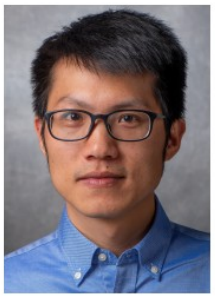
Development and Verification of Control Sequences for Single-Zone Variable Air Volume System Based on ASHRAE Guideline 36

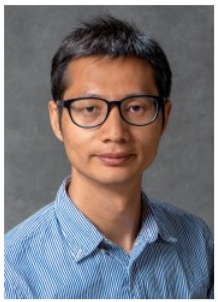
American Modelica Conference 2020

9/22/2020


Kun Zhang


David Blum


Milica Grahovac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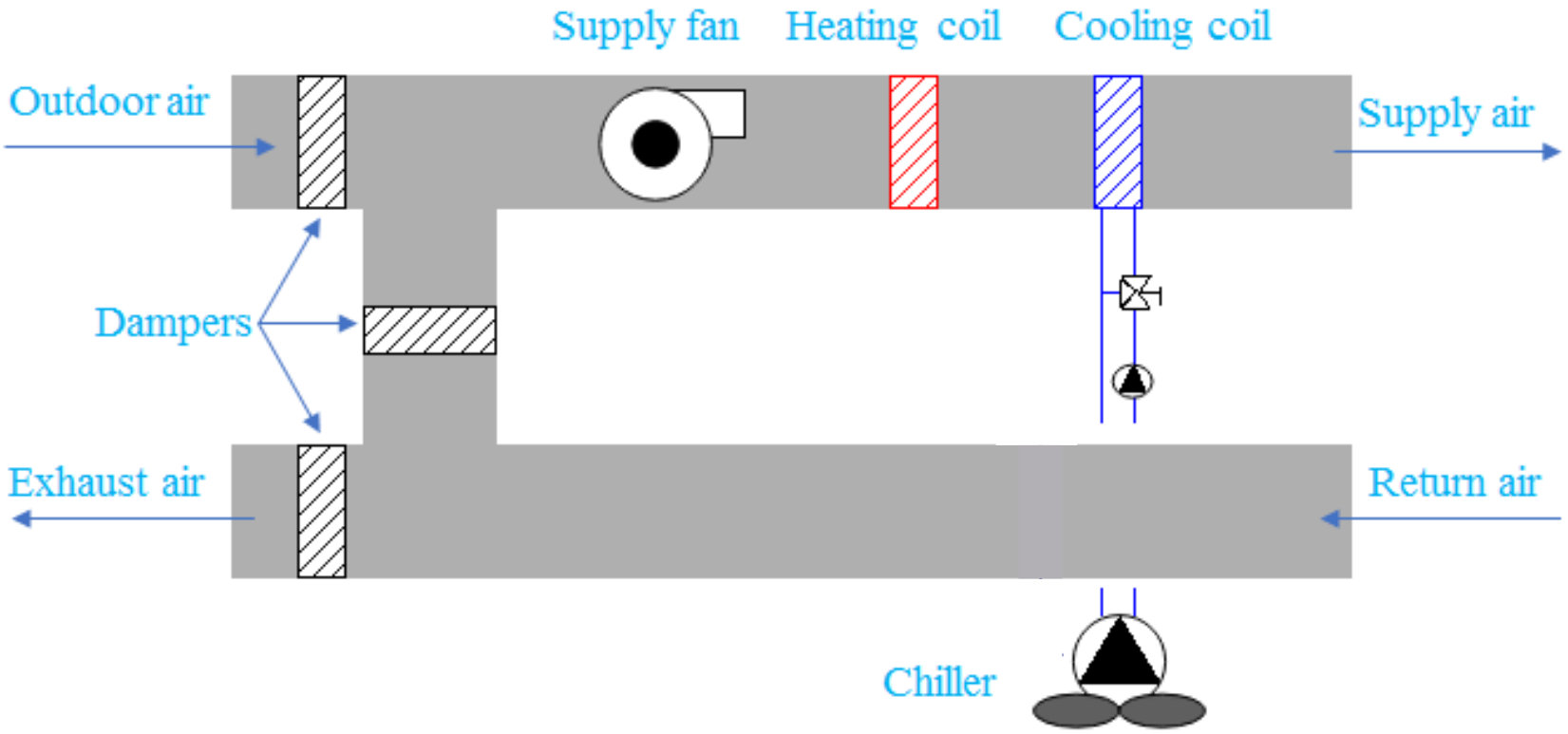
Development and Verification of Control Sequences for Single-Zone Variable Air Volume System Based on ASHRAE Guideline 36

- Background
- Sequence Implementation
- Case Study
- Conclusions

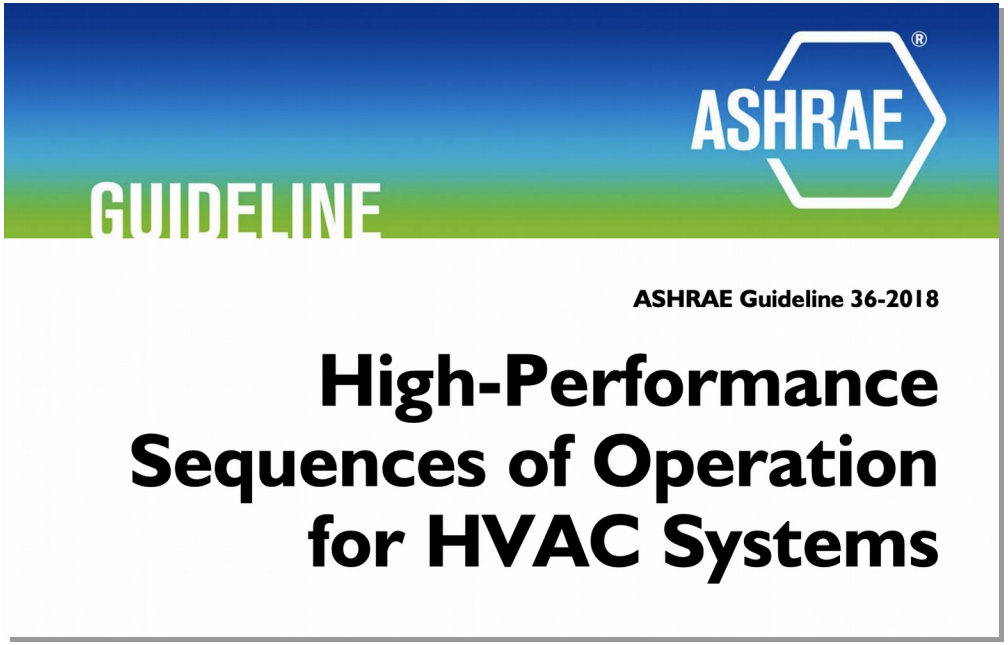
Single Zone VAV

- Often serves medium/large single-floor spaces such as small retail stores, classrooms, and auditoriums



ASHRAE Guideline 36

- Standard best-in-class sequences of operation for single and multi-zone VAV systems
- Reduce energy consumption and improve indoor environment
- Reduce time for engineering, specification, programming, and commissioning processes



Control Description Language (CDL)

- Developed in the OpenBuildingControl (OBC) project [1]
- Subset of Modelica with own data types and elementary blocks
- Allow for implementation of control sequences in computer code that can be used in explicit simulations and real buildings

