Application of Risk to Transmission Planning

IPC Grid

March 2019

Overview

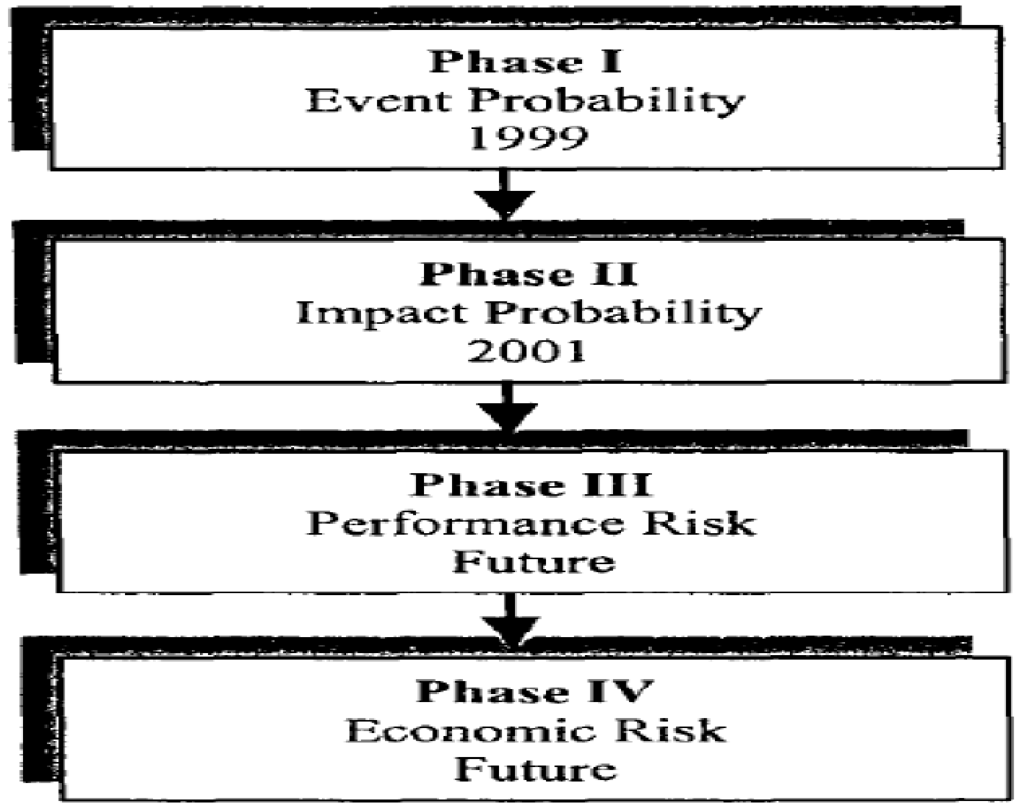
- Hamody Hindi
  - Bonneville Power Administration Planning Engineer since 2011.
- In April 2018, BPA hosted a workshop on applications of risk to transmission planning covering:
  - History in WECC
  - Application to Transmission Reliability Planning
  - Application to Operational Planning
  - Application to Commercial Planning
  - Other Applications in the Industry

Acknowledgements

- **Milorad Papic** (M’88–SM’05), works with IPC in the System Planning department. He received his Ph. D degree from Sarajevo University. Prior to his arrival at IPC in 1996, Dr. Papic held an Associate Professor position at Sarajevo University. He has over 35 years of research and development experience, teaching, planning, and reliability assessments of BESs. He is active in many committees and working groups of IEEE PES, WECC, and NERC. Dr. Papic is a member of CIGRE
- **Jeff Billinton** is the manager of Regional Transmission – North at the California ISO. He has worked at the California ISO since 2011. Jeff has a Bachelor of Science in Electrical Engineering from the University of Saskatchewan, Canada and over 29 years of experience in the electric utility industry in distribution and transmission system design, construction, operations and planning.
- **Tracy Rolstad** Received his BSEE from University of Idaho and then served in the Nuclear Navy. Tracy has been with BPA operations, and is presently a senior Power System Planner with Avista. He has also served as WECC TSS Chair, Vice chair and secretary.
- **Eric Heredia** received his BSEE from University of Portland in 2002, then joined BPA transmission planning from 2002 to 2015. Since 2015 he has worked in BPA operations as the technical lead for NWACI
- **Anita Heredia** received B.S. from University of Washington in 2003 and M.S.E.E. from PSU in 2010. She has been with the Bonneville Power Administration for 13 years in Transmission Planning, Transmission Operations, and Long Term Strategic Planning
- **Randy Hardy** served as BPA administrator from 1991 to 1997 and was a former chairman of EPRI, past Executive director of PNUCC, past president of APPA. Recently he has worked as a consultant to facilitate integration of wind energy in the PNW.
- **Ryan Egerdahl** is Manager of BPA’s Long Term Power Planning organization and has been with the agency since 2001. He graduated with distinction from the University of Minnesota Duluth with a Bachelors Degree of Finance in 1998 and received a Masters of Business Administration Degree from the University of Oregon in 2001.
- **Gordon Dobson-Mack** joined BC Hydro in 1990 and currently works for BC Hydro’s marketing subsidiary Powerex Corp as Manager, Inter-Utility Planning and Coordination. He is a Senior Member of the I.E.E.E. and a registered Professional Engineer in the Province of B.C
- **Anders Johnson** is an Electric Engineer with Bonneville Power Administration in transmission planning and long term planning.
- **Tom Coatney** has been with Bonneville Power Administration since 2009. He is currently a Senior Market Analyst in our Transmission Sales and Policy where his most recent focus has been to implement enhanced data analytic capabilities.
- **Dmitry Kosterev** is the principal transmission planning engineer for the Bonneville Power Administration. In addition to transmission planning, he has led the development of BPA’s PMU applications. He has also led dynamic model development in WECC.

