Stochastic Optimisation

Case study: hydrodesulfurization unit

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Presentation

1. Stochastic Optimisation
   - Why use Stochastic Optimisation
   - Stochastic optimisation example
2. Case Study: hydrodesulfurization unit
   - Solution Method
   - Model Predictive Control
   - Results and conclusion

Why use Stochastic Optimisation

- Measurement error
- Uncertainties in some parameters
- Examples
  - Catalyst efficiency
  - Concentrations
  - Bubble size distribution
- More accurate back-off
- Average values can lead to instability

Stochastic Optimisation example

$$\begin{aligned} \min_{X_1, X_2} = \quad & -X_1 - X_2 \\ s.t. \quad & X_1 = \tilde{b_1} \qquad (1) \\ & X_2 = \tilde{b_2} \end{aligned}$$

$$(\tilde{b_1}, \tilde{b_2}) = \begin{cases} (3,4) \\ (4,3) \end{cases} \qquad (2)$$

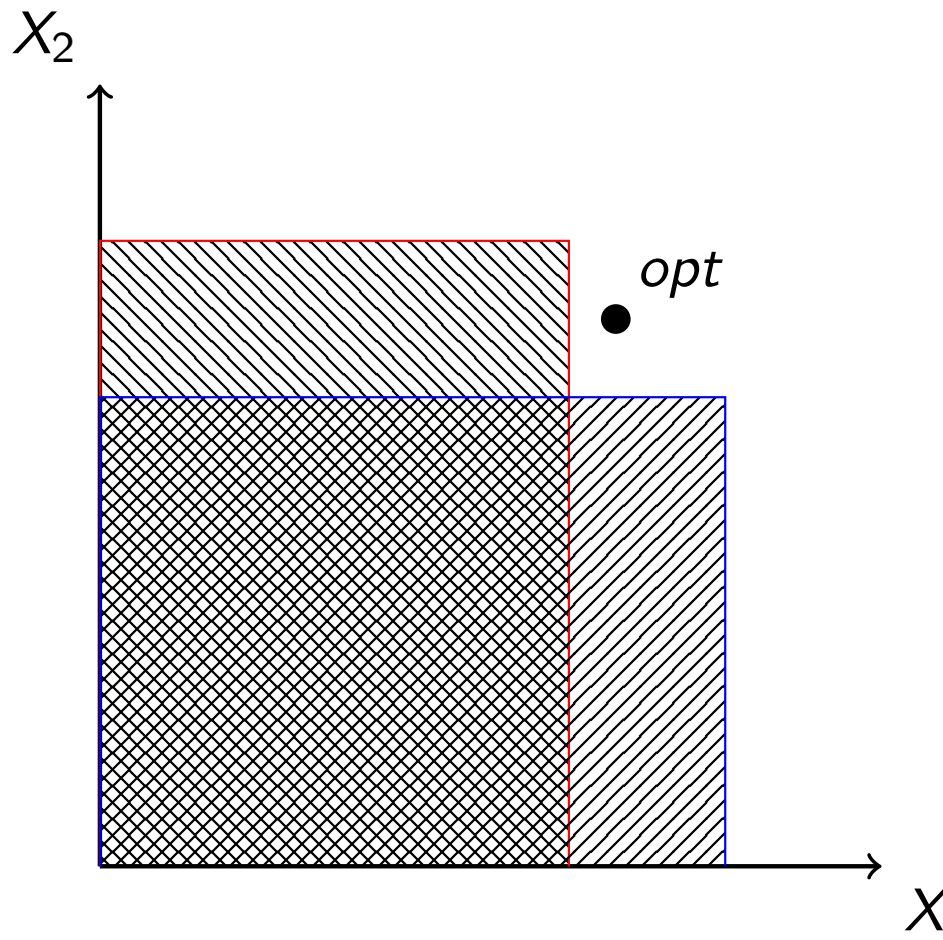
Stochastic Optimisation example

$$\min_{X_1,X_2} = \quad -X_1 - X_2$$

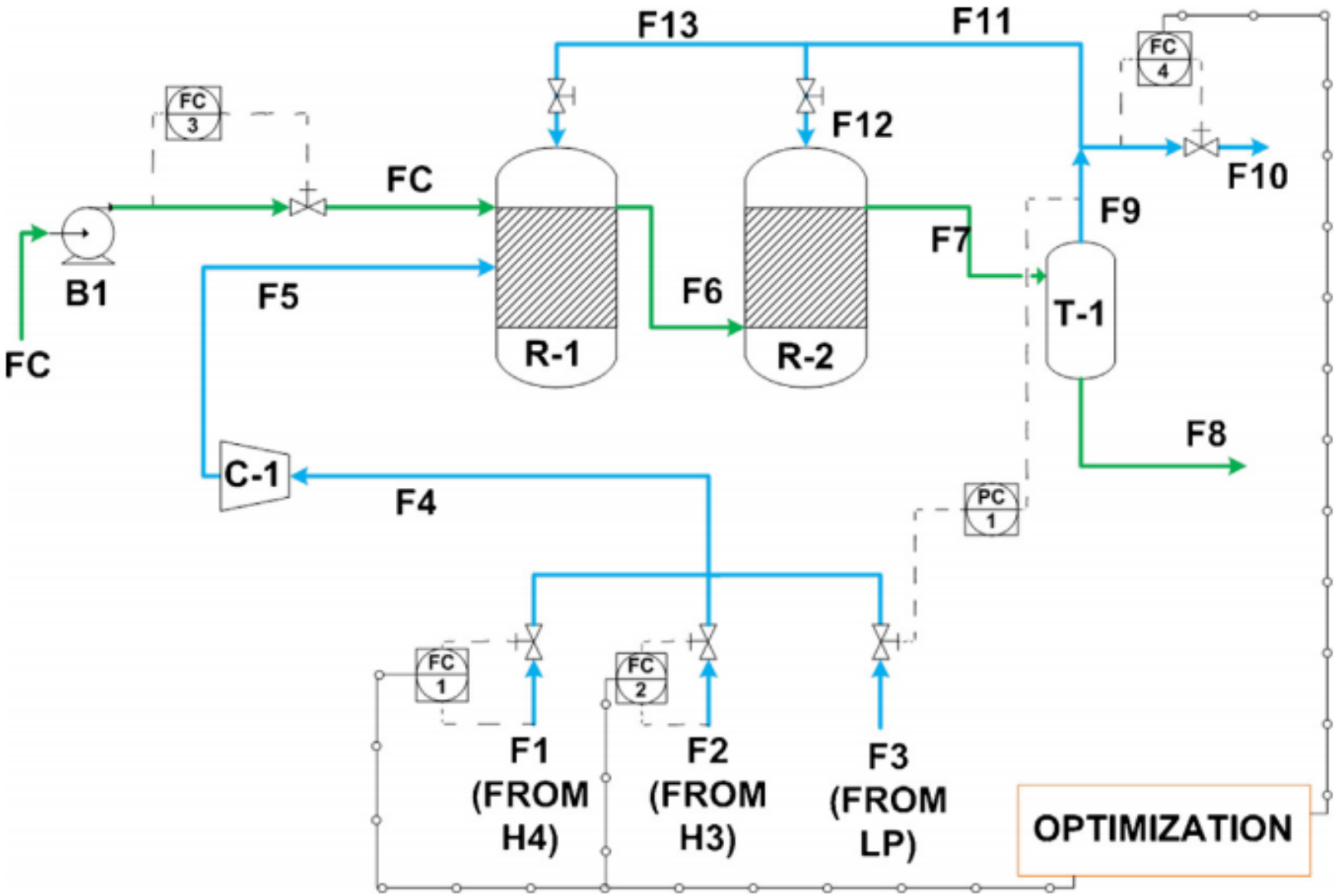
$$s.t. \quad X_1 = \tilde{b}_1 \qquad (1)$$

$$X_2 = \tilde{b}_2$$

$$(\tilde{b}_1, \tilde{b}_2) = \begin{cases} (3,4) \\ (4,3) \end{cases} \qquad (2)$$



flow diagram of the hydrodesulfurization unit



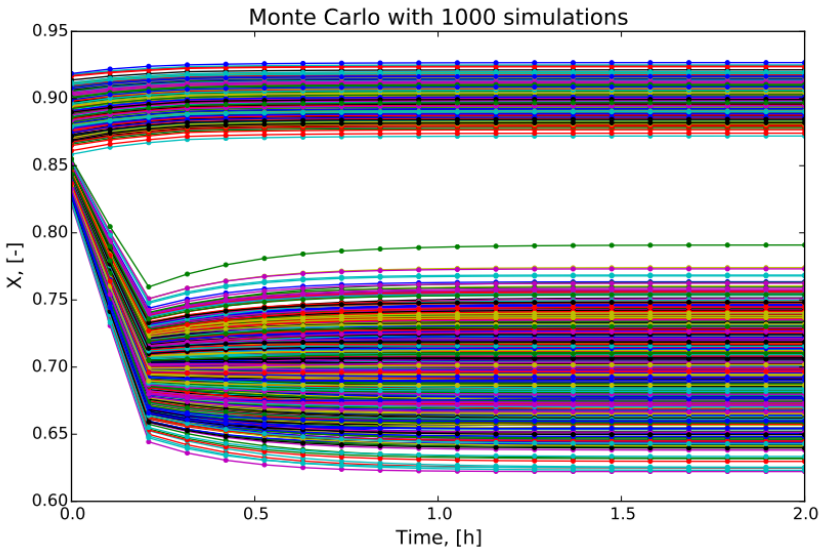
Chance Constraint method for solving stochastic optimisation

