



UTD IMPACT

September 2019



UTD creates and advances products, systems and technologies to save consumers money, save energy, integrate renewable energy with natural gas, and achieve safe, reliable, resilient end-user operation with superior environmental performance. The commercial products and technology developments shown here illustrate some of UTD's impacts and benefits for ratepayers, utilities, society, and our planet.

UTD's proven 15-year track record as a non-profit collaboration of utilities has directly impacted key energy and environmental issues. We thank the leading researchers, governmental agencies, and others who've partnered with UTD to make exciting impacts such as these highlights! 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 member companies serve more than 47 million natural gas customers in the Americas and Europe.

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

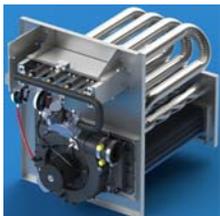


Dedicated Outside Air System/Rooftop Unit

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

COMMERCIALIZED PRODUCTS (continued)



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 new energy-efficiency option for the North American market by combining heat recovery with simultaneous heating and cooling. In a 2018-19 field test, UTD is validating the quantitative and qualitative performance of an instrumented installation.

YANMAR America Corp.

Mike Mehrvarz
770-877-7709
mike_mehrvarz@yanmar-es.com
www.yanmar-es.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 peak and total electric demand. Also available are 8- and 15-ton GHPs with VRF multizone capabilities. More than 700 units have been sold in the North America. UTD's field studies are supporting best practices for siting.

Blue Mountain Energy

Tom Young
702-339-7395
tyoung@bluemountainenergy.com
www.bluemountainenergy.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. In 2018, UTD completed a field test in Utah to further validate energy savings.

Boilerroom Equipment, Inc.

866-666-8977
www.heatsponge.com



M-Trigen PowerAire

M-Trigen's PowerAire unit provides high-efficiency microCHP with integrated cooling to homeowners, small businesses, and other users. In 2019, UTD is providing technical support for a notable demonstration and also partnering with NYSERDA, NJNG, and PERC to independently validate performance.

M-Trigen

Kevin Robert
713-574-4506 x1018
kevinr@mtrigen.com
www.mtrigen.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



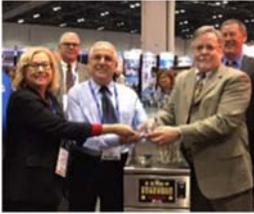
S.U.N. Equinox Solar-Assisted Heating System

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 is capable of meeting 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
tblade@solarusagenow.com
www.solarusagenow.com

COMMERCIALIZED PRODUCTS (continued)



ENERGY STAR® Fryers

In 2019 Royal Range introduced the high-efficiency RHEF-75 fryer - - 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 in 2017. 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

Linda Brugler
318-866-2488
lbrugler@frymaster.com
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@mfi.com
www.mfi.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. Developed with UTD support, it was commercially introduced by UTD partner CMR Group in 2019.

CMR Group

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

COMMERCIALIZED PRODUCTS (continued)



B6.7N

Cummins Westport 6.7L Medium-Duty NGV Engine

In December 2016, Cummins Westport Inc. began full commercial production of this 6.7-liter, 240-HP, medium-duty, factory-built, dedicated natural gas vehicle (NGV) engine for school bus, shuttle bus, medium-duty truck, and vocational uses. It meets U.S. 2017 EPA GHG requirements and CARB's optional more stringent low NO_x standard of 0.1 g/bhp-hr.

Cummins Westport Inc.

Stephen Ptucha
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sptucha@westport.com
www.cumminswestport.com



LSN

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.

Stephen Ptucha
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sptucha@westport.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.

Stephen Ptucha
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sptucha@westport.com
www.cumminswestport.com



HyperComp/3M NGV Cylinders

These lightweight Type IV NGV cylinders are manufactured using advanced 3M nanoparticle-enhanced matrix resin technology for high strength and durability. Three tank sizes of 30, 40, and 45 diesel gallon equivalent (DGE) are now offered in nine unique CNG Fuel System Solutions from Momentum Fuel Technologies, including roof mount, saddle mount, and back-of-cab designs.

Momentum Fuel Technologies

844-264-8265
www.momentumfueltechnologies.com



Ultimate CNG FuelMule™

The patented FuelMule™ mobile fueling solution dispenses eight diesel gallon equivalent per minute and fuels 35-50 medium-duty vehicles per delivery. It is used as a temporary starter station, station back-up, or for mobile onsite fueling. It logged 250,000+ miles and almost 6,000 compressor hours delivering natural gas fuel to vehicles across the U.S. in its first five years of operation.

