UTD IMPACT

Utilization Technology Development

December 2023

Leading researchers, entrepreneurs, universities, governmental agencies, governmental laboratories, customers, manufacturers, and others partner with UTD as a 501(c)(6) not-for-profit organization of utilities to develop and demonstrate affordable new gas solutions for end users, and accelerate the transition to a lower-carbon future.

Development and demonstration of economical new products, systems, and technologies helps customers save money, save energy, reduce GHG emissions, integrate renewable energy (including renewable natural gas and RE-derived hydrogen), and maintain safe, reliable, resilient operation of their homes and facilities with superior environmental performance.

Please contact us if you have any questions about UTD.

Ron Snedic (1.847.768.0572) **Rich Kooy** (1.847.768.0512)

UTD's 20 members serve more than 37 million natural gas customers in North America.

UTD helps utilities create exciting new products for their customers and maximize the impact of their energy-efficiency programs.

Together we're shaping the energy future with clean, efficient end-use technologies.

Visit www.utd-co.org for more information.

COMMERCIALIZED PRODUCTS

SMTI ANESI Gas-fired Absorption Heat Pump for Space Heating and/or Water Heating

Provides AFUE-rated efficiency of 140% (~45% gas savings) with ultra-low NOx emissions of ≤14 ng/J while using zero GWP fluids, and performs reliably in extreme cold weather. Commercially introduced in 2023 after long-term technology RD&D support from UTD, including laboratory work and prototype field applications in CA, WI, IL, TN and Canada, with support from U.S. DOE, CEC and others.

SMTI ANESI
Scott Reed
818-421-4229
sreed@stonemtntechnologies.com
www.AnesiComfort.com

Lochinvar XRGI MicroCHP

Lochinvar's XRGI efficiently produces heat and 24kW of power from the same fuel source. UTD collaborated with the CEC, SoCalGas and the others to advance this engine-based micro-CHP system towards compliance with California Air Resource Board requirements. UTD is also prototyping its use for multi-family buildings or multi-unit applications.

Lochinvar
Eric Morrow
615-318-4919
enmorrow@lochinvar.com
www.lochinvar.com

COMMERCIALIZED PRODUCTS (continued)

CleanO2 CarbinX™ Carbon Capture

CleanO2's revolutionary CarbinX unit captures CO2 from the flue gas of boilers and furnaces to reduce GHG emissions, and turns it into a beneficial consumer product. UTD's members provided technology development expertise and support to CleanO2 since 2018 to refine early prototypes and partner with CleanO2 to identify and make product improvements.

CleanO2, Inc.
Jaeson Cardiff
carbinX@cleano2.ca
www.carbinx.com

Yanmar 3-Pipe Engine-driven Gas Pump

Yanmar's 3-pipe, 14-ton Gas Heat Pump (GHP) with variable refrigerant flow (VRF) offers an important energy-efficiency option for the North American market by combining heat recovery with simultaneous heating and cooling. In a 2018-23 field tests, UTD validated equipment performance and produced public summaries of the results.

YANMAR America Corp.
Eddie Caton
770-877-7733
eddie_caton@yanmar-es.com
www.yanmar-es.com

GRIDIRON PowerPlant™ H24 and HA65

The PowerPlant HA65 from GRIDIRON (formerly M-Trigen) provides high-efficiency microCHP with integrated cooling to homeowners, small businesses, and other users. UTD provided technical support for a notable demonstration by partnering with NYSERDA, National Grid, NJNG, and PERC to independently validate performance. UTD also supported GRIDIRON in its optimization of PowerPlant HA65 to minimize emissions, and its development of PowerPlant H24.

GRIDIRON
713-574-4506
info@gridironenergy.com
www.gridironenergy.com

Sierra™ Engine-driven Gas Heat Pump

Sierra's (formerly NextAire™) 11-ton packaged GHP can efficiently heat and cool commercial buildings (up to 1.4 COP) while reducing electric demand. Also available are 8- and 15-ton GHPs with VRF multizone capabilities. UTD's field studies are supporting best practices for siting. UTD partnered with NYSERDA and National Fuel in a field test in NY state.

Blue Mountain Energy
Tom Young
702-339-7395
tyoung@bluemountainenergy.com
www.bluemountainenergy.com

Cannon Boiler Works Ultramizer®

The Ultramizer is an advanced heat-and-water recovery system for larger commercial and industrial boilers, of which there are more than 140,000 in the U.S. It increases boiler efficiency from 80% to 93% - saving customers 15% in energy while also reducing water demand.

