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Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Control Product Performance Evaluation and Reporting (CoPPER) Roundtable II

Report for Emerging Technologies

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Disclaimer

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Comments

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List of Acronyms and Abbreviations

BTL	BACnet Testing Laboratories
BTO	Building Technologies Office
CEC	California Energy Commission
CDL	Control Description Language
CoPPER	Control Product Performance Evaluation and Reporting
DER	distributed energy resource
DOE	U.S. Department of Energy
EERE	Office of Energy Efficiency and Renewable Energy
FDD	fault detection and diagnostics
HVAC	heating, ventilation, and air-conditioning

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1 Introduction

The Building Technologies Office (BTO) within the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) successfully facilitated an in-person roundtable discussion during the 2024 ASHRAE Annual Conference in Indianapolis, Indiana, focused on the Control Product Performance Evaluation and Reporting (CoPPER) project. This event follows up on an exploratory virtual stakeholder roundtable discussion held in August 2023, where the CoPPER project concept was introduced along with a discussion on high-priority use cases including interoperability, training and education, and control application testing and certification.

This event convened 32 subject matter experts with balanced representation from DOE, national laboratories, and industry. The roundtable followed a structured format, beginning with opening remarks from DOE leadership and presentations from CoPPER national laboratory project leaders that highlighted project objectives, proposed models for development and updates on other relevant DOE activities. Next, selected participants shared updates on related work within the ASHRAE Guideline 36 committee, the California Energy Commission (CEC), and the National Institute for Standards and Technology (NIST). A moderated open discussion then followed which provided feedback from session participants on priorities for development, technical approaches, collaboration opportunities, and recommendations.

Background

BTO engages regularly with stakeholders on innovative technologies, and barriers to using them to save energy and money. One area of interest is building controls, which promise to deliver energy savings cost-effectively and with efficient capital expense, but which often have value that is unclear or ephemeral when installed. BTO is establishing the CoPPER project to understand these barriers systematically, leveraging both in-house expertise and field data to develop processes for evaluating advanced building control strategies to validate advertised functionality and performance including energy savings, demand flexibility, and integration capabilities. If successful, CoPPER will enable transparent and unbiased assessment of control strategies and solutions that help building owners, energy managers, developers, consultants, contractors, and other industry stakeholders make informed decisions regarding the adoption and deployment of advanced control technologies. Building controls encompass a broad spectrum of technologies and building industry professionals. Previous and ongoing efforts exist to address validation and information challenges for some technologies and some professional stakeholders, but gaps remain. CoPPER does not intend to offer an alternative to those existing capabilities, but instead aims to identify scope gaps and provide new capabilities to fill them. As such, CoPPER is not envisioned to be a single comprehensive testbed, but rather a collection of capabilities.

Control Sequence Evaluation and Certification

One focus of these capabilities will be to support the delivery of standard high-performance control strategies in large commercial building heating, ventilation, and air-conditioning (HVAC) systems, where control systems play a significant role in delivering occupant comfort and energy savings. To achieve desired performance, appropriate logic must be implemented correctly, and the system must be free of high-impact faults. Recent advances to standardize best-in-class sequence logic, digitalize the control delivery process, identify and auto-correct faults, and develop sequence verification tools enable the development of test methods and software tools that will ensure desired control performance is achieved on every project. While test methods and tools can be developed for multiple points in the control delivery process, including pre- or post- project site installation, we intend to focus initially on tests to validate sequence logic is programmed correctly in control products as part of product release cycles or as part of a bidding and procurement process for new construction or retrofit, which may be self-reported by control vendors or implemented by a third-party rating body. With ASHRAE Guideline 36 sequences as a reference, we envision design and development of a testbed that enables unambiguous production of test results to this end and facilitates user access and ease-of-use. The testbed will leverage open-source software already supported by DOE's Building Technologies Office.

2 Meeting Logistics

Agenda

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CoPPER Overview	Tim Yoder
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b. Guideline 36 Committee Bench Tests	Chirag Parikh
c. Title 24 and CalNEXT	Gwelen Paliaga
d. HVAC-Cx	Michael Galler
Open Discussion	Clay Nesler (moderator)
a. Are the proposed CoPPER testbed(s) useful?	
b. How can CoPPER support/leverage other efforts?	
c. What are some key details to keep in mind?	
d. What efforts and people are we missing?	
e. Should there be regular coordination?	
Last Words of Advice	Clay Nesler (moderator)
Next Steps	Amir Roth

Participants

Name	Organization
Grace Bailey	Trane
David Blum	Lawrence Berkeley National Laboratory (LBNL)
Tony Bruno	Trane
Jayson Bursill	Delta Controls
Yan Chen	Pacific Northwest National Laboratory (PNNL)
Jim Coogan	Siemens
Kelly Cramm	Henderson Engineers
Scott Duncan	Georgia Tech
Paul Ehrlich	Building Intelligence Group
Brandon Elliott	Henderson Engineers
Natascha Milesi-Ferretti	NIST
Michael Galler	NIST
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Name	Organization
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Joshua Turk	NAVFAC
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3 Roundtable Introduction

Amir Roth (DOE-BTO) welcomed the participants, who introduced themselves and their organizational affiliations.

