Delivery Point Transmission Reliability Measures

Discussion document

Presented at the
SGS Transmission Reliability Benchmarking Conference

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Consultants to the Utility Industry

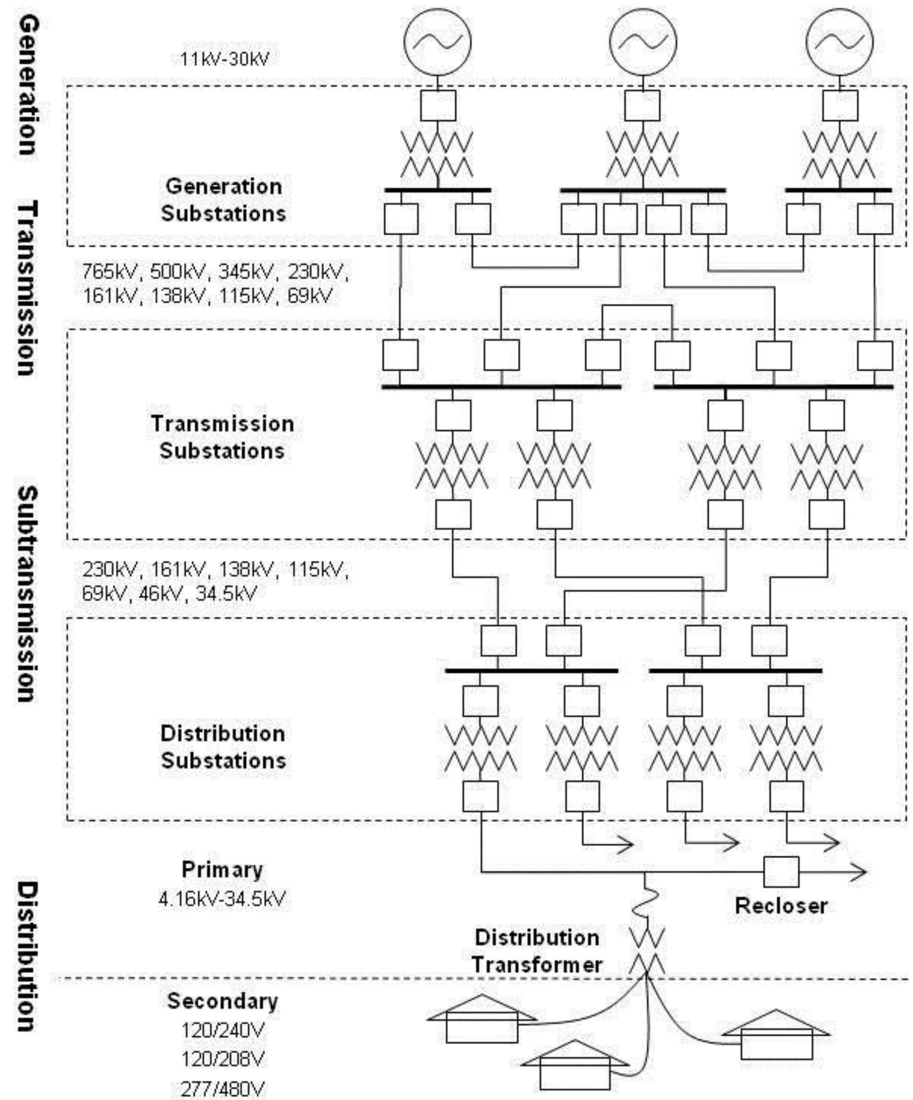
While the ‘typical utility’ is easy to envision…

Typical 1M Customer Utility Major Equipment Profile

Customers (#)	1 Million
Power Supplied (MW)	7,500
Transmission Lines (lines)	30
Transmission Line Miles (miles)	2,500
Transmission Substations (#)	20
Transmission Substation Transformers (#)	60
Transmission Substation Breakers (#)	360
Subtransmission Lines (lines)	42
Subtransmission Line Miles (miles)	2,500
Distribution Substations (#)	350
Distribution Substation Transformers (#)	875
Feeder Breakers (#)	1,750
Feeders (#)	1,500
Distribution line miles (miles)	40,000
Distribution Transformers (#)	200,000
Meters* (#)	1 Million

*North America typically has separate meter for electric, natural gas, and water; typically connect from one to 10 customers per distribution transformer due to lower secondary voltage

Simplified North American Electric Power System



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…not all ‘customers’ or delivery points are created equal…

Connected to the transmission system there may be:

