Power System Engineering, Inc.

Measuring Performance and Setting Appropriate Reliability Targets

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About PSE

- Founded in 1974
- Headquartered in Madison, WI with offices in MN, OH, IN, IA, and SD
- Serving utilities & regulators
- Engineering, Economics, Rates, Technology Experts in the Utility Industry

Learning Objectives

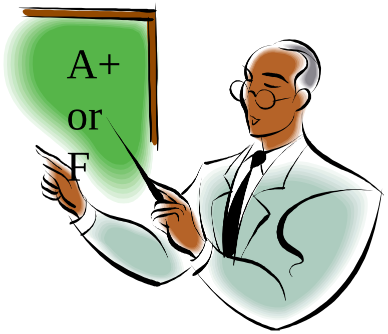
1. Introduction to statistical benchmarking
2. Why sound benchmarking is important
3. Case study of setting reliability targets and evaluating performance for two Midwest utilities

How Benchmarking Can Improve Utility Operations

1. Utility can better understand how its reliability levels compare to what is achievable
2. Develop strategic plans to maintain strengths and address identified weaknesses
3. Setting and tracking of near-term and long-term targets, goals, and incentives
4. Better understanding of how regional circumstances impact reliability
5. Understanding how other utilities are doing and investigating why

Regulatory Uses Include:

- Rate case filings can show reliability performance levels
- Regulators sometimes set targets and attach financial penalties and rewards
- Investigations in the wake of significant outages typically caused by storms
  - Best to be proactive and have a defensible methodology and strategy already in place



Regulatory Approaches to Reliability

Hands-off

- Leave it to the utility to decide

Monitor Reliability

- Utility reports reliability indexes to regulator
- No explicit target or financial implications

Target Setting/Benchmark Goal

- Regulator sets appropriate reliability target
- If utility misses the target it must submit a plan to rectify the situation

Reward/Penalty System

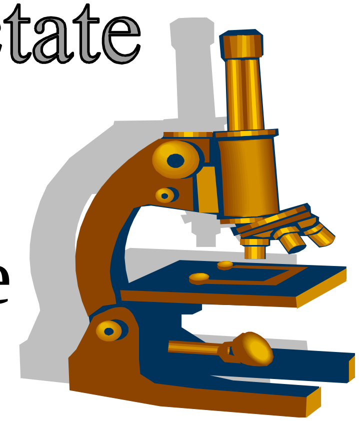
- Financial penalties and rewards attached to hitting or missing target

Design Mandates

- Regulator tells utility how to design and build its system

What Statistical Benchmarking is **Not**

- Performance benchmarking is **not** making unadjusted rate or reliability comparisons to other utilities
  - Uncontrollable circumstances dictate attainable costs and reliability!!!



- To properly investigate performance, these circumstances cannot be ignored
- Proper targets should reflect the realities of the service territory
  - If not, reliability initiatives will likely either be under-funded or over-funded

What Statistical Benchmarking **Is**

- Benchmarking is a means of establishing data value expectations using industry data and *external factors*

$$\text{SAIDI Performance} = \frac{\textit{Actual SAIDI}}{\textit{Benchmark SAIDI}}$$

  - Need to make "apples-to-apples" comparisons

    Challenging given the large differences in utility circumstances (e.g., customer density, forestation, undergrounding)

Two Approaches Popular in North America

1. Peer Group Approach

2. Econometric Approach

Peer Group Approach

Peer Group Approach

1. Determine group of very similar utilities and compare data
   - Balance between desire for a large sample and for utilities that share circumstances
2. Compare utility data to peer group statistics
   - Make conclusions and set targets based on the relative performance of the company to this peer group

Conclusion:
Good method if a group of utilities with very similar circumstances can be identified