CoPPER Project Overview

Tim Yoder (PNNL) provided a brief overview of the CoPPER project to the roundtable participants.

- The CoPPER project aims to develop processes for evaluating advanced building control strategies to validate performance expectations as claimed, such as energy savings, demand flexibility, grid reliability, and integration capabilities.
- The overall objective is to validate control system performance in a range of different scopes and domains, including embedded/supervisory controls and grid interactivity, through a transparent process and tools giving building owners reasonable confidence that the product they are purchasing meets its performance claims.
- Another objective is to provide product manufacturers and application developers that are implementing these control strategies with open-source software and tools so they do not have to develop their own individual testbeds from scratch.
- DOE recognizes that there are a lot of existing capabilities in some of these areas, and we are not trying to supersede any of them. The intent is to fill in gaps where they exist and work collaboratively with others engaged in related efforts instead of creating redundant or competing testbeds.
- The first year's efforts have mainly focused on planning for the initial phase of the project. The initial priority is performance validation for both control functionality and connectivity. Building system and device integration and interoperability is a considerable challenge in advanced controls and a focus for this project.
- Scalability and standardization are additional areas of focus, and we want to make sure the testbed is applicable to more than one type of building, HVAC application, and control system architecture and can support standards development and product certification.
- For this first year, we have settled on three main focus areas: ASHRAE Guideline 36 advanced control sequences, demand flexibility control strategies, and distributed energy resource (DER) integration with building-grid integrated controls. We are working with the DOE Connected Communities project on the last two areas and using ASHRAE Guideline 36 as the proxy for best-in-class control strategies for the first area.

ASHRAE Guideline 36 Support

David Blum (LBNL) provided an overview of ASHRAE Guideline 36 support from DOE including CoPPER development.

- DOE is supporting ASHRAE Guideline 36 development in a variety of ways in addition to the CoPPER project. There is separately funded DOE support to pilot new control sequence development for electrification, decarbonization, and grid responsiveness. This includes heat pump sequence development as well as prioritizing the control sequences in Guideline 36 based on the 80/20 principle, which is trying to determine the 20% of the guideline that provides 80% of the savings.
- Another area is establishing a more streamlined development and deployment process for new sequence development, which would include modeling and simulation of the control strategy and controlled

process to really speed up testing and complete a more quantitative analysis of the sequences before being field tested and deployed.

- The final area is to coordinate collaboration with other Guideline 36 related efforts that are ongoing within the labs, industry, and other institutions to make sure that there is limited duplication and that everyone is working towards the same goal.

- There has been previous work related to control application testbeds that was funded by the CEC as well as ongoing relevant BTO work that DOE can leverage to accomplish what we are planning for CoPPER.

Proposed Testing Functionality

David Blum (LBNL) described different types of tests that could potentially be incorporated into the CoPPER testbed.

- The first test is **system readiness**, which is essentially a checklist to make sure that the desired control sequence and the HVAC system are compatible with each other and that the required infrastructure, like sensing and actuation, is in the HVAC system to implement the control sequence.

- The next test is **performance verification**. In this test, the user evaluates whether the control sequence logic meets or exceeds performance objectives. This test would verify that the control sequence saves energy and provides adequate comfort, as well as other performance objectives, when applied to a given HVAC system.

- Another test is **product verification** testing, where the control logic is deployed in actual field controllers or in the cloud to verify that the control logic is programmed correctly in the product. All of these tests could be completed before the controls are physically installed in an actual project in the field.

- After installation of the controller hardware and application software in the field, a **fault identification and correction** test could be implemented to verify that the control and HVAC systems are free of faults that would prevent proper operation. This type of test is similar to functional performance testing and may involve recording and analyzing system measurements over a period of time. This functionality is sometimes implemented using fault detection and diagnostics (FDD) analytics software which communicates with the building control system.

- While the goal of the CoPPER project is to create tools and processes to support all of these testing needs, the initial focus will be on product verification and making sure that standard control sequences are coded correctly on commercial products, whether they be in equipment controllers, programmable field controllers, the cloud, or other software platforms.

- Note that successful product verification testing does not necessarily assure performance verification, as the control logic may not deliver the desired energy savings or thermal comfort for certain HVAC system configurations.

Previous Related Project Work

DOE laboratory personnel described examples of related project work funded by various sources.

