Vulnerability related to critical functions/ components

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Stockholm

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Outline

- Vulnerability and security of supply – definitions
- Risk and vulnerability assessment using bow tie-model
- Monitoring vulnerability and security of supply
- Vulnerability in RISK DSAM

Vulnerability related to critical functions/ components

- Objective in RISK DSAM:

- Develop methods, which can be used to describe the society's vulnerability related to critical functions/components in the distribution sector
  - Survey vulnerability indicators in use and describe state of the art
  - Propose indicators to monitor the effect of maintenance and reinvestments. Describe data needed to estimate the indicators
  - Models and methods to identify critical functions/ components.

Vulnerability and security of supply – Definitions

Vulnerability – a definition

A characteristic of an element of the critical infrastructure's design, implementation, or operation that renders it susceptible to destruction or incapacitation by a threat

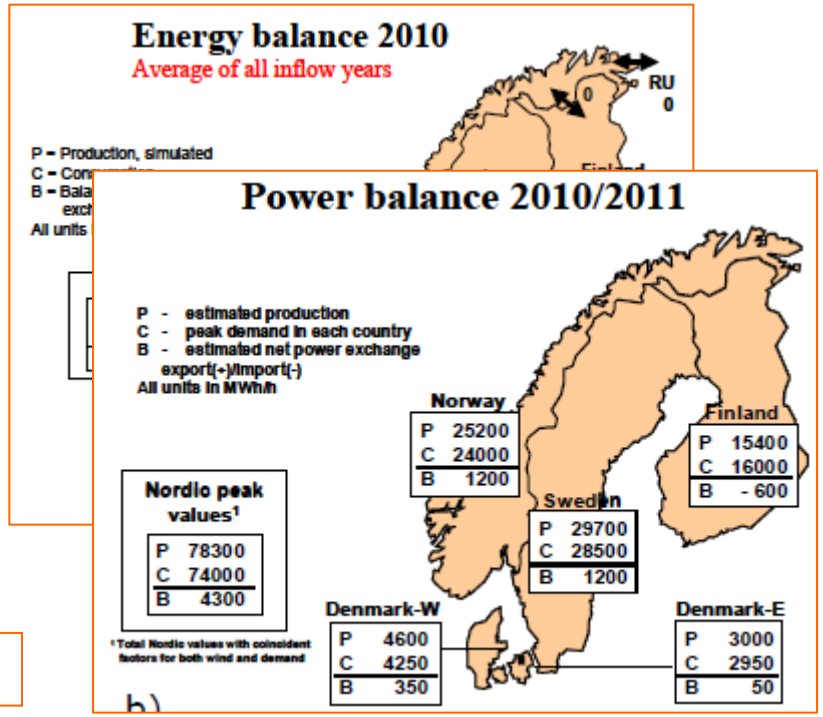
Vulnerability is closely related to security of supply

EPCIP Green Paper, COM(2005) 576 final

Security of electricity of supply - SoS

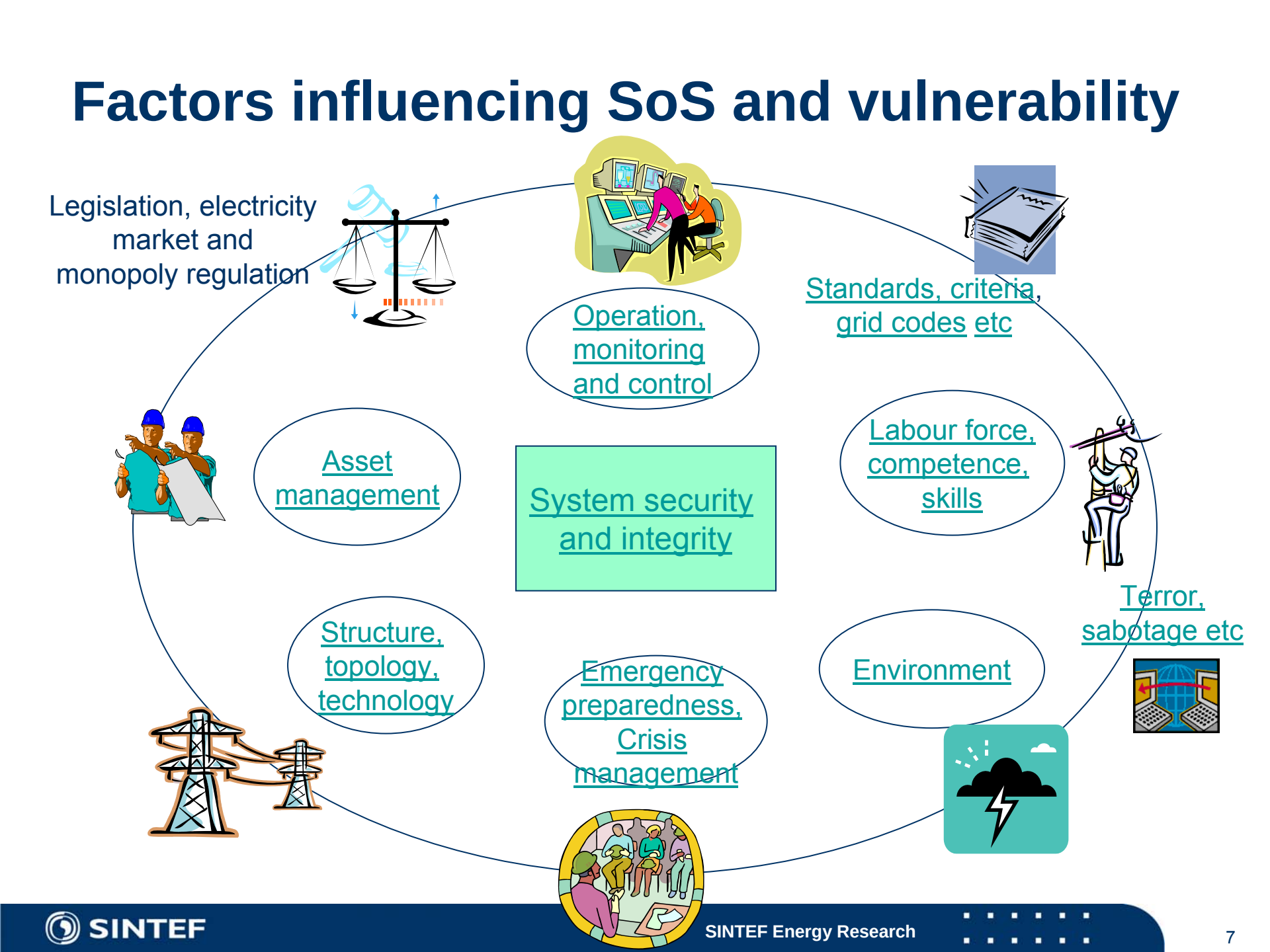
- ”***Security of electricity supply*** *means the ability of an electricity system to supply final customers with electricity*” (EU Directive)