Cannon Boiler Works, Inc.
Chris Giron
724-335-8541 x414
sales@cannonboilerworks.com
www.cannonboilerworks.com

U.S. Boiler K2 High Efficiency Gas Boiler

The K2 high efficiency condensing gas boiler offers 95% AFUE with 10:1 turndown, and uses a novel sheet metal burner from Europe. UTD validated its performance via laboratory tests to support potential gas utility MT incentives, and identified pathways to achieve <5 ppm NOx emissions.

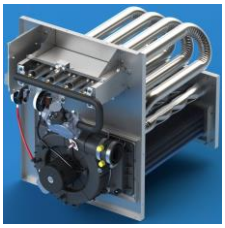
U.S Boiler Inc.
Craig Eshenaur
717-239-4490
ceshenaur@usboiler.net
www.usboiler.net

COMMERCIALIZED PRODUCTS (continued)

Condensing Dedicated Outside Air System/Rooftop Unit

Condensing heating versions of Munters Dedicated Outside Air System (DOAS) and other rooftop unit (RTU) products increase heating efficiency from 80%-81% to 90%-93%. Multiple RTU manufacturers are now offering DOAS with 90+% efficiencies, facilitated by the availability of condensing duct furnace modules first developed with UTD support.

Munters Corporation
Larry Klekar
210-249-3883
larry.klekar@munters.com
www.munters.com



Condensing Duct Furnace Modules

High-efficiency condensing heating modules developed with UTD support are now available from Beckett Gas and other OEMs, including Heatco, and are being applied to DOAS and other products including Make-Up Air Units available from multiple manufacturers including Aaon, Daikin, and RuppAir.

Beckett Gas, Inc.
Joel Mohar
440-783-7610
jmohar@beckettcorp.com
www.beckettgas.com

Gas Quality Sensor

The Gas Quality Sensor (GQS) uses solid-state infrared light absorption spectroscopy to measure Btu content and composition of natural gas and bio-methane fuels. It provides faster response at much lower cost than a gas chromatograph. It was developed with UTD support and was commercially introduced by CMR Group in 2019.

CMR Group
Jon Stendbebach
724-452-2200
918-407-4005
jon.stendebach@cmr-group.com
www.cmr-group.com

Dettson Chinook Low-Capacity Furnace

This novel low-capacity furnace permits right-sizing for low-load buildings and aids integration with renewable energy and improved building envelopes. UTD researchers identified best application practices and provided supporting technical info.

Dettson
Philippe Verhas
1-800-567-2733
pverhas@dettson.ca
www.dettson.com

iFLOW and Advanced Combination Systems

UTD researchers demonstrated how a forced-air condensing tankless water heater combi system using the iFLOW can achieve 30-50% energy savings relative to best-in-class condensing furnaces and water heaters, and used a rigorous Virtual Test Home analysis to assess annualized performance.

iFLOW
Steve Bagshaw
1-800-985-9227 ext 102
steve.bagshaw@iflowhvac.com
www.iflowhvac.com

S.U.N. Equinox Solar-Assisted Heating System

The Equinox system is a combination solar/natural gas water heating system that uses an efficient evacuated tube design. It can be used in residential, commercial, or industrial locations and can meet 100% of domestic hot-water and space heating needs. UTD validated its energy performance in a field demonstration.

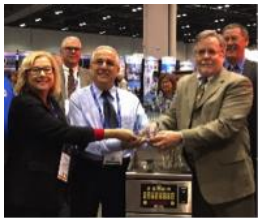
Solar Usage Now, LLC
Thom Blake
260-657-5605
tblake@solarusagenow.com
www.solarusagenow.com

iGEN Self-Powered Furnace

The innovative iGEN furnace generates its own electric power and contains an integrated battery, providing homeowners with continuous heating even during electricity outages. UTD supported the technical refinement of this product with laboratory testing, validation, and recommendations.

iGen Technologies
Michael Chatzigrigoriou
letstalk@igentechnologies.ca
www.igentechnologies.ca

COMMERCIALIZED PRODUCTS (continued)



ENERGY STAR® Fryers

Royal Range introduced the high-efficiency RHEF-75 fryer in 2019 - building on the success of the smaller-capacity, high-efficiency RHEF-45 fryer that received the National Restaurant Association's Kitchen Innovation Award and GFEN's Blue Flame Product of the Year Award. Independent testing showed 63% heavy-load cooking energy efficiency.

