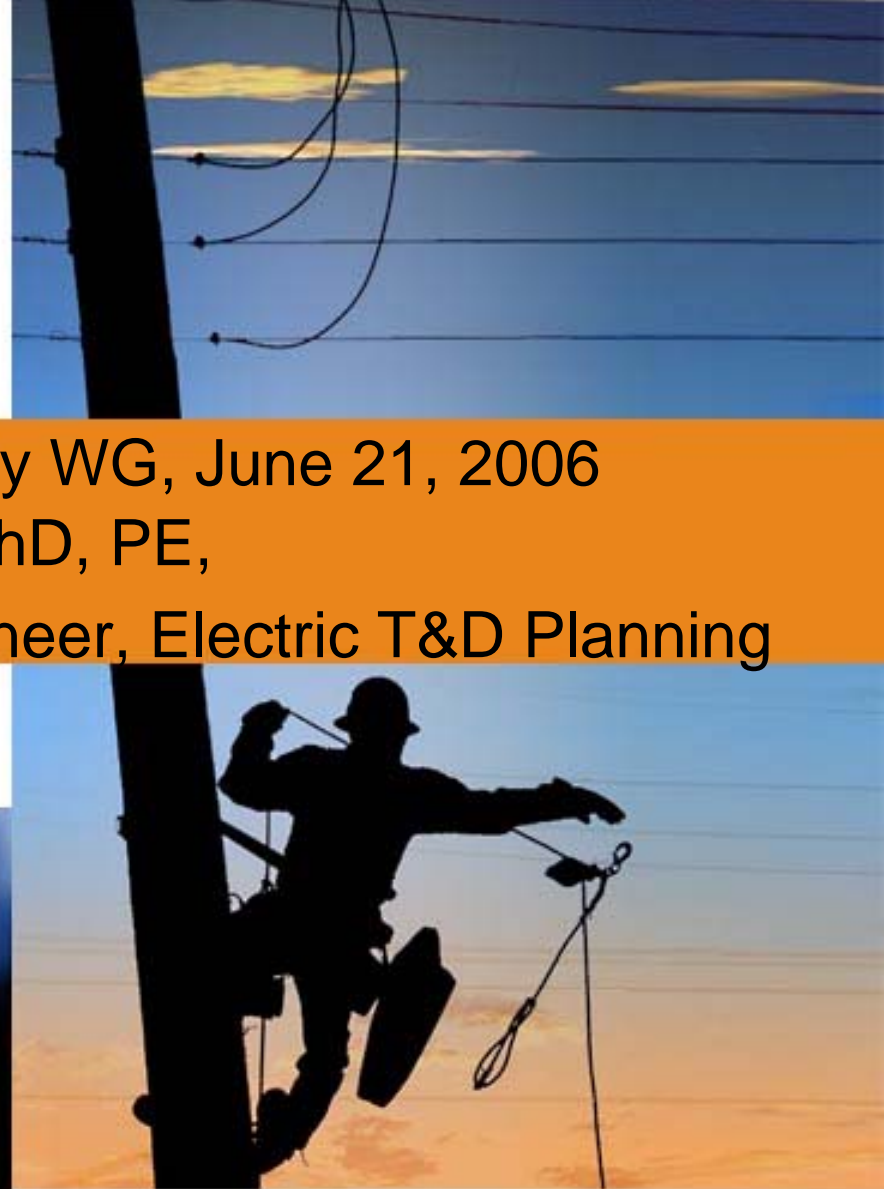




A  Sempra Energy utility



IEEE Reliability WG, June 21, 2006  
Tom Bialek, PhD, PE,  
Principal Engineer, Electric T&D Planning



# Presentation Objectives



- Historical use of reliability indices
- Propose new “customer focused” reliability measure
- Gain input on proposed measure
- Adoption in next revision IEEE 136

# Facts



- Serve San Diego and southwestern Orange Counties
- Number of electric customers – 1.3 million
  - 80% residential but 50% of energy consumption
- Number of electric distribution circuits – 952
- 4 kV circuits – 262
- 12 kV circuits – 690
- 58% underground, 42% overhead
- Underground cable circuit miles – 9,055 (Oct. 04)
- Underground cable conductor miles – 22,196 (Oct. 04)