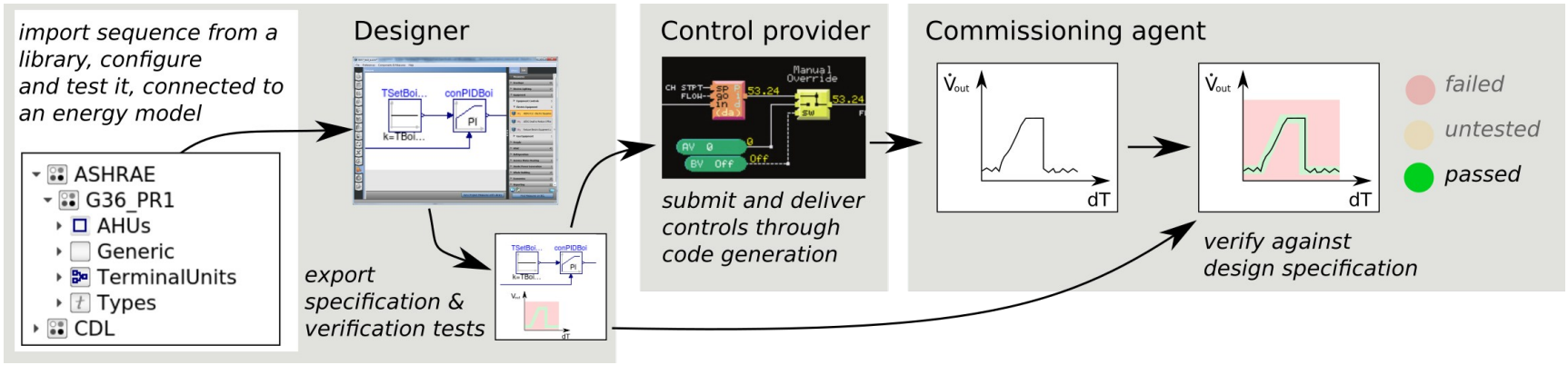
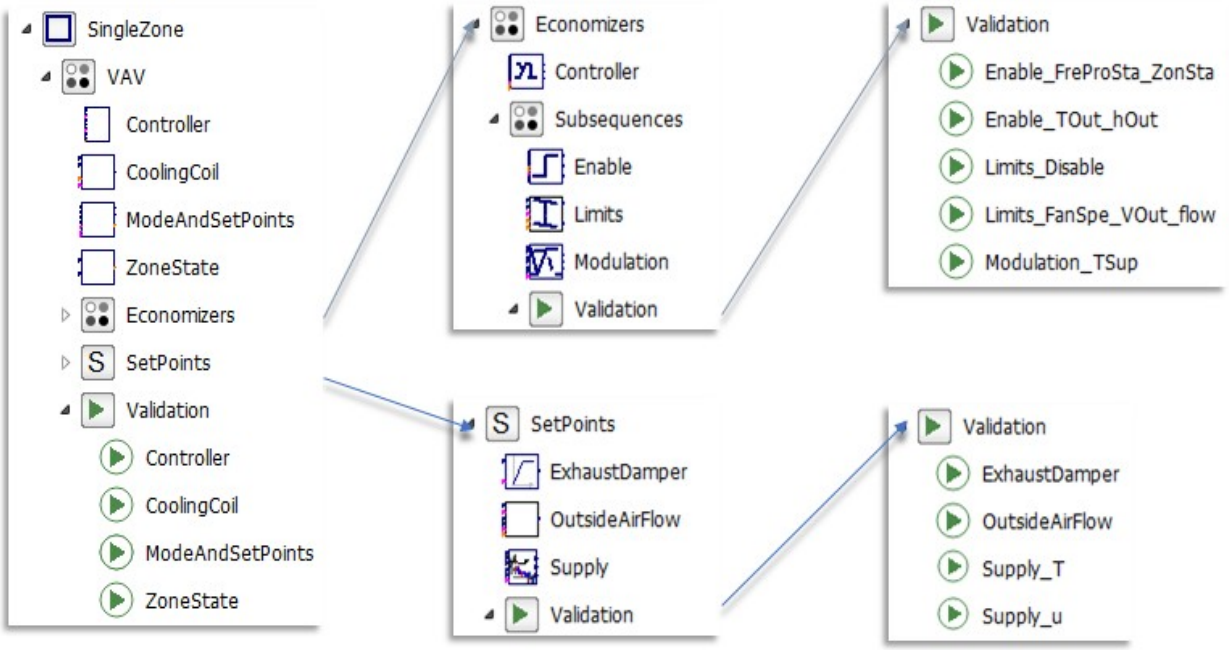


Image from http://obc.lbl.gov/

[1] M. Wetter, M. Grahovac, and J.Hu (2018). “Control Description Language.” *1st American Modelica Conference*, Cambridge, MA, USA, August.

Objective

- Multi-Zone sequences implemented in CDL and tested in [1]
- Implement Single-Zone sequences in CDL, test on simple case study, and compare to conventional sequences

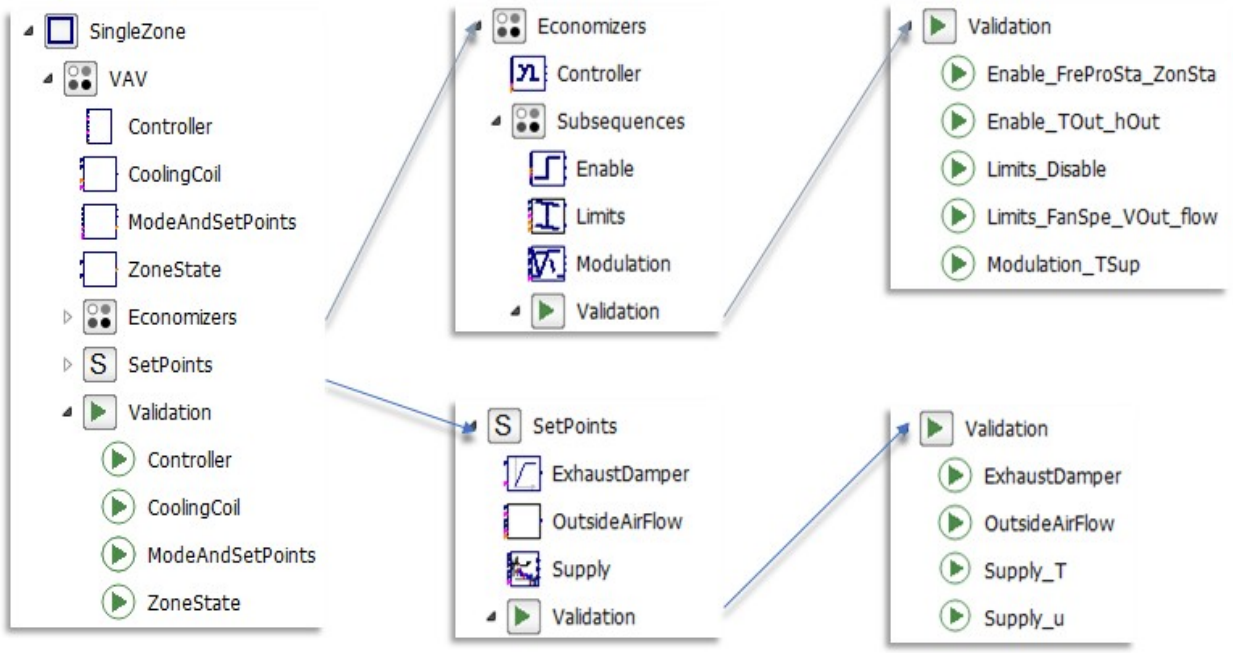


[1] M. Wetter, J. Hu, M. Grahovac, B. Eubanks and P. Haves (2018). “OpenBuildingControl: Modeling feedba control as a step towards formal design, specification, deployment and verification of building control sequences.” In *Proc. of Building Performance Modeling Conference and SimBuild*, p. 775–782, Chicago, IL, USA, September.

