

Process Commercialization:

# The 2021 Kirkpatrick Chemical Engineering Achievement Award

## IN BRIEF

HALDOR TOPSOE

BQE WATER

DOW DEUTSCHLAND

DOW INDUSTRIAL  
INTERMEDIATES &  
INFRASTRUCTURE

SAPPHIRE  
TECHNOLOGIES

To honor the efforts of those chemical engineers and their companies that have successfully commercialized a new process for the first time, *Chemical Engineering* magazine has been bestowing its Kirkpatrick Chemical Engineering Achievement Award since 1933.

The aim of the Award is to recognize and honor the most noteworthy chemical-engineering technology commercialized anywhere in the world during the two years prior to a given award year. The results for the 2021 Kirkpatrick Chemical Engineering Achievement Award are as follows:

### Winning Award

- Haldor Topsoe A/S (Lyngby, Denmark; [www.topsoe.com](http://www.topsoe.com)), for its hydrotreating catalyst TK-6001 HySwell (Figure 1)

### Honor Awards

- BQE Water (Vancouver, BC, Canada; [www.bqewater.com](http://www.bqewater.com)): Selen-IX Technology
- Dow Deutschland Anlagengesellschaft mbH (Walsrode, Germany; [www.dow.com](http://www.dow.com)): Walocel Cellulose-Ether Product
- Dow Industrial Intermediates & Infrastructure (Midland, Mich.; [www.dow.com](http://www.dow.com)): Syntegra Solvent-Free PU Dispersion
- Sapphire Technologies (Cerritos, Calif.; [www.sapphiretechnologies.com](http://www.sapphiretechnologies.com)): FreeSpin Turboexpander Generator

These companies join the long and distinguished roster of past winners, which includes such milestones as LanzaTech for Emissions-to-Ethanol Fermentation Technology (2019); CB&I and Albemarle Corp. (2017), for the AlkyClean process — the world's first solid catalyst alkylation process; Lucite International for its Alpha process for making methyl methacrylate (2009); Cargill Dow LLC for its production of thermo-

plastic resin from corn (2003); Monsanto hollow-fiber membranes for gas separation (1981); Union Carbide low-pressure low-density polyethylene (1979); M.W. Kellogg single-train ammonia plants (1967); the U.S. synthetic rubber industry (1943); and Standard Oil Development Co. aviation fuels (1939). A complete list of all past winners can be found at: [www.chemengonline.com/kirkpatrick-award](http://www.chemengonline.com/kirkpatrick-award).



Although the staff of *Chemical Engineering* organizes and bestows the award, neither the editors nor others associated with the magazine play any role in the selection or judging of the winner. Instead, the winner is selected by a Board of Judges (BOJ) comprised of current chairs of chemical engineering departments at accredited U.S. and E.U. universities (box below). The members of the BOJ are, in turn, selected by chemical engineering department chairs of accredited U.S. and E.U. universities. It is this unbiased selection process, combined with a more than 88-year tradition that makes the Kirkpatrick Award one of the most prestigious honors that a chemical process industries (CPI) company can receive.

This article presents more details about the process technologies honored in 2021.

## 2021 BOARD OF JUDGES

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## WINNING ACHIEVEMENT

### Haldor Topsoe: TK-6001 HySwell™ catalyst

Today, petroleum refiners globally must comply with ultra-low sulfur fuel legislation, and for commercial reasons, they aim to maximize production of gasoline, jet and diesel fuels. This results in tremendous demand for absolute top-tier nickel and molybdenum-based catalyst (NiMo) for ultra-low sulfur diesel (ULSD) or hydrocracker pretreat reactors.

Another driver is the availability of low-cost hydrogen. When catalytically added to middle distillate fractions, hydrogen increases the liquid volume swell and produces higher volumetric yields of valuable products. Consequently, a catalyst that maximizes hydrogen uptake into hydrocarbon streams becomes desirable. Particularly, a NiMo catalyst has high activity for such a mechanism.

