COORDINATED PRODUCTION FOR BETTER RESOURCE EFFICIENCY

INEOS THE WORD FOR CHEMICALS

tu technische universität dortmund

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

Use Case

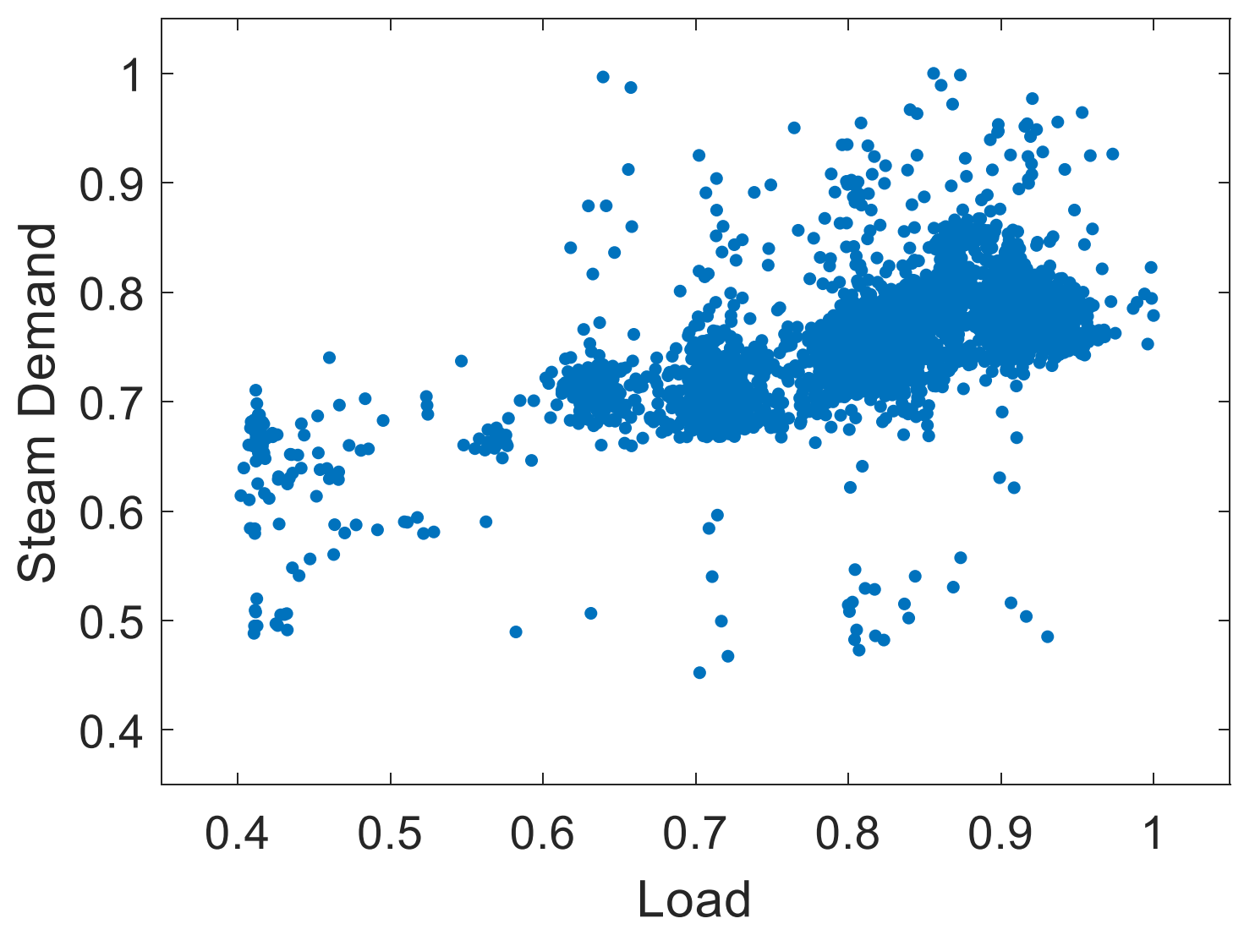