# Reliability Measures



| Year | SAIDI | IEEE | PA Bnch | SAIFI | IEEE | PA Bnch | MAIFI |
|------|-------|------|---------|-------|------|---------|-------|
| 1982 | 143.4 |      |         | 1.64  |      |         |       |
| 1983 | 100.1 |      |         | 1.35  |      |         |       |
| 1984 | 75.9  |      |         | 1.3   |      |         |       |
| 1985 | 78.7  |      |         | 0.96  |      |         |       |
| 1986 | 65.5  |      |         | 0.9   |      |         |       |
| 1987 | 99.5  |      |         | 1.17  |      |         |       |
| 1988 | 69.3  |      |         | 0.84  |      |         |       |
| 1989 | 57.7  |      |         | 0.73  |      |         |       |
| 1990 | 68.7  | Q1+  |         | 0.91  | Q1   |         |       |
| 1991 | 86.1  |      |         | 0.97  |      |         |       |
| 1992 | 72.8  |      | Q2      | 1     |      | Q2      |       |
| 1993 | 83.7  |      |         | 0.88  |      |         |       |
| 1994 | 67.9  |      |         | 0.94  |      |         |       |
| 1995 | 57.6  | Q1+  | Q1      | 0.73  | Q1   | Q1      |       |
| 1996 | 81.7  |      | Q2      | 1.04  |      | Q2      | 1.47  |
| 1997 | 89.7  | Q2   |         | 0.94  | Q1   |         | 1.32  |
| 1998 | 91.7  |      |         | 0.94  |      |         | 1.09  |
| 1999 | 65.2  |      | Q2      | 0.67  |      | Q1      | 0.80  |
| 2000 | 51.9  |      |         | 0.57  |      |         | 0.76  |
| 2001 | 52.9  |      | Q1      | 0.64  |      | Q1      | 0.86  |
| 2002 | 77.2  |      |         | 0.79  |      |         | 0.61  |
| 2003 | 76.1  |      | Q1      | 0.72  |      | Q1      | 0.85  |
| 2004 | 78.8  |      |         | 0.62  |      |         | 0.61  |
| 2005 | 58.5  |      |         | 0.57  |      |         | 0.57  |



# Reliability Indices Use



## Goal

- Drive system reliability improvements with PBR incentives

## Why

- SDG&E 1<sup>st</sup> utility in US with performance based rates
- Develop tools and techniques to focus on projects with largest reliability impacts

# Asset Management – Replacement Strategies



# Asset Management – Replacement Strategies



| Failure rates by conductor mile in outages/year |              |              |
|---|--------------|--------------|
| Cable Type                                      | All vintages | Bad vintages |
| XLPE-PEJ  | 0.00073      | N/A          |
| XLPE  | 0.554        | 0.643        |
| HMWPE   | 0.102        | 0.155        |

| Options                  | CAIDI Gain | Units   |
|--------------------------|------------|---------|
| Sub-Fusing               | N/A        | N/A     |
| Looping                  | 48         | minutes |
| Fault Indicator Addition | 20         | minutes |
| Cable Change Out         | N/A        | N/A     |

| Other Constants            |           |
|----------------------------|-----------|
| System Average CAIDI (min) | 217       |
| System Customers           | 1,300,000 |
| LACC Factor                | 0.1211    |

| Annualized Cost Savings per circuit foot: |          |              |
|---|----------|--------------|
| Cable Type                                | vintages | Bad vintages |
| XLPE                                      | \$ 3.40  | \$ 3.96      |
| HMWPE                                     | \$ 0.63  | \$ 0.95      |

|                        | Phase                |
|------------------------|----------------------|
| Cable Replacement Cost | \$ 6.50 Single phase |
|                        | \$ 9.30 2-phase      |
| (per foot)             | \$ 12.00 3-phase     |