- Subtransmission substations
- Distribution substations
- Industrial customers
- Municipal or co-op systems
- Military bases
- Transit systems
- Pumping stations (pipelines, water)
- Large campuses, malls, or airports

The impact on communities of an outage at some of these delivery points is much greater than a single ‘customer’

…So, delivery point reliability measures should be load-weighted

- Unsupplied energy (Unsupplied MWH or MWminutes)
  - Unsupplied load based on pre-interruption load, OR
  - Estimate of what load would be, esp. for longer durations
  - Annual measure divided by annual peak for each d.p., BUT
  - Added up over all d.p.'s, then divided by system peak for system measure (same issue as in distribution feeder SAIDI)
- Other issues with UE measures
  - Corresponding frequency measure?
  - Not affected by bus structure, like count of d.p.'s
  - Reflects partial restoration?
  - Includes momentaries?
  - Includes planned outages?
  - How does it compare to T-SAIDI?

$$\text{System Minutes of Unsupplied Energy} = \frac{\sum_{i=1}^{N} U_i \ x\ 60\ min/hr}{Pk}$$

Load-weighted reliability measures are also appropriate and necessary, although different than customer-weighted reliability measures

DP reliability is important because event 'size' is important

- Regulators' scrutiny is proportional to the 'size' of the event
  - NERC, states, and cities respond to major events with audits, fines, and get-well programs
- Reliability has costs that vary with severity of the event
  - Possible claims liability, public safety exposure, and societal costs all get bigger as MWs increase
  - Congestion costs related to line failure are likely to be higher when higher loads are involved
  - Customer satisfaction is affected more when communities can see widespread impacts of outages
- Load-related measures aid effective management
  - Project funding prioritization should take MW into account
  - Restoration prioritization should be affected by MW
  - Trending and benchmarking should include MW-weighted measures to ensure proper emphasis on what matters


Chicago Tribune
Chicagoland South
50¢ NEWSSTAND
Friday, August 13, 1999

DOWNTOWN BLACKOUTS

Power fails, sparks fly

"They have neglected their infrastructure for too long. . . . We are sick and tired of them, and they had better change."
Mayor Richard Daley

"This level of service under these conditions is a disgrace to us. It's a personal disgrace to me. I will not tolerate it, and you will not have to."

MW-weighted delivery point reliability is the ultimate answer to the question – why do we care so much about transmission outages?

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Major events cause regulatory scrutiny – the bigger, the more so…

Event Date	Type	Company	Regulatory Response
Jan 1997	Ice Storm	Entergy Gulf States (TX)	Audit, fine, get well programs
Jan 1998	NY/NE Ice Storm		Audits, get well programs
Jul 1999	Heat waves	Com Ed, Con Ed, PSE&G	Audits, DOE POST, get well
Jul 2001	Thunderstorm	Indianapolis Power & Light	Audit, Fines, get well
Dec 02/Feb03	Ice Storms	Duke Energy, Progress	Audits, UG Study, get well
Aug 2003	Blackout	Many companies in Northeastern North America	Congressional study, suits, new NERC rules, etc.
Oct 2003	Hurricane Isabel	PHI (Pepco, Delmarva)	Assessment, UG Study, get well
Dec 2003	Snow storm	PacifiCorp (Utah P&L)	Audit, get well
Aug-Sep 2004	Charley, Frances, Ivan, Jeanne	FPL, Progress, Southern	Rate recovery proceedings
Jul-Sep 2005	Dennis, Katrina, Ophelia, Rita, Wilma	Entergy, Southern, Progress, SCANA, FPL	Congressional hearings, audits, get-well programs
Jan, Jul, Sep Jul 2006	Wind storms Heat Wave	Con Ed – Westchester Con Ed – Northwest Queens	Audit, get-well programs
Jul 2006	Wind storm	Ameren IL & MO	Audits, get-well programs
Dec 2006	Wind storm	Puget Sound Energy, Seattle City Light	Audits, get-well programs
Dec 2007	Oklahoma Ice Storm	AEP, OG&E, Westar, OPPD	Audit, Fine, get well