Goal of the use case

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



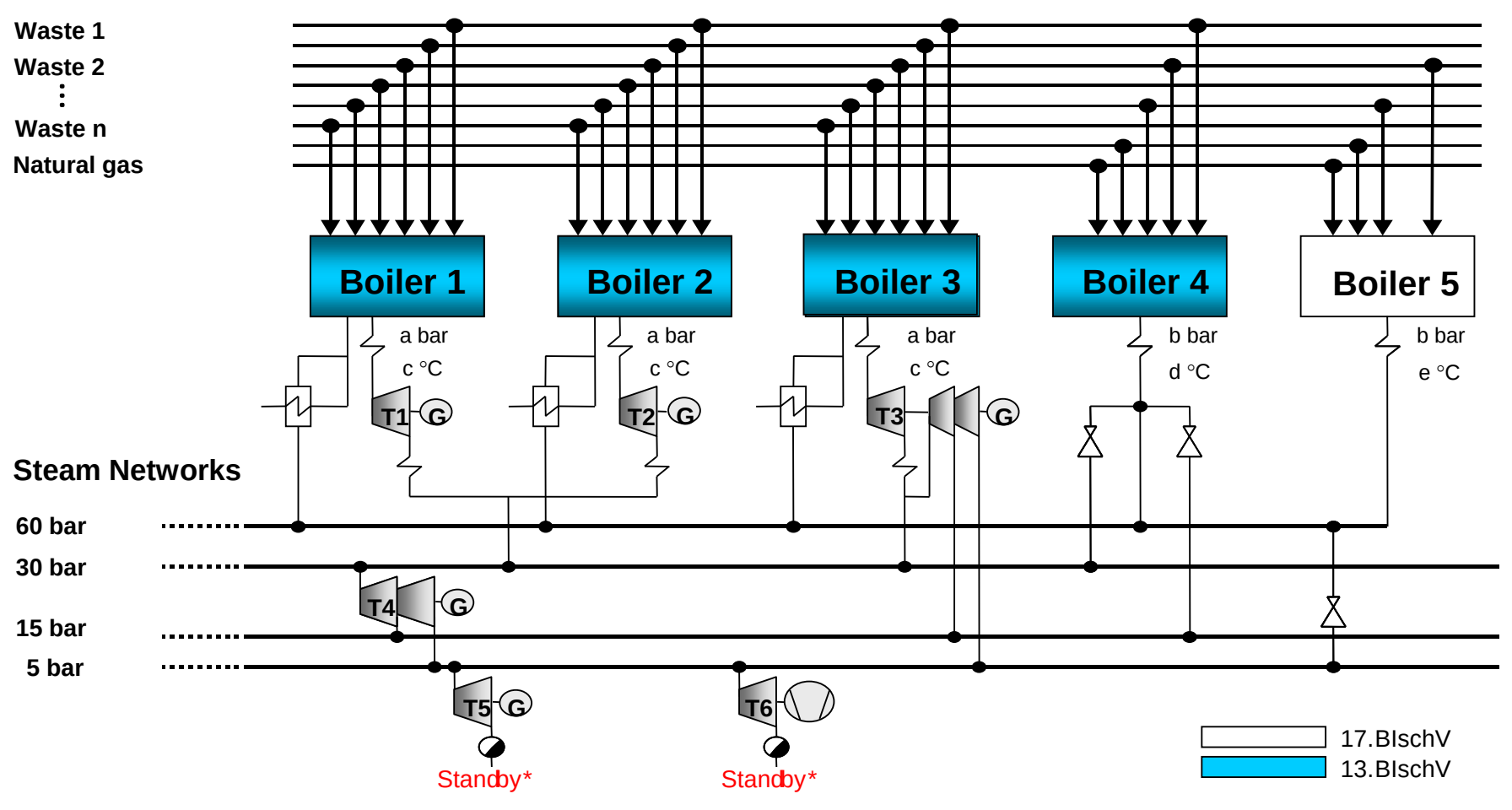
Negative effects of uncertainties

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



Modelling and Optimisation

