GARPUR FINAL CONFERENCE

Benefits of a probabilistic approach in a real system development study

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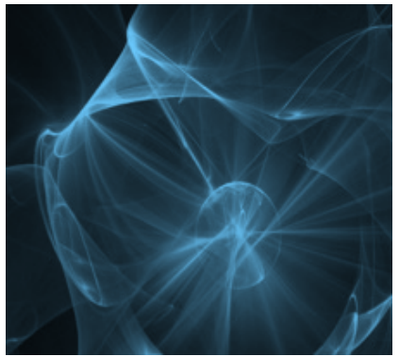
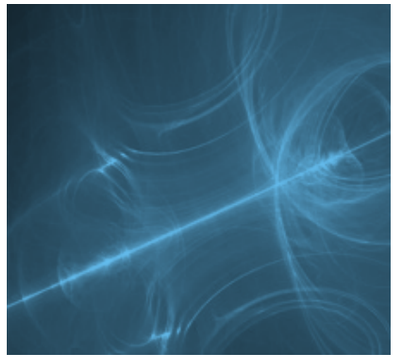
Agenda



Demand for a probabilistic approach in system development

Requirements for the approach



Application to a real case

Conclusions and outlook

Demand for a probabilistic approach in system development

Demand for a probabilistic approach in system development

Does N-1 justify **high investment costs**

Which grid expansion alternative gives us the **right level of risk…**

What is the **right balance of security of supply and investments**

…and what are the total costs for society

→ quantifying the **value of security of supply!**

Requirements for the approach

Our resources of required information

Long-term **scenarios** ← Prognosis

Comprehensive statistic - **failures** and **meantime to repair** ← Reporting system

Interruption cost model for different consumer groups ← Regulation

Simulating CA and **system response** ← In-house tool

Component reliability data

- **Precondition** for performing reliability analysis
- Learning from **past disturbances**
- Statnett operates a **standardised system** for data collecting
- Common reporting tool is used by **all Norwegian DSOs and Statnett**
- Input **detailed information** of failure
  - Component and location
  - Primary cause and consequence
  - Meantime to repair
  - Energy not served
  - Type of failure
- Result **comprehensive failure statistic**

Source [FASIT]