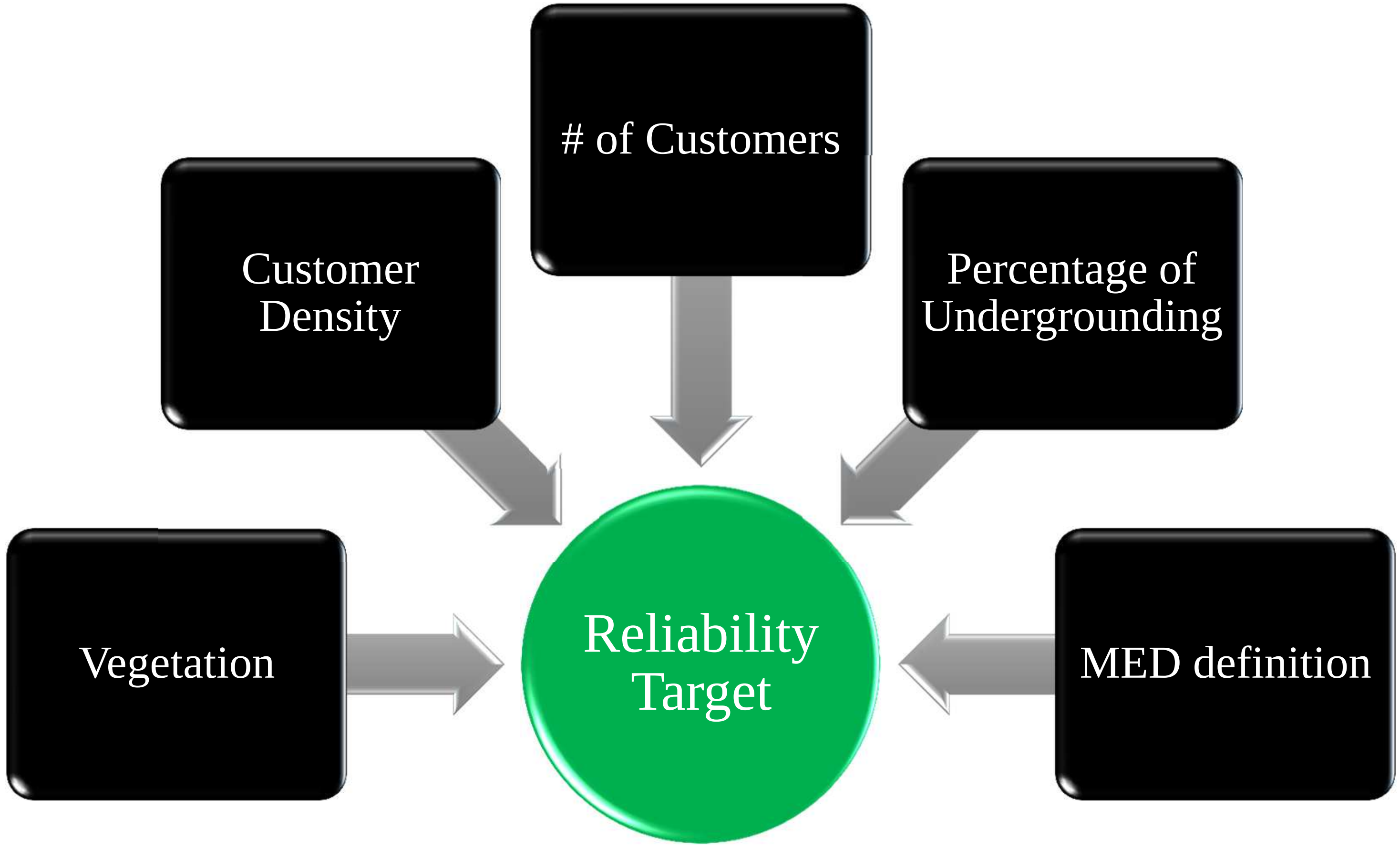
Econometric Benchmarking Approach

Simplified Example: Using all available data for U.S.

$$Benchmark\ SAIDI = X \times Vegetation + Y \times Density$$

- ✓Step 1: Fill in values for ***Vegetation*** and ***Density*** for entire sample
- ✓Step 2: Use regression techniques to estimate ***X*** and ***Y***
- ✓Step 3: Calculate ***Benchmark SAIDI*** for each utility
  - ➢This is what an "industry normal" target is for your utility
- ✓Step 4: Compare ***Benchmark SAIDI*** to actual utility SAIDI
  - ➢This is an evaluation of your SAIDI performance relative to the industry normal
- ✓Step 5: Test significance
  - ➢This tells us how much confidence we can place on the results