- Energy availability
- Power capacity
- Reliability



Power system failures

Factors influencing SoS and vulnerability

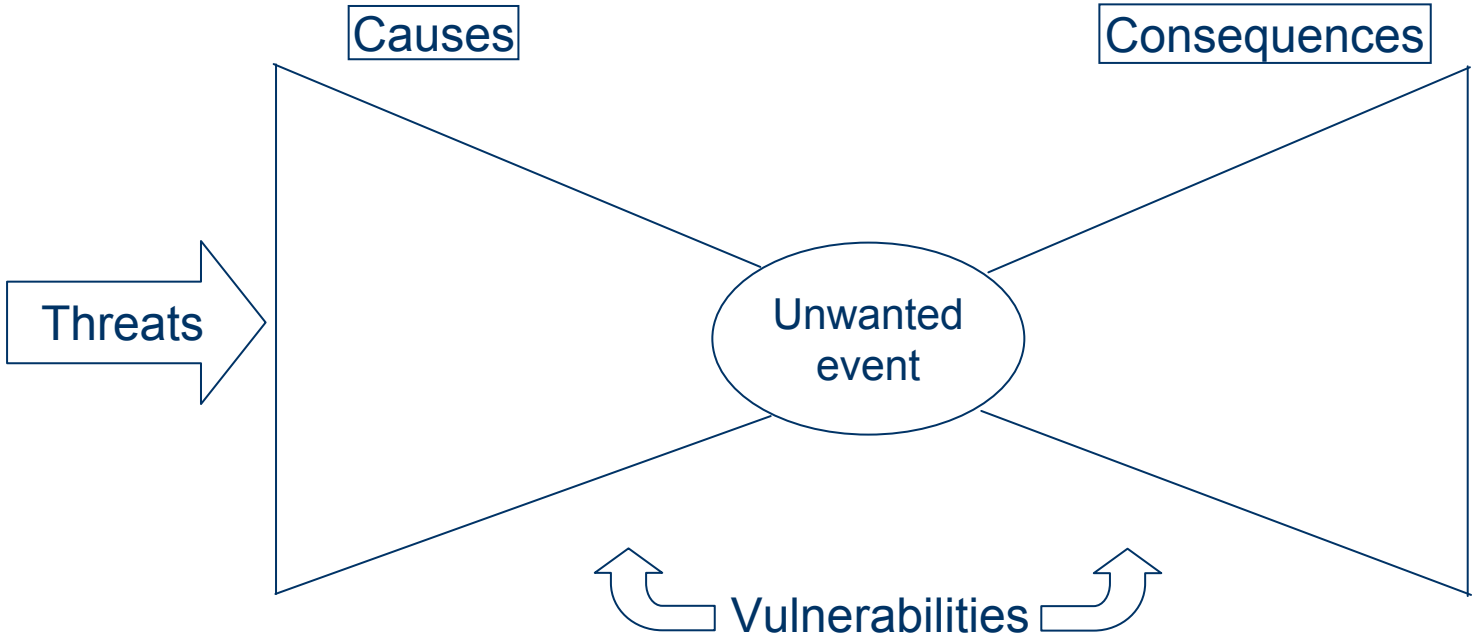


Challenges and concerns related to vulnerabilities in the power system

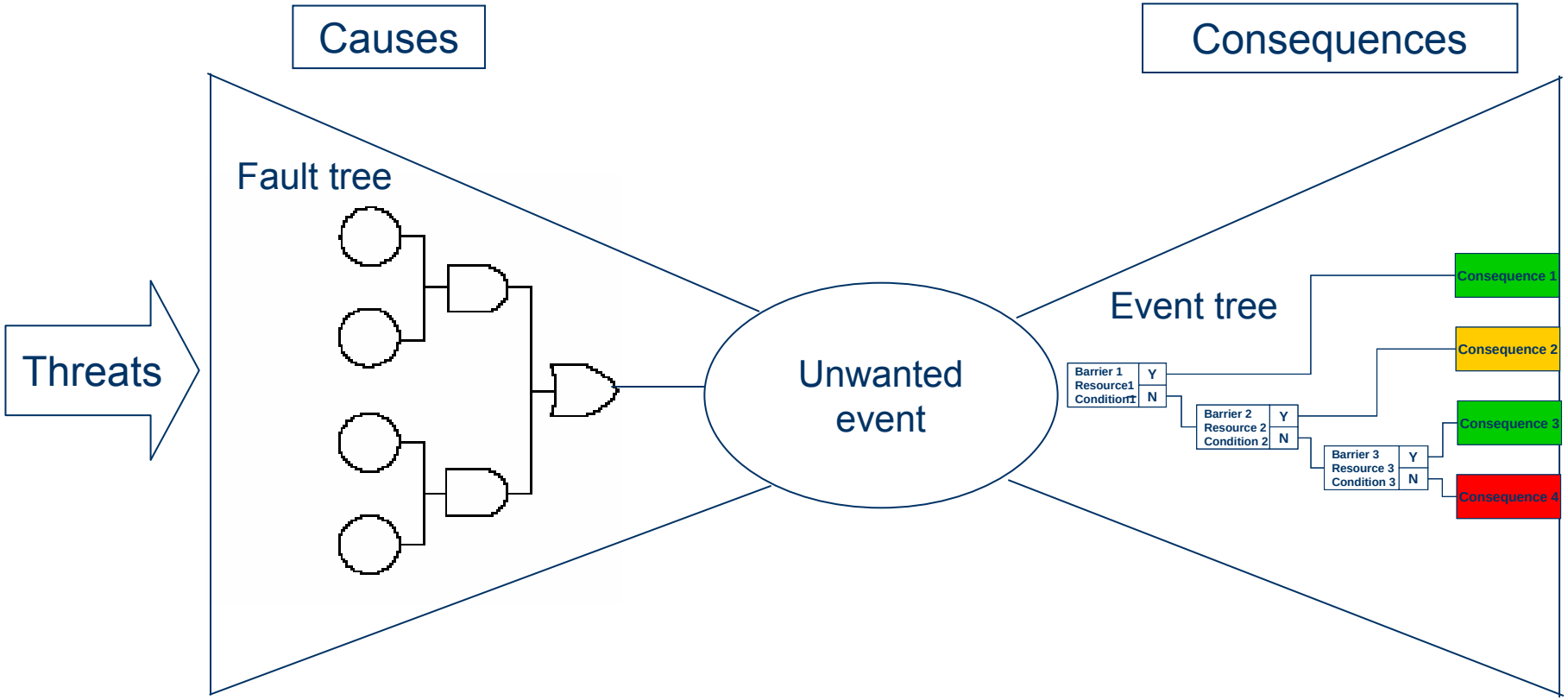
- Climate changes – increasing climatic stress
- Ageing assets
- Restructuring, outsourcing, workforce reductions
- Increasing ICT - and mutual dependencies
- Integration of distributed generation
- Terrorism and organised crime
- etc.

