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Availability and risk management in IGCC power generation plants: a structured approach for a non-mature technology

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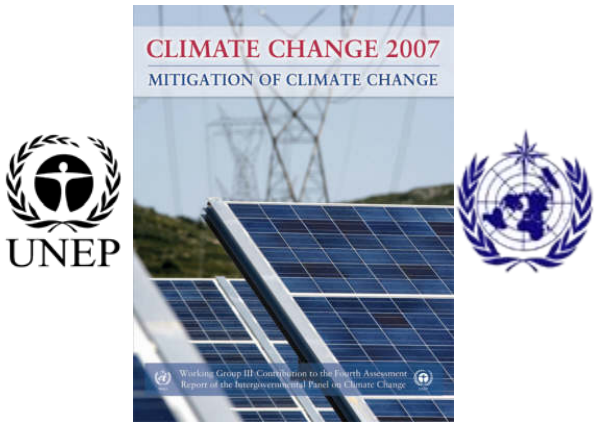
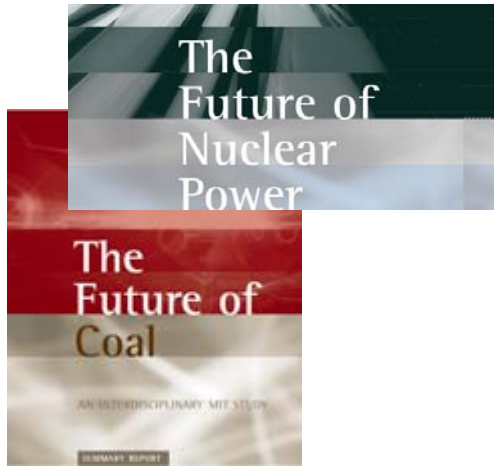
Energy production in the (near) future

Setting the environmental landscape for the future

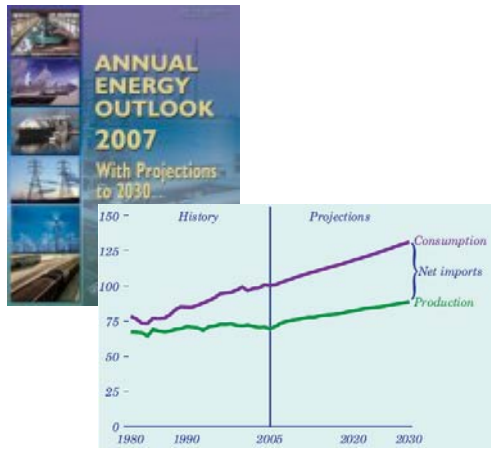
- Climate change
- (Limited) natural reserves
- Import from politically unstable regions



