Accelerating Infrastructure Planning Using a Grid-wide Approach

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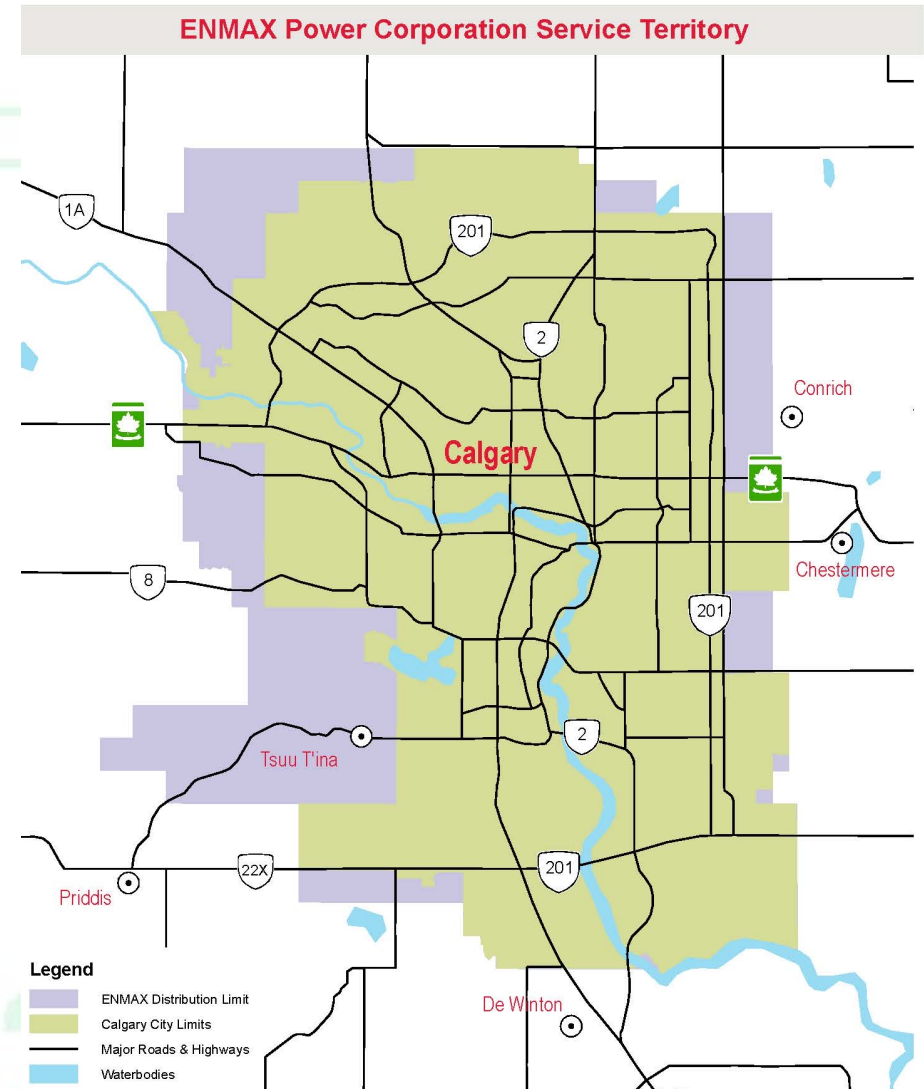Ted Zalucki, Engineered Intelligence

Agenda & Objectives

- About ENMAX and our Grid

- Motivation for Accelerating Analytics

- Overview of our 4-month Progress

- Grid Wide Insights & Benefits Gained

- Next Steps and Continuous Improvement

ENMAX Power By the Numbers

Service territory - 1089 km^2
Metered customers - 508,646
Distribution lines - 8702 km
Transmission lines - 321 km
Utility poles - 61,340
Transformers - 53,692
Substations - 43

ENMAX Power Corporation Service Territory

Legend
- ENMAX Distribution Limit
- Calgary City Limits
- Major Roads & Highways
- Waterbodies

Motivation for Accelerating Infrastructure Planning

In 2021, EPC assessed the existing process of asset analytics development. Based on the following drivers, the need to accelerate asset analytics was identified and ENGIN became part of the longer term Asset Analytics Roadmap.