Risk and vulnerability assessment using bow tie model

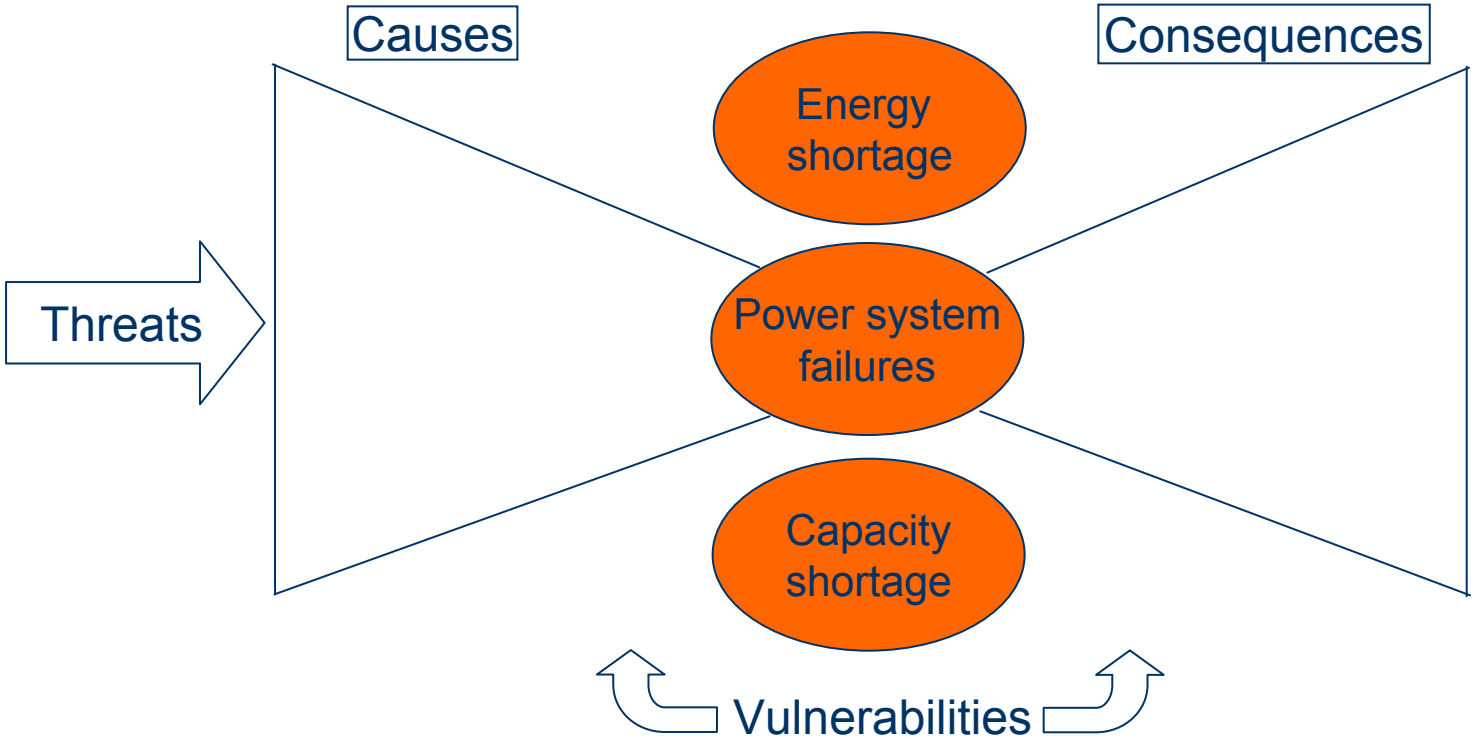
Bow tie-model



Bow-tie with fault- and event tree



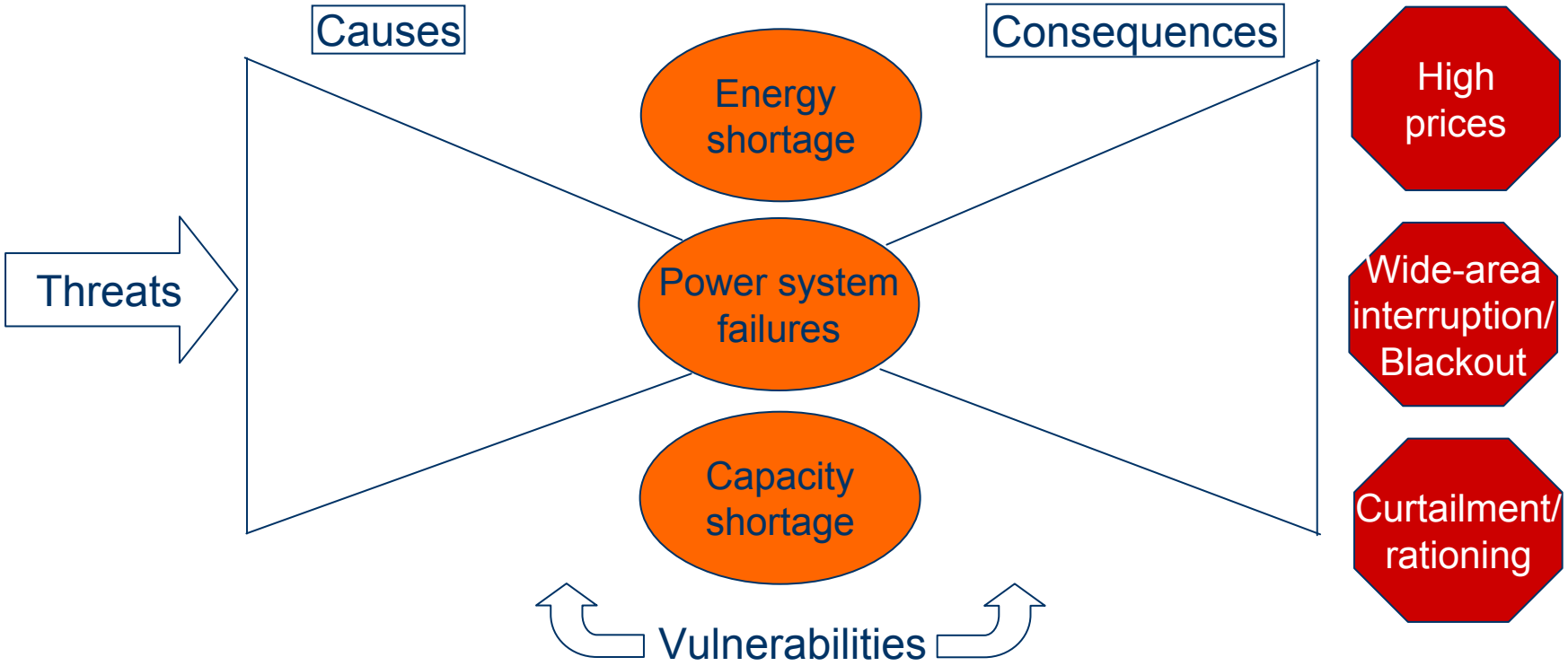
Security of supply – Unwanted events



Three types of unwanted events

Doorman, G., Kjølle, G.H., Uhlen, K., Huse, E.S., Flatabø, N.: