Risk assessment as an integrated part of distribution system reinvestment project analysis

Oddbjørn Gjerde, SINTEF Energy Research
Dag Eirik Nordgård, NTNU

Norway

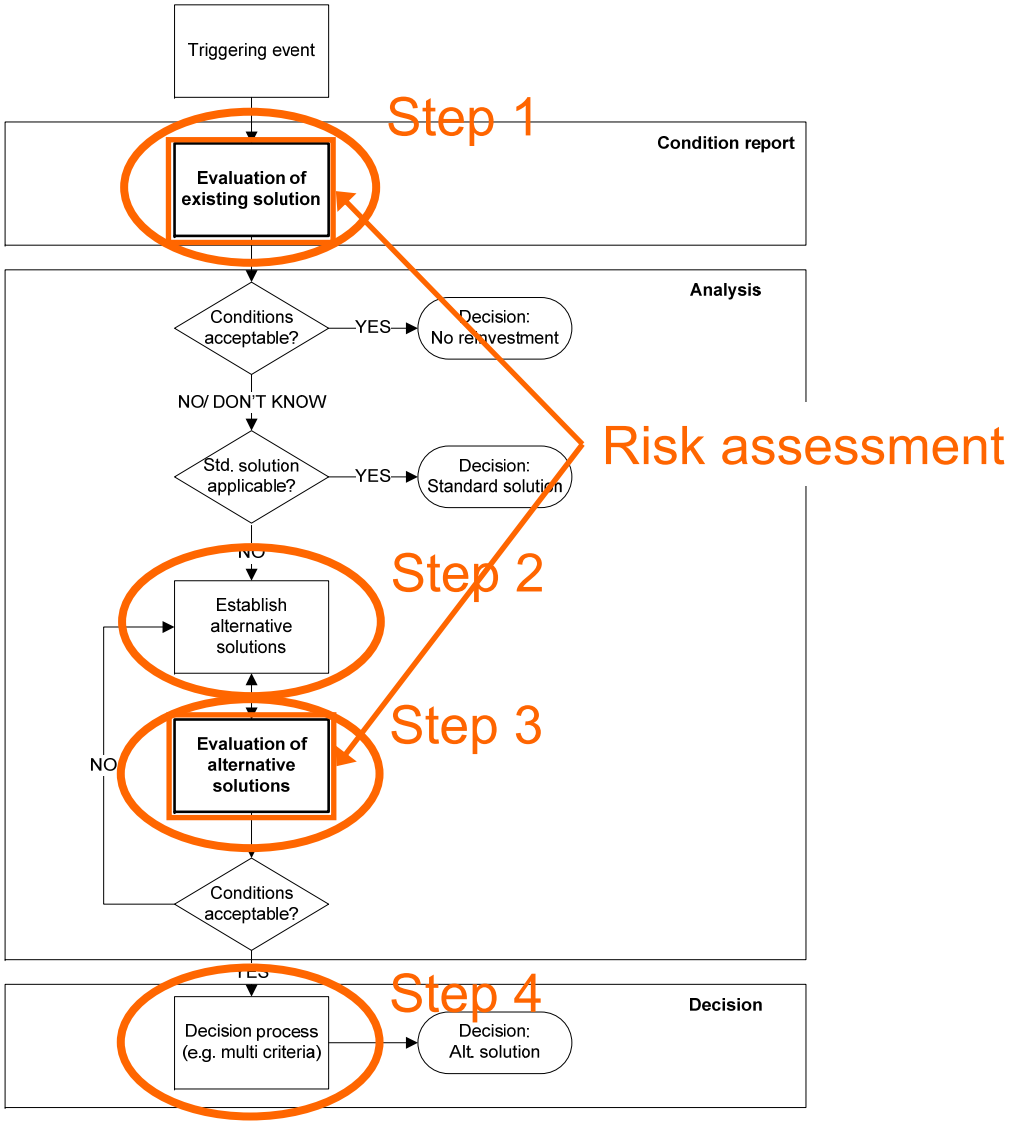
Plan for the presentation

- Background
- Process of reinvestment analysis
  - Process flow
  - Risk assessment
- Case:
  - Reinvestment analysis for MV/LV substations
- Concluding remarks

