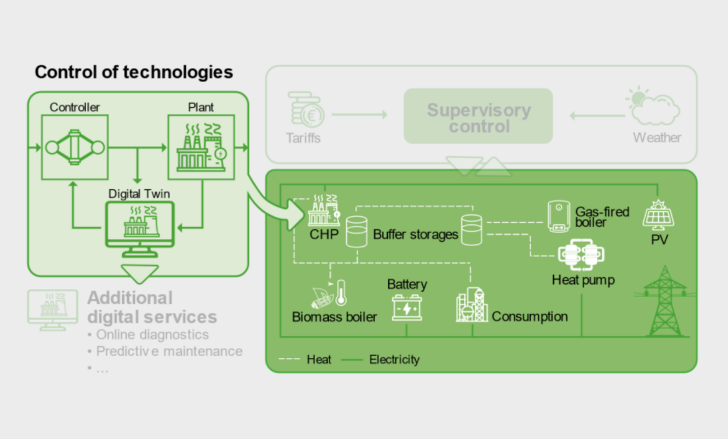

Model-based control of large-scale solar thermal plants

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Area 2.2
Automation and Control

Motivation

Large-scale solar thermal plants take an important role in supplying industrial processes as well as district heating networks with renewable heat. Depending on the application heat at different temperature levels needs to be provided. The stable temperature control throughout the whole day is of great importance to achieve a high system efficiency.

Controller development

The temperature control right after the solar collectors is challenging, as varying weather conditions directly influence this temperature and long dead times delay the control action. Here cascaded control with model-based static feedforward control was used, which considers global radiation, inlet- and ambient temperature.

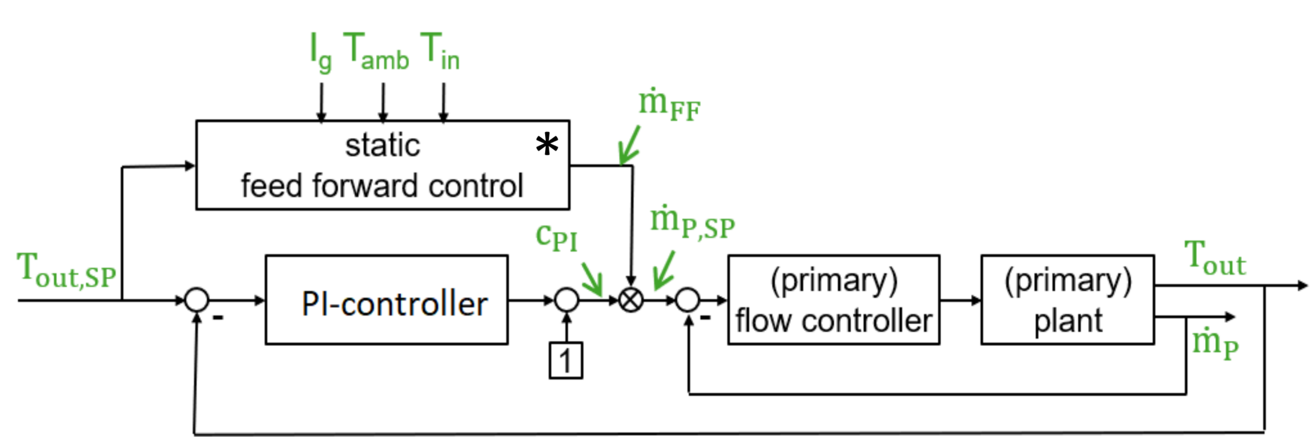

Figure 1: Control of the temperature right after the solar collector

Model-based static feedforward control

Based on a static collector model, the needed mass flow ($\dot{m}_{FF}$) to achieve the desired outlet temperature ($T_{out,SP}$) can be calculated by using the measured global radiation (I_g), collector inlet temperature (T_{in}), ambient temperature (T_{amb}) and the plant parameters ($A_{coll}, c_0, c_1, c_2, c_p$).

$$* \quad \dot{m}_{FF} = \frac{A_{coll}\left[c_0 \cdot I_g - c_1 \cdot \left(\left(\frac{T_{out,SP}+T_{in}}{2}\right) - T_{amb}\right) - c_2 \cdot \left(\left(\frac{T_{out,SP}+T_{in}}{2}\right) - T_{amb}\right)^2\right]}{c_p\,(T_{out,SP} - T_{in})}$$

Figure 2: Large-scale solar thermal plant used for validation (Source: SOLID Solar Energy Systems GmbH)

Implementation and Validation

The developed controller was implemented and validated at a large-scale solar thermal plant placed in Austria as seen in Figure 2. The plant an collector area of 6850m² and an peak power output of 4.8MW. The secondary circuit is equipped with seven stratified buffer storages holding 420m³ of water. The new controller in Figure 1 replaced the old PI-controller. A comparison in Figure 3 with the old PI-controller (left) and the new controller (right) shows a clear reduction of the oscillations in the mean collector temperature.