Vulnerability of the Nordic Power System, SINTEF Energy Research 2004, Technical report A5962

Unwanted events and Consequences



Three types of consequences

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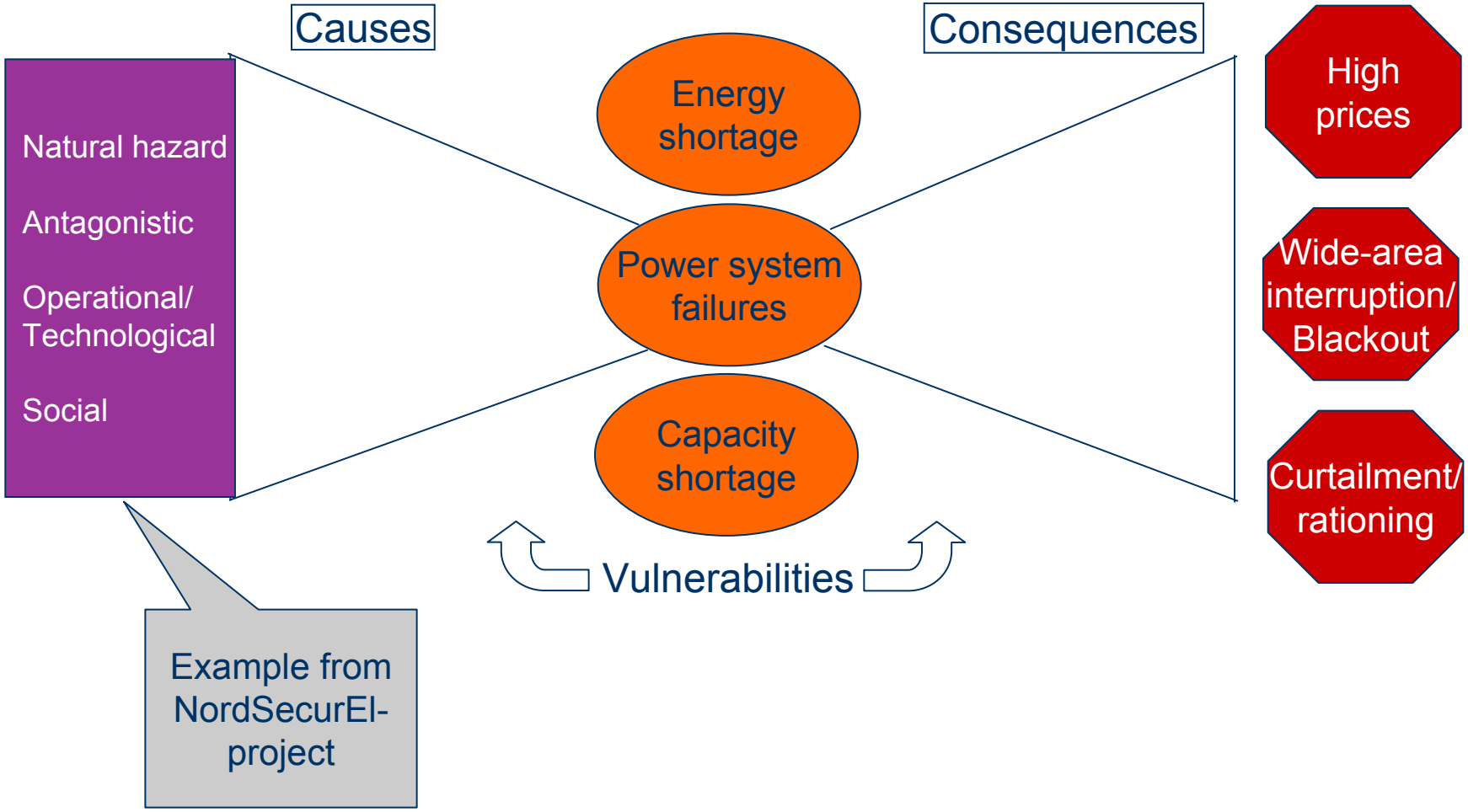
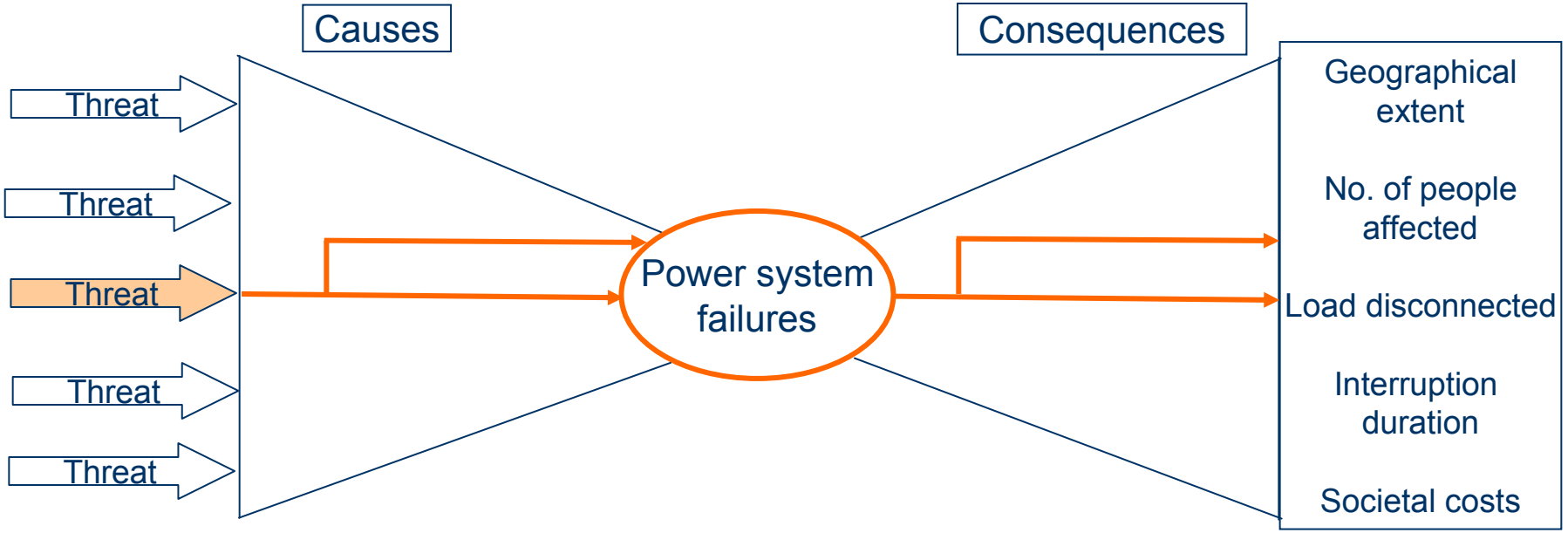
Threats, unwanted events and consequences