Petroleum refiners need catalysts with the highest possible activity. Despite the tremendous improvements in catalyst technology over the past 20–30 years, refiners are still looking for the absolute best NiMo catalyst for their ULSD or hydrocracker pretreat reactors.

So far, only unsupported catalysts have had the required activity. However, unsupported catalysts are very costly and cannot be regenerated. With these factors in mind, Topsoe decided to develop an alumina-supported catalyst to deliver the required activity — the HySwell catalyst family.

Specifically, alumina-based hydrotreating catalysts will help minimize the operating cost when targeting volume swell. Furthermore, HySwell catalysts can be regenerated, and they utilize the active metals better, which drives down cost compared to bulk-metal catalyst formulations. This is clearly more sustainable. A target activity improvement compared to standard catalysts was set to 5–7°C, which is equal to 15–20%.

**How it was done.** By employing advanced microscopy, Topsoe researchers discovered how unique catalyst preparation techniques influence catalytic functions at the atomic scale. This led to the development of an improved alumina

pore structure and optimization of the interaction between the active metals and the alumina support. As a result, Topsoe devised very active and stable CoMo/NiMo catalyst formulations.

The HySwell technology exploits this combination of higher concentration of active metals and optimized interaction to the highest degree yet. This unique technology combines the earlier BRIM and HyBRIM technologies with a new proprietary catalyst preparation step. As a result, it substantially increases the activity of both direct desulfurization/denitrogenation and hydrogenation sites without compromising catalyst stability.

In 1984, Topsoe's pioneering researchers, led by Dr. Henrik Topsøe, published results showing that there was a modified Co-Mo-S structure with substantially higher activity per active site than traditional Co-Mo-S structures. The two structures were called Type I and Type II sites.

In the early 2000s, Topsoe's commitment to fundamental research in surface science paid off again, and a new activity site was discovered: the BRIM site. Using scanning tunneling electron microscopy (STM), researchers visualized these new activity sites and have been able to elucidate the catalytic mechanisms taking place.

The BRIM sites are located close to the edges on top of the Co-Mo-S (or Ni-Mo-S) slab structures. Here, the BRIM sites act, being metallic in nature, with the  $\pi$ -electron clouds of the organo-sulfur reactants. This interaction draws the most difficult sulfur molecules in for the initial hydrogenation step, enhancing their ability to further interact with the nearby Type II sulfur vacancies.

Topsoe's HyBRIM technology was commercialized in 2013. It includes an improved production technique in which the BRIM technology is combined with a proprietary catalyst preparation step. This technique ensures better dispersion of active components on the surface of the support along with optimized metal-support interactions. Together, they



**FIGURE 1.** Shown here is the winning team from Haldor Topsoe: Anders Bo Jensen, product line director; Lars Pilsgaard Hansen, principal scientist; Per Zeuthen, senior director; Magnus Magnusson, principal scientist; Frank Bartnik Johansson, R&D director

facilitate both the formation of more active Type II sites and promote higher dispersion of the molybdenum slabs of Mo/Ni (Mo/Co).

Yet another step increase in activity is obtained through HySwell, which involves an improved production technique for NiMo hydrotreating catalysts. It combines the BRIM and HyBRIM technologies with a proprietary catalyst preparation step. Merging previous technologies with novel atomic-level insights enabled Topsoe to design a metal slab structure characterized by an optimal interaction between the active metal structures of even higher concentrations and the catalyst carrier. The activity of the Type II sites is positively influenced by the improved metal-support interaction.

HySwell technology exploits this combination of a much higher concentration of active metals and, in turn, a better Ni promotion of the sulfided molybdenum slabs through the optimized interaction. Thus, the activity of both direct desulfurization/denitrogenation and hydrogenation sites are substantially increased, without compromising catalyst stability. Ultimately, this increases both the hydrodesulfurization (HDS) and hydrodenitrogenation (HDN) performance of the catalyst.

**Commercial production.** During the catalyst development, and prior to the production at commercial scale, all the experimental catalysts have been tested and evaluated by use of advanced pilot plants, and products have been analyzed using cutting-edge analytical tools. After developing a successful and stable catalyst recipe, it was decided to

perform a commercial scale test involving production of typically 10–20 tons of catalyst. After just one well-planned test production at Topsoe's plant in Bayport, Tex., the company decided to commercialize this new high-performing catalyst.

