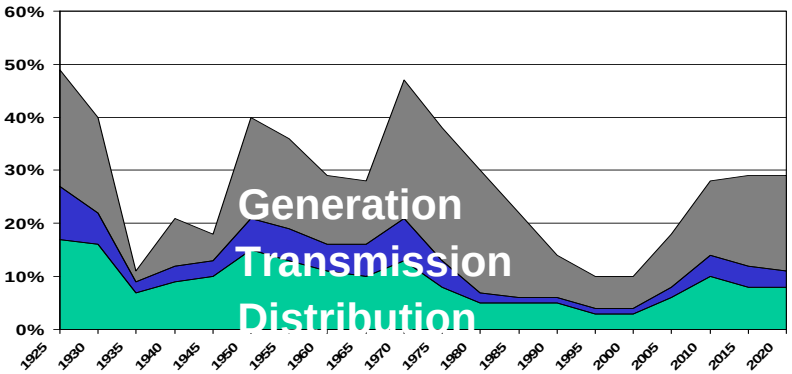
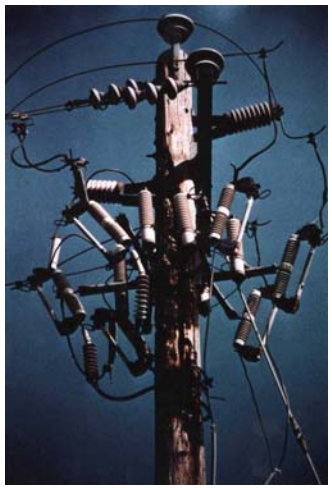
Asset Management - Drivers





- *Aging assets at North American Utilities require prioritization & optimization of Capital spending*
- *Increasing Regulatory and\or Stakeholder Scrutiny*
- *Enforceable reliability requirements*

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Aspects of Asset Management

1. Equipment-Focused: assessment of assets condition vis-à-vis long-term degradation, i.e. steel core corrosion

2. Strategy-focused: decision making enablers, e.g. investment prioritization, accomplishments/performance tracking, PAS 55, Asset Management Plan

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Specific Challenges of T&D Asset Management

- Not a controlled environment: external vs equipment caused failures
- No need to perform PM for some assets
- Hard to estimate Risk Cost of failures for T&D utilities
- Difficult to establish direct impact of Asset Failures on System Performance and Reliability indices
- History of asset failures is a combination of asset condition and stresses this asset is exposed to (hard to get)

