NREL
NATIONAL RENEWABLE ENERGY LABORATORY

BERKELEY LAB
Lawrence Berkeley National Laboratory

University of Colorado Boulder

devetry

IPBSA Project 1

URBANopt – District Energy Systems

November 15, 2021 – IBPSA Project 1

Overarching Goals

- Understanding issues that
  - relate to the control of district systems that can be addressed through the use of BOPTEST
  - would need to be addressed in order to create test cases for district systems in BOPTEST

Outline

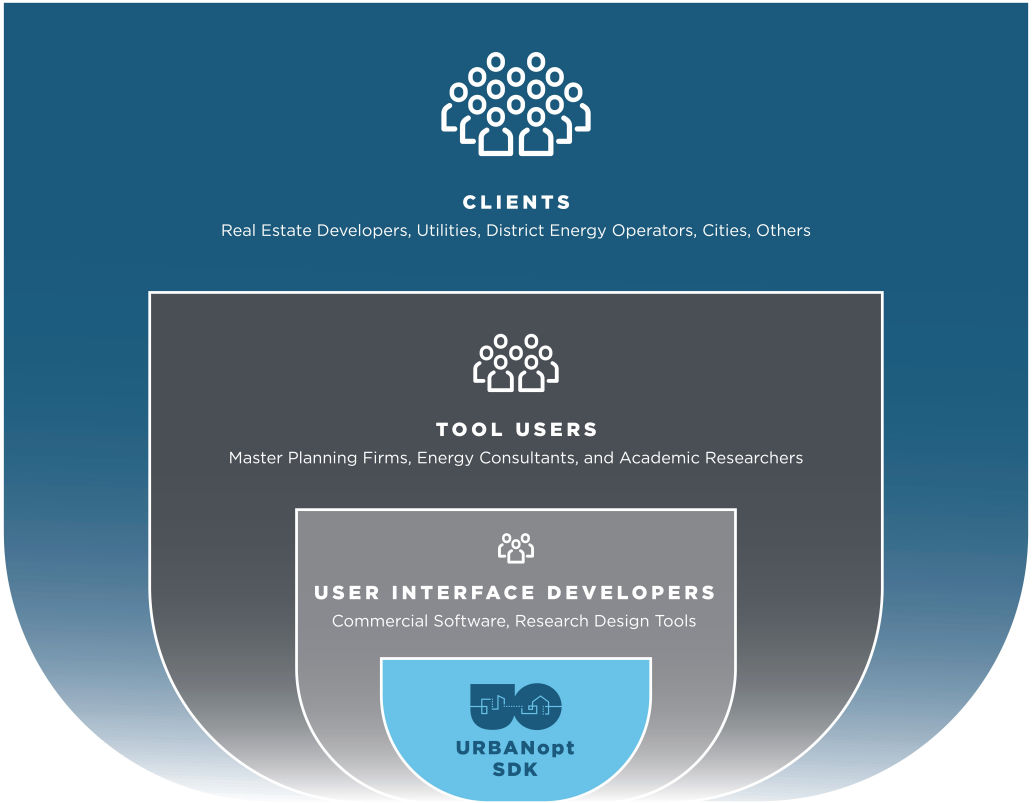
- Brief URBANopt Overview
- Brief URBANopt DES Overview
- Topics to discuss:
  - system architectures and size
  - control architectures and strategies
  - level of modeling detail
  - key performance indicators
  - the roles of real systems, real data, and digital twins

Acknowledgements

- There are many people involved across the URBANopt, URBANopt District Energy System, Alfalfa, BOPTEST, and ACTB projects. Contacts for each project are below:
  - URBANopt – Ben.Polly@nrel.gov
  - UO DES – Nicholas.Long@nrel.gov, mwetter@lbl.gov
  - Alfalfa – Anya.Petersen@nrel.gov
  - BOPTEST – dhblum@lbl.gov
  - ACTB – Gregor.Henze@colorado.edu

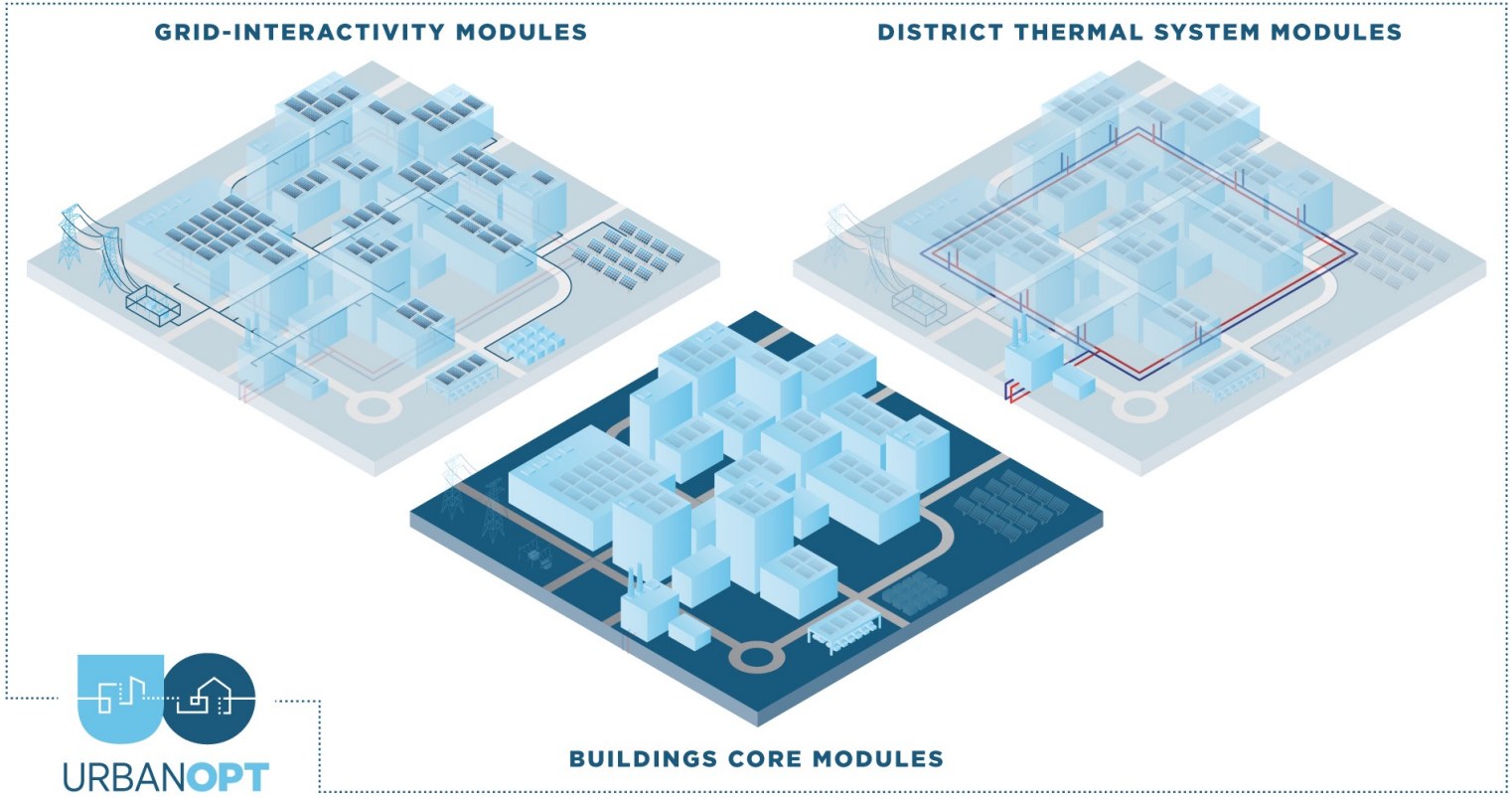
What is URBANopt?

