

Digital Twins for Parabolic Trough Plants

AuSeSol-AI: AI Methods for Autonomous and Self-optimizing Solar Energy Generation

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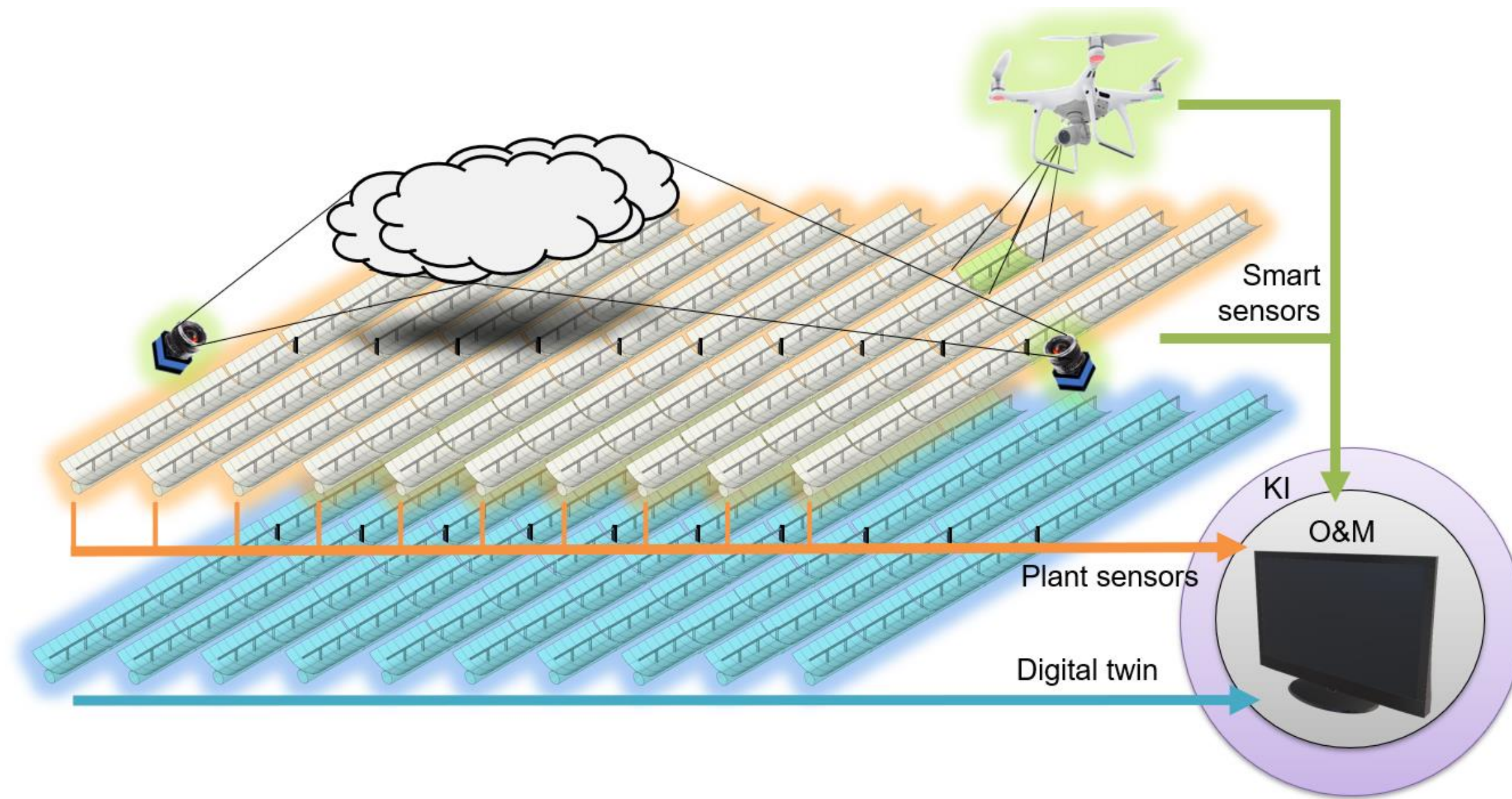
Solar process heat plant