- There has been some previous testbed development work funded by the CEC under what was called the Best-in-Class project. Taylor Engineers led that project and TRC was also involved. This work was done at LBNL and involved the development of a prototype ASHRAE Guideline 36 conformance test, where Guideline 36 applications could be loaded on a manufacturer's controller and then communicate through BACnet to a program running on a laptop which reads and writes data to control points. The prototype uses a test sheet written by an expert developer that encodes what control system outputs are expected for given control system inputs.

- **Spawn** (of EnergyPlus) is a new whole-building simulation engine that allows users to implement and execute explicit control sequence logic in closed loop simulation with high- fidelity HVAC system models. Because Spawn models HVAC in a dynamic and physically realistic way, the logic to control the system can also be written in a physically realistic way; the same control logic that Spawn reads and executes can be taken and used on a physical controller in the field. Spawn is the only simulation engine that can correctly simulate physically realistic, state-based control logic, a capability it has by virtue of its use of the Modelica modeling and simulation language.

- We also have the **OpenBuildingControl** project, which led to the development of ASHRAE Standard 231P. This project provides the ability to represent control sequence logic in a standard digital format, or Control Description Language (CDL), which allows control strategies to be implemented and tested on a computer and then digitally archived. These generic strategies can then be digitally translated into commercial control products and their proprietary programming methods.

- There is also a **Building Control Product Funnel Tool**, which is relatively simple and quantifies the error between a reference test case and system operational time series data in order to validate similarity in functional performance.

- Finally, there is the **Constrain Tool**, which verifies proper control functionality based on time series data collected from a real or simulated building using an expert-based knowledge framework.

- One critical consideration for any testing tool is that the building controls community first needs to verify that a reference implementation is correct. The reference implementation(s) need to consider specific subsequences and a range of HVAC system configurations. They also need to define unambiguous acceptance criteria and address other practical implementation issues as well.

Project Timeline

DOE laboratory personnel provided an overview of the CoPPER project timeline for the next two years.

- The CoPPER project timeline includes refining the project requirements, identifying development needs, and defining the software architecture during summer 2024. A basic testbed implementation would be completed by the end of summer, allowing preliminary user testing in the fall and winter. Testbed capabilities including additional user testing would be refined and expanded through the summer of 2025.

4 Summary of the Discussion

After the presentations by national laboratory staff, Clay Nesler (The Nesler Group) led a discussion among meeting participants starting with questions and answers related to the presentation content.

> Q: How will control manufacturers, who all have their own application libraries unique to their own products, use these tools? You said you're testing through the BACnet protocol. Are you going to just take the input and output? What about intermediate variables? How have you written those input and output points to your platform?
>
> A: The manufacturer's application libraries are basically a black box to the testbed. There would be some point mapping where the manufacturer's control system would have to be aware of what points are coming out of the testbed, which we could make available through documentation or potentially semantic models. CDL is just used as the reference implementation.
>
> Q: What if a control manufacturer claims their commercial implementation is truer to the guideline's intent than the reference implementation?
>
> A: There would have to be an industry consensus on what is correct or not. Installed system performance is very dependent on how you tune specific parameters in the control logic. You can still technically pass the test even though you're using slightly different parameters.
>
> Q: There's an assumption that all of the major control manufacturers have something that looks like this that they use to test their strategies internally.
>
> A: It is correct that most manufacturers have something that looks like the proposed CoPPER testbed at a block diagram level, but they're all different. One of the proposed use cases for CoPPER is for use in the certification of a manufacturer's controller (or application library) in which case the testbed implementation platform would need to meet specific required functional requirements.

After participant questions and answers, Clay Nesler led a group discussion among meeting participants about the CoPPER project objectives and overall approach.

- Does the market want something like that, so that an independent body validates, based on industry consensus and agreement?
- As I mentioned in the public review, when we get the reference sequence implementation written in Modelica, and I try to compare it with what an application engineer is actually programming, it's a completely different language. I've consistently run into issues where the R&D technology world is not speaking the same language that the control application folks speak. We need a clearer description of exactly what their control implementation is going to be tested against.
- I can almost guarantee that you don't have anywhere near the required consensus having reviewed the CDL implementation. There are probably only two people that understand how Guideline 36 works both in the product and in the simulation. The user shouldn't need to understand Modelica modeling language, they just need to understand the control sequence. I think the most important thing is that it's as close as possible to what's actually in the field as the manufacturer implementation.
- There are things in the guideline that aren't very good. There's stuff in there that that isn't necessarily the best way to do things and people would agree that some approaches are better, and others are worse. Manufacturers are going to do things slightly different sometimes because of their system architecture or because they want to handle the alarms differently than the guideline specifies. It's going to be really important that there is collaboration in the test planning because we expect to see differences from the

reference case for many reasons and it will be important for everyone to agree in principle that the test meets the intent of the Guideline.

- I think it's going to be really tricky for the California energy codes, that we know are coming in a year or so, to use Guideline 36 for compliance because it is written like any guideline document, which is interpretable, but not enforceable.