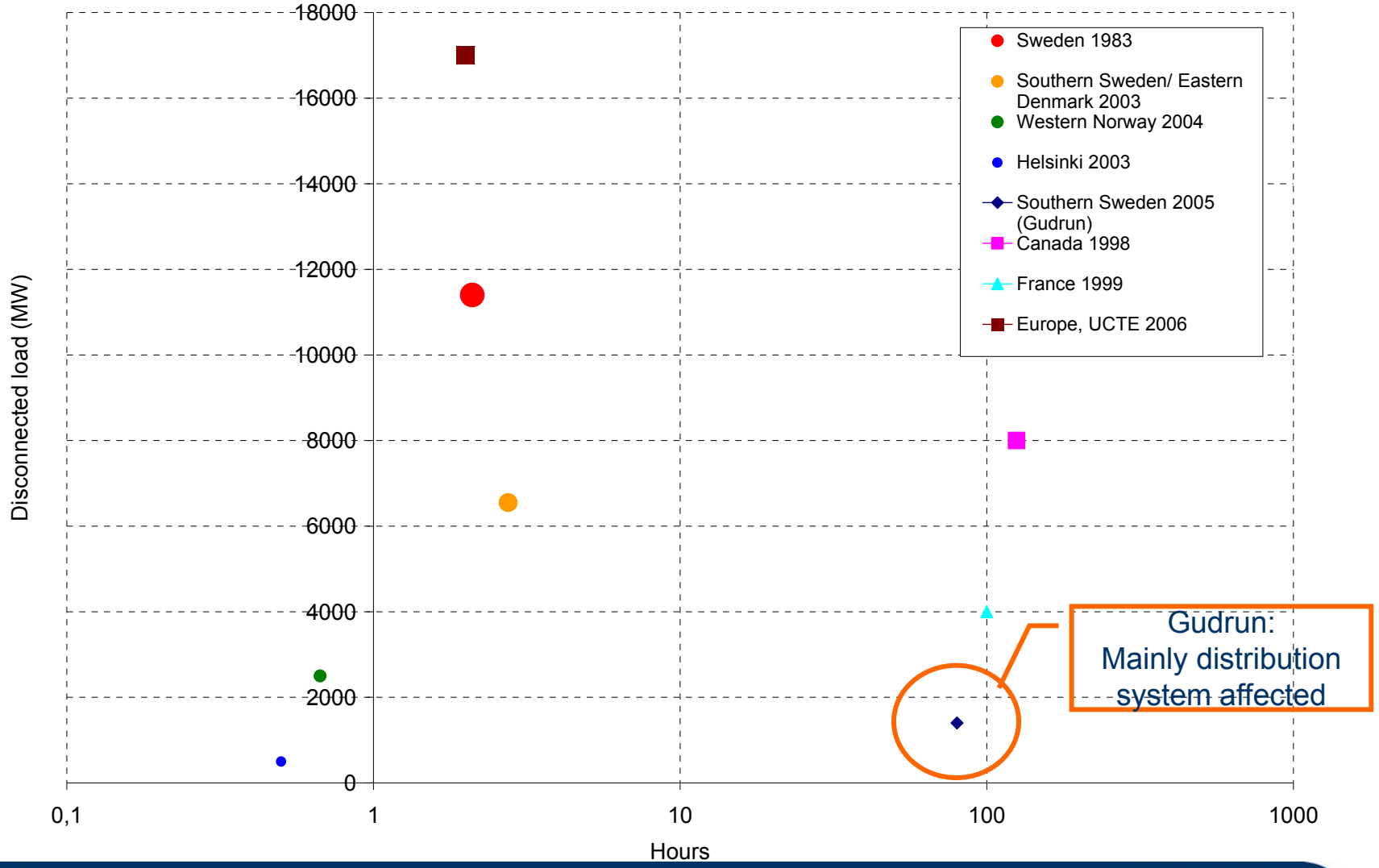
Doorman, G., Kjølle, G.H., Uhlen, K., Huse, E.S., Flatabø, N.: Vulnerability of the Nordic Power System, SINTEF Energy Research 2004, Technical report A5962

Wide-area interruptions: Chain of events and different paths



Vulnerability is primarily associated with events which potentially impose severe consequences

Historical wide-area interruptions (blackouts – examples)