Sequence Implementation

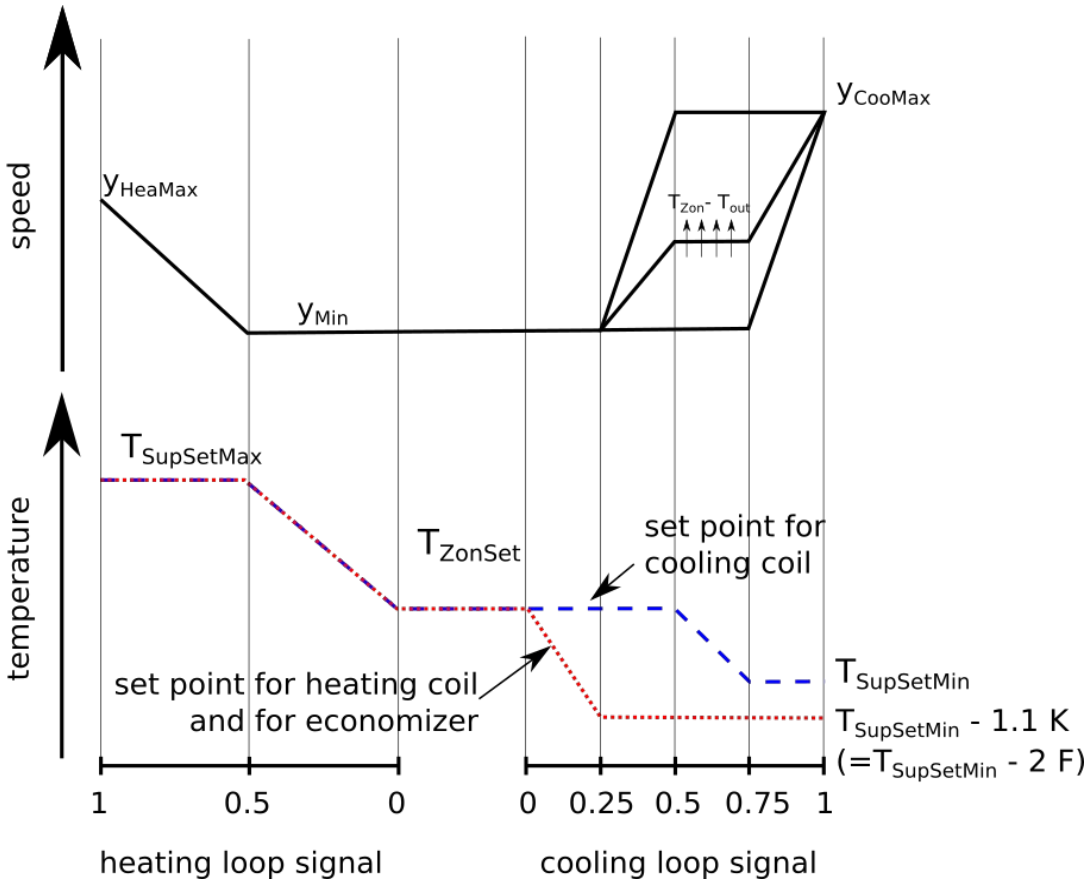
General

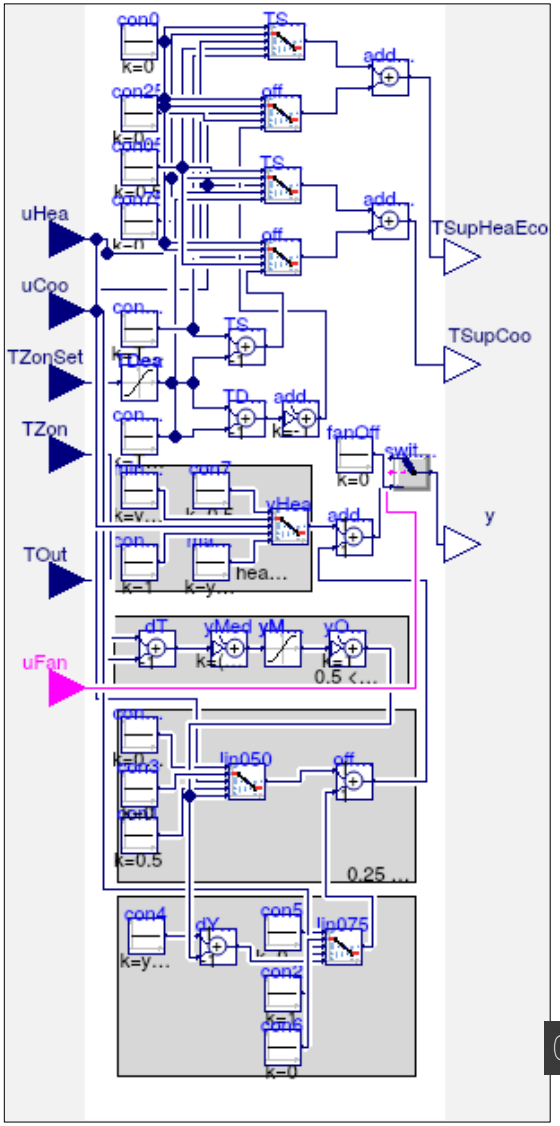
- Modular subsequences
- Documentation through HTML info sections in annotation
- Hysteresis and timers for numerical/sensor noise or chattering
- Verification models



Sequence Implementation

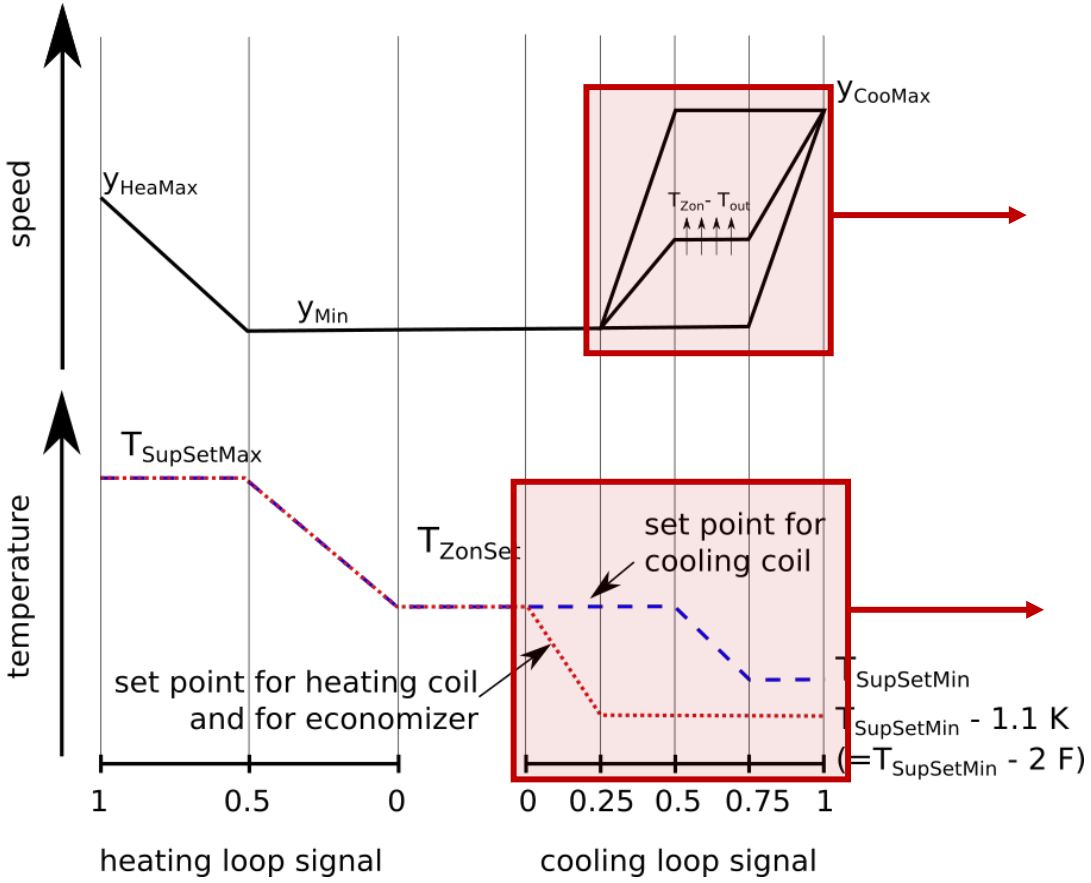
Setpoints for supply air temperature and fan speed