- One of the things we did in developing the guideline was to step back and say what was important that we were going to test. Then we created the concept of performance classes and functional groups, and then we created a test for each of those, and we need to do the same thing here. As an example, maybe a dual max VAV sequence is pretty straightforward and easy to test. Everybody should be able to produce the same chart at the end of the day. But maybe we won't agree on the way alarming is done. Maybe that's not part of the test, but we need to have a digital representation with the core requirements and then maybe include optional elements beyond that. There is work that needs to be done here.

- But the current version of the guideline is not completely correct yet. Nobody is implementing it correctly. We're trying to approach it like software engineering, where you do unit testing of one functional block at a time and when you comply with every single little piece, then you pass overall. Maybe they are mandatory tests where you have to pass all parts of the sequence. But if you handle alarms differently, you might get a warning flag or something but don't fail the overall test.

- How do you envision users being able to develop their own program based off the testbed results? I would say that you should get more information than just a pass/fail grade. You should get, for example, a time series of your outputs versus the reference outputs that would allow you to do some debugging to determine why it failed.

- I would envision that there's one giant Guideline 36 test. It would test the subsequences that you're implementing and confirm that the supply air temperature reset responds as we expect it to.

- How do you envision parsing the guideline into unit tests? There are challenges that we are having in the Guideline 36 committee in the testing working group that are working on those scopes. There are a lot of different ways to do it and more work to be done.

Paul Ehrlich (Building Intelligence Group) shared an overview of relevant activities of the ASHRAE Guideline 36 committee.

- The Guideline 36 committee recognizes that control sequence testing and validation is a big issue and an ongoing challenge. Jim Coogan has organized a task group focused on this topic. The task group has a model that looks similar to the DOE model, with slightly different numbers and classifications. It is focused on both bench testing (product) and application testing (field/project).

- The committee recognizes that there are multiple tiers of testing needed. We're starting a Guideline 36 activity within the OpenBuildingControl project to start building control sequences and testing them simultaneously. If somebody creates a factory application, is there a way to test it and make sure that the sequence works the way it's intended? Also, what are the test procedures that we need to commission an actual project in the field?

- Actual projects don't really look like Guideline 36. They start with Guideline 36, but they reflect the actual control sequence specific from the engineer of records for that project. We've been taking some manufacturer's testing procedures and found the testing to be really difficult. Some things didn't quite work the same and we had to simplify all the PID loops. We're finding it's not as easy as we first thought. We've recognized from this effort that there are a lot of elements involved in testing and a lot of additional pieces that we need. We could really use help in that area.

Chirag Parikh (Carrier/Automated Logic) talked about the task group's thoughts about bench testing control sequences.

- With "trim and respond" or "dual max airflow" sequences, if you are able to override certain sensing and control points — like the feedback of the airflow — you don't really need to have the control hardware for a bench test. We identified 10 or 12 features that can be tested in this manner.

- There are various views on how much detail is required in bench testing. Is the focus on major functional sequences, or does it include verification of every minor five-minute delay?

- But there were certain sections in the guideline where you would absolutely need control hardware, or potentially an air handling unit, because experience has shown that sometimes a program works great on a test bench but not on the actual job site.

- If manufacturers someday have to certify that their control application libraries comply with Guideline 36, we need to have some virtual/hybrid dynamic testing approach, because not every manufacturer or programmer will have access to mechanical equipment for testing.

Gwelen Paliaga (TRC) provided an overview of the current California building code change proposal and the state's emerging technology programs.

- For the 2025 energy code in the state of California, the CEC is proposing four major controls requirements based on Guideline 36 including temperature reset, static pressure reset, dual max zone logic, and economizer control. These four requirements seek to deliver 80% of the impact for 20% of the cost/effort and have been included in model building codes for 10 to 20 years. The CEC will require online reporting that vendors have self-certified that their factory application library is compliant with Guideline 36.

- One of the more challenging parts of that process has been defining what self-certification means. Ideally there would be a third-party certification based on a standard functional test. But without that, the proposal is that the vendors would self-certify in good faith.

- There is an emerging technology program in California that is administered through the utilities and some third parties. The program has recently approved funding for a project to scope a standard method of test for third-party validation of Guideline 36 sequences, and particularly to support the energy code change program. TRC, Taylor Engineers, and Eubanks Engineering Research have all received initial funding for this project.

- In some ways, the scope of the emerging technologies project is trying to meet the same goals as the CoPPER project. The current idea is to draft a standard method of test that ASHRAE might adopt. This project is just starting, but the plan is to collaborate with the Guideline 36 subcommittee and other efforts, including DOE and NIST activities, so the timing for this roundtable is perfect.

Michael Galler (NIST) provided an overview of NIST's functional performance test module and Guideline 36 related testing.