- Analytics platform for communities and urban districts
- Built on top of OpenStudio®, EnergyPlus™, and the Modelica Buildings Library
- Modular, open source platform; “underlying analytics” that can be integrated into private sector tools

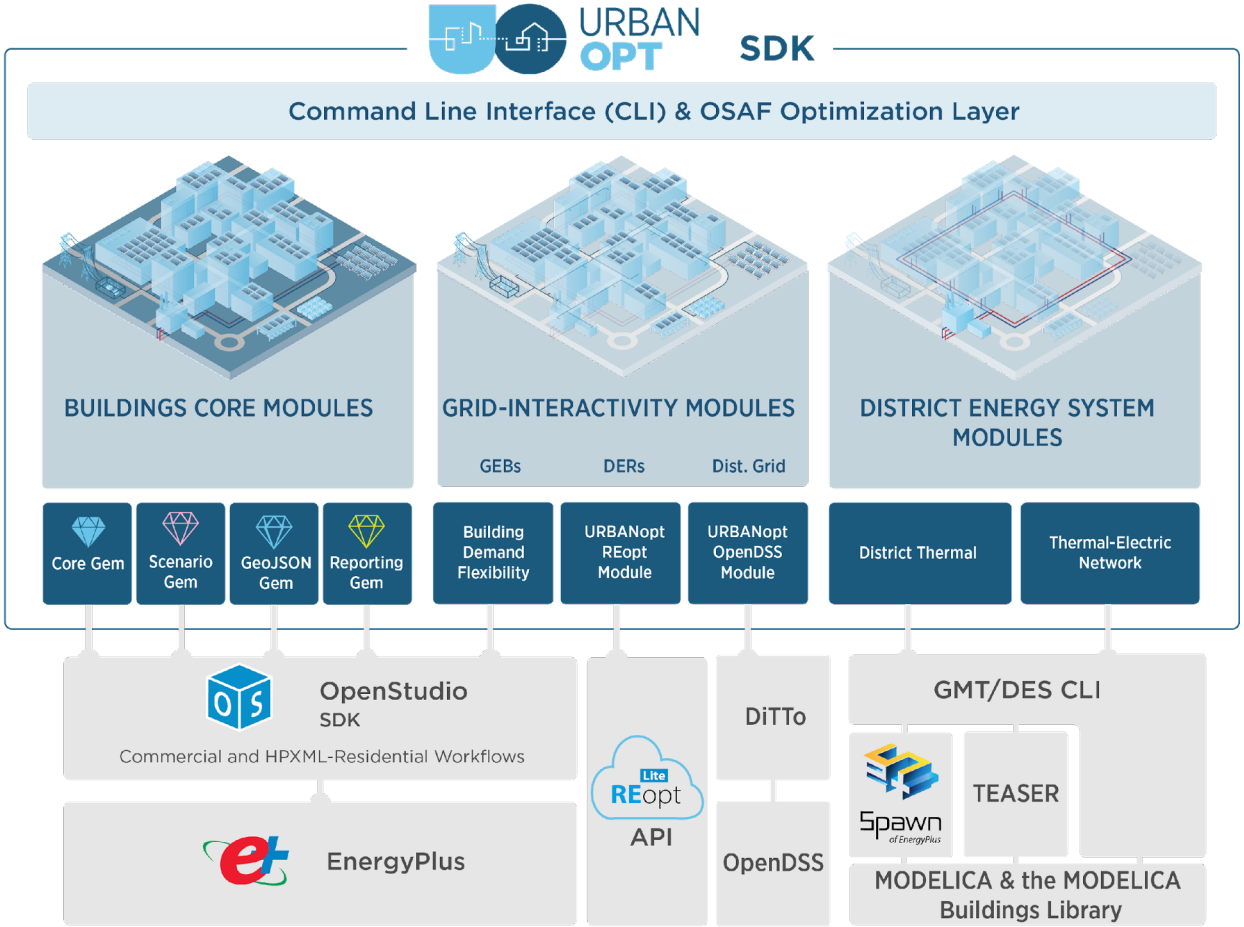


Christopher Schwing, NREL

Project Focus Areas

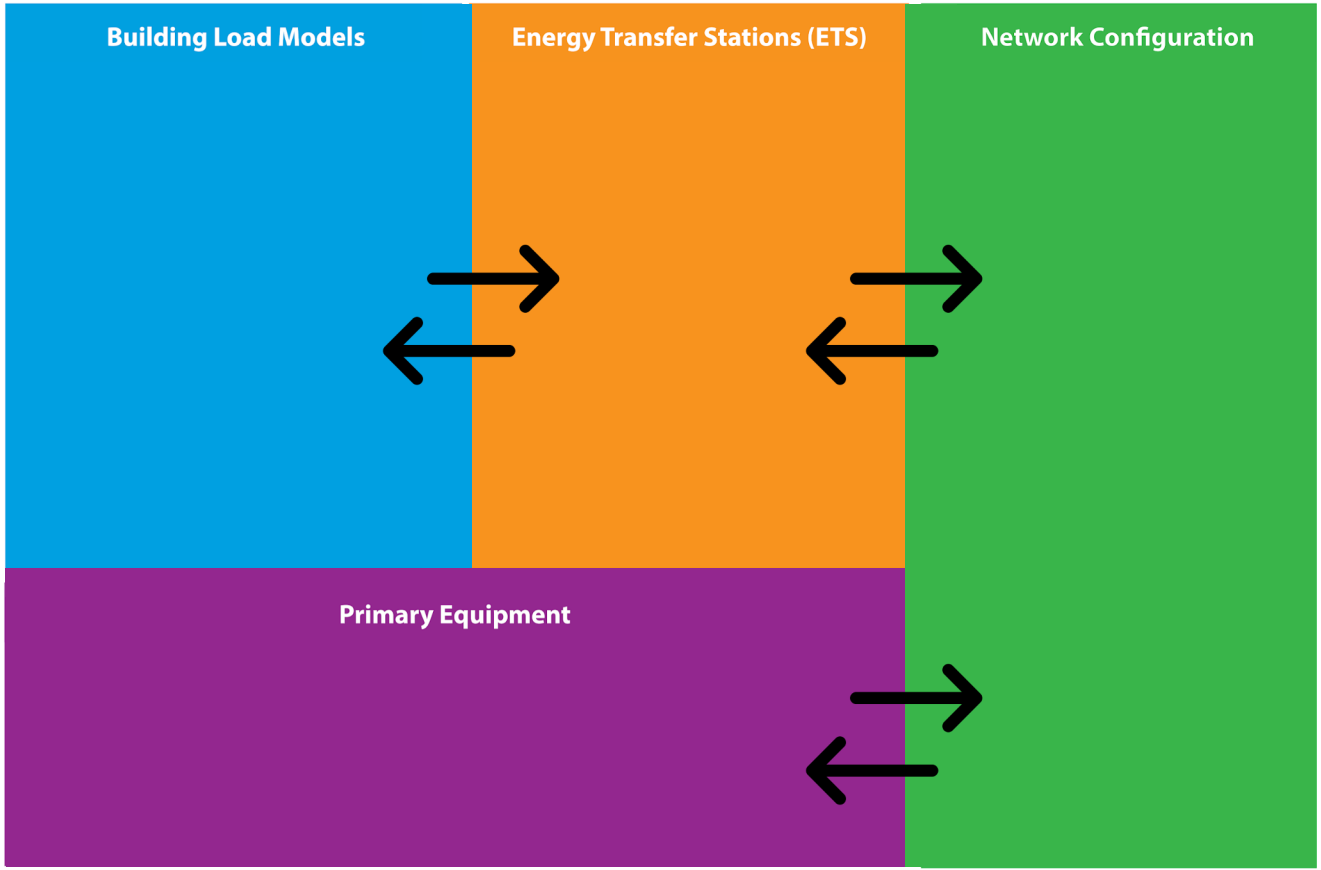


Underlying Analysis Modules