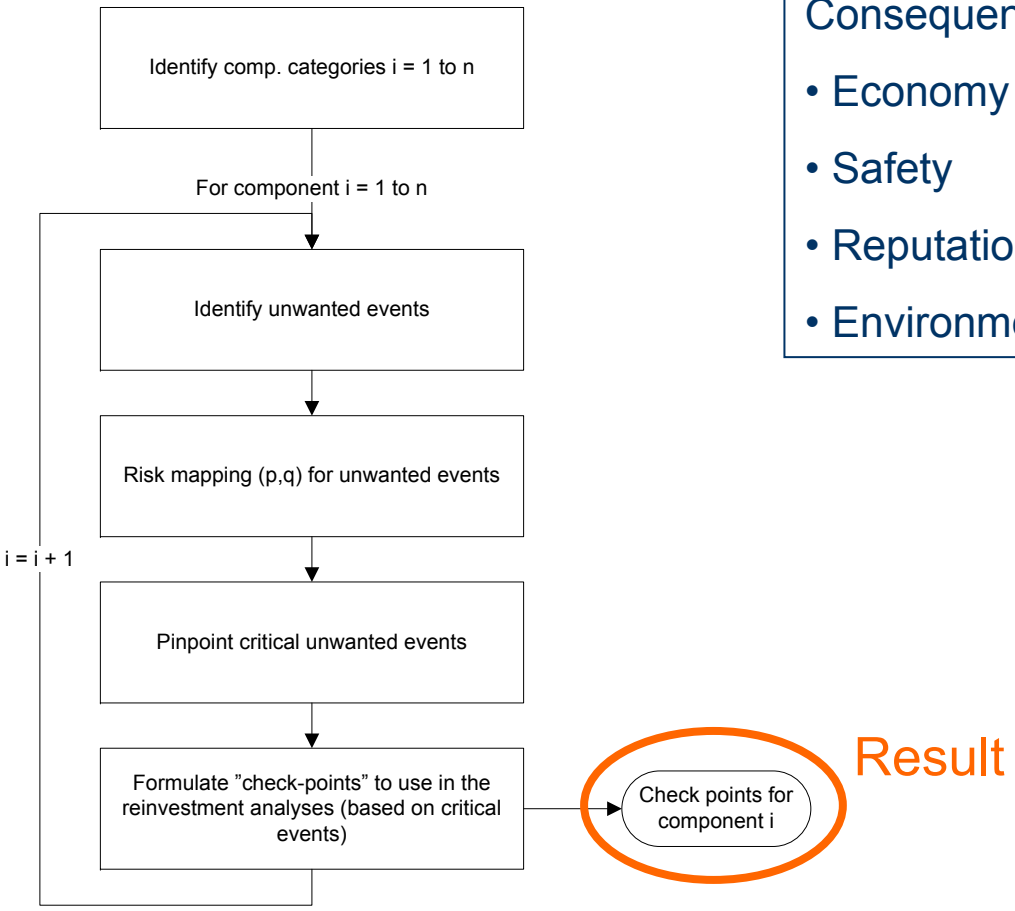
Background

- The emphasis on maintenance and reinvestment decisions is ever increasing in the electricity distribution business.
- Maintenance and reinvestment decisions are important parts of distribution system asset management, as means to control risk.
- The paper describes a framework where risk assessment is used to systematically evaluate projects regarding potential replacement or refurbishment of existing installations or sub-systems - referred to as *reinvestment projects*.
- The framework is well suited as a template for evaluating similar components – e.g. MV/LV substations

