



The Value of Customer Reliability to the Utility

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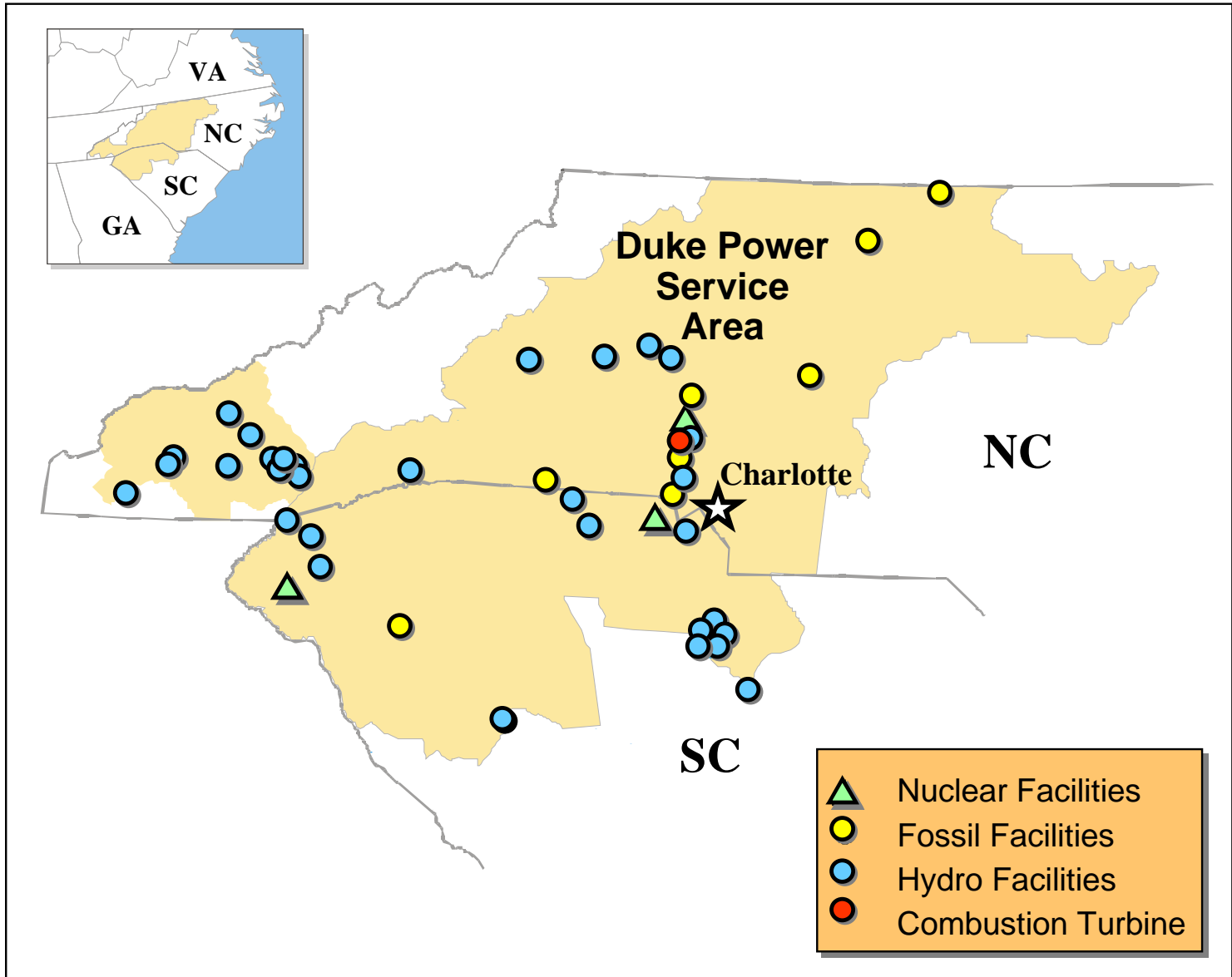
Presentation to IEEE Working Group
on Distribution Reliability

June 20, 2006
Montreal Canada

Overview

- **Service area:** 22,000 square miles in North Carolina and South Carolina
- **Customers:** Approximately 2.3 million customers
- **Employees:** 10,300
- **Generation:**
 - 8 coal-fired stations
 - 3 nuclear stations
 - 31 hydroelectric stations
 - Numerous combustion turbine units
- **System Capacity:** 19,300 megawatts
- **Transmission:** 12,700 miles
- **Distribution:** Approximately 69,900 miles

Service Area



2001 - The Value of Reliability

- NOT – The value of reliability to customers.
- INSTEAD – The value of customer reliability *to the utility*.
- SOMETIMES – The value of customer reliability *mandated by the utilities commission*.
- This definition is not the product of a think tank or a philosophical analysis. It is a part of history.

2001 – Sectionalization – The discovery of reliability value.

Five year project to improve reliability by optimizing the location of protective devices on all circuits.

We projected to have a successful result because of the following:



- Expertise in probabilistic analysis
- Projected a reasonable unit cost per circuit
- Projected overall SAIDI reduction good
- Project specifications and design rules were established
- Engineers were receiving training
- Project assessment in place
- Strategic approach

Problems arise during first year

- 2001 unit cost per circuit excessive
- Assessments show protective device placement varies from engineer to engineer.

Two Stories about the problem.

- The 8% rule.
- Terri's dilemma.

The 8 Percent Rule.

The distribution manual said that if you can add a line recloser and improve reliability on a circuit by 8%, it is justified.

Taylorsville circuit sectionalization assessment completed.

The 8% rule has been ignored by the engineers.

Why??

Terri's Dilemma

Terri: “I have 2 circuits. One has 1,000 customers on it and the other has 2,000 customers on it. I have 4 sets of line reclosers available.