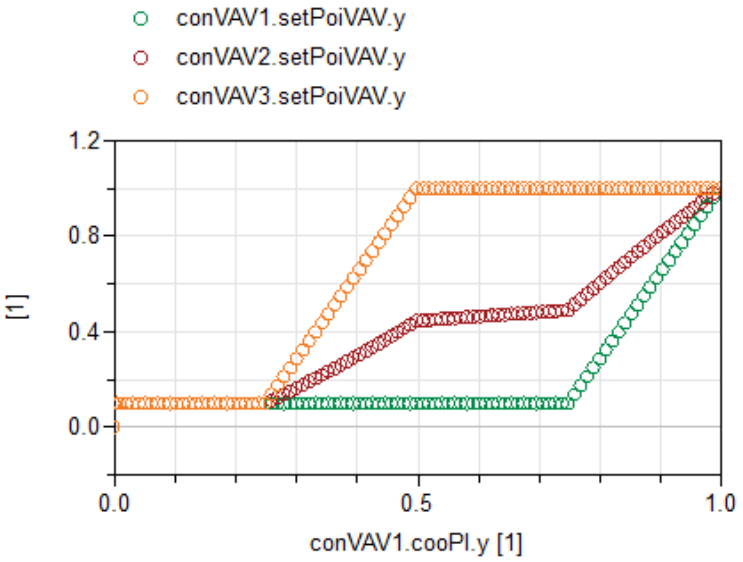


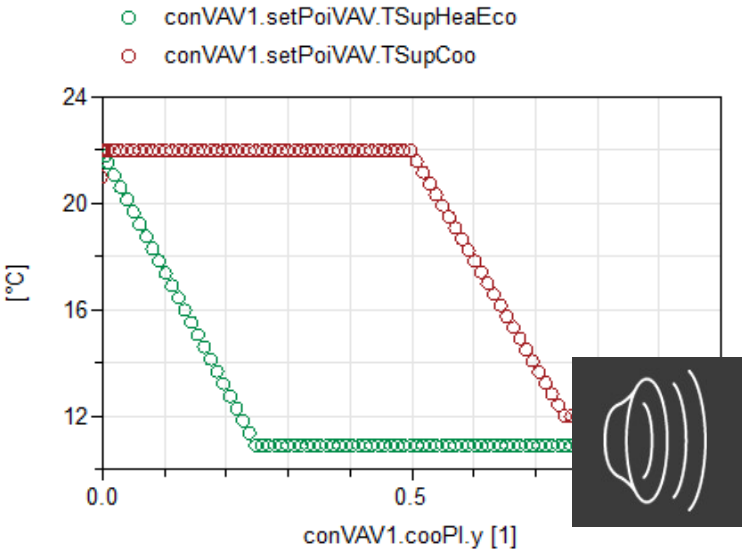


Sequence Implementation

Setpoints for supply air temperatures and fan speed

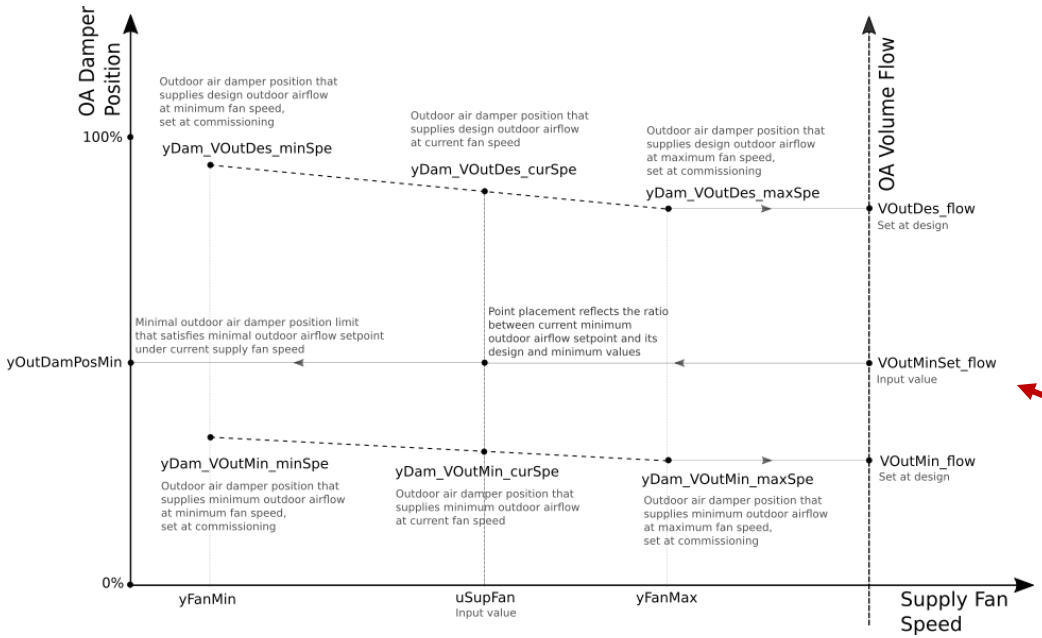


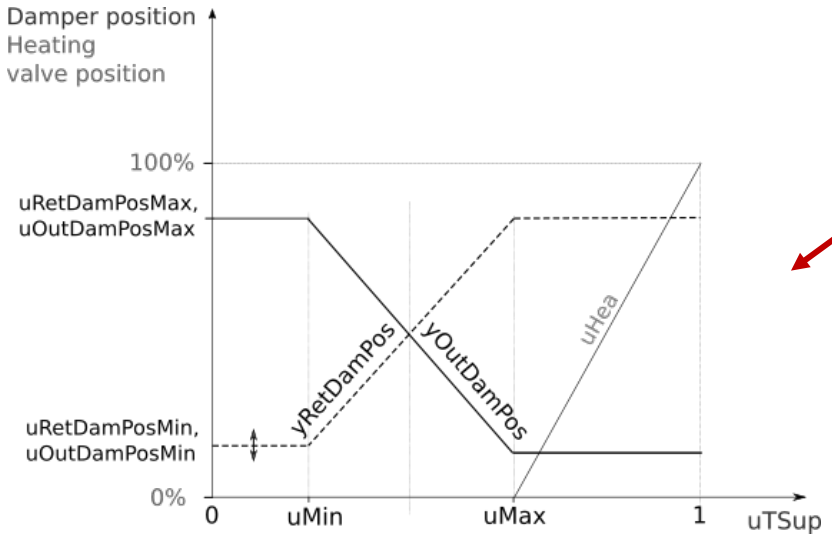


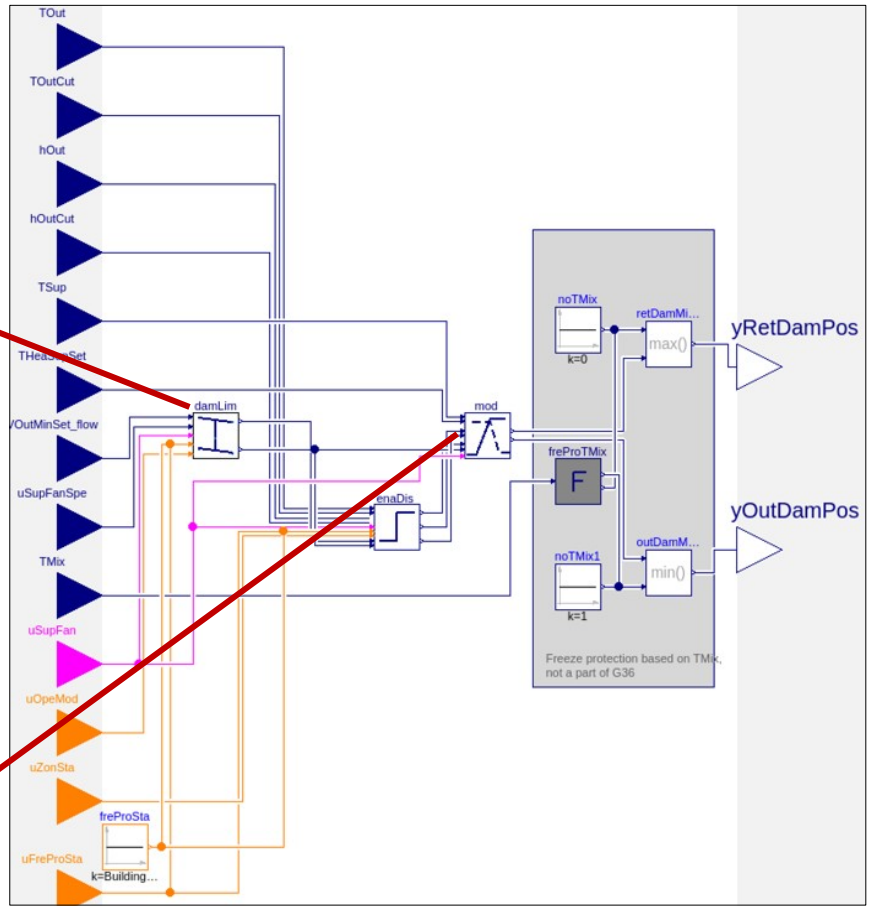


Sequence Implementation