Process of reinvestment analysis



Risk assessment flow chart

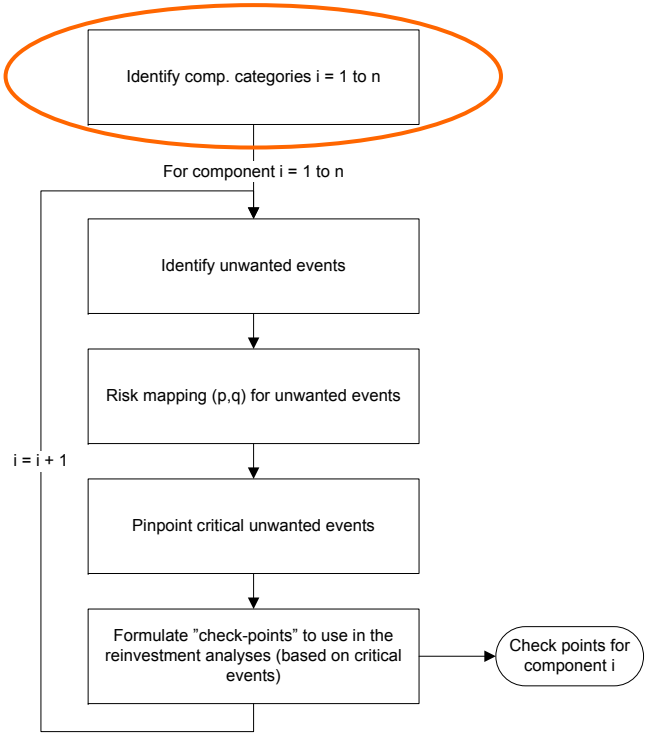


Consequence categories:

- Economy
- Safety
- Reputation
- Environment

Case study - Risk analysis framework for MV/LV substations

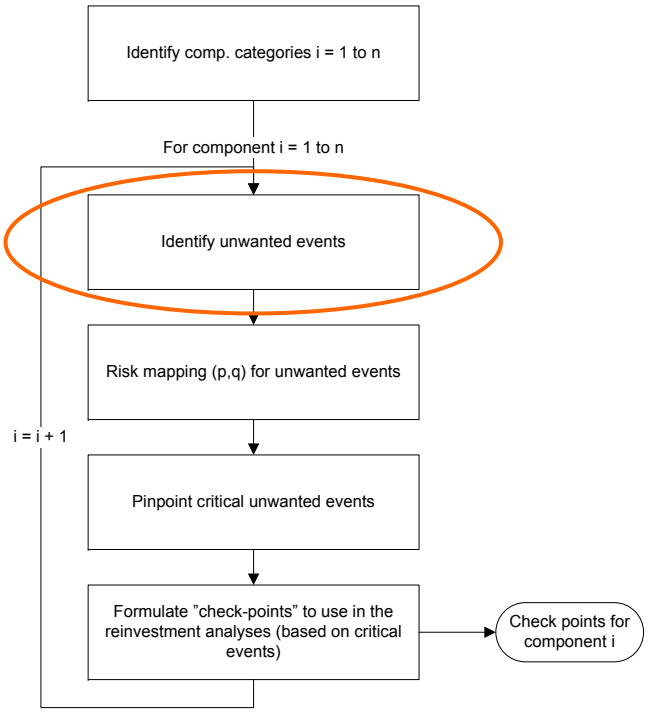
- Identify component categories for MV/LV substations
  - Building
  - Cable terminations
  - Breakers
    - Air insulated
    - SF6 insulated
    - Epoxy insulated
  - MV/LV transformer
  - Low-voltage system



Example: MV/LV transformer

- Identify unwanted events

1. Oil leakage
2. Flashover at insulators
3. Oil fire/ explosion
4. Public complaints (acoustic noise)
5. Transformer breakdown
6. Transformer running hot



Example: MV/LV transformer

Risk mapping of unwanted events

Table 1 Risk mapping for MV/ LV transformer.

