

ET Summit 2024

Presented by



Heat Pump Performance in California:

EnergyPlus Modeling Development



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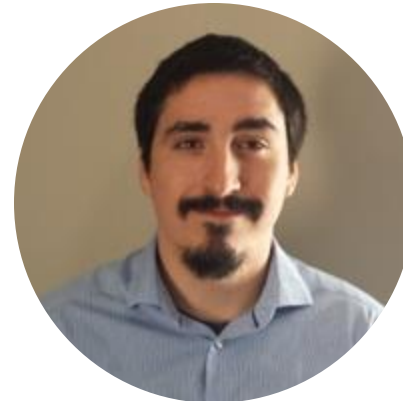


Project Collaborators

ICF



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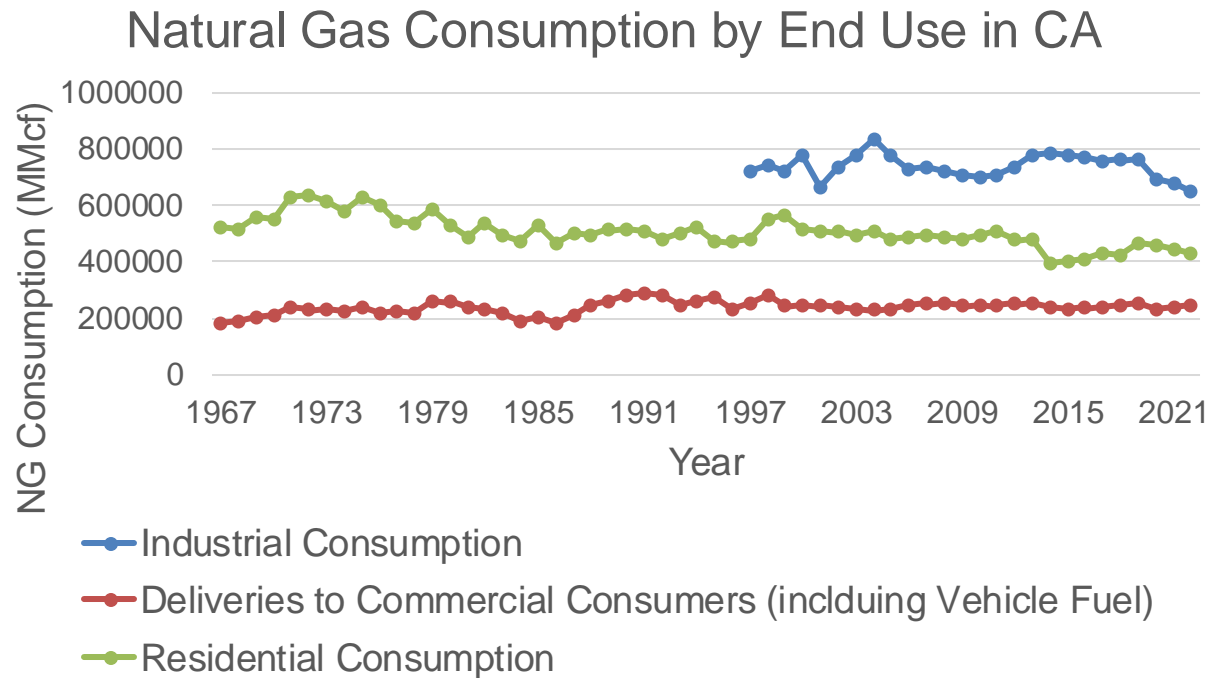
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Principal Research Engineer

Agenda

- Gas Absorption Heat Pumps (GAHP)
- Experimental Data Overview
 - Steady State & Load-Based Performance Data
- EnergyPlus Background
- Modeling Performance Curve Development
- Modeling Tool Enhancement
 - ResStock
- Next Steps

California on Emissions Control

- Water heating is the largest end-use of natural gas in California



California Bills & Legislation
SB 1477 (Building Decarbonization/Space Heating/Water Heating)
California Long Term EE Strategic Plan (CLTEESP)
AB 758 (Comprehensive EE in Existing Buildings Law)

