Proton Power, Inc.

Renewable Energy That Makes Financial Sense

Proton Power, Inc.
487 Sam Rayburn Parkway
Lenoir City, TN 37771
Tel: (865) 376-9002
Fax: (865) 671-1605
www.protonpowerinc.com

THE COMPANY STORY

Overview. Proton Power, Inc. ("PPI") has developed proprietary, patent-protected, clean renewable energy systems for the cost-effective conversion of a wide variety of feedstocks into diesel fuel, electricity, or hydrogen. All PPI systems produce a high quality, semi-activated carbon biochar product that produces significant enhancements to productivity and growth in agricultural plants, animals, and poultry, and it can be used as an effective filtration component in many industrial and agricultural applications. Also, research has revealed that graphene is present in large quantities in PPI biochar, and PPI has subsequently developed a proprietary process to upgrade the biochar into high-quality graphene products. In addition, the process water produced by PPI diesel production systems can be used in many agricultural applications. Importantly, PPI systems are financially viable at a relatively small scale making them easy to locate close to feedstock supplies. Finally, the PPI story wouldn't be complete without acknowledgment of the significant reduction in carbon footprint for PPI technology inherent to all of the system application types. Carbon savings range from a net negative carbon footprint to a slightly positive carbon footprint depending upon which system type is used and what is done with the biochar product. With any PPI system type, the carbon savings are substantial.

Experience in High Temperature Technology. The key to PPI's technological success is the ability for its pyrolysis units to continuously operate at much higher temperatures than other competing systems. PPI equipment typically operates at approximately 1100C – much higher than other pyrolysis or gasification systems that operate in the 400C to 600C range. PPI is able to do this because of the long and deep experience of its founder and CEO, Dr. Sam Weaver, and his business partner, Dan Hensley. Sam and Dan have worked together as serial entrepreneurs and partners for over 50 years, and almost all of their work has been in the area of high temperature thermochemical processes. Much of their work has been to develop and produce high temperature furnaces that operate at temperatures up to 2800C, so building equipment to operate at 1100C is well within their experience and capabilities.

History. PPI began research in 2008 and is currently in approximately mid-stage product and technology commercialization. While initially focused on the production of a hydrogen-rich syngas from biomass feedstocks for the generation of low-cost electricity, subsequent Company advancements now greatly expand the capability of this technology to produce diesel fuel, high quality biochar, and high quality graphene. The technology is extremely flexible with regard to acceptable feedstocks. PPI has tested more than 120 varieties of feedstocks that are acceptable for use by the PPI equipment – including Municipal Solid Waste (“MSW”) after appropriate pre-processing of the MSW.

The early focus of the company on hydrogen production led to the brand name of CHyP from the concept of “Cellulose to Hydrogen Power.” Next, PPI developed the capability to use the syngas produced by its CHyP pyrolysis units to power natural gas gensets in order to produce electricity in a financially viable manner. In addition, over the past several years the CHyP system has been combined with PPI proprietary fuel conversion technologies leading to the ability to produce road-ready diesel fuel that meets ASTM D975 standards via a direct conversion process from feedstock to diesel fuel. PPI systems achieve significant environmental benefits, and they produce valuable co-products such as a high-grade biochar and water.

Customer Interest: The Company initiated discussions with domestic and international customers in 2012, and customer interest has been high. From 2016 to 2018, for example, PPI hosted over 300 customer visits that were attended by almost 1000 prospective customers, and interest in the development of PPI systems remains high. These visits have resulted in multiple orders ranging from diesel to electricity to biochar-only systems.

Initial Demonstration and Commercial Facilities: In December of 2011 PPI obtained its first order for a commercial biomass-to-electricity system from Wamper’s Farm Sausage (“Wampler’s”). The system was designed to produce 500 net kW of electricity and is located at Wampler’s sausage plant near Lenoir City, Tennessee. Work began on the plant in early 2012, and the plant was commissioned the following year. The electricity generated provides power to the customer’s manufacturing process, and surplus electricity is diverted to the grid.