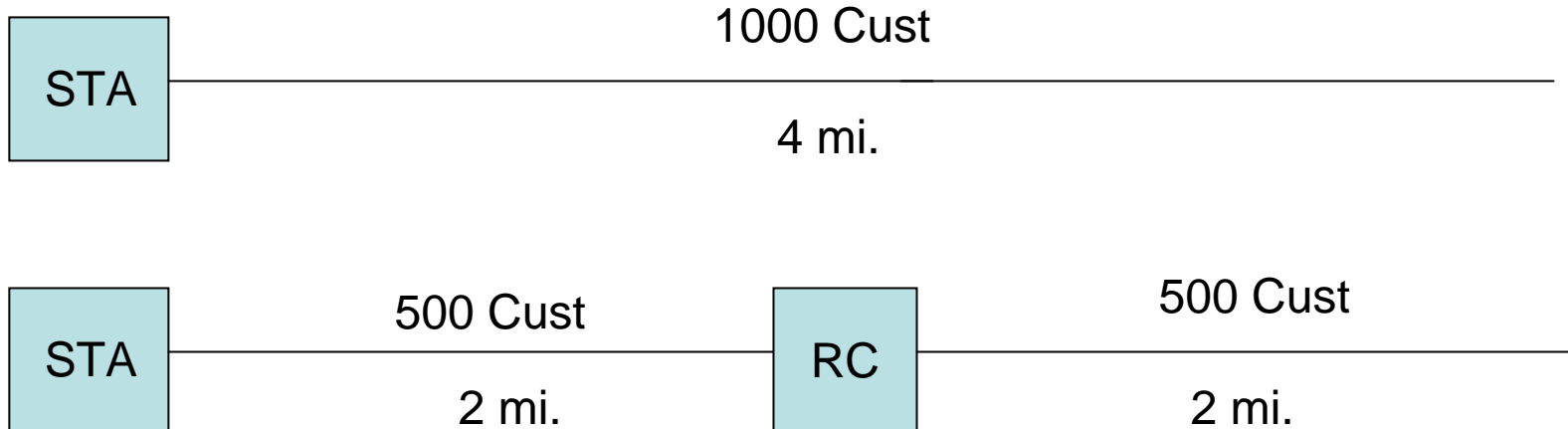
“How many line reclosers should go on one circuit and how many on the other?”

Lee: “It depends.”

Terri: “It depends on what?”

Lee: “I need some time to think.”

Reliability Value of Additional Line Recloser

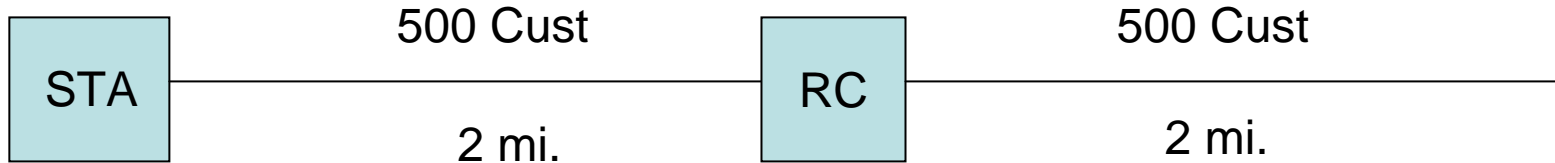


What does reliability value depend on?

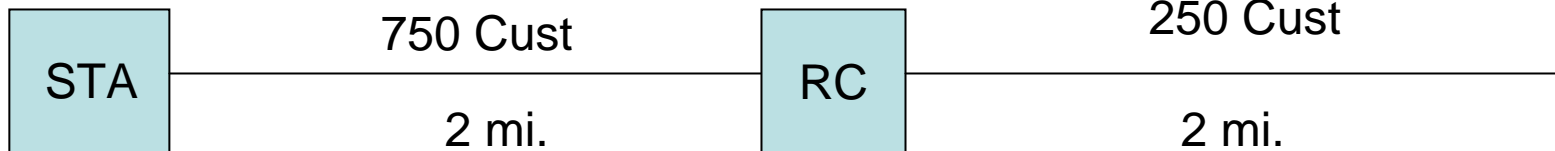
Customers upstream = 500 units

Faults downstream = 2 units

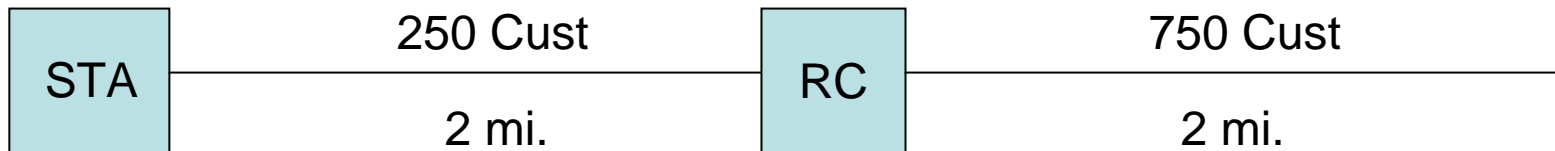
Reliability Value = Customers Upstream x Line Miles Downstream



RV = 1000



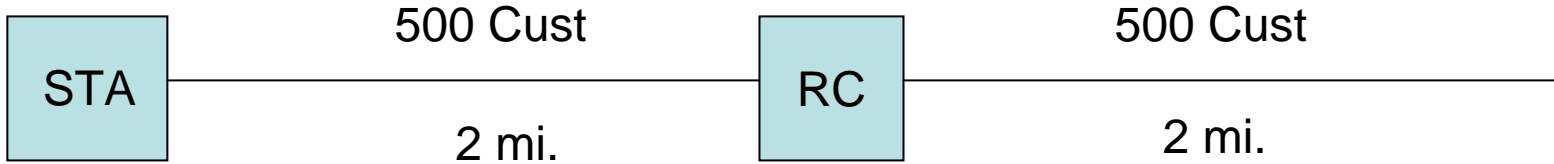
RV = 1500



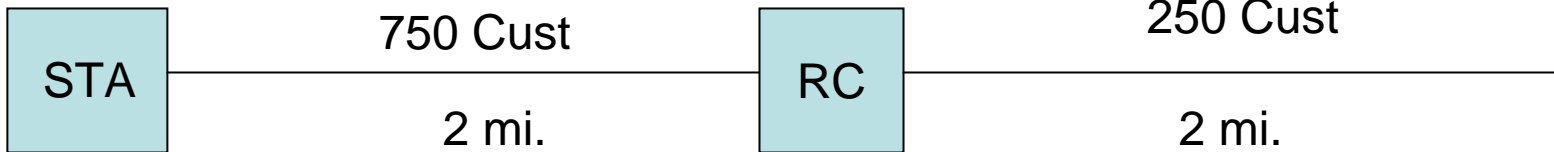
RV = 500

Experienced engineers could identify which reclosers were justified.

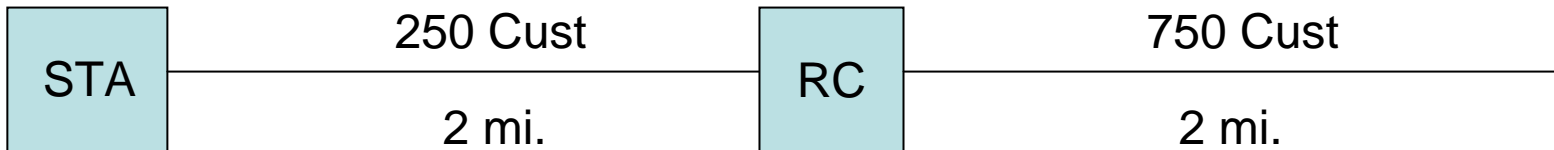
Reliability Budget = Customers Upstream x Line Miles Downstream x \$10



Reliability Budget = \$10,000



Reliability Budget = \$15,000



Reliability Budget = \$5,000

Sectionalization Project Saved

- Engineers now had a very precise way to determine if an additional protective device was justified from a cost standpoint.
- Reclosers in poor locations were moved to more favorable locations, improving reliability.
- Unit cost dropped dramatically.
- Began receiving requests to expand this methodology to other reliability projects.