- Focus sector: Multifamily (commercial) low-rise (5 stories or less)

US Energy Information Administration. "Natural Gas Consumption by End Use." https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SCA_a.htm

Objectives

- Improve low uptake at the **sector** level
 - Primarily as it relates to the **commercial** sector
- Improve low uptake at the **technology** level
- **Integrate technology performance** based on controlled (laboratory) data
 - Equipment commissioning
 - Steady state evaluation
 - Load Based (Transient) evaluation
- Develop **performance mapping** curves
- Contribute to **EnergyPlus modeling data**



Target Conditions

- Robur GAHP-A system

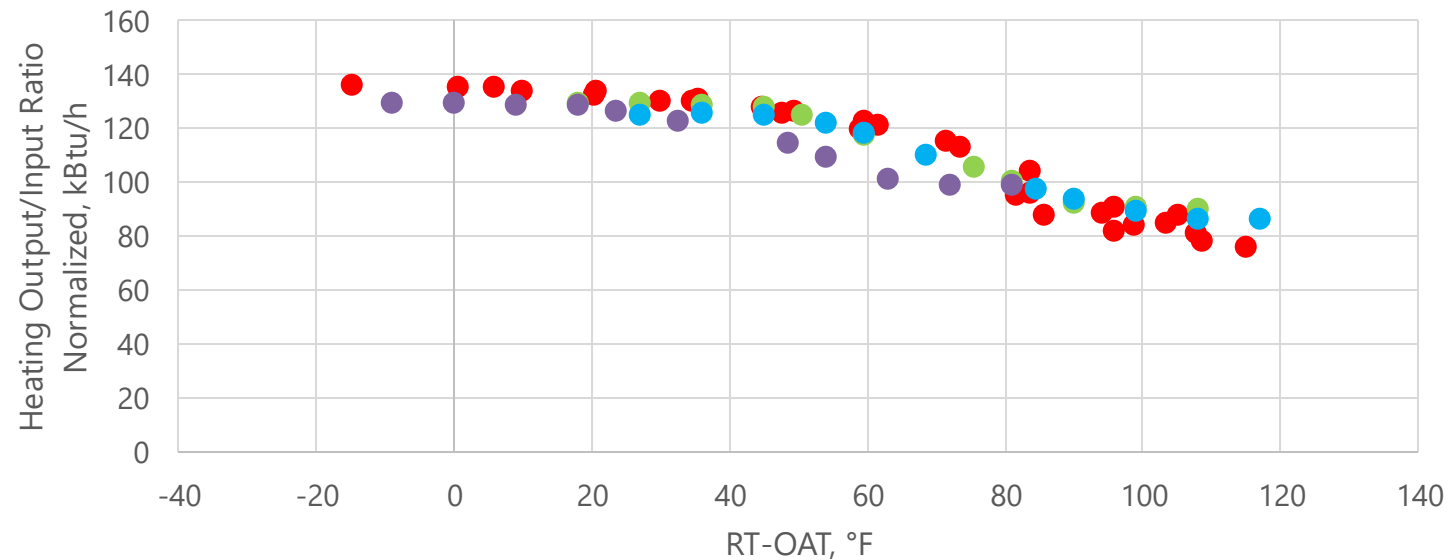


Variable	Testing Range	Number of Points within Testing Range
Flow Rate [GPM]	13.6 GPM & 7.0 GPM	2
Outside Air Temperature (OAT) [°F]	0°F-110°F	10
Return Temperature (RT) [°F]	95°F-120°F	3
Propylene Glycol [vol%]	35 vol%	1
ON Runtime [hr.]	0.1-0.9 hr.	6
OFF Time [hr.]	0.2-1.0 hr.	3

Robur. "Installation, use and maintenance manual" (2020).

