WHITE PAPER

FUEL GAS PRESSURE RECOVERY

INDUSTRIAL POWER GENERATION SOLUTIONS

JEFF EARL - VICE PRESIDENT OF BUSINESS DEVELOPMENT AND MARKETING
DANIEL TREJO - MECHANICAL APPLICATIONS ENGINEER

Executive Summary

Natural gas has emerged as a leading solution for bypassing electrical interconnection delays and supporting the rapid expansion of digital infrastructure. In the United States, established transmission and distribution networks are already being used to supply fuel to new campuses and other large industrial facilities. Engines, turbines, and fuel cells can bring behind-the-meter power online quickly, but they also expose operators to fuel-driven operating costs. At hyperscale facilities, these costs can reach hundreds of millions of dollars per year. As a result, developers are increasingly focused not only on how to bring capacity online quickly, but also on how to improve the efficiency of the systems being deployed. Solutions that extract more value from the existing fuel path are becoming more important as power and cooling loads rise together.

Fuel gas pressure recovery offers a practical way to improve the efficiency of natural gas power plants. By recovering excess pressure energy before the gas reaches the prime mover, turboexpanders can generate incremental electricity and create useful cooling. Installed upstream of the power generation equipment, they convert a required pressure reduction process into a new generation system. For facilities with both power and thermal demands, the additional energy output can improve total system efficiency and reduce operating expense by up to 2%.

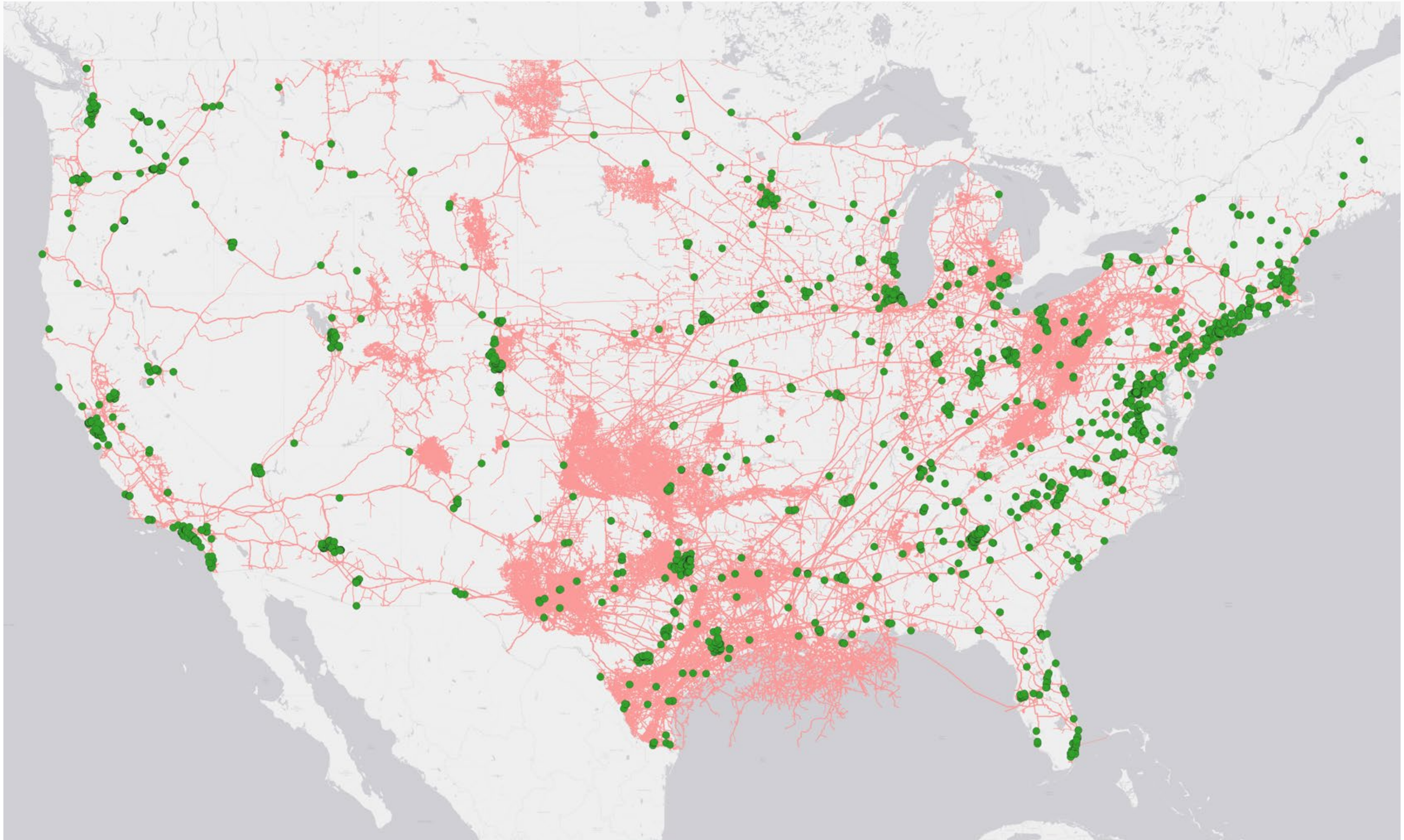


Figure 1 - Map of United States natural gas pipelines (pink) and data centers (green)

