RD&D
COMPLETED PROJECTS

JANUARY 2024

SUMMARIES FOR ALL PROJECTS COMPLETED IN THE LAST QUARTER

GTI Residential Gas Heat Pump Water Heater Field Demonstration

Program: Customer End-Use Applications
Sub-Program: Residential Appliances

Benefits
Operational Efficiency, Reduced Greenhouse Gas Emissions, Improved Air Quality

Duration
April 17, 2017 to December 31, 2023

Total Project Cost
$1,272,355

Total SoCalGas Cost
$188,125

Total Co-Funding
$1,084,230 by CEC

For this project, co-funded by the California Energy Commission (CEC), GTI Energy seeks to advance the commercialization of a residential Gas-fired Heat Pump Water Heater (GHPWH) through a five-site field demonstration, extended-life laboratory testing, and stakeholder outreach events. During 12 months of field and lab testing, GTI Energy identified and addressed several challenges, including minor mechanical failures and a need for installation guidelines addressing the new system's venting, electrical service, and space requirements. Upon project completion, GTI Energy demonstrated a product and a solid market. Preliminary results show that this technology provides energy consumption and greenhouse gas emissions reductions of roughly 54% and 49%, compared to conventional water heaters. The CEC final report can be found at: https://www.energy.ca.gov/sites/default/files/2023-07/CEC-500-2023-047.pdf

SoCalGas™

GTI Upstart Residential SOFC Lab Evaluation

Program: Clean Generation
Sub-Program: Distributed Generation

Benefits
Reliability, Reduced Greenhouse Gas Emissions, Improved Air Quality

Duration
August 17, 2020 to August 31, 2023

Total Project Cost
$206,481

Total SoCalGas Cost
$206,481

This project aimed to evaluate the performance of the Upstart Upgen 10 residential solid oxide fuel cell (SOFC) system at GTI Energy's lab. The technology was originally designed to operate on propane, but modified for testing with natural gas. Unlike other SOFC systems, Upstart claims they created the system to achieve fast start and stop times while maintaining cyclic durability. SOFCs can improve customer energy reliability while reducing GHG and pollutant emissions. The project intended to assess current, voltage, power characteristics, efficiencies, system endurance, stack degradation, load following capabilities, rapid start-up and shut-down cyclability, and emissions. The system experienced some issues early on during testing and was decommissioned and sent back to Upstart for evaluation and troubleshooting. After extensive troubleshooting and parallel product development efforts by Upstart, the team decided to wait for the next-generation system to be produced before pursuing further testing. The new system will be specifically designed to operate on natural gas. This project is considered complete and will be followed by a new project to test the new model.

Hot Tap Branch Connections, JIP

Program: Gas Operations
Sub-Program: System Design & Materials

Benefits
Reliability, Public and Employee Safety, Improved Affordability

Start Date
December 16, 2019 to September 20, 2023

Total Project Cost
$1,050,000

Total SoCalGas Cost
$30,000

Total Co-Funding
$1,020,000 by JIP Members

The objective of this joint industry project (JIP) aims to develop industry best practices for welding stub-on branch connections onto live gas mains (hot taps) and to provide a guideline that enables the least-complicated procedure to be selected for a given application. Developing and using industry best practices for specifying and installing hot tap branch connections will reduce costs and increase safety and reliability. Hot tap branch connections have long been an important aspect of pipeline and piping system operations. Previously, the team completed a report on in-service failures and guidance on fitting types and weld spacing and the PRCI Pipeline Repair Manual. In 2023, revisions were made to the 22nd edition of American Petroleum Institute (API) 1104, which is a global standard that supports industry-wide requirements for gas and arc welding used in the construction and in-service repair of pipes to improve pipeline safety, structural integrity, and efficiency by providing detailed welding procedures for qualified professional welders, inspectors, and engineers. Additionally, the project team worked on qualifying procedures using a mechanized system for in-service welding, which can make longitudinal seam welds and circumferential fillet welds. The project team worked on welding-up of 'temporary' repairs using a PLIDCO Split+Sleeve to make them permanent. The results of this JIP

may aid SoCalGas in identifying instances where in-service welding may be acceptable or prohibited. The use of this updated guidance document will increase the safety and reliability of newly constructed and repaired pipelines by avoiding misinterpretation of the requirements by users and regulators and also allow the realization of significant economic and environmental benefits.

