

## SUMMARY

**What is my research?** I am investigating modelling techniques to build more robust MPC models in wastewater treatment processes.

**What is MPC?** MPC stands for Model Predictive Control. It is used in automated controllers and improving process efficiency.

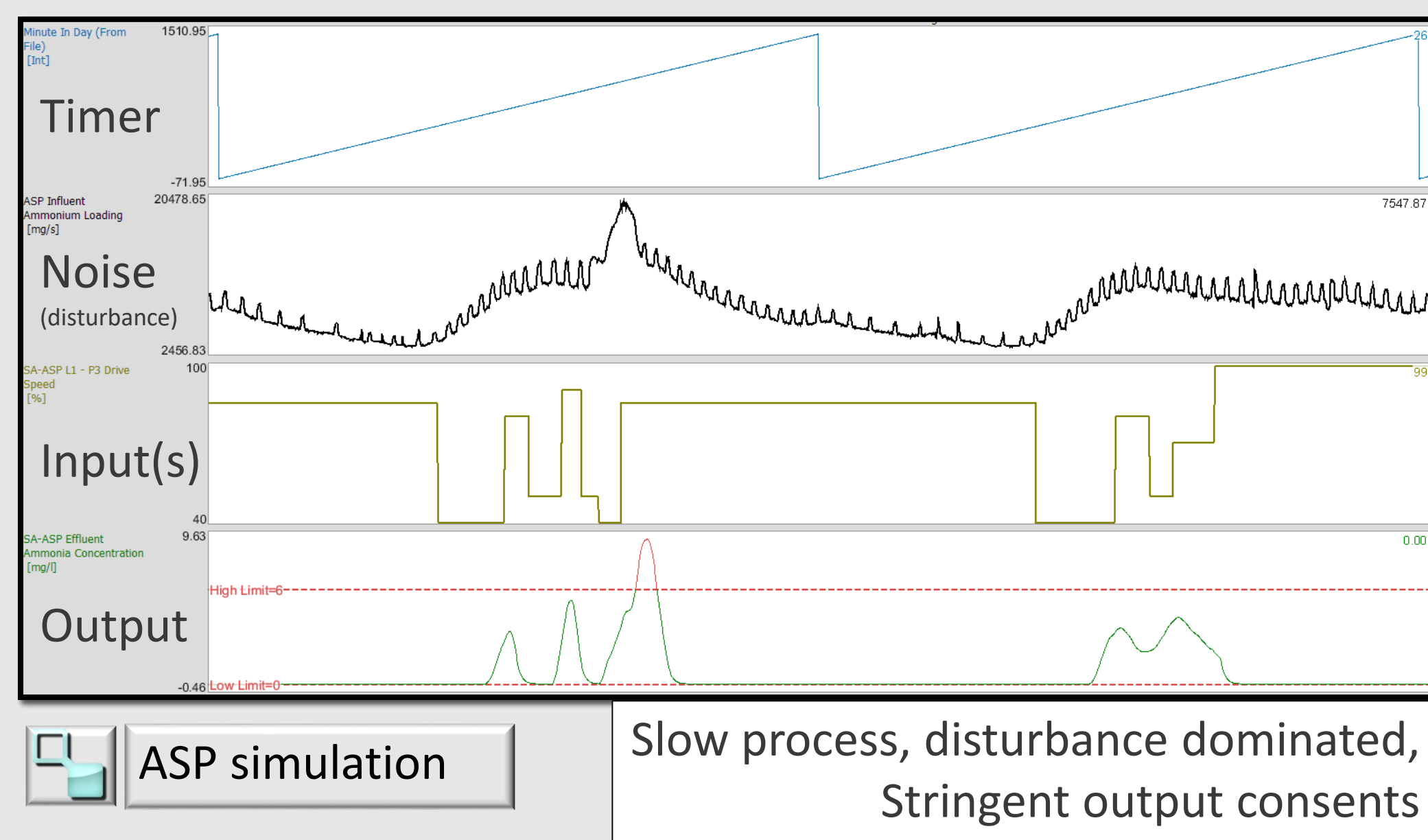
**What are MPC models?** They describe how the output signal responds to a change in input. MPC use these models to make output predictions.

**How does MPC benefit the activated sludge process?** The activated sludge process requires aeration and this consumes a lot of energy. MPC has demonstrate energy savings of over 25% [1] in a typical plant without compromising the quality of treated water.

**What are the challenges when building MPC models?** While MPC is useful, building the MPC model is difficult due to a number of reasons, including: high non-linearity, long time-delays, resource limitations, stringent output consent limits and process disturbances.

**What solutions am I looking at?** Two avenues are being explored: **Grey-Box Model Identification** and the **Sequential Design of Experiments**.