Steady State Performance Mapping

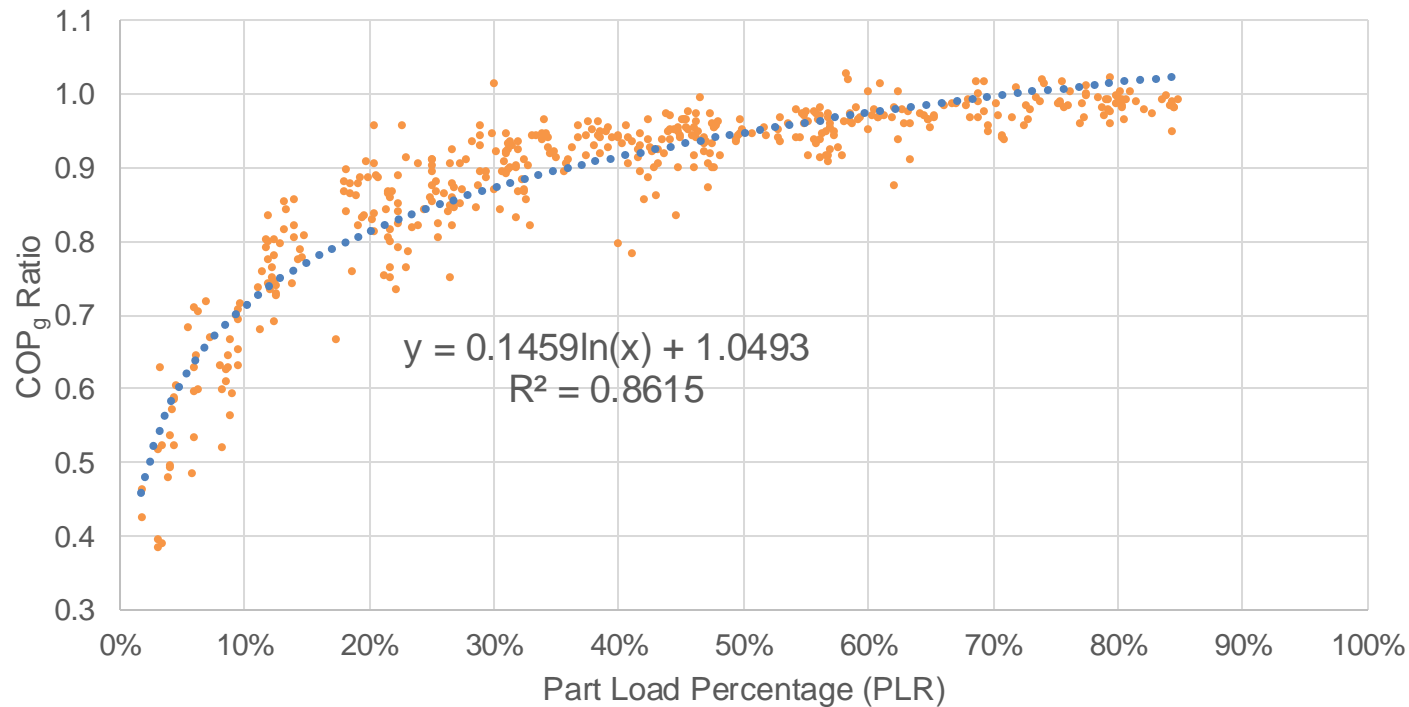
- Manufacturer's data [blue, purple, green dots] compared against experimental data [red dot] shows close alignment
 - Sufficient for part load analysis as “capacity” of unit



● Heating Output/Input Ratio @ 13.6 gpm ● MFR: 113 °F SWT | 18 °F dT | 35% PG
● MFR: 122 °F SWT | 18 °F dT | 35% PG ● MFR: 86 °F SWT | 18 °F dT | 35% PG

Load-Based Performance Mapping

- Gas only COP as a function of Part Load Percentage (PLR)
 - Based on experimental steady state (capacity) data & part load data
- Predictions of GAHP performance based on logarithmic curve



EnergyPlus Background

- Developed originally off...
 1. BLAST (Building Loads Analysis and System Thermodynamics) (released late 1970s)
 2. DOE-2 (released early 1980s)
- Born out of concerns driven by the energy crisis
- Recognition that building energy consumption is a major component of the American energy usage statistics