2004

- Transmission and Distribution (T&D) combined into Power Delivery.
- It became necessary to find a way to evaluate asset management projects across the entire spectrum of T&D.
- The “Reliability Valuation” methodology pioneered in the sectionalization project was evaluated.

It was necessary to convert the special formula to a more general form.

Reliability Value = Customers Upstream x Miles Downstream x \$10

Reliability Value = Cust x miles x (\$10)

Reliability Value = Cust x miles x (0.2 faults per mile x unit cost)

Therefore, Unit Cost = \$50 [The unit cost justified to prevent one customer outage per year.]

Reliability Value = CE x P x \$50



where CE = Customer Equivalents

and P = Probability of Outage Equivalent per year

Customer Equivalent

Outage Equivalent

NPV Equivalent

Value of Reliability

- The objective was to quantify the value of avoided “customer equivalent outages.”
- An “**outage equivalent**” is a power disturbance that causes the customer to experience a problem equivalent to a sustained interruption.
- A “**customer equivalent**” is a measure that places both large and small customers on equal footing.
- Commonly used industry measures do not allow T&D customers to be fairly represented. Also, these indices do not include the entire spectrum of disturbances.

Power Disturbances that cause “Customer Outages”



- Sustained interruptions
- Momentary interruptions
- Voltage sags
- Switching transients
- Flicker
- Harmonics
- Other