Ensure that the programs executed are maximizing benefit to the ratepayers and provides better utilization of existing assets

Asset risk models are required to support the Asset Management Strategy and development of Asset Management Plans

Move towards data driven decisions to improve the quality of business cases and other information filed in future regulatory proceedings

Due to **increasing difficulty** of meeting **SAIDI** and **SAIFI** annual targets due to cable faults, additional analytics are required to support the increased replacement rate of cables.

Existing analytics methodology is **labour intensive** and requires updated data extracts for refresh of existing analytics
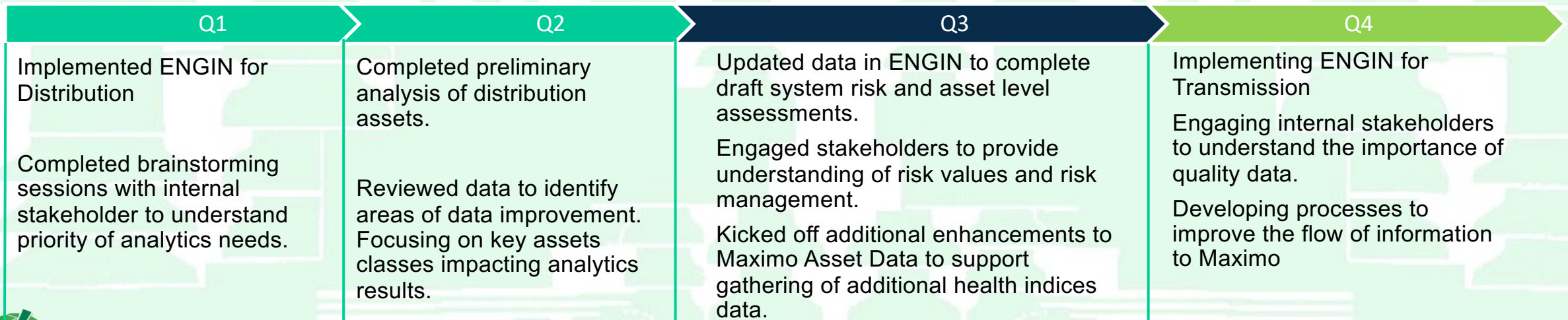
Continued **optimization of budget** due to advancements in asset analytics software
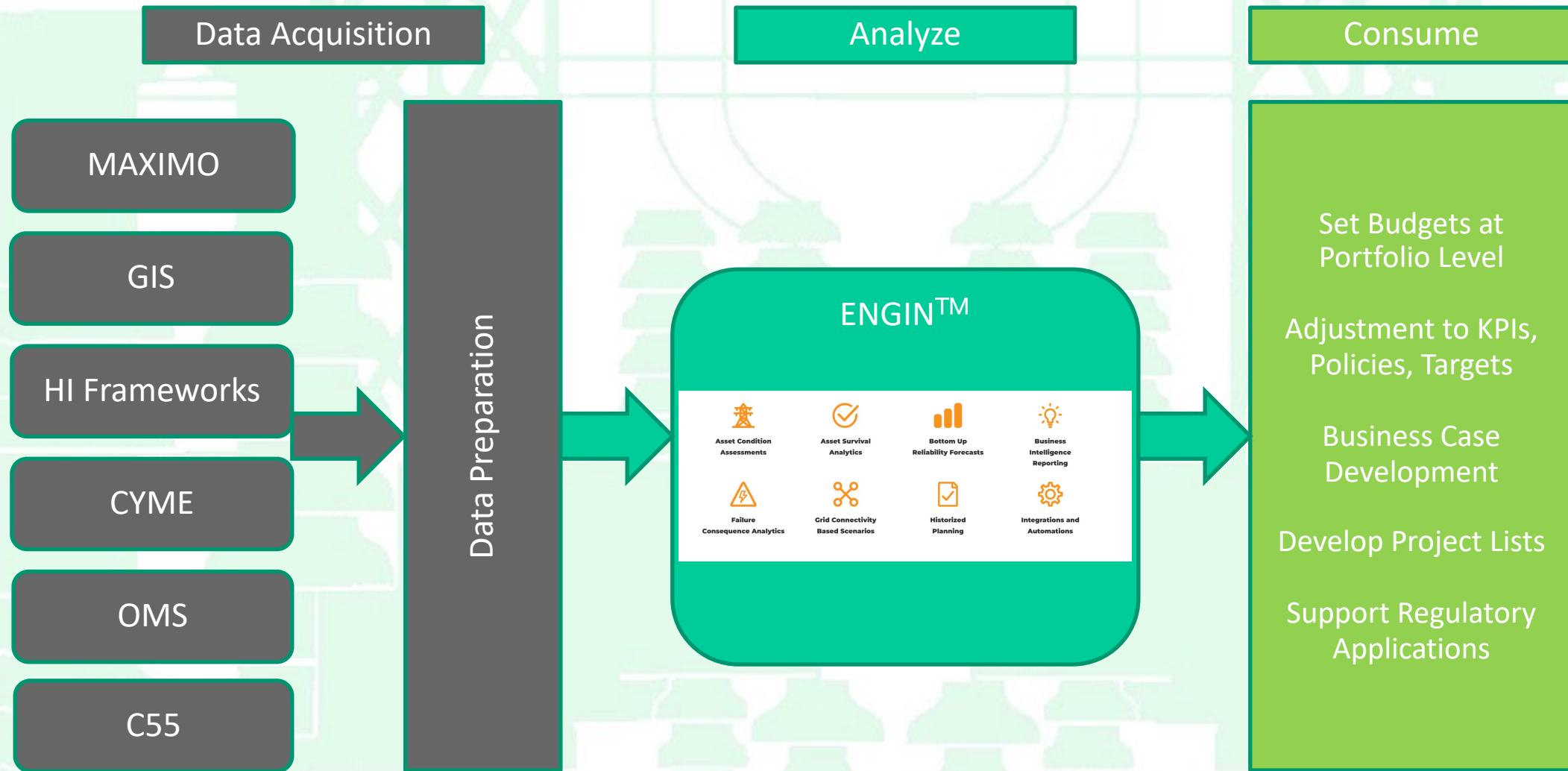
Accelerating Infrastructure Planning

