



"Meeting the World's Energy
& Environmental Challenges"

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Industry
Energy Efficiency

Products
WOWGen® - Waste Heat Recovery
WOWClean® - Pollution control

Intellectual Property
Two Patents issued
Trade secrets

Waste Heat Recovery Power Generation with WOWGen®

Business Overview

WOW operates in the energy efficiency field - one of the fastest growing energy sectors in the world today. The two key products - WOWGen® and WOWClean® provide more energy at cheaper cost and lower emissions.

- WOWGen® - Power Generation from Industrial Waste Heat
- WOWClean® - Multi Pollutant emission control system

Current power generation technology uses only 35% of the energy in a fossil fuel and converts it to useful output. The remaining 65% is discharged into the environment as waste heat at temperatures ranging from 300°F to 1,200°F. This waste heat can be captured using the WOWGen® technology and turned into electricity. This efficiency is up to twice the rate of competing technologies. Compelling economics and current environmental policy are stimulating industry interest. WOWGen® power plants can generate between 1 - 25 MW of electricity. Project payback is between two to five years with IRR of 15% 30%.

Nearly anywhere industrial waste heat is present, the WOW products can be applied. Beneficial applications of heat recovery power generation can be found in Industry (e.g. steel, glass, cement, lime, pulp and paper, refining and petrochemicals), Power Generation (CHP, biomass, biofuel, traditional fuels, gasifiers, diesel engines) and Natural Gas (pipeline

compression stations, processing plants). Sources such as stack flue gases, steam, diesel exhaust, hot oil or combinations of sources can be used to generate power. WOWGen® can also be used with stand alone power plants burning fossil fuels or using renewable energy sources such as solar and biomass.

Technology

WOW has two patents on WOWGen® power generation system. The two unique design features of the WOWGen® system are:

- Two stage Turbo Expanders and
- The use of propane as a working fluid

The second turbo expander coupled with highly efficient propane as a working fluid allows almost complete extraction of energy from the waste heat stream. This results in up to twice the efficiency of conventional ORC single expander systems.

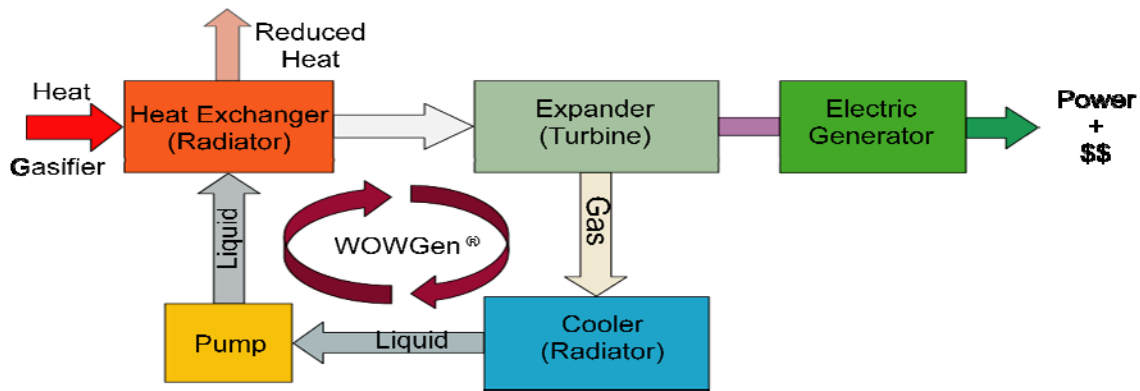
The WOWGen® power plant modulates the flow of the working fluid allowing it to follow the variations in waste heat flow (load following), maintaining its efficiency from 50% of design up to 115%. The use of commercially available off the shelf components provides reliability and performance guarantees.

WOWGen® system features

Technical features

- Temperature Range: 200°F to 2000°F
- Main Unit: Two turbo expanders, heat exchanges and pumps (protected by IP)
- Working Fluid: Propane (protected by IP)
- Installed Project costs: \$1,500-\$2,000 kWhr
- O&M costs: Low
- Efficiencies: Net 15% to 30% - up to twice the rate of competing technologies
- No reduction of efficiency with altitude
- Facilitates distributed generation
- No corrosion or contamination in the closed-loop system
- Offsets 21 tons NOx, 59 tons SOx, and 8,615 tons of CO2 (For each MW of Coal Power)
- Reduces fuel consumption, emissions, thermal pollution and conserves water resources

A schematic diagram of the process is shown below:



WOW has developed the patented Cascading Closed Loop Cycle (CCLC) based on the Organic Rankin Cycle (ORC) using off the shelf components that have been tested and have been in operation for decades. The components consist of commercially available turbo- expanders, heat exchangers and pumps, available from numerous manufacturers. WOW's systems are not reliant on exotic or custom-built equipment. Using off-the-shelf components makes WOW's system cost-effective, reliable and quick to construct. WOWGen® system components have millions of hours of reliable testing done and as a result, WOW anticipates lower maintenance cost associated with its systems.