- Hold constraint with some probability
- Exclude extreme outcomes
- No increase of variables
- Probability distribution most be given
- Chance Constraint:

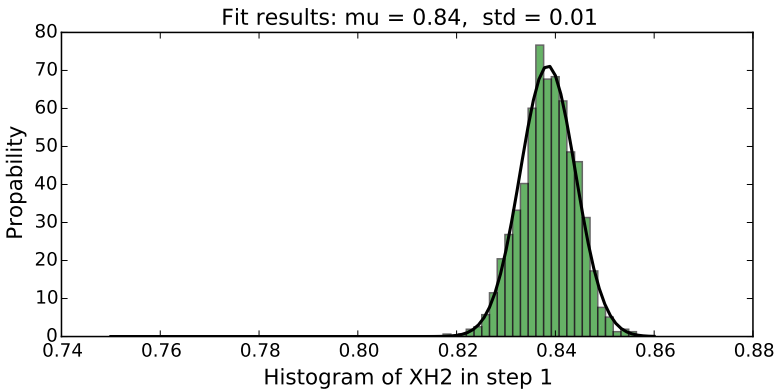
$$P(X_{H2}^{lb} \leq X_{H2}) \geq \alpha_{X_{H2}}, \quad P(X_5^{lb} \leq X_5) \geq \alpha_{X_5} \tag{3}$$

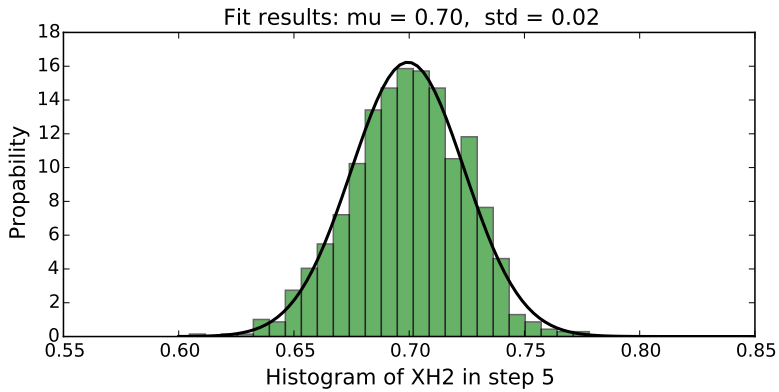
Monte Carlo simulation

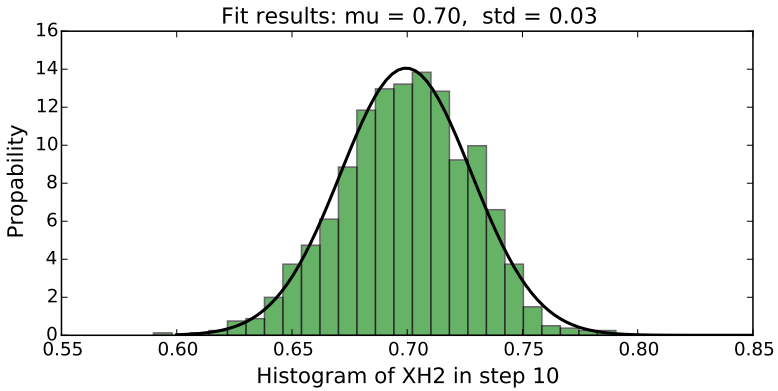
- Find probability distribution of X_{H2} and X_5
- Solve the deterministic problem first
- Run Monte Carlo simulation
- Normal distribution fitting

