
Increasing Utilization of the Transmission Grid Requires New Reliability Criteria and Comprehensive Reliability Assessment

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Why Reliability Criteria

- To ensure an appropriate degree of reliability when designing and operating the grid
- **Planning criteria** provides infrastructure to facilitate economic and reliable operation
- **Operating criteria** determines the trade-off between economic utilization of the grid and reliability

How are reliability measured?

Bad things happens:

- **How often?**
- **How long?**
- **How bad?**

The Problem: Deterministic criteria addresses quantitatively only “**how bad**”

Deterministic Operating Criteria

N-1 Criteria: test for outage of single line,
transformer, generator

Sometimes supplemented by outage of two circuits
on the same structure and other special cases

The possible consequence of events “beyond” N-1
criteria do not limit system utilization

Probabilistic Operating Criteria

These account for “**how often**” and “**how long**” in addition to “**how bad**”.

Not Used!

Why be concerned about N-1 criteria?

Ignores differences in

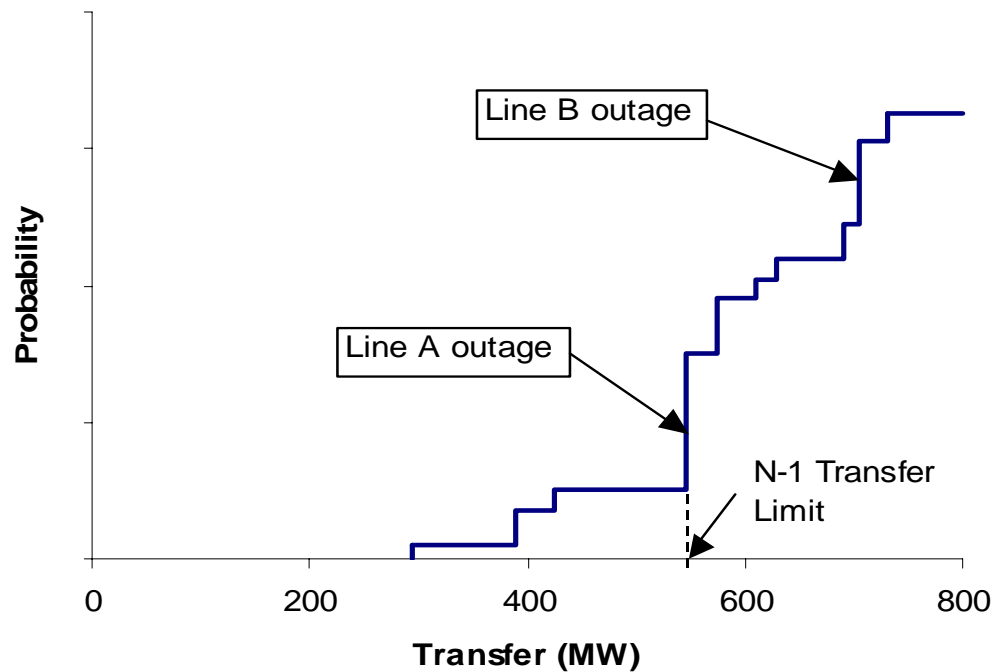
- reliability of individual components (may be orders of magnitude)
- severity of occurrences in overloads or voltage problems

Ignores

- simultaneous outages or two or more circuits
- multiple outages because of substation or protection system failures (historically disturbingly regular)

