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| **Docket Number:** | 17-EPIC-01 |
| **Project Title:** | Development of the California Energy Commission Electric Program Investment Charge 2018 â€“ 2020 Triennial Investment Plan |
| **TN #:** | 215883 |
| **Document Title:** | Glenn Gallagher Comments: Energy Efficiency Study for low-GWP Transcritical CO2 in convenience stores and small grocery stores |
| **Description:** | N/A |
| **Filer:** | System |
| **Organization:** | Air Resources Board/Glenn Gallagher |
| **Submitter Role:** | Public Agency |
| **Submission Date:** | 2/10/2017 4:27:06 PM |
| **Docketed Date:** | 2/10/2017 |

*Comment Received From: Glenn Gallagher*
*Submitted On: 2/10/2017*
*Docket Number: 17-EPIC-01*

## Energy Efficiency Study for low-GWP Transcritical CO2 in convenience stores and small grocery stores

*Additional submitted attachment is included below.*

CALIFORNIA ENERGY COMMISSION
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The Energy Commission is currently soliciting ideas and stakeholder input for the 2018 – 2020 EPIC Triennial Investment Plan. For those that would like to submit an idea for consideration in the 2018-2020 EPIC Triennial Plan, we ask that you complete the form below. Submittals are due by **5:00 p.m. on February 10, 2017.**

**Part 1. Initiative Description and Purpose:**

1. Please provide a brief description of the proposed initiative:

Energy efficiency research project: $400,000 - $500,000 over two years. The October 2016 Kigali Amendment to the Montreal Protocol requires developed countries to phasedown the production and consumption of high-global warming potential (GWP) hydrofluorocarbon (HFC) refrigerants between 2019 and 2036 to 15 percent of baseline level usage (2011-2013 annual average). While many energy-efficient substitute refrigerants are available for large refrigeration systems, the small retail food sector (convenience stores, small grocery stores) use small refrigeration systems where low-GWP refrigerant alternatives have not been adequately tested for energy performance in California climates. Specifically, using CO2 (GWP of 1) as the refrigerant in new smaller refrigeration condensing units is proposed as the most likely alternative to using HFCs with GWPs ranging from 1300 and 4000. However, their energy performance has not been demonstrated outside of initial use in Japan. Energy testing of smaller CO2-refrigeration systems that can be used in convenience stores and small grocery stores is necessary before this low-GWP technology can be adopted. (Other low-GWP refrigerant options are problematic: hydrocarbons are flammable, ammonia is toxic, and the newest low-GWP synthetic refrigerants hydrofluoro-olefins (HFOs) are not energy efficient unless blended with high-GWP HFCs.)

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Refrigeration using 100% CO2 as the refrigerant, known as "transcritical CO2" refrigeration is known to work efficiently in cooler climates, yet their performance in high ambient temperature climates such as central and southern California has not been adequately tested. Testing of actual units must be performed in typical California climate zones to ascertain if this low-GWP technology is energy-efficient or if there will be an energy penalty that would preclude its use in much of California.

Currently, the adoption of smaller transcritical CO2 systems has been negligible due to concerns over the higher initial cost and unknown energy efficiency.

**Part 2. Benefits and Impacts**

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

The impact will be the reduction of 1.0 to 1.5 million metric tonnes of CO2-equivalents (MMTCO2E) per year in California alone by using CO2 refrigeration instead of high-GWP HFCs. If the technology is proven to be energy-efficient, it will likely be adopted nationally, with annual GHG reductions of 12 to 18 MMTCO2E. Small retail food businesses will be able to continue to use refrigeration units when the HFC production and consumption cap reduces HFCs to the point where they either become unavailable or not affordable, anticipated to occur between 2024 and 2027.

Research findings will be used to develop sound GHG reduction policies by the CA Air Resources Board, California Energy Commission, and can also be used by the U.S. EPA in their refrigerant management programs. Ultimately, the research findings would be applied globally, with the potential to reduce global GHG emissions significantly.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

Actual energy usage of smaller transcritical CO2 refrigeration units would be compared to baseline HFC refrigerants such as HFC-134a (GWP 1430); and HFC blends: R-407A (GWP 2107), R-404A (GWP 3922), and R-507A (GWP 3985).

Energy savings or losses in terms of kWh per year or another unit of time would be used for comparison. Of particular interest for adoption in California would be testing under high-ambient temperature conditions.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Fricke and Sharma, 2016. Oak Ridge National Laboratory (ORNL), "High-Efficiency, Low Emission Refrigeration System", Brian A. Fricke and Vishaldeep Sharma. August 2016. Report ORNL/ TM-2016/363. Available at: https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Ref-system.pdf

Gulloa and Cortella, 2016. "Comparative Exergoeconomic Analysis of Various Transcritical R744 Commercial Refrigeration Systems", Paride Gulloa and Giovanni Cortella. Available at: https://www.researchgate.net/publication/304193732_Comparative_Exergoeconomic_Analysis_of_Various_Transcritical_R744_Commercial_Refrigeration_Systems

DOE, 2015. "Case Study: Transcritical Carbon Dioxide Supermarket Refrigeration Systems", Dept. or Energy, January 2015. Available at: https://energy.gov/eere/buildings/downloads/case-study-transcritical-carbon-dioxide-supermarket-refrigeration-systems

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

The competitive advantage will be that convenience stores and small grocery stores will be able to comply with HFC phasedown requirements by using the safe and feasible low-GWP alternative of transcritical CO2 systems designed for smaller refrigeration units.

Energy efficiency data for these low-GWP refrigeration units is not currently available for the typical climate zones found in California. Without energy efficiency data, the adoption of the transcritical CO2 refrigeration units will not occur, thus preventing the reduction of millions of tons of CO2-equivalents in California, nationally, and globally.

**Part 3. Connection to Energy Commission's EPIC Framework**
Energy Commission staff have developed a draft strategic framework to guide the CEC's planning and implementation of EPIC across triennial investment cycles. One of the objectives of the draft strategic framework is to communicate a consistent set of priorities for organizing current and future EPIC investments.

7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
    - Advance Technology Solutions for Deep Energy Savings in Building and Facilities
    - Accelerate Widespread Customer Adoption of Distributed Energy Resources
    - Increase System Flexibility from Low-Carbon Resources
    - Increase the Cost-Competiveness of Renewable Generation
    - Create a Statewide Ecosystem for Incubating New Energy Innovations
    - Maximize Synergies in the Water-Energy-Food Nexus
    - Develop Tools and Analysis to Inform Energy Policy and Planning Decisions
    - Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged Communities

If Other, Please Specify

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