Royal Range of California
Robert Lutz
951-360-1600
robert@royalranges.com
www.royalranges.com

Low-Oil-Volume Fryers

Marketed by Frymaster as Protector® fryers, this equipment increases energy efficiency while also extending cooking-oil quality and life to provide significant customer savings. Field demonstrations completed by UTD have shown an average savings of $4,800 per year per fryer.

Frymaster
800-221-4583
www.frymaster.com

ENERGY STAR Conveyor Oven

ENERGY STAR rated conveyor ovens from Lincoln include an advanced energy-management system to reduce energy consumption up to 38%.

Lincoln, a division of Manitowoc Foodservice
260-459-8200
www.lincolnfp.com

ENERGY STAR Convection Oven

This unit showed improved efficiency and 40% energy savings compared to a standard oven during field testing and achieved an ENERGY STAR rating.

Garland
905-624-0260
www.garland-group.com

High-Efficiency Broiler

This broiler features infrared burners and an energy-saving hood that showed an average of 23% energy savings during field testing. It offers more efficient cooking as well as reducing heat gain to the kitchen.

Royal Range of California
800-769-2414
www.royalranges.com

ENERGY STAR Countertop Steamer

A compact, gas-fired countertop steamer for commercial foodservice offers enhanced cooking rates while providing energy savings and reduced water consumption. It was the first gas-fired boilerless steamer on the market and received an ENERGY STAR rating.

Market Forge Industries Inc.
617-387-4100
866-698-3188
custserv@mfii.com
www.mfii.com

High-Efficiency Broiler

The Montague Company commercialized a version of the advanced broiler technology using thermostatic broiler-temperature control and an energy-saving hood. It was recognized with a Kitchen Innovations Award in 2013.

Montague
800-345-1830
www.montaguecompany.com

COMMERCIALIZED PRODUCTS (continued)

L9N

Cummins Westport 8.9L Near-Zero Emission NGV Engine

This 8.9L 320-HP NGV engine is widely used, with 50,000+ engines sold for transit, refuse-collection, and regional hauling applications since 2007. In 2016, it was advanced to become the first engine certified in North America to meet the 0.02 g/bhp-hr optional Near Zero (NZ) NO_x emissions standard (i.e. 90% lower than the current EPA NO_x limit of 0.2 g/bhp-hr).

Cummins Westport Inc.
Yemane Gessesse
812-377-5000
yemane.gessesse@cummins.com
www.cumminswestport.com

B6.7N

Cummins Westport 6.7L Medium-Duty NGV Engine

This 6.7L 240-HP natural gas vehicle (NGV) engine is used in school buses, shuttle buses, medium-duty trucks, and other vocational uses. It went into full commercially production in December 2016. It meets U.S. 2017 EPA GHG requirements as well as NZ NO_x emissions standard of 0.02 g/bhp-hr.

Cummins Westport Inc.
Yemane Gessesse
812-377-5000
yemane.gessesse@cummins.com
www.cumminswestport.com

ISX12N

Cummins Westport 11.9L Near-Zero Emission NGV Engine

This 11.9L 400-HP NGV engine is used in large trucks, buses, and refuse vehicles. Engine sales since 2013 are approaching 10,000 units and 25,000+ engines will likely be sold in N.A. by 2020, yielding emissions reductions and $600+ million in annual fuel sales. In Model Year 18, it became CWI's second engine certified to meet NZ NO_x emissions standard of 0.02 g/bhp-hr.

Cummins Westport Inc.
Yemane Gessesse
812-377-5000
yemane.gessesse@cummins.com
www.cumminswestport.com

EcoZone Ribbon Burner System

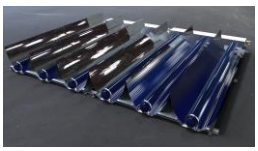
UTD and SoCalGas are supporting the demonstration of Flynn Burner's advanced new EcoZone combustion system which integrates traditional ribbon burners with metal-fiber infrared burners. An installation in California at a large commercial bakery operated by a leading U.S. grocer will evaluate NOx and CO_2 emission reductions.

