Novel Use of Existing Data for Smart Grid Preliminary Analysis and for Asset Optimization

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The forum for electrical innovations

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Introduction

- National Grid has a Smart Grid pilot underway which we desire to measure its contribution to baseline performance.
- As part of this effort this analysis quantifies the impact of I^2t on transformer longevity and the value of various mitigation techniques.
- The availability of ratio transformer asset data (over 14,500 step up or step down transformers on 1,387 feeders) and 10 years of reliability data created a unique opportunity to test this premise before expanding it to other equipment.
- Several disparate databases were interconnected in a traceable relational database that used GIS information in a novel way to elicit new information from existing data.

Introduction

- Three methods to deal with cumulative through-fault energy are evaluated:
  - reducing the number of reclose attempts
  - early targeted replacement of ratio transformers upon reaching a certain level of accumulated I^2t
  - using PulseClosing technology

Data Used for Analysis

Reliability data

- number of events,
- GIS ID for the fault location or line protective device location,
- feeder number,
- event date,
- cause for the fault (and flag transformer failure and date)

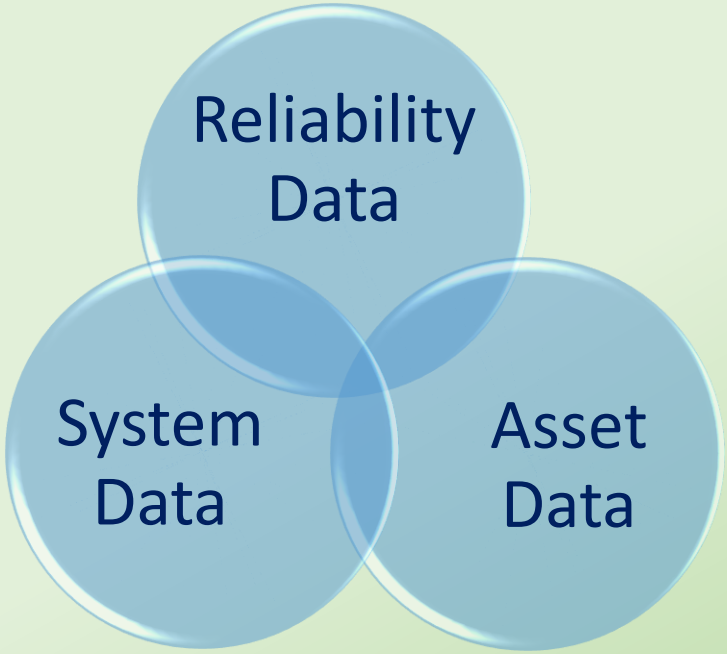
Asset data

- GIS equipment ID,
- GIS feeder segment ID, length, and upstream line segment GIS ID,
- feeder number,
- ratio transformer kVA size, winding configuration, high and low side nominal voltage, and installation date.

