Nettverksmøte Risikostyring

Statnett

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Perceiving, Predicting & Preventing Extraordinary Events

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PhD project background

- Objective: *to develop models and methods to analyse the risk of* *extraordinary events*
  - For **increased security** and/or
  - **increased utilisation** of the power system
- Supervisors:
  - Professor Kjetil Uhlen NTNU
  - Adjunct Professor Gerd Kjølle NTNU/SINTEF
- Schedule:
  - 1 April 2009 – 30 September 2012
- Funding:
  - KMB: *Vulnerability and security in a changing power system*
  - NTNU duty work: *Hardanger utvalget*
  - SINTEF: *security of supply, smart transmission grids*

SINTEF NTNU

Outline

Perceiving

- Characteristics of extraordinary events

Predicting

- Reliability assessment
- Contingency analysis

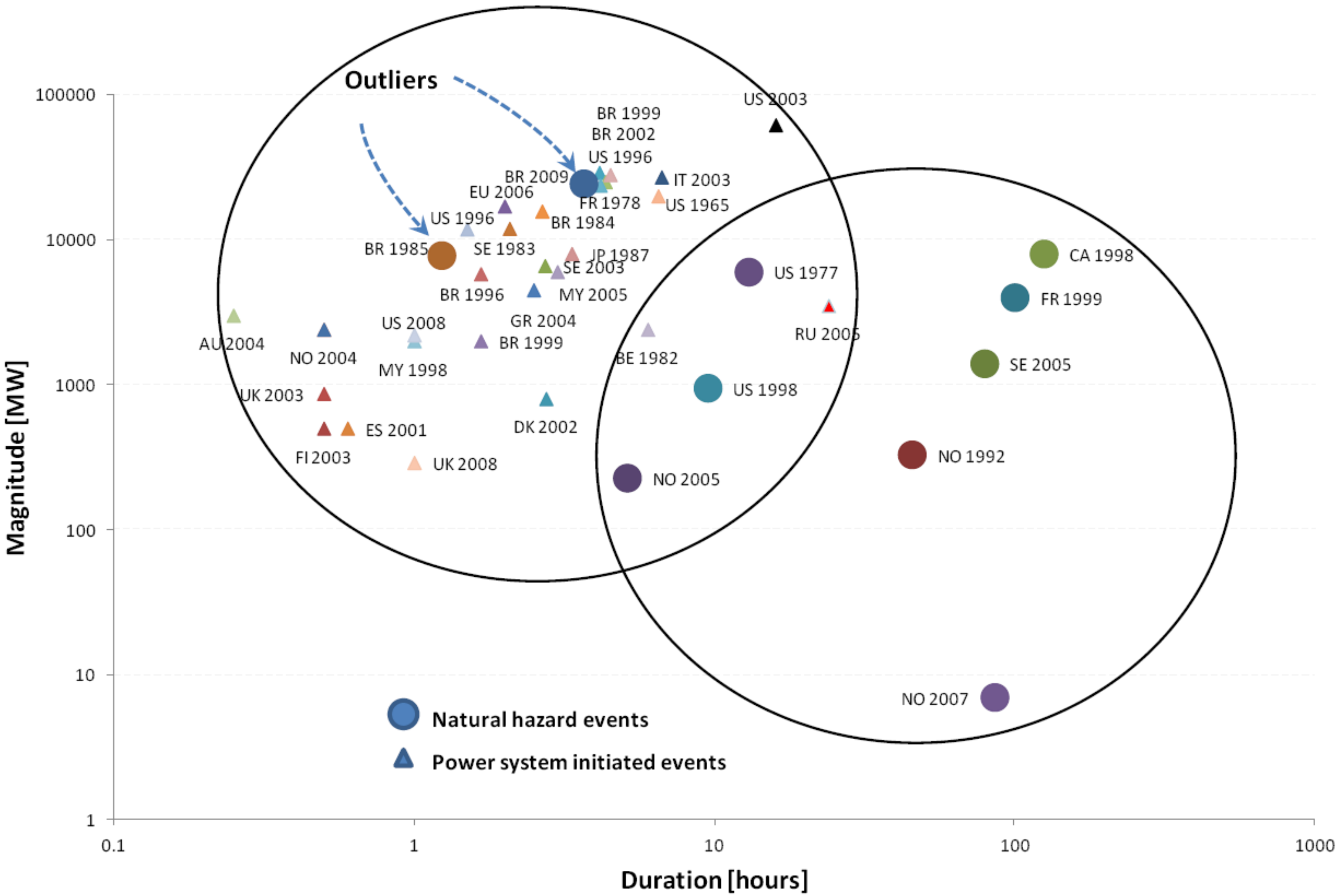
Preventing

- Mitigating solutions

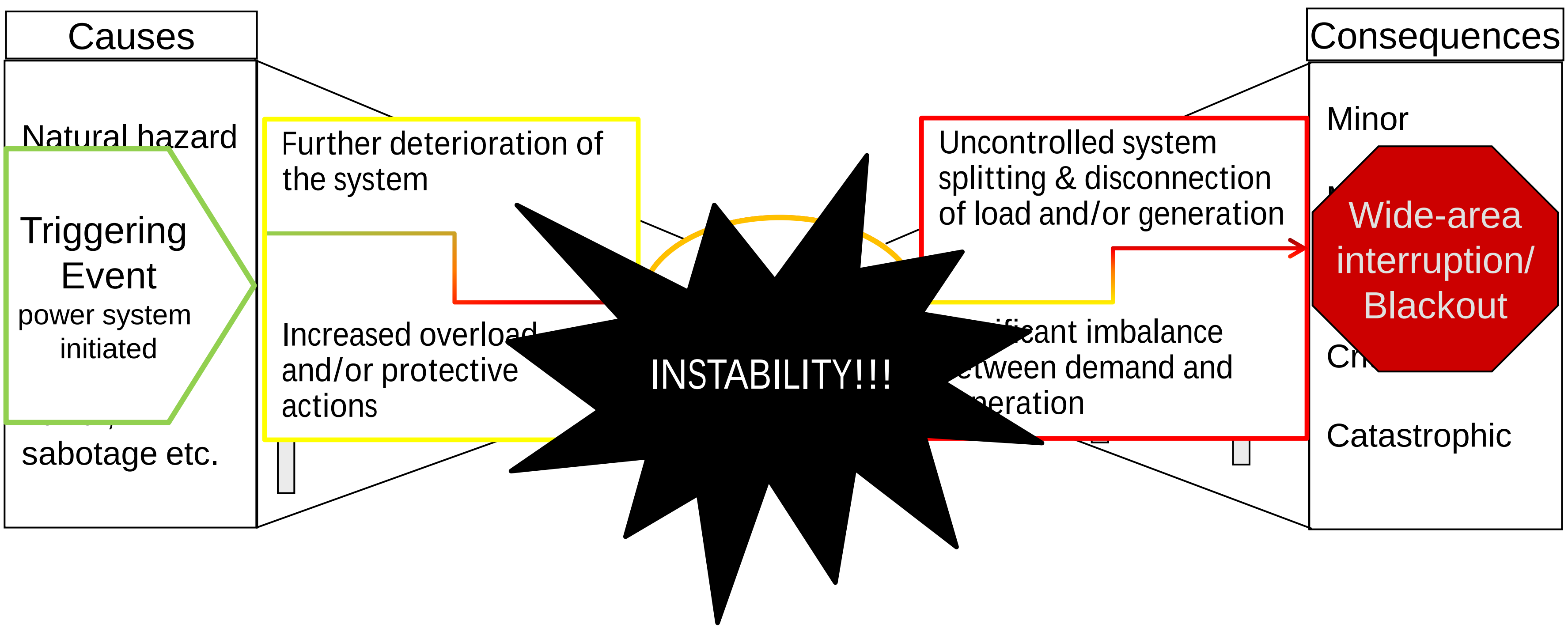
Perceiving Extraordinary Events:
What is an Extraordinary Event?

- Large disturbance – Blackout – Extreme contingency
- Wide spread consequences with high impact on society
  - SE/DK blackout 23Sept 2003: up to **2 billion SEK**
  - US/CA blackout 14Aug 2003: up to **10 billion USD**
- Difficult to predict
  - Low probability – but many unknowns affect the frequency
  - Large consequences – but many uncertainties affect the extent
- Difficult to prevent the unpredictable...