Flynn Burner
Travis Eddy
518-791-7682
travise@flynnburner.com
www.flynnburner.com

Heat Sponge Economizer for Industrial/ Commercial Boilers

In either condensing or non-condensing configurations, this heat recovery system for commercial and industrial boilers (over 140,000-unit market in U.S.) increases boiler efficiency from 80% to a range of 85%-93% (validated by UTD lab testing). It also saves customers 5%-15% in annual energy costs. UTD completed a field test in Utah to validate energy savings.

Boilerroom Equipment, Inc.
866-666-8977
www.heatsponge.com

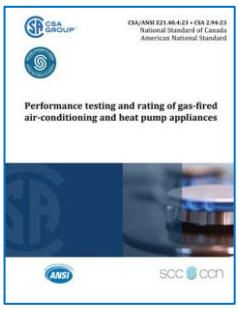


External Concentration Parabolic Collector

This patented, non-tracking, extremely-low-profile concentrator can achieve 200°C (392°F) solar thermal energy to economically serve commercial and industrial facilities and reduce GHG emissions. It can also be integrated with natural gas as a supplemental energy source. UTD provided technical and product development support and experimental validations over a seven-year period.

Artic Solar Inc.
Bill Guiney
904-513-4638
bill@articsolar.com
www.articsolar.com

KEY INFORMATION & ANALYTICAL TOOLS



CSA/ANSI Z21.40.4-23/CSA 2.94-2023 Performance Testing and Rating of Gas-Fired Air Conditioning and Heat Pump Appliances Technical Committee Support

ANSI/CSA Z21.40.4 issued in 2023 and was a major upgrade and update to the 1996 edition of this Method of Test for GHPs. Updates included: increasing what can be rated with residential seasonal efficiency metrics; enhanced calculations and test conditions to better reflect systems designed for heating operation; more optional operating points; and expanded scope to include VRF-type engine-driven systems. UTD supported participation on the Technical Task Force that updated the Standard.

Available at https://webstore.ansi.org

Reliability, Cost and Environmental Impacts of Standby Generation Systems

Generac's website provides technical information related to emissions, reliability and costs of natural gas generators that was developed with UTD's support. For example, UTD researchers published a white paper that provided new data on the reliability of natural gas service and assisted in the development of a Total Cost of Ownership calculator that compares emissions and costs of natural gas vs. diesel-fueled standby generators.

Available at https://www.gti.energy/wp-content/uploads/2019/02/Assessment-of-Natural-Gas-Electric-Distribution-Service-Reliability-SummaryReport-Jul2018.pdf and https://www.generac.com/Industrial/all-about/natural-gas-fuel

U.S. DOE Building America

Under five separate UTD projects from 2011 to 2021, UTD has developed key information and tools to support the U.S. DOE's Building America research, development, and demonstration program, which helps accelerate use of best practices by residential builders, remodelers, installers, code officials, designers, raters, teachers, and others.

Available at https://www.gti.energy/BuildingAmerica and https://basc.pnnl.gov/library

Commercial Foodservice (CFS) Equipment Calculator

This website provides the restaurant industry and others with information and tools to determine the economic and environmental benefits of using new, more advanced and efficient CFS equipment. The website was developed with UTD support and has been showcased at several restaurant trade shows. Further enhancements are underway in 2023.

Available at http://cfscalc.gastechnology.org. For more info, contact Frank Johnson; fjohnson@gti.energy

Commercial Foodservice Energy Monitoring Systems (FEMS)

A real-time energy monitoring system for use in cooking demonstrations, trade shows, test kitchens, and similar venues was developed to help CFS customers better understand the GHG reduction and economic benefits of using higher-efficiency equipment.

For more info, contact Shawn Scott; sscott@gti.energy

Virtual Test Home

A Virtual Test Home (VTH) in a laboratory was developed with UTD's support. The VTH holistically analyzes equipment and system performance by assessing part-load, annualized performance for various locations. The VTH helps accelerate the adoption of advanced gas technologies (such as GHPs, combis and modulating furnaces) in the marketplace and in performance assessment tools such as U.S. DOE's *EnergyPlus*™ or other energy software.