Ultimate CNG, LLC

Dennis Pick
703-209-4086
dpick@ultimatecng.com
www.ultimatecng.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.

Arctic Solar Inc.

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

KEY INFORMATION & ANALYTICAL TOOLS



Reliability, Cost and Environmental Impacts of Standby Generation Systems

In 2017, Generac launched a website supported by UTD research that provides technical information on costs, emissions, and reliability for natural gas generators, including a white paper on natural gas reliability and a Total Cost of Ownership calculator that compares costs and emissions of natural gas vs. diesel-fueled standby generators. In 2018, UTD researchers also published a whitepaper that substantiated the high reliability of natural gas deliverability.

Available on-line 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>

Building America



Under five separate projects from 2011 to 2019, 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. Most recently a simplified combustion safety protocol was introduced.

Available on-line at <https://www.gti.energy/BuildingAmerica> and <https://bascc.pnnl.gov/library>



Commercial Foodservice (CFS) Equipment Calculator

Introduced in 2016, with UTD support, this website hosts CFS information and tools for the restaurant industry and others to determine the economic and environmental benefits of using new, more advanced commercial foodservice equipment. The website was showcased at several restaurant trade shows during 2017-19 and improvements are underway in 2019.

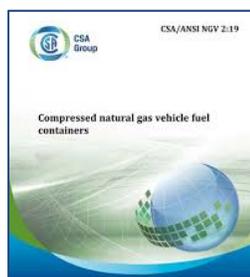
Available online at <http://cfscalculator.gastechology.org>. For more information, contact Frank Johnson; fjohnson@gti.energy



Virtual Test Home

A Virtual Test Home (VTH) in a laboratory is being expanded in 2019 with UTD's support. Leveraging the VTH, UTD has helped Navien and iFLOW demonstrate that an advanced forced-air condensing tankless water heater combi system can achieve 30-50% energy savings relative to best-in-class condensing furnaces and water heaters. The VTH is also developing data to help accelerate adoption of advanced gas technologies (such as GHPs, combis and modulating furnaces) in U.S. DOE's EnergyPlus™ and other energy software.

For more information, contact Tim Kingston; tkingston@gti.energy



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 online at www.csagroup.org. For more information, contact Ted Barnes; tbarnes@gti.energy

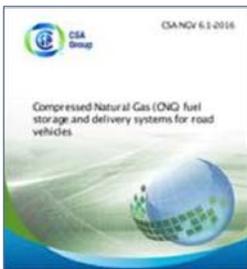
KEY INFORMATION & ANALYTICAL TOOLS (continued)



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

CSA NGV4.3 issued in 2018 and specifies the performance 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.

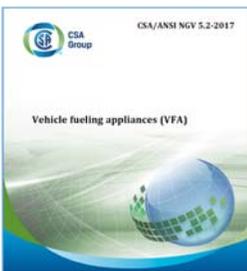
Available online at www.csagroup.org. For more information, contact Ted Barnes; tbarnes@gti.energy



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 GTI's participation on the Technical Committee.

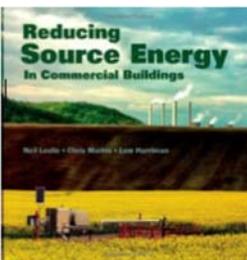
Available online at www.csagroup.org. For more information, contact Ted Barnes; tbarnes@gti.energy



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 online at www.csagroup.org. For more information, contact Ted Barnes; tbarnes@gti.energy



Source Energy Technical Data

Researchers are providing unbiased technical data on the benefits of source energy in reducing energy consumption and carbon emissions in buildings and transportation. Source energy is now included in the International Green Construction Code (IgCC) for high-performance commercial buildings, and in various American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) standards (e.g., Standard 100 for existing buildings, Standard 105 method for comparing building energy performance, Standard 189 for high-efficiency green buildings, and Standard 214 for building energy performance rating).

For more information, contact Neil Leslie; nleslie@gti.energy



Source Energy and Emissions Analysis Tool

The Source Energy and Emissions Analysis Tool (SEEAT) allows calculation of the source energy and greenhouse-gas emissions related to point-of-use (site) energy consumption by fuel type for each energy-consuming device. The source-energy and carbon-emission calculation methodology used accounts for primary energy consumption and related emissions for the full fuel cycle for residential and commercial buildings, industrial applications, and light-duty vehicles. SEEAT data is also used in the GTI-developed Energy Planning Analysis Tool (EPAT).