…And 2008 was no exception

Selected Sample of Events

Event Date	Event Description	Companies hit hard	Customers Affected (000)	Days to Restore
Jan 2	Winter Storms	PG&E	2,600	10
Feb 10	High Winds	AYP, AEP, Dom, Duke	300	0.5 to 4
Feb 26	Transmission failure	FPL	900	0.5
Apr 9	Severe Thunderstorms	Oncor	500	3.5
Jun 10	Severe Thunderstorms	PSE&G, PECO	500	4
Jun 17	Severe Thunderstorms	Oncor	200	2.5
Jul 23	Hurricane Dolly	AEP-TX	200	8
Aug 4	Severe Thunderstorm	ComEd	600	1.5
Aug 19	Tropical Storm Fay	FPL, Progress	600	3.5
Aug 31	Hurricane Gustav	Entergy, CLECO	2,100	2.5 to 9
Sep 6	Tropical Storm Hanna	Dominion, Progress	100	0.5
Sep 12	Hurricane Ike-coastal	CenterPoint, Entergy	3,400	2 to 19
Sep 14	Depression Ike-inland	AEP, FE, AYP	2,400	3 to 8
Oct-Nov	Wildfires threaten trans.	SCE, LADWP, CAISO	600	
Dec 11	NE Ice Storm	Nat'l Grid, NU	1,700	10
Jan 27	MW Ice Storm	E.on, AEP	1,300	7
Feb 12	High winds	AYP, AEP	500	5

FPL Announces Preliminary Findings Of Outage Investigation

February 29, 2008 JUNO BEACH, Fla. – Florida Power & Light Company today announced preliminary findings of its ongoing investigation into the cause of an outage affecting approximately 584,000 customers on Tuesday, Feb. 26.

While still preliminary, the results of the investigation so far indicate that human error was the primary factor immediately responsible for the event, which began at 1:08 p.m. Eastern Time. A field engineer was diagnosing a switch that had malfunctioned at FPL's Flagami substation in west Miami. Without authorization, the engineer disabled two levels of relay protection. This was done contrary to FPL's standard procedures and established practices. Standard procedures do not permit the simultaneous removal of both levels of protection.

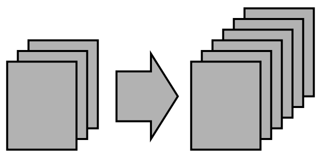
During the diagnostic process, a fault occurred and, because both levels of relay protection had been removed, caused an outage ultimately affecting 26 transmission lines and 38 substations. One of the substations affected serves three of the generation units at Turkey Point, including a natural gas unit as well as both nuclear units, which, as designed, automatically and safely shut down due to an under-voltage condition. Also affected were two other generation plants in FPL's system. Total impact to the system was a loss of 3,400 megawatts of generating capacity.

"First, I want to reiterate my apology to our customers …," FPL President Armando Olivera said. "These preliminary findings address the most pressing questions that have been posed. We are committed to completing a full and thorough investigation, to cooperating fully with the appropriate regulatory agencies and to sharing our findings publicly when the investigation is completed. We will address any issues that are identified in order to prevent a recurrence," Olivera said. "While the investigation is ongoing, to this point we have no indication that there are any deficiencies with the design of our facilities or with our maintenance procedures. However, out of an abundance of caution, we have implemented interim changes governing relay protections to prevent a recurrence," Olivera said.

The final account of customers affected by this incident on Tuesday totals 584,000 customers, or 13 percent of FPL's total. Of these, 66 percent had power restored within an hour, 90 percent within two hours and virtually all customers whose service was affected by this event had service restored by 4:30 p.m. …

Capital prioritization values the benefits of avoiding outages

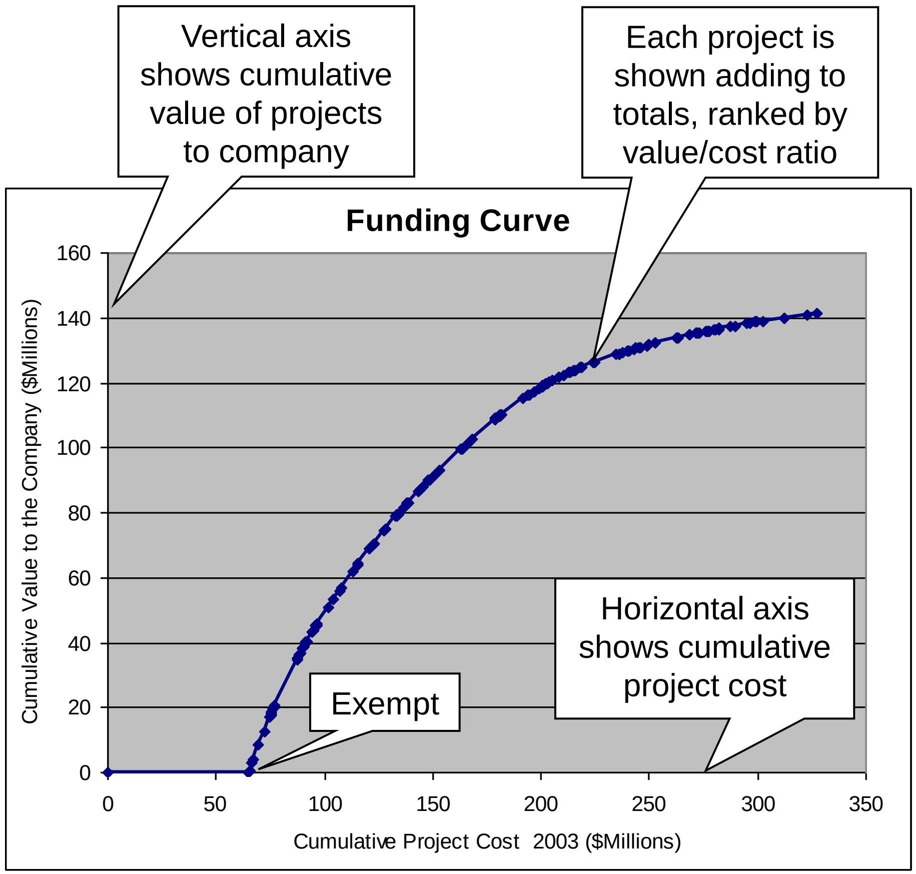
The ‘funding curve’ ranks each major project/option by its ‘bang per buck’