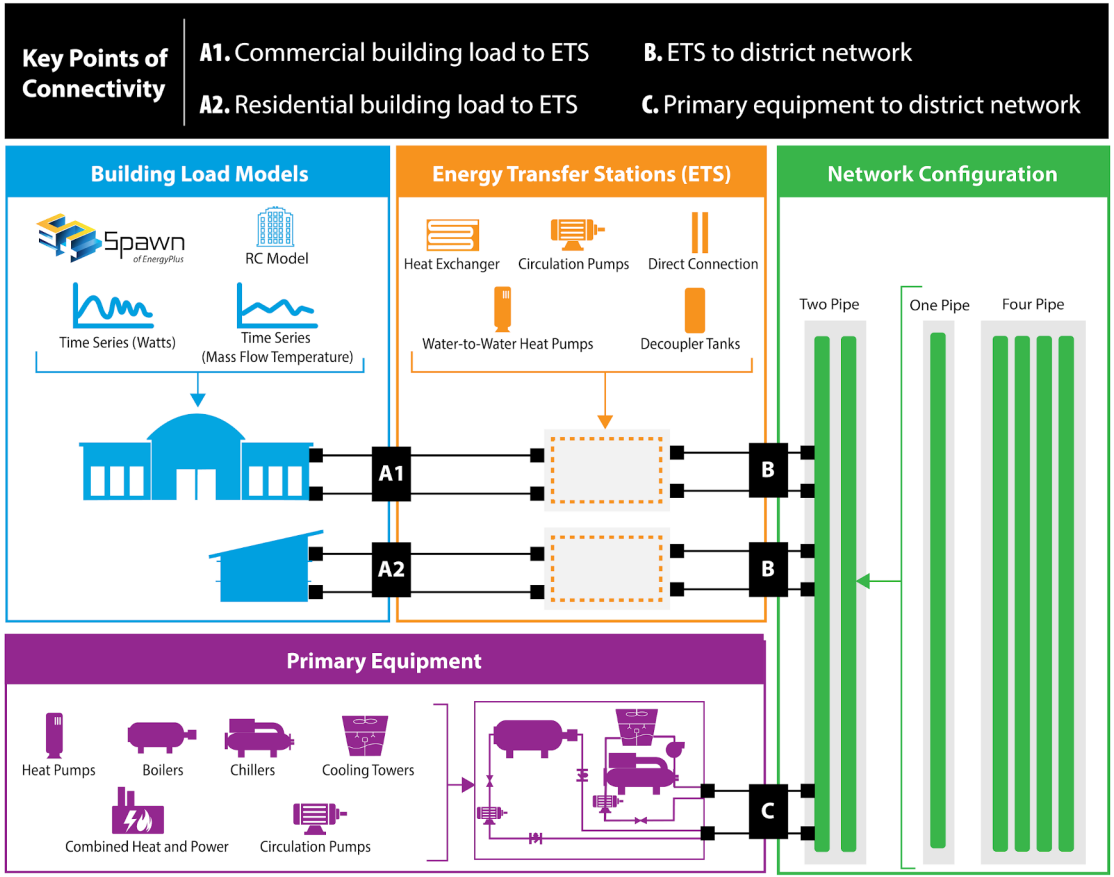
URBANopt DES Overview

District System Architecture



Marj Schott / NREL

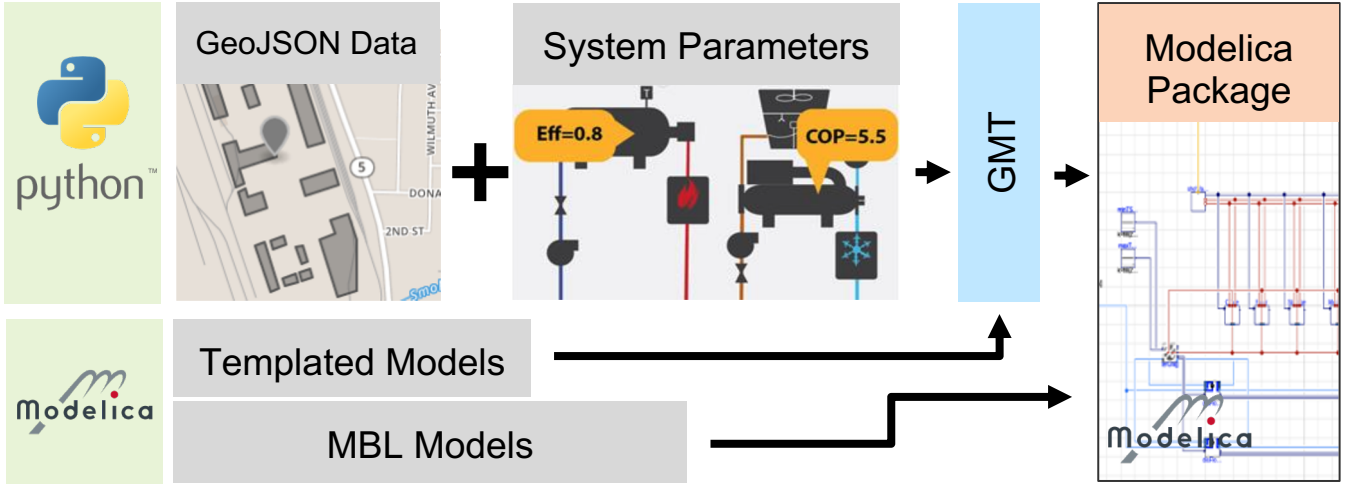
District System Architecture



Note that the location of the primary equipment can be centralized or distributed, and that not all primary equipment component models or network configurations are represented in the diagram.