Available online at www.cmictools.com and www.epat.gastechology.org. For more information, contact Neil Leslie; nleslie@gti.energy

TECHNOLOGY ADVANCEMENTS



Gas-fired Absorption Heat Pump Residential Water Heater

The latest generation of this efficient residential Gas-Fired Heat Pump Water Heater, with a projected Uniform Energy Factor (UEF) of 1.20-1.30 and ultra-low NO_x emissions of ≤10 ng/J, is undergoing a five-unit field test with a prospective manufacturing partner in southern California, with support from CEC, UTD, SoCalGas and others. When commercially available, it will be the only residential water-heating technology with a source-energy-based EF ≥1.0.

Project Manager: Paul Glanville



Gas-fired Absorption Heat Pump for Space Heating or Commercial Water Heating

This Gas Absorption Heat Pump (GAHP) for space heating or water heating applications is undergoing a four-unit field test in WI and TN with prospective UTD manufacturing partner Trane and support from U.S. DOE, UTD and others. The GAHP has field-demonstrated an Annual Fuel Utilization Efficiency of 140%, with 45% gas savings, an estimated financial payback period of as low as three years, and ultra-low NO_x emissions of ≤14 ng/J. The GAHP demonstrated continued operation under extreme cold weather conditions in WI during the Jan-Feb 2019 Polar Vortex.

Project Manager: Paul Glanville



Ultra-Low NO_x Burner

This innovative firetube boiler technology has more than two 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. UTD's partner Power Flame Inc. is helping businesses in 2019 meet NO_x emission regulations without sacrificing energy efficiency.

Project Manager: David Cygan



Low NO_x Ribbon Burner System

A new low NO_x combustion system reduces NO_x emissions by 50% in food processing, thermoforming, and other industrial applications. The system was evaluated in bench-scale, pilot scale, and full-scale production settings and has demonstrated transparent operation at an industrial bakery in California. In 2019, post-demo monitoring will continue at the bakery is along with commercialization activities with UTD's partner Flynn Burner Corp.

Project Manager: Yaroslav Chudnovsky



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. A 2014 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 for broader application sizes (e.g. to 400 kW / 400 BHP).

Project Manager: David Cygan



Low NO_x Advanced 3D-Printed Nozzle Burner

A novel design for next-generation retention nozzles leverages new additive manufacturing capabilities and equipment. In 2019, UTD is evaluating technology licensing applications in boilers and air heating. Laboratory tests to date have demonstrated a robust, high-efficiency (3-6% increase), ultra-low emissions burner, and >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

TECHNOLOGY ADVANCEMENTS (continued)



Gas-Fired Warewasher

UTD is funding the laboratory development of a new prototype gas-fired warewasher. UTD project 1.18.B estimated annual savings of \$1,100-\$9,000 (depending on size and type) for restaurant, cafeteria, and other commercial food service operators - - while saving energy and chemicals - - and these results supported partnering discussions with warewasher manufacturers at the N.A. Association of Food Equipment Manufacturers in February 2019.

Project Manager: Shawn Scott



Cost-Effective Small-Scale Compressor for Natural Gas Vehicles (NGVs)

A cost-effective small-scale compressor could significantly change the NGV fueling market. With UTD cost share and U.S. DOE funding, GTI and the University of Texas, Austin (using specialty materials from Argonne National Laboratory) developed a novel approach using a linear motor with only one moving piston and operated a prototype successfully in the lab. The technology is currently being scaled up to 50 SCFM capacity with UTD funding.

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. In 2019, the technology is moving to a pilot field scale-up demonstration in California.

Project Manager: David Cygan



CARB-Compliant Engine-Based Micro-CHP System

UTD researchers are collaborating with the California Energy Commission and SoCalGas to advance and commercialize the first-ever engine-based micro-CHP system that complies with California Air Resource Board requirements. A system offered by a major manufacturer in an influential market like California could spark the U.S. micro-CHP market.

Project Manager: Tim Kingston



Low-NO_x Furnace

Low-NO_x combustion systems were developed in cooperation with SCAQMD and five residential furnace manufacturers to achieve emissions levels less than 14 ng/J. Innovative burner materials, including metal mesh and metal foam, were used to achieve even heat transfer and uniform flame temperatures. UTD completed durability testing in 2017.

