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

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# Why Reliability Criteria

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- 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?

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Bad things happens:

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

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

# Deterministic Operating Criteria

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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

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

**Not Used!**

# Why be concerned about N-1 criteria?

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Ignores differences in

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

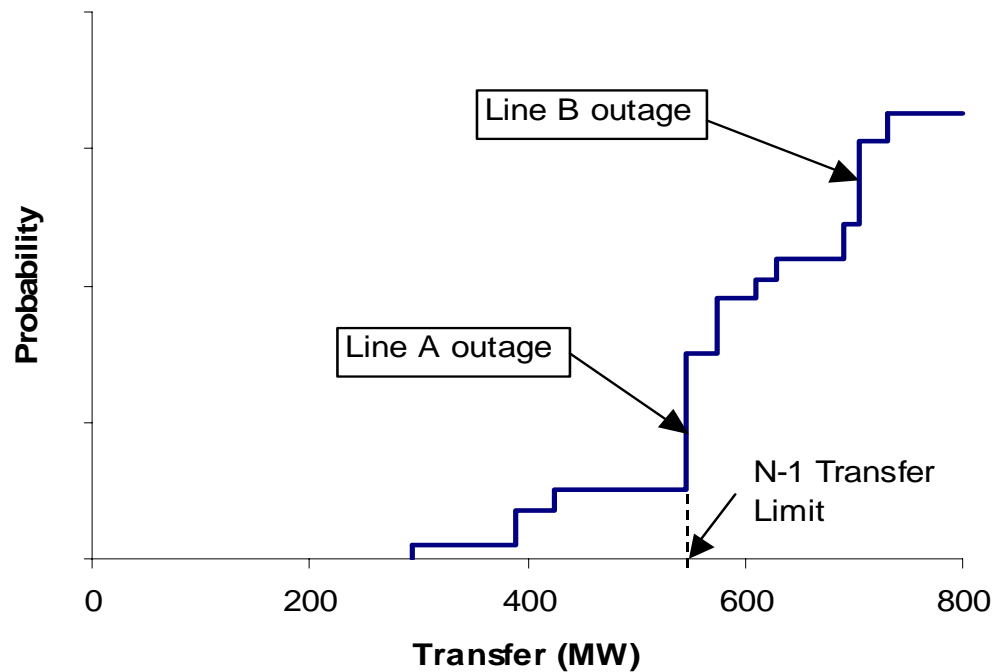
Ignores

- 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

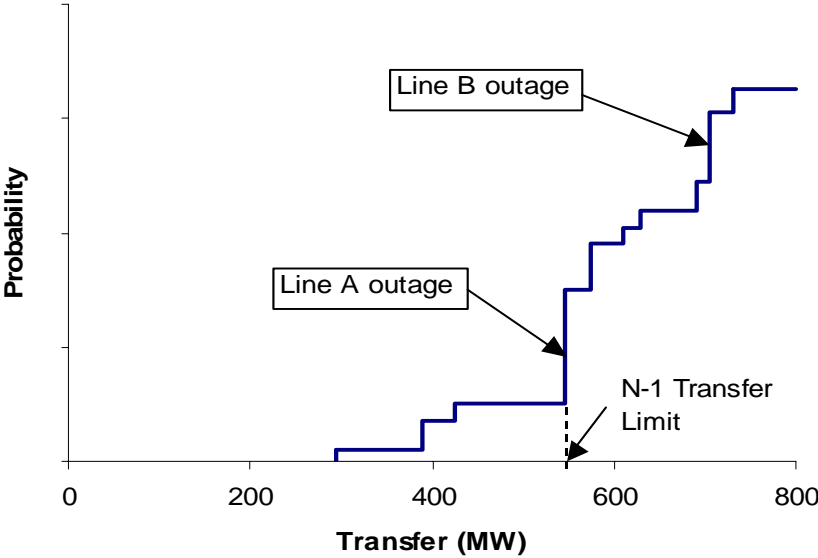
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Probability of exceeding line ratings