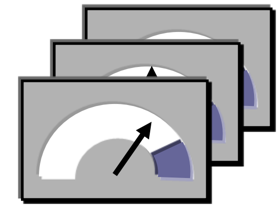


Option Development

Developing cost-effective <u>alternatives</u> for possible funding

- Additions
- Upgrades
- Replacement
- Maintenance
- Standards
- Systems





Results Monitoring

Measuring & managing the <u>drivers</u> of the funded projects and processes

- Benchmarking
- Unit costs
- Failure rates
- Event impacts
- Value added

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Costs of reliability failure have various sources…

- **Restoration**
  - Rolling a crew, switching to make field ties for partial restoration, installing a mobile
  - Replacement of failed equipment, e.g., fuse, pole, transformer
  - Calls, customer contact, media relations, public information
- **Collateral damage**
  - Explosion, fire, or high-energy fault may damage related equipment
  - Contingency may cause overload-related damage or premature deterioration
  - May cause tripped lines or units that causes uneconomic dispatch
- **Customer claims**
  - Loss of refrigerated food, process batches, medical support
  - Not liable for ‘acts of God’, but provable negligence may be culpable
  - Legal costs to defend against suits, negotiate settlements
- **Penalties, fines, audits, remediation, and reporting**
  - Audit or investigation of root cause (internal and external resources)
  - Compliance with recommendations for future avoidance of that event
  - Costs multiplied by remediation at all similar substations or all reliability programs
  - Possible fines, refunds, or disallowances
  - Cost of increased reporting, scrutiny, and lost ‘benefit of the doubt’
- **Financial impact through lost image/confidence**
  - Loss of customer satisfaction with rates – possibly lower allowed return in next filing
  - Loss of influence with the public and media – dealing from weakness in negotiations
  - Loss of investor confidence – possible decline in share price, bond rating

…and vary considerably by type of event

Potential Cost to the Company		Typical Cost per Event
$ 1 Million per year	**Claims & payments**	$50 - $100 per claim made; higher for C&I than residential
$5 Million per year	**Penalties, fines, (PBR-like)**	$10 - $50 per customer out
$10 Million per year	**Outage restoration & collateral damage**	$500-$100,000 per outage
$25 Million per year	**Major event audits, mandated programs, remediations, reporting**	$10,000-$100,000 per MWH $50-$200 per customer out
$25 Million per year	**Adjustments to rate base and allowed rate of return**	$10,000-$100,000 per MWH

Reliability affects customer satisfaction

- Reliability is only one component of overall satisfaction; typically 20%
- Increasing the satisfaction score for that component by 5 points may require a 0.25 reduction in SAIFI
- For a company with 1 million customers, a 0.25 reduction equates to 250,000 fewer interruptions
- If the cost of eliminating each interruption is $100, the total cost would be $25 million for a 5-point improvement in that component, which might yield only a 1-point improvement in the overall satisfaction score

As yet, no studies have been done to see how a MW-weighted measure might affect satisfaction similarly, or perhaps even more

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Typical 'customer commitments' cover less than 1% of customers

Customer refund programs (paid only to those customers whose claim fits the criteria)

