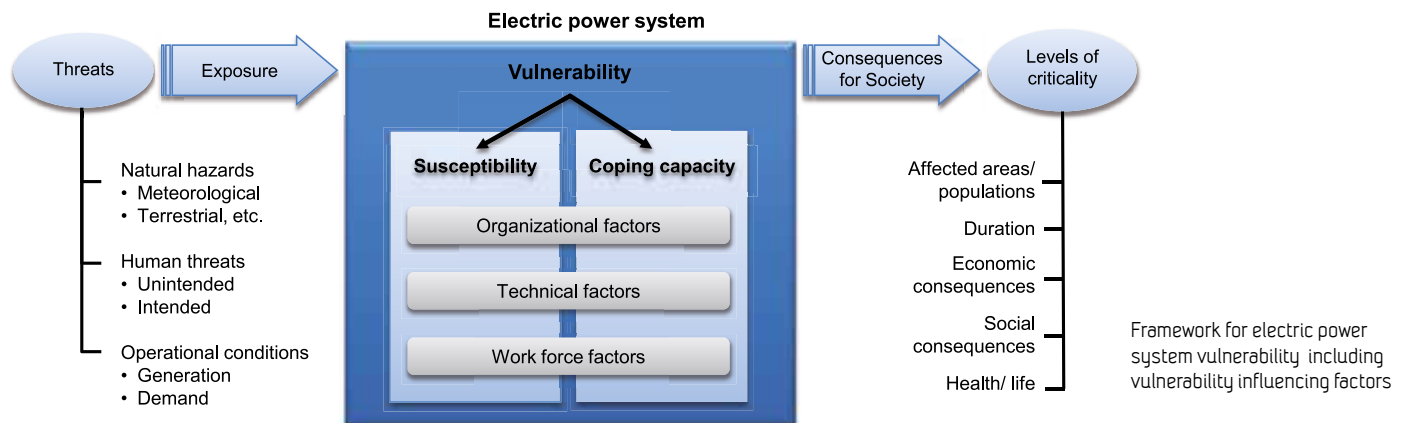


Monitoring vulnerability in electric power systems

Society is increasingly dependent on a secure electricity supply to cover basic needs. At the same time, the power system is under change that may affect the vulnerability* and security of electricity supply. We have developed a framework of indicators and methods that can be used to monitor and classify vulnerabilities. This will contribute to improved planning and operation of the power system.



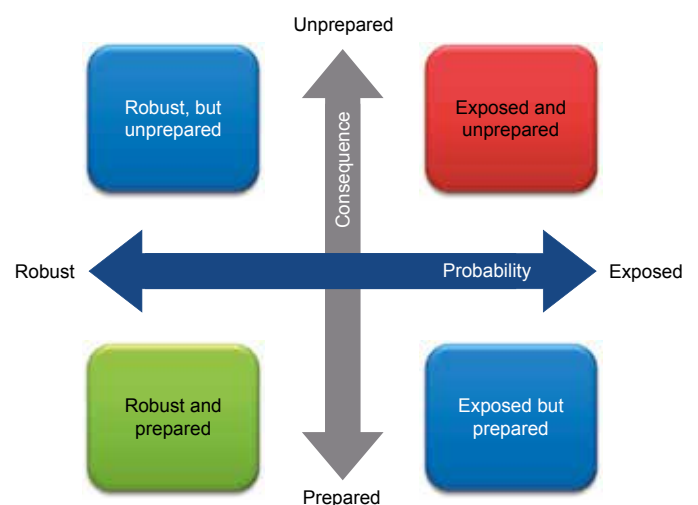
Challenge

- Society is critically dependent on electricity
- The electric power system is an ageing infrastructure, exposed to increased strain due to
 - increased utilization
 - climate change
 - integration of intermittent generation
- Increasing interdependencies on ICT (smartgrids)
- How will this affect the vulnerability of the system?

For this purpose, we need vulnerability analyses as well as suitable indicators that can be used to measure and monitor vulnerability in power systems.

Conclusion

- New knowledge is achieved regarding vulnerabilities in the changing power system:
 - a scientific basis for monitoring vulnerability
 - a methodical framework for vulnerability analyses
- The knowledge-building project recommends how to develop indicators and define methods, scales and the necessary data to be collected.
- These results contribute to improvements in inspections, long-term planning of investments, emergency preparedness planning, etc.