- In 2020, we started examining internal data to develop analytic variables that support risk modelling:
  - Failure Curves
  - Health Indices
  - Criticality
  - Risk
- This plan would not see risk models developed until 2023.
- Although the data is still being refined, we now have draft risk models that can be compared within our Distribution System Assets

Analytics Roadmap

Q1	Q2	Q3	Q4
Implemented ENGIN for Distribution Completed brainstorming sessions with internal stakeholder to understand priority of analytics needs.	Completed preliminary analysis of distribution assets. Reviewed data to identify areas of data improvement. Focusing on key assets classes impacting analytics results.	Updated data in ENGIN to complete draft system risk and asset level assessments. Engaged stakeholders to provide understanding of risk values and risk management. Kicked off additional enhancements to Maximo Asset Data to support gathering of additional health indices data.	Implementing ENGIN for Transmission Engaging internal stakeholders to understand the importance of quality data. Developing processes to improve the flow of information to Maximo

High Level ENMAX System Components

Data Acquisition

- MAXIMO
- GIS
- HI Frameworks
- CYME
- OMS
- C55

Data Preparation

Analyze

ENGIN™

- Asset Condition Assessments
- Asset Survival Analytics
- Bottom Up Reliability Forecasts
- Business Intelligence Reporting
- Failure Consequence Analytics
- Grid Connectivity Based Scenarios
- Historized Planning
- Integrations and Automations

Consume

- Set Budgets at Portfolio Level
- Adjustment to KPIs, Policies, Targets
- Business Case Development
- Develop Project Lists
- Support Regulatory Applications

