Simulation-Based Design and Optimization of Waste Heat Recovery Systems

WBS 2.1.0.80 (NREL) and WBS 2.1.0.81 (LBNL)
National Renewable Energy Laboratory
Lawrence Berkeley National Laboratory
10/1/2018 – 9/30/2021

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Presented by Kyle Benne

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Overview

Project Title:

Simulation-Based Design and Optimization of Waste Heat Recovery Systems

Timeline:

Project Start Date: 05/01/2018

Budget Period End Date: 9/30/2021

Project End Date: 9/30/2021

Barriers and Challenges:

- Waste heat energy sources are not evaluated in connection to potential end users, namely buildings
- District energy systems are not evaluated with integrated design tools that are able to quantify value of waste heat

AMO MYPP Connection:

- 3.1.12 Waste Heat Recovery Systems
  - Lack of end use for waste heat
  - Low temperature waste heat
- 3.1.13 Combined Heat and Power (CHP) Systems

Project Budget and Costs:

Budget	DOE Share	Cost Share	Total	Cost Share %
Overall Budget	$3,000,000	$250,000	$3,250,000	8%
Approved Budget (BP-1&2)	$3,000,000	$250,000	$3,250,000	8%
Costs as of 3/31/19	$100,000	$10,000	$110,000	10%

Project Team and Roles:

- Kyle Benne, NREL Co-PI, Project Management
- Nick Long, NREL, Software Architecture and Building Modeling
- Amy Allen, NREL, District System Optimization Methods

- Michael Wetter, LBNL, Co-PI, Project Management
- Antoine Gautier, LBNL, Technical Lead, 4th and 5th Gen Models

- Wangda Zuo, University of Colorado – Boulder, 1st and 2nd Gen Models

- Valentin Gavan, ENGIE Lab CRIGEN, Industry Feedback

- Thomas Ochtera, City of Westminster, CO, Test case

Project Objectives

- Create a **software modeling tool** that increases the utilization of **waste heat energy** sources in district energy systems, by quantifying the **value proposition to consumers and producers** of waste heat

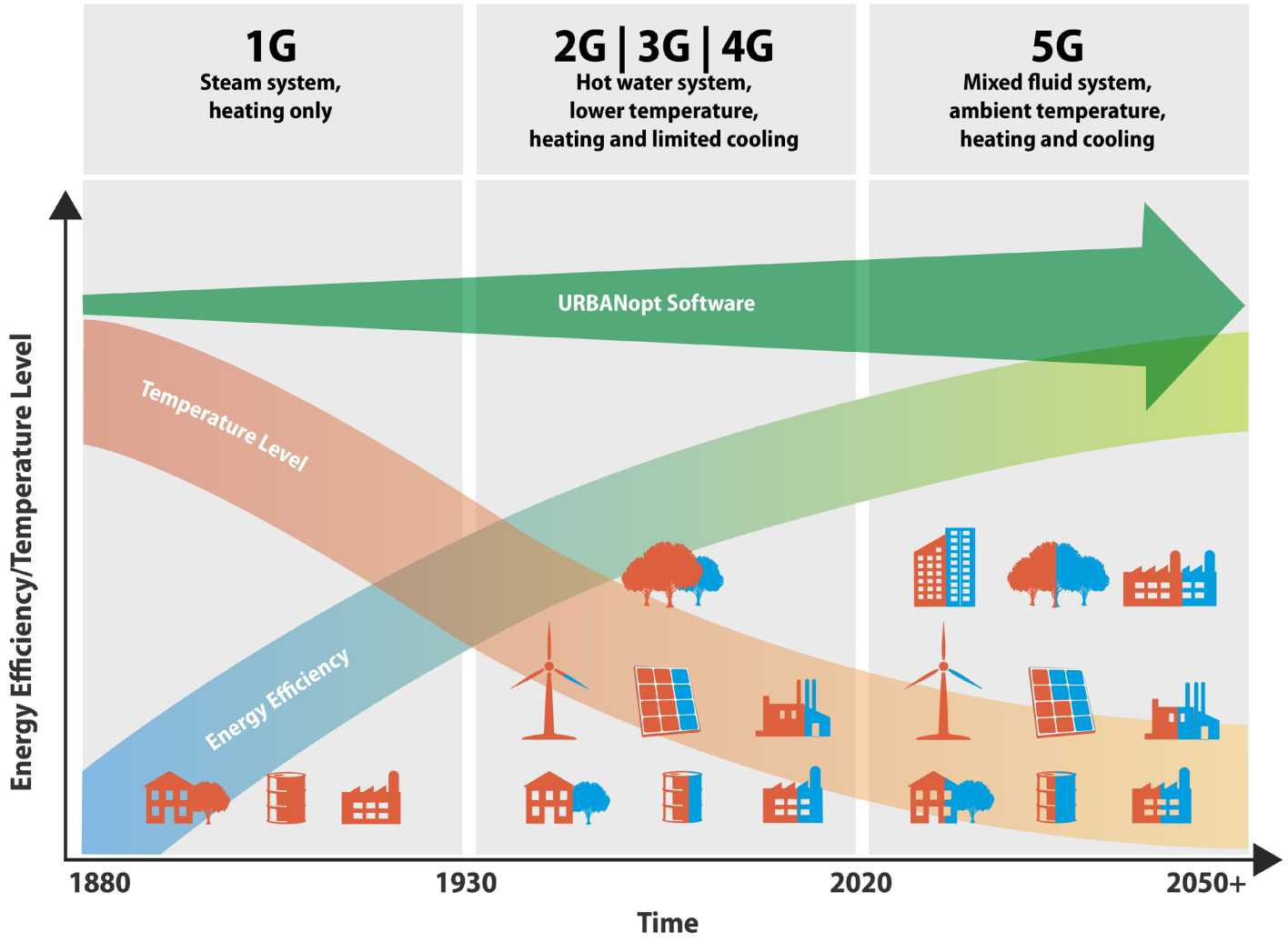
- Quantify **unrealized value** for the waste heat **producer** (Industrial Process)