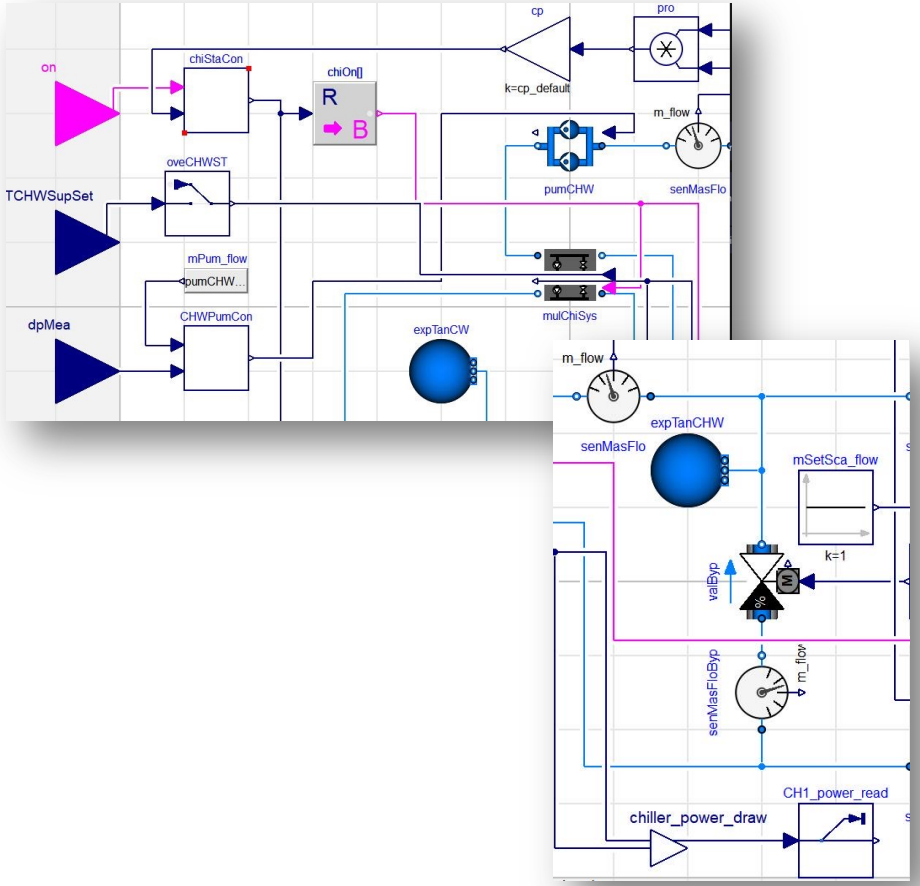
GeoJSON to Modelica Translator (GMT)

- BSD 3-Clause, open source
  - Source: https://github.com/urbanopt/geojson-modelica-translator
  - Test Suite: https://github.com/urbanopt/geojson-modelica-translator-examples
  - Integrated with GitHub Actions and runs with JModelica (Docker-based)
- Python-based
- Depends on TEASER, Modelica Buildings Library