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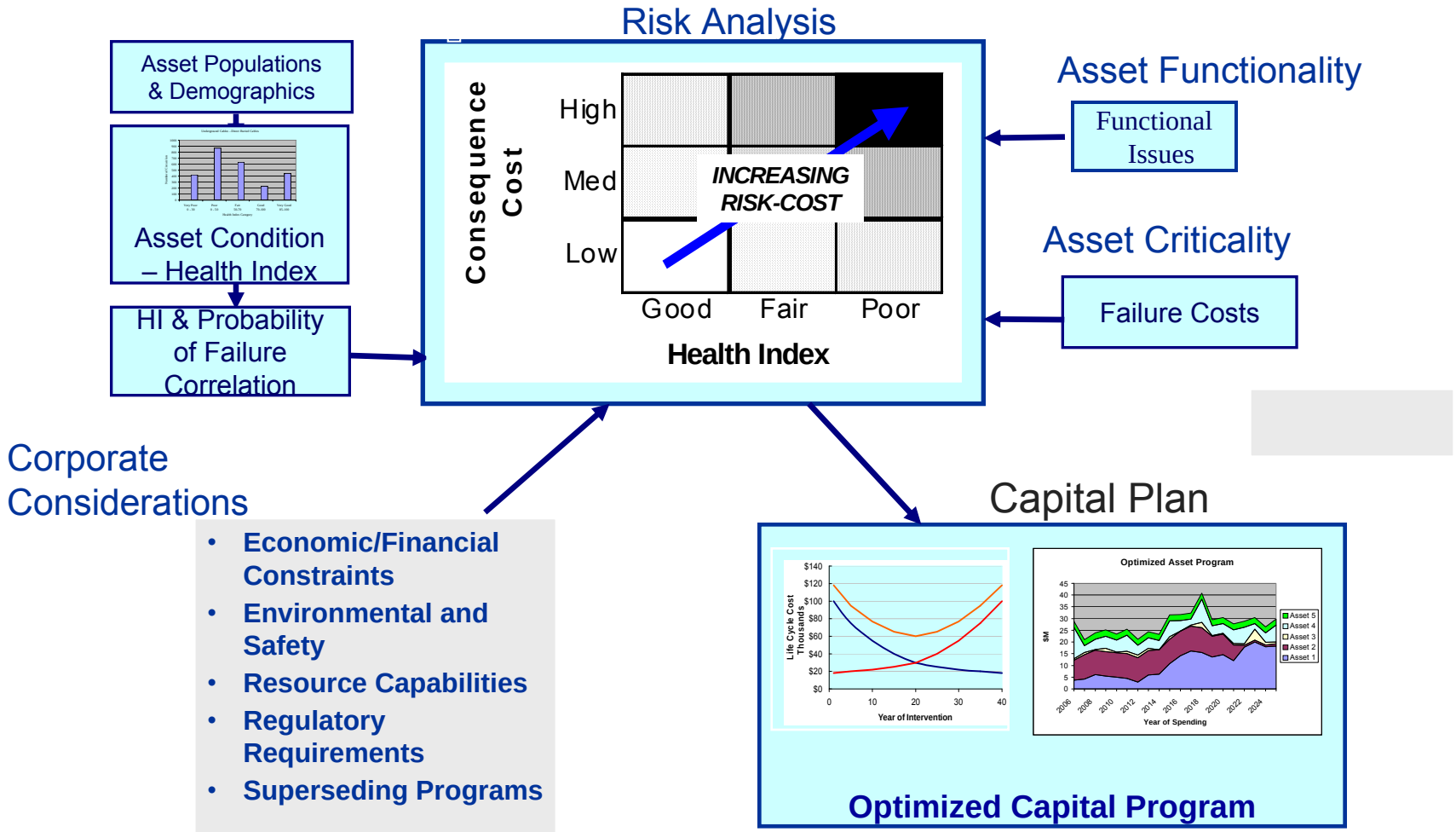
ACA & Risk Methodology Components



Functional and Corporate Considerations

- **Functional Issues**
  - **Obsolete – lack of spare parts or tech support**
  - **Functional Obsolescence (Exceeding equipment rating)**
  - **New Regulatory Standards (NERC)**

- **Corporate Issues**
  - **Economic/Financial Constraints**
  - **Environmental and Safety**
  - **Resource Capabilities**
  - **Regulatory Requirements**
  - **Superseding Programs**

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Health Index Formulation

$$HI = \frac{\sum_{m=1}^{5} \alpha_m (CPS_m \times WCP_m)}{\sum_{m=1}^{5} \alpha_m (CPS_{m.max} \times WCP_m)}$$

where

$$CPS = \frac{\sum_{n=1} \beta_n (CPF_n \times WCPF_n)}{\sum_{n=1} \beta_n (CPF_{n.max} \times WCPF_n)} \times 4$$

CPS --- Condition Parameter Score
WCP --- Weight of Condition Parameter

CPF --- Condition Parameter Factor
WCPF --- Weight of Condition Parameter Factor

α_m --- Data availability coefficient for condition parameter (=1 when data available, =0 when data unavailable)
β_n --- Data availability coefficient for condition factor (=1 when data available, =0 when data unavailable).

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Categories of Condition Data

Asset Condition data can include:

- **Age**
- **Historical and present utilization and stress**
  - loading, tension
- **Test Data**
  - unique to each component –DGA, Furan, moisture content, partial discharge, Doble, IR thermography, torsional strength, etc
- **Inspection Data**
  - corrosion, leaks, cracks, etc
- **Maintenance Program and Records**
- **Reliability Statistics, i.e. Failure and Outage Data**
- **Environmental Conditions**
- **Manufacture**
  - original quality, product performance industry wide
- **Information and opinions from client's staff**