History of Risk Application in WECC

- 1996 WECC initiated a Probability Based Risk Criteria (PBRC) effort based on membership survey of existing deterministic criteria
- 1998 PCC approved the PBRC Phase 1 implementation plan.
- PBRC phase 1 developed Performance Table W-1 which accounted for event probabilities
- Ultimate Goal was to produce a more economically efficient system without sacrificing transmission system reliability
- Considered MTBF, Robust Line Design Features, Exposure Analysis, and Consequence of an outage to reclassify outages based on risk analysis
- Followed Classical Reliability theory of Roy Billinton and others



"Probabilistic Based Transmission Planning and Operation Criteria Development For the Western Systems Coordinating Council" M. Beshir, 1999 PES meeting

PBRC Stalls

- PBRC did not gain traction in industry because:
  - Collecting Outage data is challenging
  - Occurrence of a single event can significantly change performance requirements
  - Computation can be intensive compared to deterministic method
  - Dealing with high impact low probability events is difficult (i.e. 3 PV event June 2004)
  - Deterministic method has served industry fairly well

TPL-0010-WECC-CRT-3, retired 2016

NERC and WECC Categories	Outage Frequency Associated with the Performance Category (outage/year)	Transient Voltage Dip Standard	Minimum Transient Frequency Standard	Post Transient Voltage Deviation Standard (See Note 3)
A	Not Applicable	Nothing in addition to NERC.		
B	≥ 0.33	Not to exceed 25% at load buses or 30% at non-load buses. Not to exceed 20% for more than 20 cycles at load buses.	Not below 59.6 Hz for 6 cycles or more at a load bus.	Not to exceed 5% at any bus.
C	0.033 – 0.33	Not to exceed 30% at any bus. Not to exceed 20% for more than 40 cycles at load buses.	Not below 59.0 Hz for 6 cycles or more at a load bus.	Not to exceed 10% at any bus.
D	< 0.033	Nothing in addition to NERC.		

Performance Level Adjustment Record (PLAR)

Facility Outage	Specified Category	Adjusted Category	>300 Yr MTBF	Date BOD Approved
Hassayampa-Pinal West and Hassayampa-Jojoba 500 kV ine	C	D	No	6/27/2012
Hassayampa-Pinal West and Jojoba-Kyrene 500 kV line	C	D	No	6/27/2012
Hassayampa-North Gila existing and 2nd Future 500 kV lines	C	D	No	12/8/2010
Palo Verde-Westwing Line 2 and Palo Verde-Rudd 500 kV lines	C	D	No	12/8/2010
Imperial Valley-Miguel and Imperial Valley-Central 500 kV lines	C	D	No	4/16/2008
Both Palo Verde-Westwing 500 kV lines	C	D	No	Aug-03
Raver-Echo Lake and Shultz-Echo Lake 500 kV lines	C	D	Yes	Aug-02