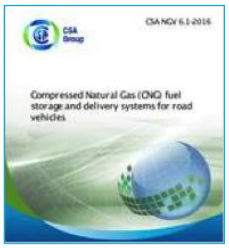
For more info, contact Tim Kingston; tkingston@gti.energy An overview is also available at https://neea.org/product-council-documents/virtual-test-home

KEY INFORMATION & ANALYTICAL TOOLS (continued)

CSA NGV4.3 NGV Storage and Delivery Standard Technical Committee Support

CSA NGV4.3 was updated in 2022 and specifies requirements for temperature compensation control used to prevent compressed natural gas (CNG) dispensing systems from exceeding a safe fill level of vehicle fuel storage container(s). It contains safety performance guidelines and field evaluation methods for existing dispensing systems. UTD supported participation to lead the Technical Task Force that created the Standard in 2018 and updated it in 2022.

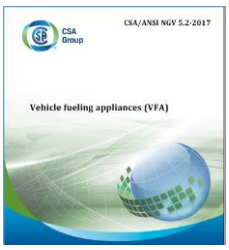
Available at www.csagroup.org



CSA NGV6.1 NGV Storage and Delivery Standard Technical Committee Support

CSA NGV6.1 was introduced in 2016 and defines the requirements for the balance of systems and equipment onboard a NGV, which is not otherwise defined by NGV1 for the receptacle or NGV2 for the storage containers. UTD supported participation on the Technical Committee.

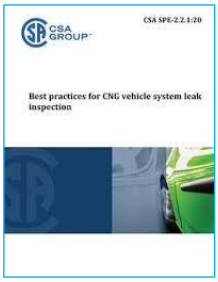
Available at www.csagroup.org



CSA NGV5.1 and NGV5.2 Fueling Appliance Standard Technical Committees Support

CSA NGV5.1 was introduced in 2015 and updated in 2016, and provides mechanical, physical, and electrical requirements for residential fueling appliances (RFAs) that dispense natural gas for NGVs, including indoor and outdoor fueling appliances that connect to residential gas piping. A complimentary standard, NGV5.2 for vehicle fueling appliances (VFAs) in non-residential locations, has been developed and was published in late 2017. UTD supported participation on both of the Technical Committees.

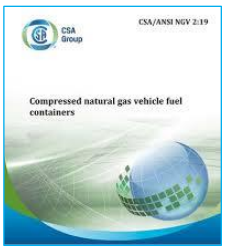
Available at www.csagroup.org



CSA SPE-2.21.1:20 Best Practices for CNG Vehicle System Leak Inspection Standard Technical Committee Support

In 2020, the first edition of CSA SPE-2.21.1 was published. It provided additional specific guidance and best practices to enhance user safety and mitigate potential leaks. Recommendations regarding in-service leak detection, inspection and repair are provided, including leak detection methods. UTD supported participation on the Technical Committee.

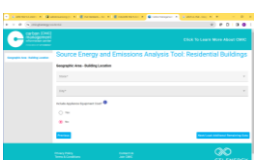
Available at www.csagroup.org



CSA NGV2 CNG Vehicle Fuel Containers Standard Technical Committee Support

The sixth edition of CSA NGV2 issued in 2019 and contains updated information and requirements for the material, design, manufacture and testing of serially-produced, refillable Type NGV 2 containers intended only for the storage of CNG for vehicle operation. The 2019 revision includes localized fire tests and conformable storage topics. UTD supported participation to lead the Technical Task Force that created the Standard.

Available at www.csagroup.org



Source Energy and Emissions Analysis Tool

The Source Energy and Emissions Analysis Tool (SEEAT) calculates source energy and greenhouse-gas emissions related to point-of-use (site) energy consumption by fuel type for each energy-consuming device in residential and commercial buildings. The methodology accounts for primary energy consumption and related emissions for the full fuel cycle.

Available at https://cmic.gti.energy/residential and https://cmic.gti.energy/commercial

TECHNOLOGY ADVANCEMENTS

Hydrogen-Blended Gas in Residential, Commercial and Industrial Applications

UTD is performing substantial testing on the blending of hydrogen into natural gas and the performance of blended fuels in multiple categories of equipment that are commonly used in residential, commercial and industrial applications. UTD is also developing new burner technologies that can operate on up to 100% hydrogen fuel.