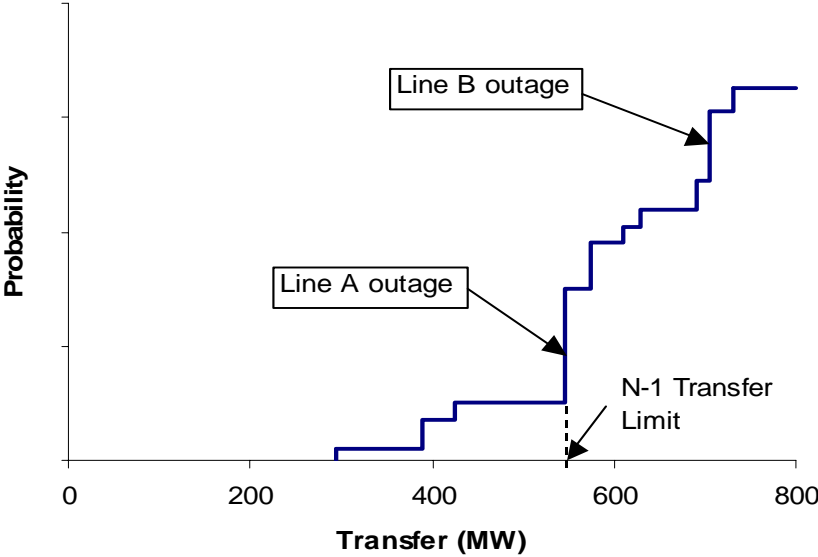
Probability of exceeding line ratings for single and two-circuit outages

Probability of exceeding line ratings

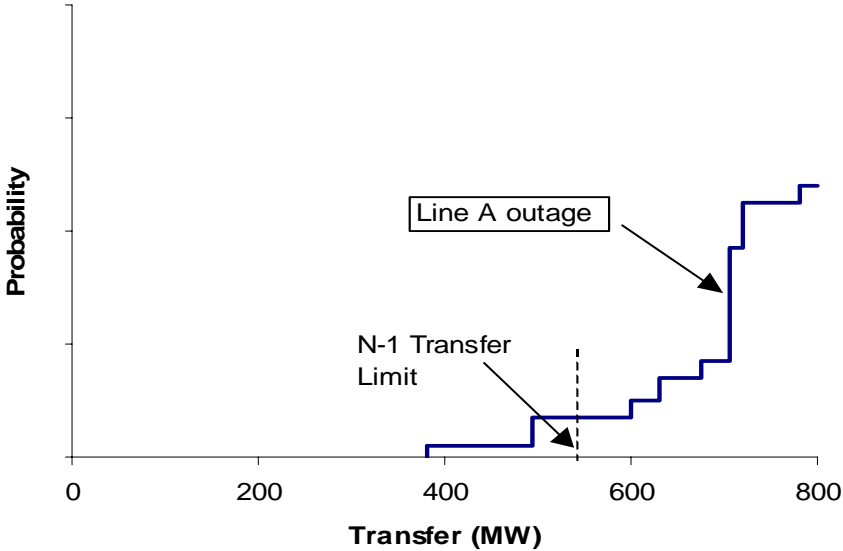


Probability of exceeding line ratings for single and two-circuit outages

Probability of exceeding line ratings



Probability of exceeding 130% of line rating



How about blackouts?

In general N-1 criteria do not address the type of disturbances that causes blackouts

Thesis:

Blackouts have been infrequent in the past –
not because events beyond N-1 criteria do
not happen on a regular basis
**but because systems most of the time
have had adequate margin to handle the
“beyond criteria” disturbances.**

Probabilities have been our friends!