Impact of Blended H2 on Threaded Connections (M2021-007)

Program: Gas Operations
Sub-Program: System Design & Materials

Benefits
Public and Employee Safety, Reduced Greenhouse Gas Emissions

Duration
August 9, 2021 to September 27, 2023

Total Project Cost
$238,517

Total SoCalGas Cost
$21,271

Total Co-Funding
$217,246 by NYSEARCH Members

The objective of this project was to determine if hydrogen natural gas blends cause any change in the presence or absence of leaks and the leak flow rate for threaded connections that conform to National Pipe Thread (NPT) standards. This project developed the test protocols for both NPT and out of spec (non-NPT) connectors; performed tests to assess the change in a leak or leak flow rate with a 20% hydrogen blend; evaluated the impact of various pipe dopes and sealants and if hydrogen blends influenced this variable; and established procedures for creating threaded connection leaks and methods to measure leak flow rates with hydrogen blends. Results showed the hydrogen in natural gas blend did not appear to create more leaks than natural gas. The project also addressed whether existing leaks have a higher gas flow rate with the 20% hydrogen blend of gases than with pure natural gas. Results of this inspection indicated a slight increase in flow rate with the blended gas, following analysis, the difference identified was deemed statistically insignificant. However, significant differences in overall failure rates among the thread sealants were observed. A proposal for further research is being developed. SoCalGas will use this research to support the determination of a hydrogen- natural gas blend limit for distribution systems that could contribute to a statewide Hydrogen injection standard.

INGAA - Geohazard Management JIP

Program: Gas Operations
Sub-Program: System Inspection & Monitoring

Benefits
Reliability, Public and Employee Safety

Duration
July 18, 2022 to September 26, 2023

Total Project Cost
$567,996

The objective of this project was to provide a high-level, concise framework for pipeline operators to utilize in managing geohazards. Currently, no best practices or recommended procedures for geohazard data management exist. The deliverables included detailed recommended practices and guidelines for implementing a geohazard land movement management program. A secondary goal was to support potential rulemaking by the Pipeline and Hazardous Materials Safety Administration related to geohazard management. In March 2023, the project team produced a document titled “Framework for Geohazard Management” for the development

Total SoCalGas Cost
$42,996

Total Co-Funding
$525,000 by JIP Members

of a high-level framework for the management of multiple types of geohazards and associated implications to pipeline structural integrity. A second document was completed in April 2023 that provided recommendations for the management of landslide hazards for operating onshore welded steel pipelines. The recommendations in this document are applicable for onshore transmission pipelines conveying natural gas, hazardous liquids, and carbon dioxide. If implemented appropriately, these practices will reduce the potential of landslides damaging pipelines and causing unintentional releases. The two recommended best practices could aid SoCalGas with its geohazard management framework and landslide threat evaluations.

QSI Nano-Power Generation System Proof-of-Concept

Program: Clean Generation
Sub-Program: Operations Technology

Benefits
Operational Efficiency

Duration
September 9, 2019 to November 14, 2023

Total Project Cost
$50,000

Total SoCalGas Cost
$50,000

This project aimeds to conduct a proof-of-concept test of the QuSwami, Inc (QSI) patented Nano-Power Generation System, running on natural gas. QSI's system utilizes Electricity Emitting Diodes (EEDs), which directly and efficiently generate power from an energy source via gas-phase catalytic reactions. The reactions occur on an EED's nano-surface, where hot electrons are generated. QSI's foundational research shows that direct conversion of chemical energy from gas-phase catalytic reactions can achieve higher fuel efficiency than most existing electricity generation technologies. The project will scope included re-designing the reactors to withstand the higher temperatures required for the testing, measuring exhaust composition, and measuring output voltage from the EEDs. QSI relocated their lab during 2022 and is in the process of obtaining permits, at which point testing will resume In 2022, QSI moved its laboratory and dedicated time to securing permits for its new location.. The project concluded due to challenges in advancing facility permitting and establishing a proof of concept of the technology. The contract naturally terminated on June 30, 2023, without an extension.