- The Functional Performance Test Module (FPTM) tool has been used to exercise specific portions of the Guideline 36 sequences in hardware in our lab. The Virtual Cybernetic Building Testbed (VCBT) includes physical building controllers with Guideline 36 compliant sequences loaded in them. The FPTM tool includes a series of building models that allow the real-time control of building systems and equipment that are actually installed in buildings.

- The FPTM tool has been integrated with HVAC-Cx, a commissioning assistance tool. The tools are open source, and under continuous development, but don't include any Guideline 36 specific functionality at this point.

- For California we are implementing specific tests in the FPTM that exercises the controllers to identify performance exceptions. We will extend the functionality as needed to meet their needs.

Clay Nesler then moderated an open discussion among the participants using the following prompts: 1) Is this activity mainly something for manufacturers, code regulators, and/or consulting engineers? 2) What efforts and people are we missing in this discussion? 3) Who else should we engage with and how should we coordinate these various activities? and 4) What are some key technical details to keep in mind during the development?

- Whatever tool gets created, the biggest thing for me is actual support, human support. The things necessary to make this useful for the folks that do this for a living are human support, training, user guides, a lab to test your products, or the ability to recreate the tool in your factory or R&D center.

- The tool needs to be open-source and capable of being integrated into GitHub pipelines and workflows.

- There are two different paths for certifications: self-certification, where you perform a test on your desktop, and then lab certification. One question for designers and code people is whether both options are viable or whether we want one or the other?

- Should we be thinking about moving the efforts that are reflected in Guideline 36 from an ASHRAE guideline to an ASHRAE standard as we move forward by defining the method of test and certification? Those are fundamental questions, not necessarily technical, that are fundamental based on how we view what's needed for performance verification and validations.

- I could see where there are portions of Guideline 36 — the 80/20 impact areas — where a validated set of sequences for use in policy and programs based on a standard could be helpful. That way a standard test could be referenced in the code and used as the basis for compliance and then leave Guideline 36 to expand in scope to address different applications.

- Do we have a way to think about what the market need is and what the minimum performance requirements are for options A, B, and C, and then leave the higher performance options to Guideline 36? We do this now in Standard 90.1 and 189.1, and also now with Standard 90.2. There are lots of examples where there's a stretch version with advanced sequences of operation versus a minimum sequence of operation.

- Does anybody have any thoughts on the use of a test lab versus self-testing? Is the intent that this will be developed and handed off to a BTL-type organization? Is DOE potentially willing to fund a group that would do this testing, or would this be a self-funded BACnet type of organization? This might be a question for five years from now.

- The approach that LonMark International used was the self-test using a desktop certification. Both approaches have been used in the past and they have different requirements. For specifying engineers to benefit, it would be nice to have a laboratory and a sticker from third-party certification that I could specify and then come to the site and see the sticker on the controller.

- I'm happy that we're aiming for self-certification. I can see that things could go beyond that, but self-certification is what we're aiming for in California a year from now. There is nothing that would keep you from being able to run a bench test on your desk and then submit to a testing lab for certification.

- We are hearing from this small group here that owners would likely prefer certification organizations versus vendor self-certification. Manufacturers will generally prefer self-certification due to the overhead

involved in laboratory testing. Perhaps we need a hybrid option, where we're building a standard testbed that could be run by a manufacturer and they're the ones doing the actual testing.

- So going back to California Title 24, a number of years ago there was an added requirement for economizer diagnostics. The manufacturers self-certified, but there was a prescriptive functional test process and reporting that's included in the appendix of the code. I find that fairly stringent and transparent and sufficient for the California market, which was the intention of the Guideline 36 references. The manufacturer is running the tool and being able to get the checkmark. This is a lot better than where we're at now and it would satisfy both parties. Manufacturers need minimum requirements for a test procedure and a standard method of test so they can self-certify.

- Parts of Guideline 36 have notes on performance expectations but are less prescriptive in nature. How is that going to be handled, as most certification procedures have been quite prescriptive?

- What happens when somebody develops something that performs better than Guideline 36 from an energy perspective? This initial CoPPER effort is focused on compliance with Guideline 36, but we're hoping to eventually do the performance piece as well. This could include a baseline best in class or minimum performance and then a best-in-class benchmark.

- An actual field test is likely more important than the product testbed evaluation. For a new product design, the testbed system represents control of a well-functioning HVAC system. In reality, many or most control projects involve old systems. You have to do a lot of modifications to accommodate different levels of system configuration, performance, and instrumentation. The system verification testing in the field needs to be a critical element of this process.

- There's a huge distinction between new construction projects with new controls built from the ground up versus improving existing legacy systems. With new controls, you can load control sequences in the factory, make sure the system works, and install it in the building and have it be 95% of the way there. In existing buildings with limited legacy systems, it's the final verification step that has to happen which is in the testing gray area. I highly recommend distinguishing between existing building retrofit with legacy limitations versus new construction when developing test approaches.