Solar tower system



Parabolic trough system



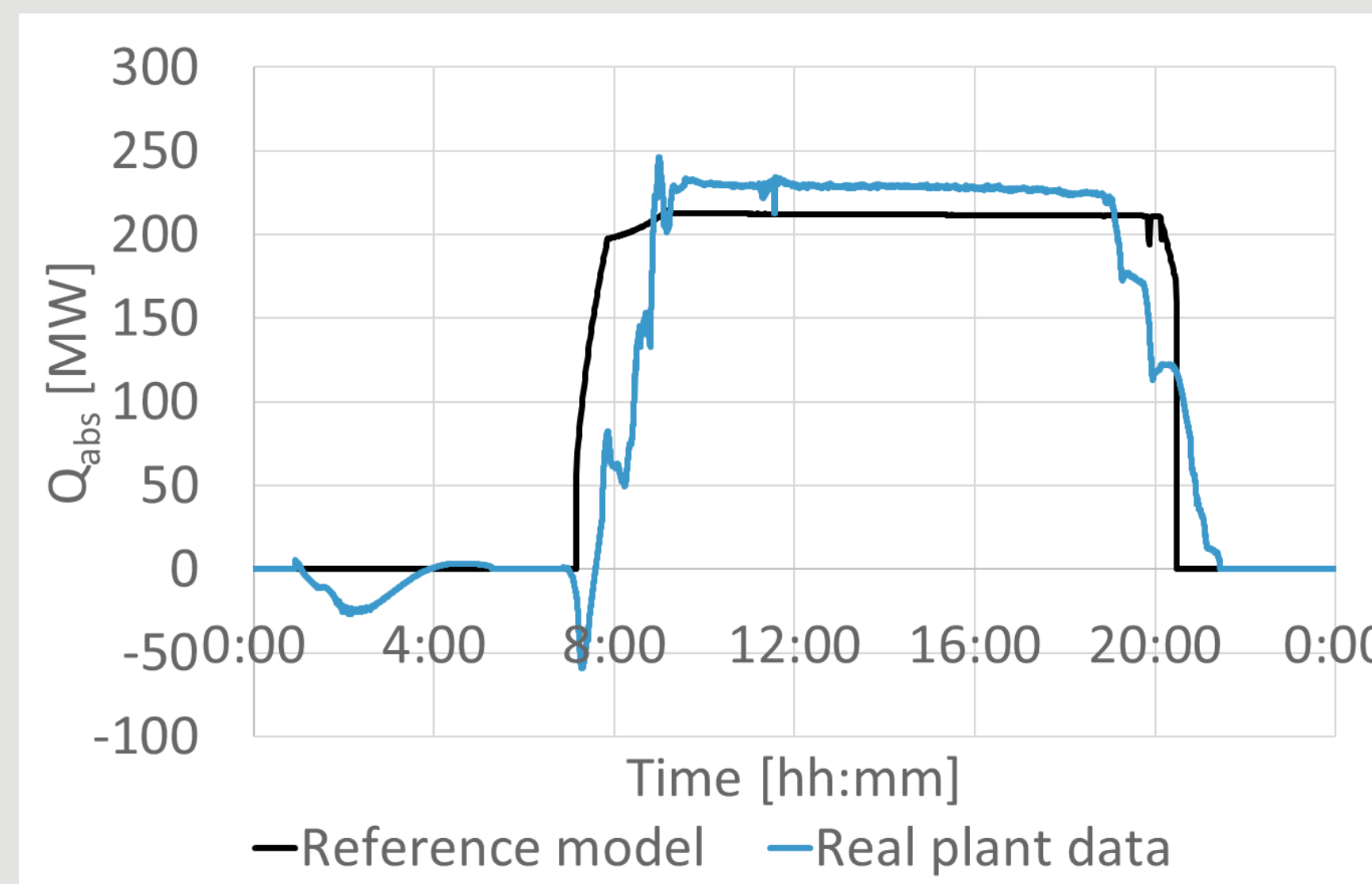
Overview of the AuSeSol-AI Project: AI methods are implemented for three different technological paths.