Project Manager: Frank Johnson



ENERGY STAR Residential Gas Dryer

UTD worked with a major manufacturer to develop one of the first commercially-available gas-fired ENERGY STAR clothes dryers (included at energystar.gov/products/appliances/clothes_dryers). UTD is currently investigating next-generation technologies and developing an early-stage prototype residential gas dryer to substantially further increase operating efficiency.

Project Manager: Shawn Scott

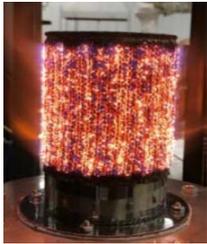
TECHNOLOGY ADVANCEMENTS (continued)



iGEN Self-Powered Furnace

The innovative new iGEN furnace generates its own electric power and contains an integrated battery, providing homeowners with continuous heating even during electricity outages. Initial units produce about 45 MBtu/hr and 1kW of power, with reported 95% heating system efficiency. UTD is supporting the technical refinement of this new product in 2019 with laboratory testing, validation, and recommendations.

Project Manager: Tim Kingston



Ultra-High-Efficiency, Combination 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 during 2018. UTD is funding additional research in 2019.

Project Manager: Alex Fridlyand



Next Generation Liquid Desiccant-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: Doug Kosar



Self-Powered Tankless Water Heater

Tankless water heaters yield higher levels of efficiency than storage-type water heaters but 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 2019, are analyzing opportunities to economically integrate TEG and other technologies into a prototype water heater design.

Project Manager: Aleks Kozlov



Low NOx, High-Efficiency Burners for Commercial Food Service Equipment

UTD is helping manufacturers respond to pending new regulations on NOx emissions of CFS equipment and simultaneously improve energy efficiency by developing and demonstrating prototype equipment that uses advanced burner concepts or components. Both novel new burner configurations as well as state-of-the-art burner technologies are being evaluated.

Project Manager: Frank Johnson



High-Efficiency Gas-Fired Rotary Heat Pump for Food Processing

UTD is partnering 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. The new technology has the potential to be about twice as efficient as conventional processes. A prototype system at a field host site will generate performance data during 2019.

Project Manager: Yaroslav Chudnovsky

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: Yaroslav Chudnovsky



Next Generation Infrared Burner

In partnership with a leading U.S.-based product manufacturer, 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 natural gas.

Project Manager: Sandeep Alavandi



Residential Furnace Retrofit for High-Efficiency Heating and Humidification

December 2017, results of the novel Transport Membrane Humidifier (TMH) in four homes in Minnesota demonstrated a 14% increase in furnace efficiency while providing humidification without water supply. Discussions with potential licensees are in progress.

Project Manager: Dexin Wang



Advanced Combustion System for Next Generation mCHP

An advanced combustion system with thermochemical heat recovery has been created and demonstrated with UTD's support in a laboratory. Applying the system to a Stirling-based micro-CHP system can increase fuel-to-electric efficiency from 12-15% to 30%. Testing in 2019 demonstrated low NOx and CO emissions at ≤ 9 ppm (at 3% O₂, dry).

Project Managers: Dave Kalensky and Aleks Kozlov

WORKING WITH PARTNERS TO CO-FUND UTD INITIATIVES

In 2018, each \$1.00 in new UTD funding was leveraged by \$5.1 of direct funding from government and industry partners for related end-use R&D. GTI secured \$21.9 million from federal and state government partners and \$5.2 million in funding from manufacturing partners and other gas industry resources (outside of UTD). Manufacturing partners also provided significant, additional in-kind co-funding. Examples include:

- > California Energy Commission (CEC) funding of three new projects totaling \$4.4 million. Efforts include new NGV vehicle drivetrain, natural gas/renewable solar systems for industrial applications, and micro CHP systems.
- > California Air Resources Board (CARB) funding of \$5.1 million for advanced low-emission vehicle demonstrations.
- > U.S. Department of Energy (DOE) funding of \$0.8 million for advanced vehicle and power system R&D.
- > U.S. Department of Defense (DOD) funding of \$11 million to demonstrate new natural gas energy efficiency and resiliency technology at military facilities.
- > More than \$4.4 million in other gas industry funding for a range of emerging technology efforts aiming to support the evaluation of commercial readiness of new higher-efficiency natural gas technologies.