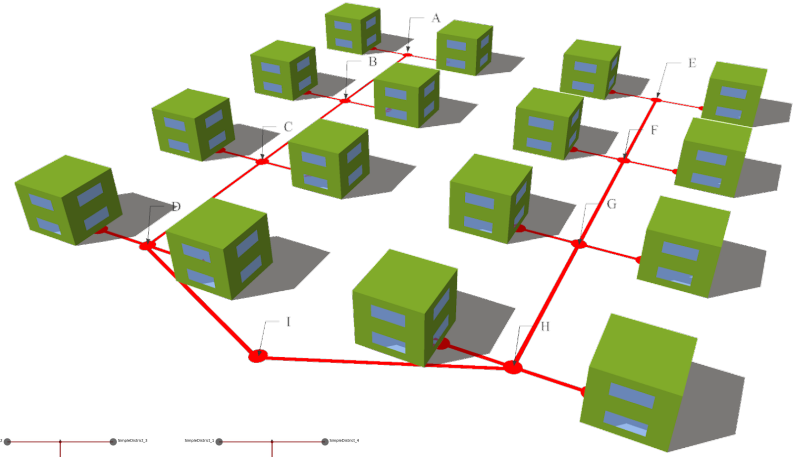
DES Controls

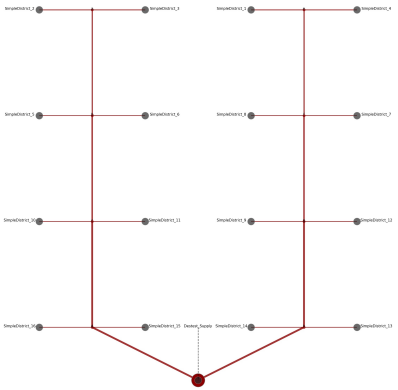
- New area for URBANopt DES
- Actively developing an external supervisory controller using BOPTEST (service-branch)



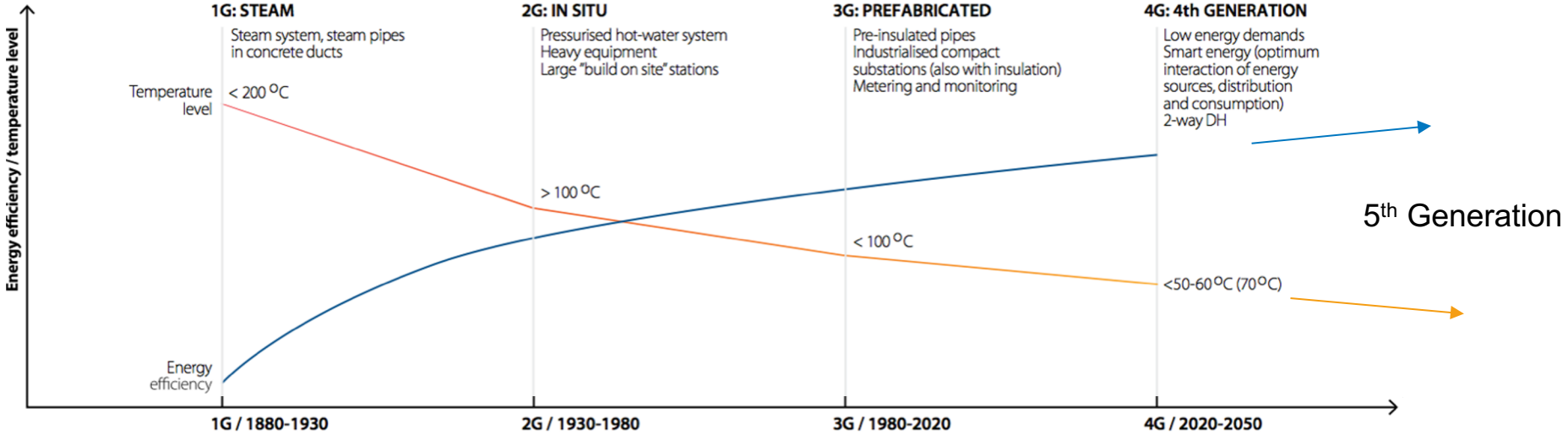
System Architectures: DESTEST

- DESTEST has an 8, 16, and 32 building test network
- What other configurations are needed?
  - Multiple sources?
  - Load diversity?