Interruptions caused by Animal and Bad Arrester Faults

Sustained Interruptions – Tap Fuses

10 Cust

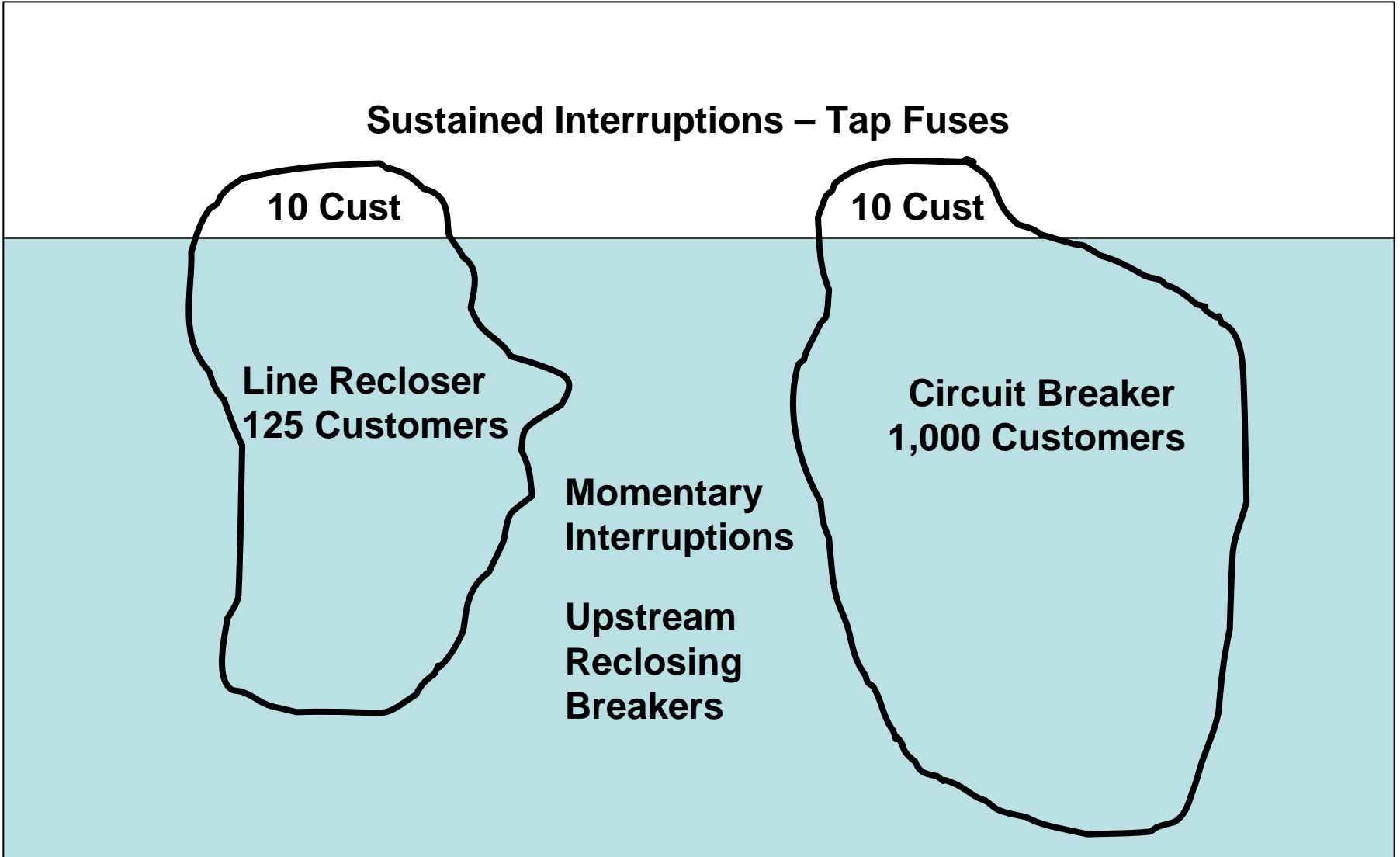
Line Recloser
125 Customers

10 Cust

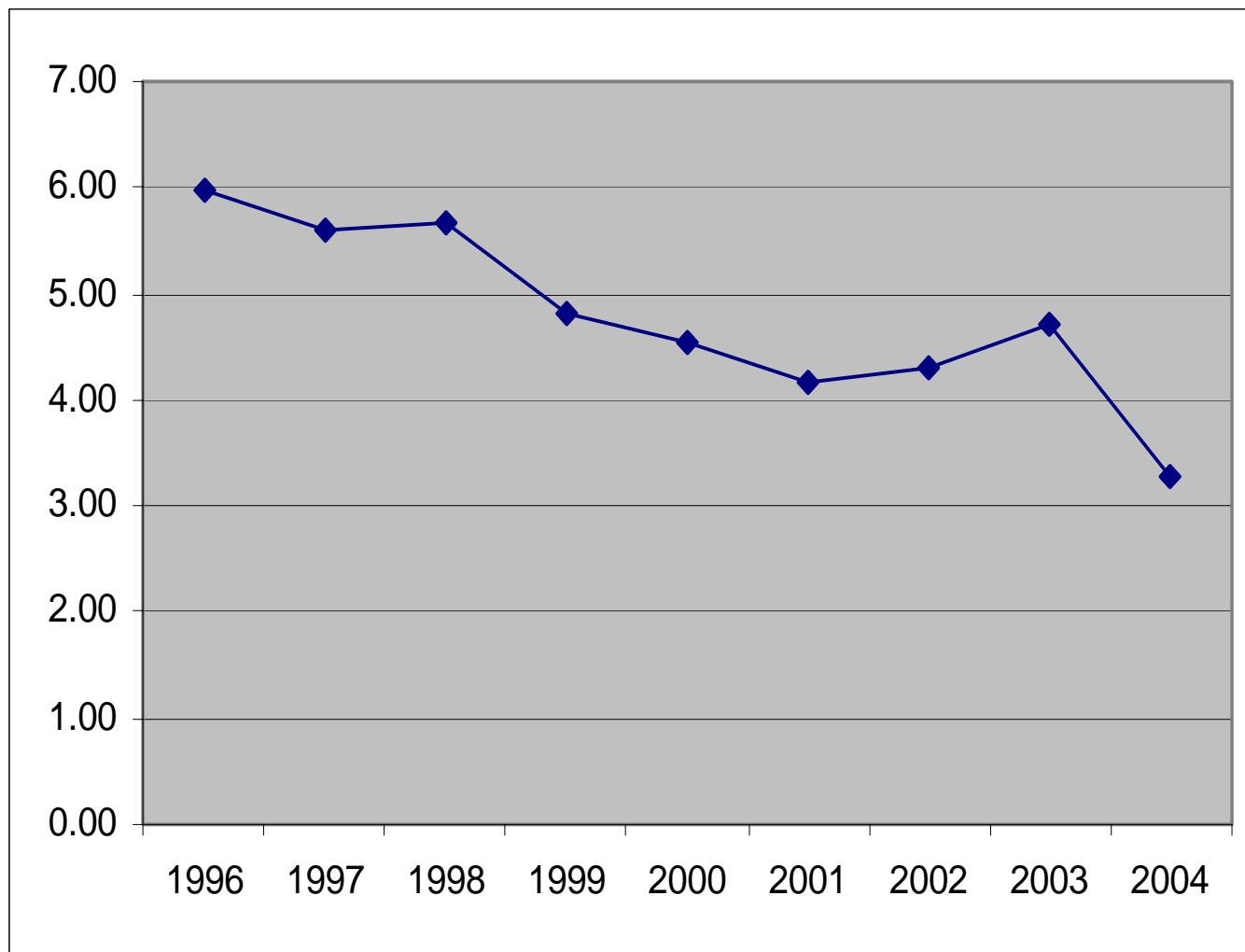
Circuit Breaker
1,000 Customers

Momentary
Interruptions

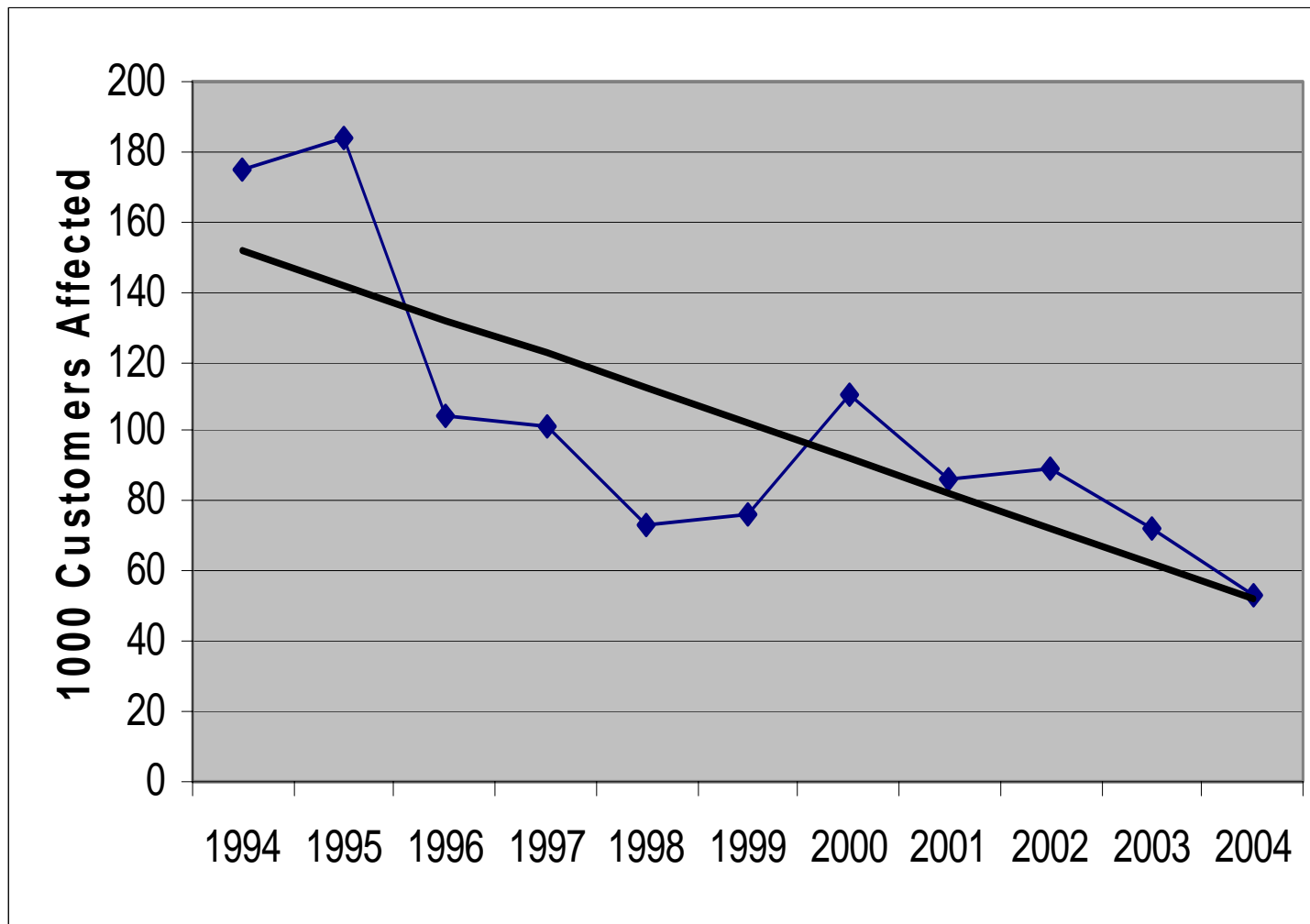
Upstream
Reclosing
Breakers



D-MAIFI History



Animal SAIFI History



Customer Equivalent Example

100kV Tree Farm BI – 16,753 CE

Car Ret – 2,086 CE

Looper Electric – 660 CE

Paylor Ret – 5,141 CE

44kV Thava (Paylor Tie) – 952 CE

44kV Camp Tower (Paylor Tie) – 448 CE

Rocky Pt (Paylor Tie) – 7,466 CE

Low Tech – 91 CE

Surefire M – 381 CE

Town Electric #10 – 3,074 CE

Vision Ret – 3,920 CE

Vision Ret 1203 – 936 CE

One Customer – 1 CE

\$ Value of Avoided Customer Equivalent Outages



\$50 per customer equivalent is the voluntary, fair value that Duke Power now spends to avoid a customer outage.