- Provide **cost savings** to the waste heat **consumer** (Buildings in a district)

- Increase the overall adoption of advanced district energy systems and growing the demand for waste heat recovery

Technical Innovation - “URBANopt”

Bring analysis tools up to the “5G” challenge



Technical Innovation - Continued

- New capability to **co-simulate** buildings, thermal district, and waste heat sources together

- Enables analysis of 4th and 5th generation district thermal systems
  - Key characteristic is low or **near ambient temperature**
  - Heat pumps must move heat to match demand (buildings)
  - Energy quality (ie temperature) is important
  - Dynamics between sources and sinks is important
  - Crucial need for hydraulic and control modeling tools to support the design process and optimize controllability and scalability (phased development)
  - **Much higher potential for low quality waste heat**

- Thermal storage can be evaluated to phase shift mismatches between sources and sinks

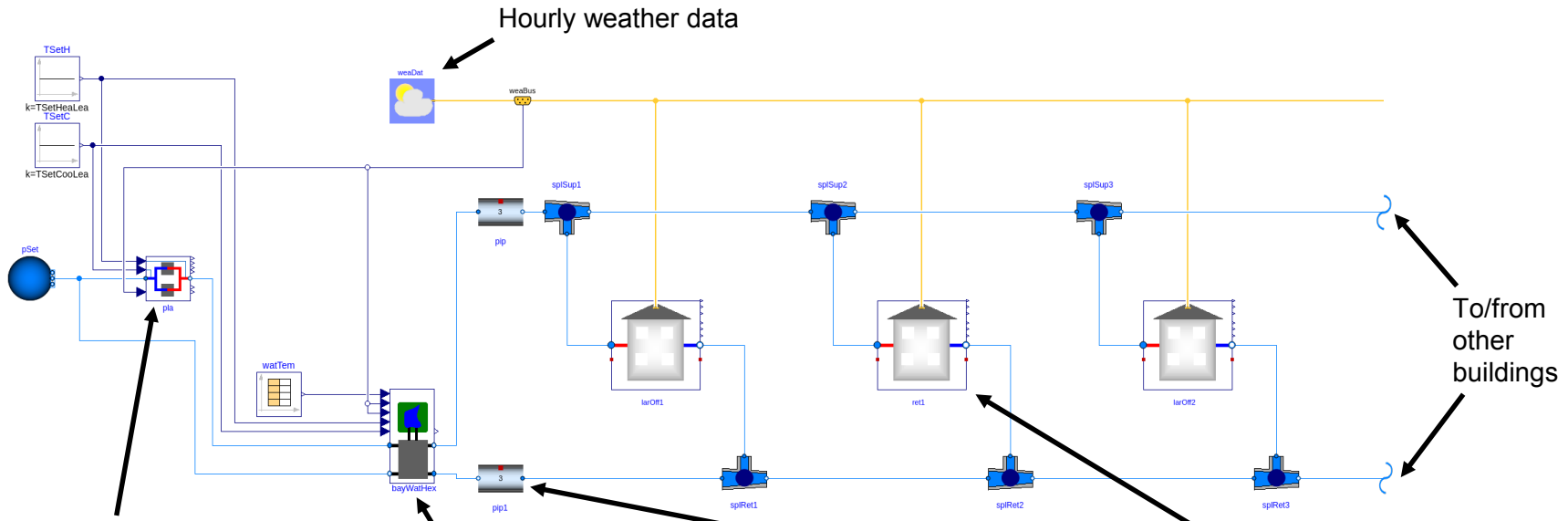
Technical Approach

- Start with existing URBANopt platform
  - Originally internal NREL research project (LDRD)
  - EnergyPlus based engine
  - Thermal loop is idealized whereas temperature levels strongly impact energy efficiency
  - Cannot represent realistic systems controls, temperature and pressure transients
  - Difficult to accurately model advanced low temp districts

- Apply next generation equation based modeling engine
  - Modelica

- Leverage key DOE investments (Actively supported by Buildings Technology Office)
  - Spawn of EnergyPlus
  - Modelica Buildings Library
  - Existing URBANopt platform

Technical Approach, Continued



System model:
Tracks temperatures and pressure anywhere in the system.
Allows for development of advanced controls within and among buildings, such as for transitive energy markets.
Seamless integration with electrical network models (AC and DC).
simulationresearch.lbl.gov/modelica

Results and Accomplishments

- Started work in FY19
- Completed first technical advisory group meeting
  - 14 industry and academic representatives so far
- Milestone 1, technical requirements and software design is complete
- Upcoming milestone in FY19 focus on developing new component models. “The building blocks of system models”
  - Energy transfer stations
  - Plant models
    - One combined heat and power
    - One heat exchanger for interfacing with waste heat sources

Technology Transition Plan