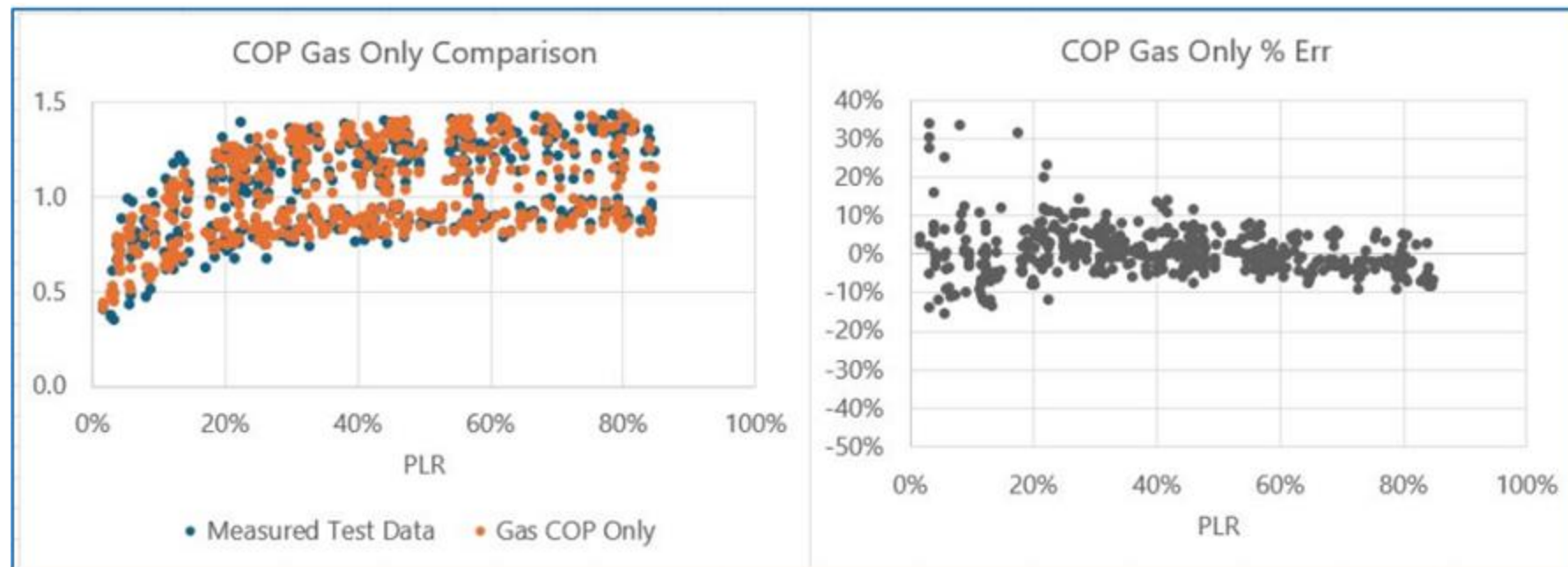
EnergyPlus Modeling Integration

- Objective: forecast...
 - (1) Energy Consumption
 - (2) Utility Bills
 - (3) Greenhouse Gas Emissions
- Targeted audience:
 - (1) California Policymakers
 - (2) Program Designers
 - (3) Software Developers
 - (4) Manufacturers



Modeling Development

- EnergyPlus modeling parameters developed and plotted with experimental data
 - Modeling parameters can be predicted within $\pm 5\%$
- Overall modeling accuracy of COP (Gas Only) is approximately $\pm 6\%$



Guada, Alejandro; Van Dixhorn, Lee; Fridlyand, Alex; Katz, Ari. "Robur GAHP A Performance Mapping." GTI Energy, 2023.