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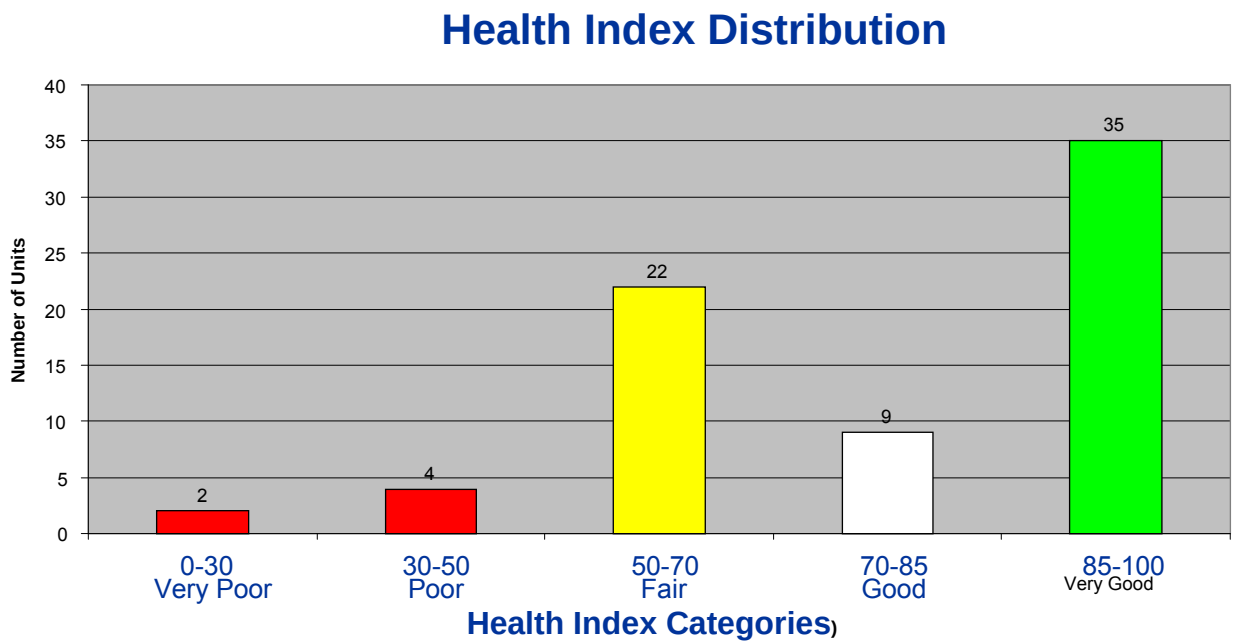
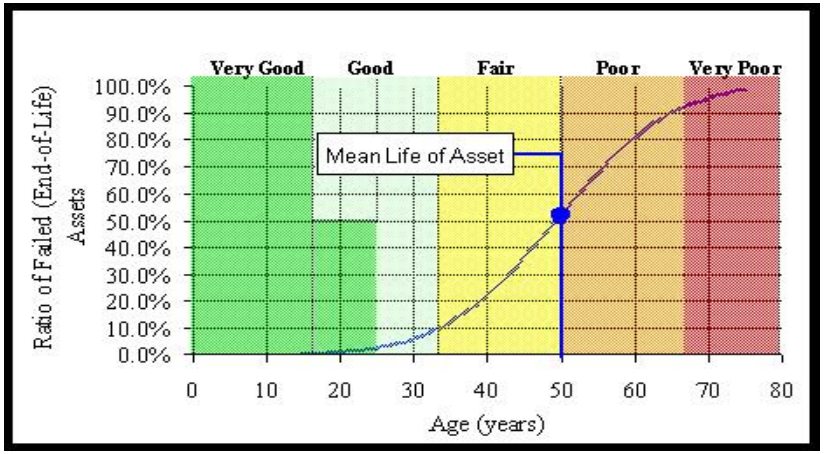
Typical Health Index Results

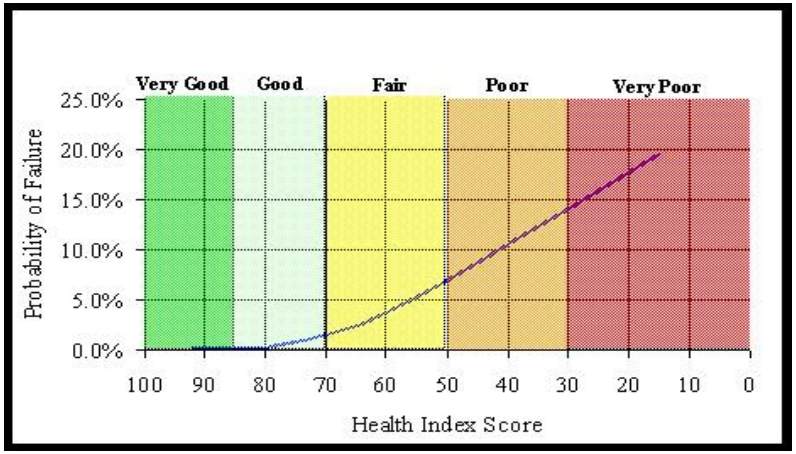


Asset Condition and Probability of Failure

Correlating Health Index results to Probability of Failure:

- ***HI Formulation Design***
- ***Estimate Effective Age***
- ***Estimate Probability of Failure***
- ***Adjust with Increasing Data***





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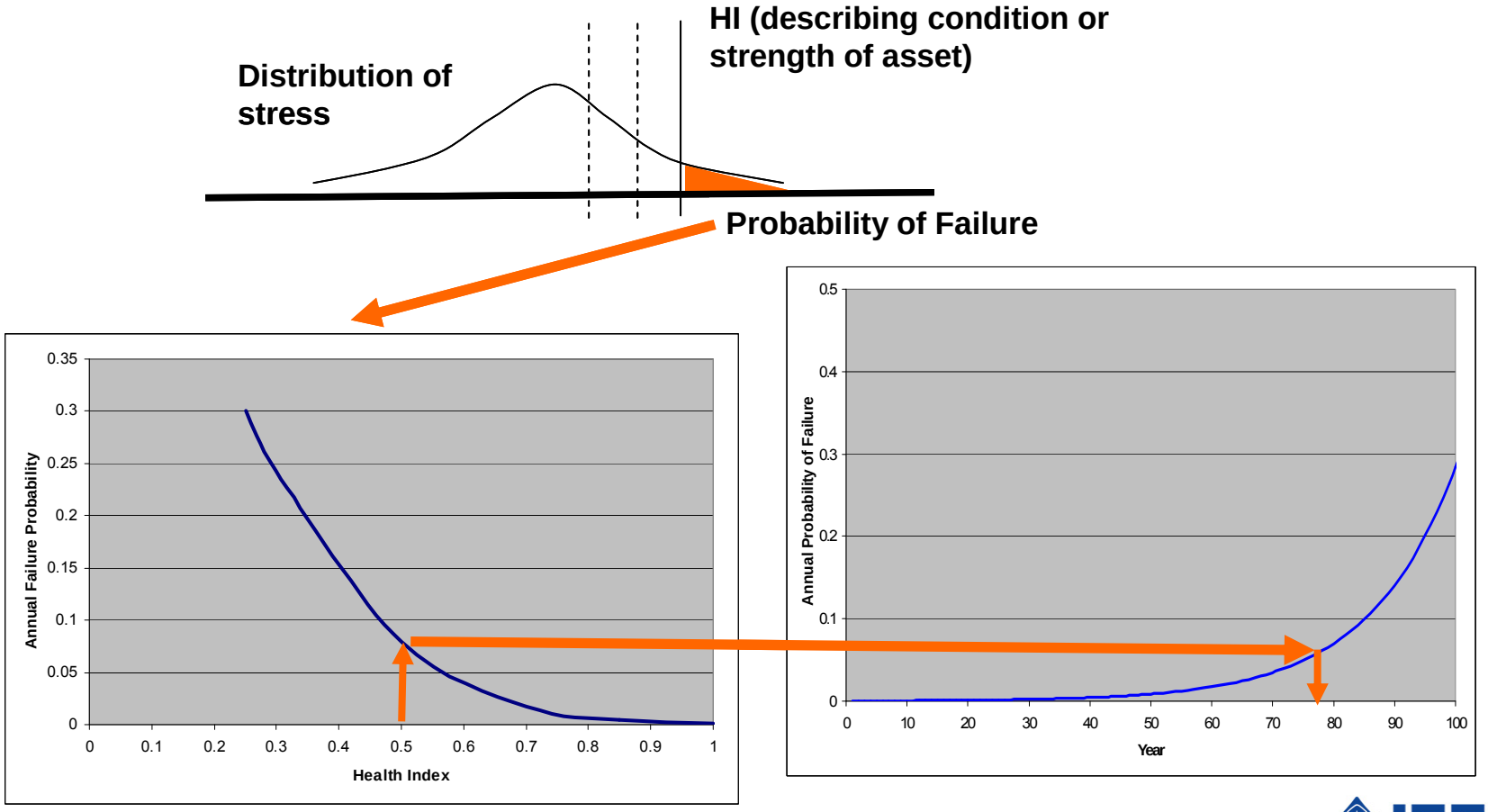
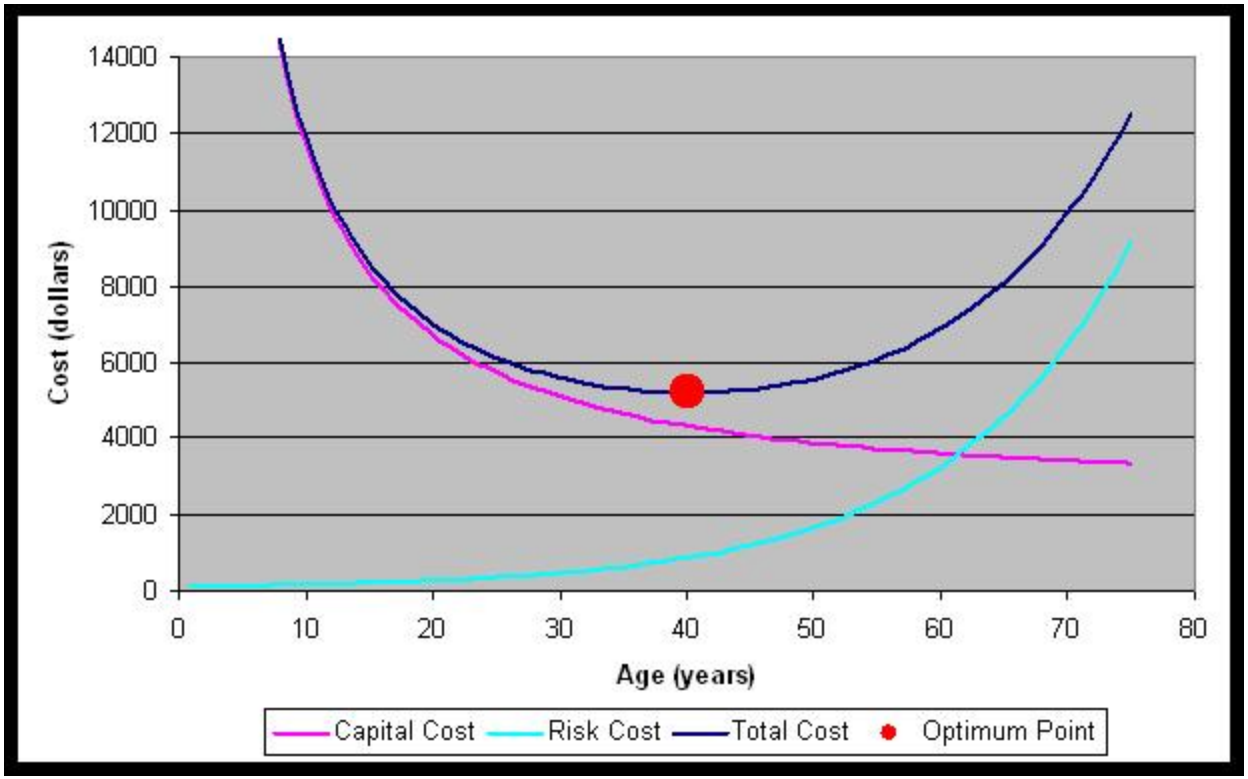
Relating Condition & Failure Probability to Effective Age & Replacement Timing