Last Words of Advice

In closing, Clay Nesler thanked the participants for their active participation and asked them to share "one last word of advice" (in the form of a short post) to the DOE team and other participants so that the research team can collectively have the greatest impact in the shortest time.

- I would add simplicity — simple start, simple to use, simple to apply are some good priorities.

- When you are developing a test procedure, start with a simple question that the test is supposed to answer rather than defining a process or procedure.

- Most organizations are going to be doing these tests once or twice a year — not very often.

- Be very specific about what is being tested and what is being verified.

- I think we miss something if CoPPER, and some of the other activities we talked about today, aren't coordinated. I think there's some great work being done.

- I don't think that that these initiatives and self-certification have to be mutually exclusive. I think that some of this testing, these tools if they're done properly, could be used by a manufacturer and used for self-certification to get that check. I don't think they have to be looked at as exclusive, alternate paths.

- This is amazing what you guys are working on — it's going to work well. Sharing it with manufacturers can help them do their own self certification and third-party certification is important as well.
- Manufacturers say their systems work in all the buildings. Can these tools be accessible to commissioning agents too, as they are the ones that have to customize the sequences for individual buildings?
- Use the testbed to verify if Guideline 36 is actually the gold standard or if we need to make some modifications. We can't assume that just because someone implements Guideline 36, that every system they install works great in the field. This could provide a lot of feedback to the Guideline 36 community and identify areas for improvement.
- Think about building operators (e.g., training) when developing the platform.
- Distinguish between new construction and existing buildings when defining test requirements.
- Demonstrate concrete examples and success stories to drive adoption and use.
- Incorporate the NIST tool somehow.
- Share the tools and platform with manufacturers, third parties, and commissioning agents early in the development process.
- Fail-fast with early prototypes and stakeholder feedback.

Next Steps

DOE leadership thanked the participants for participating in the roundtable session and committed to publish a summary report on the DOE BTO controls website. They noted that additional stakeholder roundtables are planned over the coming year along with the publication of the Energy Management and Control Systems Research and Development Opportunities (EMCS RDO) report.

5 Presentation Slides

CoPPER Support for Testing ASHRAE Guideline 36

DOE Stakeholder Roundtable

ASHRAE Annual Conference
Indianapolis, IN

June 25, 2024

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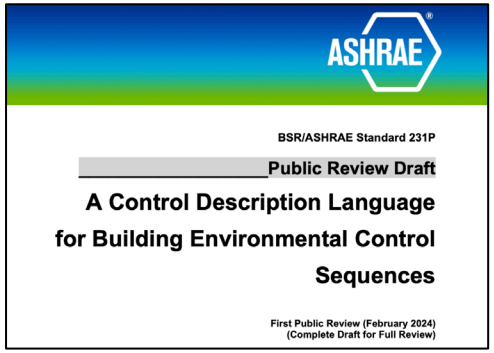
Near-term Focus – Product Verification Testing

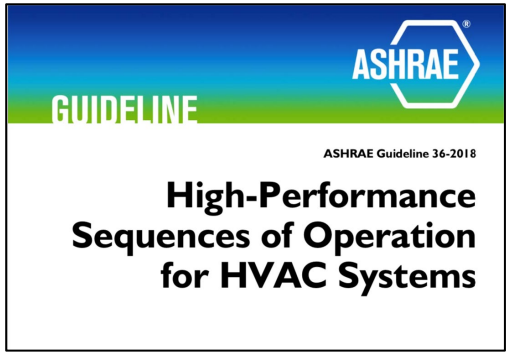
Long-term Goal: Create tools and processes to support all testing needs