Project Managers: Multiple

Robur K18 Gas Heat Pump for Residential Space Heating and/or Water Heating

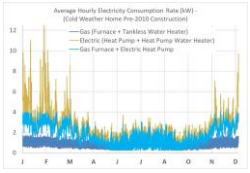
UTD is supporting the potential introduction into the North American market of Robur's K18 Gas Absorption Heat Pump. This 60,000 Btu/hr thermally-driven air-source heat pump will offer very high efficiency operation, with support from a long-established manufacturer. UTD is performing laboratory testing to establish detailed performance curves, which can be incorporated into energy modeling tools in order to accelerate product adoption in North America.

Project Manager: Alejandro Baez Guada

Ultra-Low NO_x Burner

This innovative firetube boiler technology has more than three years of proven successful operation at a Mission Linen Supply facility in California. It improves efficiency and achieves NO_x emissions below 9 vppm, while avoiding the significant efficiency, capital cost, and/or operating cost penalties if conventional Selective Catalytic Reduction or burner enhancements such as external Flue Gas Recirculation and/or High Excess Air firing were used.

Project Manager: David Cygan



Hybrid Fuel-fired and Electric-driven ResCom HVAC Systems

Researchers are evaluating emerging or commercially-available hybrid gas furnace/electric heat pump products in the North American market, in order to identify the more promising hybrid systems and develop installation and operation guides that can help end users accelerate their integration of electricity derived from renewable energy with fuel-fired equipment.

Project Manager: Navin Kumar

FlexCHP High-Efficiency Ultra-Clean Power and Steam Package

This innovative CHP package allows flexible steam production while meeting stringent California emission levels without a SCR system and across the full range of firing rates — achieving NO_X levels 50% below CARB limits. An installation in California operates with 84+% system efficiency and system emissions well below 9 ppm NO_X. UTD has provided long-term support, including efforts to apply the technology to broader application sizes (e.g. to 400 kW / 400 BHP).

Project Manager: David Cygan

Boostheat Thermal Compression Heat Pump

UTD researchers are collaborating with a European developer of a novel high-efficiency thermal compression-based heat pump technology, to help accelerate its potential introduction into North America. Leveraging global technology developments and partners can speed time to market for new technologies for end users, and help address key North American needs such as optimizing application with forced-air distribution systems, and potential integrated air conditioning capability.

Project Manager: Alex Fridlyand

TECHNOLOGY ADVANCEMENTS (continued)

Gas-Fired Warewasher

A gas-fired warewasher is being advanced in conjunction with a leading OEM. The estimated annual savings for restaurant, cafeteria, and other commercial food service operators is $1,100-$9,000 per warewasher (depending on size and type) while also saving energy and chemicals, when compared to electrically-heated warewashers that operate at lower temperature and thus require one-time use and environmental impact of chemicals.

Project Manager: Shawn Scott

Cost-Effective Compressor/Expander for Natural Gas and Hydrogen-fueled Vehicles

With UTD cost share and U.S. DOE funding, GTI Energy and the University of Texas, Austin developed a novel approach using a linear motor compressor with only one moving piston. The technology was recently scaled up to 50 SCFM capacity with UTD funding, and gas expansion applications are also being developed. The technology has the potential to significantly enhance CNG and H2 vehicle fueling operations.

Project Manager: Jason Stair

On-Demand Heat and Power System

This unique new technology has received a remarkable three rounds of funding from U.S. DOE ARPA-E, along with UTD and other co-funding support. This technology captures and stores renewable energy (or other resources, including waste heat), augments it with natural gas as needed, and delivers heat and power on-demand to commercial, industrial, and other users. The technology has been demonstrated at a pilot field installation in California.

Project Manager: David Cygan

SMTI Gas-fired Absorption Heat Pump Residential Water Heater

A field test of five prototype units of this efficient residential Gas-Fired Heat Pump Water Heater was successfully completed in Southern California during 2020, with support from CEC, UTD, SoCalGas and a prospective manufacturing partner. The unit has a projected Uniform Energy Factor (UEF) of 1.20-1.30 and ultra-low NOx emissions of ≤10 ng/J. Potential commercial production is being evaluated.

Project Manager: Paul Glanville

Energy Recovery Heat Exchanger

UTD researchers collaborated with CEC to demonstrate in California an advanced recuperator to increase energy efficiency at an aluminum die casting operation. Test results (independently audited) demonstrated 6-16% energy reduction. A technology transfer plan to introduce this technology from Europe to North America was developed to take next steps.