Fuel Gas Pressure Recovery Process

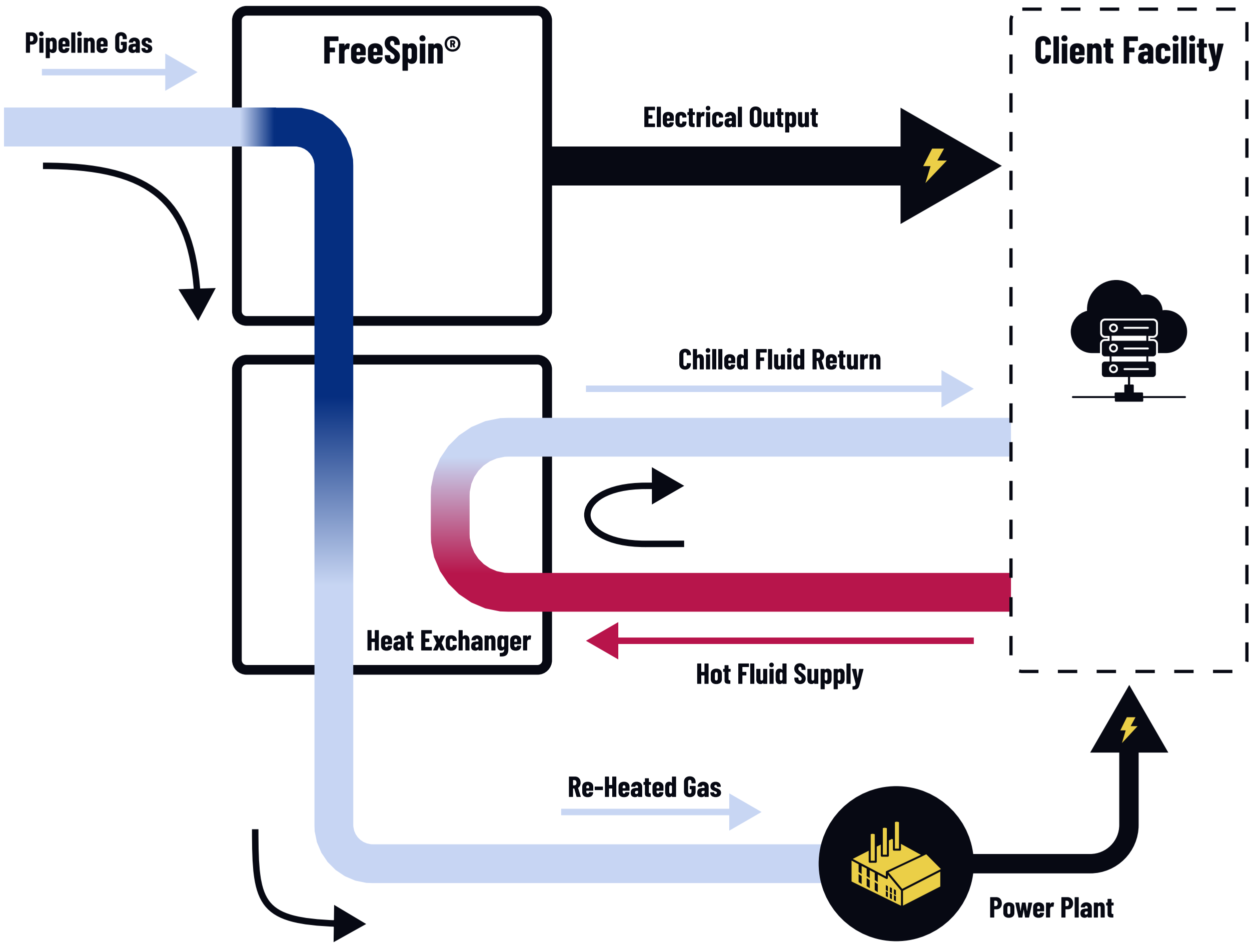


Figure 2 - An integrated power and cooling system

High-pressure natural gas delivered to data centers and other large facilities must be reduced to the operating setpoint required by on-site generation equipment. A turboexpander installed upstream of that equipment captures pressure drop and converts it into electricity. As the gas expands through the turbine wheel, it rapidly cools and creates a low-temperature stream that can be used in facility heat exchange processes. The fuel gas then continues downstream at the pressure required by the prime mover. When electricity generation and cooling are both utilized by the facility, total energy output can increase by up to 2%.