4 Month Progress: Full Distribution Network

Asset Condition Assessments

Asset Survival Analytics

Bottom Up Reliability Forecasts

Business Intelligence Reporting

Failure Consequence Analytics

Grid Connectivity Based Scenarios

Historized Planning

Integrations and Automations

Asset Classes with Full Risk Analysis

Overhead System

- Poles
- Transformers
- Conductor
- Reclosers
- Switches

Underground System

Cable
Civil: manholes, vaults,
   pedestals, tubs, pull boxes
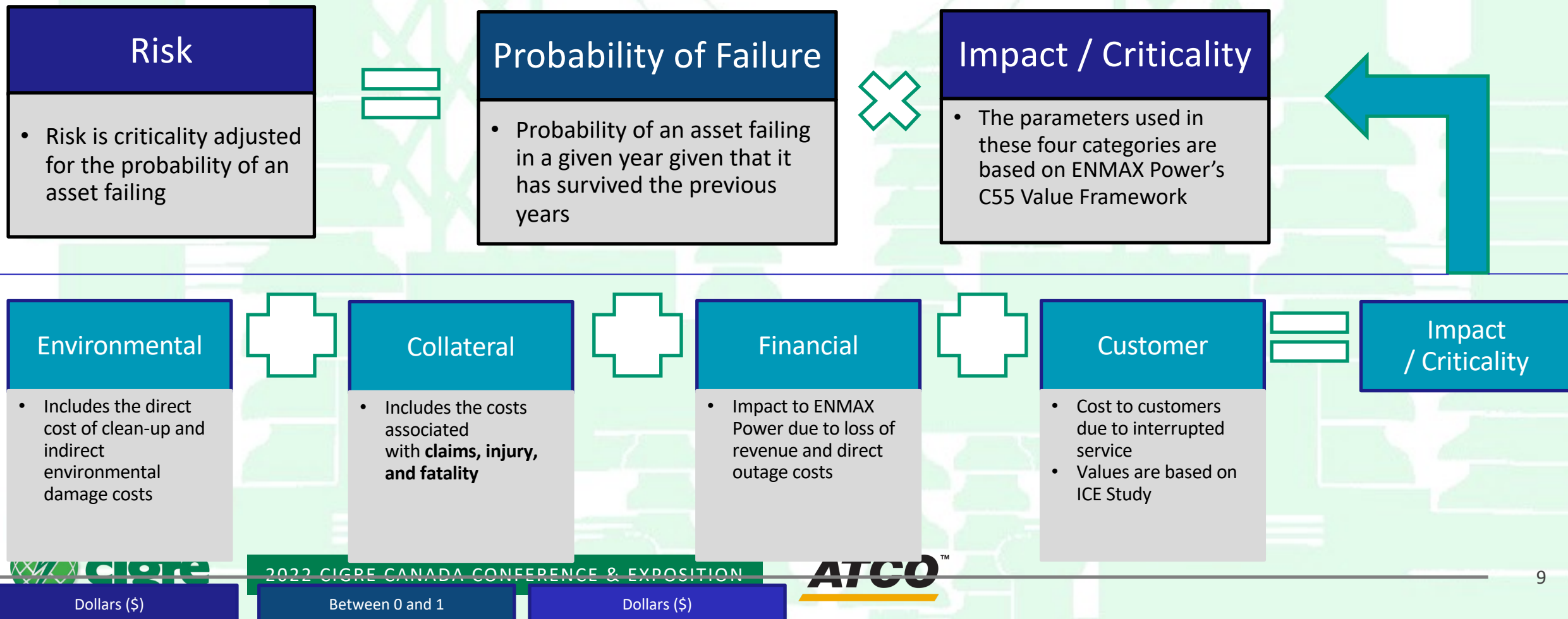Padmount switches
Padmount Transformers