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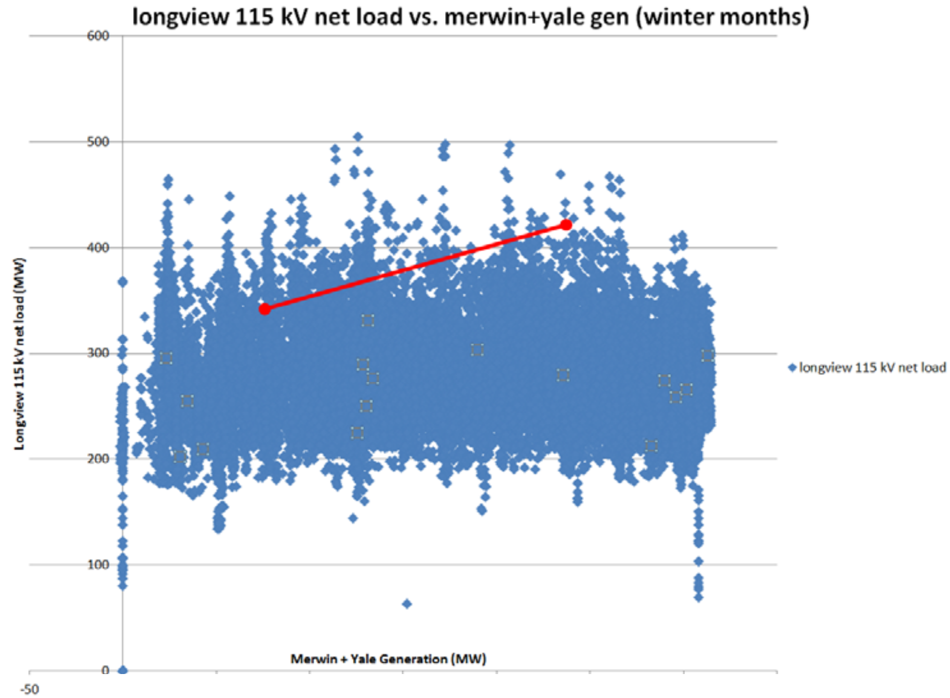
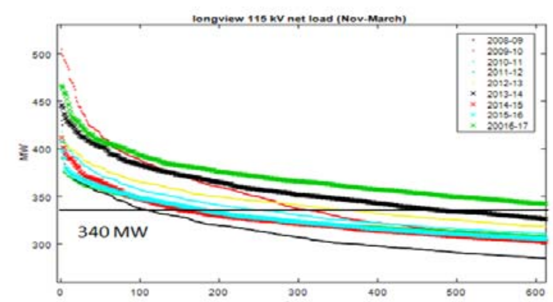
Local Load Area Planning

- Classical outage probability is hard to apply to BES
- Even without it, plenty of opportunity for risk analysis within NERC TPL framework
  - What duration, frequency, and magnitude of load loss is acceptable?
  - If you lose two critical pieces of equipment during peak load, you may have to shed some load to prevent worse system impact, as allowed by the NERC TPL standard
  - When do you plan for load loss vs. launching a system reinforcement?

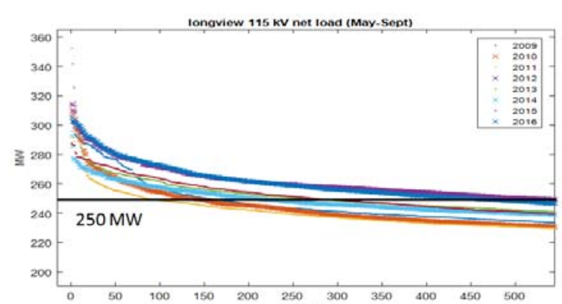


Load Duration

WINTER



SUMMER



CAISO Standards

- Exceeds NERC and WECC requirements
- Describes requirements in configurations must be looped vs. radial (avoid consequential load loss)
- Single contingency cannot result in > 250 MW load loss (consequential)
- High density urban load areas may not rely on NCLL for P2-P7 except as a bridge measure

How to Prioritize Projects?

- Avista's Approach: Priority = (Consequence) x (Probability)

- Limitations
  - LGIA's
  - Load service
  - Delayed projects
  - Limited Resources

$$\text{Consequence Factor} = (\text{Stability} + \text{Thermal} + \text{Voltage}) \times (\text{Load} + \text{Generation})$$

Stability and Thermal Factors		Voltage Factors	
Extreme, widespread	10	**Load Loss**	10
Severe, multiple	5	**Very Low (<0.8pu)**	5
Moderate, localized	2	**Low (<0.95pu)**	2
Minor, small impact	1	**High**	2
None	0	**None**	0
Load Affected		**Generation Affected**	
Total MW of load subjected to inadequate performance or required to drop to mitigate violations		Total MW of generation subjected to inadequate performance or required to drop to mitigate violations	