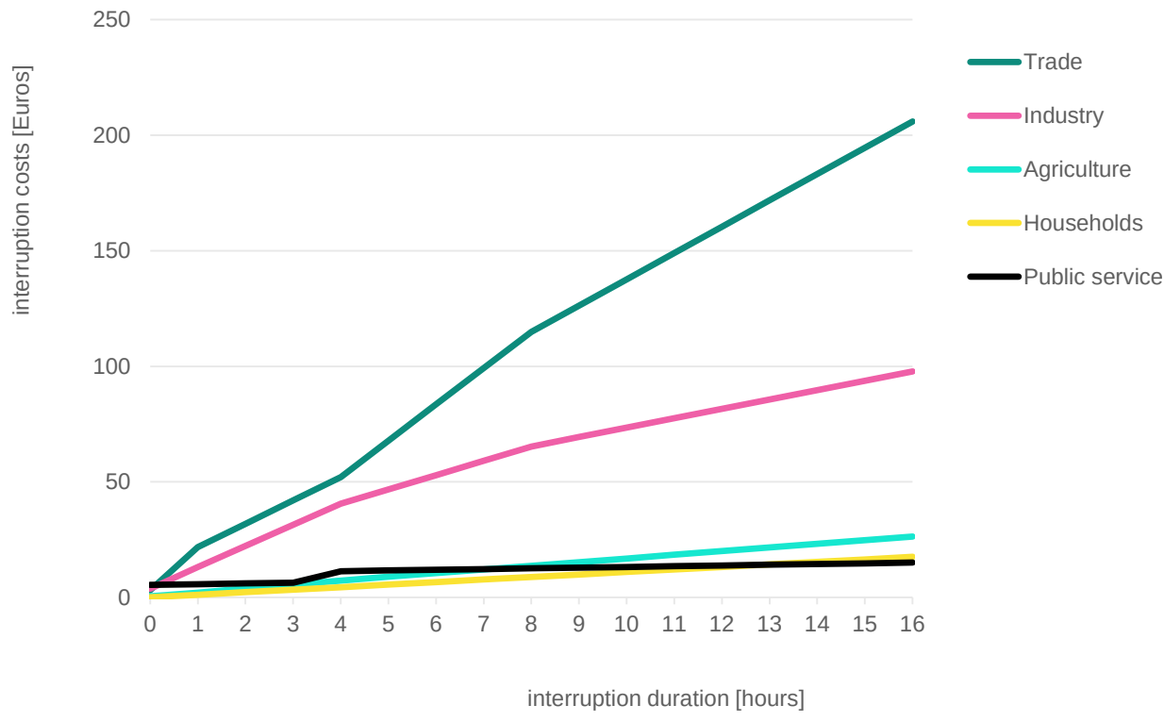
Costs of energy not served

In Norway **5.5 Million Euros** in interruption costs due to contingencies in the transmission grid in 2015

- Regulatory framework
- Energy not served due to disturbances over 1 kV

→ Reporting

- Costs of energy not served
- For several consumer groups
- Correction factors for costs of each consumer (month, days, hours or announced outage)

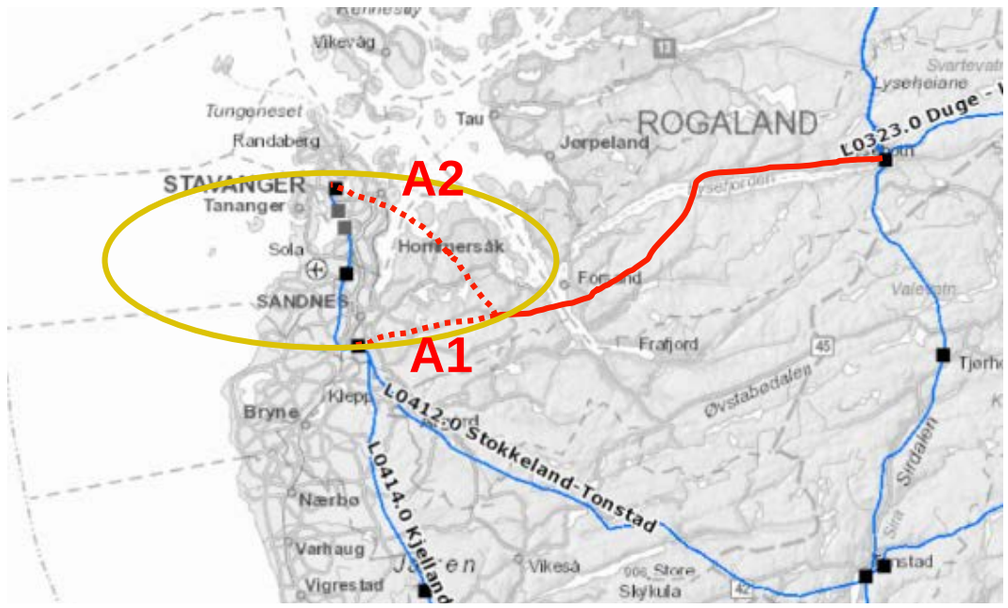


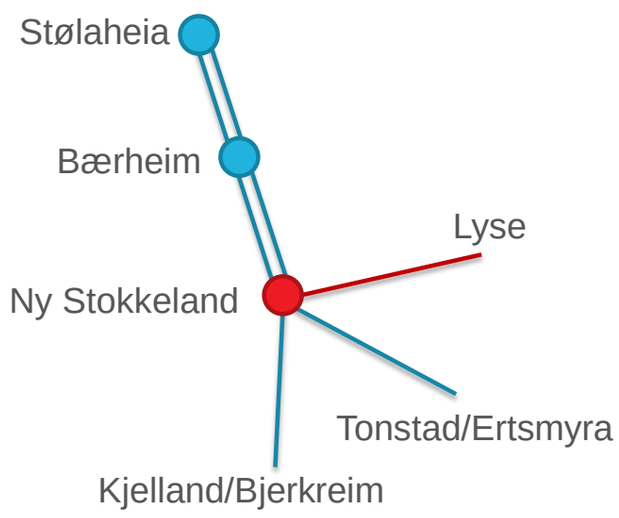
Source [KILE]