Secondary Network

Network transformers
Network protectors
Cable
Vaults, manholes, tunnels

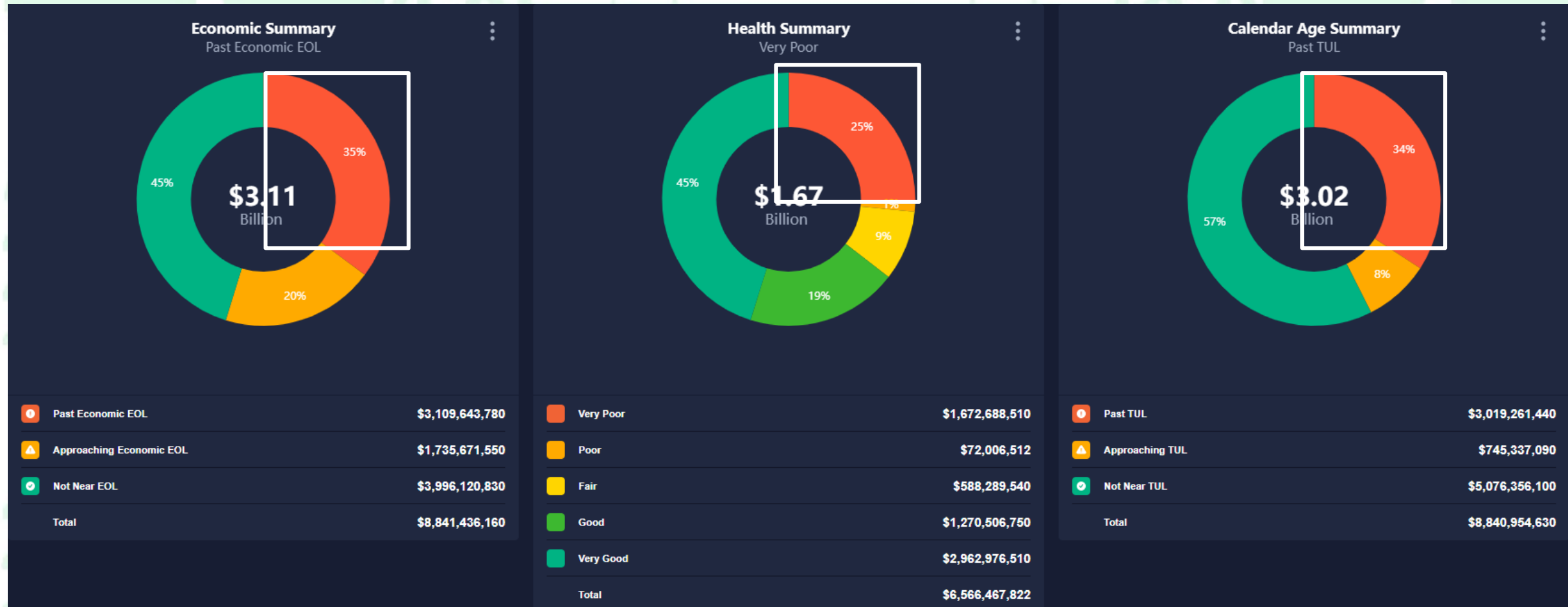| Subsystem	Asset count (#)	Replacement value ($)
O/H Distribution	200,000	$2.5B
U/G Distribution	300,000	$5.0B
Network	5,000	$250M
Civil	25,000	$1.5B