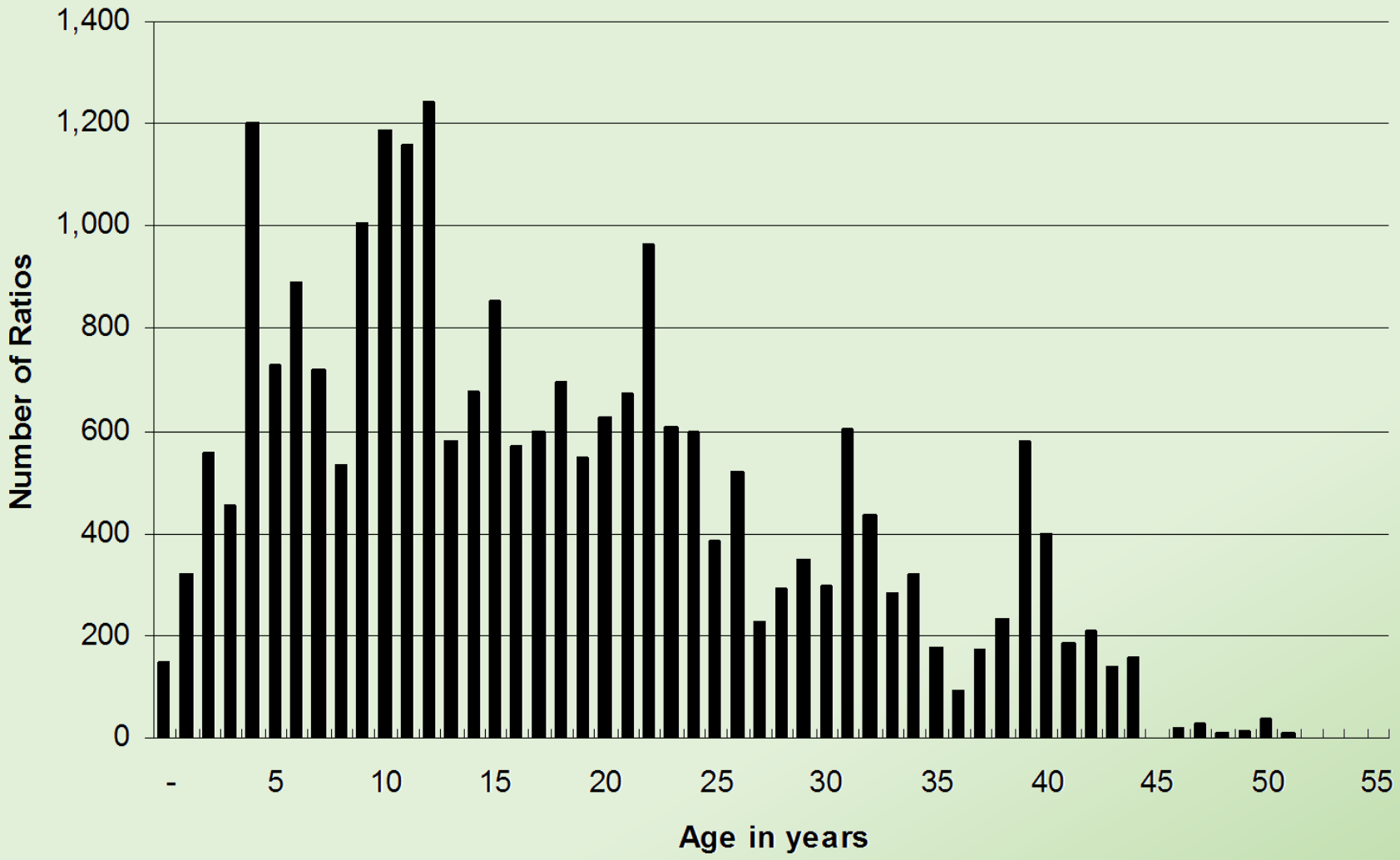
Transformers with missing data were omitted from this analysis.

System data

- substation low side bus fault current was adjusted for each fault to account for distribution feeder impedance impacts on fault current

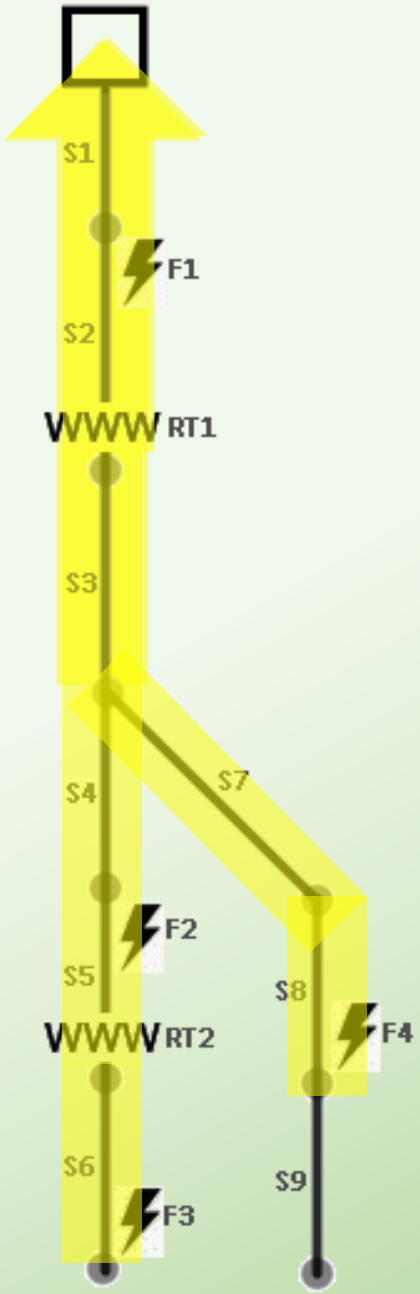


Ratio transformer age profile



Illustrative one-line & fault tracing process

For every interruption recorded, an upstream trace was initiated at the fault location or when not known then at the protective device primary feeder segment.



