





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

Project:

Improved energy and resource efficiency by better coordination of production in the process industries



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# COORDINATED PRODUCTION FOR BETTER RESOURCE

**The goal of the CoPro project** was to develop and to demonstrate methods and tools for process monitoring and optimal dynamic planning, scheduling and control of plants, industrial sites and clusters under dynamic market conditions, to provide decision support to operators and managers and to progress to automated closed-loop solutions to achieve an optimally energy and resource efficient production.

CoPro brought together 17 partners from 8 EU countries, including 5 industrial end users and 6 technology providing SMEs. The project developed solutions for the **plant-wide optimisation of large plants, for balancing production and consumption in industrial parks for industrial symbiosis**, and addressed **power plant scheduling** and **demand-side response**. It further developed online data analytics for **anomaly detection**, and **decision support** for plant operators and managers. The solutions can be integrated into the IT infrastructure of the plants via an **integration platform** that supports the connection to different IT systems. CoPro developed **model libraries**

for the efficient development of advanced optimisation-based solutions and techniques and software for **hybrid modelling** and **model management**.

**The developments of CoPro** were motivated by and applied to challenging use cases from different sectors of the process industries:

- (Petro-)chemical production;
- Cellulose fiber production;
- Production, formulation and packaging of consumer goods;
- Sterilisation and packaging of food.

CoPro demonstrated that significant savings of energy and resources are possible by using advanced technologies for monitoring, decision support, optimisation, and planning and scheduling.

## The CoPro partners

### Industrial end users and use case providers



### Technology providing



### Universities



Universidad de Valladolid



### Research institutes



Sector:

## Chemicals

## Steel

Summary:

### The Problem

- INEOS in Köln operates a power plant that incinerates off-gases of the production plants and produces steam and a part of the electricity that is required for plant operation.
- The steam demand of the site depends on the operation of the plants which is exposed to

uncertainties.

- An imbalance in the steam network results in inefficient operation of the power plant.

## The Solution

- A framework for the optimal operation planning of the power plant considering uncertainties in the steam demand has been developed.
- The plan is re-calculated on a rolling horizon, and the model parameters and the scenarios for the future steam demand are updated based on the most recent information from the plants.
- The uncertainty-aware solution reduces the adverse effects of the uncertain steam demand.

Theme:

Plant-wide monitoring - SPIRE02-2016

Keywords:

Combined heat and power plants, Steam demand uncertainty, Scheduling, Stochastic optimisation, Optimisation on a moving horizon, Dynamic electricity price

Type:

**Case study**

**Software**

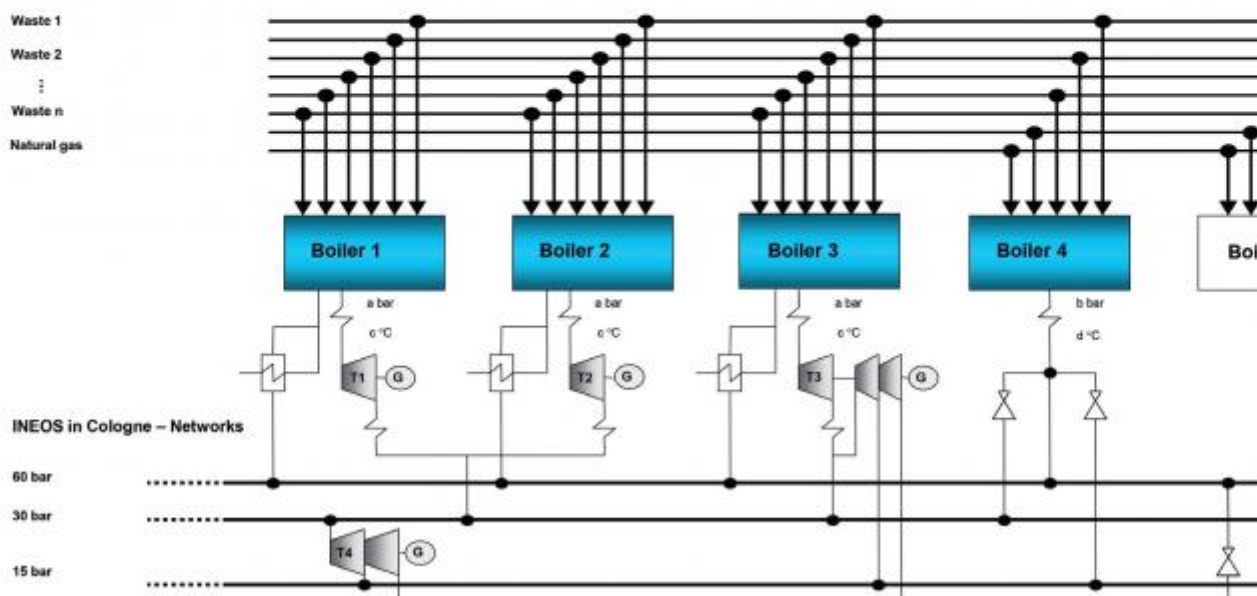
**Poster**

## Resources

Link:

Technology Short Desc.: Optimisation operation of an industrial power plant under demand uncertainty

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



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

## The problem

### The steam demand uncertainty

At the site of INEOS in Köln, more than 20 production plants are operated. The central power plant that consists of several boilers and turbines produces steam at different pressure levels for the operation of the production plants. Furthermore, electricity is produced as a by-product, which covers a part of the total electricity demand of the site. The power plant incinerates off-gases from the plants.