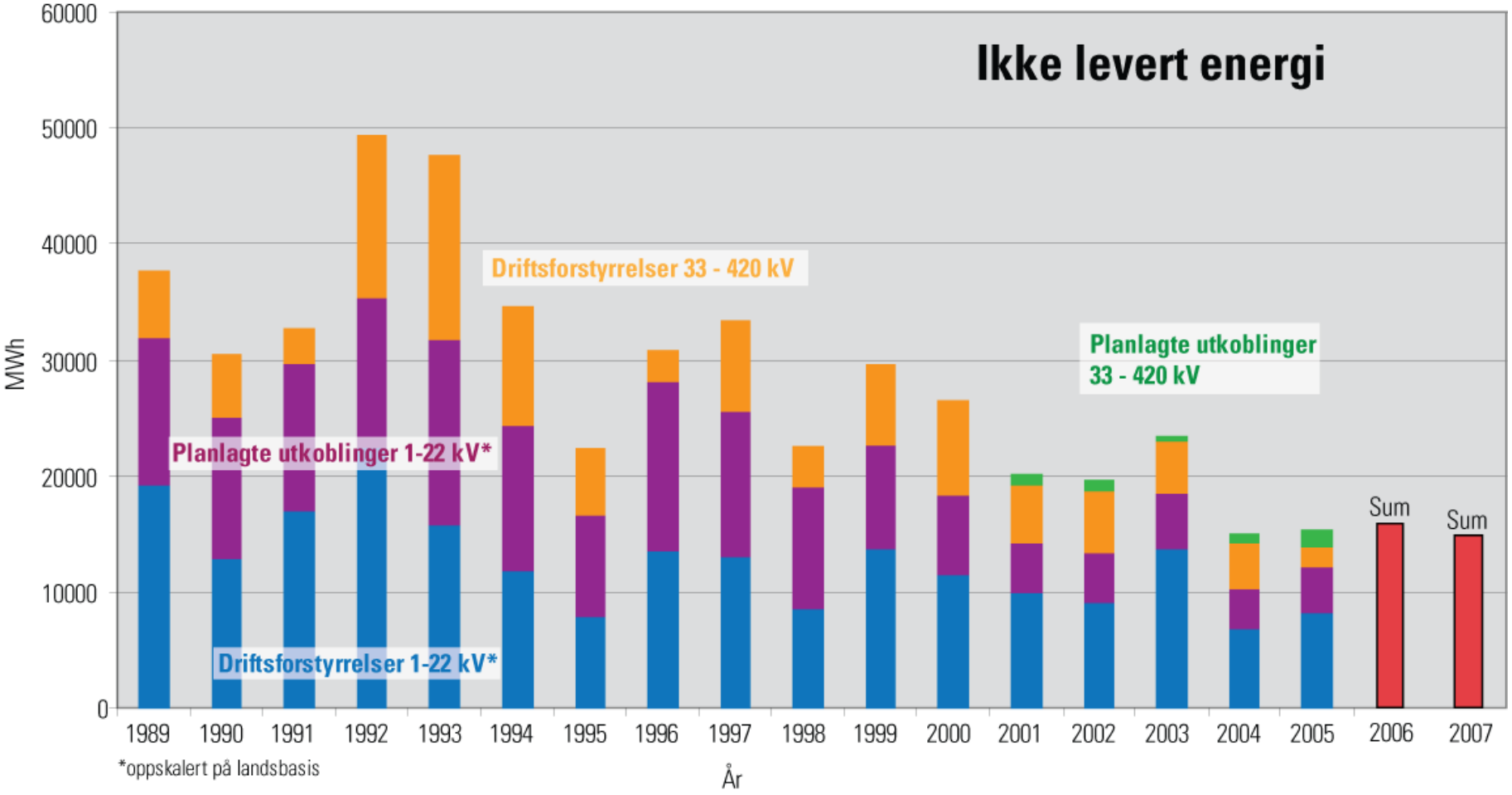


Monitoring vulnerability and security of supply

Monitoring security of supply – state of the art (in Norway)

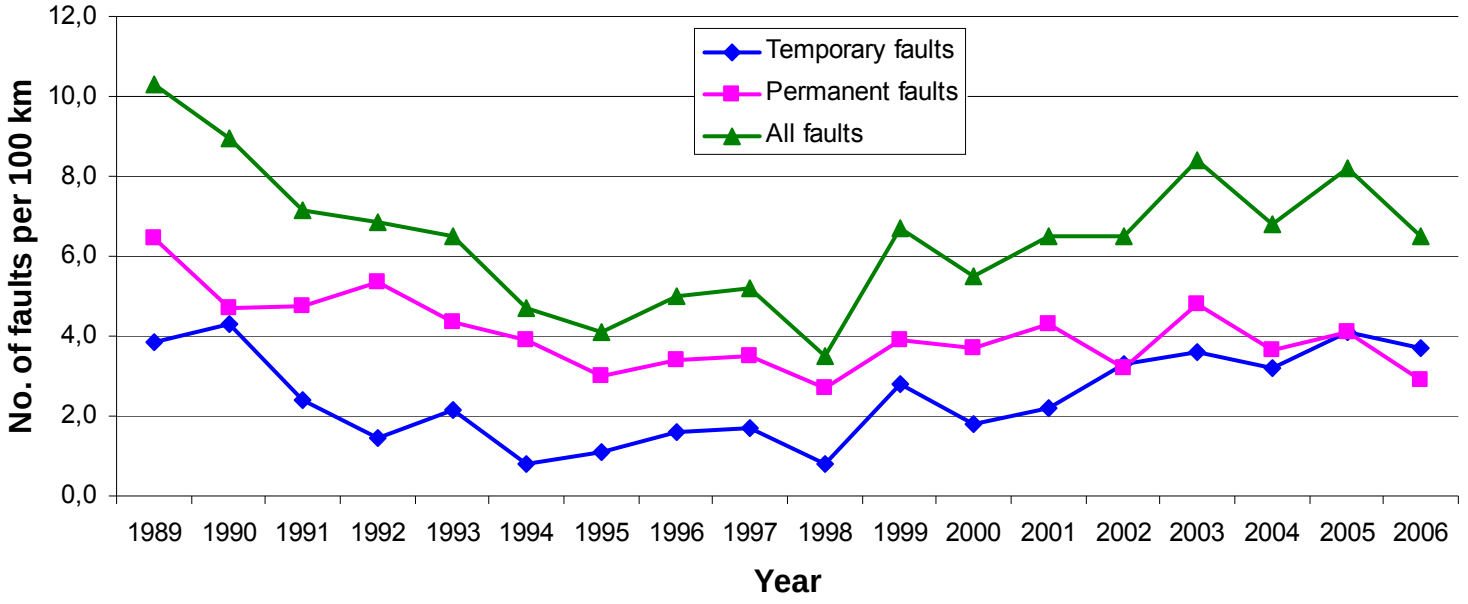
- Energy and power balance
- Fault and interruption statistics
- Learning from blackouts/ major events
- Risk and vulnerability assessment
- Age development of assets
- Investment costs
- Maintenance and reinvestment costs

The reliability of supply is improving…?

