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

Joël Luyk & Dimitrios Karydas
TU/e

Ninth International Probabilistic
Safety Assessment and Management Conference
An ISAPSAM Conference
18-23 May 2008 Hong Kong, China
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
Coal as an energy source and Integrated Gasification Combined Cycle (IGCC) as the related conversion technology is one alternative.
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

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

Challenges include:

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

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

\[\text{Maurstad, 2005}^{2}\]

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

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.**
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 H₂S 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
Example: financial risk

- 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.