Application to a real case

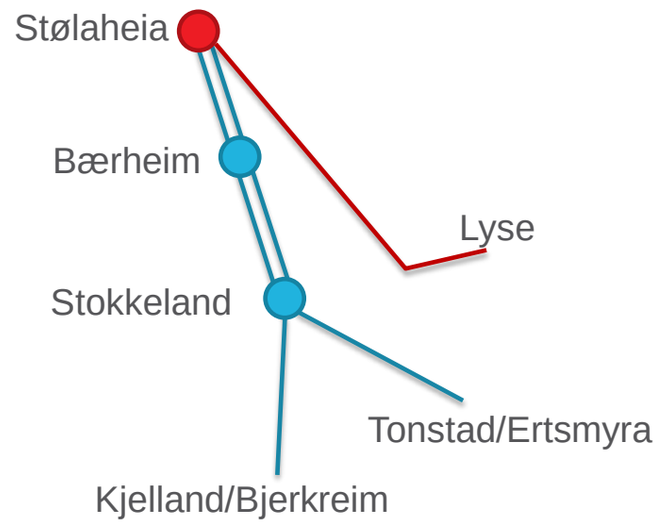
Method applied to a real case

- **Grid expansion and reinvestments** are needed for the area of Stavanger after 2025
- Different alternatives possible
- What is the **value of security of supply?**
- What is the **cheapest alternative for society?**