The need for a digital twin

- Model needs to be self-adaptive as the state of the plant changes over time
- Applicable in different power plants with varying layout
- Continuously updated to the current plant state
- Model represents the state of the plant at a given time
- Thermal output of the solar field as indicator for good or poor performance

Hybrid model: Physical + AI model

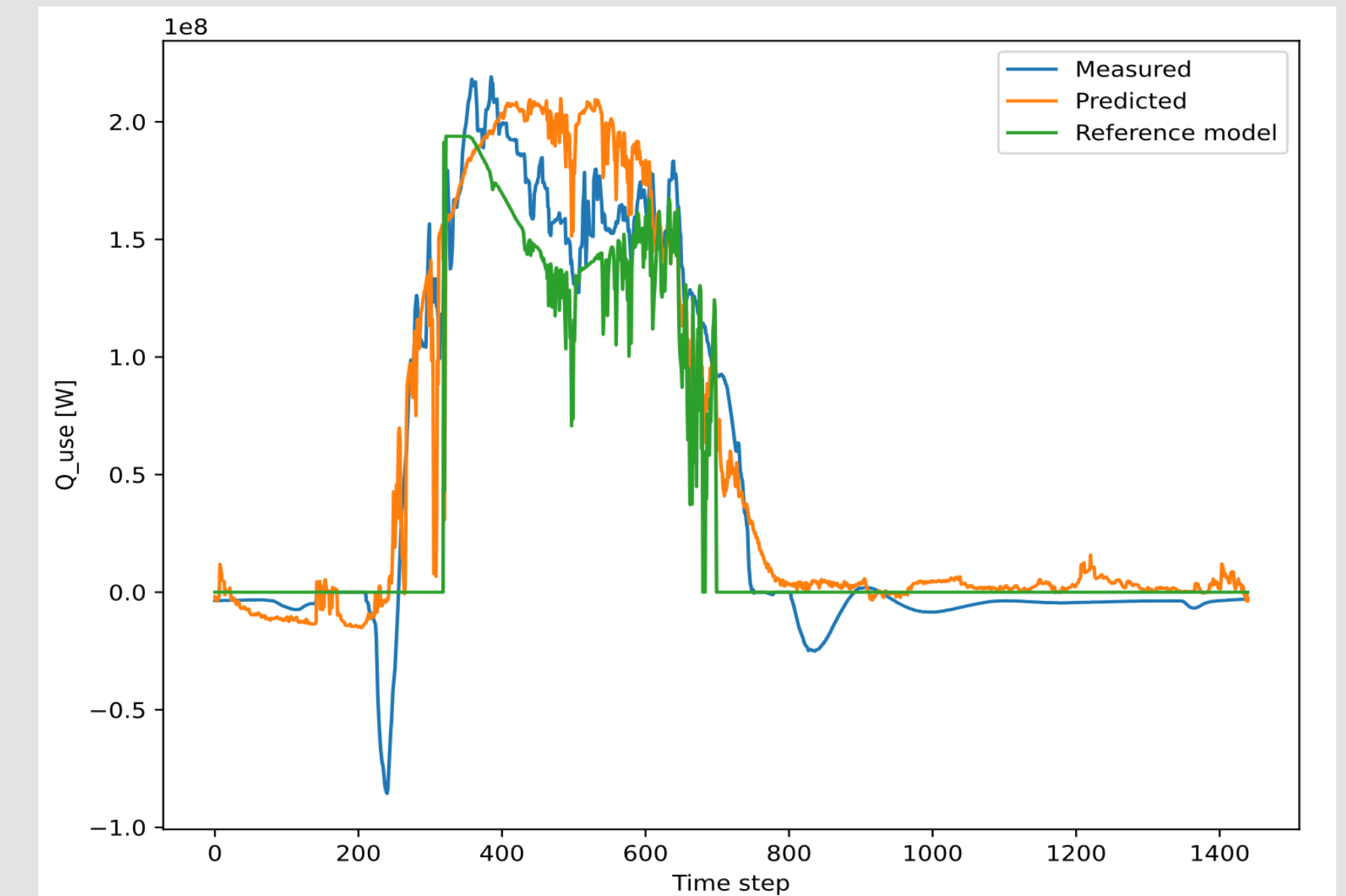
- Reference model: Simple physical model for steady-state calculations
- If data availability is low (e.g. new systems), initially a pure steady state model
- Increased AI share if enough operational data is available
- AI model fills the gap between steady state model and real plant behavior