If a utility does not voluntarily adopt a policy of avoiding customer outages, the commission may step in and mandate a policy.

Need Additional Information?

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Appendix I: Duke Power Reliability Concepts

- The two things customers care most about are cost and reliability.
- Avoid sub-optimization through system analysis and strategy.
- "You don't get what you expect, you get what you inspect."
- Have dedicated reliability engineers in every location.
- Establish a reliability culture.
- Get the data.

Duke Power Reliability Concepts – page 2

- Daily outage follow up
- Root cause analysis of outages
- Strategically focused reliability programs
- Establish a sound cost/benefit balance for reliability programs – when does the cost exceed the benefit?
- Fix the worst problems on all the circuits, not all the problems on the worst circuits.
- The only thing worse than ignorance is the illusion of knowledge.

Appendix 2: Supplemental information on Duke survey of customer satisfaction with reliability.

This survey was unique in that, for the first time, the individual customer satisfaction scores could be matched with each customer's actual sustained outage records. Both the 2003 and 2004 surveys showed the same general results.

R&R Questions: On a Scale of 1 to 10, tell us how you feel about the kind of service you have received.



How often your power goes off.

How long your power is off when there is an outage.

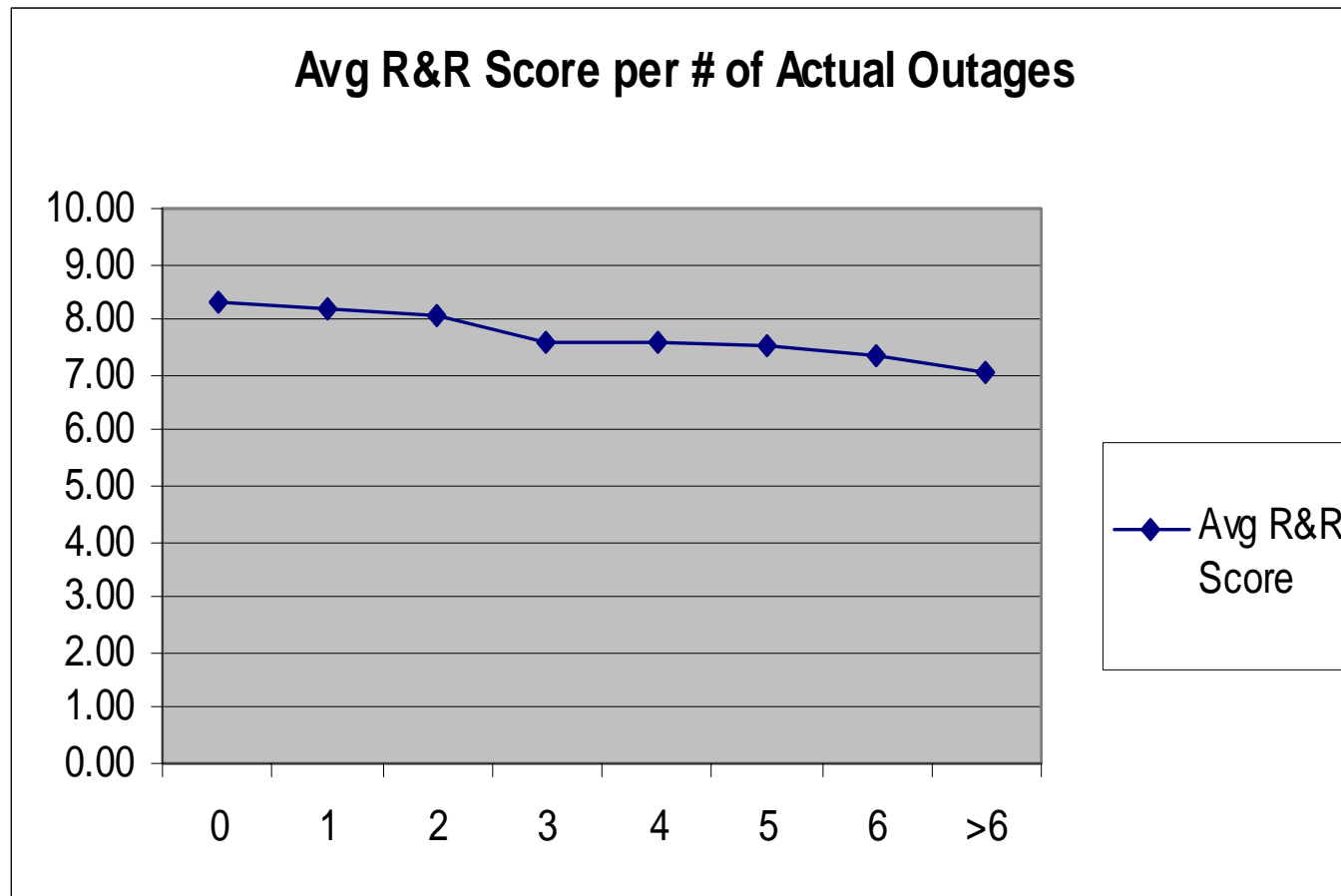
The ability of Duke Power to avoid brief interruptions of five minutes or less.

The ability of Duke Power to provide electricity service without spikes or surges.