Two-stage optimisation

Some of the data are uncertain

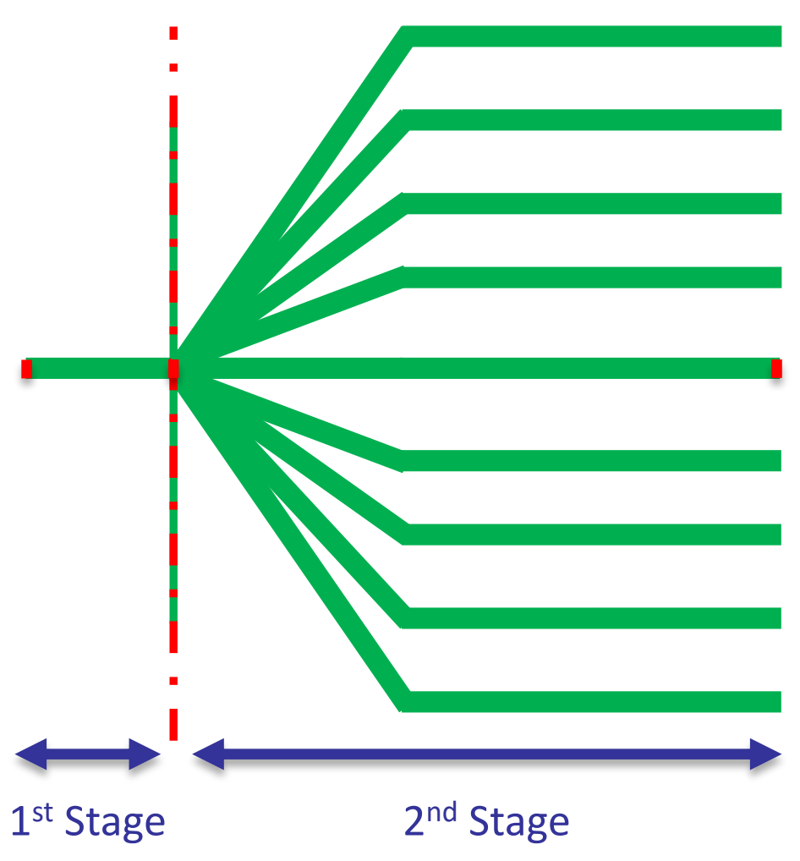
- Described by a set of discrete scenarios

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 realisation of the uncertainty