Perceiving Extraordinary Events:
Event categories



Perceiving Extraordinary Events: Identifying Critical Characteristics



The final phase of a large disturbance is:

- Highly dynamic and
- Unstable

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Perceiving Extraordinary Events: Summary

- Difficult to assess risk
  - Many uncertainties in probability and consequence
- Critical characteristic of extraordinary events
  - Instability

Outline

Preventing

- Mitigating solutions

Predicting

- **Reliability assessment**
- **Contingency analysis**

Perceiving

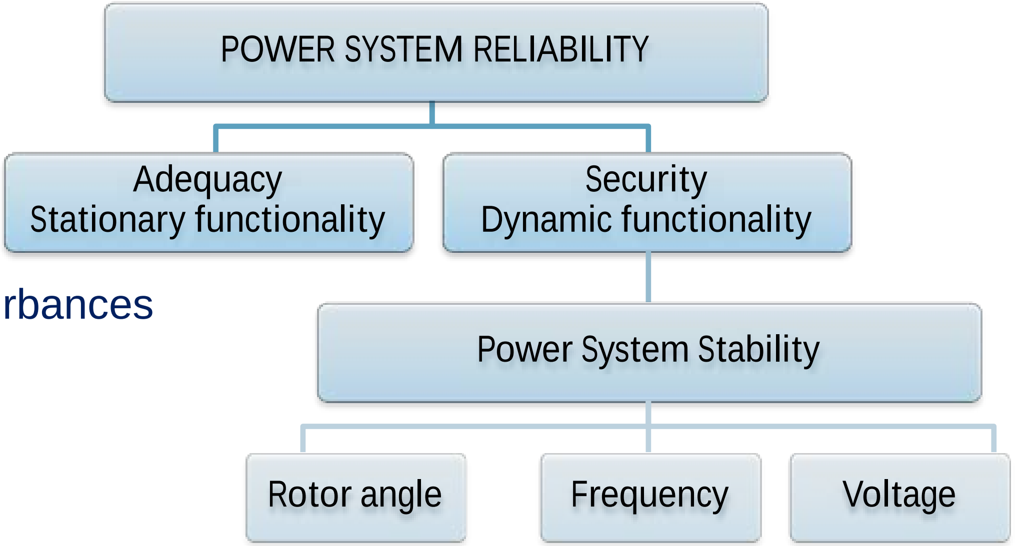
- Characteristics of extraordinary events

Predicting Extraordinary Events:
Power System Reliability Assessment

q Differentiation between:

ØAdequacy: the ability of the system (generally transmission and generation) to satisfy the demand

ØSecurity: the systems resilience to disturbances (i.e. capability to regain stable operation when exposed to a disturbance)



ØConventional techniques focus on power flow, calculating adequacy and neglecting the dynamic functionality

ØThe most urgent phase of en extraordinary event is unstable:
® identification of the point-of-instability is vital to prevent uncontrolled disconnections, separation and blackout

Predicting Extraordinary Events: Contingency analysis

N-1 secure system operation

– Loss of any one component should not affect the load

- Conventional contingency analysis techniques are used to identify *N-1* secure transfer capacity
  - i.e. Thermal & Stability limitations
  - **Based mainly on power flow calculations**