Conclusion

- The use of the new controller has improved the control quality. Both the mean absolute error and the variance have been significantly reduced.

	MAE in °C	Variance in °C²
Old controller	2.1	6.8
New controller	1.1	1.5

- The new controller is parameterized mainly by using plant parameters that are available from plant design, easing the controller parametrization.

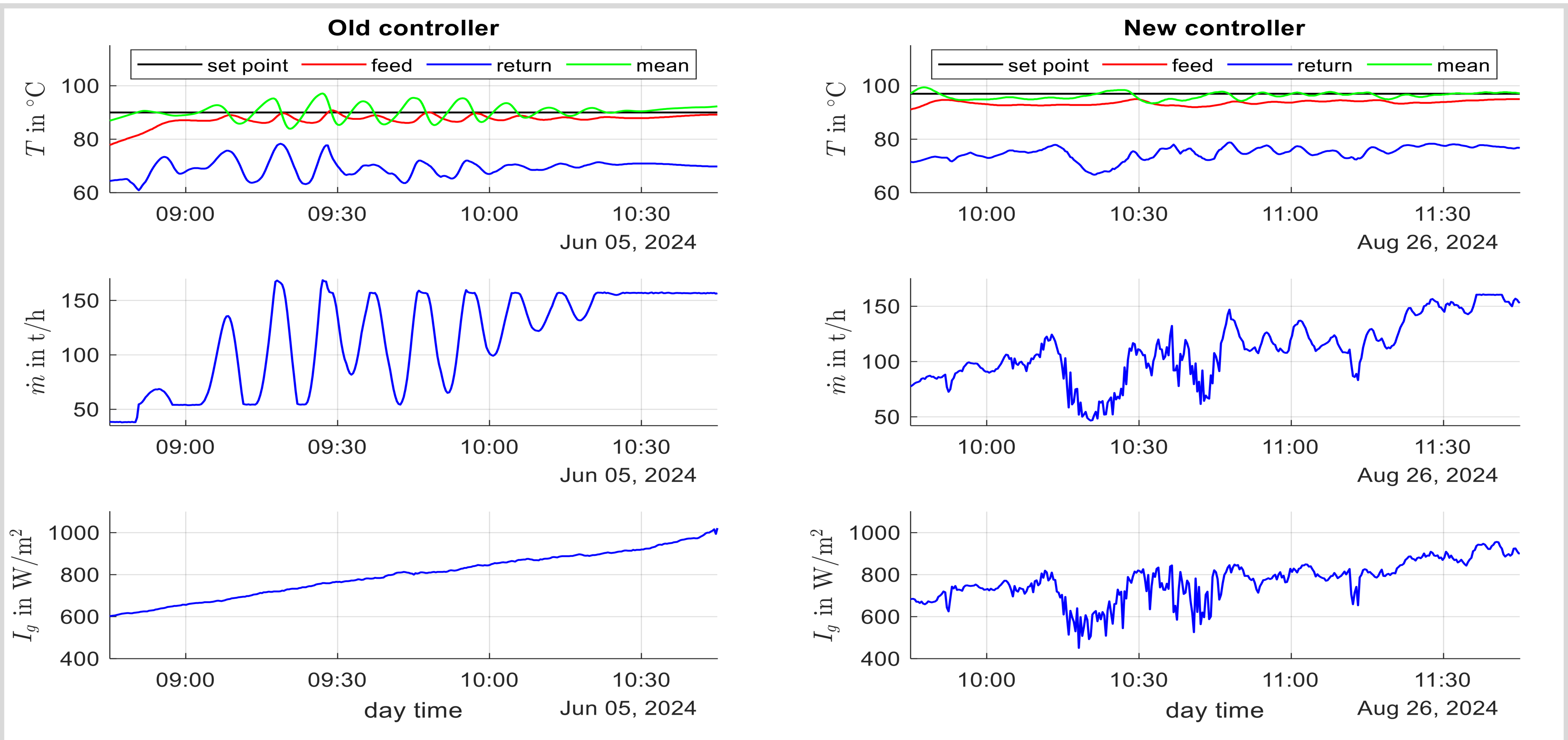

Figure 3: Validation showing the improvement with the new controller compared to the old controller

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