**DO NOT CHANGE ANY DATA ABOVE THIS GRAY LINE.**

| Cable Change Out             |         |              |
|------------------------------|---------|--------------|
| Item                         | Phase   | Quantity     |
| Main Branch Total Footage    | Single  | -            |
|                              | 2-phase | -            |
|                              | 3-phase | -            |
| Replaced Branch Footage      | Single  | -            |
|                              | 2-phase | -            |
|                              | 3-phase | -            |
| Failure Rate                 |         | 0.643        |
| Annualized Cost Savings Rate | \$      | 3.96         |
| Branch Total Customers       |         | 272          |
| Cable Replacement Cost       | \$      | -            |
| Other Costs                  | \$      | -            |
| Project Cost                 | \$      | -            |
| Gain In Number of Failures   |         | 0.00000      |
| SAIDI Gain                   |         | -            |
| SAIFI Gain                   |         | -            |
| PBR Gain                     | \$      | -            |
| Annualized Cost Savings      | \$      | -            |
| <b>RTR</b>                   |         | <b>0.000</b> |

| Sub-Fusing                 |         |              |
|----------------------------|---------|--------------|
| Item                       | Phase   | Quantity     |
| Main Branch Total Footage  | Single  | -            |
|                            | 2-phase | -            |
|                            | 3-phase | -            |
| Sub-fused Branch Footage   | Single  | -            |
|                            | 2-phase | -            |
|                            | 3-phase | -            |
| Failure Rate               |         | 0.643        |
| Branch Total Customers     |         | 272          |
| Sub-fused Branch Customers |         | 58           |
| Project Cost               | \$      | 25,000       |
| SAIDI Gain                 |         | -            |
| SAIFI Gain                 |         | -            |
| PBR Gain                   | \$      | -            |
| <b>RTR</b>                 |         | <b>0.000</b> |

| Looping                   |         |              |
|---------------------------|---------|--------------|
| Item                      | Phase   | Quantity     |
| Main Branch Total Footage | Single  | -            |
|                           | 2-phase | -            |
|                           | 3-phase | -            |
| Failure Rate              |         | 0.643        |
| Branch Total Customers    |         | 272          |
| Project Cost              |         | \$ 25,000    |
| SAIDI Gain                |         | -            |
| PBR Gain                  | \$      | -            |
| <b>RTR</b>                |         | <b>0.000</b> |

| Fault Indicator Addition  |         |              |
|---------------------------|---------|--------------|
| Item                      | Phase   | Quantity     |
| Main branch total footage | Single  | -            |
|                           | 2-phase | -            |
|                           | 3-phase | -            |
| Failure Rate              |         | 0.643        |
| Branch Total Customers    |         | 272          |
| Project Cost              |         | \$ 8,000     |
| SAIDI Gain                |         | -            |
| PBR Gain                  | \$      | -            |
| <b>RTR</b>                |         | <b>0.000</b> |

|            |             |
|------------|-------------|
| <b>436</b> | d2721874412 |
|------------|-------------|

INPUT IS ONLY REQUIRED IN THE TAN CELLS.



# Asset Management – Replacement Strategies



DISTRICT: **NC**    CIRCUIT: **Test**    DATE: **11/18/2002**    IER(\$/KW): **0**    SAIDI TARGET: **0.1**    BY: **D. Engineer**

Circuit improvement    Presentation Model

SWITCHING MODE: **Urban**    Rural    ADDITIONAL TIME (HRS): **0**    Model Type: **Feeder**    FAILURE RATE: **2007 COND FAILURE RATES**

| BASE  | CASE | BASE | CASE  | BASE | CASE | BASE  | CASE |     |
|-------|------|------|-------|------|------|-------|------|-----|
| S1-1  | G    | G    | S2-5  | G    | G    | S3-9  | ScA  | ScA |
| S1-2  | G    | G    | S2-6  | N    | N    | S3-10 | F    | F   |
| S1-3  | G    | G    | S2-7  | N    | N    | S3-11 | ScA  | ScA |
| S1-4  | G    | G    | S2-8  | N    | N    | S3-12 | ScA  | ScA |
| T-1   | N    | N    | T-2   | G    | G    | T-3   | G    | G   |
| S4-13 | R    | R    | S4-14 | N    | N    | S4-15 | N    | N   |

| SAIDI IMPROVEMENT |         |          | SAIFI IMPROVEMENT |          |          | MAIFI IMPROVEMENT |            |             |
|-------------------|---------|----------|-------------------|----------|----------|-------------------|------------|-------------|
| BASE CASE         | CASE 1  | NET GAIN | BASE CASE         | CASE 1   | NET GAIN | BASE CASE         | CASE 1     | NET GAIN    |
| 0.46476           | 0.32550 | 0.13926  | 0.005672          | 0.005277 | 0.000395 | 0.00073395        | 0.00299145 | -0.00225750 |