Examples of Variables to Include



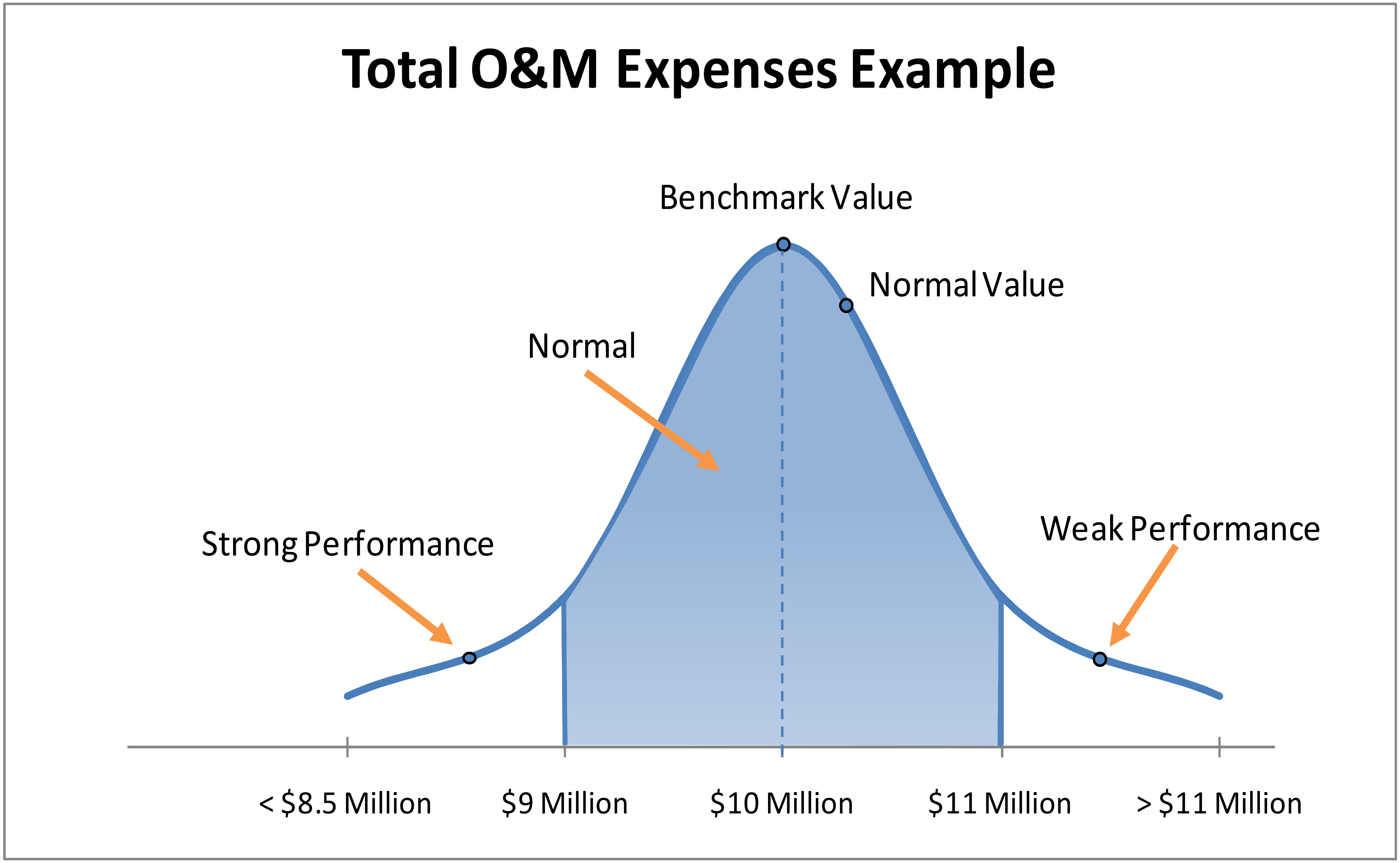
NRRI's Thoughts on the Two Approaches

Method	Ease of Application	Reliability of Results	Data Requirements
Peer Group	Easy to Apply	**Not Reliable/Medium Reliability**	Low Data Requirements
Econometric	Medium/High Difficulty	**Medium/High Reliability**	High Data Requirements

*** Source: National Regulatory Research Institute

High accuracy of results is necessary to give regulators and managers confidence to act on benchmarking results!

How Much Confidence Should We Put Into This?