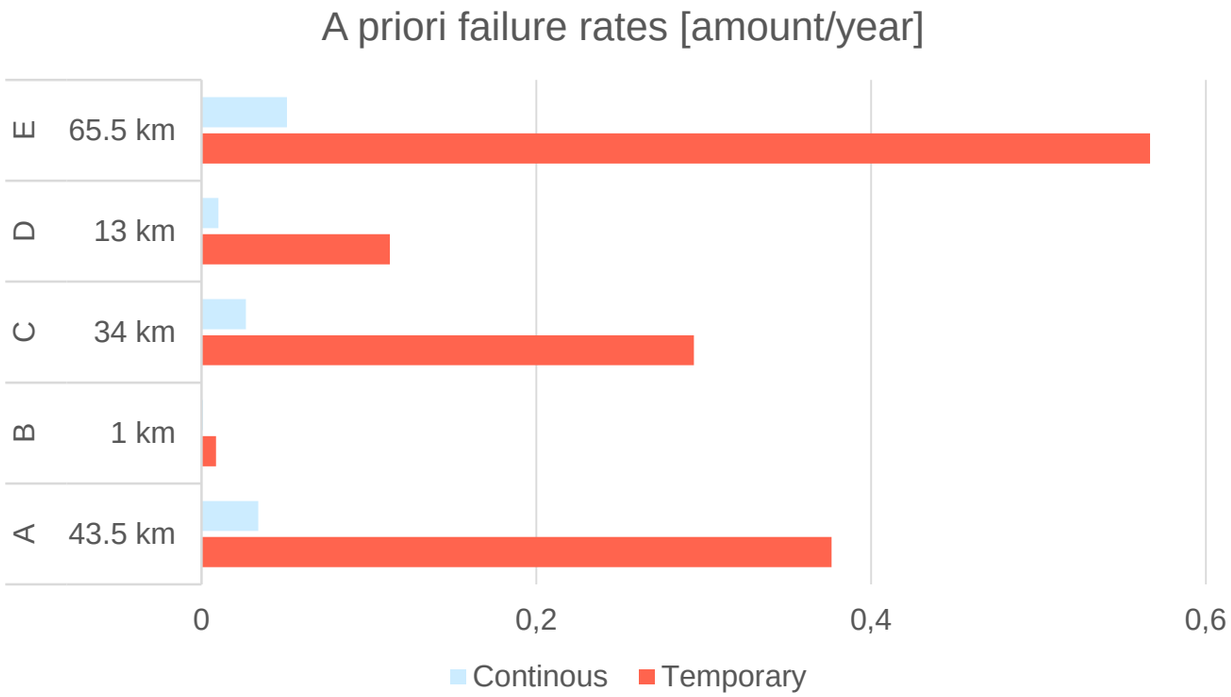
Alternative 1

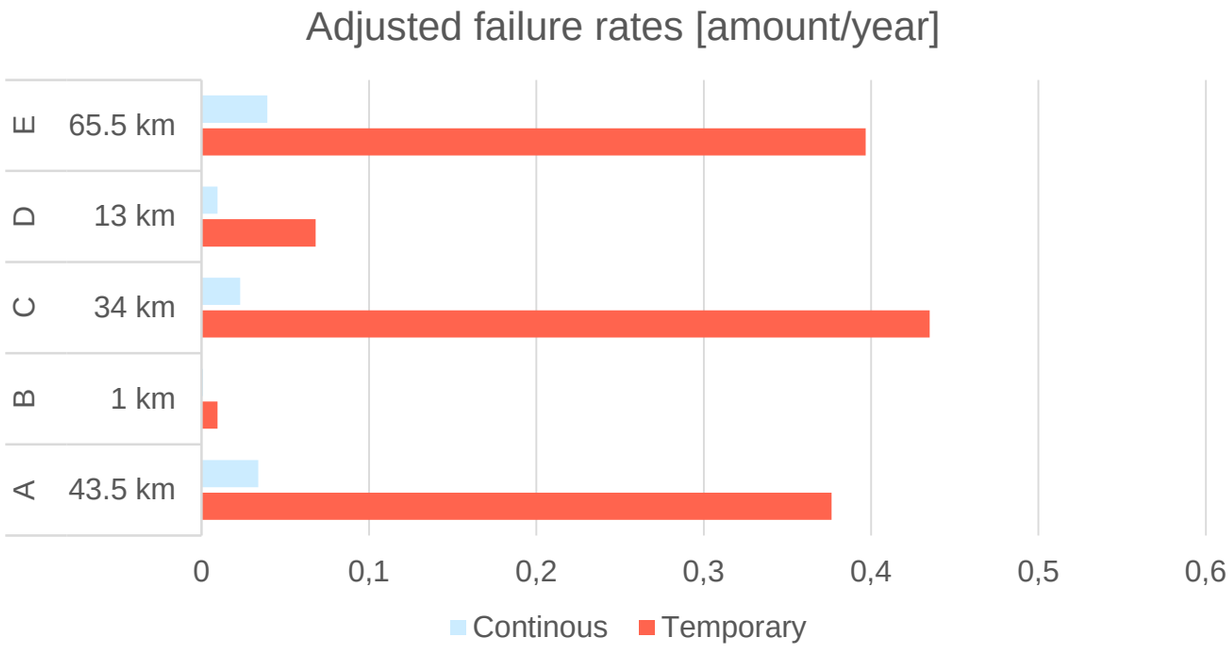


Alternative 2

Failure statistic

- Distinction in **temporary** and **continuous failures**
- **Seasonal dependence** (winter, summer & spring/fall)
- **68** transmission grid components
- Bayesian adjustment
  1. A priori = generic long-term failure rate
  2. Adjust a priori with actual failure observations of the component for the identical period
  3. Adjusted failure rates per line