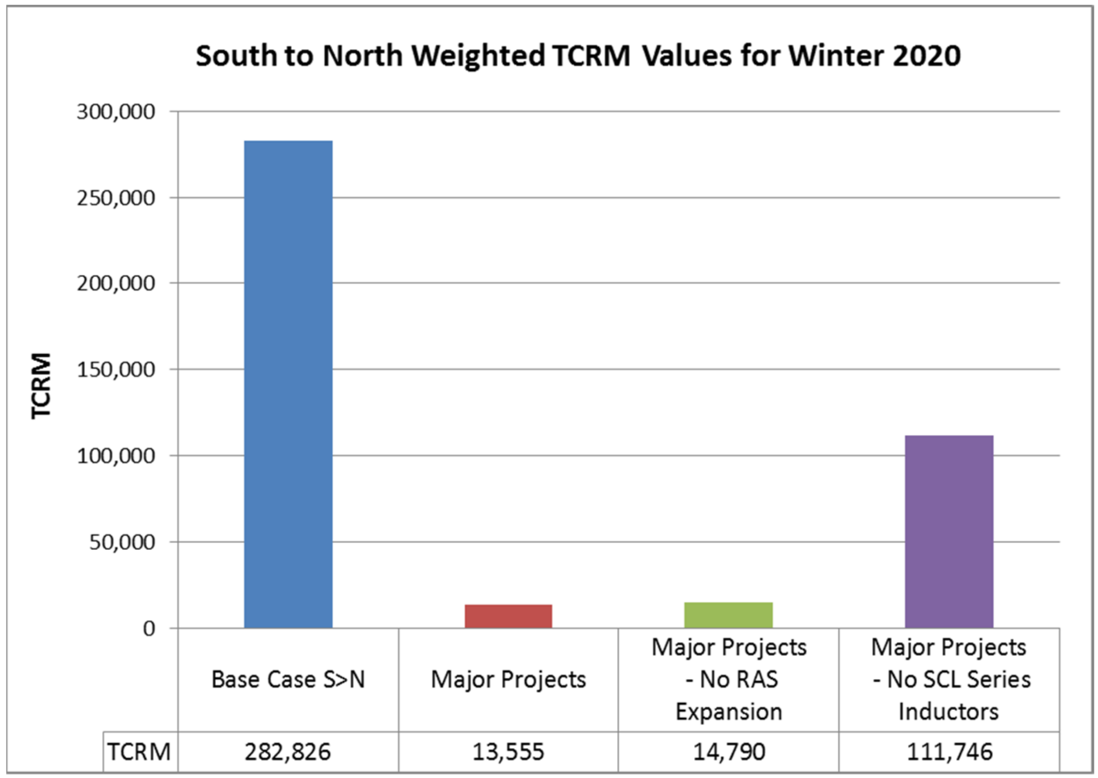
$$\text{Probability Factor} = \text{Seasonal Condition} \times \text{System Condition} \times \text{Time Frame}$$

Seasonal Condition Factors		System Condition Factors	
All Seasons	1	**P0 – All line in service**	1
Average (occurs frequently)	0.75	**P1 – N-1**	0.5
Light Loading	0.25	**P2, P4, P5, or P7 – Multiple outages**	0.1
Summer and Winter Peak	0.25	**P3 or P6 – N-1-1**	0.075
Summer or Winter Peak	0.125		

Time Frame Factor	
Present	1
Future	$1/(Start - 2014)$

Risk of Transmission Curtailment: Puget Sound Area Case Study

- Curtailment Events in winter 2004 and 2009 heightened concerns that transmission curtailment could result in firm load curtailments in the Puget Sound Area, despite the Planning Criteria being met



- 21 million scenarios analyzed
- Conclusions:
  - Clear benefit for reinforcements, especially series inductors
  - Clearly no benefit for RAS expansion
  - Considered "usual suspects" based on operating experience