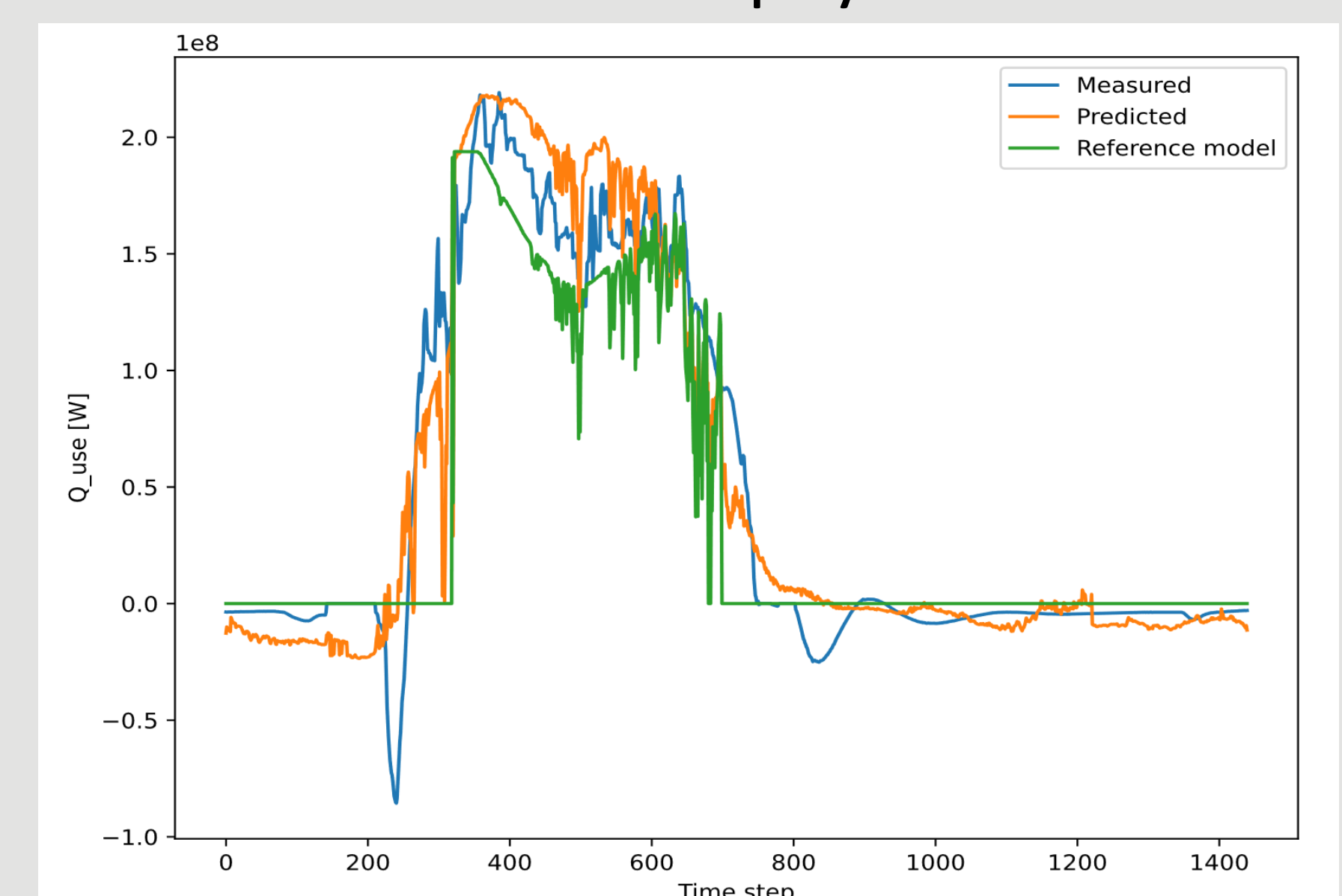
First results

- Measured thermal output shows characteristic shape due to cosine losses
- Negative values of Q due to large fluid runtime from inlet to outlet
- NN only model resembles DNI input
- Physical model shows characteristic shape of Q_{use}
- Physical model shows large deviations to measured values
- Both models: physical and NN can currently not deal with fluid “dead time”
- Physical model is more conservative (late start up, early cool down)
- Best results with NN + physical model, followed by NN and pure physical model $R^2_{NN+physical} = 88.5\%$, $R^2_{NN} = 87.1\%$, $R^2_{physical} = 80.7\%$

Only Feedforward NN



Feedforward NN + physical model



Conclusions

- General shape and size of the thermal power output can be predicted with both models
- The prediction is best with the NN + physical model
- Parameters of physical model can be additional source of errors and uncertainties

Outlook

- Operational data of previous days for model improvement
- Use the time series character of the data to improve model

Acknowledgements

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