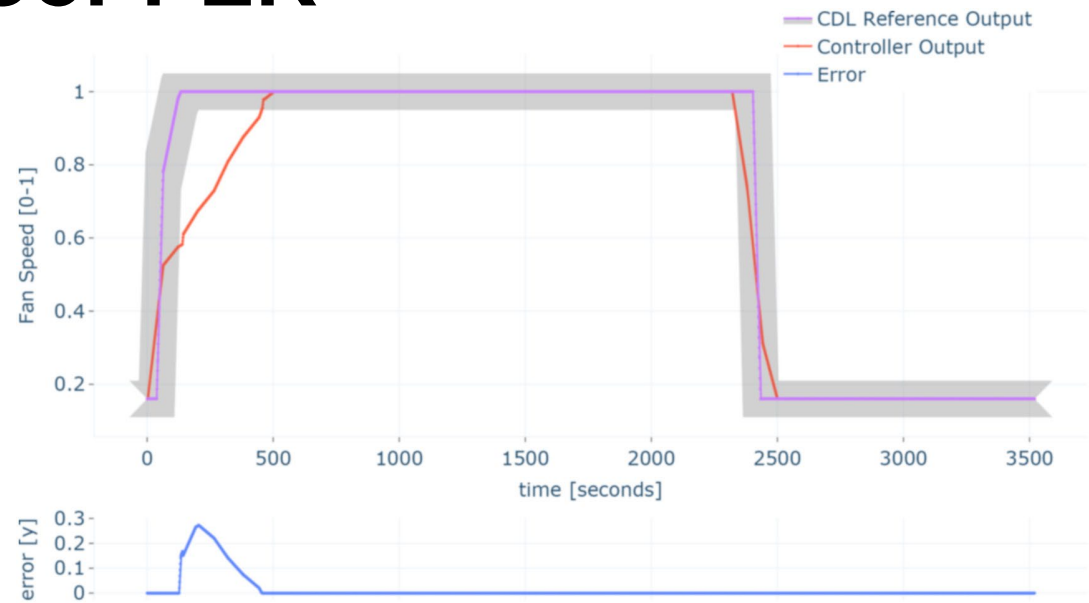
Test No.	Test Name	Project Installation	Expected Result
0	System Readiness	Pre	Control sequence, HVAC system, and infrastructure are appropriate.
1	Performance Verification	Pre	Control sequence logic meets or exceeds performance objectives.
2	Product Verification	Pre	Control sequences are coded correctly on deployment products.
3	Fault ID and Correction	Post	Control and HVAC systems are free of faults that would prevent their operation as intended.
4	Operational Verification	Post	Control and HVAC systems are operating as intended and meeting performance objectives.

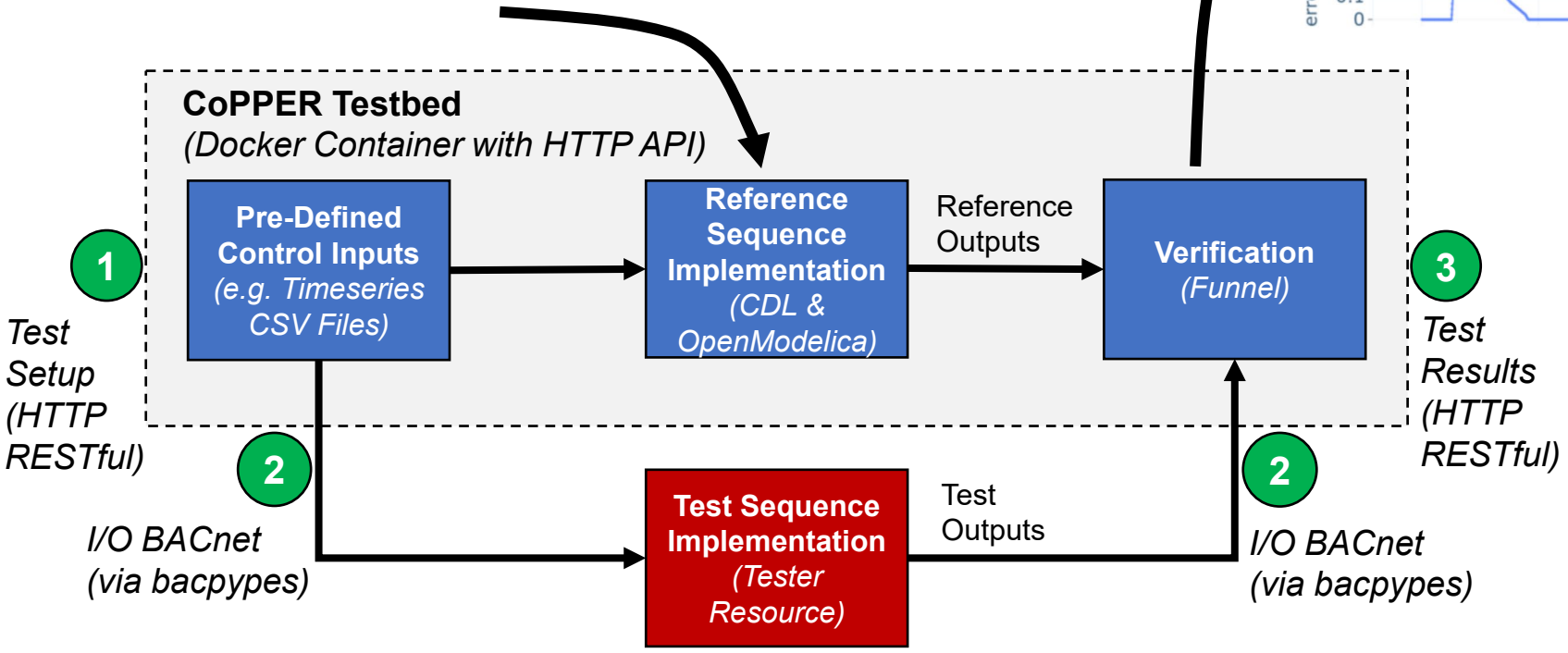
Envisioned Tool Development in CoPPER

Product Verification ("Test 2")