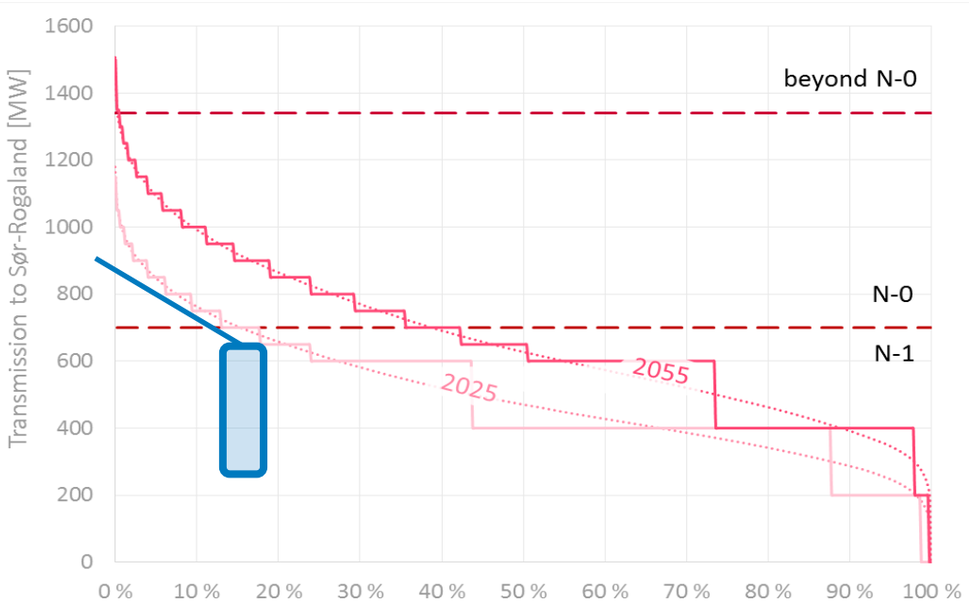




In-house tool and costs of consequences

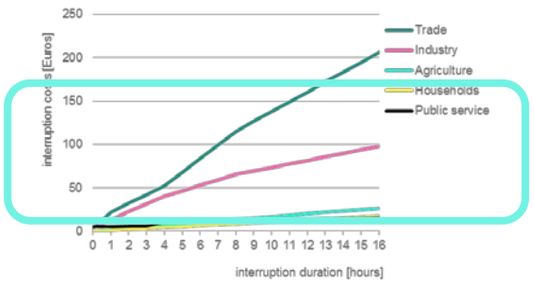
Scenarios

- Define load-flow levels and yearly shares



Consequences for each load-flow level

- PSSE API/python: AC-load flow; contingency analysis and consequences of failure
- Topology measures and redispatch
- Load shed and interruptions