Topsoe manufactures its own pseudo-böhmite, which is the raw material for the alumina support. This allows full control of the entire manufacturing process and coupled with tight quality control in manufacturing, it enables Topsoe to achieve the desired catalyst performance.

Since it was launched in 2019, Topsoe has achieved ten sales, with several already installed and performing excellently, according to the company. The TK-6001 HySwell has delivered up to an impressive 17°C improvement compared to the previous catalyst in a commercial unit.

## HONOR ACHIEVEMENT BQE Water Selen-IX™ process

Responding to growing environmental issues associated with selenium pollution in the mining industry, BQE Water developed the Selen-IX technology as an industry-specific solution to manage the selenate form of selenium in wastewater. While selenium can be present in many chemical forms, selenate is the most prevalent and most difficult to remove.

Commercialized in 2020, Selen-IX represents a disruption in selenate treatment dominated by biological reduction systems by offering capabilities other systems cannot. Specifically, Selen-IX can:

- Meet end-of-pipe selenium limits <2 ppb without reliance on dilution
- Produce stable inorganic solid residue with off-take potential
- Remove selenate “selectively” from wastewater containing a cocktail of ions without adding any chemical reagent or constituent to the water that was not previously present
- Remove selenate without transforming any part of it into a more bioavailable form of selenium such as organo-selenium or selenocyanate
- Adjust rapidly to fluctuations in feed water flow and composition
- Operate intermittently with instant ramp up/down regardless of feed



**FIGURE 2.** Shown here are the ion-exchange columns of the first industrial-scale Selen-IX plant

water temperatures

**The Selen-IX process.** The novelty underlying Selen-IX is the unique integration of ion exchange (IX) and electro-reduction (ERC) to remove selenate to levels well below North American selenium regulations that currently range from 1 to 10 parts per billion (ppb), while also eliminating the generation of a liquid brine waste that is associated with conventional IX and membrane treatments. A U.S. patent for Selen-IX was issued in 2018.

Selen-IX is comprised of two main unit processes. In the IX part of Selen-IX, non-selective strong base anion resins are used to selectively capture selenate from influent to produce regulatory compliant effluent for discharge into the environment. Once saturated with selenium, brine is used to elute selenium from the resin to enable its re-use in subsequent cycles, similar to conventional IX. A compelling feature of Selen-IX is the recycling of brine through ERC treatment. Recycling eliminates liquid waste typical of conventional IX and imparts selectivity to resins that are otherwise non-selective.

The purpose of the ERC process is to remove selenate from the brine down to levels enabling the brine to be re-used in the IX and to fix the selenium into stable non-toxic solids. At the heart of the ERC is an electrochemical cell that features a sacrificial iron anode similar to electrocoagulation (EC). However, unlike conventional EC that releases iron into solution to co-precipitate metals and metalloids without changing their valence, the ERC changes the selenium oxidation state from +6 to 0 to create a solid matrix that gives stability to Selen-IX solids with minimal risk of selenium re-release.

## Development timeline.

Development of Selen-IX began in 2012 at a bench scale in BQE Water's laboratory in Vancouver, Canada. Promising results garnered the attention of a coal producer. In 2013 a mobile pilot plant was constructed and the first pilot campaign to remove selenate from coal process waters was carried out.

This project successfully achieved the objective of producing effluent containing <5 ppb selenium.

Further bench-scale development took place in 2014, followed by a second pilot campaign for a gold project in development. Selenium contamination of water was recognized as a key issue in the permitting of the project. Results of the pilot demonstrated selenium removal to <1 ppb and enabled the mine owner to satisfy an integral condition of their environmental assessment certificate.

A third and final pilot was completed at the end of 2015 for a copper and gold project. As part of the permitting requirements, Selen-IX was piloted to demonstrate the removal of selenium from mine water to <1 ppb. The results were in compliance with the site-specific regulations and enabled the mine owner to secure the necessary environmental permits to advance their project.