Risk Analysis

The purpose of the risk calculation is to **normalize and quantify, in dollars, the impact of an asset failing**. A high risk value, relatively, indicates the impact to customers and ENMAX Power would be higher if an asset were to fail.
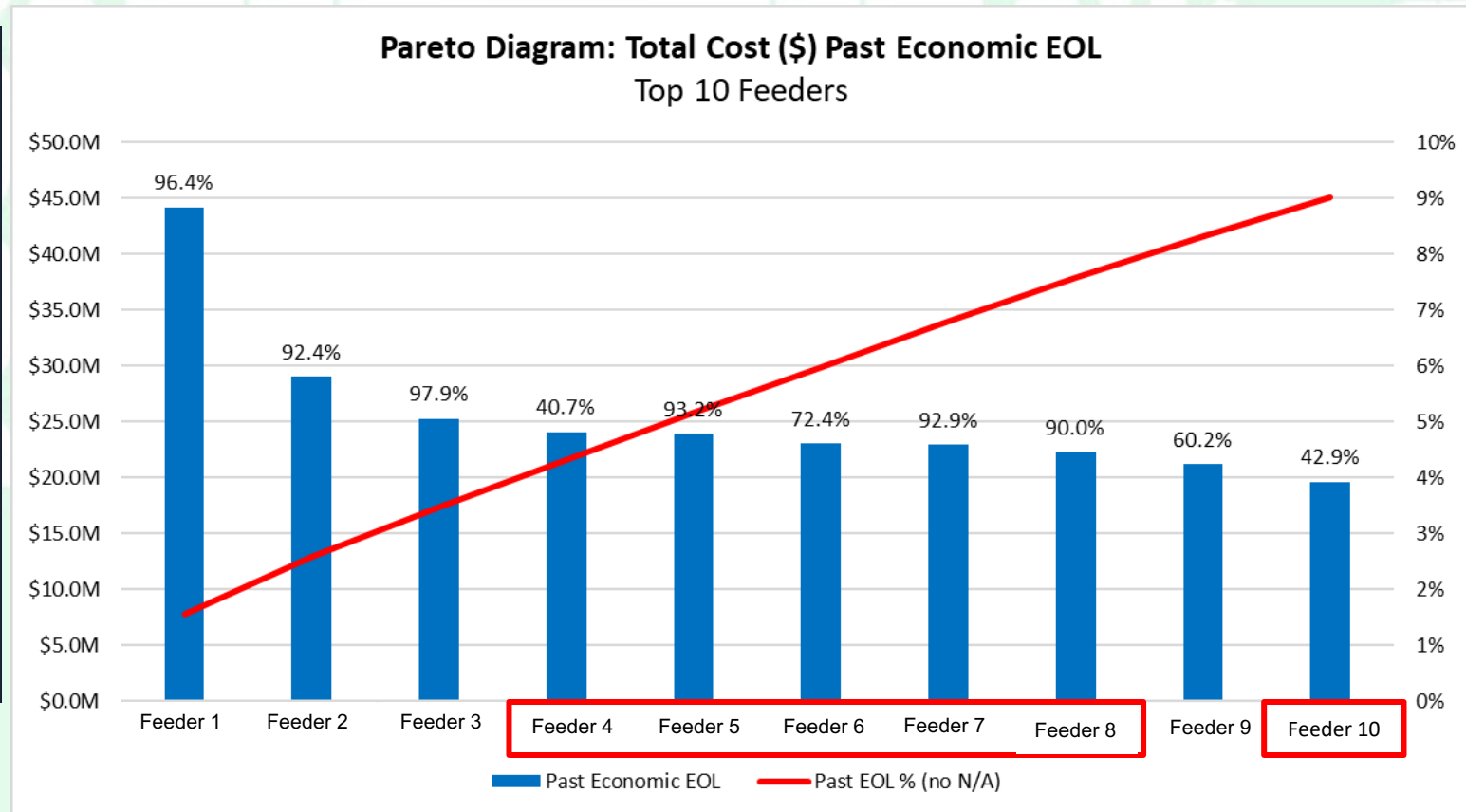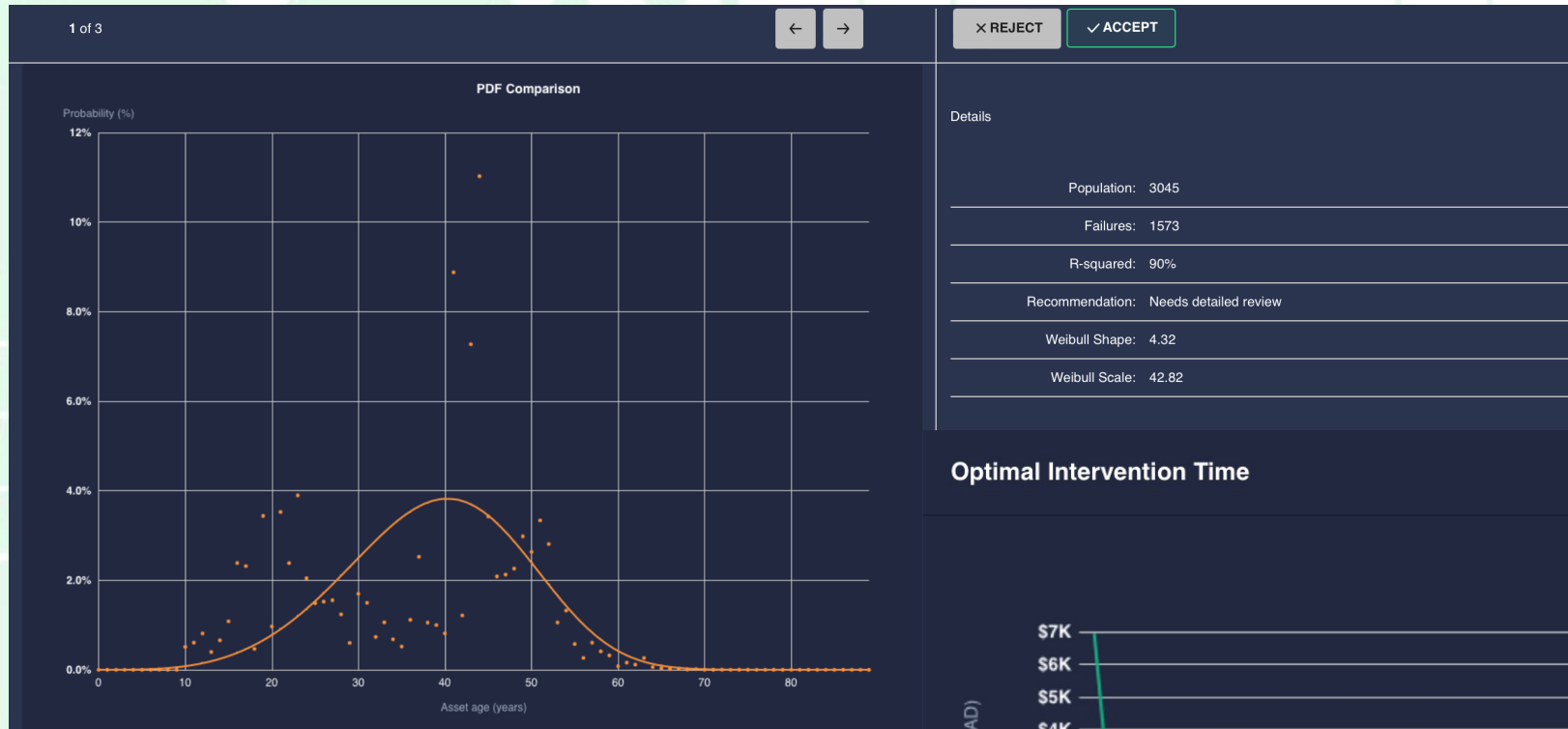
Risk