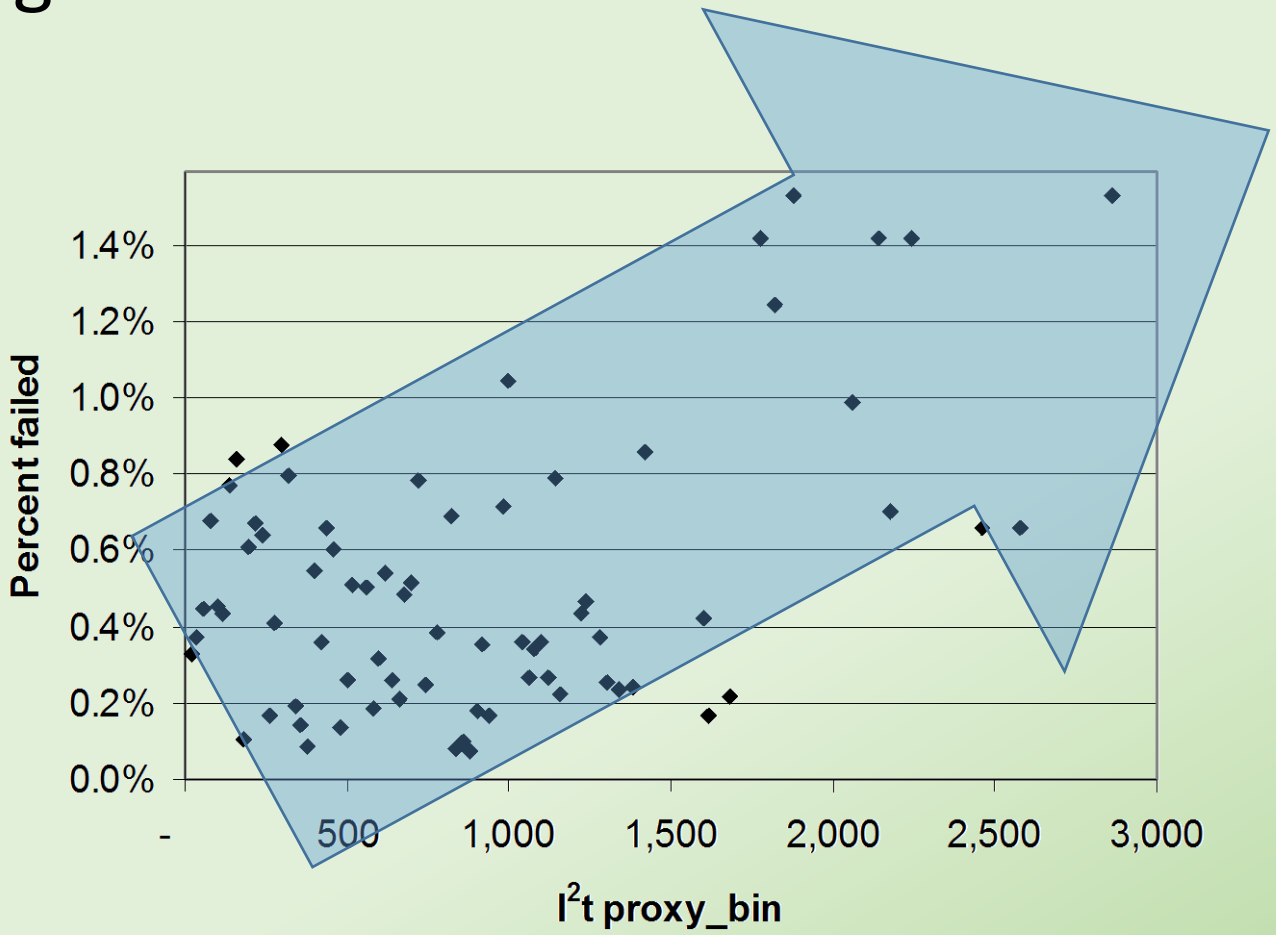
Analysis of possible failure trends

- The data was reviewed searching for possible trends due to:
  - Age
  - Winding configuration
  - Nominal voltage
  - Number of fault events experienced by a transformer

No discernable patterns emerged.