Throughout the many bench- and pilot-scale testing campaigns, progressively better process efficiencies were achieved which had the positive impact of reducing capital and operating costs for Selen-IX while producing effluent containing <1 ppb selenium.

**Inaugural Selen-IX Plant.** After the positive results from their pilot and the success of the industrial demonstration project, the copper and gold client made the decision to proceed with a full-scale Selen-IX plant (Figure 2). Located in Northern British Columbia, the capabilities of Selen-IX are perfectly suited for the requirements and conditions of this remote mine site where selenate is the main contaminant of concern.

Specifically, provincial regulators applied a <2 ppb end-of-pipe discharge limit for selenium. Due to its

northern location, large flows of cold water will require treatment seasonally. This necessitates a robust system with predictable operation and minimal upsets that can offer quick ramp-up following the spring freshet and quick turn-down prior to the freeze-up of water in fall.

Construction of the 1,000 gal/min capacity Selen-IX plant was substantially completed in fall 2019 but freezing temperatures delayed commissioning to spring 2020. Performance testing of the plant concluded in September 2020 and from there, the plant operated continuously at the maximum design flow, where it met performance expectations and produced effluent containing <2 ppb selenium.

## HONOR ACHIEVEMENT

### Dow Deutschland: Walocel™ M120-01

Cellulose ethers are vital additives for dry mortar cementitious-tile adhesives, because they help ensure mortars retain water, which is required for durable bonding between tile and substrate. The water-retention efficiency improves with increasing solution viscosity, which scales with polymer molecular weight. To be economical, the cellulose used to synthesize the polymer is preferably pulp from wood sources and thus the polymer chain length is limited by nature.

Launched in 2020, Walocel M120-01 Cellulose Ether is the first scaled commercial product obtained by long-chain branching. Overcoming nature's limitations in molecular weight is a step-change innovation compared to standard cellulose ethers, enabling dosage reduction in mortars by up to 25% without compromising performance.

**Production process.** Walocel cellulose-ether production involves cellulose grinding, batch-wise etherification, purification with hot water, drying and milling (Figure 3). Etherification of the cellulose is a three-phase heterogeneous reaction of cellulose, where surface area, solid-liquid volume ratio, and mixing speed are critically important. As the target was to long chain branch the high-molecular-weight cellulose

chains without causing significant gelation, new process technology was needed. The challenge during the product development was to introduce the crosslinker into a well-established process and achieve its homogenous distribution resulting in high reaction yield and optimized batch run rates.

From polymer science literature it was known that long-chain branching reactions are probabilistic processes dependent on crosslinker concentration, crosslinker end-group reaction kinetics, and the parent polymer molecular weight distribution. The key is to promote the probability of a single graft between two parent chains versus other outcomes. While the simplest modeling conclusion is to use a very dilute crosslinker concentration, this does neither comprehend the myriad possible outcomes nor ensure a successful process or a viable production window.

**Scaleup.** After successful testing of first laboratory-scale high-molecular-weight prototypes, systematic process investigation focused on key reaction engineering variables started. At laboratory scale, dilute additions can be supported by high shear mixing rates; at production scale, this option is not possible. At laboratory scale, heats of reaction are more easily managed as the vessel surface area to volume ratio is large compared to production scale. Managing reaction heat and reaction pathways, while not significantly reducing run rates, is much more challenging. Other approaches to maximize crosslinker dispersion needed to be developed using analytical tools that enabled following post-reaction outcome versus process parameters. These efforts demonstrated a viable production process window that delivers water-soluble cellulose ethers confirmed by systematic in-house and users' mortars application tests.