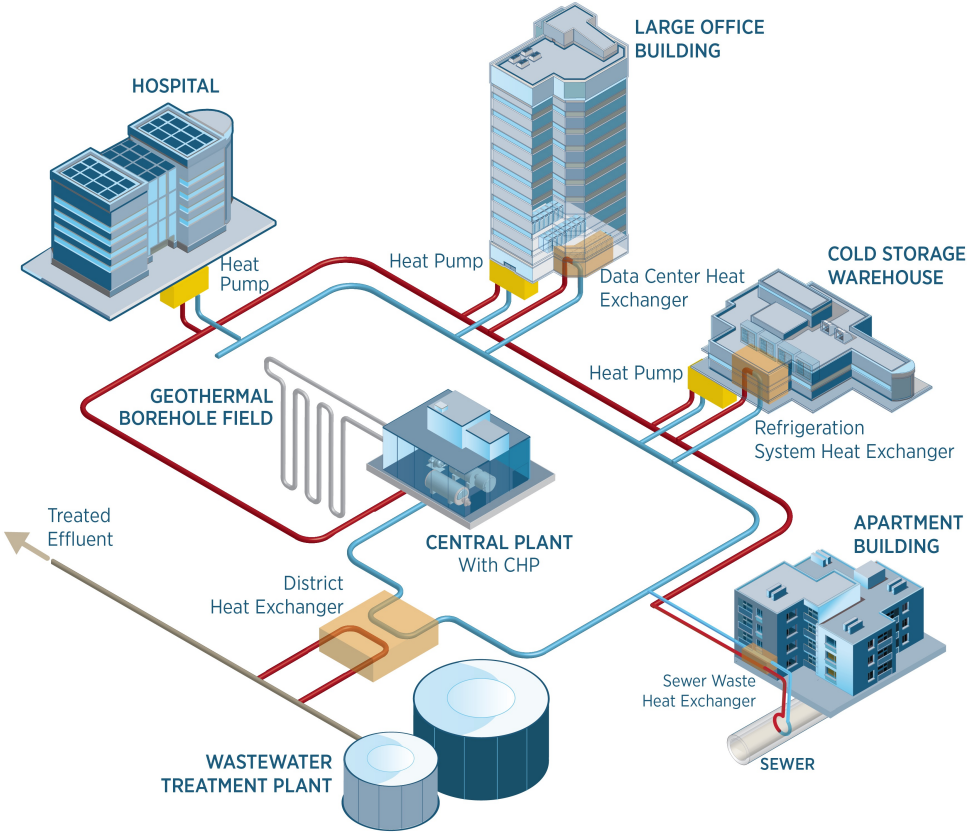


District Heating and Cooling Generations



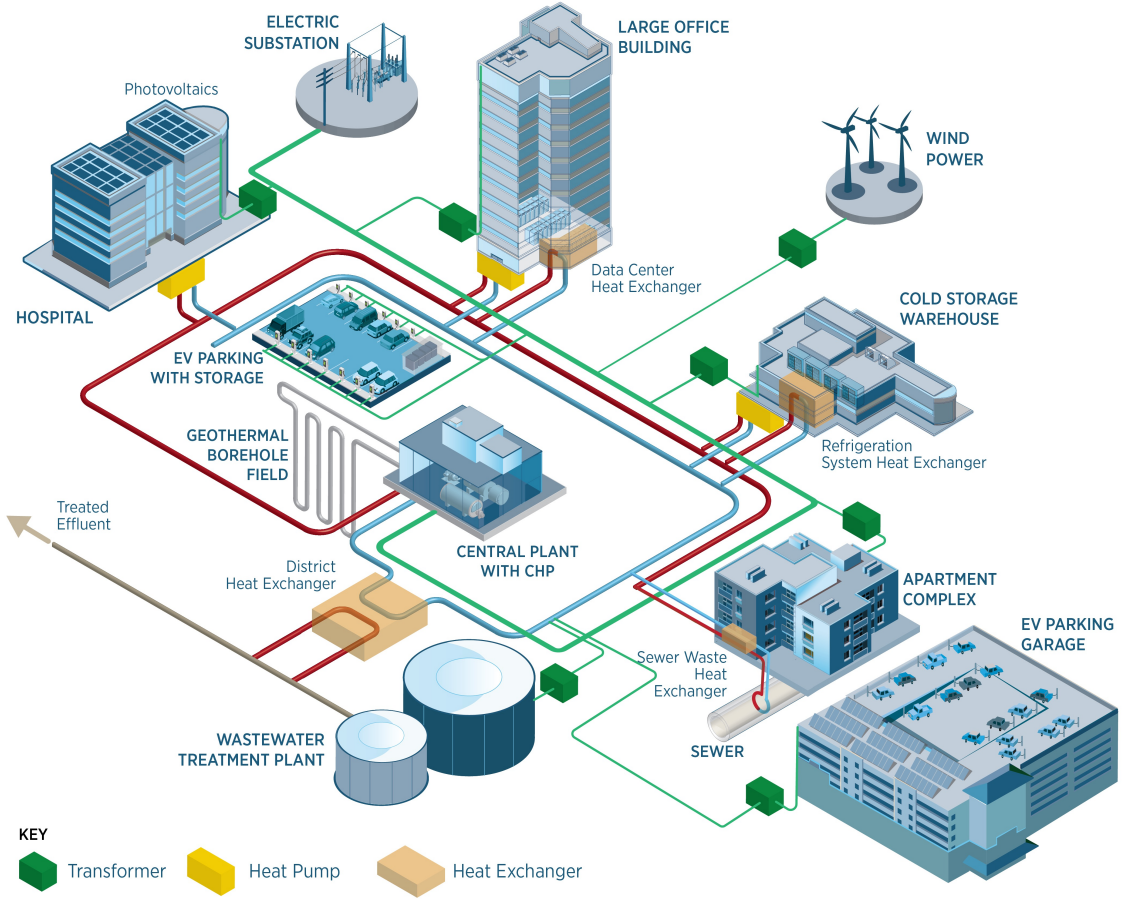
Source:
http://ecopolis.danfoss.com

Desired Analytical Architecture



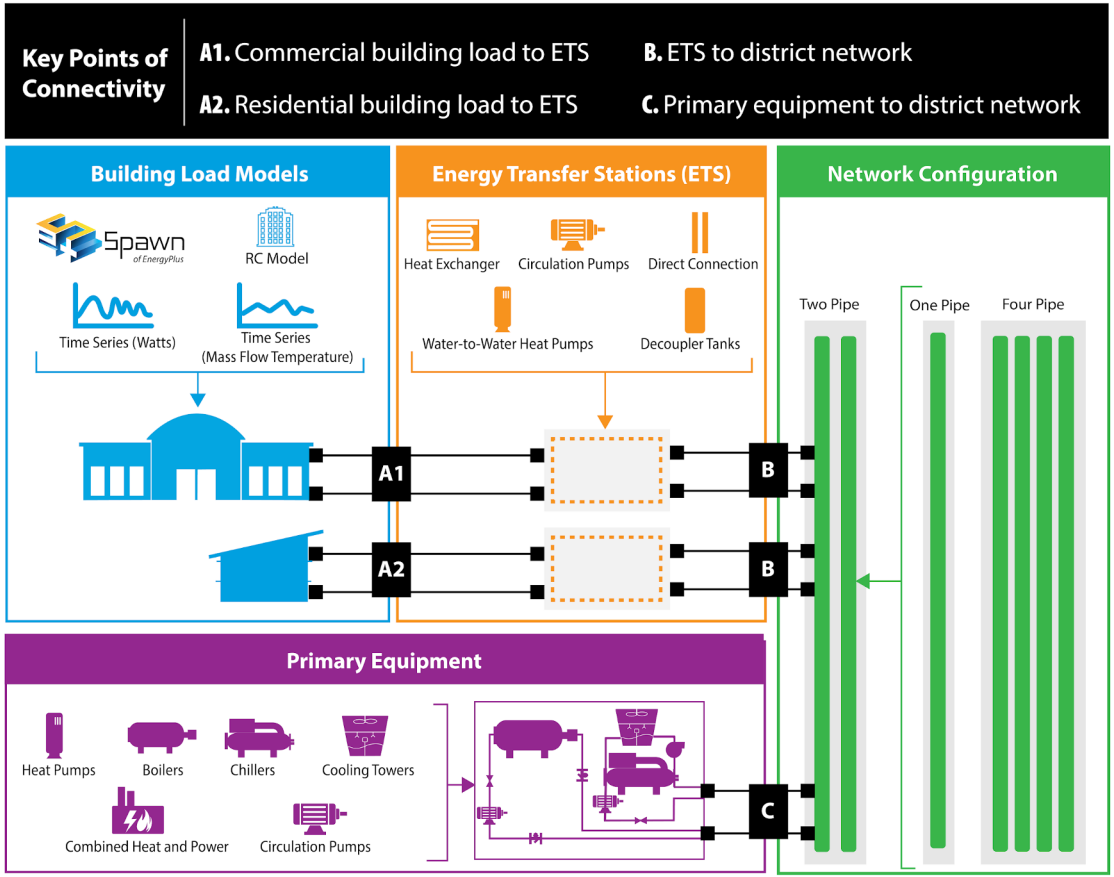
Source: Marjorie Schott, NREL. Adapted from http://arbonus.ca/what-we-do/northern-community-energy-systems/