Most Popular Reliability Indexes

- **SAIDI**: Sustained Average Interruption Duration Index
  - Sum of all sustained outage minutes experienced by customers divided by total customers
- **SAIFI**: Sustained Average Interruption Frequency Index
  - Sum of the number of sustained outages experienced by customers divided by total customers
- **CAIDI**: Customer Average Interruption Duration Index
  - SAIDI/SAIFI (Average duration during an outage)

Categorizing Normal and Major Events

Power Outage

Normal Event

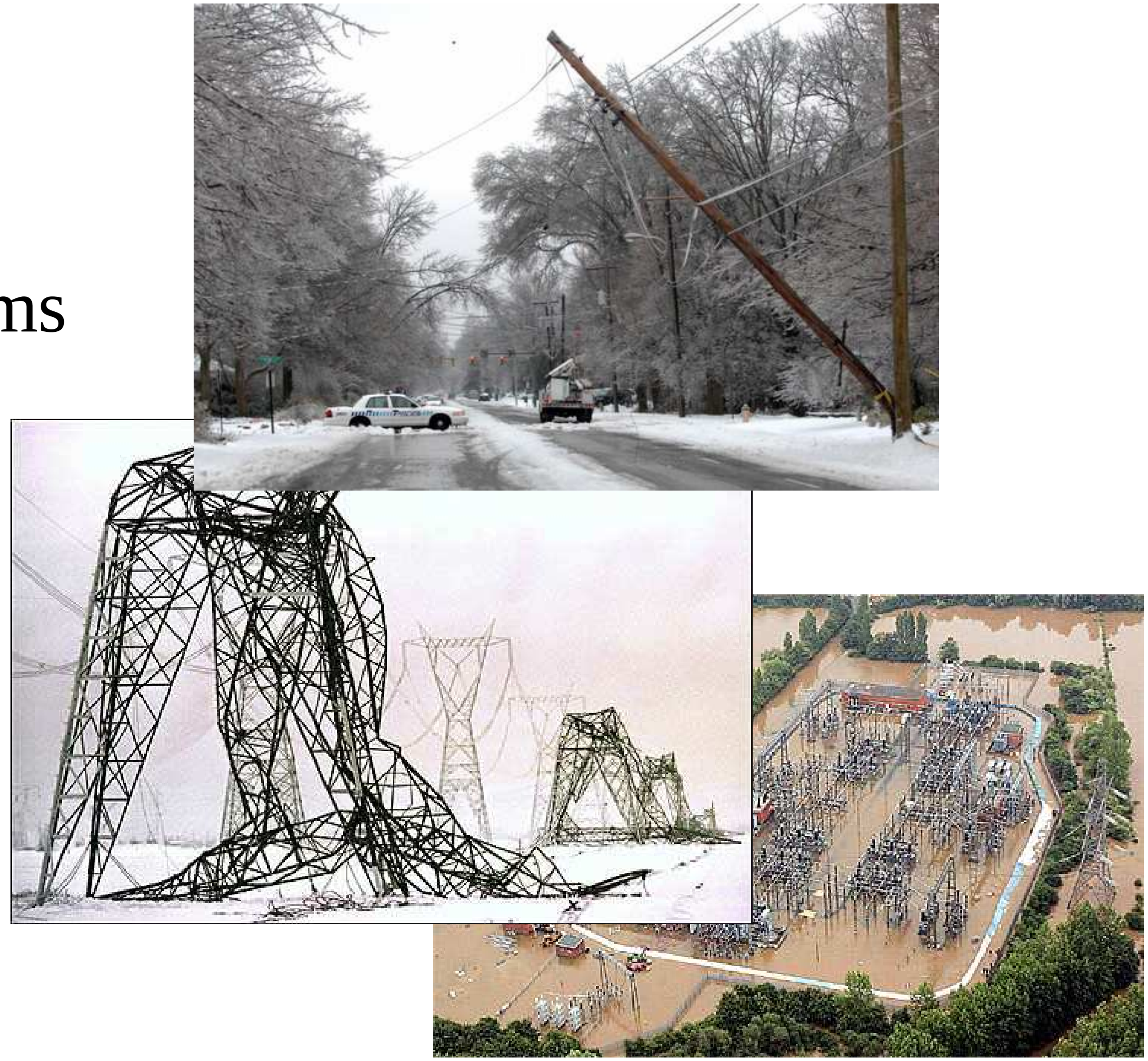
- Regular occurrence
- Small geographic areas
- Few customers affected
- Day-to-day performance

