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Vulnerability indicators

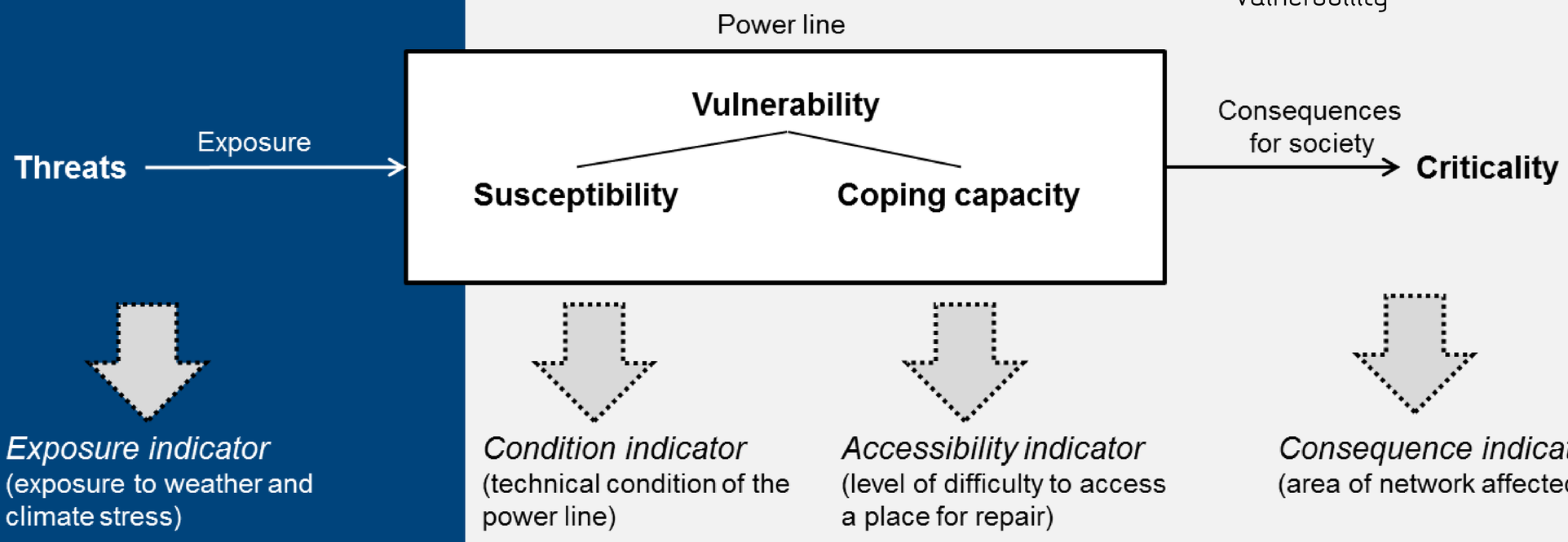
Developing indicators for monitoring vulnerability of power lines – case studies

Challenge

- The power system is vulnerable with possible severe consequences in form of wide-area interruptions
- Indicators to monitor and predict these vulnerabilities are needed

Conclusion

- The framework can be applied to develop indicators for measuring the vulnerability of critical power lines
- More effort is required for developing a consistent set of vulnerability indicators
- Aggregation rules are critical for understanding on higher levels
- More effort has to be invested to design indicators for future development of vulnerability



Selected vulnerability indicators for the case study of power lines

Method

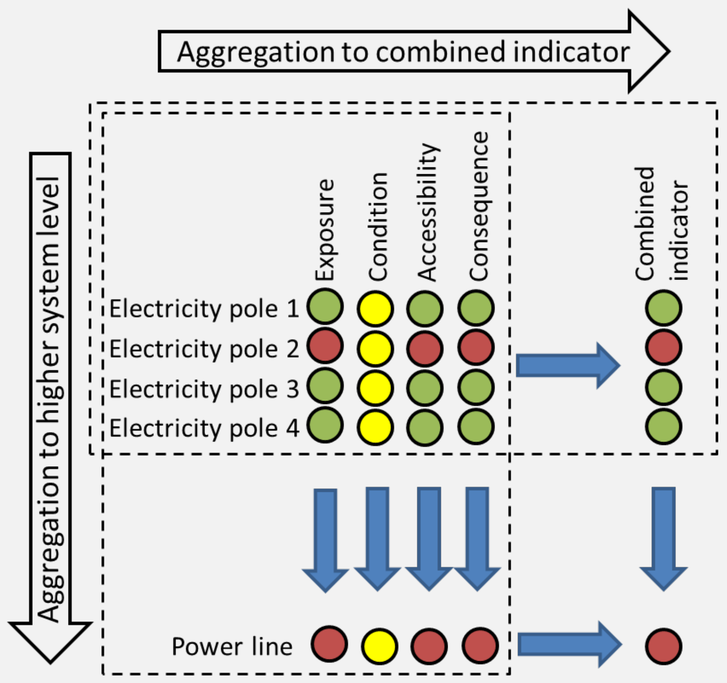
- A framework and development process for vulnerability indicators is designed
- Main vulnerability dimensions are: threat, susceptibility, coping capacity, and criticality
- The framework and process is tested for critical power lines in four case studies
- All indicators are estimated per electricity pole location to allow for monitoring special vulnerable points in the network
- Same scale for all indicators to allow for comparison and straight forward aggregation

	Method	Data source	Scale
Exposure	Expert assessment based on available information	Reports about corrosivity, wind speed and ice loads	0 (extreme) 100 (little) Steps of 20
Condition	Calculation based on data	Reported deviations from maintenance inspections	0 (very poor) 100 (perfect) Steps of 25
Accessibility	Expert assessment based on available information	Map material	0 (hard) 100 (easy) Steps of 20
Consequence	Expert assessment based on available information	Location of circuit breakers and location of critical loads	0 (critical) 100 (little) Steps of 20

Selected approaches for vulnerability indicators

Results

- Indicator values are aggregated from pole to line level
- Combined indicators including all dimensions of vulnerability are calculated
- The combined indicator can be used as a single indicator for vulnerability at the aggregated level



Approach for indicator aggregation

- Weighted average was chosen as method for both aggregating and combing indicators
- Larger weight was given to low indicator values to sustain the information of critical values

	Exposure	Condition	Accessibility	Consequence	Combined
Distribution power line A	49	92	51	17	41
Regional power line A	50	60	73	10	39
Distribution power line B	100	44	40	10	34
Regional power line B	84	75	65	10	43

Results of aggregated indicators for the four case studies

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