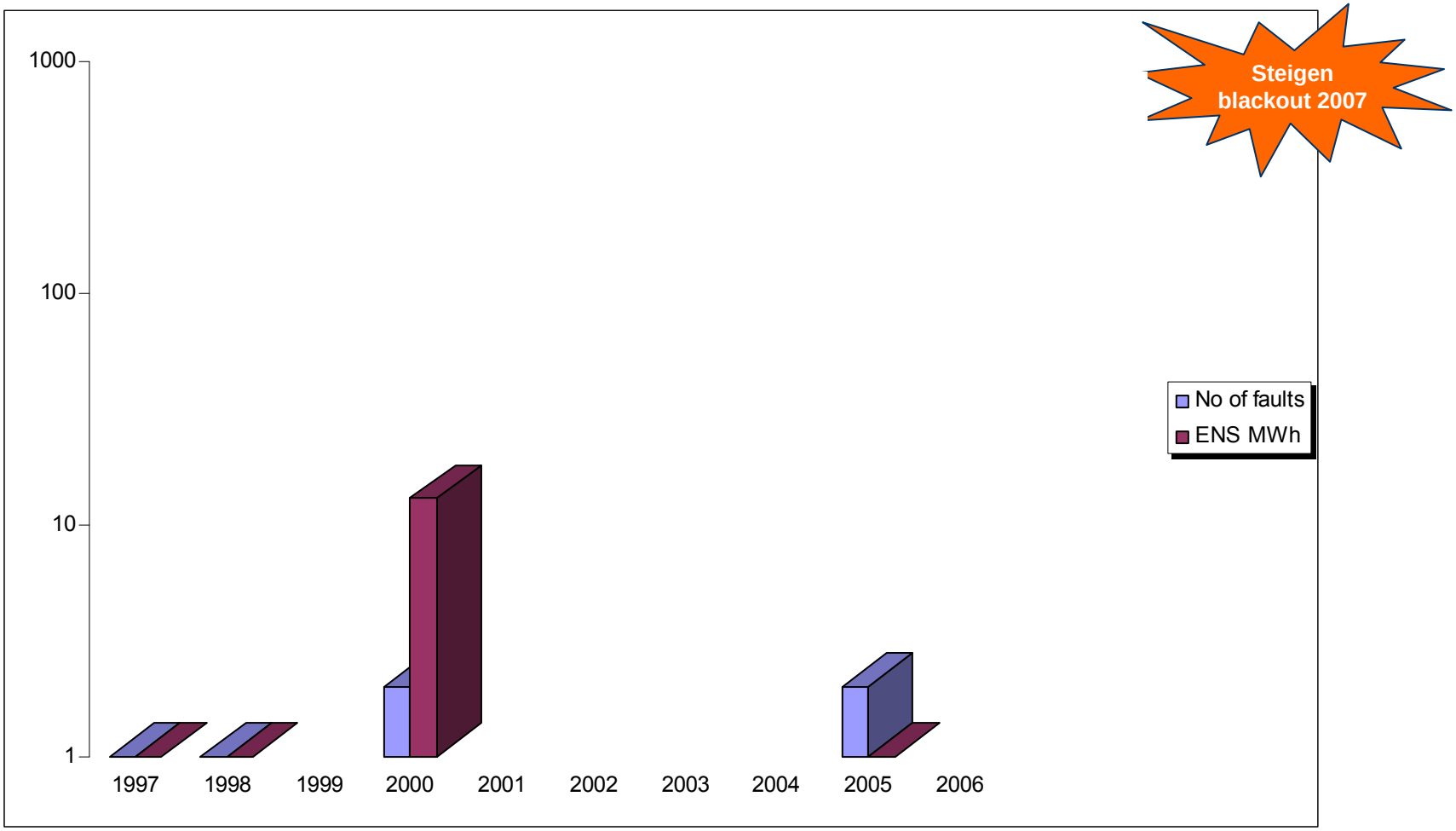


Energy not supplied for the Norwegian power system

Example from fault statistics: fault rate for 22 kV overhead lines (Norway)



Example from fault statistics, 66 kV overhead lines in North of Norway



Fault statistics give historical information about failed components only

Examples of SoS-indicators in use

- Number of interruptions
- Interruption duration
- Energy not supplied
- Interruption costs
- Cost of very long interruptions (> 12 hrs)
- Fault rate
- Number of line repairmen
- Number of reserve units
- Vegetation management (frequency etc.)

Vulnerability in RISK DSAM

Example relevant for the vulnerability activity in RISK DSAM

- *How will the maintenance or reinvestment influence the distribution system's susceptibility towards the 150 year storm – and the society's vulnerability?*

