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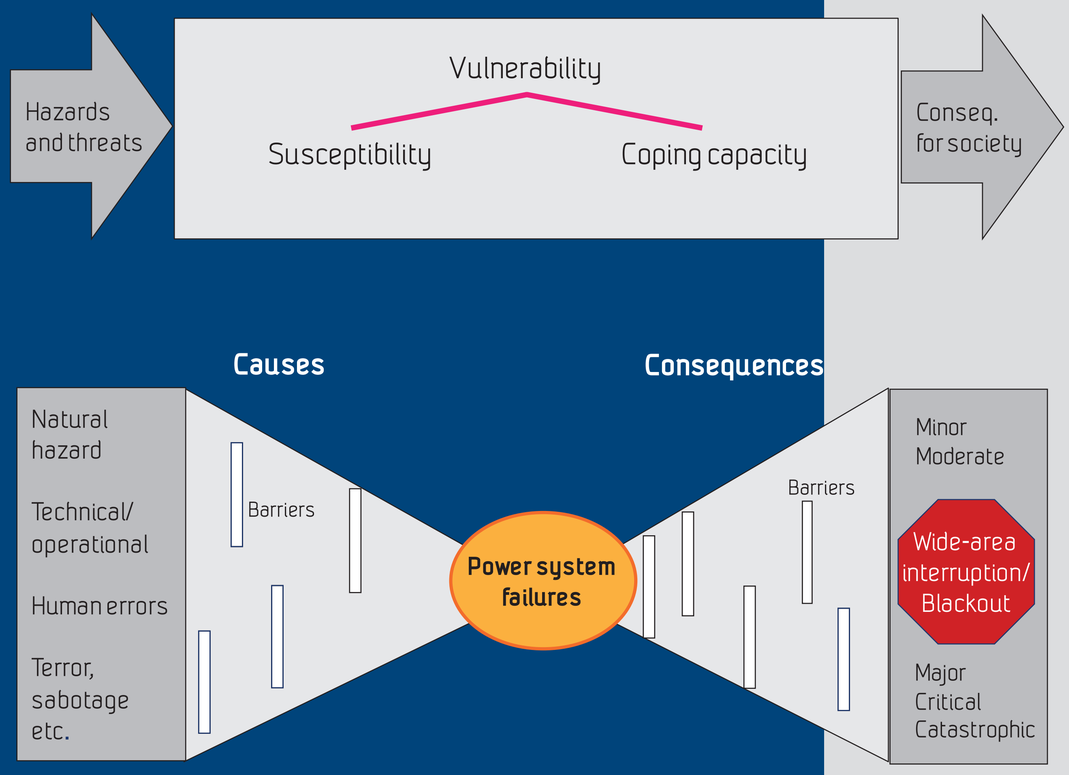
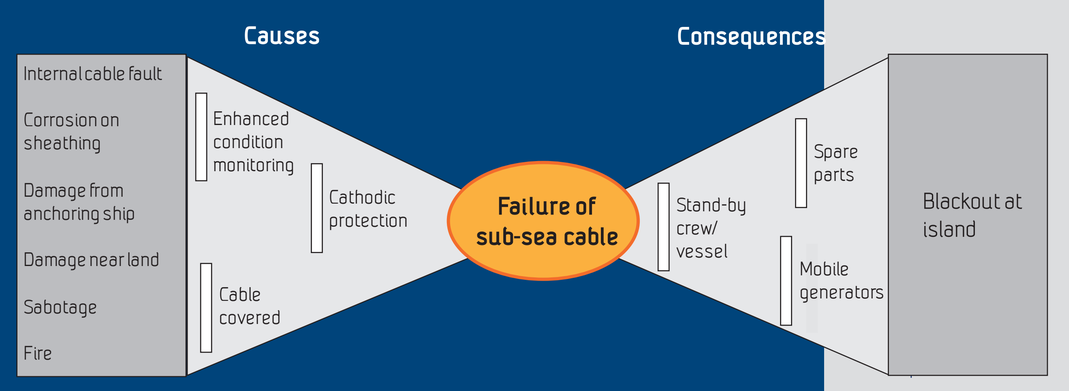
Planning & System Development
Paper 0805

Vulnerability framework



Case study - power supply to island



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Indicators to monitor and manage electricity distribution system vulnerability

Vulnerability indicators

Objectives

- Describe how indicators to monitor and manage distribution system vulnerability can be identified and established.
- Based on the bow-tie framework for vulnerability analysis, structuring threats, unwanted events, consequences and barriers.

Vulnerability indicators

- Outcome vs activity based
- Leading vs lagging
- Leading indicators are necessary to predict future vulnerability

Case study - power supply to island

Indicator	Description	Aspects covered				Indicator type			
		Hazard/ threat	Susceptibility	Coping capacity	Consequence for society	Leading	Lagging	Activity	Outcome
Technical condition	Technical condition index of sub sea cable based on condition monitoring program						X		
Prognosis for technical cond.	Estimated future condition index of sub sea cable based on prognosis model					X			
Fault frequency	Fault history of the actual cable						X		
ENS	Energy not supplied caused by failure of sub sea cable						X		
CENS	Cost of energy not supplied caused by failure of sub sea cable						X		
Visual impression	Visual impression of any damages and if coverage near shore is ok.						X		
Work force	Qualified work force available, in house or through other contracts						X		
Cable repair vessel	Preparedness contract on cable repair vessel signed, time horizon for repair.						X		
Spare parts	Spare parts for sub sea cables in stock						X		
Mobile generators	Mobile generators available, in house or through contracts, capacity and time horizon						X		
ROS analyses carried out	Risk and vulnerability (ROS) analyses carried out by system operator							X	
Weather	Normal or adverse weather.						X		
Weather forecast	Normal or adverse weather.					X			
Climate prognoses	Precipitation, wind, temperature (years) ahead in time					X			

Results

- A framework for identification and establishing indicators to monitor and manage distribution system vulnerability.
- A case study showing the application of the framework for failure of a sub-sea cable supplying an island in Norway.

Conclusions

- A picture of present vulnerability can be established by combining various lagging, activity and outcome indicators.
- Future vulnerability can be estimated through leading indicators by including a prediction model.

Example:

Lagging	Leading	Activity	Outcome
Technical condition of sub sea cable	Prognosis for technical condition of sub sea cable based on ageing model	Enhanced condition monitoring related to corrosion on sheathing and improved cathodic protection	Development of corrosion on sheathing and technical condition