Or this…



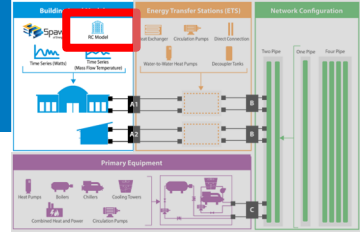
Source: Marjorie Schott, NREL. Adapted from http://arbonus.ca/what-we-do/northern-community-energy-systems/

Model Level of Details



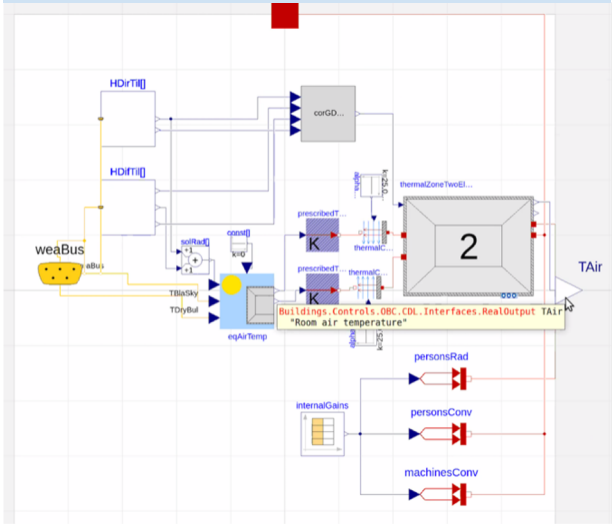
Note that the location of the primary equipment can be centralized or distributed, and that not all primary equipment component models or network configurations are represented in the diagram.

TEASER/RC Loads

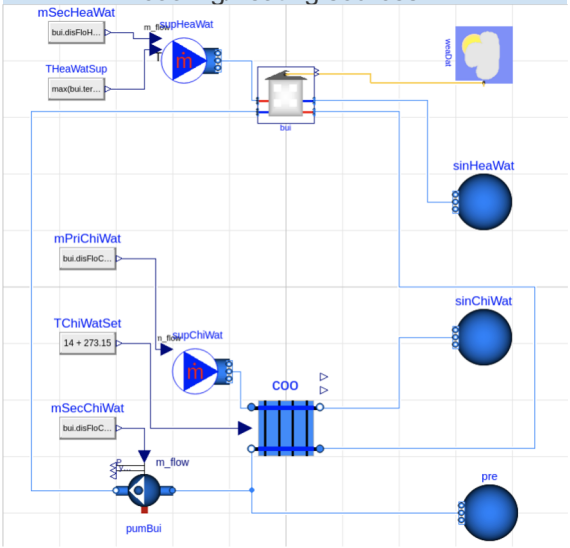


- Use TEASER to export of MBL/IBPSA RC models
- NREL has provided updates to Aachen's TEASER library
- Upon export "tweaks" applied to TEASER models
  - e.g., add heat port, add fraction latent, add moisture balance, add TAir

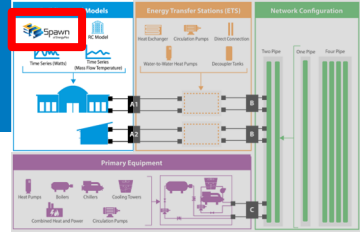
Teaser thermal Zone Model



TEASER building connected to indirect cooling ETS and "infinite district cooling/heating sources"

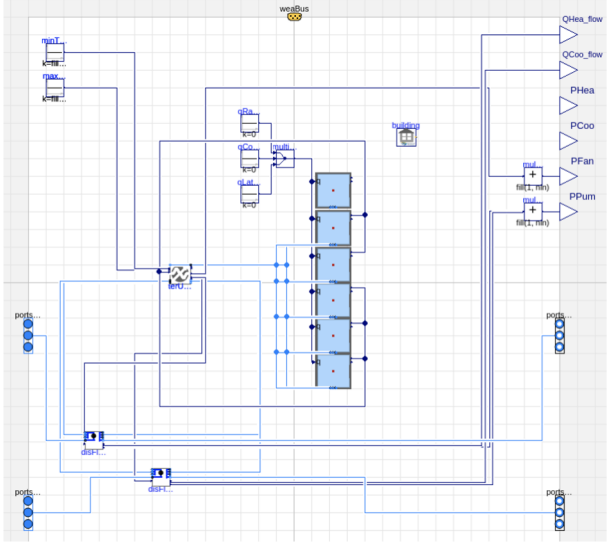


Spawn of EnergyPlus Loads

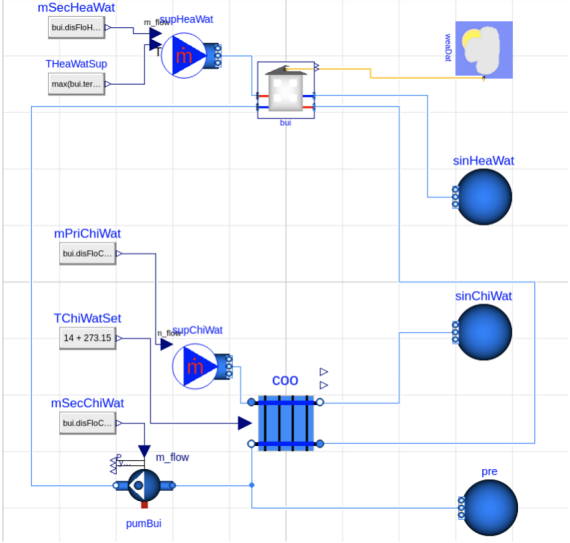


- Leverage Spawn of EnergyPlus for loads and zone heat balance
- Each thermal zone connected to terminal unit