Economizer Control

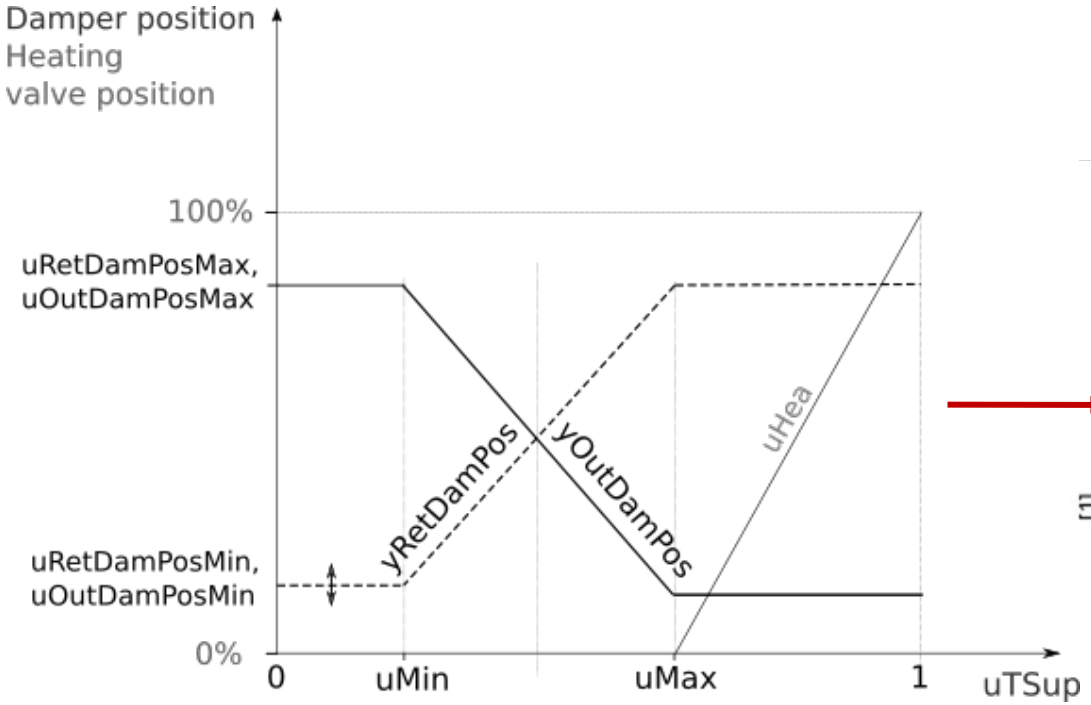


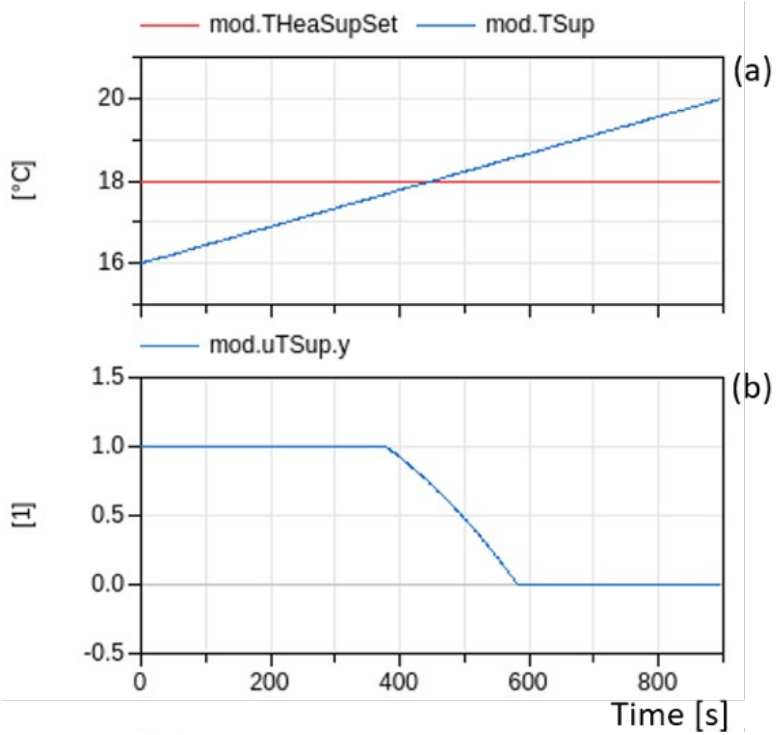


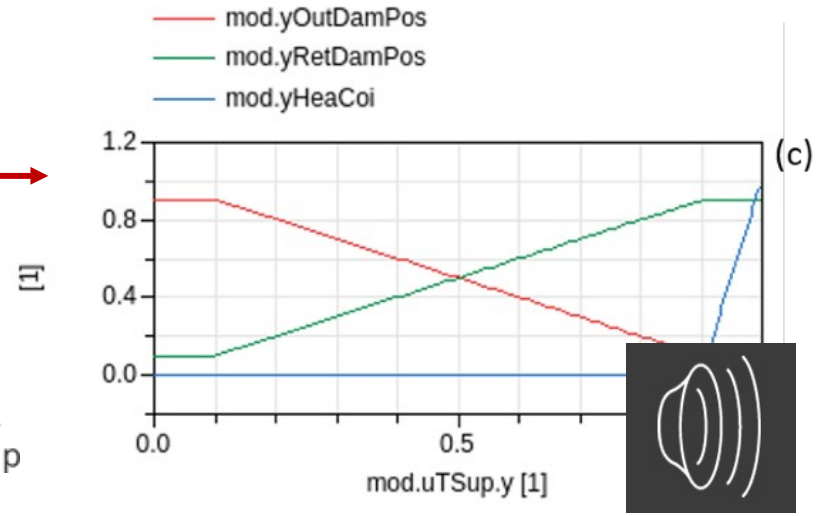


Sequence Implementation

Economizer Control



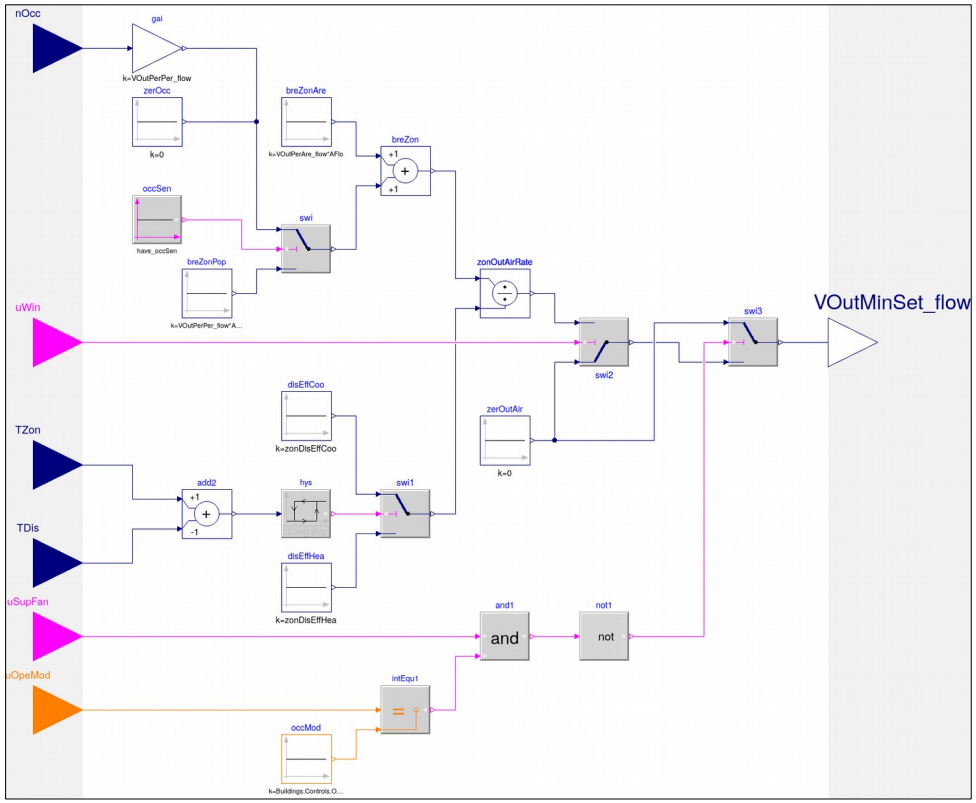


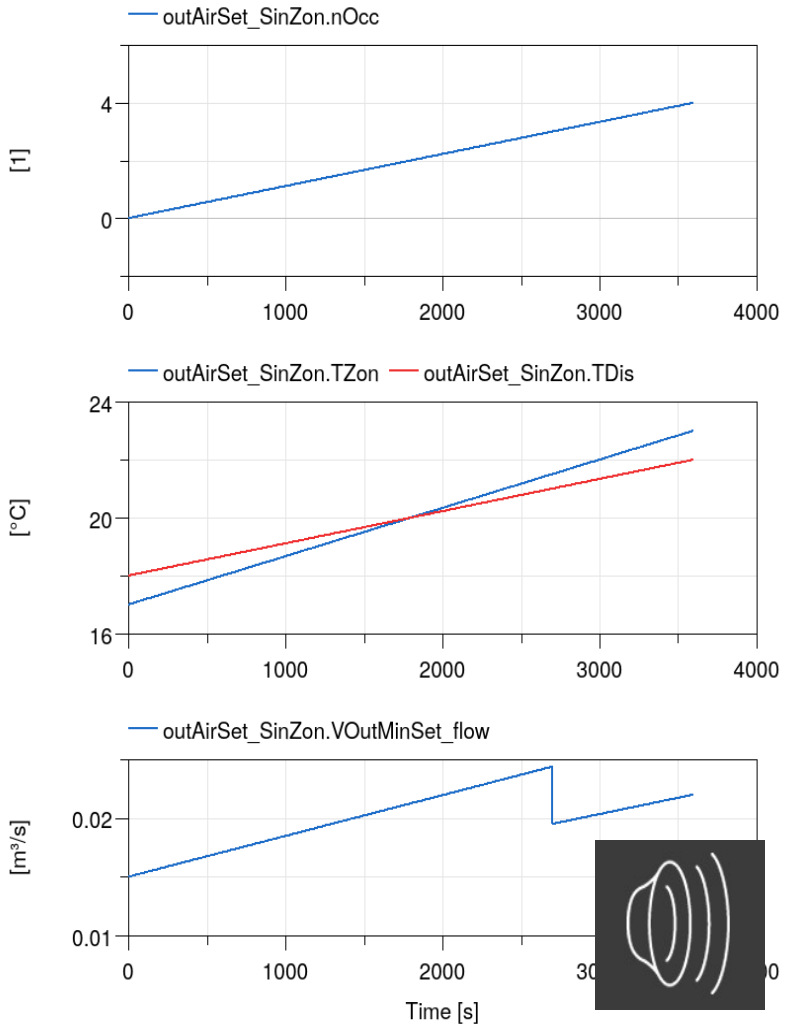


Sequence Implementation

Minimum Outside Airflow