Intergovernmental Panel on Climate Change



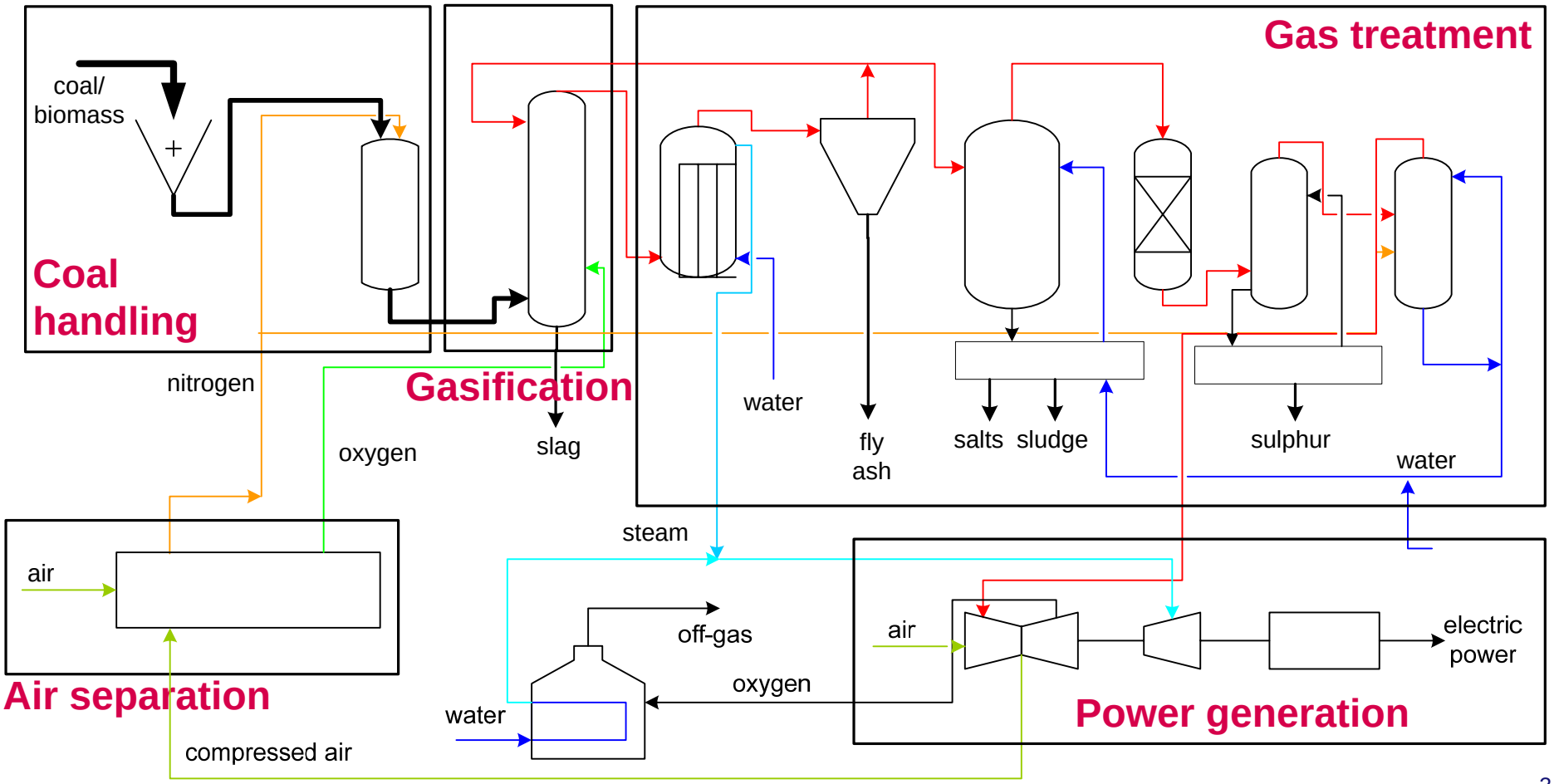
MIT studies



DOE Annual Energy Outlook

Integrated Gasification Combined Cycle

Coal as an energy source and **Integrated Gasification Combined Cycle (IGCC)** as the related conversion technology is one alternative.



IGCC's potential

According to MIT's *Future of Coal* study[1], IGCC combined with Carbon Capture and Storage (CCS) is one of the leading candidates for (future) power generation.

Benefits include:

- (CO_2) Emissions reduction
- Large reserves
- Little dependency on natural gas or oil
- Technology benefits

[1]S. Ansolabehere et. al., *"The Future of Coal: options for a carbon-constrained world"*, Massachusetts Institute of Technology study, 2007, Cambridge, MA.

The marginal sustainability of IGCC

Despite IGCC's great promise, commercially operating IGCC power plants are in a phase of marginal economical sustainability.

[Maurstad, 2005]:

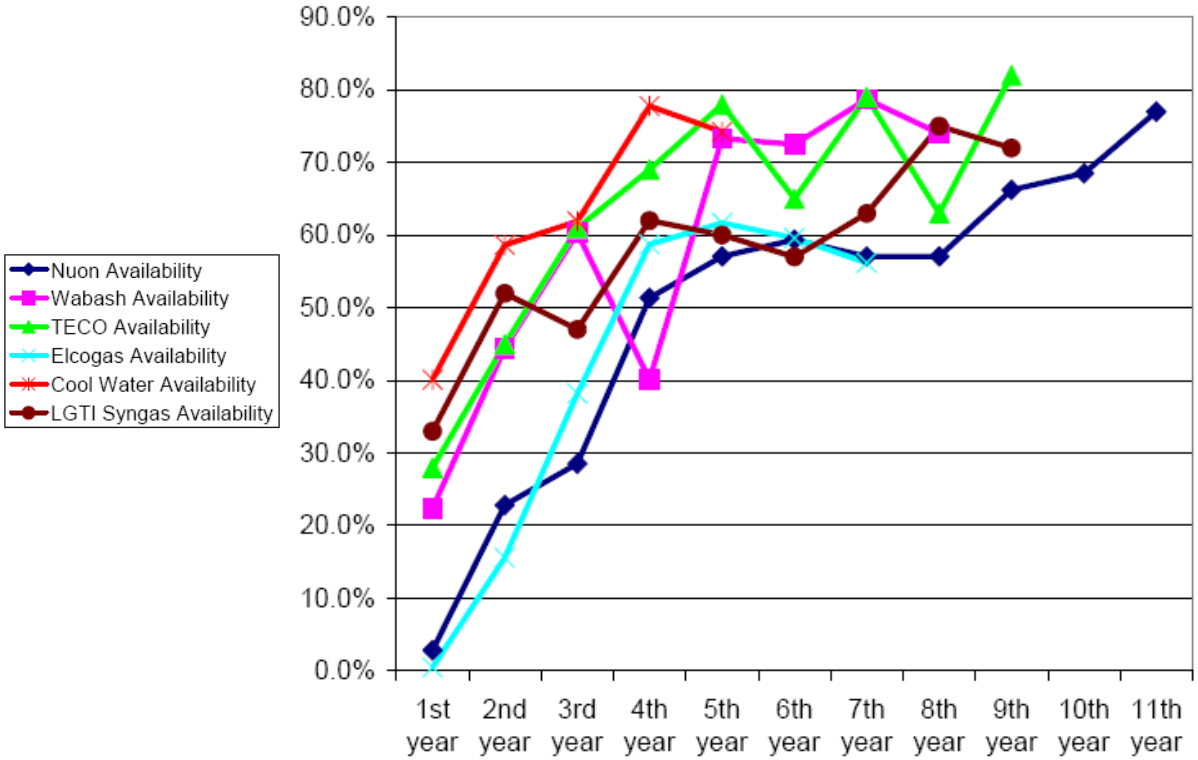
*"Main challenges facing IGCC technology today are **capital cost and availability**"*

Challenges include[2]:

- Higher capital cost compared to other power generation plants
- Plant viability without subsidies
- **Low plant availability during early operation**

[2]J.N. O'Brien, J. Blau and M. Rose, *"An Analysis of The Institutional Challenges to Commercialization and Deployment of IGCC Technology in the U.S. Electric Industry, Recommended Policy, Regulatory, Executive and Legislative Initiatives"*, Global Change Associates, 2004.

Lower than expected availability



Likely causes:

- Uniqueness of plant
- High level of plant integration
- Operation IGCC plant versus PC plant

To be cost competitive, availability should be around 80-90% per year

History of IGCC availability for the start-up of coal-based units[3]

[3]J. Phillips. *"Integrated Gasification Combined Cycles with CO_2 Capture"*, GCEP Research Symposium, 2005, Stanford University.

The need for a structured approach

From an investment and operational perspective, a structured approach to risk and availability management tailored to IGCC is missing.

Key elements

- Should complement current risk & availability practices (HAZOP, Failure analysis, Risk Inventory studies)
- Little to no historical data, high level of integration: both parametric and structural uncertainty → **Bayesian Networks**
- Making decisions in abnormal circumstances, operating philosophy IGCC versus PC → **Scenario-based Training**