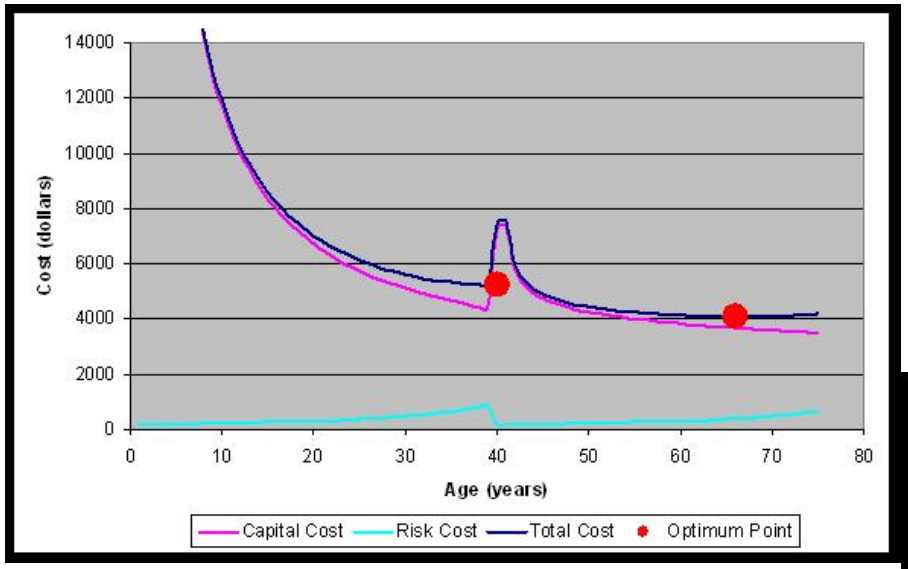
Probability of Failure includes stress and condition (strength)