UCI Low NOx Water Heater Retrofit for Hydrogen Blends Development

Program: Customer End-Use Applications
Sub-Program: Residential Appliances

Benefits
Reliability, Public and Employee Safety, Reduced Greenhouse Gas Emissions, Improved Air Quality

The project's objective was to take existing low NOx water heaters and improve the operational limits of hydrogen tolerance. The project's goals were to evaluate the modifications that would allow adding additional hydrogen, to carry out the improvements, and demonstrate the amount of additional hydrogen that could be blended and allow reliable operation. The team did laboratory testing to evaluate general observations, ignition, flashback, and efficiency. In addition, the team

Duration
July 25, 2020 to
May 31, 2023

Total Project Cost
$273,468

Total SoCalGas Cost
$241,468

Total Co-Funding
$32,000 by Rheem

quantified emissions to understand how the NOx, carbon monoxide and unburned hydrocarbon (UHC) levels change with increased hydrogen addition. In 2021, the team evaluated, baselined, and proposed several modifications to the water heaters they received. Some methods they used to assess the water heaters included thermal imaging of the burner top to understand the temperature distribution, thermocouples to measure the surface temperature, and fuel control to vary the hydrogen-natural gas mixture. In 2022, the team completed the initial testing of their appliance set. The research team focused on design modifications to improve the hydrogen tolerance of the burners and is evaluating those modifications under comprehensive safety, performance, and emissions testing. A journal publication was released on March 3, 2023.
https://www.sciencedirect.com/science/article/pii/S036031992300722X

UTD Field Evaluation of Indoor Air Quality in Residential Kitchens (1.20.K)

Program: Customer End-Use Applications
Sub-Program: Residential Appliances

Benefits
Public and Employee Safety, Reduced Greenhouse Gas Emissions, Improved Air Quality

Duration
July 1, 2020 to
October 31, 2023

Total Project Cost
$335,000

Total SoCalGas Cost
$92,235

Total Co-Funding
$242,765 by UTD Members, BHE

Through field evaluations, this project aimed to determine the effect of cooking emissions on residential indoor air quality (IAQ) in a scientific manner in real-world situations. This project presented the opportunity to collect field data to differentiate emissions from cooking processes versus those from appliances by comparing direct-vent range hoods versus recirculating hoods. The team prepared a residential kitchen ventilation test setup in a laboratory facility to provide additional comparative data. Activities included 1) interactions with the property manager to schedule the installation of remaining IAQ sensor packages and range sensor arrays; 2) surveying tenants for IAQ and cooking procedures; 3) scheduling a controlled-cook event where residents will be participating in cooking the same product, such as pizza, stir fry, etc., and the team will compare the kitchen IAQ data among apartments; 4) analyzing IAQ data from multi-unit residences; and 5) planning for switchover of select gas to electric ranges. In 2022, the IAQ sensor packages and range cooking-location sensors gathered gas and particulate measurements from six kitchens in ENERGY STAR units and six Phius-occupied units. (Phius is a non-profit organization committed to decarbonization.) The gas and particulate data were analyzed during cook events and non-cooking periods. Researchers compared ventilation strategies based on gas and particulate measurements between the direct-vent range hood in the ENERGY STAR units and the recirculating hood and heat-recovery ventilator in the other units. A more detailed project description can be found in the 2023 UTD Annual Report.

UTD HeatAmp Adsorption Thermal Heat Pump (1.21.A)

Program: Customer End-Use Applications
Sub-Program: Residential Appliances

Benefits
Operational Efficiency, Reduced Greenhouse Gas Emissions, Improved Air Quality

Duration
December 31, 2021 to May 31, 2023

Total Project Cost
$140,000

Total SoCalGas Cost
$3,200

Total Co-Funding
$136,800 by UTD Members

The objective of this project was to advance the development of a cost-competitive, fuel-fired Thermal Heat Pump technology from HeatAmp of Sweden. The team sought to optimize a cost-effective alpha prototype "burner/boiler" assembly and design a system for future evaluation in GTI Energy's laboratory. The unit draws in and upgrades ambient heat via an outdoor fan coil. The sorption module drives the heat pump effect, which houses ammoniated salts. The system aims to achieve a projected energy and emission reduction of >33% vs. standard fuel-fired equipment. The primary target were domestic hot water applications, with options for combined space and water heating ("combi") or pool heating functions. In 2022, the team readied the alpha burner and boiler assembly for testing. Upon completion of testing, HeatAmp planned to ship proprietary hardware to the research team. In parallel, researchers intended to complete the burner and boiler test plan with HeatAmp's input and, upon finalization, make necessary preparations to facilitate experimental testing of the burner and boiler. The team prepared a system design analysis memo based on the whole-system modeling currently underway. Under a subsequent phase, the project team will fabricate, evaluate, and improve full-packaged prototype heat-pump water heaters. A more detailed project description can be found in the 2023 UTD Annual Report.