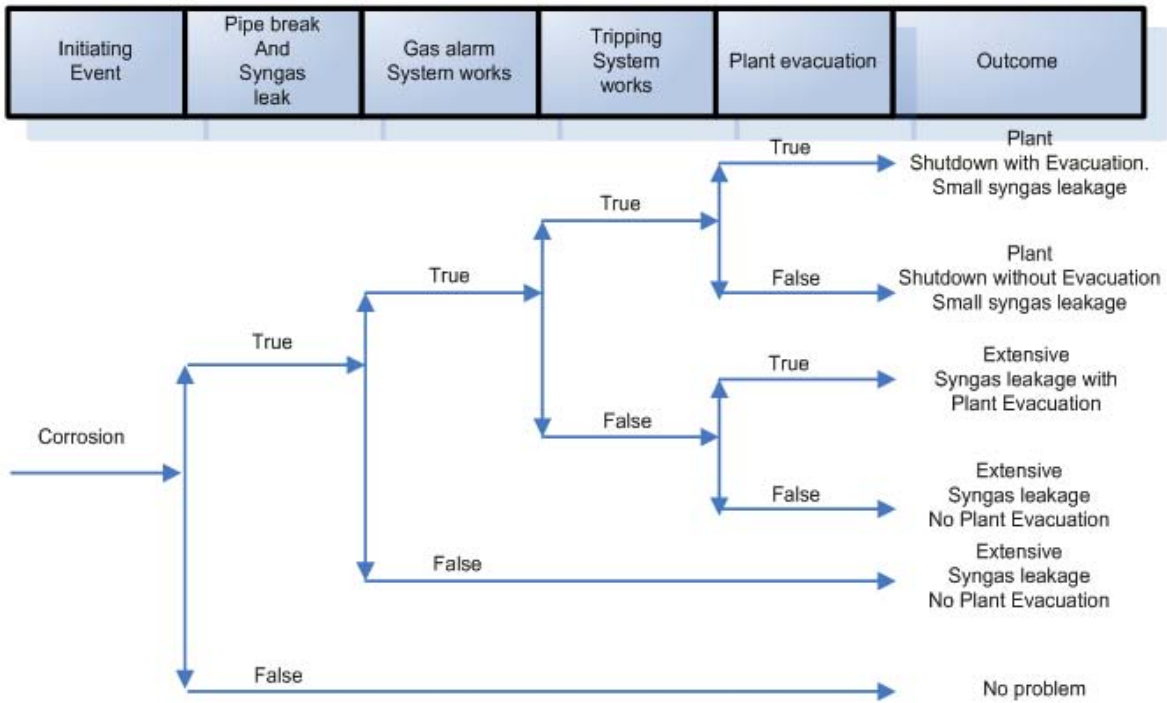
Case study conducted (ongoing) within Dutch IGCC plant.

Starting point: scenarios

Scenario: Starting with an initiating event, a sequence of events that results in an undesirable outcome with respect to risk or availability.

Example:

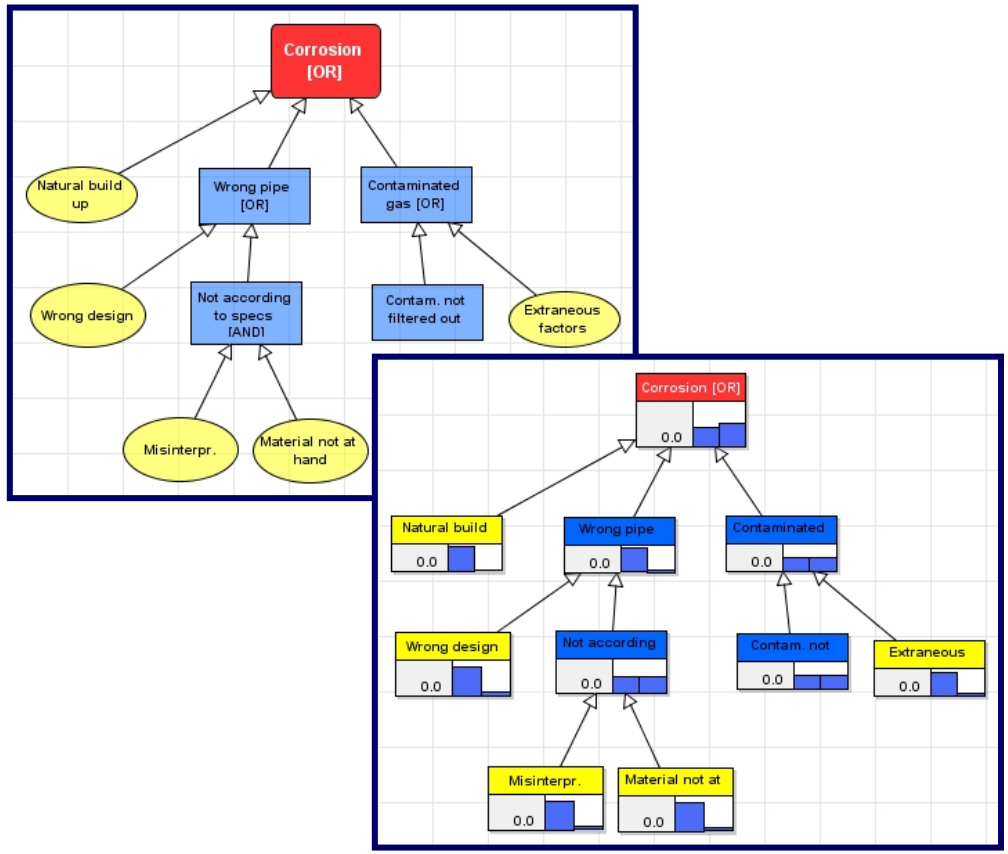
Corrosion in H_2S pipe in Syngas Treatment function