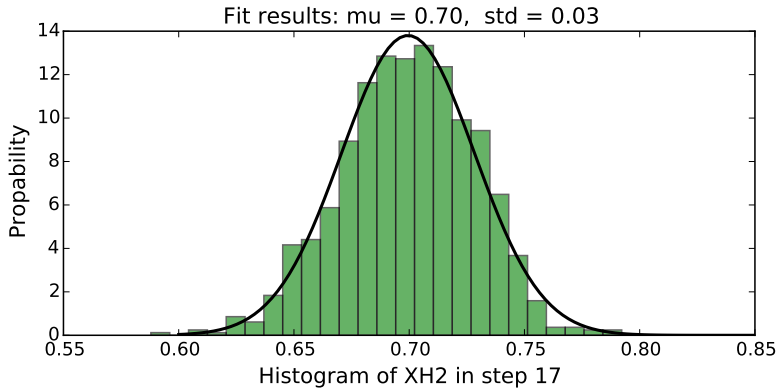


Normal Distribution fitting









Number of constraint violations

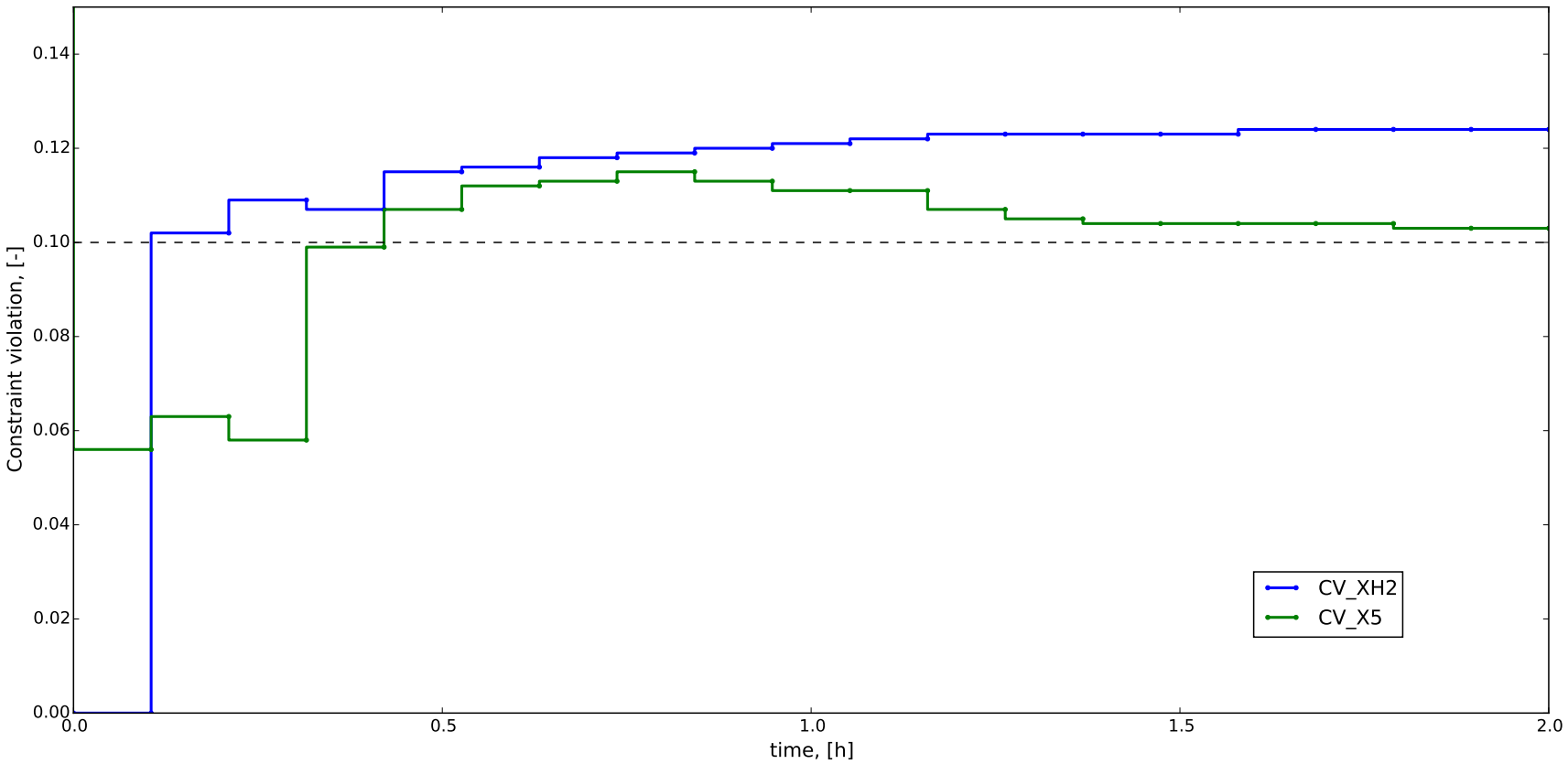
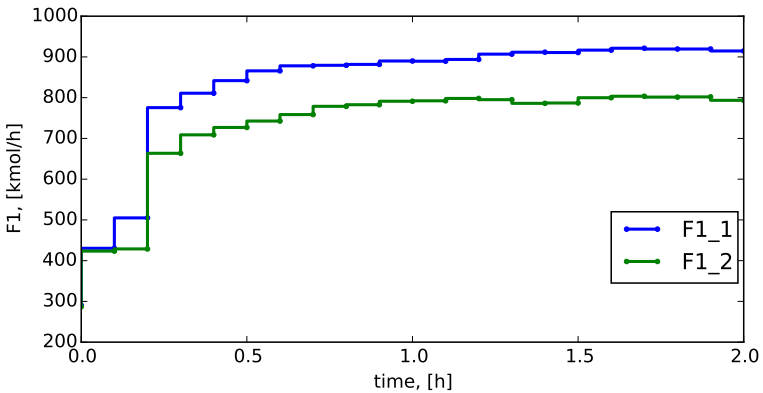
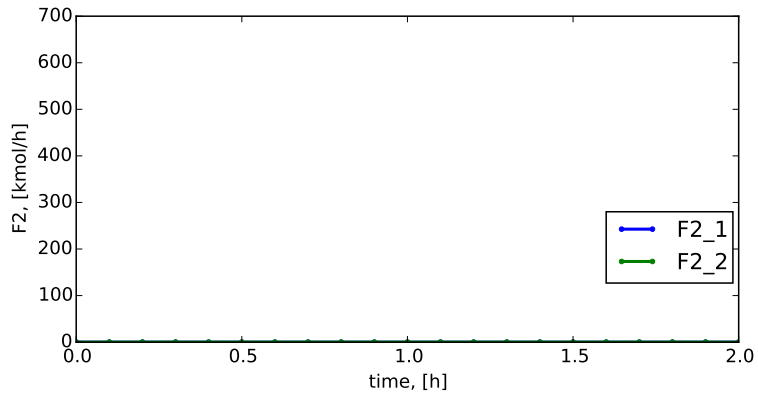