UTD Integrated CHP System for Multi-Family Buildings (1.20.J)

Program: Clean Generation
Sub-Program: Integration & Controls

Benefits
Reliability, Operational Efficiency, Improved Affordability, Reduced Greenhouse Gas Emissions, Improved Air Quality

Duration
June 1, 2020 to August 30, 2023

Total Project Cost
$250,000

Total SoCalGas Cost
$30,000

Total Co-Funding
$220,000 by UTD Members

This project aimed to evaluate a laboratory microgrid design featuring an EC Power/Lochinvar XGRi25micro combined-heat and power (mCHP) unit within a multi-family context,coupled with best-in-class electric heat pumps (EHPs) responding to heating and cooling demand. The project integrated the mCHP system with the EHP to communicate and perform in power lead mode, size the appropriate thermal storage for multi-family scenarios, and characterize the space and water heating part-load performance. The results demonstrated that integrating the mCHP with an EHP could yield a Coefficient of Performance (COP) exceeding 100%. Additionally, the microgrid exhibited the potential to reduce electric loads by 27%, lower installation cost by 43%, and achieve GHG emission rates equivalent of 25% of U.S. national gird average. The team completed and submitted the final report.

UTD Low Emission Efficient Burner for Ovens and Dryers (2.20.A)

Program: Customer End-Use Applications
Sub-Program: Commercial Applications

Benefits
Reliability, Public and Employee Safety, Operational Efficiency, Reduced Greenhouse Gas Emissions, Improved Air Quality

Duration
June 1, 2020 to September 29, 2023

Total Project Cost
$200,000

Total SoCalGas Cost
$23,800

Total Co-Funding
$220,000 by UTD Members, Preheat Inc.

The project's objective was to advance the commercial introduction of a new burner that would reduce emissions, energy use, and operations and capital expenses for many end users. Novel burner technology was previously developed in project No. UTD 2.15.D. This project tested the air-process heating assembly focusing on the burner performance and progress from a laboratory to a field test site. Specific tasks included (1) integrating the burner assembly at the laboratory, (2) evaluating the burner performance at the laboratory, (3) designing and integrating the assembly at the host site, and (4) evaluating prototype-burner performance at different operations and process conditions. In 2020, the project team completed the burner assembly and the crossflow process-air section fabrication. In 2021, the team installed the air and fuel trains for the burner and the crossflow air for flow, pressure, and temperature measurements. In 2022, an improved second prototype burner design was fabricated based on a computational fluid dynamics analysis that further reduced emissions by improving the mixing by more than 30%. The burner was assembled and installed in the furnace, similar to the previous burner assembly, with pressure and temperature instrumentation and air and fuel plenums. The project team conducted burner shakedown testing and preliminary tests on this improved design. Laboratory testing of the enhanced burner design was expected to lower emissions and improve turndown. The prototype testing simulates the host site test setup and demonstrates proof of concept. The prototype enables market demonstration while reducing integration risks with the host-site system. A more detailed project description can be found in the 2023 UTD Annual Report.

UTD Low NOx Ribbon Burner - Phase 3 (2.12.M.3)

Program: Customer End-Use Applications
Sub-Program: Commercial Food Service

Benefits
Improved Air Quality**Duration**
July 1, 2019 to May 31, 2023

Total Project Cost
$125,000

Total SoCalGas Cost
$33,000

Total Co-Funding
$92,000 by UTD Members,

This project aimed to transfer prior patented technology (UTD project 2.12.M) to introduce a commercial product with one or more major baking industry manufacturers. The project team developed an innovative, cost-effective, low-NOx ribbon burner combustion system. Subsequently, they demonstrated it in a full-scale production environment at a wholesale commercial bakery in California. Results of the prototype unit in the field test showed a 50% NOx reduction and approximately 5% energy savings. A 30% market penetration in the baking industry in California would result in an estimated reduction in natural gas consumption of 1.3 to 1.5 million therms per year, carbon emission reductions of

Flynn Burner, Selas Heat Technology

7,500 to 10,000 tons per year, and NOx emission reductions of 200 to 300 tons per year. In 2021, the project team began expanding the technology commercialization outreach beyond U.S. markets into Europe and Asia. The project team completed several technical communications. The project team identified some combustion-equipment manufacturers that may be interested in licensing and commercializing the technology. In 2022, the project team continued discussions with baking industry leaders (manufacturers, suppliers, and end users) and investment entities. The technology has attracted the interest of baking-industry OEMs and end-users at 2022 BakingTech. The team identified a potential commercialization partner, and they initiated licensing discussions. A more detailed project description can be found in the 2023 UTD Annual Report.