Analysis of possible trends

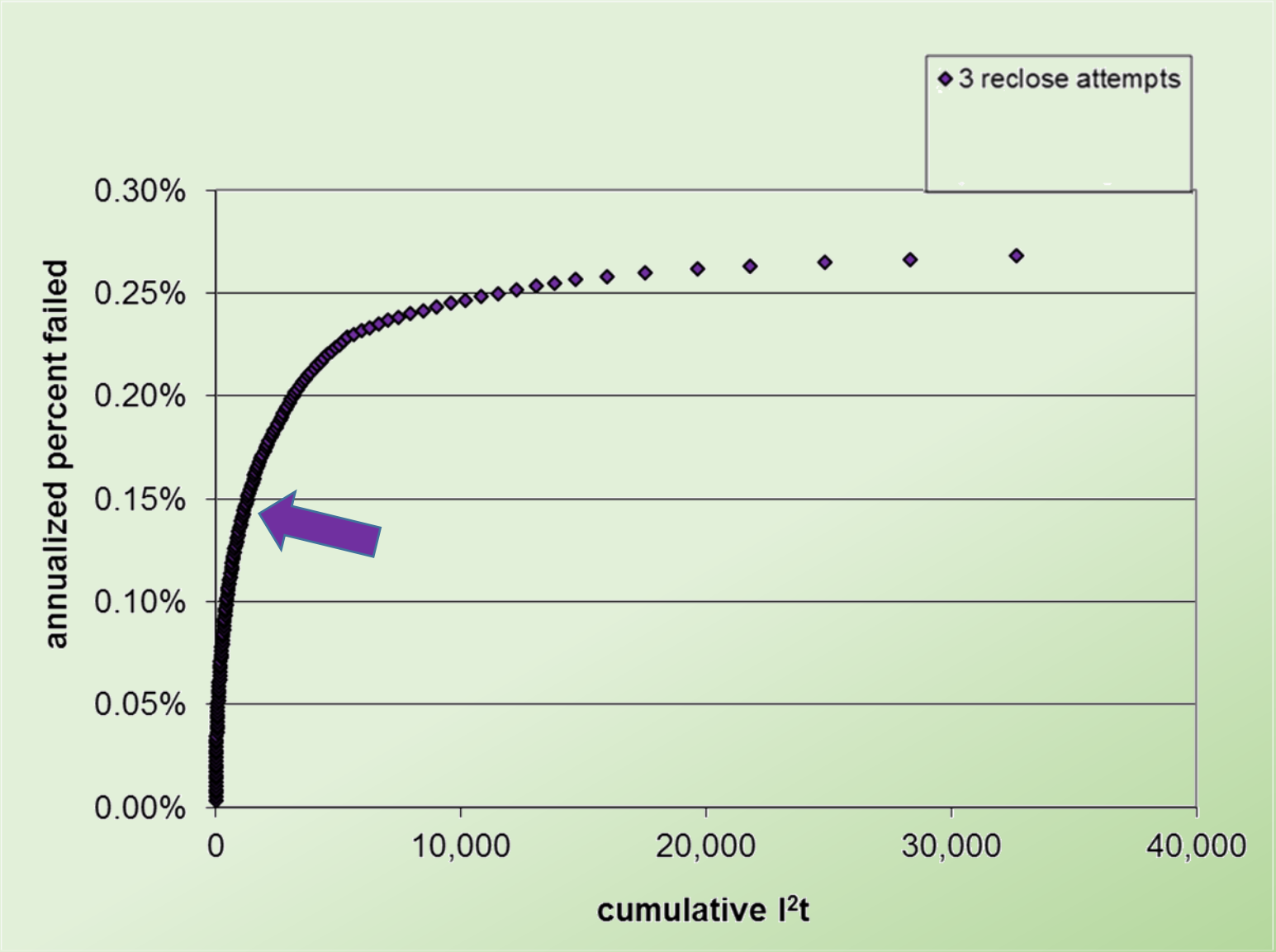
- A discernable pattern for failures correlated to I^2t emerged.



I^2t mitigation comparison

Value of Early Replacement

- Replacing transformer at a specific I^2t reduces risk of failure
- but discards useful remaining life and thus adds cost
- Invites regulatory inquiry on investment base