Major Event

- Infrequent occurrence
- Large geographic area
- Significant number of customers affected
- Crisis mode

Typical Causes of Major Events

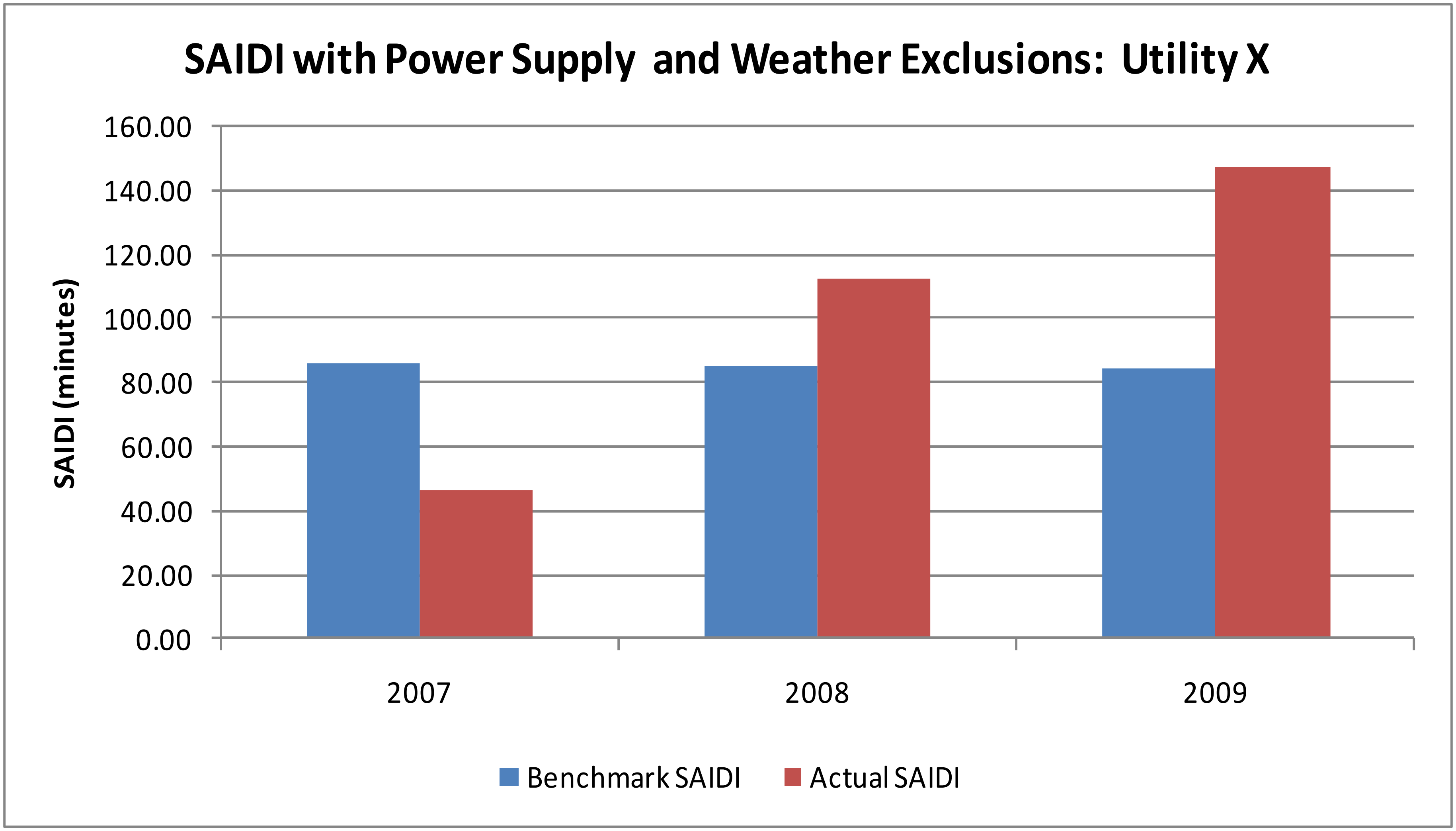
- Extreme Winds
- Ice Storms
- Early Snow Storms
- Forest Fires
- Floods
- Cascading Blackout