Predicting Extraordinary Events: Summary

- Conventional techniques are insufficient to assess the risk of blackouts

  ® Novel / unconventional risk assessment techniques are required

Outline

Preventing

- **Mitigating solutions**

Predicting

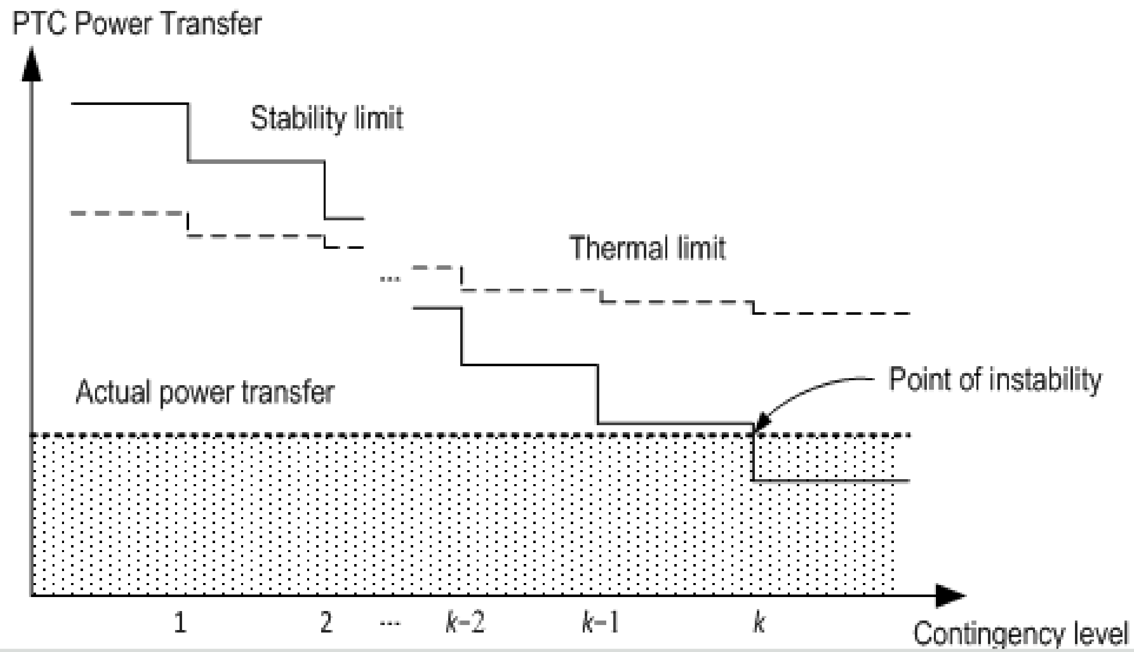
- Reliability assessment
- Contingency analysis

Perceiving

- Characteristics of extraordinary events

Preventing Extraordinary Events:
Unconventional risk assessment techniques

Risk of blackout:
No. of subsequent failures leading to instability



k_{min}-index

Examples from historical events:

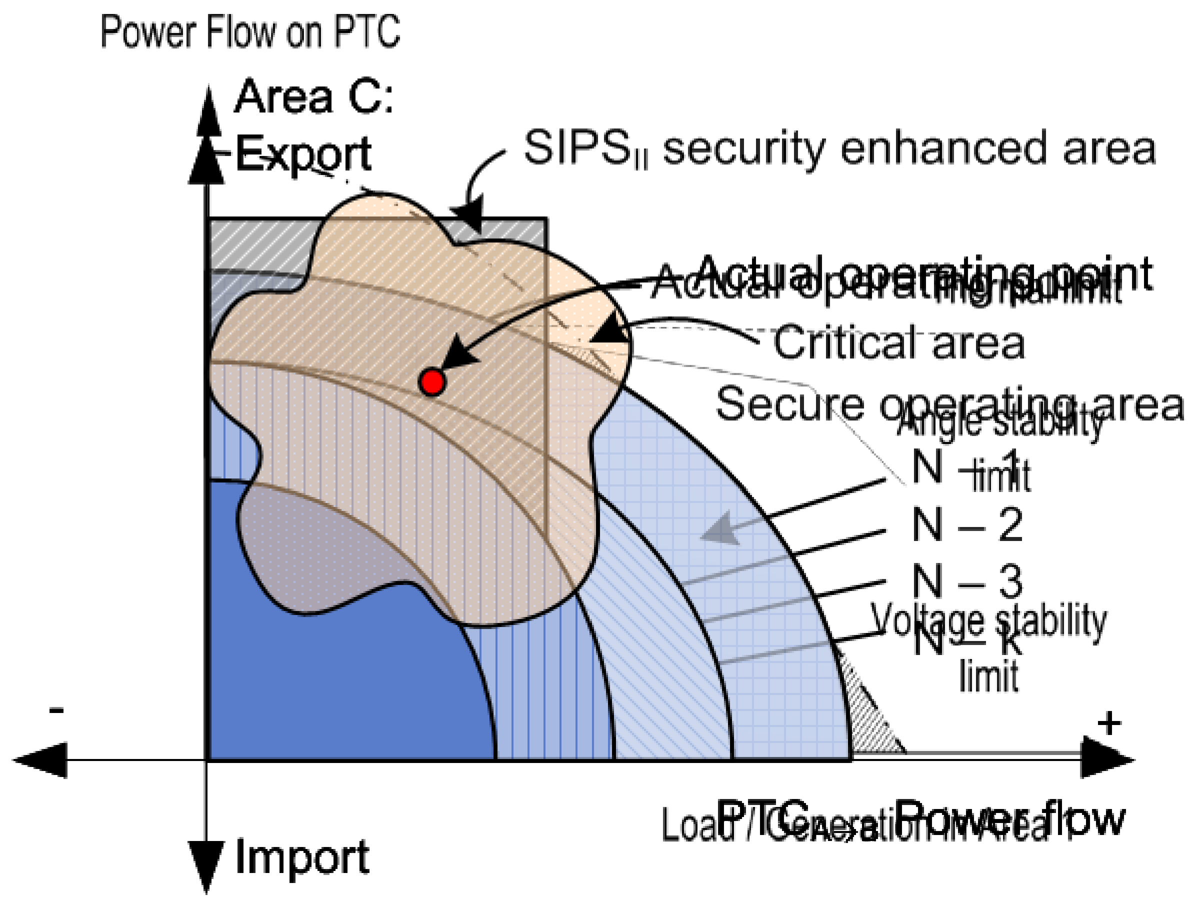
- Sweden/Denmark 2003: $\boldsymbol{k_{min}} \leq \mathbf{2}$ (independent faults)
- Italy 2003: $\boldsymbol{k_{min}} \leq \mathbf{2}$ (thermal overload)
- Europe 2006: $\boldsymbol{k_{min}} \leq \mathbf{3}$ (manual operation)
- Brazil 2009: $\boldsymbol{k_{min}} \leq \mathbf{3}$ (extreme weather)

Preventing Extraordinary Events:
Novel visualisation techniques

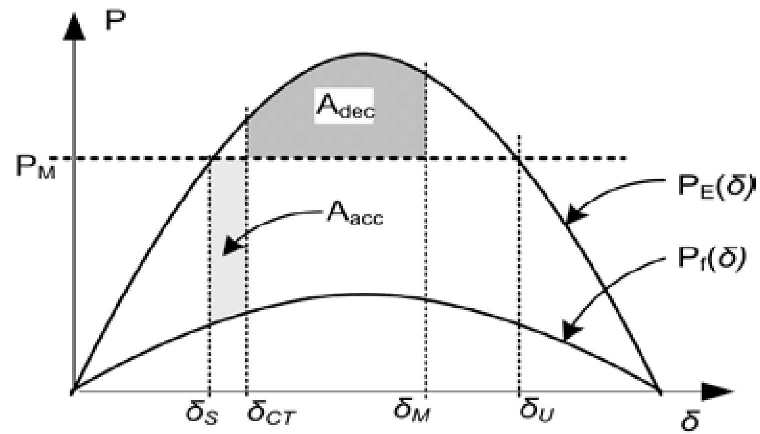
I: Secure operating area and actual operating point