ComEd "Commitment"	$60-$100 per customer interruption over 8 hours
IPL refund	$100 per customer interrupted over 36 hours in the storm of July 8, 2001
PacifiCorp guarantee	$50-$100 per customer for missed service levels, e.g., $50 for residential over 24 hours, $100 C&I $25 for each additional 12 hours
Entergy-Texas refund	$33 per customer (for 120,000 customers)
Michigan refund (Rules 44, 45, 46)	$25 per customer for frequent (>7) or long outages (over 16hours normal, over 120 hours catastrophic)
ConEd	$100 (residential) - $2,000 (commercial) for outages over 12 hours that caused spoilage or loss since 1973, increased to $350 - $7,000 after summer of 1999

Typical PBR-like penalties are just enough to get attention

PBR-like penalties - based on targets for service quality indicators for the whole company

Utility	State	Custs. (000's)	Target Indicator	Target	CI's Over Target	Penalty ($000's)	Penalty Per CI
IPL	IN	433	SAIFI	0.67	14,506	$1,000	$68.94
SCE	CA	4,271	Outages	10,900	18,300	$1,000	$54.64
SDG&E	CA	1,185	SAIFI	0.90	11,850	$250	$21.10
Westar/KCP&L	KS	1,028	SAIFI	1.44	308,400	$3,000	$9.73
CMP	ME	550	SAIFI	1.80	79,200	$400	$5.05

IPL - $1M penalty (each) assessed for any more than 2 of 8 indicators missed; assume 5% SAIFI miss will trigger

SCE - Has +/-1100 outage deadband; $1M penalty per 183 outages; assume 100 CI/outage

SDG&E - $250k per .01 change in SAIFI up to $3.75M

Westar/KCP&L - Up to $3M penalty for up to .3 miss on SAIFI, increasing geometrically ($300k for .06 miss)

CMP - $400k penalty per 'point', 8% miss on any of 8 indicators (incl. SAIFI, CAIDI) gets 1 point

Major events that make front-page news are the most expensive

Major event costs – including audit, fines, mandated programs, reporting, and compliance

Utility	State	Custs. (000's)	Year	Event	Audit	Event MWH	Remedy $million	$k per MWH
ComEd	IL	3,470	1999	Substation failures	✓	5,000	$1,100	$220
ConEd	NY	3,055	1999	Network failure	✓	2,675	$281	$105
Pepco	DC	696	1999	Network failure	✓	1,600	$45	$28
GPU	NJ	1,028	1999	Substation failure	✓	6,000	$56	$9
Entergy	TX	550	1997	Ice Storm in TX	✓	5,000	$25	$5

$$\frac{\$24\text{k}}{\text{MWH}} \times \frac{.005\text{MW}}{\text{Customer}} \times \frac{\text{Hour}}{60\text{ Min}} = \frac{\$2.00}{\text{CMI}} \times \frac{100\text{ min}}{\text{outage}} = \frac{\$200}{\text{CI}}$$

Evidence indicates that feeder outages due to weather and normal deterioration generate much less remedial cost than substation failures at peak or widespread and catastrophic system events.

For this reason, values equivalent to $200 per CI are used for the latter while values like $25-50 per CI are used for the former.

The impact on rate base and allowed return is also significant

Utility	Rev ($Bil.)	Custs. (000's)	Issue	Potential Impact
ComEd	15.0	3,400	Partial disallowance of remediation in distribution service tariff	$500 million
GPU/JCP&L	2.0	1,000	Disallowance of a portion of distribution costs in rate request due to reliability problems	$220 million

On a rate base of $3 billion, a 50 basis point disallowance amounts to $15 million per year, comparable to some of the largest PBR penalties.

With a rate of return on rate base of 11 percent, a disallowance of $100 million from inclusion in the rate base reduces income by $11 million per year.

On a rate increase request of 5 percent of $1.5 billion distribution revenue, granting only 50% of the request would amount to $37.5 million per year.

Observations and Key Questions

Observations

- Major events cause major responses, and regulators tend to react when the impact on communities is large, which can mean disruption of only a few delivery points, but many MWs
- Internal management systems pay heed to both customer-weighted and MW-weighted measures, both for prioritization of projects and for restoration of outages
- Both for the utility and the community, costs are proportional to load, and so measures to avoid costs should take load into account

Key Questions

- Although regulators use SAIDI and SAIFI for monitoring and incentivizing reliability, how would they react to an outage to a single delivery point with over 100 MW of load?
- Do your internal management processes and external communications reflect the reality of how management and regulators react to large blocks of unserved energy?

Questions?

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Be careful what you measure. People often respond to what you measure even more than what you say you care about.