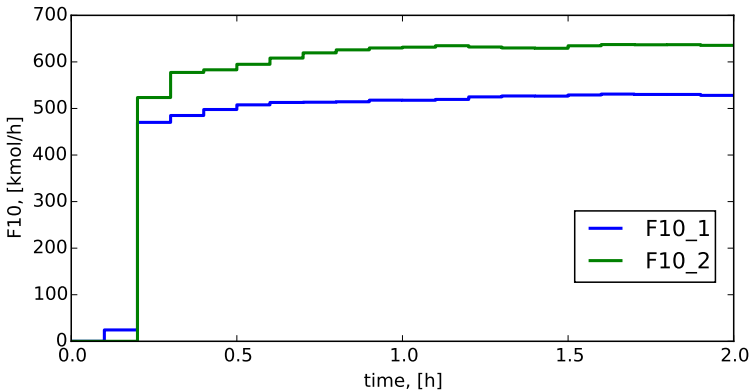
Figure:

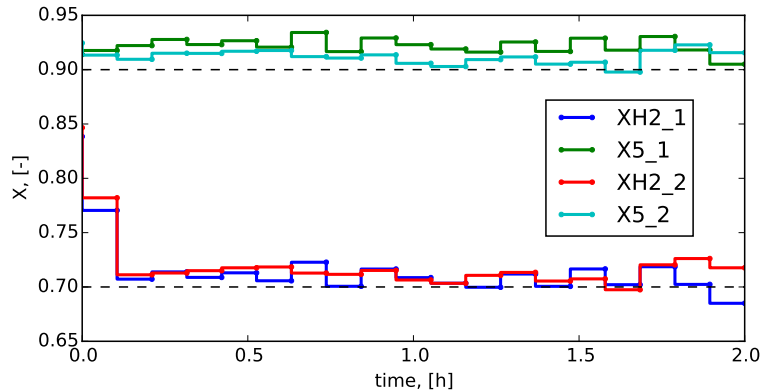
MPC

- Offline optimisation: Blue Line, $(._1)$
- Online optimisation: Green Line, $(._2)$









Different optimisation tactics for MPC

Optimisation type	# Monte Carlo	Computational time [s]	Cost [euros]
Offline	1000	245	1522
Online	1000	2100	1329
Online	100	470	1346

Conclusion

- Stochastic optimisation can handle uncertainties
- Not normal distribution of the outcome
- Online optimisation best
- Online optimisation takes to long