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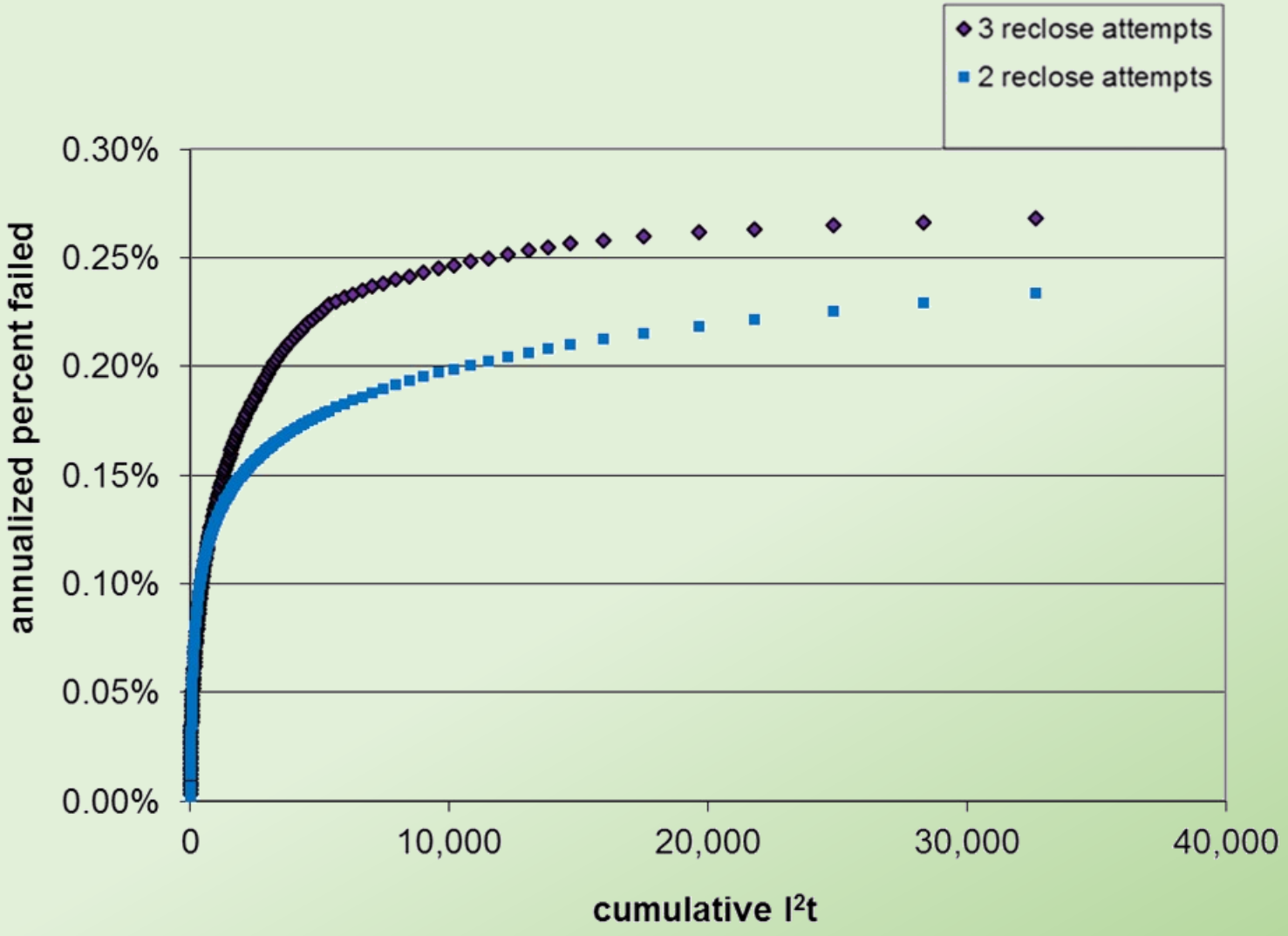
Value of Reducing the Number of Reclose Attempts

- Reduces failure risk
- Increases SAIDI and CAIDI by increasing customers impacted