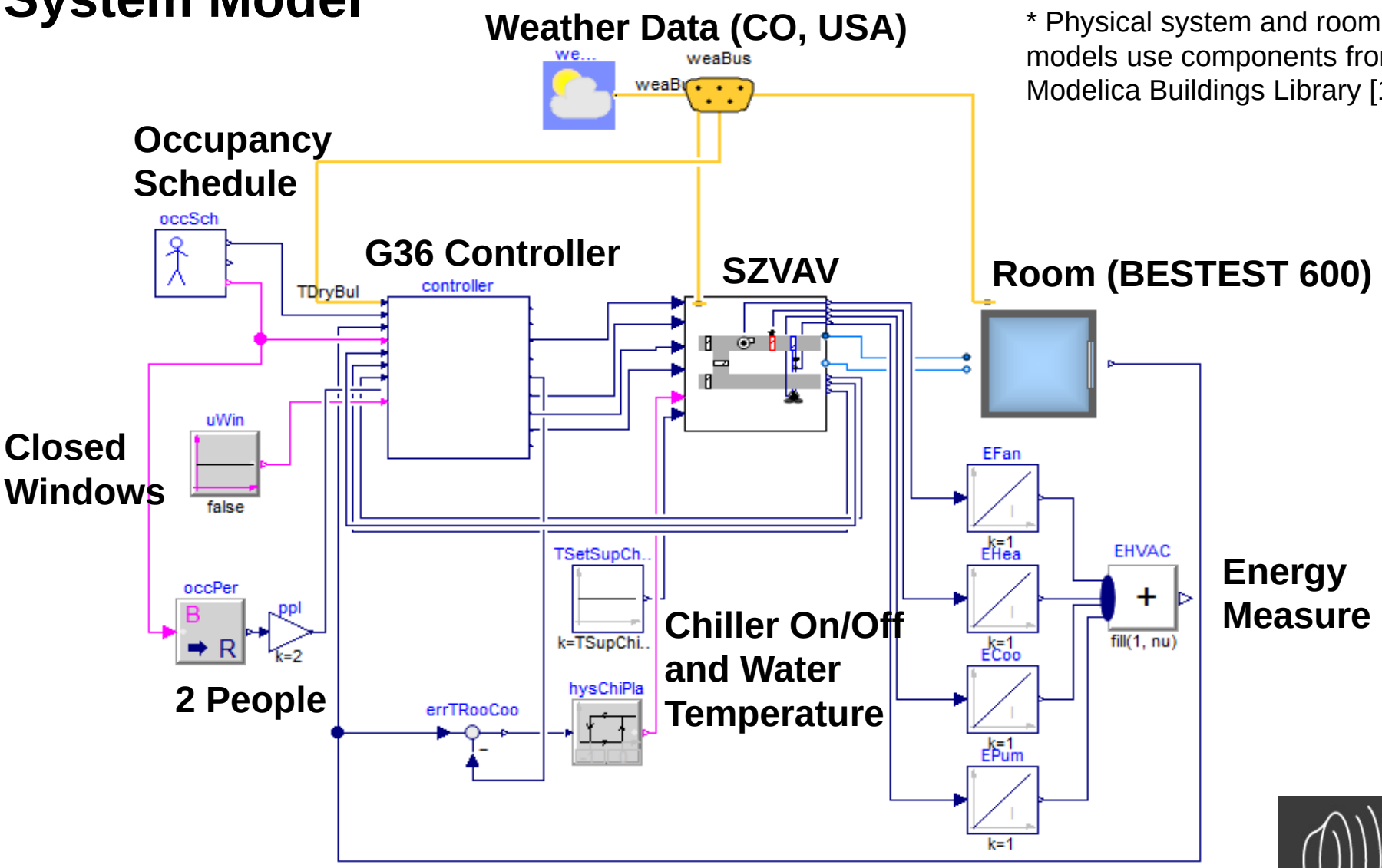
- Min OA flow calculated based on ASHRAE Guideline 62.1-2013
- Includes people, area, and air distribution effectiveness components





Case Study

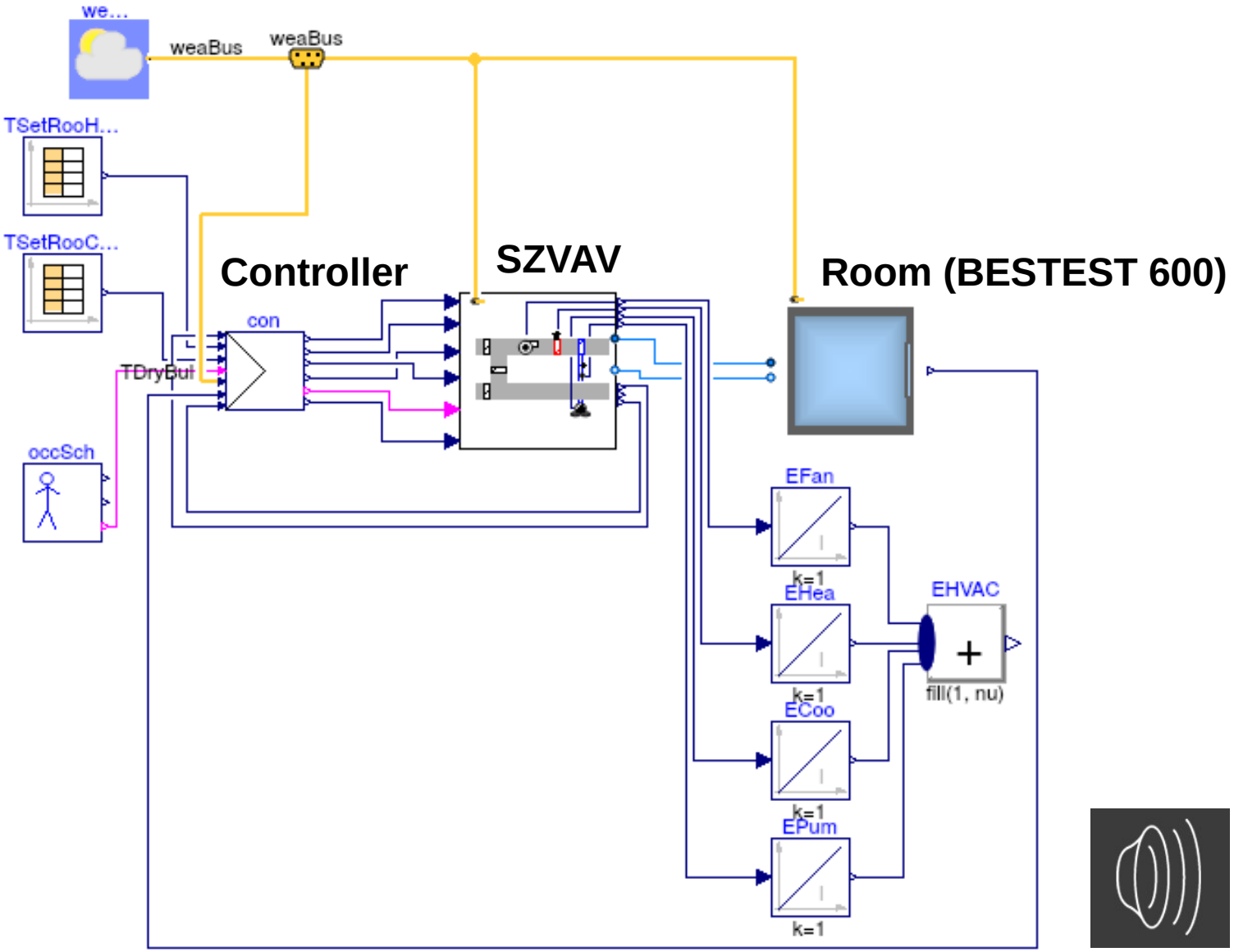
System Model



* Physical system and room models use components from Modelica Buildings Library [1]