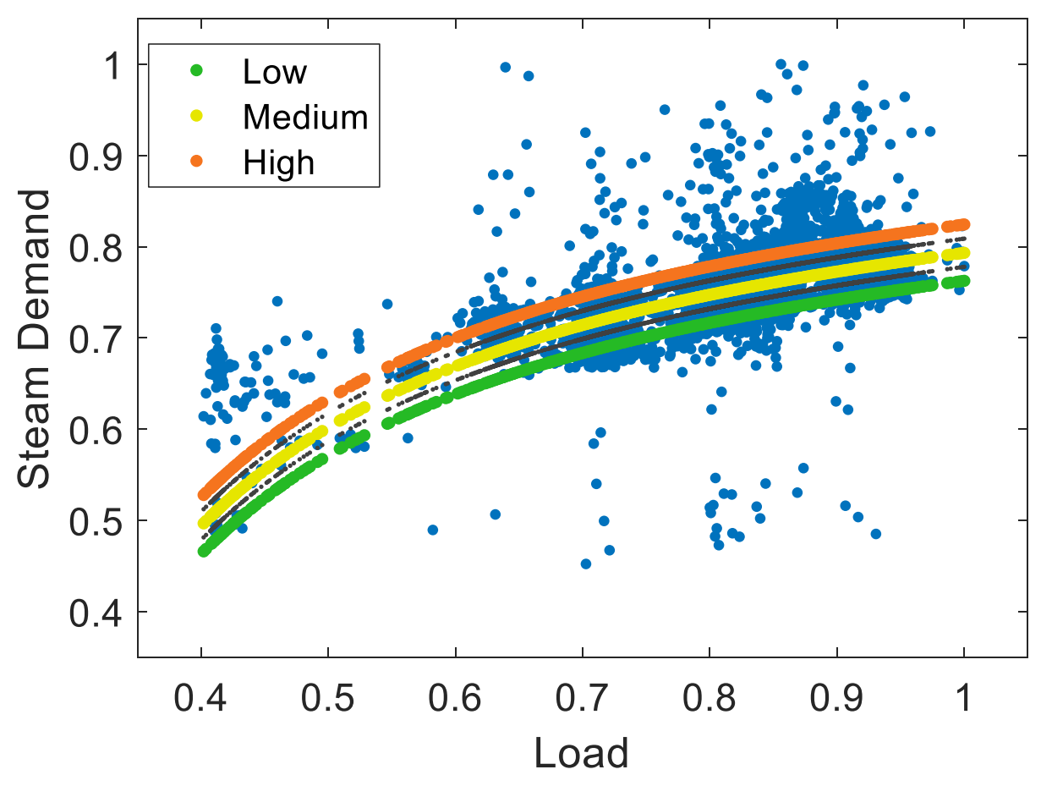


Model of the uncertainties

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

min (opearation costs)
s. t. mass balances,
model equations,
energy balances,