| ECONOMIC JUSTIFICATION |              |       |        |       |          | POWER SAVINGS |         |             |
|------------------------|--------------|-------|--------|-------|----------|---------------|---------|-------------|
| O&M Cost/Yr            | Project Cost | RTR   | VR     | None  | PBR Gain | BASE CASE     | CASE 1  | NET SAVINGS |
| \$0                    | \$120,000    | 2.190 | 10.159 | 0.000 | \$37,167 | 0.00000       | 0.00000 | 0.00000     |

| CONDUCTOR LENGTHS IN FEET |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
|                           | M1    | L1    | L2    | M2    | L3    | L4    | M3    | L5    | L6    | M4    | L7    | L8    | M5    | L9    | L10   | M6    | L11   | L12   | TOTAL  |
| OH_07                     | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 18,000 |
| XLPE_07                   | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 18,000 |
| *                         | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0      |

| RECOMMENDED REPLACEMENT LENGTHS IN FEET |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |    |     |     |       |
|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|----|-----|-----|-------|
|   | M1 | L1 | L2 | M2 | L3 | L4 | M3 | L5 | L6 | M4 | L7 | L8 | M5 | L9 | L10 | M6 | L11 | L12 | TOTAL |
|   | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0   | 0  | 0   | 0   | 0     |

| CUSTOMERS | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 5,400 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| PEAK AMPS | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0     |

SYSTEM CUSTOMERS: **1,237,797**    CIRCUIT CUSTOMERS ON RECORD: **0**    CUSTOMER YEAR: **0**

COPIED SCENARIO:    SELECT SCENARIO TO COPY (INCLUDE BASE):    INCLUDE CASE: **PROJ COSTS, RTR...**    **Copy Scenario**

VERSION: 07/22/02 ERDP

Process Model    Refresh Model    Print Model    Print Calc. Detail    Update EQ Costs    Undo Last Entry

# Moving Forward



## Goal

- Identify new or revised “customer focused” electric reliability PBR indices for use beginning in 2008

## Why

- SDG&E historically in the 1<sup>st</sup> or 2<sup>nd</sup> quartile for electric reliability
- New reliability measures to direct reliability investments while representing customers’ expectations regarding outages

# Moving Forward



## What do customers want ?

Results of recent customer focus groups (January 2006) confirm customers are more likely to be satisfied when:

- Outage durations of less than 2-3 hours.
- Outage frequency less than 2-3 outages per year.
- SDG&E provides accurate estimates for return to service.

# Moving Forward



## What is “Customer Focused” ?

- The ability to direct resources to those customers who are experiencing outages.