UTD Membrane Based Ionic Liquid Absorption Heat Pump for Commercial HVAC (1.20.I)

Program: Customer End-Use Applications
Sub-Program: Commercial Applications

Benefits
Reliability, Public and Employee Safety, Operational Efficiency, Reduced Greenhouse Gas Emissions, Improved Air Quality

Duration
August 1, 2020 to August 21, 2023

Total Project Cost
$1,800,000

Total SoCalGas Cost
$24,033

Total Co-Funding
$1,775,967 by DOE, PERC, UTD Members

The objective of this project was to develop innovative thermally driven cooling technology for commercial heating, ventilation, and air conditioning (HVAC) applications. The U.S. Department of Energy (DOE) awarded prime funding to the University of Florida (UF) to lead this technology development effort through project management, technical design and shared laboratory development with GTI. The project team demonstrated the technology in a prototype ultra-high-efficiency dedicated outdoor air system. The core technology under development is a novel, scalable absorption system for dehumidification using a highly efficient open double-effect liquid desiccant cycle enabled by non-crystallizing ionic liquids. This absorption system is built upon a compact membrane-based heat and mass exchanger with no desiccant entrainment. The compact size facilitates retrofitting existing building infrastructure. Regeneration of the system is driven by efficient heating (natural gas, propane, waste heat, solar, etc.). Modine Manufacturing, a commercial HVAC market leader, will provide industry support. In 2021, the project team completed a study regarding the impact of direct firing the desorber concerning capacity, hot spots (material reliability), and other factors. In 2022, the project team completed the commissioning and testing of the desorber using a working fluid that simulates the ionic liquid. A more detailed project description can be found in the 2023 UTD Annual Report.

UTD Triathalon 2030 5-ton Cold Climate Gas Heat Pump (2.19.D)

Program: Customer End-Use Applications
Sub-Program: Commercial Applications

Benefits
Operational Efficiency, Reduced Greenhouse Gas Emissions

Duration
July 1, 2019 to September 15, 2023

Total Project Cost
$994,368

Total SoCalGas Cost
$3,487

Total Co-Funding
$990,881 by UTD Members, NYSERDA

The objective of this project was to assist in prototype design of a new 5-ton natural gas engine-driven cold climate heat pump. The project involved developing market and functional design requirements, a detailed design review, and an energy and economic modeling of the proposed design. The first stage of this project was to develop a product design to determine the performance, reliability, serviceability, and cost targets. The Triathlon 2030 design focus was on heating and cooling applied to small commercial building load profiles, including office, lodging, restaurants, fitness, health care, box retail, strip malls, light commercial, and education. The major technical design challenge was to re-design and improve engine-heat recovery for cold-climate operation. Researchers developed Energy Plus™ models to compare energy costs and full-fuel-cycle greenhouse gas emissions for the GHP prototype design vs. conventional equipment, taking into account current and future power-generation mix and the natural gas supply. Based on published laboratory data, the GHP prototype design has the potential to achieve seasonal efficiencies of 1.6 COPg cooling and 0.9 to 1.2 COPg heating. A draft report on the Triathlon 2030 GHP design and its value proposition for New York State was developed and presented to NYSERDA project team meeting in July 2021. A more detailed project description can be found in the 2023 UTD Annual Report.

UTD Zero Emissions Processes with Carbon Recovery (2.21.C)

Program: Customer End-Use Applications
Sub-Program: Industrial Process Heat

Benefits
Operational Efficiency, Improved Affordability, Reduced Greenhouse Gas Emissions, Improved Air Quality

Duration
July 1, 2021 to October 31, 2023

Total Project Cost
$150,000

Total SoCalGas Cost
$15,000

Total Co-Funding
$135,000 by UTD Members

This project was intended to develop a new synthetic air combustion (SAC) process to 1) improve industrial boiler or furnace efficiency when using natural gas, 2) lower carbon dioxide emissions, and 3) provide a means to capture or convert carbon dioxide into valuable products. The team conducted laboratory tests in industrial conditions, and the results were intended to compare calculated and experimental results when using SAC versus typical air-fired combustion. The objective was for this process technology to help create a lower-carbon future while using natural gas in industrial boilers and furnaces. In 2021, the project team conducted synthetic air-combustion tests using artificial air containing oxygen and carbon dioxide at ambient temperature in a commercial burner. Results confirmed that burners run well on synthetic air. The team has conducted tests with preheated artificial air containing steam. In 2022, technicians modified the experimental furnace test platform to prepare for the next round of tests. A more detailed project description can be found in the 2023 UTD Annual Report.