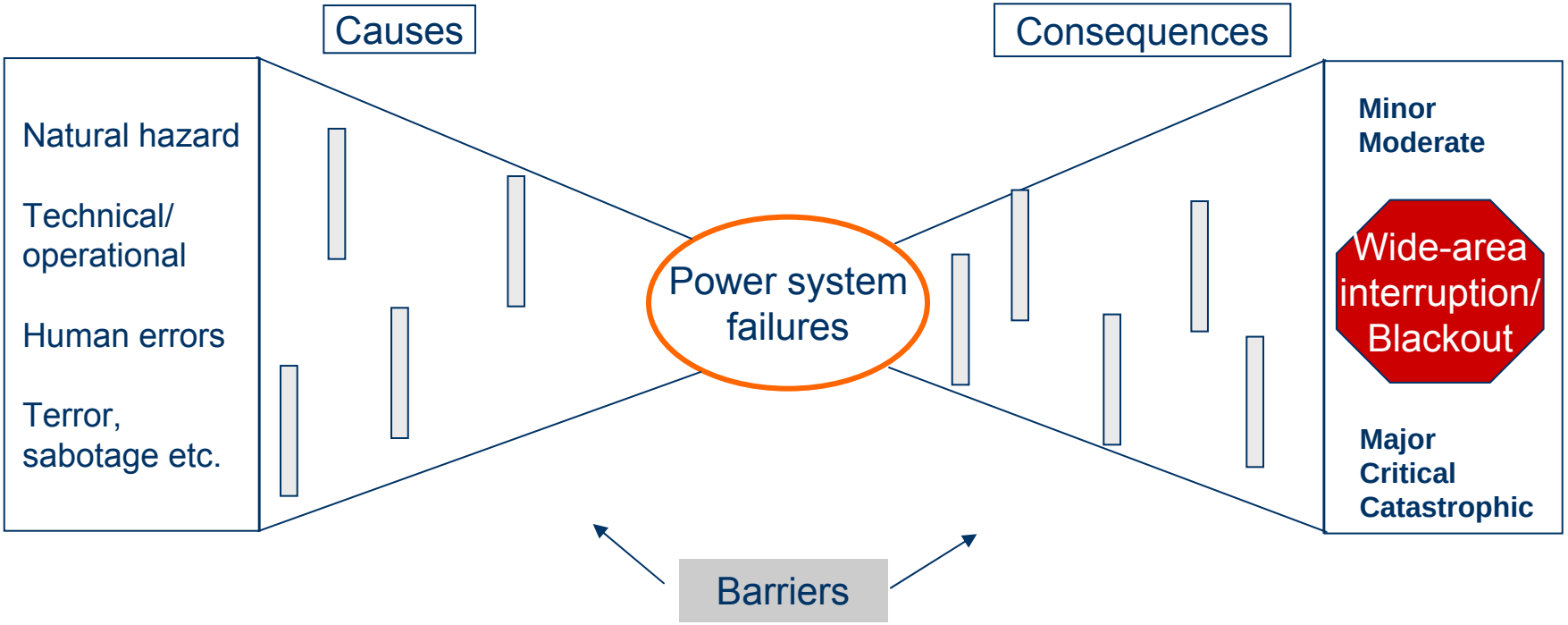
Is it possible to define indicators capable of monitoring the effect of maintenance and reinvestment regarding vulnerability?

Vulnerability indicator

Parameter providing information about vulnerability

Work in progress …

Vulnerabilities and barriers



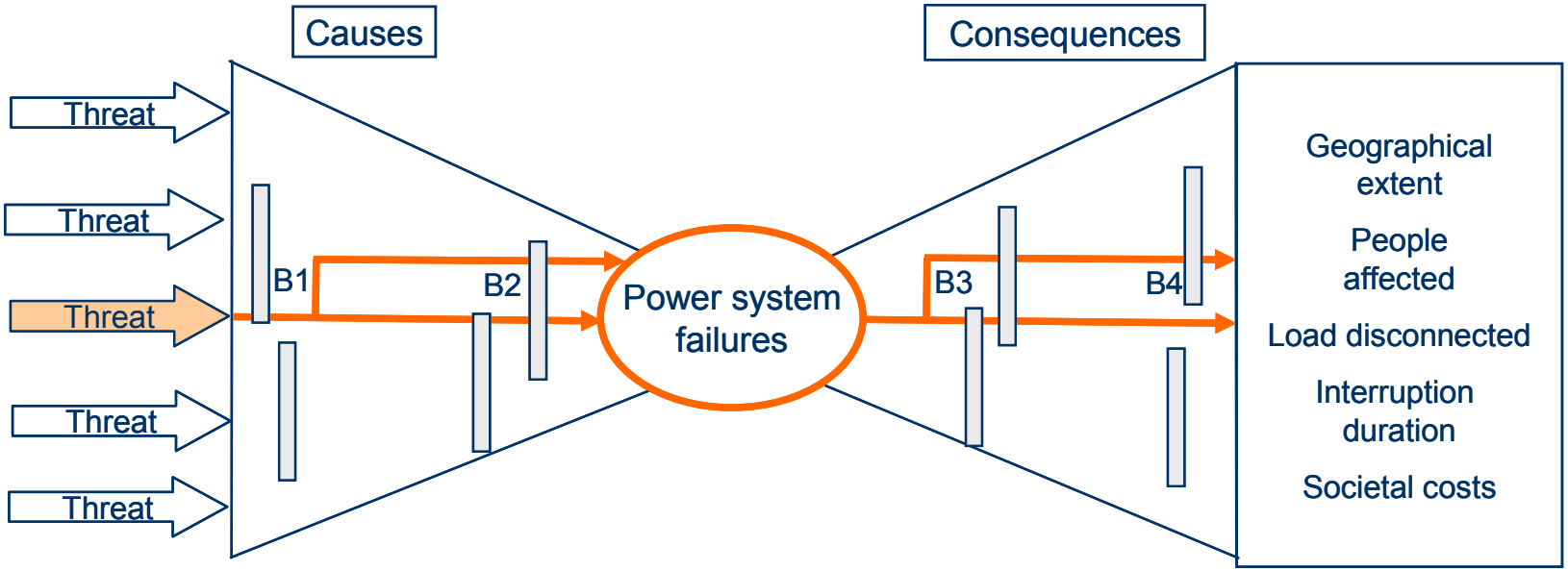
Vulnerability is related to the barriers; if a barrier doesn't exist or is out of function the system may be vulnerable

Barrier – a definition

Something that can either prevent an event from taking place or protect against its consequence

E. Hollnagel, 2004

Different types of barriers



B1: Barriers to prevent component failure

B2: Barriers to prevent power system failure

B3: Barriers to facilitate restoration

B4: Barriers to reduce end-users consequences

Effect of maintenance and reinvestments – examples of barriers

- Type B1 :
  - Limiting presence of degraded components by preventive maintenance and replacement
  - Design improvements to increase redundancy or strength
  - Vegetation management
  - Replacing overhead lines with cables
- Type B2:
  - Testing of protection settings and schemes
- Type B3:
  - Standardisation of spare parts, maintenance friendly components

Work in progress in RISK DSAM …

- Identify relevant threats and how maintenance and reinvestments can limit component failure or facilitate restoration
- Identify a set of vulnerability indicators regarding maintenance and reinvestments and describe data needed to estimate the indicators
- Methods to identify critical components/functions

Vulnerability and security in a changing power system – related project

- Indicators and methods to monitor and classify vulnerabilities in electric power grids
- Methods and operational tools for power system risk and vulnerability analysis and assessment of the level of security of supply
- Duration 2009 – 2012
- Budget: 16,6 mill. NOK ≈ 1,8 mill. Euro