PPI, via a relationship with the University of Tennessee (“UT”), began investigations as to whether the syngas produced by CHyP units could ultimately be used to produce fuels. In 2011, UT purchased a single CHyP unit from PPI that it then used for experiments in this and other areas. PPI was allowed access to this unit, but access was difficult and limited, so early in the development of the PPI biomass-to-diesel technology, it was apparent that there is a need for a demo system that would enable PPI to conduct research and development (“R&D”) on a commercial-sized system on a round-the-clock basis.

To accommodate those needs, PPI constructed a demo system at a site that it had previously purchased near Rockwood, Tennessee. The initial demo system was commissioned and became operational in May of 2014. R&D testing was immediately initiated on a 24/7 basis to expedite the development of the PPI diesel technology.

In February of 2014, PPI signed a contract to sell the entire Rockwood site to a customer from Singapore whereby PPI was to ultimately build a system consisting of 6 production modules capable of producing a total of approximately 20,700 gallons per day from woody biomass arriving at the site in the form of whole logs.

The first production module was brought online in February, 2017, and the second module was completed in August, 2020. Ownership of that plant has changed a number of times over the years, including a recent change of ownership in July of 2021. At the time of this writing, the new owner has not finalized its plans regarding further expansion of the system.

Subsequent to those initial projects PPI has built a solid pipeline of additional projects that are either already under construction or in the final phases of development.

Continuous Improvement Through R&D and Operational Experience

PPI’s equipment and technology - whether to produce diesel fuel, hydrogen, electricity, or graphene – is commercially viable today due to significant investments in ongoing research and development as well as many hours of operational experience that has allowed to continually optimize and improve its product offerings. Dr. Weaver’s and Mr. Hensley’s product development strategy has always been to build commercially-sized products as opposed to building lab scale models and then scaling up to commercial size. This has allowed PPI to develop, test, and improve the final commercial product, solving problems along the way that apply to the actual commercial application versus a lab model. In addition, another development philosophy has been to do development on a 24/7 basis. This significantly reduces development time, allowing PPI to develop products multiples of times faster than its competitors.

As PPI has evolved, the learnings and experience that have been gained during the development process have been instrumental to bringing the full array of commercially-viable system offerings to its customers.

Wampler's. The Wampler's project is PPI's first commercial electricity project, and as previously mentioned, it is a 500 kW electricity system that was commissioned in 2013 at a site near Lenoir City, TN. The system was installed to provide partial power to Wampler's sausage processing plant, but for most of its operational life it has been used discontinuously in R&D and demonstration modes on behalf of PPI per an agreement with the owner.

Since their commissioning, the four CHyP units have operated for more than a combined 6600 hours running the generators and a roughly equal amount of time running experiments and testing equipment. Because the equipment is only run about 6 hours per day max the total available time was about 12,000 hours. During that time several operational issues have been discovered and addressed, R&D experiments have been done that have led to optimization of system performance, and many customers have visited the site for a demonstration of the system.

Some of the operational issues that were resolved are listed below:

1. Syngas storage: For an electricity system, there is a need for an intermediate storage of syngas between the CHyP units and the gensets. Initially, PPI had selected a flexible bladder storage unit, but it was found to be sub-optimal, because it tended to leak. It was discovered that the root cause of the leaking was because the fabric of the bladder did not contain the tiny hydrogen molecules very well. The solution was to go to a steel storage tank.

2. Feedstock conveyance to the CHyP units: There were problems with the system that was used, called a Pro-Vey system, to distribute feedstock chips to the the individual CHyP units. The Pro-Vey system distributes feedstock by using pucks attached to a steel cable that are pulled through a steel tube that can be bent to allow for a very flexible design of the feedstock system. However, in actual operation the Pro-Vey system tended to bind, especially in turns of the tube, which caused loud "squealing" to occur and a significant number of breaks of the steel cable. This problem was solved by 1) using a modified system called a Chain-Vey system where a stronger steel chain is substituted for the steel cable, and 2) increasing the radius of turns in the tubing to make for a smoother flow.