Production-plant-scale implementation of Walocel M120-01 Cellulose Ether required design and

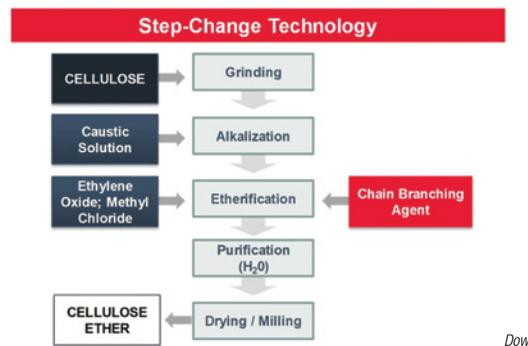


FIGURE 3. The production steps for producing Walocel cellulose-ether are shown here

installation of a tailor-made dosage system and changes to mixing speed and reactor solid-liquid volume ratios. The need for homogenous distribution of reactants in the heterogeneous reaction mixture and process safety requirements also impacted the design.

The combination of spray-nozzle design, understanding of the mixing behavior inside the ploughshare reactor depending on the filling level and swelling behavior of cellulose raw material during the process, process automation strategy and the measurement instrumentation were key engineering parameters for a successful and reproducible process development on plant scale. Without negative impact on the reaction itself, as well as the reaction temperature profile, the controlled crosslinking step using a bifunctional diglycidyl ether could be successfully added into the high-quality and highly cost-optimized cellulose ether reaction process.

The production of Walocel M120-01 Cellulose Ether required addition of a new reactive substance to an existing reaction process. Because cellulose ethers are produced under pressure and the final product is water washed to remove byproducts from etherification, any new reactant must be thoroughly studied for both reaction and environmental safety. To ensure the highest level of process safety, a stepwise process development combined with a structured management of change (MOC) process was applied. Once identified, suitable substance classes with low chemical hazards were evaluated in cooperation with Dow's Reactive Chemicals group

prior to laboratory-scale process development. Beginning with low crosslinker addition, the impact on the reaction was monitored for heat of reaction and byproducts.

The commercial-scale production of Walocel M120-01 Cellulose Ether has been running without incident since 2019 at a sold-out scenario of the production assets. So, the new process implementation required a tight implementation batch schedule as well as a low-risk approach to help minimize off-specification production.

## HONOR ACHIEVEMENT Dow Polyurethanes Syntegra™ PU Dispersion

Due to its similarities with actual leather, microfiber leather has become the dominant replacement material for genuine leather in recent years. However, current processes for making microfiber leather have severe deficiencies. Syntegra Waterborne Polyurethane (PU) Dispersions are solvent-free dispersions that achieve high performance with an excellent sustainability profile. Microfiber leather manufacturers can use Syntegra Waterborne Polyurethane Dispersions in their existing processes to produce the most sustainable, high-quality microfiber leather available.

Presently, the most commonly used process of microfiber leather production is based on the polyurethane-in-dimethylformamide (DMF) solution approach. First, the pre-fabricated nonwoven sheet is impregnated into 25–35% PU-in-DMF solution, followed by washing with DMF-water mixtures to reduce the DMF content and microcellular structure generation. Then the formed intermediate sheet will be washed by toluene or sodium hydroxide aqueous solution to remove unnecessary fiber components to generate the “micro” fiber structure. Finally, the microfiber leather will be finished by drying. In the whole procedure, DMF is used due to its low viscosity, easy processability and porous structure generation.

However, DMF is classified as a Substance of Very High Concern by the European Chemicals Agency. The ZDHC (Zero Discharge of Hazardous Chemicals) has set proac-