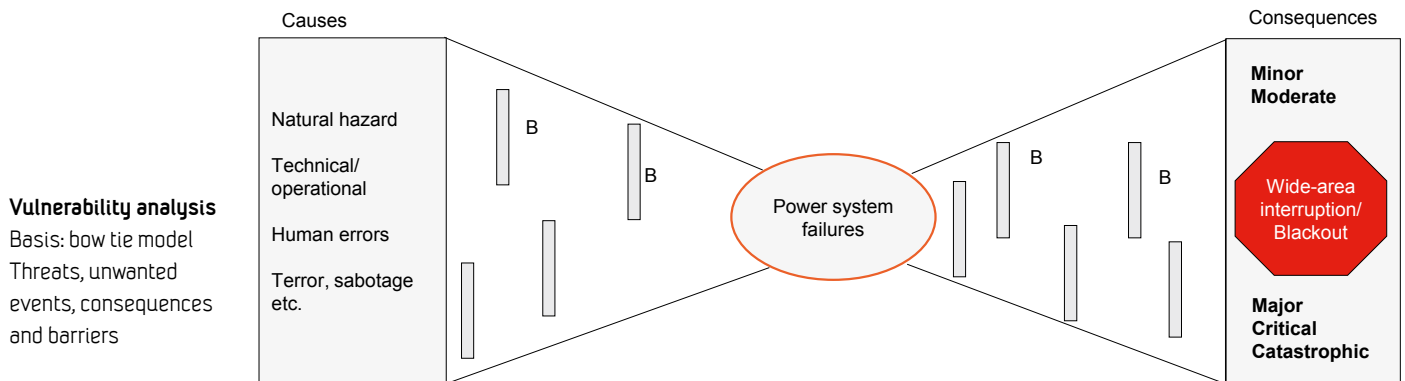
Vulnerability affects the probability and consequence of extraordinary events

* Vulnerability is here defined as an internal attribute of the system and is divided in susceptibility and coping capacity towards a certain hazard or threat.

Knowledge-building project Vulnerability and security in a changing power system (2009 - 2013)
granted by the Research Council of Norway.

Project focus

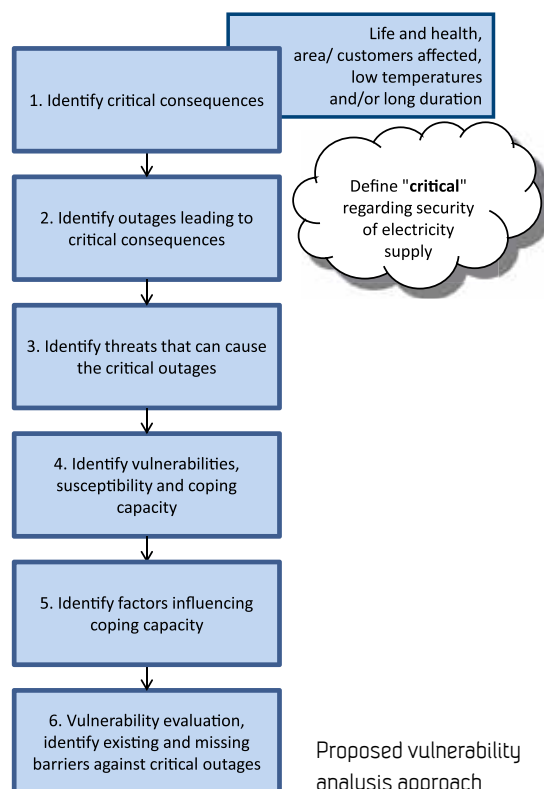
- Main stakeholders: energy authorities, system operators and network companies
- Extraordinary events: High impact, low probability (HILP)
- Failures and disturbances potentially leading to wide-area or long-lasting interruptions with severe impact on society
- Vulnerability divided in susceptibility and coping capacity, related to various threats
- Dedicated vulnerability analysis and indicators



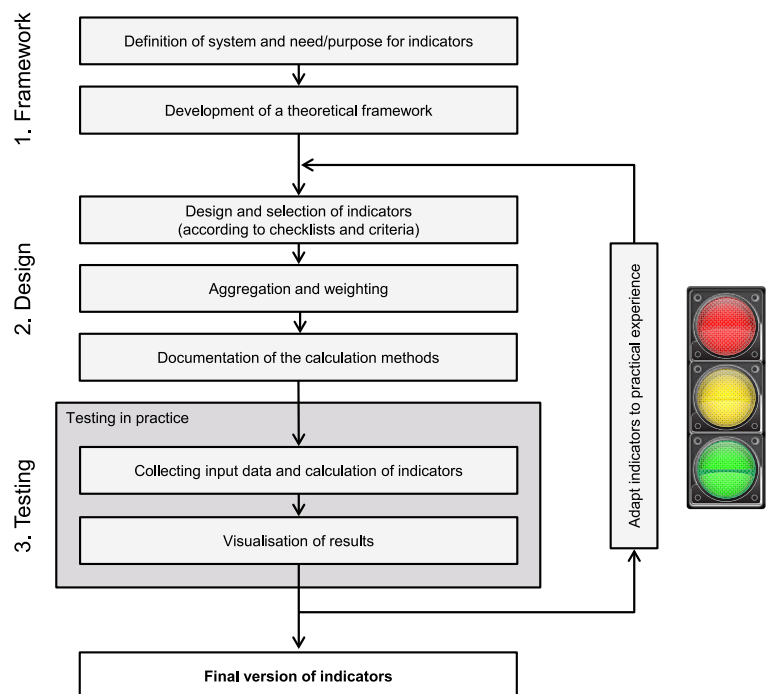
Results and findings

Results are obtained in three different areas:

- A framework of definitions, indicators and methods that can be used to monitor and classify vulnerabilities in electric power grids
- Methods and tools for power system risk and vulnerability analysis of extraordinary events
- Case studies to illustrate the development and use of vulnerability indicators and methods, and analyses of historic blackouts to learn from past events



Proposed vulnerability analysis approach



Proposed vulnerability indicator development process