3. Tar management: One of the issues with the production of syngas is that there are also tars that are produced that must be managed for optimal system performance. PPI developed a patented method, called the "recapture", to use the incoming feedstock to filter tars from the syngas by bubbling the syngas through the incoming biomass, but that was not enough to eliminate all of the tars from the syngas. Some tars were still entrained in the syngas after the recapture, and they would tend to condense onto the sides of the syngas piping, eventually restricting syngas flow. PPI then developed a scraper component to scrape the condensed tars from the inside of the syngas tubing, but that system needed to be cleaned frequently, causing an unacceptable maintenance issue. PPI's ultimate solution was to install a scraper auger, and that change has provided a successful permanent solution to the issue.

4. Performance optimization: Much of the R&D work done at Wampler's was done to optimize the performance of the system, i.e., to find the right combination of temperature profile and speed of throughput of feedstock through the CHyP units so as to optimize the energy content of the syngas which, in turn, optimizes the production of electricity. This was accomplished at Wampler's, and later the Wampler's system was used to also optimize the production of hydrogen for the hydrogen application. It is important to note that the same CHyP unit design is used across all PPI system applications; performance optimization is accomplished for specific applications by finding the correct

combination of temperature profile and feedstock throughput through extensive R&D testing. It is also important to note that the R&D testing that PPI conducts is inherently more rigorous than continual operation as it pertains to the reliability of the CHyP units and the system. R&D testing entails many more starts/stops of the units, wider variation in temperature and feedstock throughput rates, and testing of a number of different feedstocks, so the R&D process itself led to a more robust and reliable design of the CHyP units.

5. Heater reliability: One of the key components of the CHyP units is the heater assembly. This is a customized design of concentric electric heating elements embedded in ceramic insulation that provides the required heat flux to achieve the high temperatures inherent in the CHyP pyrolysis units. PPI outsourced the manufacture of this component to an experienced heater manufacturer, but early on the reliability of other heaters was poor with heaters failing in as little as 2 hours. Continued work with the supplier has now increased the heater average life to 5 years. It is questionable whether this deficiency would have been discovered, if PPI did not employ rigorous R&D tests and 24/7 operation during testing.

University of Tennessee and Rockwood Systems. PPI, via a relationship with the University of Tennessee ("UT"), began investigations as to whether the syngas produced by CHyP units could ultimately be used to produce fuels. In 2011, UT purchased a single CHyP unit from PPI that it then used for experiments in this and other areas. PPI was allowed access to this unit, but access was difficult and limited, so early in the development of the PPI biomass-to-diesel technology, it was apparent that there is a need for a demo system that would enable PPI to conduct research and development ("R&D") on a commercial-sized system on a round-the-clock basis.

To accommodate those needs, PPI constructed a demo system at a site that it had previously purchased near Rockwood, Tennessee. The initial demo system was commissioned and became operational on May 24, 2014. R&D testing was immediately initiated on a 24/7 basis to expedite the development of the PPI diesel technology.

In February of 2014, PPI signed a contract to sell the entire Rockwood site to a customer from Singapore whereby PPI was to ultimately build a system consisting of 6 production modules with each production module capable of producing approximately 3450 gallons of diesel fuel per day (or approximately 20,700 gallons per day from all 6 production modules) from woody biomass arriving at the site in the form of whole logs. Proton Power installed all 48 CHyP units.