- Risk is criticality adjusted for the probability of an asset failing

=

Probability of Failure

- Probability of an asset failing in a given year given that it has survived the previous years

×

Impact / Criticality

- The parameters used in these four categories are based on ENMAX Power's C55 Value Framework

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Environmental

- Includes the direct cost of clean-up and indirect environmental damage costs

+

Collateral

- Includes the costs associated with **claims, injury, and fatality**

+

Financial

- Impact to ENMAX Power due to loss of revenue and direct outage costs

+

Customer

- Cost to customers due to interrupted service
- Values are based on ICE Study

=

Impact / Criticality

Dollars ($)	Between 0 and 1	Dollars ($)

Accelerated Insights

Economic Summary
Past Economic EOL

$3.11 Billion

45% · 35% · 20%

🔴	Past Economic EOL	$3,109,643,780
🟠	Approaching Economic EOL	$1,735,671,550
🟢	Not Near EOL	$3,996,120,830
	Total	**$8,841,436,160**

Health Summary
Very Poor

$1.67 Billion

45% · 25% · 1% · 9% · 19%

🟧	Very Poor	$1,672,688,510
🟠	Poor	$72,006,512
🟡	Fair	$588,289,540
🟢	Good	$1,270,506,750
🟩	Very Good	$2,962,976,510
	Total	**$6,566,467,822**

Calendar Age Summary
Past TUL

$3.02 Billion

57% · 34% · 8%

🔴	Past TUL	$3,019,261,440
🟠	Approaching TUL	$745,337,090
🟢	Not Near TUL	$5,076,356,100
	Total	**$8,840,954,630**

Accelerated Insights

Economic Summary
Past Economic EOL

$1.8B (20%)
$1.4B (16%)
$5.6B (64%)

$1.77 Billion

Past Economic EOL		$1,769,027,200
Approaching Economic EOL		$1,441,110,910
Not Near EOL		$5,631,599,600
Total		$8,841,737,710

Pareto Diagram: Total Cost ($) Past Economic EOL
Top 10 Feeders

96.4% 92.4% 97.9% 40.7% 93.2% 72.4% 92.9% 90.0% 60.2% 42.9%

Feeder 1, Feeder 2, Feeder 3, Feeder 4, Feeder 5, Feeder 6, Feeder 7, Feeder 8, Feeder 9, Feeder 10

Past Economic EOL — Past EOL % (no N/A)

Accelerated Insights

Accelerated Insights

Risk Costs Projection (Scenario Comparison)

Legend: ■ Baseline Scenario ■ Current Spend ■ Double Spend

Y-axis: Risk in Billions ($)