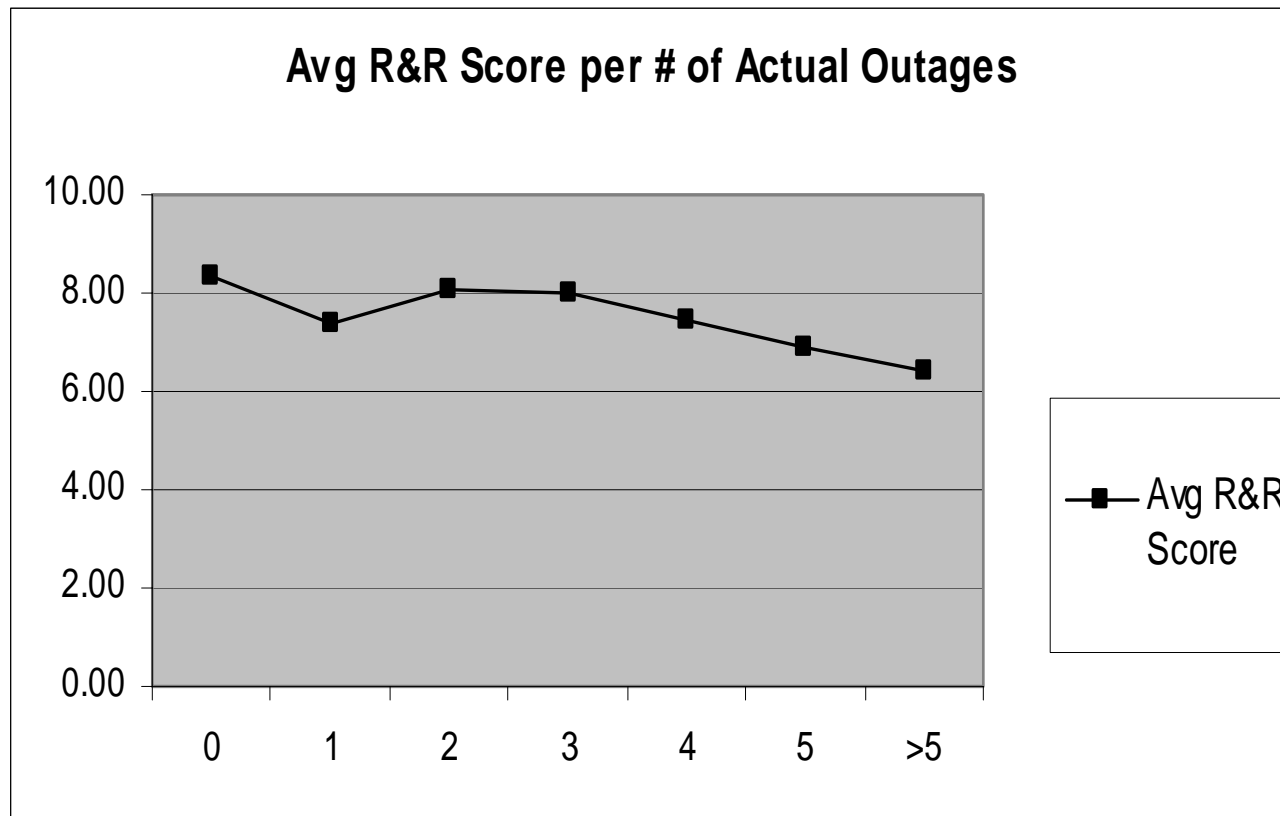
The ability of Duke Power to adequately maintain their distribution wires, poles, and transformers.

How fast Duke Power starts working on an electrical emergency.