Decreasing Margins – Increasing Utilization of the Grid

Grid elements are becoming more uniformly loaded at levels near their ratings

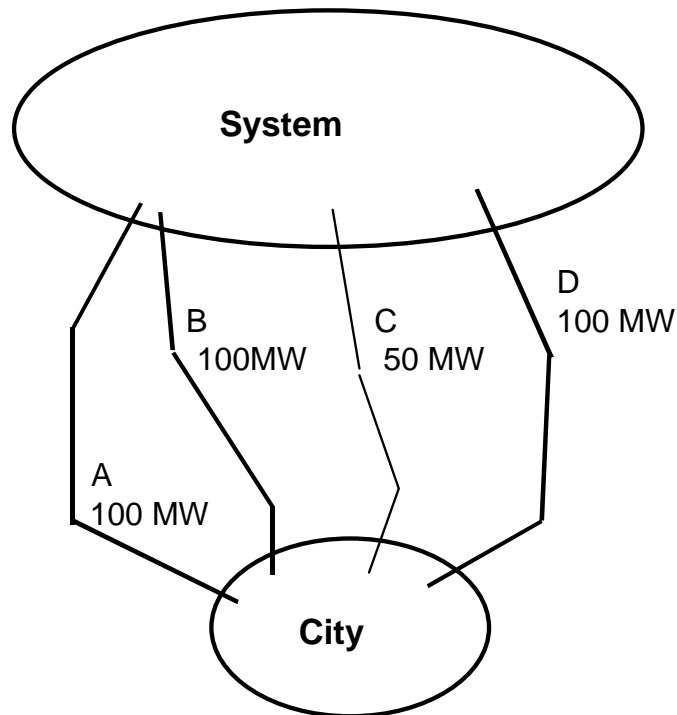
- New generation located to utilize spare Grid capacity (determined by N-1)
- Pressures from multiple participants in the open access paradigm (maximize utilization within N-1)
- FACTS devices including **PAR** and **series reactors** to balance loading on parallel paths
- Relaxed ratings (higher wind speed assumptions)
- Dynamic ratings and transient ratings
- SPS or RAS systems
- Operating procedures for specific contingencies

Another concern

Time exposure to high grid loadings may be increasing because of increased diversity in system utilization

Probabilities are getting less friendly!

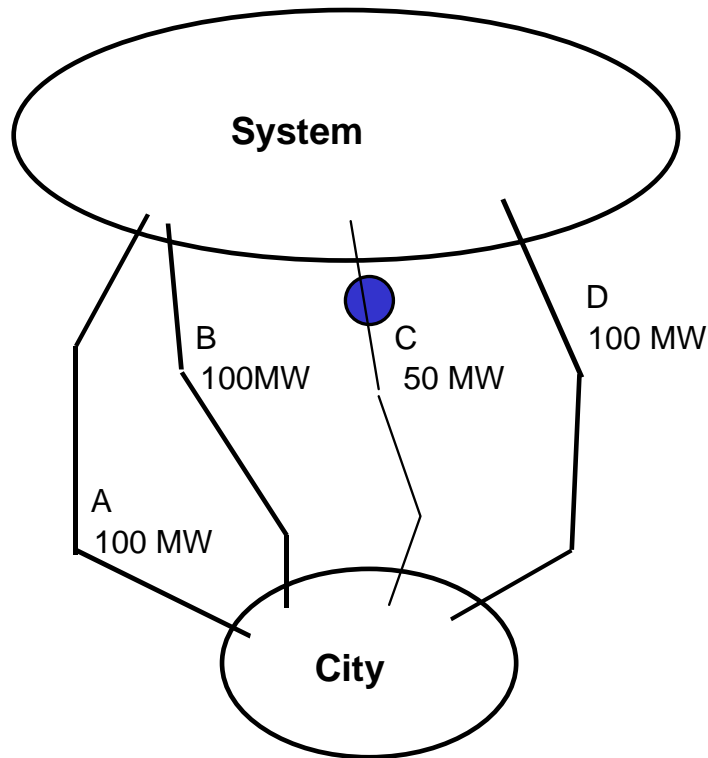
City relying on imports over multiple paths – one weak path



1. Equal impedances on all paths
2. Max import = 150 MW (N-1)
3. Two-circuit outage loads C to 75MW.

50% overload is manageable as emergency loading (some load shedding)

Reliability impacts of ideal **FACTS device**



1. Increased import desired
2. Separation blacks out city
3. **FACTS device** in line C will limit post-contingency loading of C to 50 MW
4. Max import = 250 MW
5. Two circuit outage loads line rated 100 MW to 200 MW
(100% overload and Blackout)

A Reppen Prediction

- Systems operated in accordance with present N-1 criteria will experience more and more severe instances of high risk of blackouts
- On-the job training of operators will become more effective – less boredom
- Producers of backup equipment will become the new darlings of Wall street

What options do we have?

- Improve deterministic criteria
 - More comprehensive criteria
 - Test criteria using probabilistic techniques
- Use probabilistic criteria and methods in operation: possible but perhaps not likely