However, for a variety of reasons, chief among them that the customer had several lengthy periods of interrupted payments to PPI, the project incurred substantial delays so that the first production module was not completed and operational until February, 2017. Subsequently, there were further issues around customer payments to PPI, and the project was suspended shortly after the commissioning of production module #1. The customer ultimately sold the Rockwood facility to another owner in April of 2020. The new owner commissioned one more production module to the site before being forced into bankruptcy in 2021. A third owner purchased the facility out of bankruptcy, and that owner's plans for the facility are currently unclear.

However, during the time between February of 2017 and April of 2020, the original customer allowed PPI to use Rockwood production module #1 as a demo/R&D system. During that timeframe hundreds of system experiments were executed, and the CHyP units logged over 10,000 hours of run time. More than 20,000 gallons of diesel fuel were produced during that time – most of which met ASTM D975 standards.

The combined operational hours at both UT and Rockwood led to many significant breakthroughs that make the PPI diesel system a fully viable commercial system today. Some of those are listed below:

1. Direct diesel conversion: PPI's initial path toward renewable fuels production was developed assuming that renewable fuels could be produced by producing bio-oil at low temperatures from one set of CHyP units, hydrotreating the bio-oil using hydrogen that was economically produced by another set of CHyP units, and then hydrocracking the resulting molecules to produce various renewable fuels. PPI followed that path for 16 months and was ultimately able to produce some diesel fuel, aviation fuel,

and gasoline. However, this method proved to be not viable economically. Coincident to the hydrotreating/hydrocracking pathway R&D work, PPI was conducting experiments on its own biomass-to-electricity system in its Lab where syngas was produced at high temperature (i.e., 1050C) for optimized electricity production. However, it was observed that a large quantity of hydrocarbon molecules were formed in the syngas that were problematic to the operation of the electricity genset. Subsequent analyses showed that these hydrocarbons contained a high proportion of diesel molecules. This was the breakthrough that led to the design of the PPI diesel system that optimizes the quantity of diesel molecules produced and effectively separates the diesel fuel from other constituents of the syngas. This design that facilitated the direct conversion of biomass molecules to diesel molecules, without the use of any catalysts, was implemented and effectively proven in December, 2013. This direct conversion process is unique to PPI and is enabled by PPI's ability to conduct pyrolysis at very high temperatures.

2. Optimized Venturi design: One of the key components of the PPI diesel system is the Venturi that causes diesel fuel molecules contained in the syngas to condense into liquid diesel fuel. Iterations of the design during R&D work at Rockwood led to an optimized design of the Venturi that effectively captures and converts almost all of the diesel molecules in the syngas into a liquid form.
3. Elimination of distillation step: In early versions of the PPI diesel system, a final distillation step was necessary to separate "light ends" - light condensable liquid products such as benzene – from the final liquid diesel fuel. R&D work at Rockwood eventually led to optimal system operating parameters that virtually eliminated light ends, thus saving both capital expense and operating expense.
4. Optimized isolation valve design: Isolation valves are used to ensure that the least amount of ambient air gets into the heater tube of the CHyP units. Throughout the R&D work at Rockwood, the PPI design of the isolation valves was changed several times until a perfected design was achieved. This leads to safer operation and better performance.
5. Feedstock testing: Over 40 varieties of feedstock were tested at both Rockwood and Wampler's over the time that these systems have been in place. These tests combined with PPI's Lab tests of feedstocks led to indications as to the values of the most important parameters of feedstocks that lead to optimized performance of the PPI systems. PPI has tested over 120 different feedstocks in its Lab for physical and chemical properties.
6. Performance optimization: As with Wampler's, much of the R&D work done at Rockwood was done to optimize the performance of the system, i.e., to find the right combination of temperature profile and speed of throughput of feedstock through the CHyP units so as to optimize the production of diesel fuel.

Singapore Demo System. A small, 2 CHyP unit demonstration system is in operation in Singapore that is used to demonstrate the biomass-to-diesel capability of the PPI technology. The system was purpose-built by the owner as a demonstration system that is used by the owner to display the capabilities of the PPI diesel system to the owner's prospective clients. The owner has been very gracious to allow other PPI prospective customers to visit the facility.