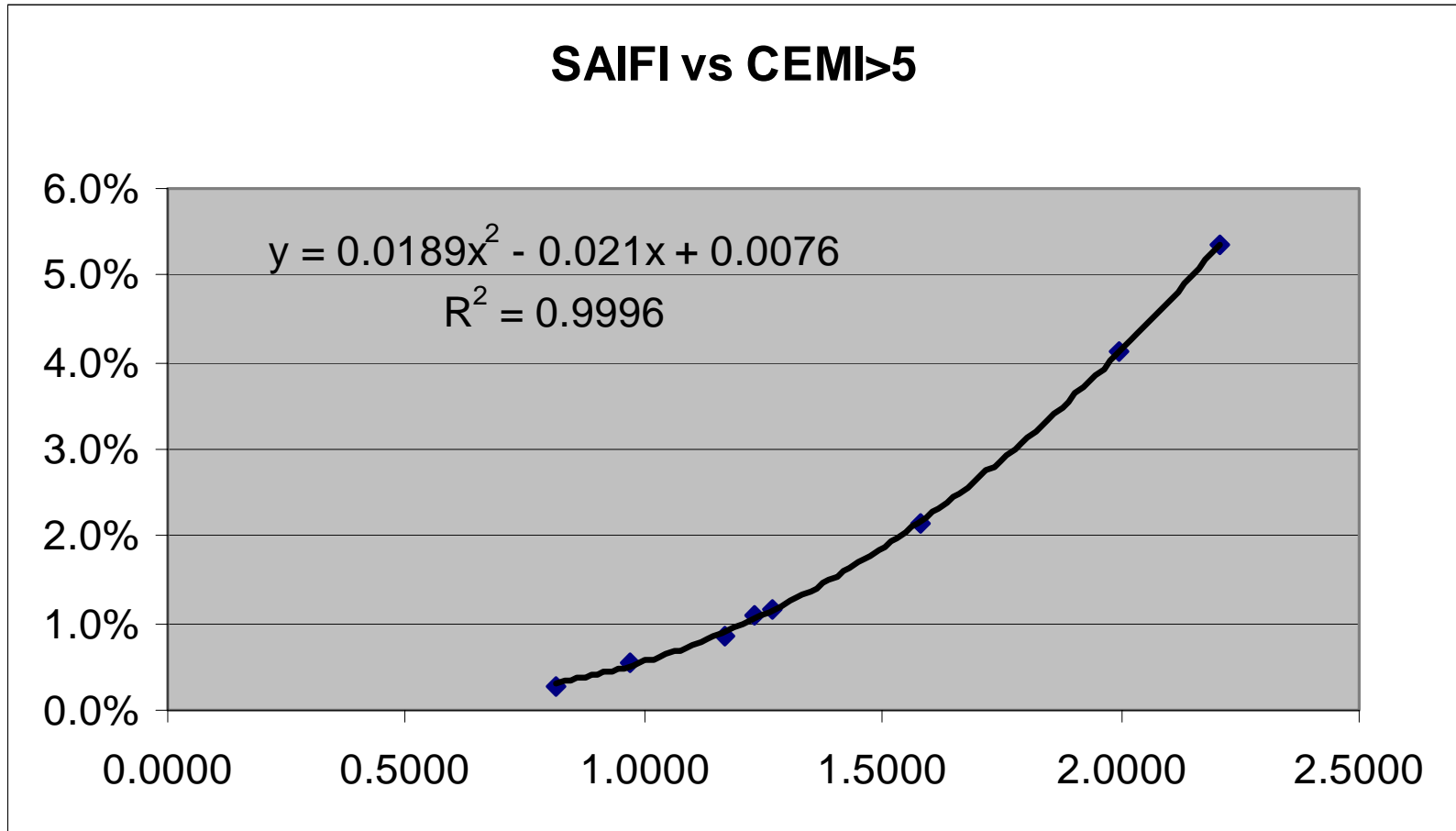
Frequency vs. Customer Satisfaction



Small Business Outage Frequency



Relationship of Repeat Outages to Overall Outage Frequency

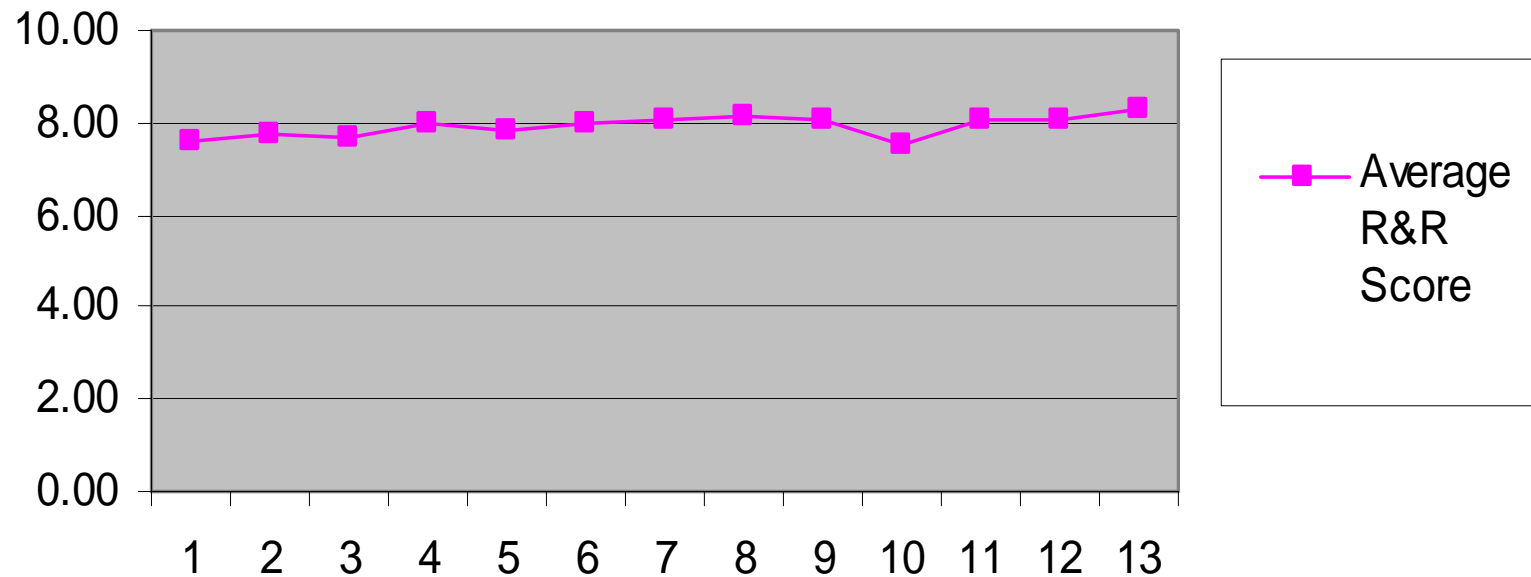


Most Recent Outage

- The hypothesis was that customers are more irritated if they have experienced a recent outage vs. an outage some time ago.
- To test this hypothesis, the elapsed time between the customer's most recent outage and the customer satisfaction survey date was compared to the survey results.

Most Recent Outage

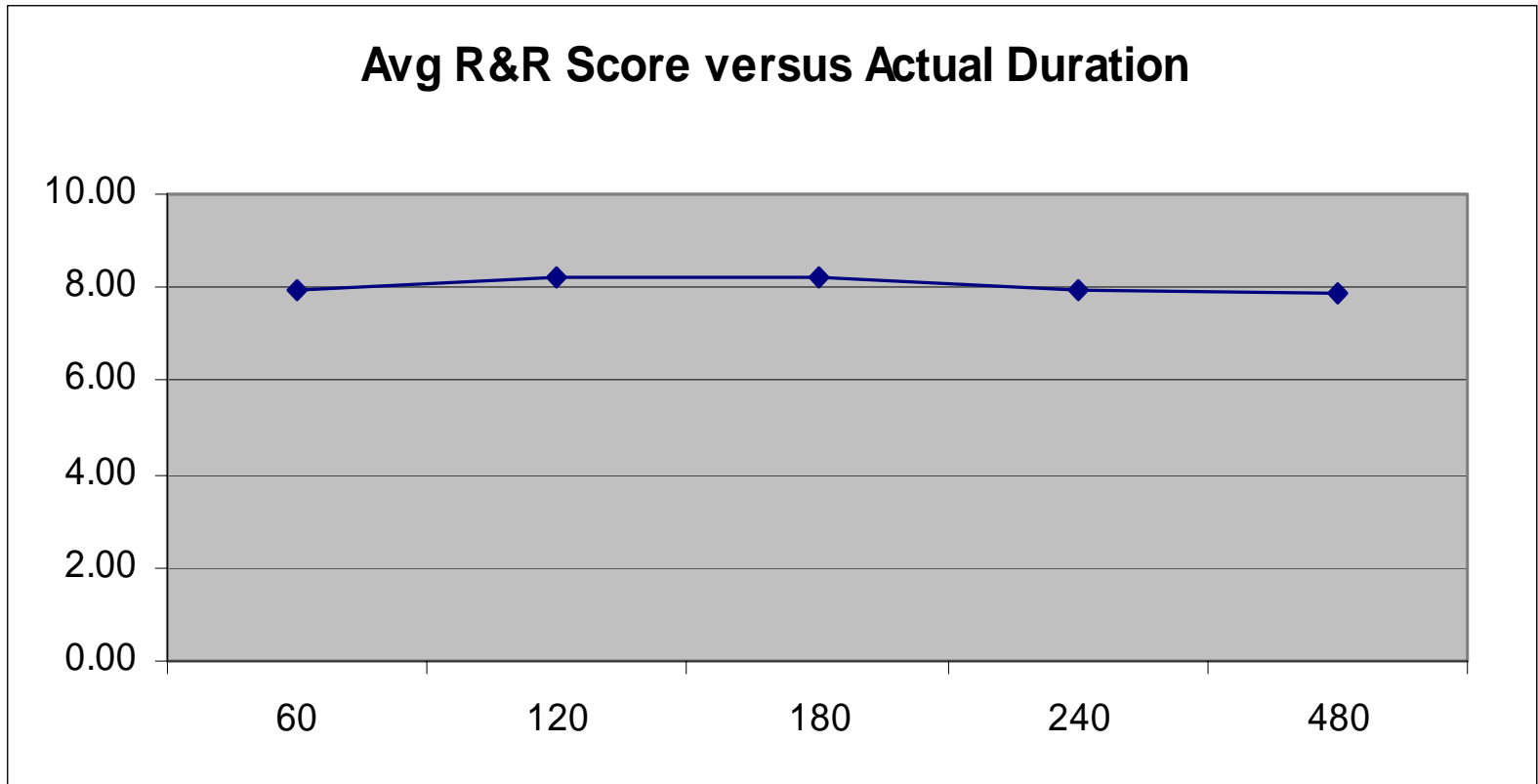
Average R&R Score vs # of Months since Last Outage