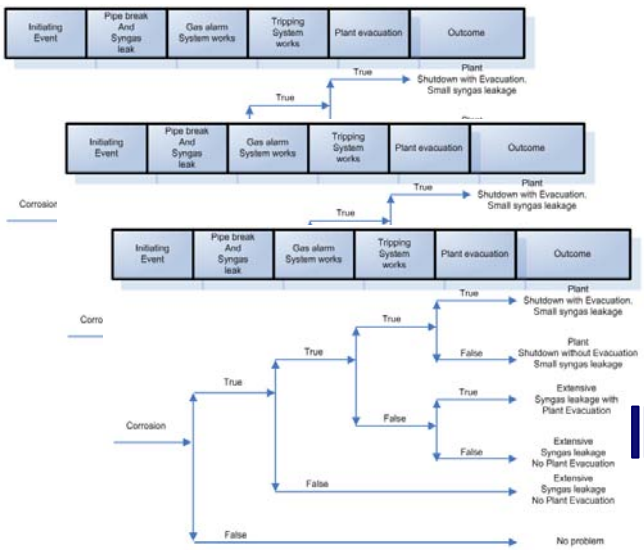
Bayesian Networks

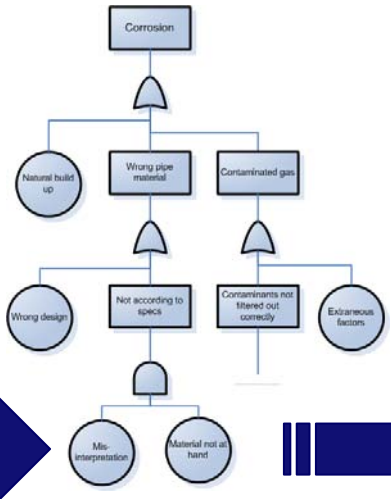
A graphical probabilistic model that represents variables and their probabilistic interdependencies.

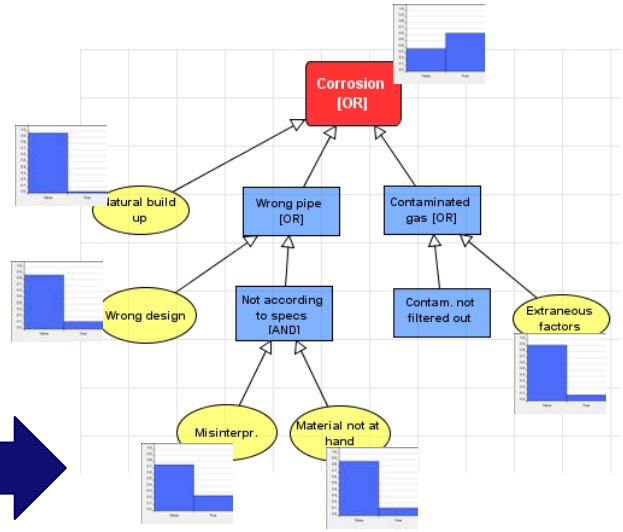
- Update prior beliefs when new data become available
- Distributions vs. point estimates
- Causal relations at plant level
- **Predict & train**