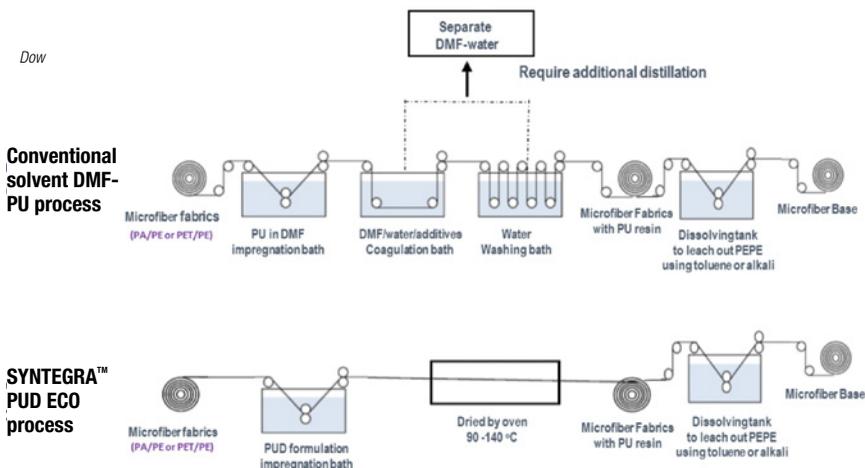


FIGURE 4. The waterborne PU dispersion process by Dow Syntegra YF4000 PUD is much simpler than the DMF-PU process. DMF-PU processes are easily retrofitted for Syntegra

tive goals to reduce DMF use in the leather industry for the coming years.

Aqueous polyurethane dispersions (PUD) are regarded as one of the most promising eco-friendly solutions for DMF replacement. These realize a low viscosity and a high PU resin content system by dispersing the PU particles into water. However, the synthetic leather industry is still facing technical challenges associated with PUD microfiber fabrication. Generating “leather-like” haptics is very challenging with a good chemical resistant PUD.

In response to these technical challenges, Dow developed and commercialized Syntegra YF4000 PUD for waterborne microfiber leather fabrication, as well as its post-formulation and process for good haptics microfiber leather. These dispersions are generated using Dow’s patented Bluewave technology. Synthetic leather can be designed by varying the PU polymer structure to create a cost-effective product with excellent chemical resistance. Bluewave technology, utilizing a process intensive continuous dispersing device, generates an easy-to-disperse product without using organic solvents. The final PUD product has a high solid content (>54%), which saves shipping costs (reduces the transportation of water and packaging sizes), conserves energy and reduces the overall carbon footprint for the product. Additionally, Syntegra lends itself to be easily implemented with a simple retrofit of existing solvent-

based processes (Figure 4).

In a conventional DMF-PU process, there is one DMF-PU tank for resin impregnation and several DMF-water tanks for washing and an additional DMF-water distillation step needed to separate DMF and water. With Dow’s waterborne process, only a single impregnation PUD tank is needed, followed with a drying oven to remove the water. Since the impregnation tank and oven are already installed in most synthetic leather factories, no new design or capital investments are required to implement Dow’s new technology.

### Mechanical dispersing process.

Dow’s proprietary Bluewave Mechanical Dispersing Process is the foundational technology needed to create the emulsified polyether-based PUD. Bluewave technology utilizes the high-internal-phase emulsion (HIPE) mechanism to generate sub-micron polyurethane particles using a surfactant that is effective without an organic solvent. With accurate metering of the PU prepolymer, surfactant and water into a novel rotor/stator in-line mixer, a well-defined particle size distribution can be generated. Within the same rotor/stator, reaction of these particles with an amine chain extender allows tailoring of the physical properties of the PUD. Finally, water is injected within this novel rotor/stator to break up and dilute the HIPE to the desired final solids level. This compact and efficient process generates the PUD continuously with particle formation, reaction and dilution steps occurring within seconds.

**Scale-up and production.** The Syntegra PUD family was commercially launched in microfiber applications in 2020, which has total addressable market of 300,000 metric tons (m.t.) in China.

## HONOR ACHIEVEMENT Sapphire Technologies: FreeSpin turboexpander

Sapphire Technologies, a subsidiary of Calnetix Technologies, has brought to market an axial flow-through, magnetic bearing, turboexpander generator (Figure 5) for pressure reduction energy recovery. The FreeSpin In-line Turboexpander (FIT) generator offsets carbon emissions and improves the transmission efficiency of natural gas pipelines by recovering high-pressure energy at pressure reduction stations (PRSs) and converting it into electricity. A single unit can offset up to 1,200 tons of CO<sub>2</sub>-equivalent (CO<sub>2</sub>e) emissions and generate 2.5GW of power per year. Market barriers of entry for this technology have been brought down by this invention for its small footprint, non-contact operation (magnetic bearings), zero maintenance, hermetic sealing and minimized capital cost.