Year	Baseline Scenario	Current Spend	Double Spend
Year 0	$0.95	$0.80	$0.70
Year 1	$1.60	$1.40	$1.30
Year 2	$2.30	$2.10	$1.90
Year 3	$3.00	$2.70	$2.50
Year 4	$3.70	$3.20	$2.90
Year 5	$4.40	$3.70	$3.50
Year 6	$5.00	$4.40	$3.90
Year 7	$5.70	$5.00	$4.40
Year 8	$6.30	$5.50	$5.00
Year 9	$6.90	$6.10	$5.30

Value Realized

Within the Asset Performance Analytics Team, ENGIN has improved the asset analytics output, direction and data improvements the team is accountable for. With regards to support of internal stakeholders, ENGIN analysis has been leveraged in immediate asks to support asset prioritization and to improve long term Asset Management strategy

Customer Value & Impact

Leveraging the analysis to better support customers, we were able to prioritize asset replacements and predict number of customer outage minutes saved due to an equipment replacement. Furthermore, by examining economic of life, we could leverage this value to understand which replacement year would result in the lowest cost to the taxpayer.

Improved Team Productivity

Since implementation of ENGIN, majority of effort is spent on improving data quality wholistically and analyzing data to support Capital, Maintenance and System Operations Teams. In the past, this time would have been spent on developing analytics metrics in Excel sheets and addressing data issues one asset at a time.

Accelerated Asset Level & System Level Analysis

Analysis has been leveraged to justify asset replacements by analyzing risk for specific assets class, contribution to SAIDI and SAIFI and risk in comparison to other assets classes.
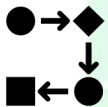
Asset Management Strategy & Process Improvements

The development of risk models are a key component in developing Asset Management Plans. This information is leveraged in Civil AMP development.
To streamline analytics to support capital planning schedule, process maps and RASCI were developed to streamline and support to ensure usability and applicability of the risk analysis.

Asset Risk Enhancements

In addition to using risk for draft asset level analysis, system level risk discussions were held. This is a significant step in discussions around risk mitigation, risk tolerance and risk spend efficiency for improving asset strategies.

Advanced Data Quality

With the preliminary insights, we have focused efforts on improving asset age information and initiated projects to improve tracking of cable assets information that can be imported into ENGIN

Use Case Examples

1 — Cable Replacements

Use Case: Ranking UG cable to determine 6km to replace

Application: To support additional cable replacements for 2023

Outcome: Recommendation will be used to prioritize replacement of 6km of cable for design and engineering to start in Q4

2 — Cable Burial Method Comparison

Use Case: Comparing direct buried and in-duct secondary cables

Application: Used to choose installation method for a cable replacement project

Outcome: Used Total Cost of Ownership (TCO) as metric and duct was selected as installation method due to lower TCO

3 — Conductor Comparison

Use Case: Comparing risk of 336 Poly to #4 conductor

Application: Validation of whether existing #4 replacement program should be changed

Outcome: Results show that #4 carries about 3x as much risk per m as 336 Poly, confirming the #4 replacement program is valid

4 — Network Transformer Prioritization

Use Case: Ranking network transformers for replacement

Application: To support network transformer replacement plan for 2024 capital scope

Outcome: Ranked network transformers by risk, including a risk adder for any transformers that had a hazard attached

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The Data Journey

- Continuous improvement: initial data gathering and load into ENGIN has identified areas for future improvements

  - Data is living: ENMAX now has a data framework and understanding of how input data influences different outputs

  - Next step: detailed analysis and testing of results, refine data

  - Next step: targeted data improvements to support AM use cases

  - **Updated failure curves for U/G Cable assets**

Active	Default	Name of Study	Data Snapshot	Study Run Time	Run Duration	Status	Label	
		Name of Study	Data Snapshot	Study Run Time	Run Duration	Status	Label	
⏻	○	Automated study run	9	2022-03-15 09:13 PM	29:1	Complete	Insights set 1: original	⋮
⏻	◉	Automated study run	7	2022-03-15 07:39 PM	33:12	Complete	Insights set 2: updated cable curves	⋮

2022 CIGRE CANADA CONFERENCE & EXPOSITION

Next Steps

Kicked off Transmission Network expansion, mirroring and connecting analysis and kicking off another 4-month sprint

Automating Load Forecasting and creating dynamic load at risk model

Adding Digital Twin and online DGA sensor analysis

Automation of all data pipelines – Copperleaf, Maximo, ESRI…

Exploring other use cases on the same framework