From Scenario to Bayesian Network



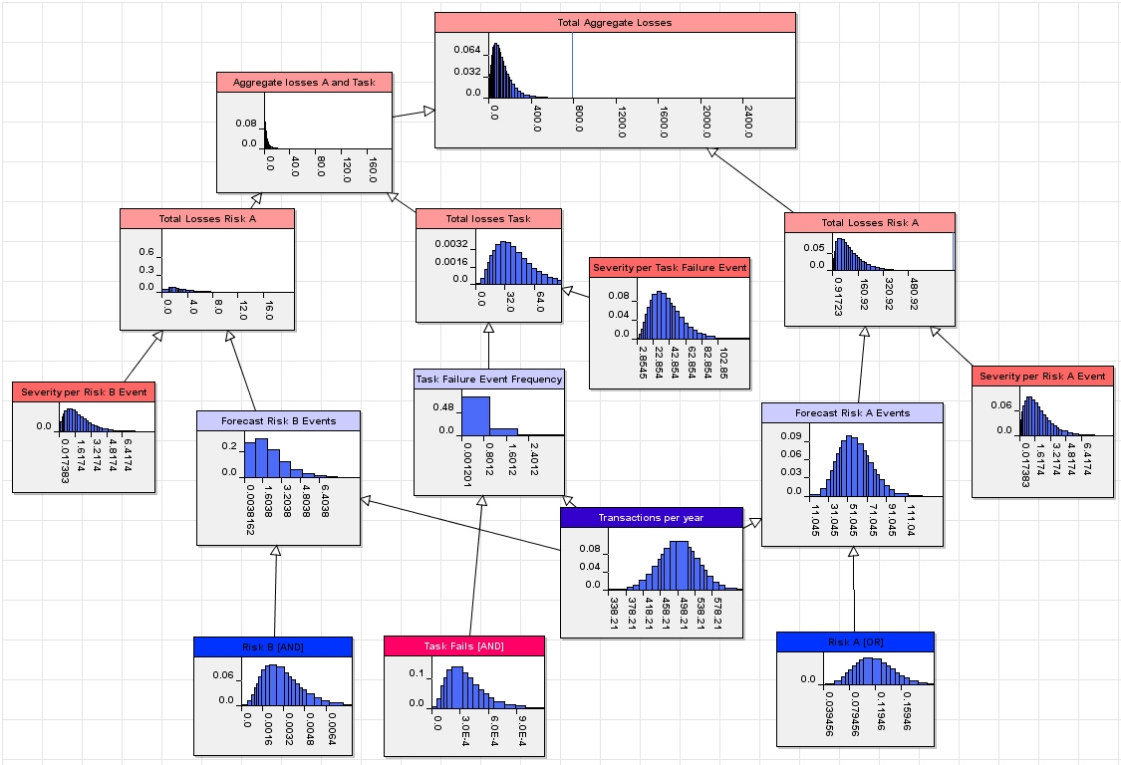




Scenario **Fault tree** **Bayesian Network**

Quantification of Bayesian Networks

Example: financial risk



Extracted from AgenaRisk®

Estimate likelihood:

- Binomial
- Exponential
- Normal
- Uniform
- Manual
- Etc.

Scenario-based Training (1)

Operators rarely deal with abnormal circumstances and are not trained in making decisions in these circumstances.

Primary objective:

- Envision scenario to operators
- Decision support system

Secondary objectives:

- Scenario check
- Increase awareness of function dependence
- IGCC operating philosophy

Scenario-based Training (2)

Major steps:

- Scenario enhancement
- Translate scenario into "script"
- Pre-test, Training, Post test
  - Audio-visual presentation
- Training → 4 questions:
  - How to prevent?
  - How to detect?
  - What is the diagnosis?
  - What actions are you going to take?

Conclusions

- A structured approach to risk and availability management tailored to IGCC is missing.
- An approach which complements existing methods and practices with Bayesian Networks and Scenario-based Training is proposed.
- The proposed approach is being applied within a Dutch IGCC plant, which makes it possible to report on further case study findings in a next paper.