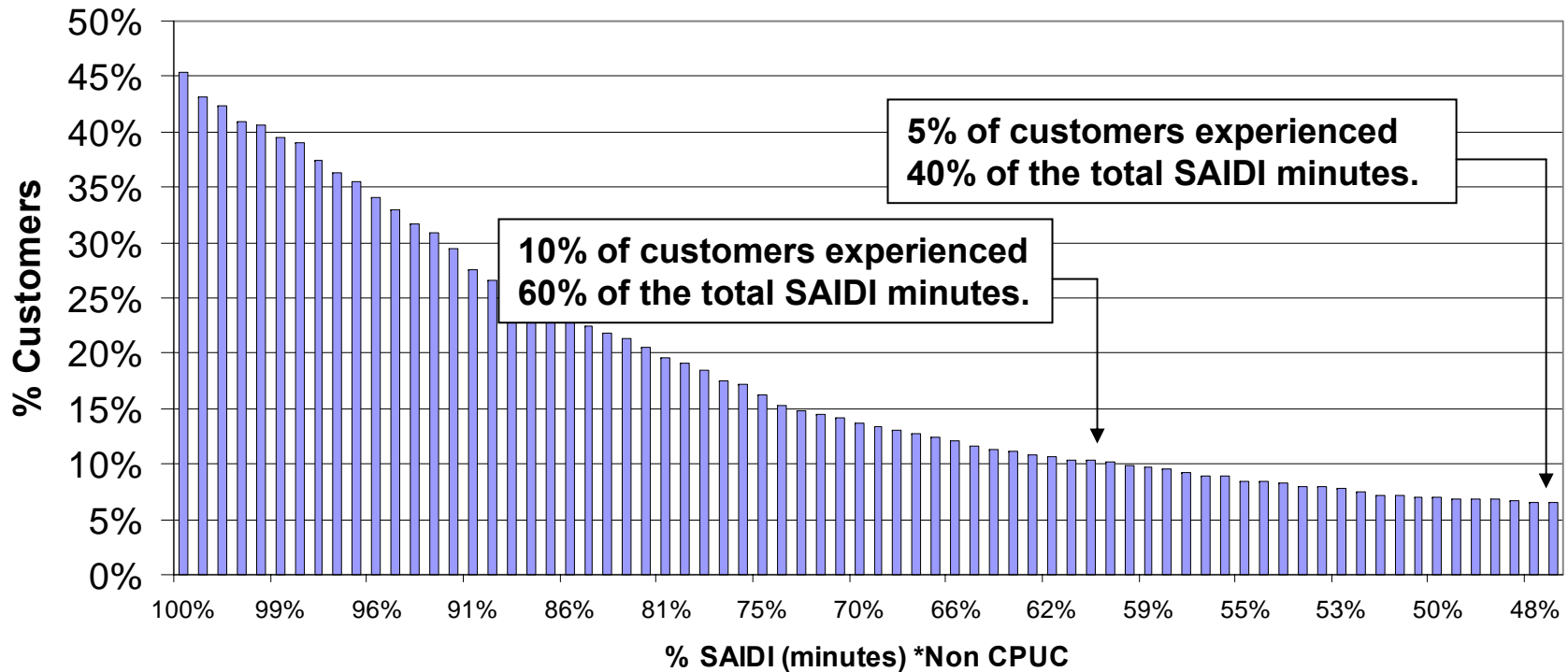
## Why ?

- A small segment of customers is experiencing an increasing amount of outage minutes
- In 2004, 10% of customers experienced 60% of the SAIDI minutes

# Moving Forward



## % Customer vs % SAIDI (2004)



# Moving Forward



## How to direct resources toward customers experiencing outages

- Identify reliability indices focused on those customers rather than using system wide reliability indices.

## Existing reliability Indices

- SAIDI, SAIFI, & MAIFI

## Reliability indices that are “Customer Focused” ?

- SAIDET - SAIDI exceeding threshold
- CEMI – Customers experiencing multiple interruptions

# Moving Forward



## What is SAIDET?

- SAIDET represents the SAIDI minutes attributable to customers experiencing outage durations beyond an annual interruption minute threshold

## Why SAIDET?

- Customer focused index rather than system wide average index
- Focus company resources on customers experiencing reliability issues
- More likely to improve customer satisfaction

## Why not % of customers above threshold (CEMI)?

- Focus would be on borderline customers and not those exceeding threshold
- Critics would argue system could be gamed



# Moving Forward



## Why SAIDET?

- Focus on customers experiencing poor reliability rather than a system wide average index.

### % of Customers Affected

| Year | SAIDI | Threshold |       |       |       |       |       |      |      |      |
|------|-------|-----------|-------|-------|-------|-------|-------|------|------|------|
|      |       | 60        | 90    | 120   | 150   | 180   | 210   | 240  | 270  | 300  |
| 2000 | 51.93 | 21.5%     | 14.5% | 10.7% | 6.7%  | 5.2%  | 4.6%  | 4.3% | 3.4% | 2.8% |
| 2001 | 52.87 | 24.2%     | 13.9% | 10.6% | 8.3%  | 6.7%  | 4.9%  | 4.2% | 3.6% | 3.3% |
| 2002 | 77.35 | 31.1%     | 23.2% | 16.9% | 12.5% | 9.9%  | 7.7%  | 6.5% | 6.3% | 6.1% |
| 2003 | 76.14 | 33.0%     | 23.6% | 16.3% | 13.2% | 10.8% | 9.5%  | 6.9% | 6.2% | 5.3% |
| 2004 | 78.75 | 32.6%     | 25.3% | 20.6% | 15.8% | 13.3% | 10.8% | 9.1% | 8.2% | 7.9% |
| 2005 | 58.71 | 25.7%     | 16.2% | 11.5% | 9.2%  | 8.3%  | 7.0%  | 6.8% | 5.9% | 4.8% |