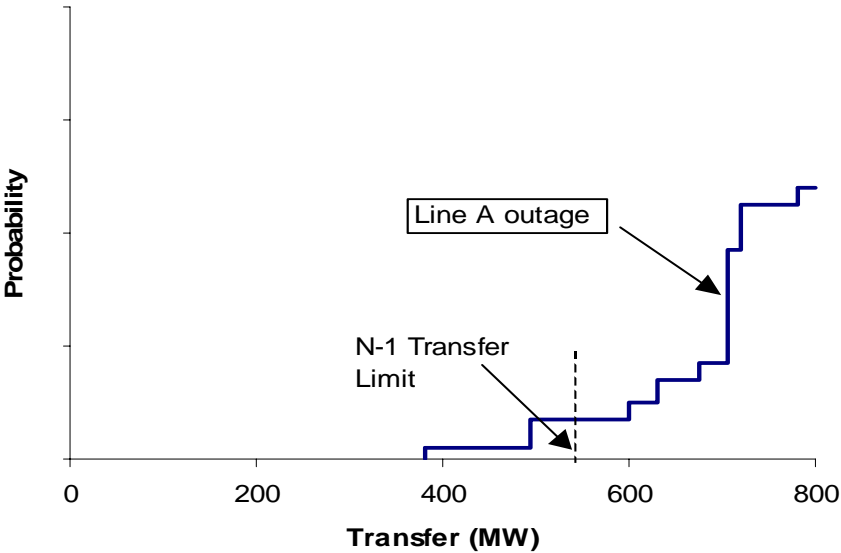


# Probability of exceeding line ratings for single and two-circuit outages

Probability of exceeding line ratings



Probability of exceeding 130% of line rating





# How about blackouts?

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

# Thesis:

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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!**

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# Decreasing Margins – Increasing Utilization of the Grid

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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

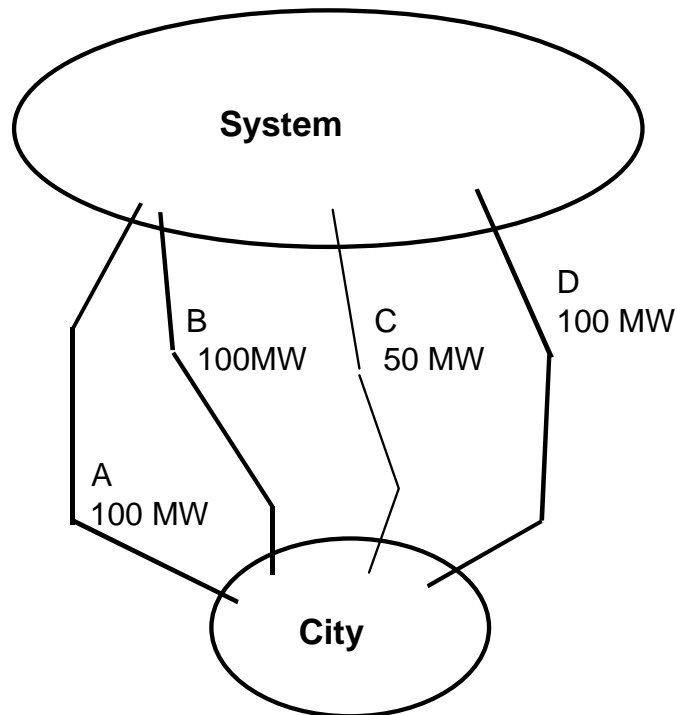
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**Time exposure** to high grid loadings may be increasing because of increased diversity in system utilization

**Probabilities are getting less friendly!**

# City relying on imports over multiple paths – one weak path

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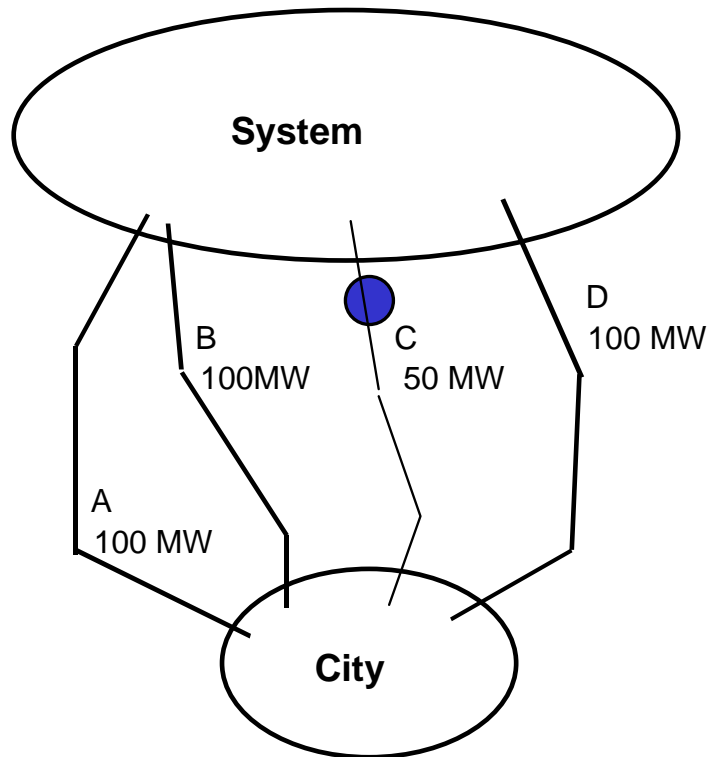


1. Equal impedances on all paths
2. Max import = 150 MW (N-1)
3. Two-circuit outage loads C to 75MW.

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

# Reliability impacts of ideal **FACTS device**

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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

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- 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?

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