The planning of the operation of the power plant requires the steam demand profile at the different pressure levels. The demand is however uncertain for the medium-term future due to the disturbances and different operation strategies, even if the production plants follow the production plan exactly. (Fig. 1)

Some decisions which have to be made before the exact steam demand known have a long-term effect, which limits the flexibility to react to the demand variations. A deviation of the realised demand profile from the planned profile causes an imbalance of the steam network which results in an inefficient operation of the power plant.

## The solution

### A framework for optimisation under demand uncertainty

The framework developed in CoPro solves two-stage optimisation problems on a rolling horizon and combines the advantages of both **preventive** and **reactive** scheduling methods to reduce the adverse effects of the steam demand uncertainties.

**Two-stage optimisation** takes possible realisations of the demand profiles and their probabilities into consideration instead of assuming an average steam demand for planning. The decisions are classified into 1<sup>st</sup>-stage decisions, which have to be taken before the uncertain demands are known, and 2<sup>nd</sup>-stage decisions, which can be adapted optimally after the realisation of the demand uncertainty (Fig. 2). When the 1<sup>st</sup>-stage decisions are optimised, it is taken into account that for each scenario the 2<sup>nd</sup>-stage

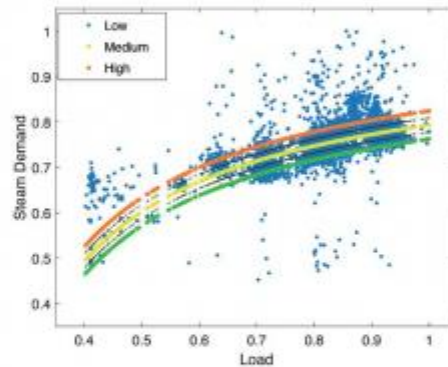


Fig. 1: The steam consumption of a production plants at INEOS in Köln and three possible approximated demand profiles

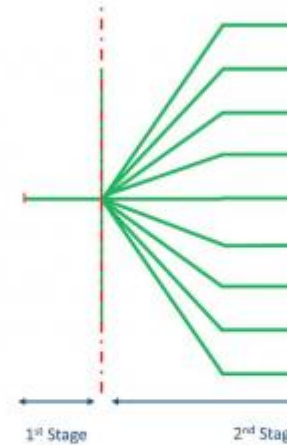


Fig. 2: The demand representation optimisation

decisions are adapted to the uncertainty. For each scenario, the 2<sup>nd</sup>-stage decisions are different but the 1<sup>st</sup>-stage decisions must be the same.

The rolling-horizon optimisation solves the planning problem by repeatedly moving the optimisation horizon forward and updating the parameters at the beginning of each run.

The two-stage optimisation of the power plant is formulated as a Mixed Integer Linear Program (MILP) using the modelling and optimisation platform AIMMS. Some properties of the plant such as e.g. equipment efficiencies are assumed to be constant. In order to reduce the inaccuracies that are caused by this assumption, a parameter update procedure is employed. For the simulation of the power plant another platform that uses models of relatively high complexity, which is however not used to plan the future operation. When the stochastic MILP is solved on a rolling horizon, the model parameters are updated with the values from this platform calculated based on the current operation and are assumed to be constant on the horizon of this optimisation.

It was observed that the current steam demand has an influence on the probability of the realisation of the different scenarios in the future. This fact is incorporated into the optimisation framework by updating

the probability distribution of scenarios based on the information of the current situation.

The developed framework is able to reduce the likelihood of extreme shortcomings in the steam network which can be avoided by the production plants to reduce the operational costs. Furthermore, under normal conditions, the framework can reduce the **operational costs** of the power plant when compared to a deterministic solution.

## The summary

### Handling the uncertainty of the demand in the optimisation of the operation of the power plant

A new optimisation framework for the power plant operation was developed which considers the uncertainty in the steam demand. A parameter update procedure increases the accuracy of the optimisation which is used in the two-stage optimisation. The optimisation framework is able to reduce the extreme shortcomings in the steam network which could impair the stable operation of the production plants and power plant. The reduction of their utilisation during the daily operation, the two-stage optimisation can reduce the overall operational costs of the power plant in the long run compared to a deterministic optimisation.

## The developers



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