equipment constraints,
mode transitions constraints,
demand targets

Optimisation on a rolling horizon

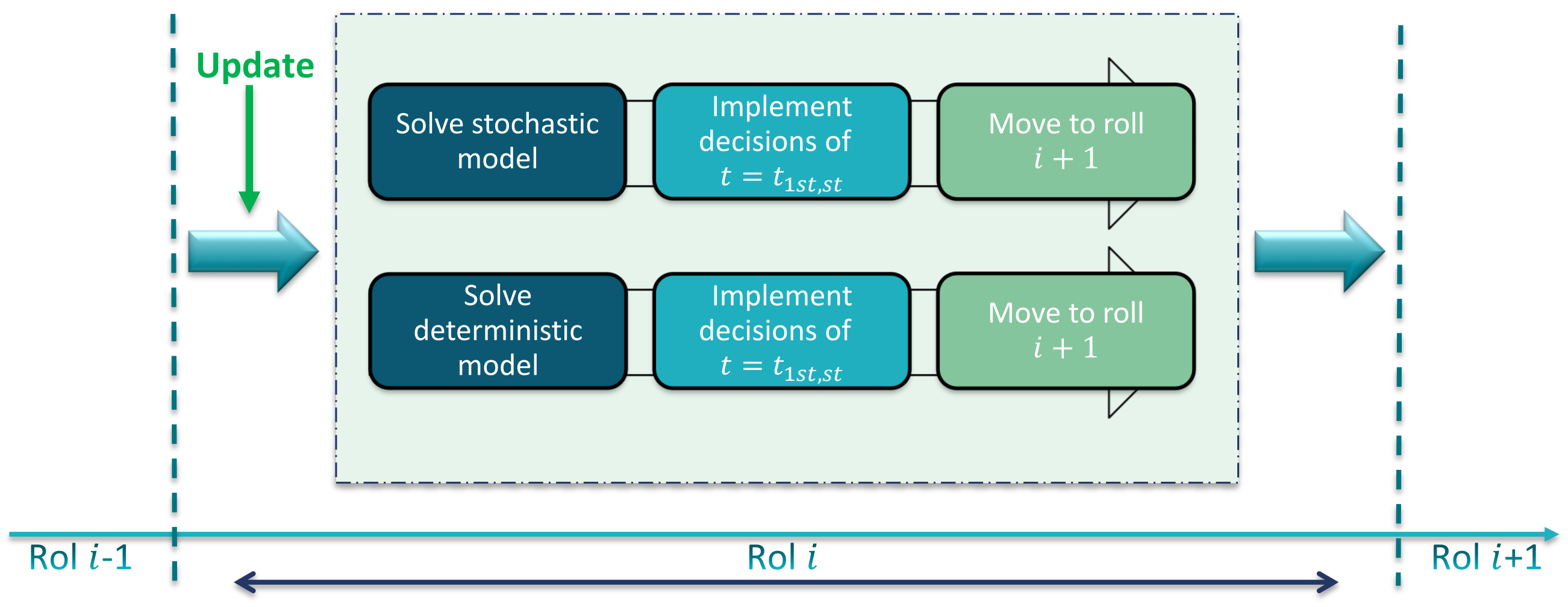
Combines the advantages of **preventive** and **reactive** scheduling