## FRAMEWORK



Step tests on the input signals to observe how the output responds

Experimentation

1  
Grey-Box Model Identification

MPC Model

3  
Sequential Design of Experiments

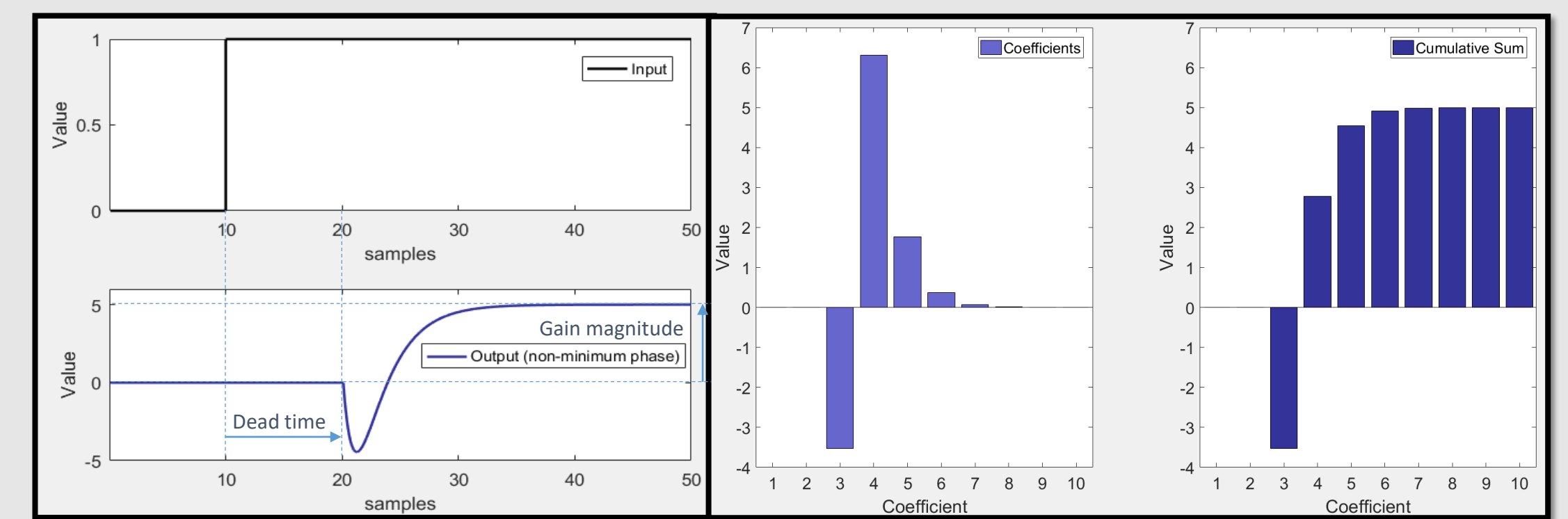
### Capturing more information-rich data from experiments

- Design of step tests to obtain better (more information-rich) data
- Better data → better MPC models → better process optimisation
- The Fisher Information Matrix (FIM) is used to assess the information content of a dataset (the inputs and outputs)
- The step-tests for the next experiment is designed to maximise the information content (the output is estimated from MPC model)
- Constraints are added so the designed input trajectory should not violate output consents or damage process equipment