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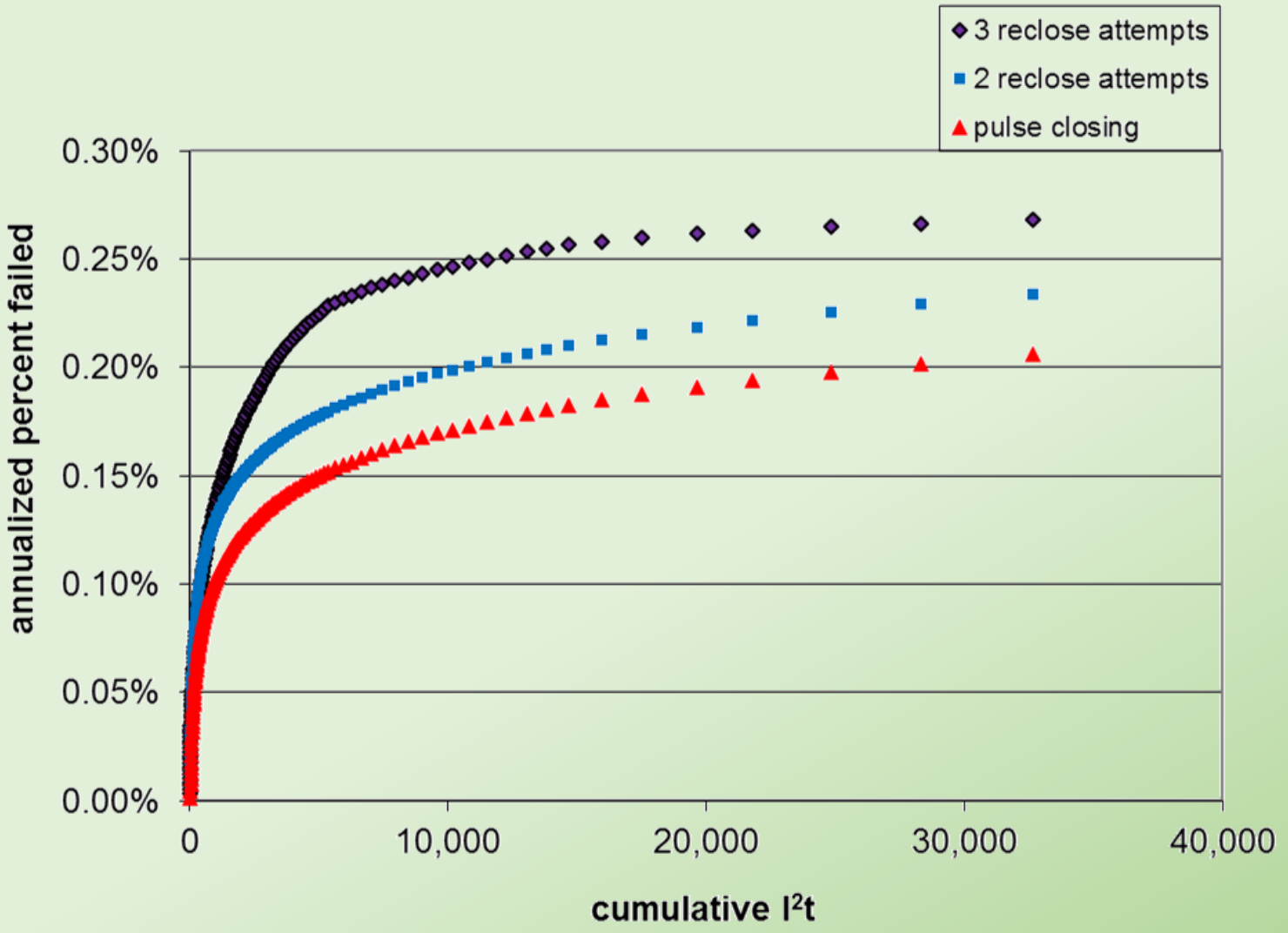
Value of PulseClosing

- Eliminates I^2t for all retries thus decreasing failure risk
- Allows capture of full useful equipment life
- Allows more retries to improve SAIDI and CAIDI without further detrimental I^2t accumulation



Next Steps

- The relational connectivity model and tracing routine will be enhanced for calculating precise impedance and fault current for each feeder segment.
- In future this analysis will also be expanded to include substation transformers.
- This analysis with next step improvement added will be used in bench marking National Grid's Smart Grid pilot and in further analysis and asset management.
- Due to the sparse nature of the historical data, National Grid believes there is an opportunity for the industry to cooperate in a collective pooling of data in a confidential manner. If companies are interested in such collaboration please let us know.

Conclusion

- Several disparate databases were interconnected in a traceable relational database that used GIS information in a novel way which created new information from existing data.
- Results show that cumulative I^2t for each ratio transformer can be used to quantify and predict failure risk.
- This result can now be used for asset optimization by flagging devices for maintenance, early replacement, or to change reclosing strategy based on value to the customer in terms of equipment cost versus change in reliability.
- As an alternative, devices with PulseClosing technology can be used, retaining reliability performance and improving equipment life. The value of this mitigation method can now be quantified.

Questions?

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PulseClosing

- Uses a very fast point-on-wave close-open operation (3-8msec) to test line for fault
- Doesn’t stress or damage the power system equipment
- Doesn’t cause voltage sags for up-line customers
- Device stays open or recloses depending whether the test detects a fault