SBIR·STTR America's Seed Fund

U.S. DEPARTMENT OF ENERGY | SBIR/STTR Programs Office

"We put the fuel in fuel cells®." That's a Precision Combustion, Inc. (PCI) vision. PCI is developing compact and efficient fuel processors allowing fuel cells to use conventional fuels. For high efficiency Solid Oxide Fuel Cells (SOFCs) in particular, PCI's Microlith® autothermal reformer (ATR) converts diesel, biofuel, gasoline or natural gas into the high hydrogen content syngas mixtures that fuel the SOFCs, while also removing sulfur. The fuel diversity broadens the market for fuel cells. PCI has built on its ATR breakthrough to develop other fuel processors for multiple applications, achieving SBIR Phase III successes for mobile and stationary fuel cells, military gensets, and IC engine improvements in efficiency and emissions. It all started with the SBIR program.

FACTS

PHASE III SUCCESS
Following a DOE SBIR Phase I & II and consequent development of a fuel processor for SOFCs, PCI received multiple contracts from DoD, ARPA-E and private industry, for a total of over $30M in post SBIR funding.

IMPACT
Leveraging the company's own core knowledge in the areas of catalysis and sorbents, PCI has developed a fuel reformer that enables SOFCs to operate with diesel and other conventional fuels.

DOE PROGRAM/OFFICE
Office of Fossil Energy (FE)

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PCI's original breakthrough was a new design for a catalytic reactor that enhances heat and mass transfer by avoiding the buildup of boundary layers in the reactor. PCI does this using a wire-mesh substrate and other features that substantially boost the rate at which both heat and reactants (fuel and oxidants) reach and leave the catalytic surface, together with innovative system design. The result is the ability to operate at high selectivity and efficiency in a much smaller reactor with rapid transient response and more uniform internal temperature and mixing for longer life. The greater mass transfer rate also reduces the amount of expensive catalyst that is needed.

The higher rate at which the ingoing gas contacts the catalyst makes it possible to use much smaller reformers with the same reaction rate of larger reactors, lowering costs, which is particularly suitable for mobile applications. PCI has built an ATR that is 1 cubic foot for a 250 kWe fuel cell; ATR reformers for smaller fuel cells range down to coke can size. Improved heat transfer and the smaller size mean faster startup and load changes, within seconds compared to minutes for conventional reformers. The design also improves total conversion of complex hydrocarbon components, reducing hydrocarbon slip that can damage the SOFC stack. Sulfur compounds in the fuel are converted completely to hydrogen sulfide, which is easily captured in a PCI-designed sulfur removal module.

R&D work that made these developments possible was supported by a Department of Energy (DOE) SBIR Phase II project awarded in 2008 by the Office of Fossil Energy (FE), followed in 2010 by a DOE SBIR Phase III Xcelerator project. The technology expanded to a variety of new reformer designs, with Department of Defense (DoD), DOE, and National Aeronautics and Space Administration (NASA) SBIR support, and is now part of PCI's fuel cell system in development under multiple SBIR and Phase III projects funded by the DoD to provide the military with compact, lightweight fuel cell systems using logistics fuels.

PCI's use of Federal funds offers a great example of cross-agency efforts aimed at developing dual use technologies to be implemented in both civil and military applications. The technology has attracted $30M in DoD Phase III funding from different DoD Programs, including the development of a 10-kW fuel cell system for military tanks (U.S. Army), a 2-kW system for unmanned aerial vehicles (U.S. Navy), and a 1.2-kW system for emergency missions (U.S. Transportation Command). Another DoD project involves modifying PCI's core reformer technology for the purpose of producing H_2 on the battlefield. PCI's expanding family of fuel processors have also come back to the DOE in several ARPA-E projects, including the development of high-efficiency, compact power generators, and a new project developing a large stationary natural gas-fueled fuel cell power generator with extended efficiency limits. PCI also developed a simplified hydrogen augmentation reformer for improving internal combustion engine efficiency and emissions. The latter project was awarded a new DOE SBIR Phase I and II, and is currently supported by a DOE SBIR Phase IIB, with an automotive Original Equipment Manufacturer (OEM) and Tier 1 support for engine prototype trials.

When asked about the company's business model, CEO Kevin Burns explained that PCI's mission is to create energy sector innovations. PCI does not focus on a single product or application but on a portfolio of core technologies that are synergistic among themselves and can lead to multiple product applications. Commercialization plans are tailored to the opportunity, and could mean creating a separate PCI division to make the product, a license to an industrial partner, or a hybrid of the two where

the PCI's division makes a core component (e.g. the fuel processor) while the licensed partner assembles the commercial product system. This approach allows PCI to leverage technology across multiple SBIR awards and to have varying application-focused collaborations with industrial customers. Although the different projects have different technical objectives and serve different markets, they can leverage common core technologies, allowing PCI to work on them in a parallel fashion without diluting company's resources. Developing intellectual property such as patents is a priority because IP creates added value, protecting partners' business using the technology developed by PCI.

PCI also serves both individual component and system markets that vary with the market situation. For fuel cells, for example, PCI supports other fuel cell system developers across most applications with its compact fuel processors, balance of plant components and targeted improvements. At the same time, PCI is separately developing a fuel cell system design focused on the unique challenges of mobility for the military. In other cases, PCI's technology is licensed to third parties. This is the plan for PCI's automotive hydrogen generator. PCI's steam generator for oil production, which started as a DOE SBIR Phase I and II, provides a hybrid example: PCI signed a joint venture agreement with an oil producer funding further Phase III development while receiving a system license and buying the core components from PCI.

PCI has not attempted to raise private equity capital for its longer term R&D business: "Our mission is innovation and sustained growth in capability, not exit," says Mr. Burns. Instead, PCI has obtained development capital from strategic partners and customers with expectations focused upon the specific applications of interest to each partner. Also, PCI has received substantial interest from the DoD and its primes in PCI's technology and applications. As DoD often funds technology development relevant to its interests, DoD and prime contractor Phase IIIs have provided the advanced development investment required for key PCI technologies including dual use applications with civilian markets. However, PCI is considering the potential for obtaining venture and strategic partner capital focused upon spinoffs supporting specific product applications.

SBIR has been key to PCI's development. As Mr. Burns explains, "SBIR supports PCI's early stage innovation and development, giving us the chance to create new technologies while also building follow-on commercialization support from both the private sector and the government. We've built a world-leading technology base in advanced catalytic reactors and sorption reactors and systems using the SBIR program as the seed funding. We are using this American technology to potentially revolutionize a wide set of applications from fuel cells to automobile engines to generators to air cleaning systems, boosting efficiency and lowering emissions. We especially like the DOE SBIR program because its focus is on efficiency and emissions, which is also the focus of our technology."

Nevertheless, Mr. Burns says that PCI is selective in its use of the program. "We only apply for a Phase I when there is a reasonable chance for a major advance, and PCI does not apply for a Phase II unless 1) the Phase I results suggest a Phase II prototype can be successful and 2) a viable concept exists for how to progress to Phase III and carry the prototype further into the market." He concludes, "The point of the SBIR program is to create innovations that change the world. That's our objective also."

Claudia Cantoni, Commercialization Program Manager, DOE SBIR/STTR, August 2019.