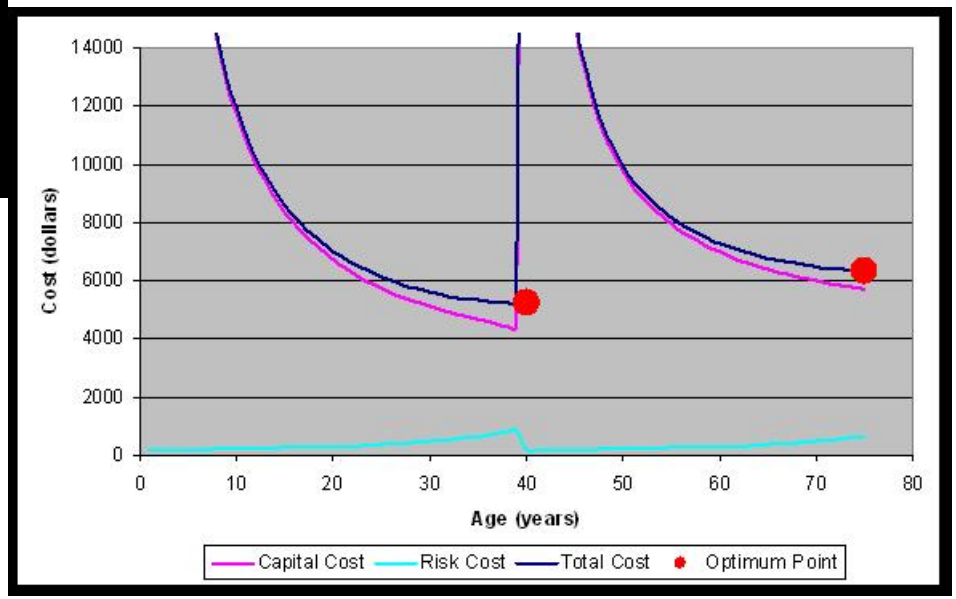


Economic End-of-Life - Replacement



Cost Effective and Non-Cost-Effective Refurbishment





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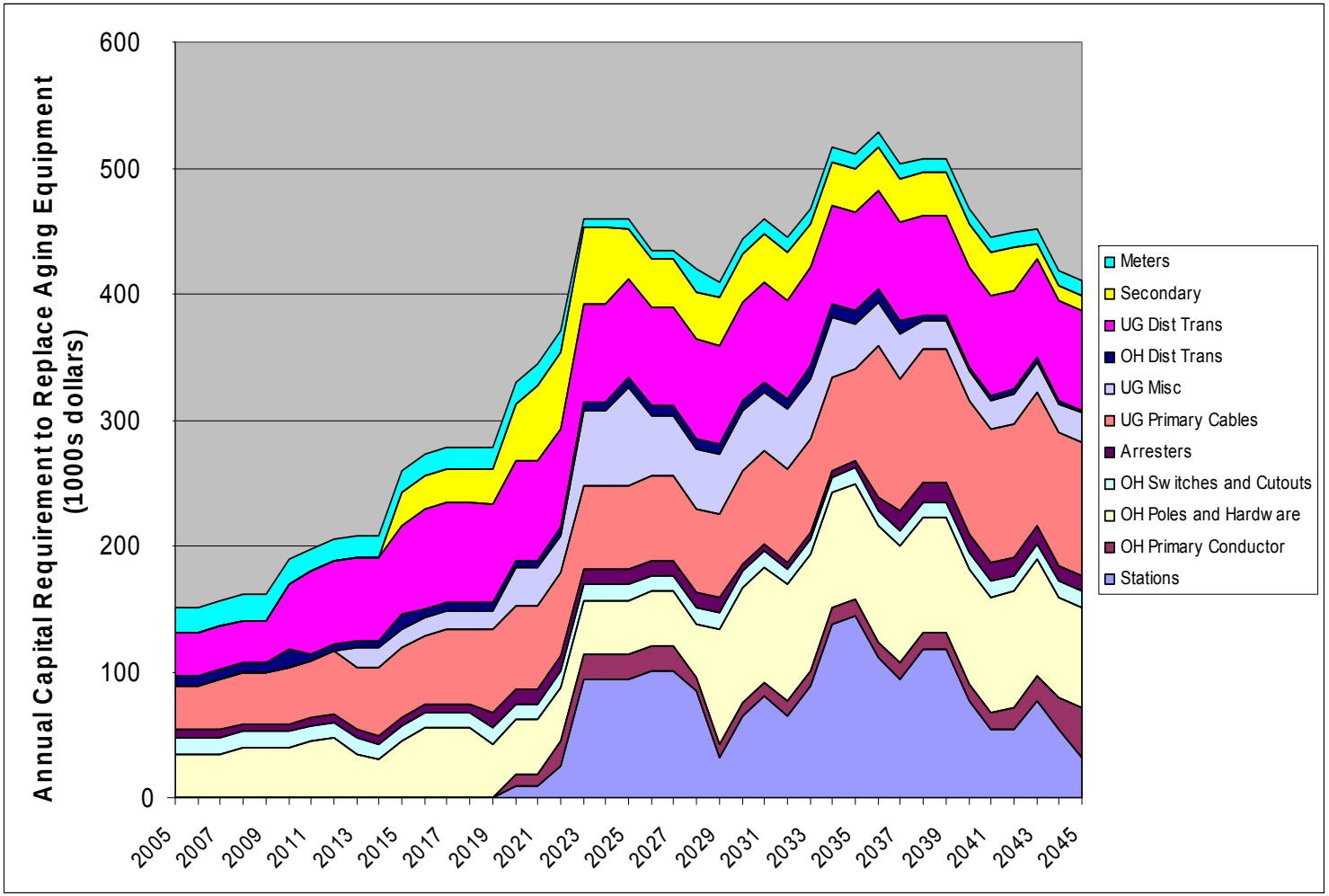
Optimized Capital Plan - Tidal Wave



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Overhead Lines Asset Categories

- Supports (Poles and Towers, including foundation)
- Conductor (including shield wire)

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Condition Parameters for Poles

- **Mechanical and Electrical Testing**
  - ✓ Pole test
  - ✓ Ground Test
- **Pole Visual Inspection**
  - ✓ Rot
  - ✓ Holes
  - ✓ Woodpeckers
  - ✓ Ants
  - ✓ Lean
  - ✓ Other Damage
- **Other Components Visual Inspection**
  - ✓ Guy wire
  - ✓ Cross-arm
  - ✓ Ground
- **Age**

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Condition Parameters for Towers

- Steel Members
- Foundation
- Age

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Non-Laboratory Conductor Condition Parameters

- **Conductor Performance**
  - Broken strands (CMs)
  - Conductor hardware problems (CMs)
  - Visual observations
- **Shield wire Performance**
  - Broken strands (CMs)
  - Shield wire hardware problems (CMs)
  - Visual observations
- **Insulators (CMs)**
  - Damage
  - Flashover
  - Contamination
- **Age**
- **Loading**
- **Outage Record**

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Laboratory Assessed Conductor Condition Parameters

- ***Conductor Testing (Corrosion and Vibration):***
  - Tension
  - Torsional Ductility
  - Remaining Zinc Galvanizing
  - Aeolian Vibration Endurance
  - Galloping Endurance
  - Accelerated Corrosion
  - Tension and Elongation at Failure
  - Wrap
- ***Shield Wire Testing (Corrosion):***
  - *Tension*
  - *Torsional Ductility*
  - *Remaining Zinc Galvanizing*
  - *Tension and Elongation at Failure Test*
- ***Splices Electrical Resistance Test***

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KEY POINTS

- Asset Management involves centralized decision making based on the TOTAL life cycle cost
- Age of Assets ≠ Asset Condition where Asset Condition is a measure of LONG-TERM degradation (not defect management)
- For Transmission Lines, asset condition should be used in estimating a PERCENTAGE of total population in poor/very poor condition rather than condition of specific individual assets
- Having TEST RESULTS is the best way to determine asset condition: lacking in most North American utilities

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QUESTIONS?

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