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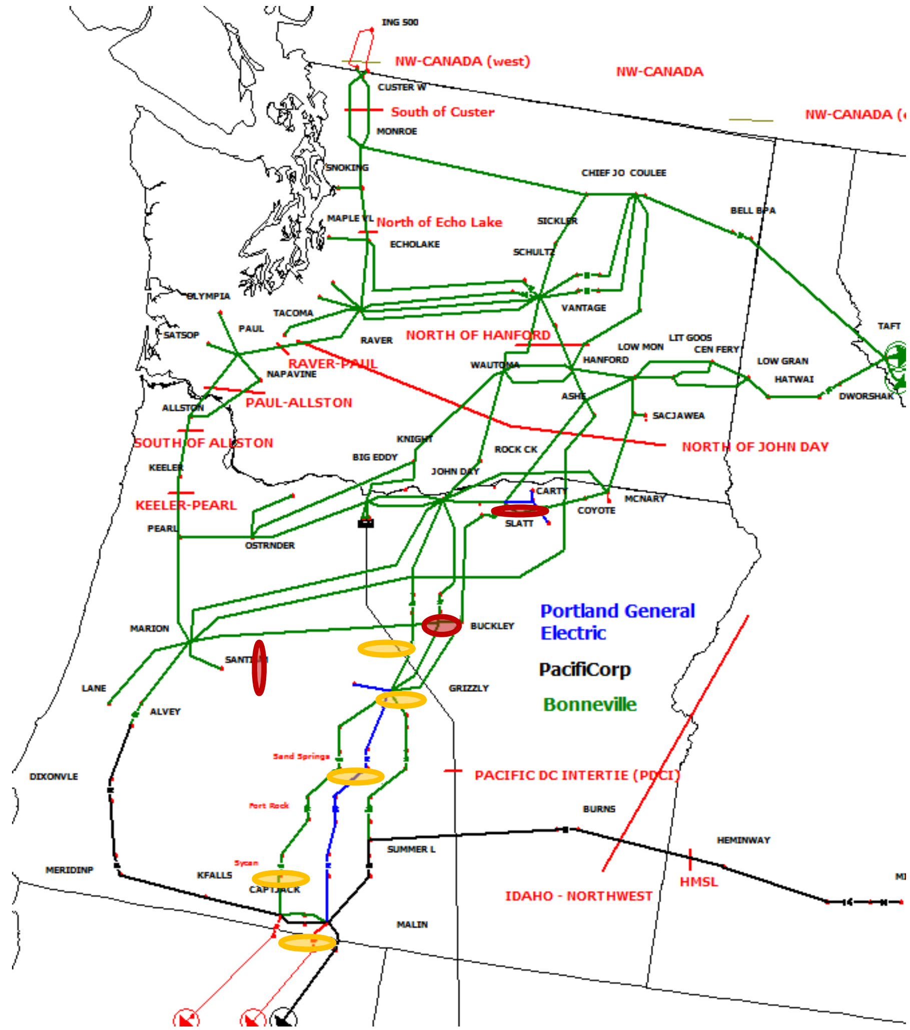
Risk Based Planning Applied to COI

- Since 1996 we've had 7 simultaneous N-2 line loss events while COI flow was high
- 5 were in PNW, 2 in CA
- For PNW events, at least 1 of 2 lines was restored back in service within 6 minutes
- For CA events, manual reclosing took over 40 minutes
- Some of these events were Adjacent line losses (which operations sets limits for)
- Some of these N-2 events were non-adjacent common corridor line losses, which operations does not currently sets limits for

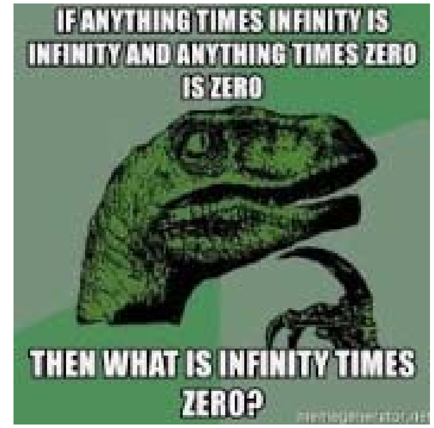


Adjacent Circuits Common Tower Circuits

Risk Based Planning Applied to COI

- Scenario:
  - forced maintenance outage of a major 500 kV line
  - Need to set new COI limits until outage is over
- Option 1 (used today):
  - Set COI limit based on ADJ N-2 resulting in 100% thermal limit (used today)
  - COI limit: 2500 MW
- Option 2:
  - Set COI limit based on ADJ N-2 stability limit (voltage stability, transient stability, or 125% thermal limit)
  - COI limit: 3400 MW
- Option 3:
  - Set COI limit based on ADJ N-2 only if there are special conditions increasing risk of N-2 in the area (fires)
  - COI limit: 4300 MW

Conclusions



- Classical Probabilistic Reliability is challenging to implement because of outage probability
  - Hard to gather enough good data
  - Hard to fit classical outage probability within existing NERC standards
- NERC TPL standard allows for application of risk and probabilistic analysis
  - Selection of Scenarios (load level, generation, etc.)
  - More likely contingencies have a higher performance requirement
  - How much load loss and firm transmission curtailment to rely on?
- Alignment of Planning and Operations is critical to optimize utilization of the system

Questions?


WE'LL NEED A RISK ANALYSIS ON THIS PROJECT BEFORE I CAN APPROVE IT.
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S. Adams
RISK 1: INDECISIVENESS
RISK 2: OVERANALYSIS
RISK 3: CLUELESSNESS
RISK 4: MICROMANAGE-MENT...
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