Project Manager: David Rue

Customized Affordable Retrofits of Building Envelopes and Mechanicals

Researchers are advancing a new technology that can rapidly integrate highly innovative building envelope improvements with next-generation HVAC equipment retrofits to reduce GHG emissions by >50%, while providing significant operating cost savings for and minimal disruption to homeowners, residents in income-eligible housing or multi-family buildings, and others.

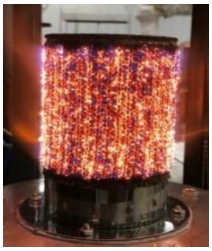
Project Manager: Jason LaFleur

TECHNOLOGY ADVANCEMENTS (continued)

HeatAmp Adsorption Thermal Heat Pump

The product development effort couples a proprietary triple-state sorption technology with a novel product design integration that is expected to yield a family of cost-effective, high-efficiency, robust appliances with few moving parts. Example applications are water heating or combination water/space heating. UTD is helping HeatAmp develop its new product with laboratory testing, validation, design recommendations, and a review of applicable N.A. engineering standards.

Project Manager: Paul Glanville



ThermoLift Ultra-High-Efficiency, Heating/Cooling Vuilleumier Cycle Heat Pump

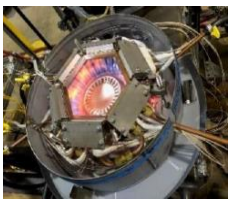
Vuilleumier cycle-based heat pumps could provide a step-change efficiency improvement over vapor absorption- or compression-based cycles, achieving cooling COP > 1 and heating COP > 2. UTD is working with a leading developer to advance key system components using both computational and experimental analysis, to help achieve performance goals in alpha prototype testing funded by DOE, UTD and others.

Project Manager: Alex Fridlyand

Next Generation Liquid Dessiccant-based, Heat-Driven HVAC System

Liquid desiccant-based systems can efficiently remove moisture from air and reduce the amount of mechanical energy and water required by conventional HVAC technologies that de-humidify, condition, and re-humidify space air. In cooperation with NYSERDA and others, UTD is testing a novel new non-corrosive, non-toxic desiccant in a gas-driven system that offers a potential 30% increase in COP on a seasonal basis over conventional HVAC technologies.

Project Manager: Rich Swierczyna



Self-Powered Water Heaters

Higher-efficiency water heaters typically require the added expense of an electrical connection and are susceptible to power outages unless a separate battery back-up system is installed. UTD researchers have assessed leading thermoelectric generator (TEG) technologies, and in 2023 are further analyzing opportunities in coordination with a major OEM to economically integrate TEGs and other technologies into a prototype water heater design.

Project Manager: Sandeep Alavandi

Emerging Fuel Cells

UTD researchers are experimentally testing and evaluating several fuel cells that are entering (or exploring entry into) the North American market in order to serve residential and light commercial end users. UTD research is also working to identify and optimize the applications that can maximize the benefit of the high efficiency and reliability of these units.

Project Manager: Tim Kingston

High-Efficiency Gas-Fired Thermal Vacuum Heat Pump for Food Processing

UTD partnered with CEC, SoCalGas, and others to demonstrate an innovative high-efficiency, thermal-vacuum, gas-fired heat pump technology for food drying applications at a commercial food processing company. It has the potential to be about twice as efficient as conventional processes. A prototype system at a field host site generated performance data during 2021. Other applications of this technology for agricultural applications are underway by UTD in 2023.

Project Manager: Dave Cygan

TECHNOLOGY ADVANCEMENTS (continued)

CNG/RNG Locomotive

With prime funding from U.S. DOE, UTD and other entities are funding the development of a prototype locomotive that can run on fossil or renewable natural gas to serve Class I, II or III railroads in multi-engine, line-haul service, but achieve Near Zero Emissions and target 20% less fuel consumption than a diesel locomotive. UTD's project partners include Cummins Inc.

Project Manager: Bart Sowa

Distributed RNG/Biogas Production

UTD is partnering with leading technology developers such as Chomp to increase renewable natural gas (RNG) or biogas production at end-use customer sites in order to reduce landfill requirements, reduce the transport of food waste, and meet de-carbonization goals. UTD is supporting technical advancements such as improved instrumentation and designs.

Project Manager: Travis Pyrzynski

High Efficiency Convection Oven

In partnership with a leading OEM, UTD researchers tested design changes and innovations to achieve a 10% efficiency improvement vs. best-in-class Energy Star convection ovens. By their inherent design, these ovens constantly flow hot air out of the oven. There are an estimated 650,000-700,000 convection ovens in the US, according at a 2015 DOE study.