- Model parameters updated at the beginning of the optimization horizons and assumed as constant
  - Burner and boiler efficiencies, Lower Heating Values (LHVs), 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



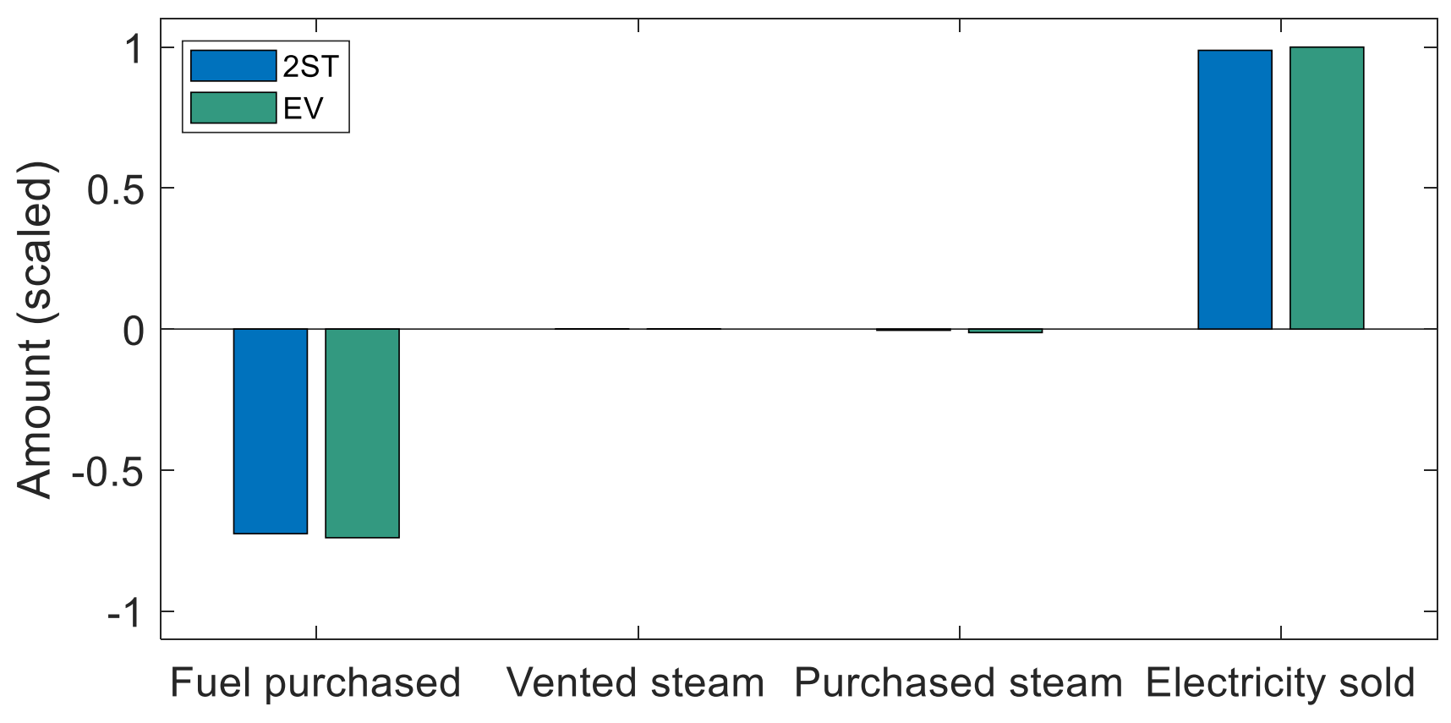
Results

Test case I: Normal operation

The realisations of the steam scenarios are simulated using 160 optimisations

- Each optimisation with a horizon of 56 h

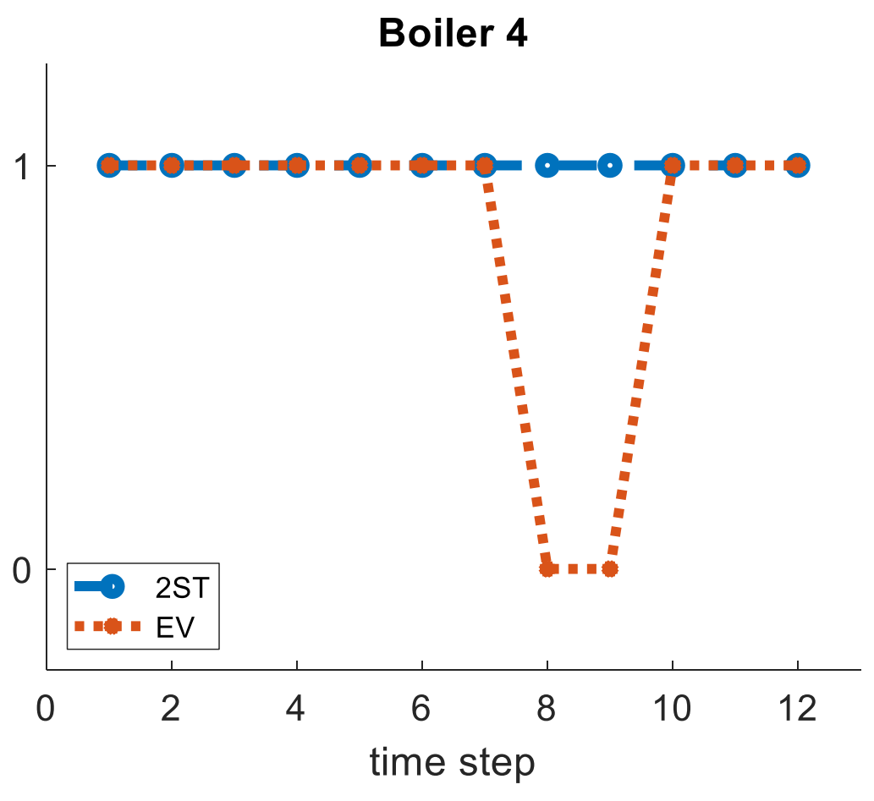
The stochastic solution improves the economics by **10.7%** compared to the deterministic solution