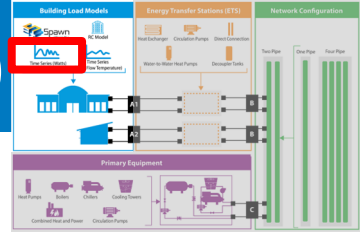
Spawn connected to terminal units



Spawn building connected to
indirect cooling ETS and
“infinite district cooling/heating sources”

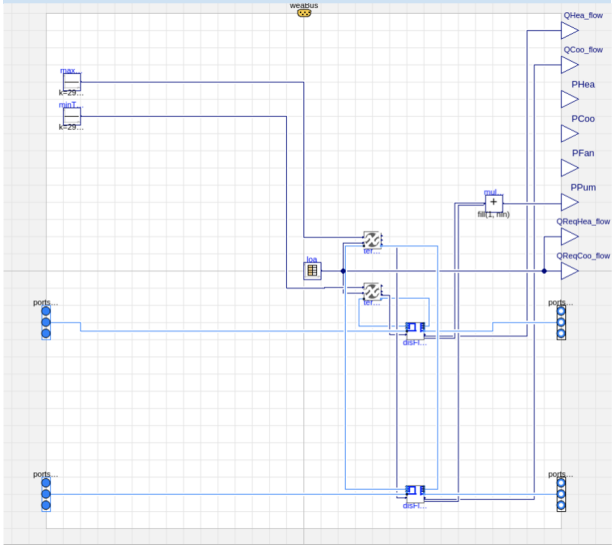


Time Series : Building Loads (kW)

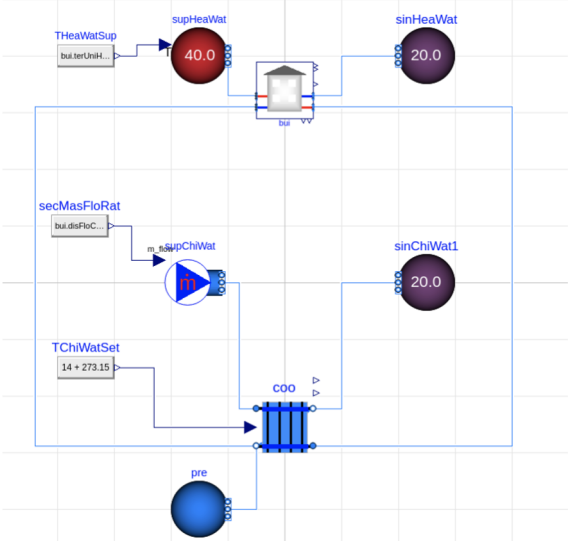


- CSV file of building thermal loads
- Precomputed loads for ~1,200 U.S.-based reference buildings
  https://github.com/urbanopt/openstudio-prototype-loads

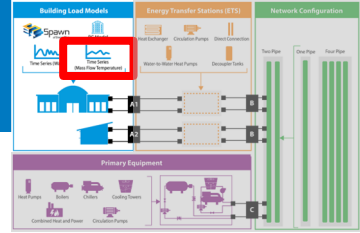
Time series loads connected to terminal unit



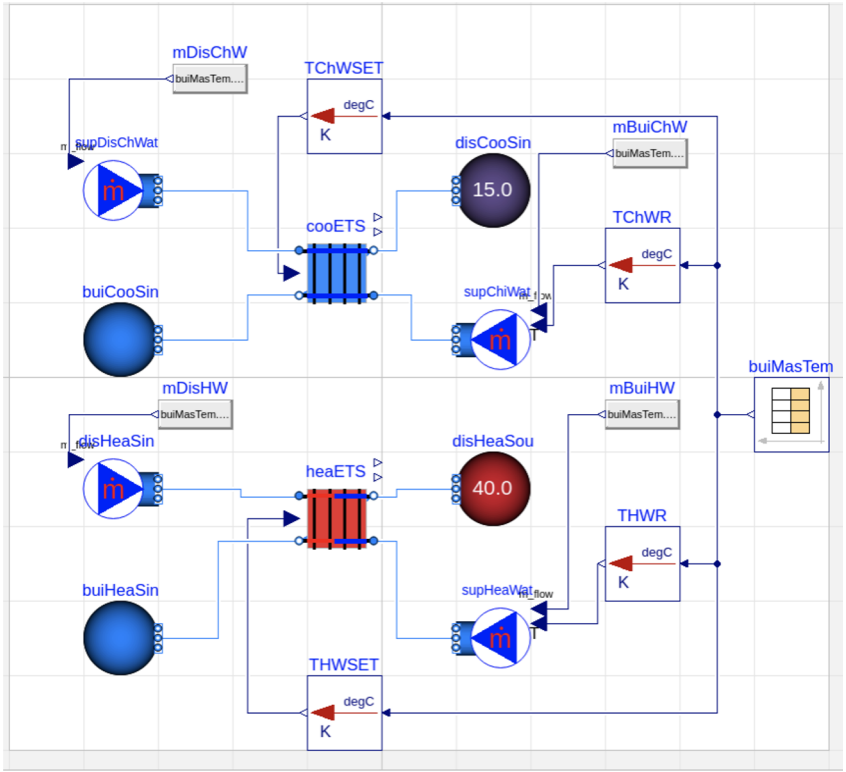
Time series load's Building connected to indirect cooling ETS and "infinite district cooling and heating sources"



Time Series: $\dot{m}$ ΔT



- OpenStudio Measure developed to export CSV file of heating and chilled waters mass flow rates, supply and return temperature.
- Connected to indirect energy transfer stations ETS.
- Infinite heating and cooling district sources.



District Level KPIs

- Ideas:
  - Overall energy consumption
  - Load met by district system
  - Occupied thermal comfort for all buildings
  - Length of district pipe
  - Installation costs / operation costs

University of Colorado Boulder

Thank you!

Anya Petersen Anya.Petersen@nrel.gov
Antoine Gautier agautier@lbl.gov
Nicholas Long, nicholas.long@nrel.gov
Ted Summer, ted@devetry.com
Wangda Zuo, wangda.zuo@colorado.edu