Safety risk

Consequence ► / Likelihood ▼	Insignificant	Minor	Moderate	Major	Catastrophic
Frequent					
Probable					
Occasional					
Remote					
Improbable				1, 3	

Environment risk

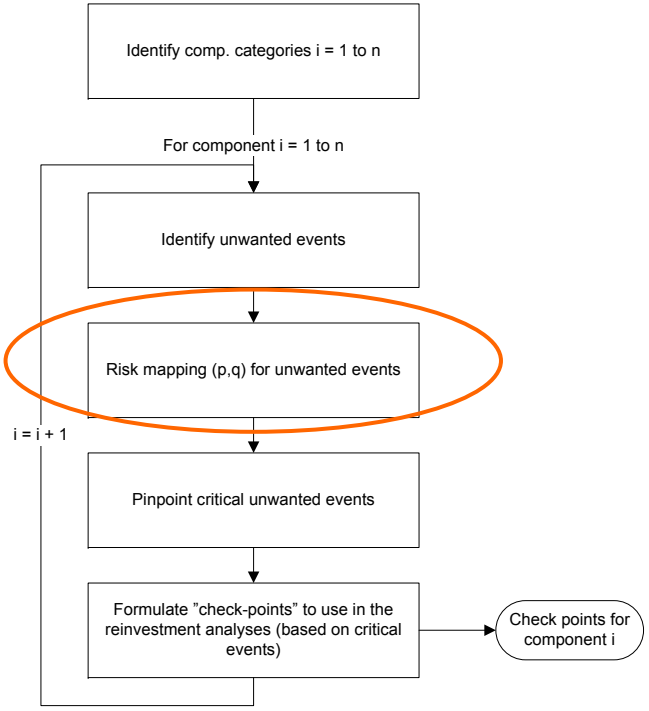
Consequence ► / Likelihood ▼	Insignificant	Minor	Moderate	Major	Catastrophic
Frequent					
Probable					
Occasional					
Remote	1 (with coll.)		1 (without coll.)		
Improbable	3, 5 (with coll.)		3, 5 (without coll.)		

Reputational risk

Consequence ► / Likelihood ▼	Insignificant	Minor	Moderate	Major	Catastrophic
Frequent					
Probable					
Occasional					
Remote	1 (with coll.)	4	1 (without coll.)		
Improbable					

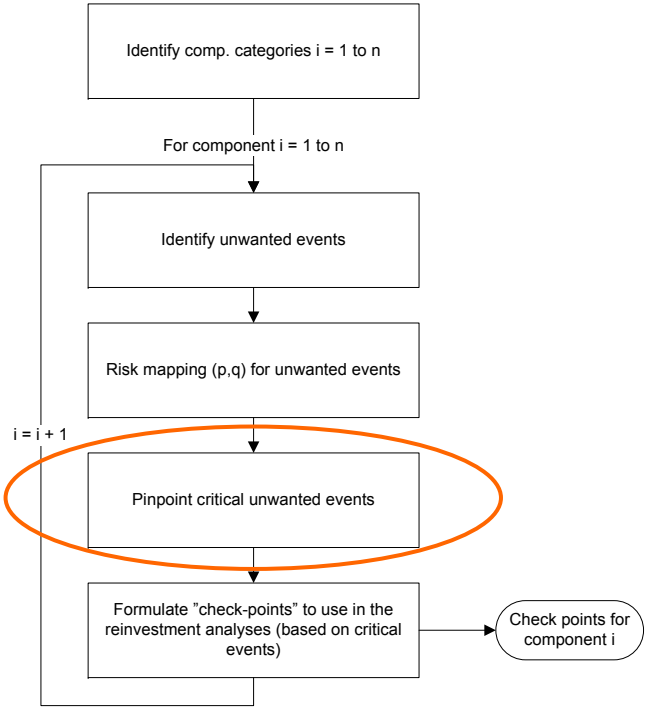
Economical risk

Consequence ► / Likelihood ▼	Insignificant	Minor	Moderate	Major	Catastrophic
Frequent					
Probable					
Occasional					
Remote		1, 2, 6			
Improbable			3, 5		