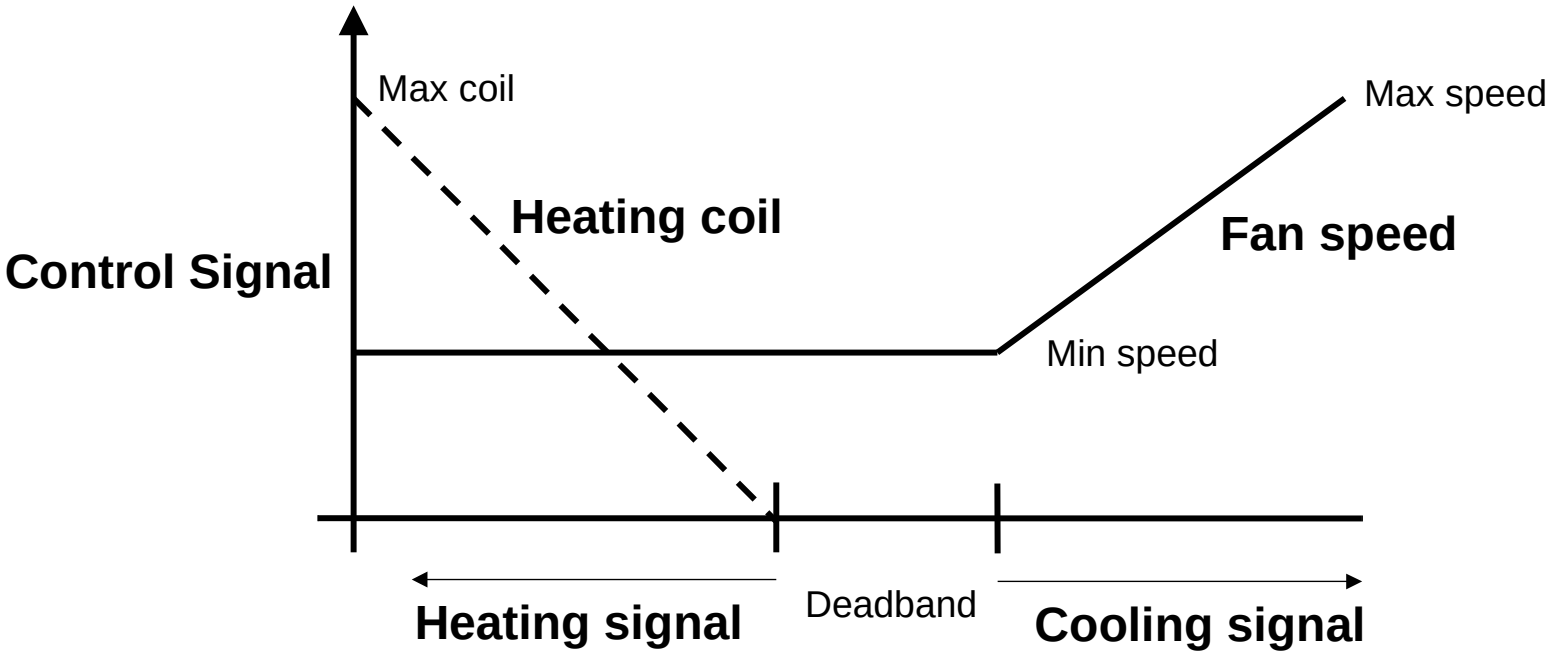
[1] M. Wetter, W. Zuo, T. S. Nouidui, and X. Pang (2014). ”Modelica Buildings library.” *Journal of Building Performance Simulation*, *102*(1), 253–270. https://doi.org/10.1080/19401493.2013.765506

Baseline Control



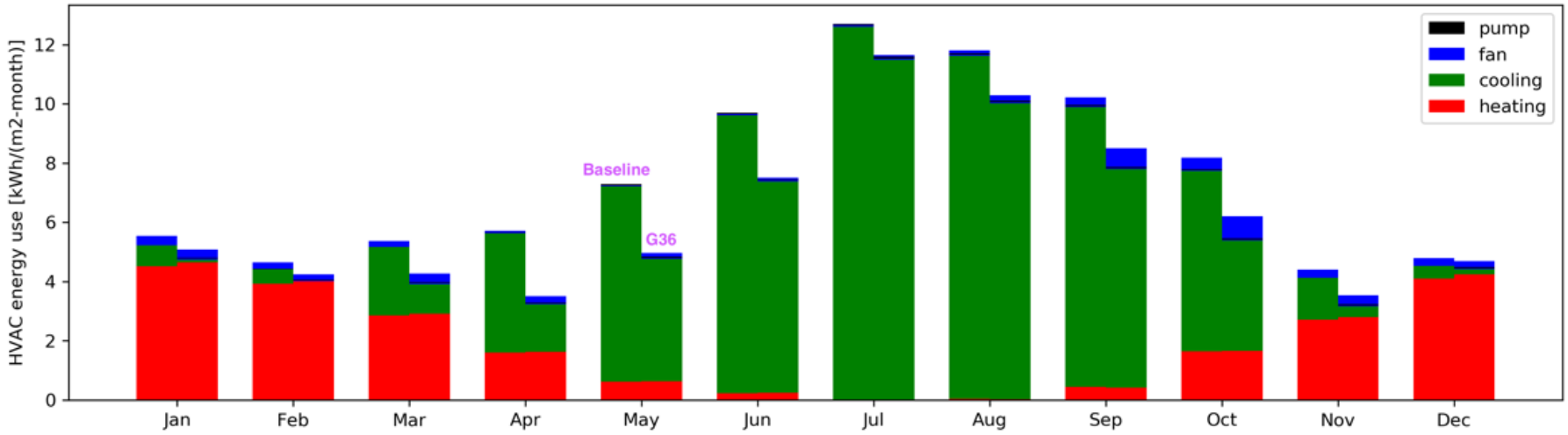
Baseline Control

- Single-Maximum airflow control
- Constant cooling supply air temperature setpoint
- Dry-bulb enabled economizer
- Min OA damper position set to meet min OA flow at min fan speed



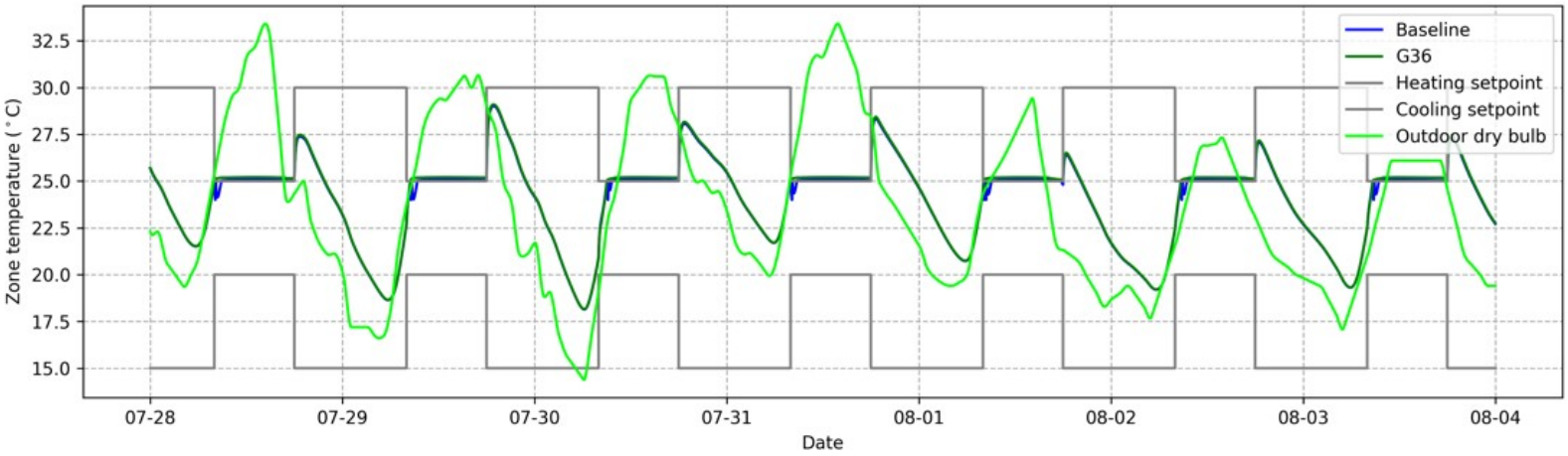
Results

- G36 saved yearly 17.3% energy
- Savings from cooling energy and expense of some fan energy

