## Optimisation of the operation of an industrial power plant under demand uncertainty

### Use Case

The goal is to optimise the operation of a power plant in an industrial production site under uncertainty of the future steam demand. The power plant of INEOS in Köln is the subject of the investigation.

### Challenges of operation planning

- Uncertainty in steam demand
  - Influence of operators
  - External influences which are not considered
  - Deviations from the production plan
  - Other unknown sources

### Negative effects of uncertainties

- Excessive steam in the network
  - Condensation of the steam
  - Venting of the steam
- Insufficient steam in the network
  - Buy steam from provider (limited)
  - Change production rates of plants

### Two-stage optimisation

Some of the data are uncertain

- Described by a set of discrete scenarios

First-stage decisions

- “Here and now” decisions, taken prior to the realization of the uncertainties

Second-stage ( recourse) decisions

- “Wait and see” decisions, taken to react to the realization of the uncertainty

### Model of the uncertainties

- 3 demand regions are defined
  - Two deviation points in the second stage
  - A variation of the probabilities of the scenarios with the current state is identified

### Formulation of the optimisation

The optimisation is formulated as an MILP

- Mass and energy balances
- Time-invariant enthalpies
- Linear models for the equipment
- Binary variables for the operating modes and mode transitions of the equipment

### Optimisation on a rolling horizon

Combines the advantages of preventive and reactive scheduling

- Model parameters updated at the beginning of the optimization horizons and assumed as constant
  - Burner and boiler efficiencies, Lower Heating Values (LHV), enthalpy of the streams, injections, bypasses, balance errors
- Update of the probability distribution of the scenarios

### Comparison framework

Simulates the operation of two planners

- Simulates a set of steam demand realisations
- The set represents the distribution of the scenario probabilities
- Compares the results of planning for the approaches

### Test case I: Normal operation

The realisations of the steam scenarios are simulated using 160 optimisations

- Each optimisation with a horizon of 56 h

The stochastic solution improves the economics by 10.7% compared to the deterministic solution

### Test case II: An extreme scenario

Shows the difference between a deterministic and a stochastic solution in handling extreme cases

- Deterministic solution does not cover all of the possible realisations in the future, and can fail in reacting to extreme changes

### Summary and conclusion

New optimisation framework developed

- Handles the uncertainty of the future steam demand
- The model parameters are updated online
- Reduces the chances of extreme shortcomings in the steam network
- Reduces the operational costs for the normal daily operating conditions significantly

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**Developers:**

Keivan Rahimi-Adli, M.Sc. keivan.rahimi-adli@ineos.com

Prof. Dr. Sebastian Engell sebastian.engelli@tu-dortmund.de

**Further contact:**

Benedikt Beisheim, M.Sc. benedikt.beisheim@ineos.com

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**Web:**

www.copro-project.eu

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