Operating Impact

FreeSpin® can be integrated into transmission or distribution pipelines feeding a facility's prime mover. Tables 1 and 2 evaluate common gas-fired turbines, engines, and fuel cells at typical operating specifications. Pressure recovery alone can improve nameplate output by up to 1%. When the cooling capacity is integrated with the facility, total energy output can improve by up to 2% over nameplate. Facilities with meaningful thermal loads, including data centers, are especially well positioned to capture this added value.

Table 1 – Pressure recovery only

Incremental electricity generated upstream of the prime mover

Manufacturer Model	Nameplate Rating (kW)	Pressure Energy (kW)	Increase to Nameplate (%)
Mitsubishi M501 JAC	453,000	514	0.1%
Siemens SGT6-5000F	196,000	390	0.2%
Siemens SGT-800	57,000	165	0.3%
GE Vernova LM2500XPRESS	36,800	85	0.2%
Mitsubishi FT8 MobilePac	30,941	73	0.2%
Wärtsilä 50SG	18,880	107	0.6%
Baker Hughes NovaLT16	16,200	31	0.2%
INNIO Jenbacher J624	4,404	30	0.7%
Caterpillar G3520K	2,567	15	0.6%
Bloom Energy Server 6.5	325	1	0.3%

Up to 1%

Increase to nameplate from pressure recovery alone

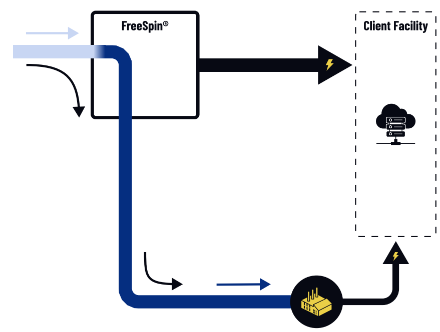


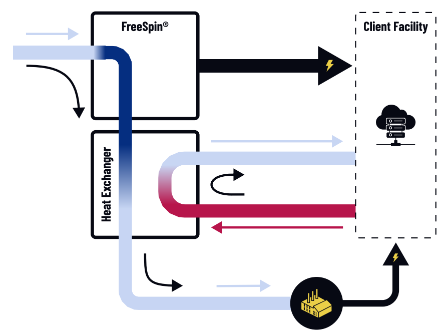
Table 2 – Integrated Power + Cooling

Combined impact when cooling is integrated with heat exchange processes

Manufacturer Model	Pressure Energy (kW)	Cooling Capacity (kW)	Combined Increase (%)
Mitsubishi M501 JAC	514	1,872	0.5%
Siemens SGT6-5000F	390	1,104	0.8%
Siemens SGT-800	165	394	1.0%
GE Vernova LM2500XPRESS	85	224	0.8%
Mitsubishi FT8 MobilePac	73	190	0.9%
Wärtsilä 50SG	107	178	1.5%
Baker Hughes NovaLT16	31	90	0.8%
INNIO Jenbacher J624	30	49	1.8%
Caterpillar G3520K	15	25	1.6%
Bloom Energy Server 6.5	1	2	0.9%

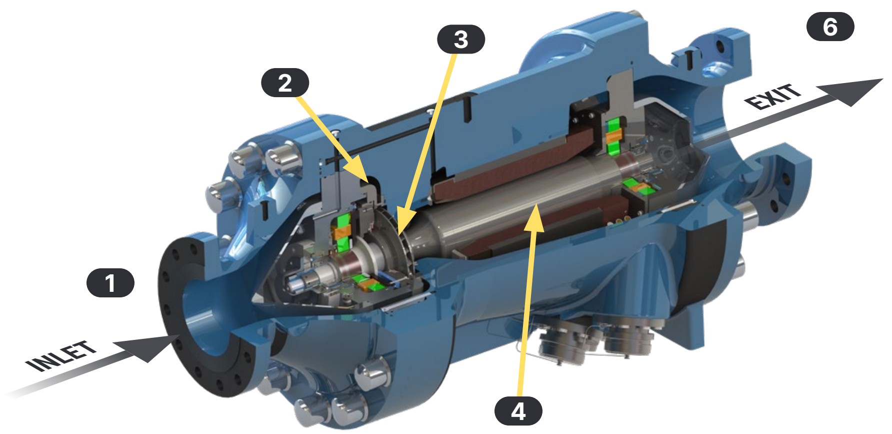
Up to 2%

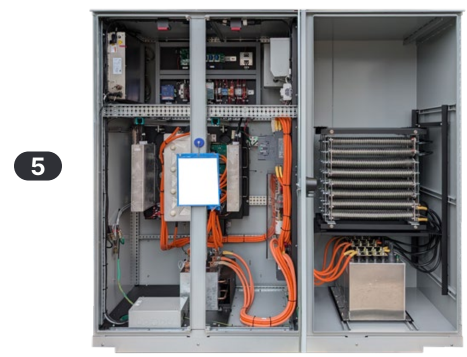
Total energy increase with integrated power + cooling



