Energy Research and Development Division

FINAL PROJECT REPORT

OpenBuildingControl

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California Energy Commission

Gavin Newsom, Governor

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PREPARED BY:

Primary Authors:
Michael Wetter (MWetter@lbl.gov)[1]
Paul Ehrlich[2]
Antoine Gautier[1]
Milica Grahovac[1]
Philip Haves[1]
Jianjun Hu[1]
Kun Zhang[1]

[1]Lawrence Berkeley National Laboratory
One Cyclotron Road
Berkeley, CA 94720
Phone: 510-486-4000 | Fax: 510-486-4000
https://www.lbl.gov

[2]Building Intelligence Group
1751 SW Prospect Drive
Portland, OR 97201
Phone: 651-204-0105
https://www.buildingintelligencegroup.com

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PREPARED FOR:
California Energy Commission

Karin Perrin
Project Manager

Virginia Lew
Office Manager
ENERGY RESEARCH AND DEVELOPMENT DIVISION - Energy Efficiency

Laurie ten Hope
Deputy Director
ENERGY RESEARCH AND DEVELOPMENT DIVISION

Drew Bohan
Executive Director

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PREFACE

The California Energy Commission's Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission and distribution, and transportation.

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission to fund public investments in research to create and advance new energy solutions, foster regional innovation, and bring ideas from the lab to the marketplace. The California Energy Commission and the state's three largest investor-owned utilities — Pacific Gas and Electric Company, San Diego Gas & Electric Company, and Southern California Edison Company — were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The Energy Commission is committed to ensuring public participation in its research and development programs that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and include:

- Providing societal benefits.
- Reducing greenhouse gas emission in the electricity sector at the lowest possible cost.
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with clean, conventional electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

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All figures and tables are the work of the author(s) for this project unless otherwise cited or credited.

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ABSTRACT

Best practice control sequences are often not implemented correctly, or are not implemented at all, in large commercial buildings. This typically leads to 10-30% energy waste, along with reduced occupant productivity and unnecessary equipment wear. The current process of designing and implementing such control sequences is a manual process that starts with designers who often don't have adequate training, then requires controls programmers to interpret and program a verbose written sequence. This process has been shown to fail to deliver high performance control sequences at scale. The OpenBuildingControl project digitizes the current control delivery process. The project is developing tools for system designers to select control sequences, assess their energy performance and load flexibility potential using whole building simulation, specify the sequence for implementation using machine-to-machine translation by a control provider and formally testing the as-installed sequences by a commissioning agent. The project developed tools for each stage of this delivery process. The key innovation of the project is the development of the Control Description Language, a language that allows such a digitized control delivery process with end-to-end verification. Libraries of control sequences have been implemented using the Control Description Language, and their performance has been demonstrated using whole building energy simulation. An automated translation of such sequences to a commercial control product line has been conducted using a prototype translator. Tools for formal verification of as-installed control sequences relative to their specification have been developed and demonstrated. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) started the process of forming a committee to make this language an ASHRAE/ANSI Standard. This new standard will complement existing and emerging ASHRAE standards for building communication and semantic modeling by providing a standard for expressing the control logic - the actual brain of the building. We expect this language and the process it enables to be an important contribution to the deployment of high performance building control sequences at scale because it allows taming the complexity of the control delivery process, which is continually increasing due to the need for higher performance and increased load flexibility to meet goals for net zero energy and increased renewable integration.

Keywords: *OpenBuildingControl, commercial buildings, energy efficiency, automation, high-performance controls, description language, sequences of operation, BACnet, ASHRAE*

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