## OUTPUT

2  
Model Predictive Control

MPC

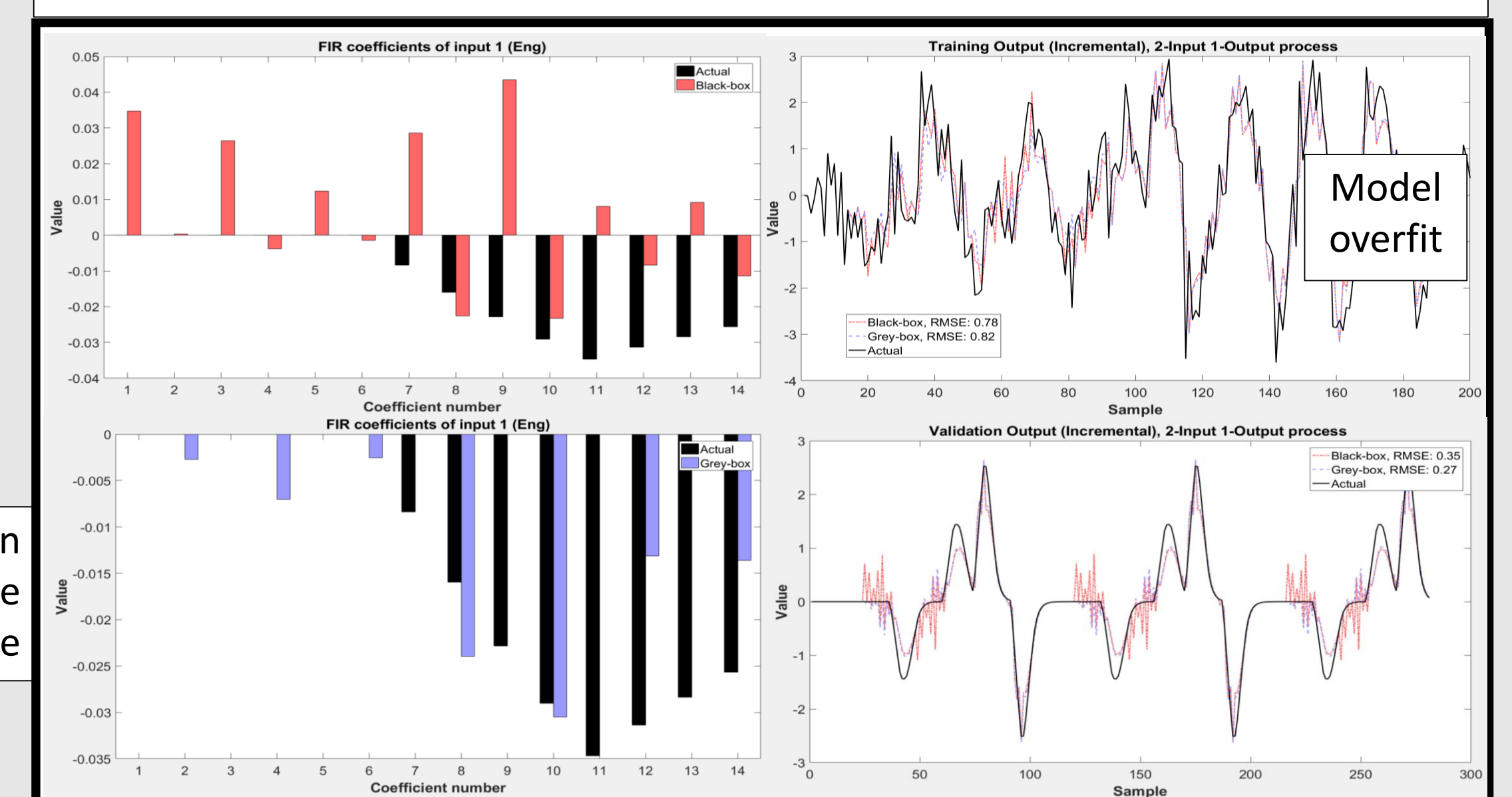


MPC models describe how the output responds to a change in an input signal

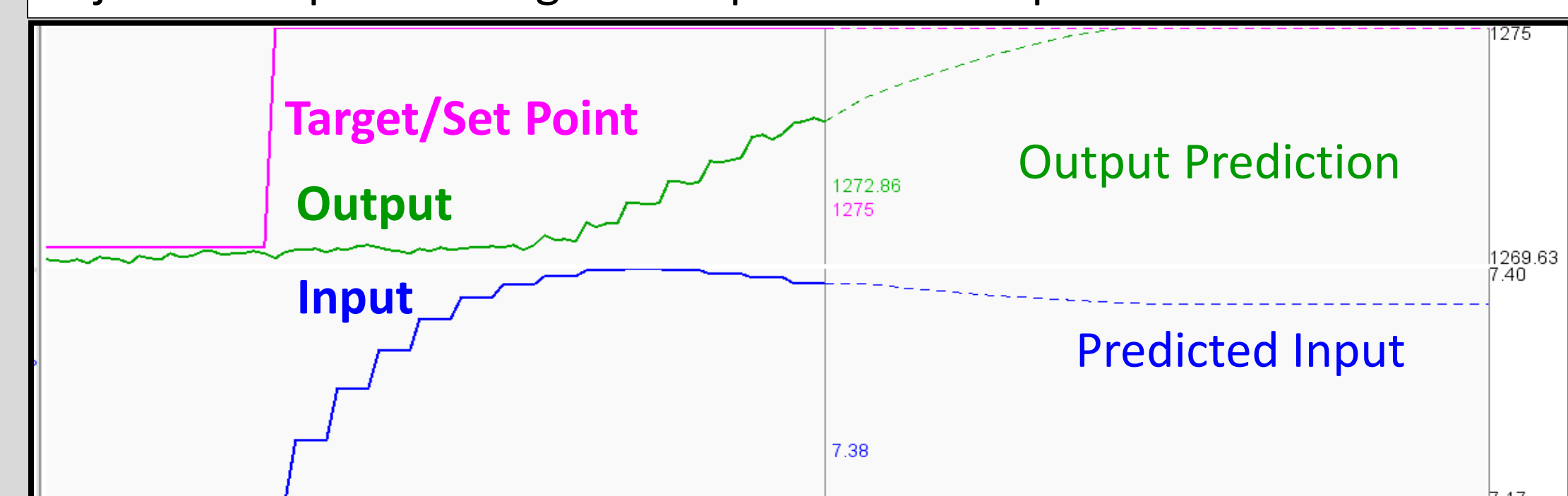
### Enhancing black-box modelling with process knowledge

- **Black-box models:** built purely by statistical analysis Without sufficient information-rich data, black-box models overfit and perform poorly
- **Grey-box models:** process knowledge is incorporated as constraints to black-box models
- Constraints: gain magnitude, minimum/non-minimum phase, dead-time

### Example: black-box vs grey-box model



Automated controller uses the MPC model to predict the output and adjust the input to bring the output to the set point



Set point changes Disturbance response