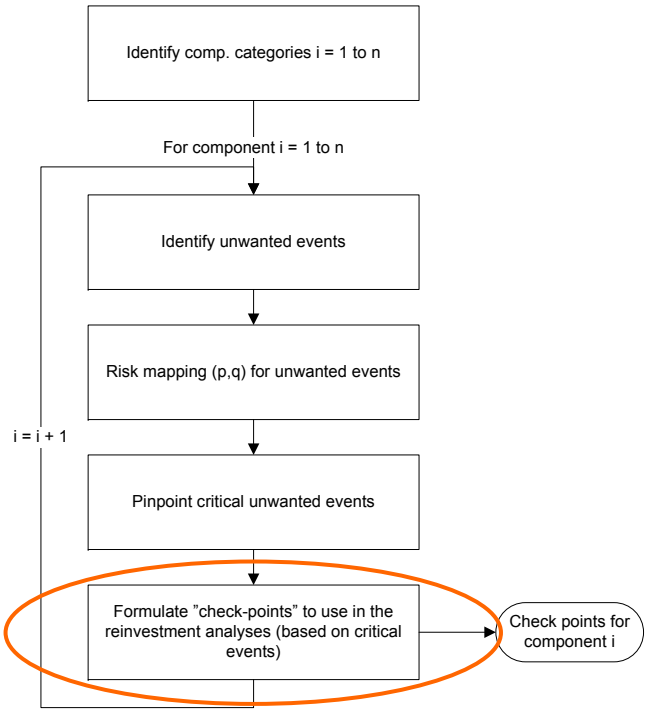
Example: MV/LV transformer

- Pinpoint critical unwanted events
  - Safety risk:
    Oil leakage, oil fire/ explosion
  - Environmental risk:
    Oil leakage, oil fire/ explosion, breakdown (without oil collector)
  - Reputation risk:
    Oil leakage
  - Economic risk:
    Small (acceptable)



Example: MV/LV transformer

- Formulate ”check-points”
  - Insulating medium?
    Oil / dry
  - Transformer condition?
    Worse/average/better
  - Oil collector underneath?
    No/yes
  - Any other circumstances?



Checklist for MV/LV substation

Component/ sub system	Current state	Alternative 1	Alternative 2
A. Building			
A.1 Adequate protection against unauthorised access			
A.2 Safe escape route in case of unexpected event			
A.3 Substation easily accessible			
A.4 Tagging on walls			
A.5 Intrusion of water			
A.6 Any other circumstances	-	-	
B. Cable terminations			
B.1 Termination type	Oil filled	Oil filled	Dry
B.2 Partial discharges audible	No		
B.3 Any other circumstances	-		
C. Breakers			
C.1 Breaker type	Air	Air	SF6
C.2 Condition	Average	Average	Better
C.3 Enclosure	Closed	Closed	Closed
C.4 Any other circumstances	-	-	-
D. Low-voltage system			
D.1 Enclosure	Open	Protected	Protected
D.2 Single pole switches	Yes	Yes	No
D.3 Any other circumstances	-	-	-
E. Transformer			
E.1 Insulating medium	Oil	Oil	Oil
E.2 Condition	Average	Average	Better
E.3 Oil collector underneath?	Yes	Yes	Yes
E.4 Any other circumstances	-	-	-
Investment cost [kNOK]		100	800
Remaining lifetime [years]		< 10	> 30

Alternative 1:
Minimum solution

Alternative 2:
New substation

Concluding remarks

- A concept of risk assessment applied to replacement or refurbishment evaluation is described
- It represents a compact and understandable evaluation and documentation of the problem and possible solutions
- The approach is suitable for repetitive reinvestment analysis as exemplified for MV/LV substations