Generating Electricity

Designed for demanding oil and gas service, FreeSpin® combines a high-speed permanent magnet generator, a radial inflow expansion turbine, and active magnetic bearings in a compact package. High-pressure gas drives the expansion turbine, converting pressure energy into rotational energy for electricity generation. FreeSpin® is available in skid-mounted modules rated at 300 kilowatts of electrical generation and 5 MMBTU per hour cooling capacity.



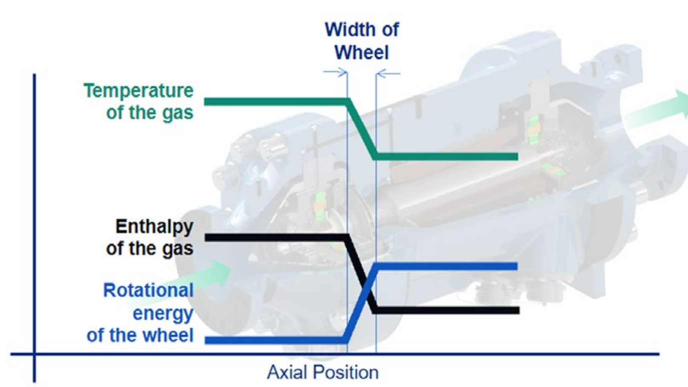


1. High Pressure gas flows into the turboexpander
2. Guide vanes direct gas to turboexpander wheel
3. Wheel converts the gas' translational energy into rotational energy
4. Permanent magnet generator converts rotational energy into electricity
5. Current is transmitted from the generator to the power electronics, where frequency is adjusted
6. Low pressure, cold gas exits the turboexpander

Creating Cooling

The same expansion process that generates electricity instantaneously cools the gas. FreeSpin® is rated to operate at temperatures as low as -20 degrees Fahrenheit (-29 degrees Celsius), creating a low-temperature fluid stream that can be integrated into facility heat exchange processes. This dual-output design allows a single system to support both power production and thermal management.

The expansion turbine wheel is manufactured from Inconel 718, a high-strength, corrosion-resistant nickel-chromium superalloy selected for demanding operating conditions. As fuel gas expands across the wheel, pressure energy is converted into rotational energy to drive the generator, while simultaneously creating cooling.



Conclusion

Data center developers are increasingly specifying natural gas-fired engines, turbines, and fuel cells to bring new capacity online faster. Fuel gas pressure recovery improves the performance of those systems by turning a required process operation - pressure reduction - into incremental electricity and useful cooling. Instead of letting that energy dissipate across a valve, operators can capture it to improve total site efficiency without additional fuel input.

As power and cooling demands continue to rise together, the most valuable solutions will be those that extract more output from infrastructure already being deployed. Fuel gas pressure recovery is a practical, modular way to do that. It complements the prime movers already being evaluated for data center deployment and strengthens the overall business case for behind-the-meter natural gas generation. For data centers and other large industrial facilities, turboexpanders offer a near-term path to lower operating cost, better thermal integration, and more productive use of the natural gas supply already arriving at the site.

About the Authors

Jeff Earl

Vice President of Business Development and Marketing

Jeff Earl is the Vice President of Business Development & Marketing for Sapphire Technologies. He brings extensive experience in partnering and contracting, and has executed equipment and commodity deals throughout the chemical and energy industries.

Jeff joined Sapphire Technologies in 2021 and leads the company’s domestic and international business development and marketing efforts.

Prior to joining Sapphire Technologies, Jeff was an Account Manager at Messer (formerly Linde) and held various commercial roles in the industrial gas industry since 2016. He holds an M.B.A. and a B.E. in Chemical Engineering from Stevens Institute of Technology in New Jersey.

Daniel Trejo

Mechanical Application Engineer

Daniel Trejo is an Application Engineer for Sapphire Technologies. He brings a great deal of experience in designing and performing analysis work on static and rotating equipment used in the oil & gas and energy industry.

Daniel joined Sapphire Technologies in 2025 and leads application engineering efforts, taking customer process information and developing best fit solutions.

Prior to joining Sapphire Technologies, Daniel worked as a Thermal Process Engineer at Technip Energies and held various roles in the oil & gas and energy industry since 2016. He holds an MS in Mechanical Engineering from Cal Poly Pomona in California.