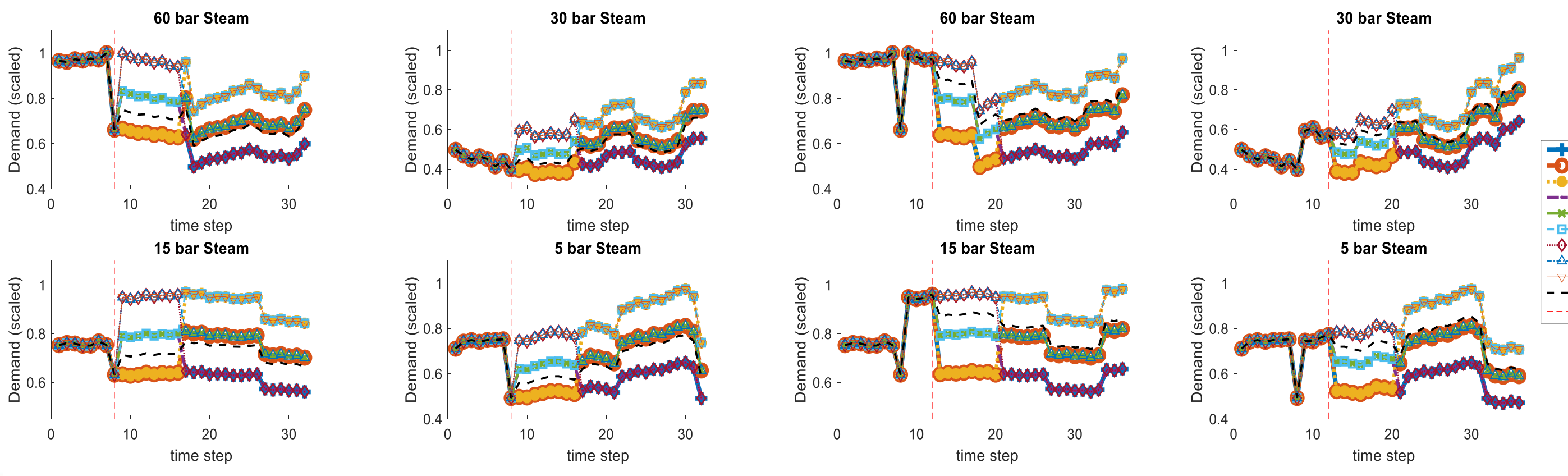


Test case II: An extreme scenario

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

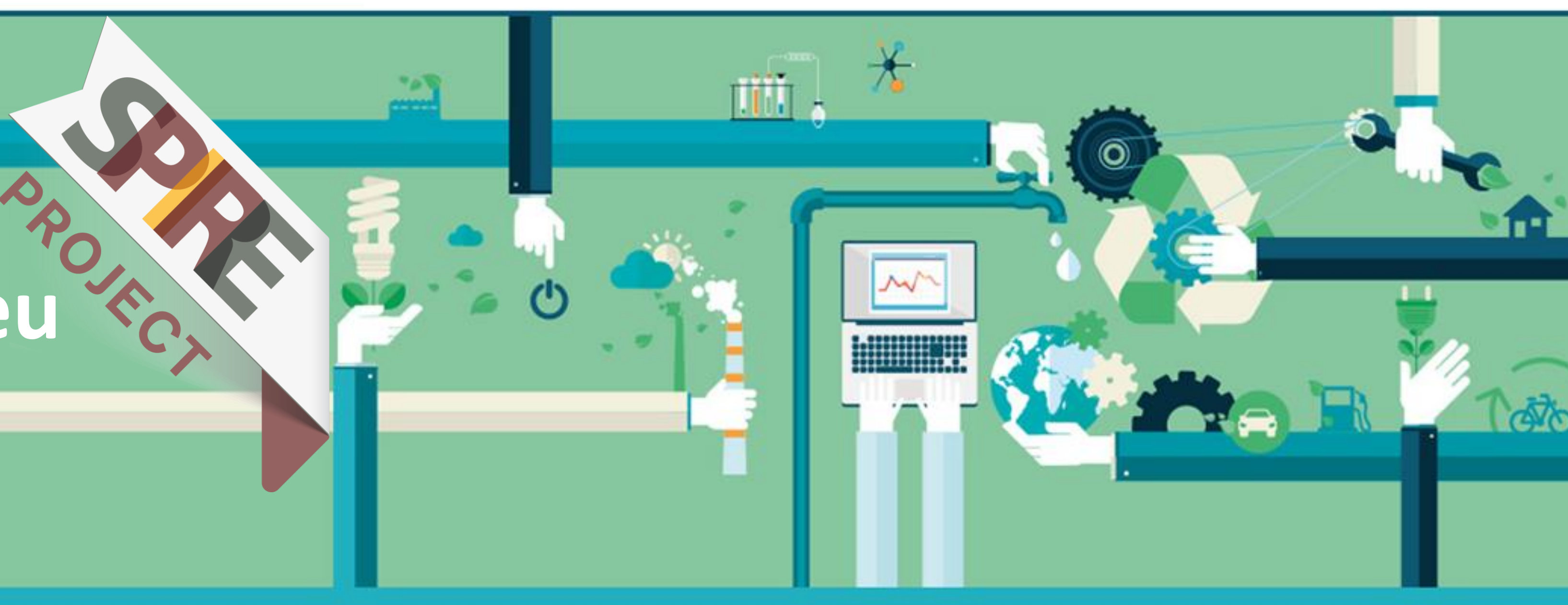




Summary and conclusion

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



www.copro-project.eu

Developers:
Keivan Rahimi-Adli, M.Sc. keivan.rahimi-adli@ineos.com
Prof. Dr. Sebastian Engell sebastian.engell@tu-dortmund.de

Further contanct:
Benedikt Beisheim, M.Sc. benedikt.beisheim@ineos.com

SPIRE Sustainable Process Industry through Resource and Energy Efficiency

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723575