Natural gas pipelines consume energy by compressing natural gas for high density, high efficiency transport. A significant portion of upstream compressor energy consumption is recoverable through a turboexpander generator downstream. Expansion downstream is achieved through a Joule-Thomson (JT) valve, providing an adiabatic pressure drop for the gas. To prevent pipeline freezing from the JT effect, gas pre-heating is implemented upstream from decompression to raise the gas temperature before JT expansion, an energy-consuming process. Instead of losing pressure reduction and heating energy to the environment, the turboexpander generator recovers the energy by reduction of pressure and enthalpy.

Sapphire's FIT uses a radial inflow expansion wheel to convert the gas stream energy into rotating energy and then transmits the energy to the permanent-magnet rotor. The generator then converts the rota-



**FIGURE 5.** Shown here is Sapphire's FreeSpin In-line Turboexpander (FIT) system

tional energy into electricity that is transmitted to the variable-speed drive (VSD). The VSD conditions the electricity to match the voltage and frequency of the local grid. The produced electricity can then be used to offset facility electrical burden or for sale to the local electric utility.

In August 2019, outside of Bologna, Italy, a partnership between BHGE Nuovo Pignone and Calnetix in the installation of first turboexpander generator at a natural gas PRS was the basis for forming Sapphire Technologies. This installation proved successful, producing 95% of the designed power generation. The installation paired a transcritical CO<sub>2</sub> heat pump for gas pre-heating instead of a natural gas boiler, further increasing the system efficiency. In February 2021, the second and third FIT systems were installed at a PRS in Japan with a Japanese gas utility within 1 week of delivery, proving the ease of hardware installation.

An estimated 5,000 natural gas pipeline PRSs exist in the U.S. alone, all with the capability of FIT installation. These PRSs have the capability to produce power from several hundred watts up to several megawatts. Assuming a single FIT is installed at each of these stations, 12,500 GW of power can be recovered or 6M tons of CO<sub>2</sub>e emissions reduced. That's enough power for 1.17M U.S. homes, according to the U.S. Energy Information Admin. (EIA) 2019 average residential home annual power consumption, or to convert 370,000 people to net-zero CO<sub>2</sub>e emissions per year according to "Our World In Data 2019" carbon footprint report.

With applicability to hydrogen and other compressed gases, the FIT will play a key role in maximizing efficiency of consumer gas energy consump-

tion and reduction of CO<sub>2</sub> emissions.

**Commercial implementation.** In 2019, Calnetix and BHGE Nuovo Pignone commissioned a 300kW turboexpander generator designed to recover energy during pressure let down at a city gate station outside of Bologna, Italy. Calnetix provided the active magnetic bearing system, PM generator, and power electronics while BHGE provided the turboexpander housing, aerodynamic section, and skid. This was the first natural gas turboexpander project that sparked the interest in developing a product.

From 2019 to 2021, amidst the pandemic, Sapphire completed the development, building and deployment of the first FIT units to be installed at a LNG terminal station in Nagoya, Japan. Two units are currently being commissioned: a 125 kW and a 280 kW, in parallel, producing a total of 405 kW.

During the development of the first FIT systems, Sapphire Technologies was established with the intent of delivering pressure to power solutions for the pressure reduction industry. Backed by Calnetix engineering and 80+ patented technologies, Sapphire's FIT product is poised to provide a safe and reliable turboexpander product for a broad scope of pressure let down applications.

The FIT provides a way to capture the energy lost in pressure reduction. The FIT generator extracts kinetic energy from the pressure reduction and allows for the generation of electricity with no added pollution.

The FIT consists of a high-performance, high-speed permanent-magnet generator with an integrated radial in-flow expansion turbine and low-loss active magnetic bearings (AMBs). The FIT is designed to have the process gas flow through the system, which cools the generator section and eliminates the need for auxiliary cooling equipment. The power electronics for FIT combine the variable speed drive (VSD) and magnetic bearing controller (MBC) into one cabinet. The VSD allows for a consistent and clean delivery of generated power from the FIT to the grid.

*Edited by Gerald Ondrey*