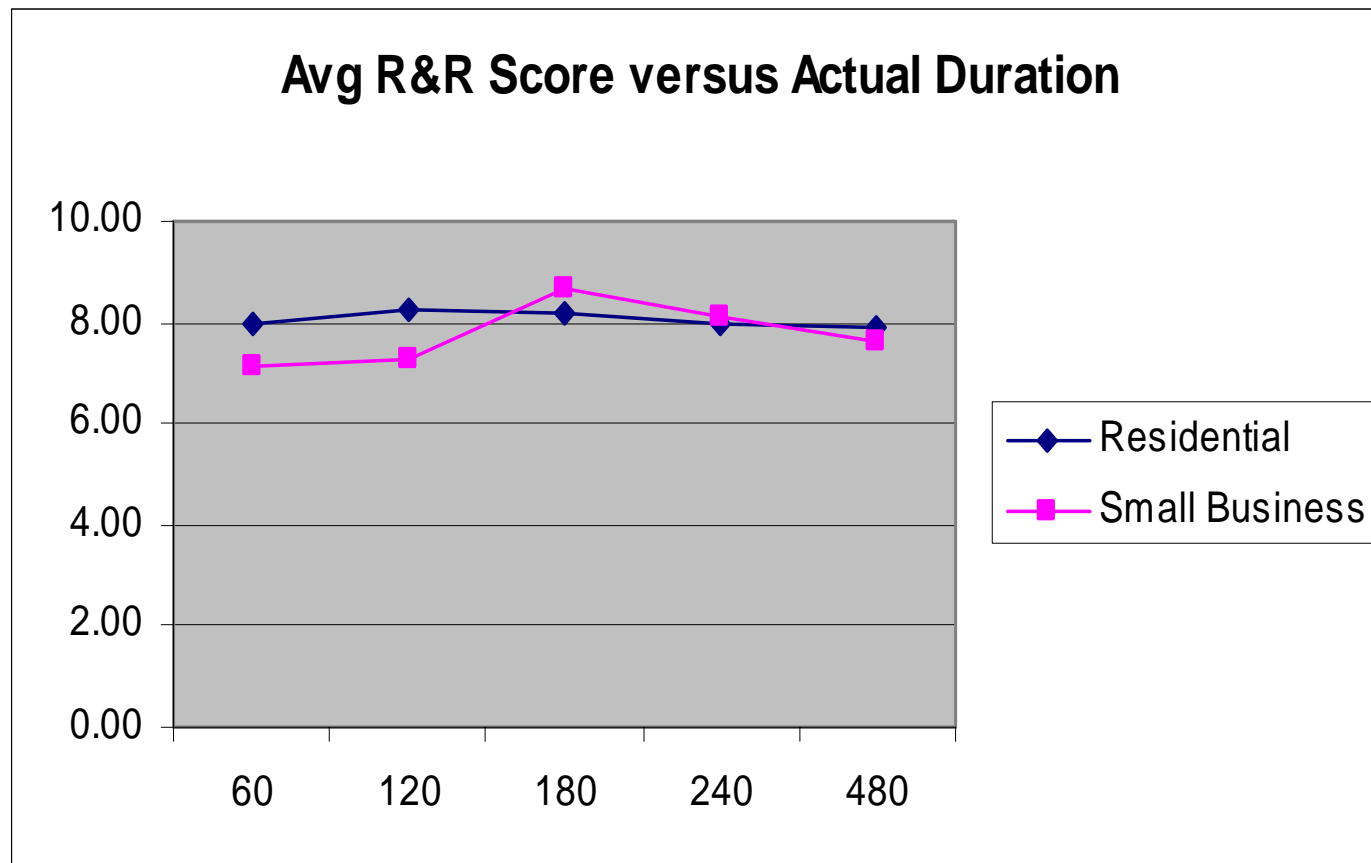
Outage Duration

- The hypothesis was that customers become more irritated if outage events last longer.
- To test this hypothesis, the duration of the customers' outages was compared to the survey results.
- The analysis was done using average duration of customers' outages, longest customer outage, and average duration without December 2002 Ice Storm.

Duration in Minutes vs. Customer Satisfaction



Duration in Minutes vs. Customer Satisfaction



Conclusions

- Outage frequency has a significant effect on customer satisfaction.
- Timing of outages has some effect on customer satisfaction, but the effect is not significant.
- By the evidence, outage durations of less than 24 hours do not appear to have a significant effect on customer satisfaction. This 2003 result was unexpected, but was also confirmed by the 2004 annual survey.

Appendix 3: Reliability Lessons Learned

From a presentation by Lee Taylor to the Working Group on System Design - Winter Meeting of the IEEE Power Engineering Society - February 1, 1995 - New York

Reliability Lessons Learned

- Consider EVERY fault to be preventable, until you can prove otherwise.
- Spend as much time as possible performing field investigations of momentary and sustained outages. Do not stay in the office, get out in the field. Keep reports and computer analyses to a minimum. Automate all reports.
- Most fault sources conform to known theory - lightning resistant designs of distribution systems being a prime example.
- Teach construction personnel the WHYS of outage resistant design, in addition to the hows. (Specification manuals usually show how, not why.)

Reliability Lessons Learned

- Communicate by personal contact and by visiting field locations. Do not rely solely on distributing manuals, memos, or other written communication. Hold training seminars at field locations. You often do more good by training one or two people in an informal setting than you do by training thirty people in a formal session.
- Do not depend on video taped training sessions. They are only a supplement.
- Take local engineers and operations personnel out in the field and show them the fault sources.
- Take management out in the field to see the fault sources. Management will not understand unless they see the problem first hand. Intellectual understanding does not equate to involved, active understanding.

Reliability Lessons Learned

- Always walk the lines and look at each pole and span from every side with a good pair of binoculars.
- If anyone says "I rode the line", you can be certain they have missed 90% of the fault sources.
- The most effective training is field training, where the student can study each pole from every side. Slides and photographs only show one view and are only supplementary training tools.
- Local construction habits can create unique fault sources that may not occur in other locations.

Reliability Lessons Learned

- NEVER assume that the lines are being built according to the specification manual. Many linemen prefer to build structures similar to the way they were taught, or like a pole nearby, or by the preference of their foreman or supervisor. The specification manual may be the last choice.
- For the most part, linemen and operations personnel DO NOT know why faults occur. Also, they do not know that they do not know.
- Outage investigators will only see what they have been trained to see. If they have not been trained, they will not see much (except trees!).