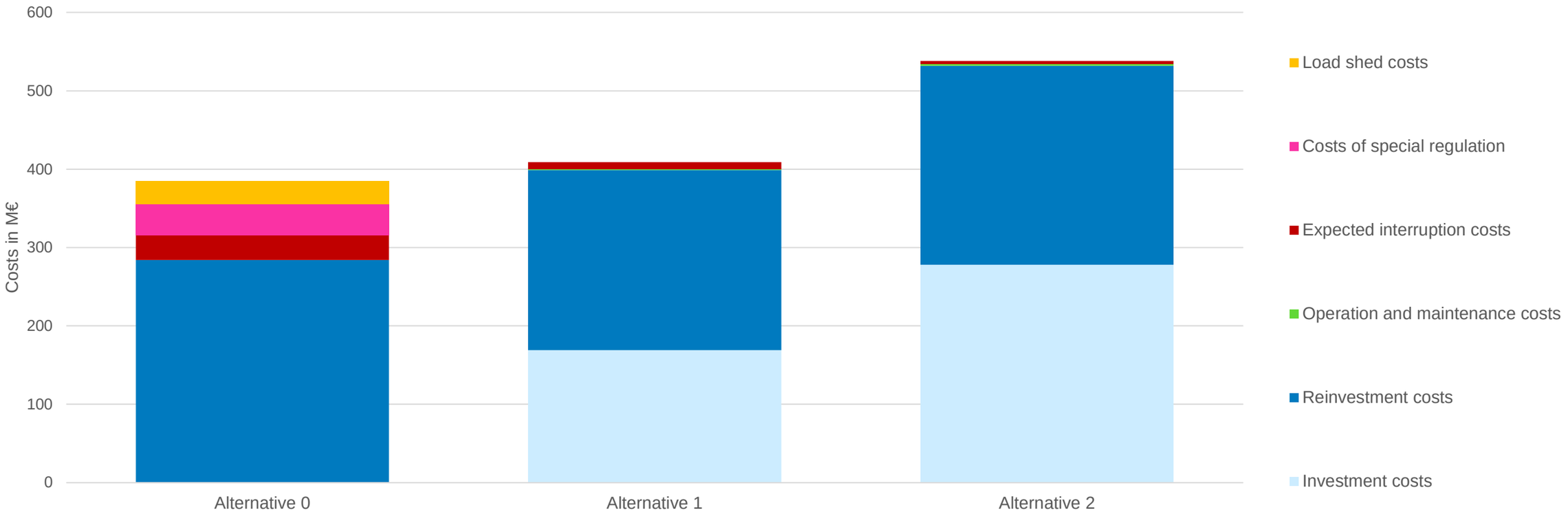


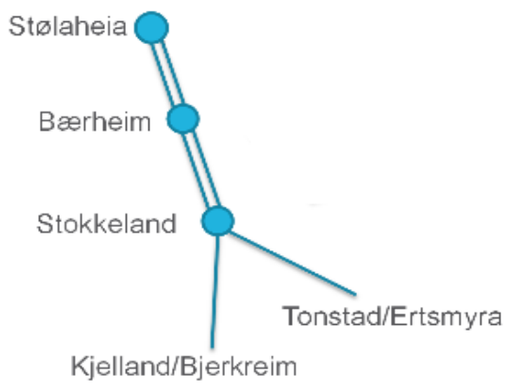
$$\lambda_i^B = \frac{\alpha + \sum n_i}{\beta + m}$$

Consequence x **Share** x **Cost of consequence** x **Probability of failure**

= **Expected interruption costs**

Results


600
500
400
300
200
100
0
Costs in M€
Alternative 0
Alternative 1
Alternative 2
Load shed costs
Costs of special regulation
Expected interruption costs
Operation and maintenance costs
Reinvestment costs
Investment costs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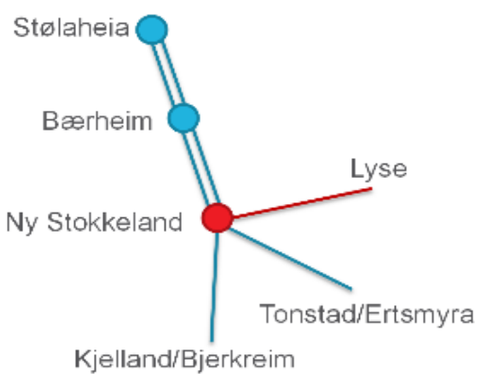
Bærheim
Stokkeland
Tonstad/Ertsmyra
Kjelland/Bjerkreim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Lyse
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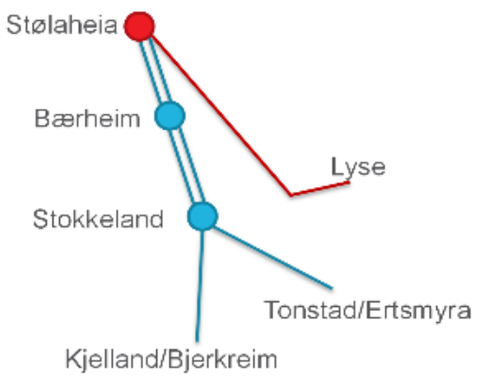
Stølaheia
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Conclusions and outlook

Conclusion

- **Probabilistic approach** is a good way to evaluate the **security of supply**
- **25% savings** in investment costs and society
- Comprehensive failure history is crucial

Outlook

- **Improvement** of in-house tool
- Modelling of **wind** and **lightning dependent failures probabilities**
- Merging of **geo-information** and **historical weather data**
- **Monte-Carlo simulations** to capture multi-failure scenarios during severe weather conditions
- **Company strategy** focuses on enhanced probabilistic approaches

THANK YOU FOR YOUR ATTENTION

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http://www.garpur-project.eu/

Reference

[KILE] https://lovdata.no/dokument/SF/forskrift/1999-03-11-302

[FASIT] http://fasit.nsp01cp.nhosp.no/