MISCELLANEOUS DIESEL INFORMATION

Performance. Many operating hours at Rockwood have shown that PPI diesel systems consistently produce the following:

1. Diesel fuel: **100 gallons of diesel fuel per dry metric tonne** of feedstock processed by the CHyP units provided that the feedstock meets minimum criteria
2. Biochar: **13%-15% of the dry metric tonnes of feedstock** processed by the CHyP units.

Reliability. The operating life of the major components of the CHyP units are as follows:

1. Heater: 5 years
2. Heater tubes: 5 years
3. Augers: 6-9 months.

Independent Third Party Verification. A number of customers and others have hired third party consultants to verify the performance of the PPI systems. Some customers do not want to share the information, but the following are noteworthy:

1. SGS fuel analyses: Multiple independent analyses were conducted by SGS – one of the most respected laboratory companies in the fuels industry – and showed that PPI diesel fuel meets the requirements of ASTM D975 Ultra-Low Sulfur Diesel. Copies of those analyses are available upon request.
2. Laboralec: This Belgian laboratory was hired by one of PPI's prospective customers to evaluate PPI's technology. The study indicated positive approval of the PPI technology. PPI purchased the rights to this study, and it is available upon request.
3. Insurance company: A major provider of performance warranty insurance, Aon, brought its technical partner in to evaluate PPI's technology. The technical report was very positive to the extent that Aon now offers various performance insurance instruments for the PPI technology. This report is not available for distribution.

Approvals/Registrations. The diesel fuel produced by the PPI diesel system has earned the following:

1. US EPA Part 79 Registration as a renewable diesel (October, 2017)
2. US IRS 637 Registration (December, 2017)
3. EU REACH Registration: A PPI customer paid $500,000 to have this registration administered.

GRAPHENE

The most recent business development opportunity that PPI is actively pursuing is the production of graphene.

Graphene is a substance that has many extremely positive attributes in the areas of strength of materials, electrical conductivity, thermal conductivity, and more. The issue that has limited graphene's use in the marketplace is its very high cost (initially up to $500 per gram) due to very high production costs and small product yields.

The biochar produced by PPI's high-temperature process is composed of a very high proportion of graphene.

PPI has developed a proprietary process that produces a high-quality graphene (PPI calls it, "ProCene") from the biochar that is produced as a co-product from all PPI systems. PPI's process enables it to produce ProCene at very high volumes and at significant low production costs – a quantum improvement for the graphene market. It is noteworthy that an important key to making ProCene of consistently high quality is to start with the high quality biochar (PPI calls it, "Pro-C") that is only available from PPI CHyP units.

PPI has also perfected a process to convert PPI biochar to a medium grade graphene, called "ProCnano", that lends itself well to applications such as strengthening concrete, anti-corrosive paints and coatings and many other applications.

PPI intends to retain the intellectual property to produce ProCene and ProCnano. These products are, therefore, produced and distributed by PPI directly.

FACILITIES

PPI operations are headquartered in Lenoir City, TN, with manufacturing and office space totaling 89,000 sq. ft. across three locations on 50+ acres of land. Included in these three facilities is an 11,000 square foot laboratory facility dedicated to ongoing PPI research and development.

ABOUT PROTON POWER, INC.

Proton Power is a C corporation registered in the state of Tennessee as of October 3, 2005. Headquarters are located in Lenoir City, Tennessee.

For more information about the company, please contact Sam C. Weaver, CEO, at scweaver@protonpower.com or (865) 389-4713.

While Proton Power, Inc. endeavors to ensure that the information in this document is correct and fairly stated, Proton Power makes no representation or warranty of any kind in this document and shall in no case be liable for any errors or omissions or damages, regardless of legal theory, for any use or reliance upon this information.

Due to continuous business improvement, information is subject to change without notice.