**13% SAIDI Increase**  
For 2000 to 2005

**37% SAIDET Increase**  
For 2000 to 2005

Greater % of customers are experiencing longer outages



# Moving Forward



## Reasons for increasing SAIDET

- Majority of customers are seeing improved reliability
  - Faster restoration for majority of customers
  - Fewer outages per customer
- Increase in the amount of underground distribution
  - Increasing underground cable failures due to bad vintage cable
  - More difficult to identify underground faults
  - Longer restoration times for underground customers

# Moving Forward



## SAIDET

At Threshold Values

| Year | SAIDI | Threshold |      |      |      |      |      |      |      |      |      |      |
|------|-------|-----------|------|------|------|------|------|------|------|------|------|------|
|      |       | 60        | 90   | 120  | 150  | 180  | 210  | 240  | 270  | 300  | 330  | 360  |
| 1995 | 57.59 | 26.0      | 18.2 | 13.5 | 10.4 | 7.7  | 6.0  | 4.9  | 4.1  | 3.4  | 2.8  | 2.4  |
| 1996 | 81.66 | 37.7      | 27.3 | 21.8 | 18.6 | 16.4 | 14.7 | 13.3 | 12.0 | 10.9 | 10.0 | 9.1  |
| 1997 | 89.66 | 47.5      | 34.4 | 27.1 | 22.1 | 18.6 | 15.7 | 13.3 | 11.1 | 9.5  | 8.4  | 7.6  |
| 1998 | 91.70 | 49.8      | 38.1 | 31.5 | 27.3 | 24.1 | 21.4 | 19.0 | 17.1 | 15.5 | 14.0 | 12.9 |
| 1999 | 65.21 | 34.7      | 25.7 | 20.3 | 16.4 | 13.5 | 11.3 | 9.2  | 7.7  | 6.6  | 5.4  | 4.3  |
| 2000 | 51.93 | 29.9      | 23.5 | 19.4 | 16.5 | 15.0 | 13.9 | 12.8 | 11.8 | 11.2 | 10.7 | 10.2 |
| 2001 | 52.87 | 29.4      | 22.3 | 18.2 | 15.1 | 12.7 | 10.9 | 9.6  | 8.4  | 7.4  | 6.3  | 5.4  |
| 2002 | 77.35 | 46.9      | 37.1 | 30.3 | 25.7 | 22.1 | 19.6 | 17.7 | 15.9 | 14.1 | 12.6 | 11.1 |
| 2003 | 76.14 | 49.8      | 40.2 | 33.8 | 29.4 | 26.0 | 23.1 | 20.8 | 19.1 | 17.7 | 16.4 | 15.4 |
| 2004 | 78.75 | 57.7      | 48.5 | 41.2 | 35.8 | 31.8 | 28.0 | 25.4 | 23.0 | 20.8 | 18.6 | 16.7 |
| 2005 | 58.46 | 36.0      | 28.8 | 24.4 | 21.5 | 19.0 | 16.7 | 14.7 | 12.8 | 11.2 | 9.7  | 8.4  |

### Averages

|           |      |      |      |      |      |      |      |      |      |      |      |      |
|-----------|------|------|------|------|------|------|------|------|------|------|------|------|
| 2001-2005 | 68.8 | 43.9 | 35.4 | 29.6 | 25.5 | 22.3 | 19.7 | 17.6 | 15.9 | 14.2 | 12.7 | 11.4 |
| 1995-2005 | 78.2 | 44.5 | 34.4 | 28.2 | 23.9 | 20.7 | 18.1 | 16.1 | 14.3 | 12.8 | 11.5 | 10.3 |
| 1981-2005 | 75.6 | 38.7 | 29.0 | 23.3 | 19.5 | 16.7 | 14.4 | 12.5 | 10.9 | 9.5  | 8.4  | 7.5  |



# Moving Forward



## SAIDET

### Advantages

- Immediate focus is on customers above threshold
- Duration index similar to SAIDI
- Addresses problem area instead of just system average
- Enhanced cable project directly impacts SAIDET
- IEEE may adopt SAIDET as a reliability index in future
- Influence over duration and frequency

### Risks

- Less easily understood and communicated to regulators and employees
- Upward trend due to increasing branch cable failures

# Moving Forward



## SAIDET

- IEEE 1366 next revision?