Modeling Tool Enhancement

- Using ResStock to model GAHPs installed in multifamily buildings for central WH and combi applications.
- Developing a new workflow to combine individual unit models into a multifamily building and then plumbing layout for the whole building.
- Need a generic sizing algorithm for the number of heat pumps and storage tanks depending on building size, application, and climate zone
- Discovered a bug in the current GAHP model implementation in E+ that will be fixed in the next release



Building stock
characteristics
database

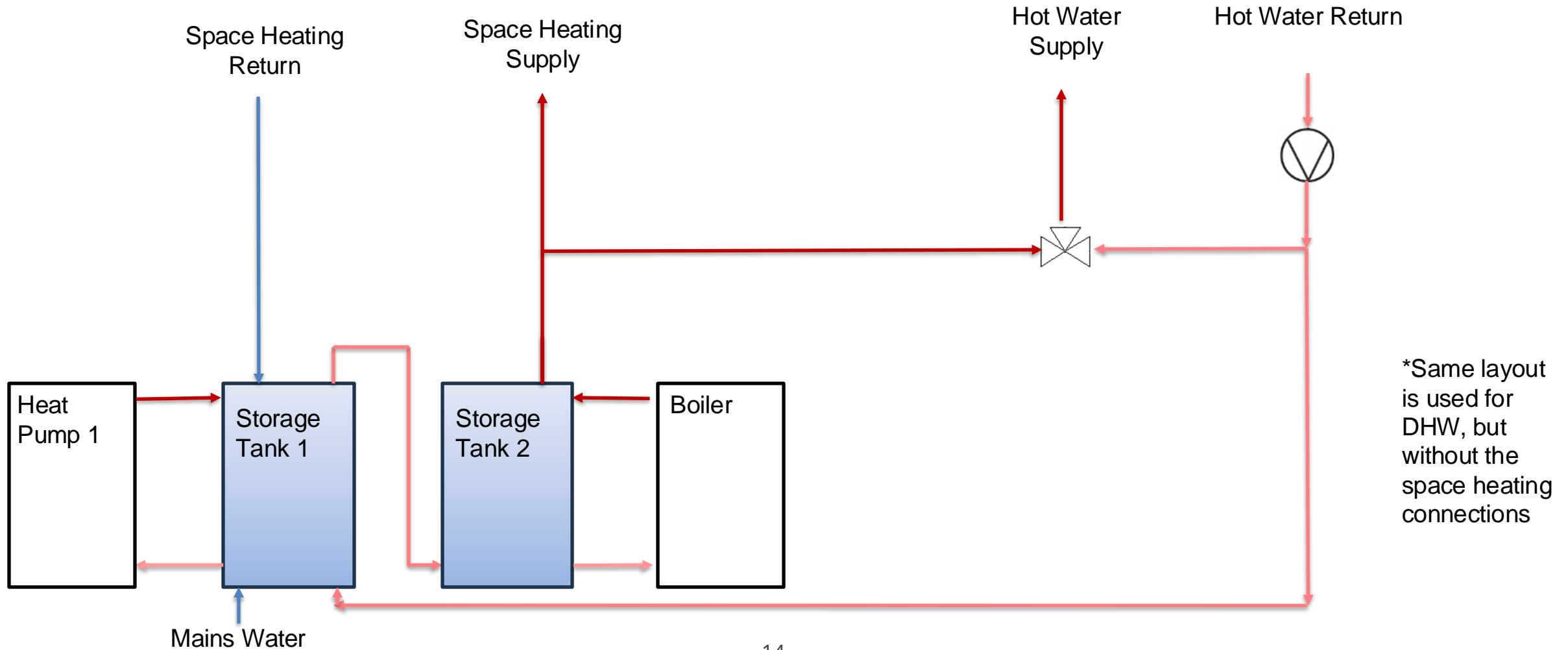


Physics-based
computer
modeling



High-
performance
computing

Combi Application Plumbing Layout



Recommendations

Next Steps

- Finalize equipment sizing calculations
 - Total storage volume required, number of heat pumps, size of any backup heating
 - As a function of location, number of units served, and low/high users of hot water
- Finalize control algorithm coordinating heat pumps and backup
- Estimated project completion: March 2025

This project was conducted through the ICF implemented, SoCalGas administered California Statewide Gas Emerging Technologies Program.

The project report can be found on cagastech.com
For more information, contact get@caenergyprograms.com

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