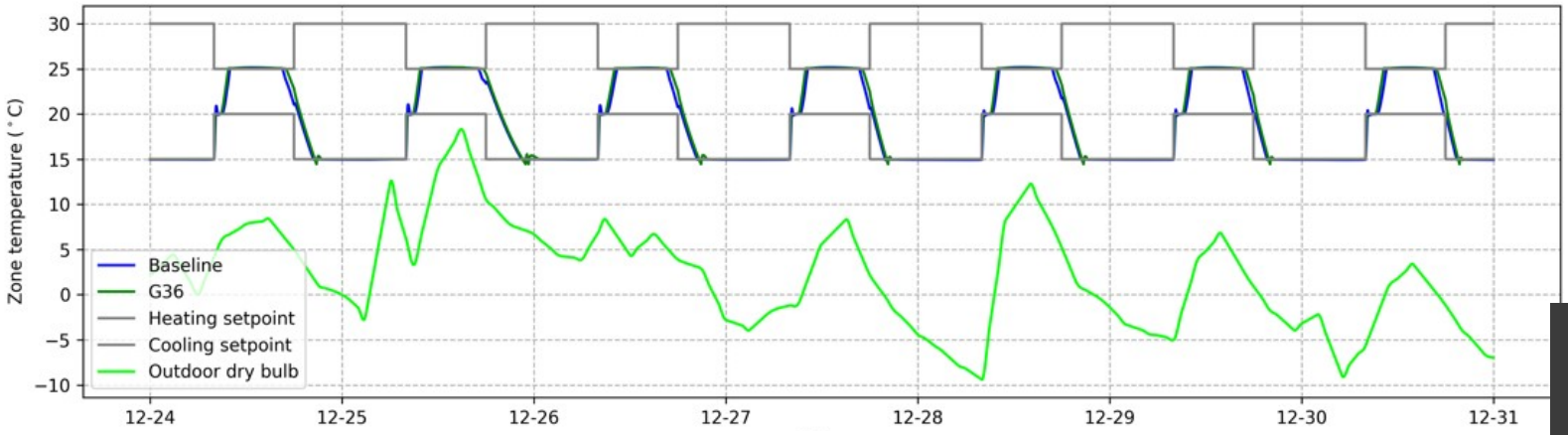


Results – Zone Temperature

Summer

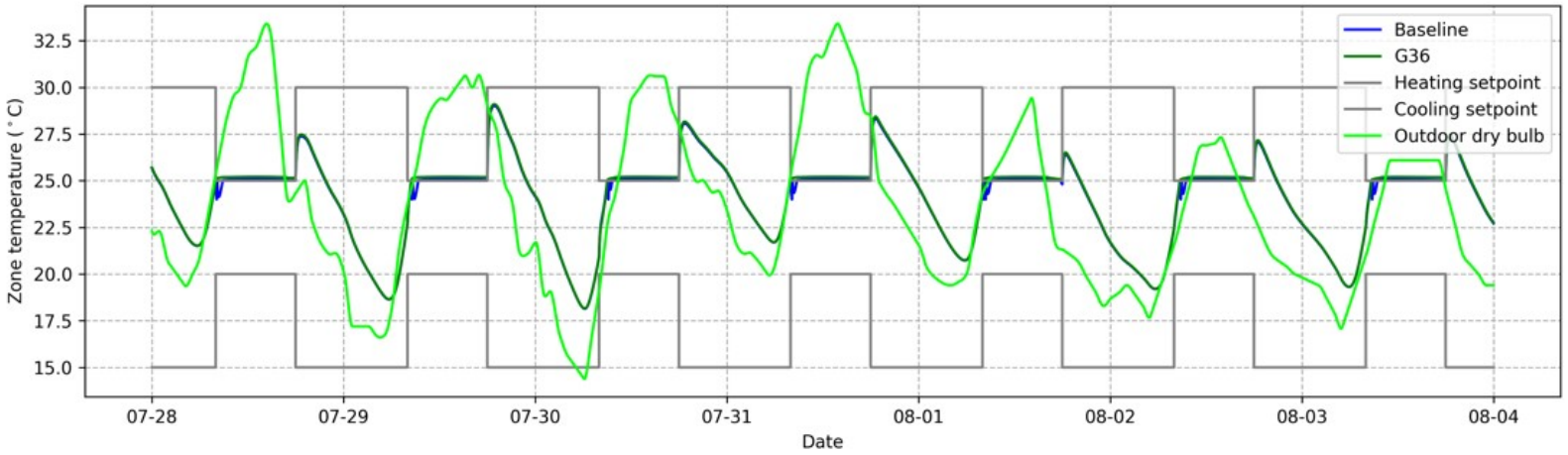


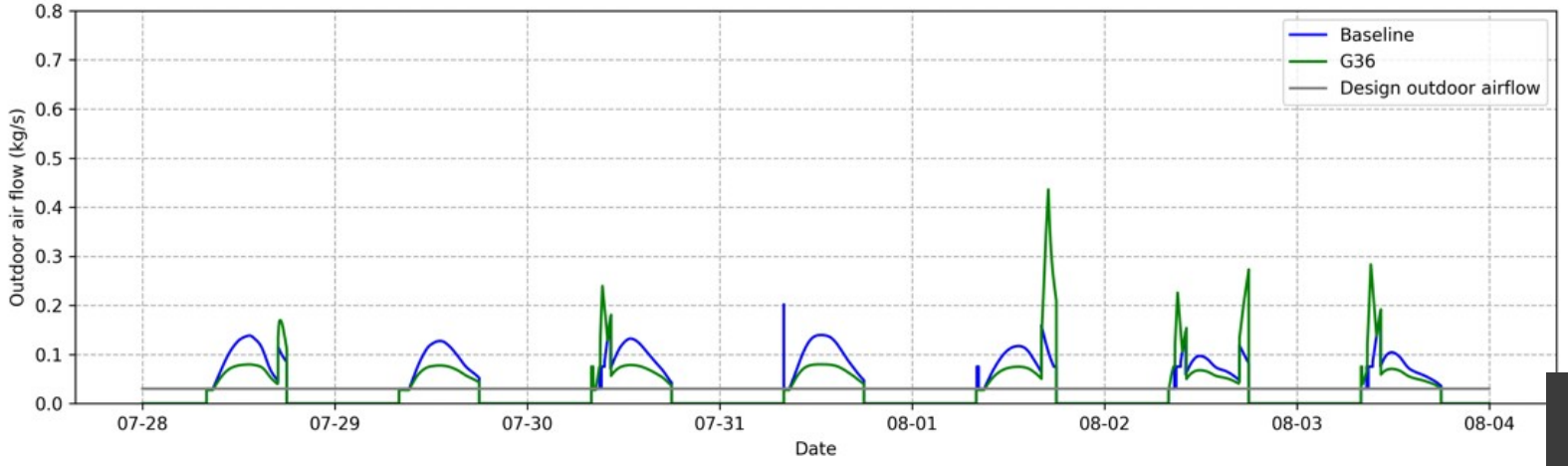
Winter



Results – Outside Airflow

Summer





Conclusion

Summary

- ASHRAE Guideline 36 sequences developed to save energy and implementation cost for multi and single-zone VAV systems
- Single zone sequences implemented in CDL and tested in closed-loop case study using Modelica
- Found to save 17.3% yearly energy over a conventional controller due to improved utilization of economizer free cooling
- Sequences and models available in the Modelica Buildings Library

Future Work

- Testing in additional climates
- Testing against additional control baselines
- Continued code maintenance in Modelica Buildings Library

Acknowledgements

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Thank you!

Questions?

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