Key Features:

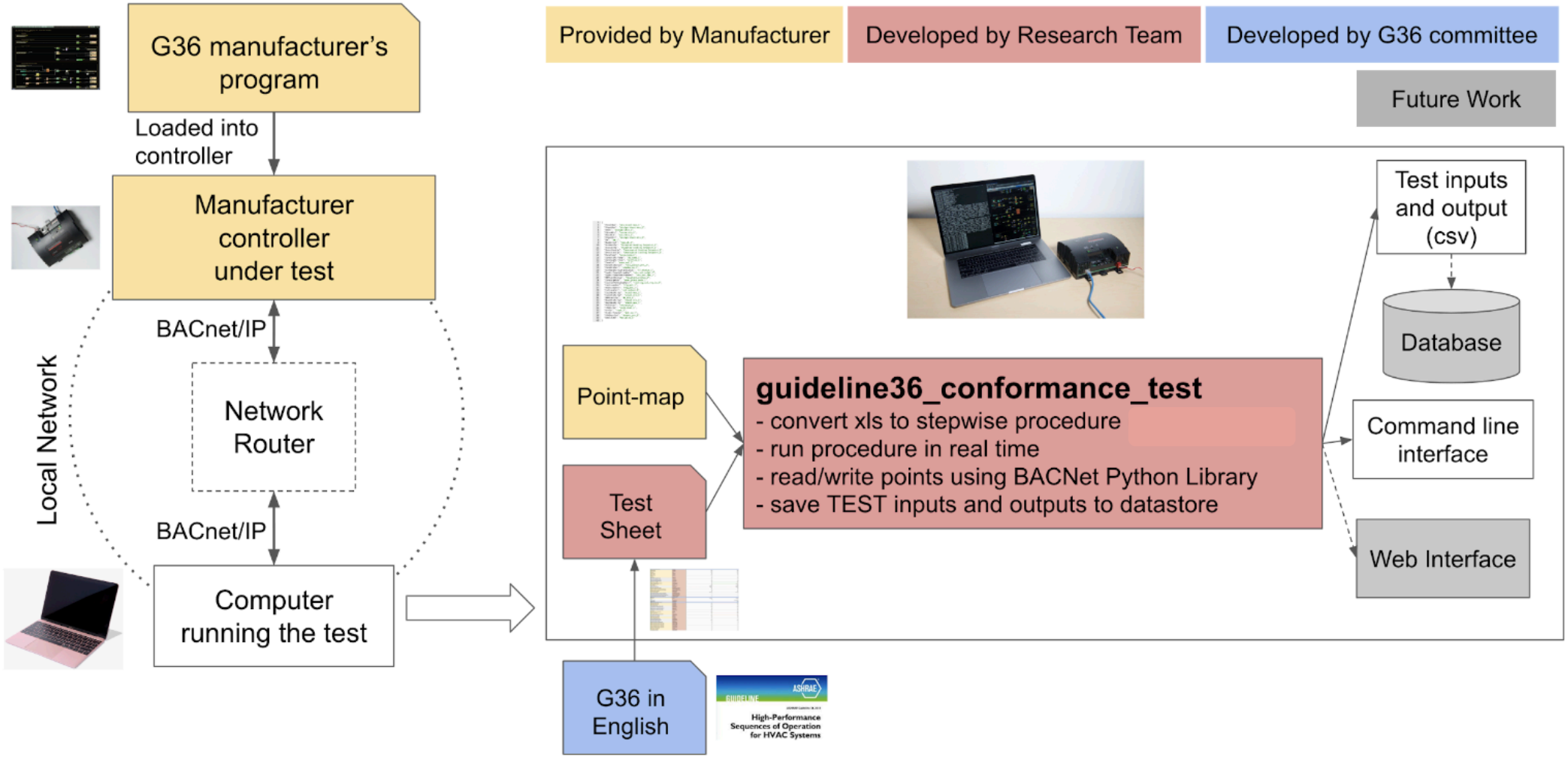
- Reference implementation in 231p
- Configurable reference sequences on runtime
- Transparent and sustainable maintenance
- Rapidly deployable cross-platform or as web-service

Needing Attention:

- Verifying reference implementation
- Scoping tests for sub-sequences and specific system configurations
- Defining acceptance criteria

Previous CEC Work in “Best-In-Class” Project

Prototype ASHRAE Guideline 36 Conformance Test from LBNL



From Pritoni et al. 2020 at https://escholarship.org/uc/item/30k5m6s1 and see open-source code on GitHub at https://github.com/LBNL-ETA/guideline36_conformance_test

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