Definition of a Major Event Day

- Major Event Day (MED) definitions vary by jurisdiction and utilities
- IEEE 1366-2003 is becoming more standard
  - 2.5 beta methodology
- Other approaches include defining a severe day if 10% or 15% of customers affected
  - Some definitions have time durations attached

Distribution Only "Good Weather" SAIDI Results



Sample SAIDI Results

Categories Of Interest (Account #)	2006-2010 Average				
	Average Benchmark	Average Actual	Ratio	Statistically Different from Benchmark?	Performance Finding
Total SAIDI (in minutes)	240	176	0.73	Yes	Better Than Normal
SAIDI (Distribution-Only Outages)	214	140	0.65	Yes	Better Than Normal
SAIDI (Distribution-Only and Good Weather Outages)	129	140	1.09	No	Normal

Why It's So Important to Adjust for Service Territory Characteristics

- Especially true in distribution functions where assets are literally spread all across the service territory
  - Unlike most industries with concentrated production facilities (factories, power plants)
- Simple benchmarking comparisons will likely be misleading
- "Apples to apples"

Targets by Region

- Geographic regions within a utility could also have separate targets
  - Urban versus rural areas
  - Vegetation differences in certain regions
  - Undergrounding differences
- Probably not an optimal strategy to have the same reliability across diverse regions
  - Some are more challenging than others
  - Will cost a lot more to hit the same target in one region versus another region

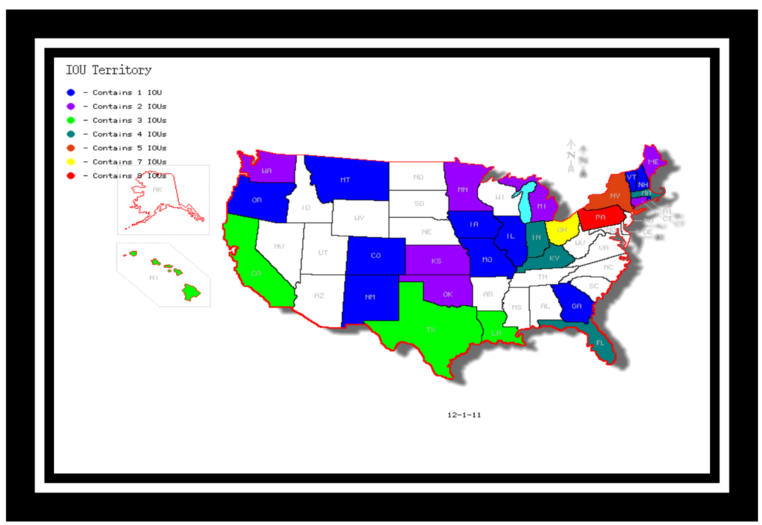
Reliability Benchmarking Case Study

- Sample of 76 U.S. IOUs
- Publically available data
- Major Event Day outages excluded