Project Manager: Shawn Scott

Thermal Ejector Technology to Recover Energy and Water from Hot Flue Gases

In a field demonstration at a large industrial plant in California, UTD researchers partnered with CEC and a major manufacturer to apply a novel new thermal ejector technology which recovers useful process water from the plant's humid exhaust gas, which in turn increases energy efficiency. Discussions to install the technology at larger scale at other facilities are in progress.

Project Manager: Lee Van Dixhorn

Energy Recovery System for Brewing and Distilling Operations

UTD researchers are testing a novel heat exchange system to recover previously-wasted energy at two micro-breweries in California, with funding from UTD and prime funding from CEC. Project goals include to recover 15-25% of heat from brew kettles, and reduce CO2 emissions by up to 25%, while maintain superior process operations.

Project Manager: David Rue

Ionic Liquid Technology for Residential and Commercial Gas Heat Pumps

Researchers at the University of Florida and Micro Nano Technologies are partnering with UTD to design and demonstrate an early prototype of a low-cost, ultra-high-efficiency thermally-driven heat pump for residential and commercial water heating or combination water heating/space heating which employs the unique thermal properties of ionic liquids.

Project Manager: Paul Glanville

TECHNOLOGY ADVANCEMENTS (continued)

High Efficiency Commercial Clothes Dryer

An advanced natural-gas-fired commercial clothes dryer is being created and demonstrated at laboratory scale that has the potential to save at least 50% of the energy used in the commercial clothes drying sector. It is being developed in partnership with Oak Ridge National Laboratory and others, with financial support from U.S. DOE and UTD.

Project Manager: Dave Cygan

Next Generation Infrared Burner

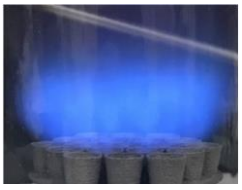
In partnership with a leading OEM, UTD-funded researchers are testing a variety of unique metal foam materials in a laboratory to evaluate their potential performance as next-generation, high-efficiency, rapid-response, low-emission infrared burners that are directly fired with fossil or renewable natural gas. Field tests are in development.

Project Manager: Sandeep Alavandi

Furnace Retrofit for High-Efficiency Heating and Humidification

Tests of a patented Transport Membrane Humidifier (TMH) technology in four homes in Minnesota demonstrated a 14% increase in furnace efficiency while providing humidification without water supply. Interested licensees should contact Rich Kooy at rich.kooy@utd-co.org.

Project Manager: Dexin Wang



Low NO_x Energy-Efficient Advanced 3D-Printed Nozzle Burner

A novel design for next-generation retention nozzles leverages new additive manufacturing capabilities and equipment. In 2023, UTD is evaluating applications for boilers, water heating and air heating. Laboratory tests have demonstrated a robust, high-efficiency (3-6% increase), ultra-low emissions burner, with >10:1 turndown. It achieved 50%-75% reduction in NO_X emissions compared to current burners, with the potential to reach <5 ppm NO_X.

Project Manager: Sandeep Alavandi

WORKING WITH PARTNERS TO CO-FUND UTD INITIATIVES

In 2022, each $1.00 in new UTD funding was leveraged by $4.8 of funding from government and industry partners for related end-use R&D. GTI Energy secured $15.1 million from federal and state government partners and $9.9 million from manufacturing partners and other gas industry resources (outside of UTD) for related end-use R&D. Manufacturing partners also provided significant additional in-kind co-funding.

Examples include:

- U.S. Department of Defense (DOD) funding of $8.1 million to apply advanced energy efficiency, renewable energy, microgrid, and hybrid technologies to reduce DOD GHG emissions and energy use while increasing resiliency.
- U.S. Department of Energy (DOE) funding of $2.3 million to develop and test novel technologies to achieve very high space heating efficiencies, and to advance hydrogen as a transportation fuel.
- California Energy Commission (CEC) funding of $3.7 million for new projects to advance hydrogen as a low carbon fuel for transportation, industrial, and large commercial customer applications.
- New York State Energy Research and Development Authority (NYSERDA) funding of $0.8 million to develop innovative insulation technologies to achieve deep energy building envelope retrofits.