II: *N-k* security

III: Security enhancement by automatic actions

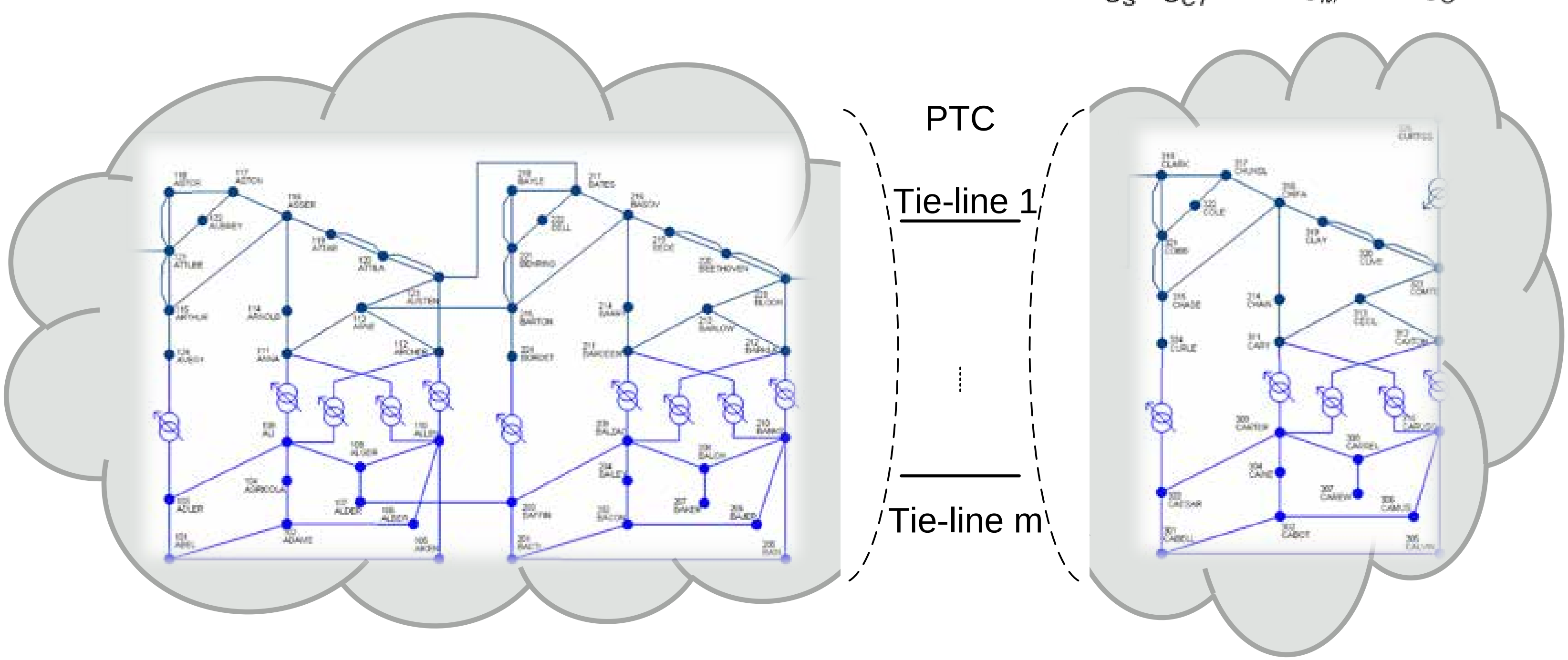


Preventing Extraordinary Events:
Novel stability assessment techniques



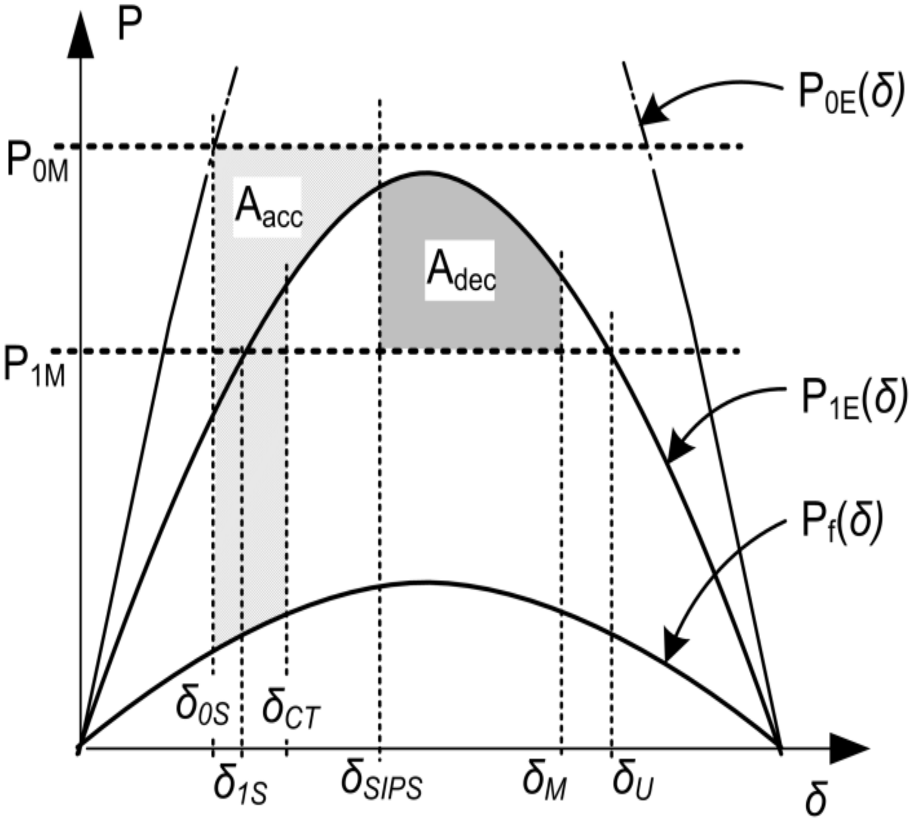
Equal-Area Criterion

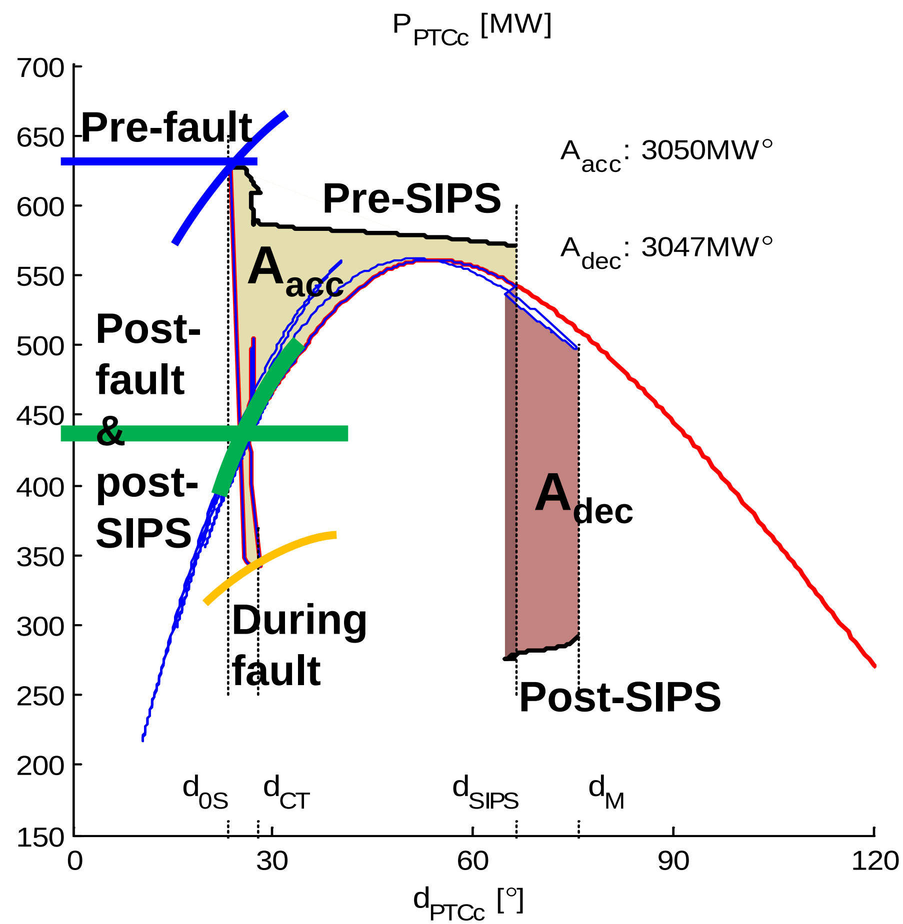
Øapplied on a system



Preventing Extraordinary Events:
Novel instability prevention techniques

Equal-Area Criterion used for SIPS improvements





Conclusions

- Analysing risk of extraordinary events require
  - Unconventional risk & reliability techniques
    - Including multi-level contingency analysis
    - And dynamic models and tools
- Several solutions identified to improve perception, prediction & prevention of extraordinary events, but:
  - There are still many challenges & opportunities ahead!

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