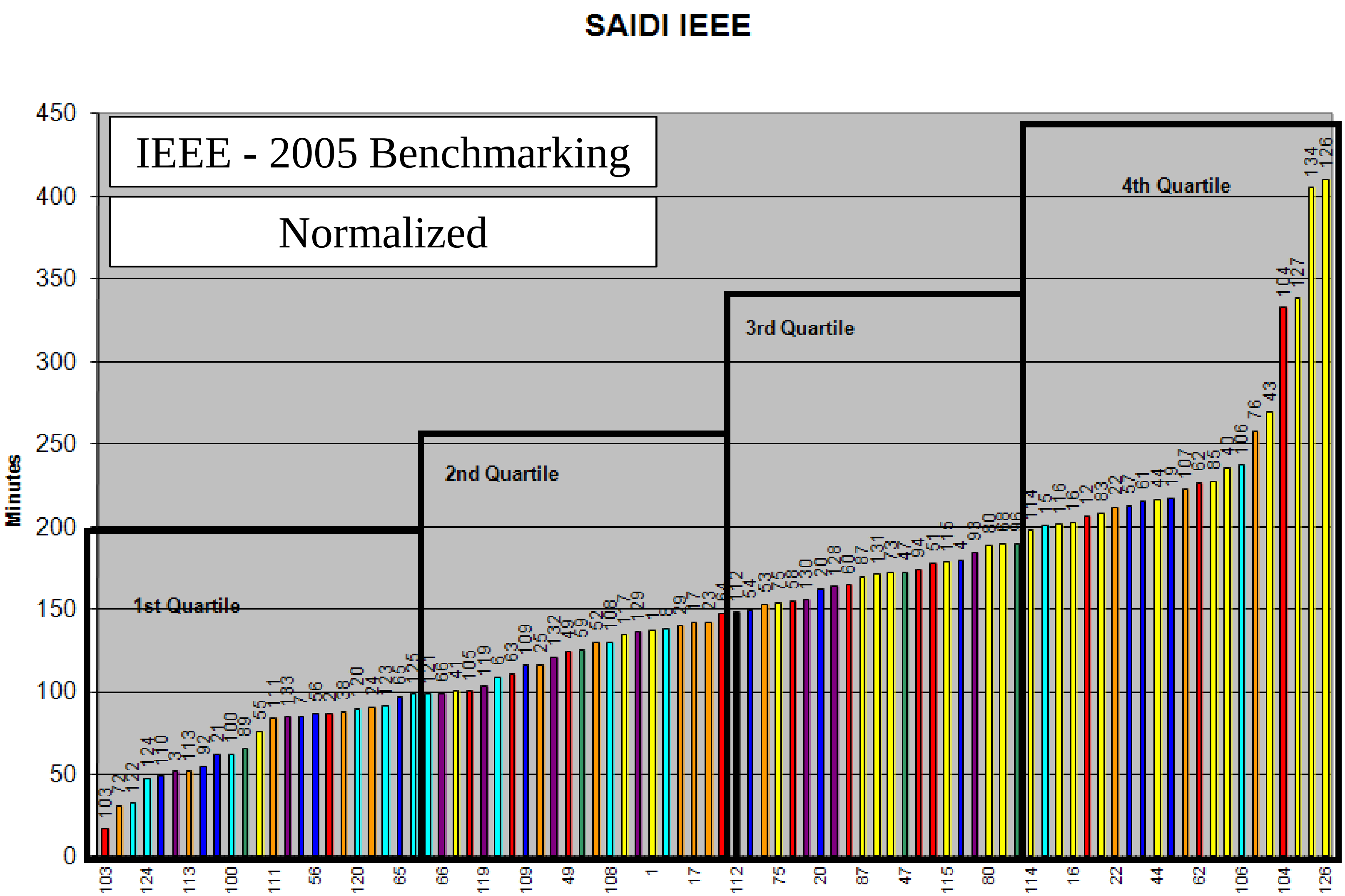
Variable	Units	Mean	Std. Dev.	Max	Min
SAIDI	Index	132.99	67.40	520.50	29.50
SAIFI	Index	1.21	0.46	3.87	0.47
Number of Customers	Number	970,946	1,109,545	5,278,736	25,878
% plant underground	Percent	0.20	0.10	0.48	0.02
Density	Ratio	43.94	23.05	150.09	16.74
% service Territory Forested	Percent	0.41	0.25	0.94	0.00

Why is Publically Available Data Preferable?

1. You can know who you are comparing yourself against and can make adjustments accordingly
2. Tends to be a bias in voluntary datasets
   - Top quartile performers join
   - 3rd and 4th quartile performers either don't join or drop out



Measuring Electric Power Reliability



Rural IOU vs. Urban IOU

- Rural IOU is smaller, less dense, less undergrounding, but with more vegetation than the Urban IOU
- Who is just naturally going to have the better reliability indexes?
  - Targets based on industry indexes will likely be too challenging for the rural utility and not challenging enough for the urban utility.
    - Said another way, the rural utility's target will cause them to spend too much on reliability and the urban utility's target will cause them to spend too little on reliability (relative to industry norms)

Developed Econometric Models

- SAIFI model with no MED outages

	Translog Model parameter estimate	Box-Cox Model parameter estimate
CONST	0.070**	0.070**
N	-0.050**	-0.032**
D	-0.098**	-0.110**
U	-0.080**	-0.114**
F	0.102**	0.108**
D^2	-0.055	-0.071
U^2	-0.021	-0.037
F^2	0.029**	0.031**
D*U	0.172**	0.131*
D*F	0.126**	0.138**
U*F	-0.141**	-0.143**
IEEE	-0.017	-0.007
TREND	0.000	-0.002
Rbar-sqr	0.322	0.321
λ		-0.200
**Coefficient estimates significant at least at the 95% confidence level.		
*Coefficient estimates significant at least at the 90% confidence level.		

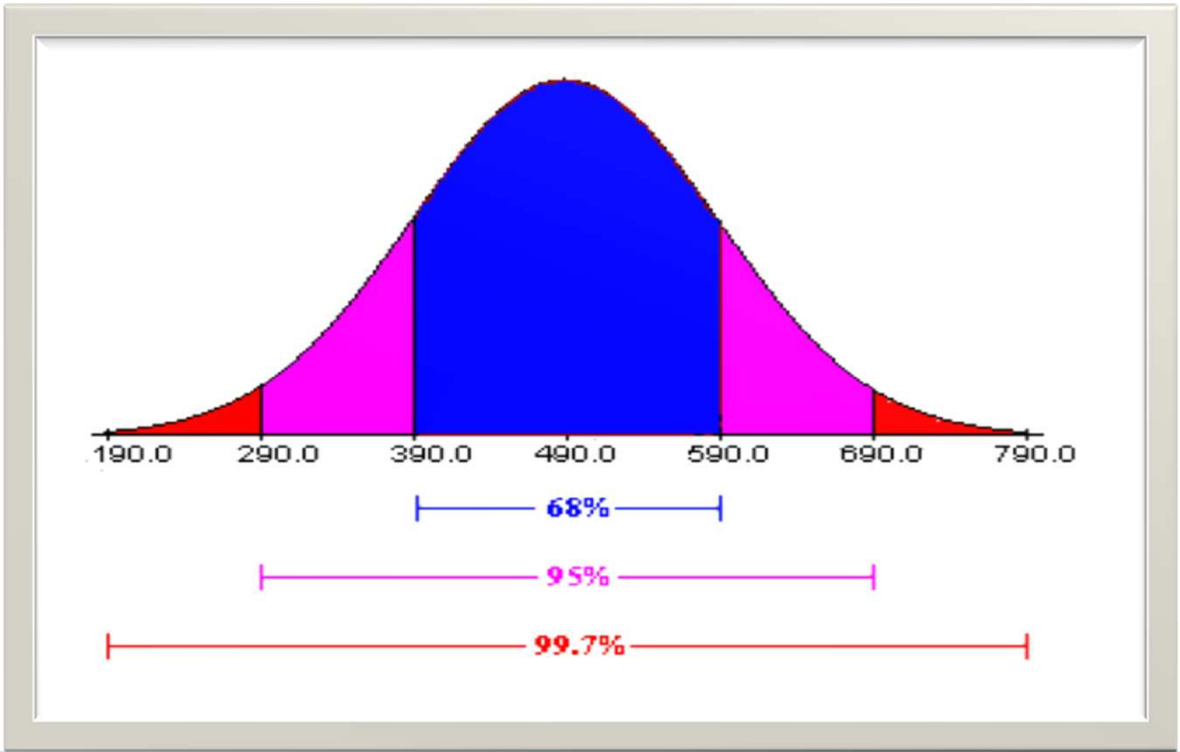
Econometric Benchmark Results

- While the urban utility has the lower indexes, the rural utility is performing much better relative to its benchmarks

Utility	Actual SAIDI	Benchmark SAIDI	% Difference
Rural	91	147	-38%
Urban	78	86	-10%

Targets based on Confidence Intervals

- An “industry norm” target is right in the middle (490.0 in this example)
- A target with a 95% confidence level in beating the industry can be set (290.0 in this example)



Summary

- Reliability benchmarking can be used to:
    1. Evaluate past performance and communicate this to internal management and external stakeholders
    2. Set internal goals and targets (utility-wide and by region)
    3. Help in determining if reliability-driven capital and O&M spending should increase or decrease (and in what region) to align with corporate goals
- Proper benchmarking requires adjustments to the service territory conditions faced by utilities
    1. Peer group
    2. Econometric

Questions?

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