WOWGen® will demonstrate optimal efficiency in the capture of waste heat in the range of 300° F to 1000° F with conversion efficiency of up to 30%. In many cases, this is two to three times the conversion efficiency of competing technologies. For example, this allows WOW to increase the power output of a diesel-powered generator by 15-20% and that of a simple cycle turbine by up to 40%. Contrast this with an improvement in the utility industry of only 0.49% in 2004 (based on heat rates and information from the ACEE, 2008) ¹.

By using two turbo expanders in a cascading system, WOWGen® is able to capture additional heat and put it to work to generate twice as much electrical power than single expander systems without sacrificing reliability.

The WOWGen® system uses propane as the heat exchange medium. It can capture heat from nearly any heat source and efficiently convert it to power. Until development of the CCLC, there has not been an efficient method to convert to electrical power the majority of waste heat generated by industrial processes. The use of propane is beneficial because of its unique thermodynamic properties. Propane requires only 15% of the heat per pound to vaporize compared to water. It has a very high coking temperature, allowing it to capture heat directly from the source. This avoids an intermediate capture step that adds complexity and cost to the system and results in heat transfer losses. Propane also has a higher auto-ignition temperature than thermal oils, gasoline, natural gas, etc. - a key safety benefit.

Market Opportunity

Energy Efficiency is one of the least-polluting and fastest-growing US energy sectors. Over the last 50 years this sector has seen tremendous growth both in energy saving and job creation in the US. In 2004, an estimated \$300 Billion was invested in this sector and overall 1.6 million jobs were added (ACEEE, 2008)². Investment in Energy Efficiency is poised to expand by \$400 Billion by 2030, resulting in an annual energy efficiency market of \$ 700 billion in 2030 (ACEEE, 2008)³. It is estimated that the U.S. economy wastes 55% of the energy it consumes leading to total waste

¹ *The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture*, American Council for an Energy-Efficient Economy, May 2008, p 24.

² *The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture*, American Council for an Energy-Efficient Economy, May 2008.

³ *The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture*, American Council for an Energy-Efficient Economy, May 2008.

heat recovery potential of 192 GW, of which Industrial Waste Heat potential is 156 GW. (EIA, 2007)⁴F.

In the US alone, electrical conversion losses cost the economy over \$100 billion per year. The use of the WOWGen® technology could save industrial customers billions each year. Industries that can benefit from WOW are Process Industries (e.g. steel furnaces, paper mills, lime plants and MSW thermal treatment), Fossil Fuel Fired Power Generation, Renewable Energy Generation and Oil/Gas.

Market Drivers

The interest to capture waste heat and make manufacturing more energy efficient is led by the following current trends:

- Rising energy costs and high volatility
- Increased focus on energy independence, security and distributed generation
- Public pressure on greenhouse gases, carbon emissions and global warming
- Incentives, tax credits, emission credits and incentives
- Legislation: Energy Policy Act of 2005 (EPACT) and Energy Independence Act of 2007
- Growing strength of EPA to regulate CO2 and greenhouse gasses
- Kyoto Protocol (180 countries)

Competitors

WOW's main advantages are higher efficiency, ability to handle temperature and flow variability and lower capital investment. The two leading methods for cogeneration - Steam Turbines and the Single Stage Organic Rankine cycle (ORC) are limited by the temperature range, operating costs and efficiencies. Steam systems need exhaust gases at least 1,000° F and have higher life cycle costs. The ORC's operating range is roughly 200° F to 400° F and it is less efficient at higher temperatures. WOW efficiently generates power using any exhaust stream over 200° F and offers up to 100% greater conversion efficiency than its competitors. Furthermore, the WOWGen® solution reduces O&M costs, thermal pollutions, emissions and conserves water resources.

	Primary Focus	Temp Range	Competitors
WOWGen® (CCLC)	500 kW to 50 MW	200 to 2000°F	CCLC - Protected by IP
Steam Turbines	> 50 MW	1000 to 1500°F	GE, Siemens Industrial Services, Murray, MAN, Alsthom, Dresser Rand
Single-Stage Organic Rankine Cycle	200 kW to 5 MW	300 to 500°F	GE, Atlas Copco, Mafi Trench, MAN, Turboden Systems, Recycled Energy Development (RED), Ormat, UTC, Kalina, Thermal Energy

Business Model

Industrial operations spend large amounts of money on energy, much of which is wasted as heat going up the stack. This waste heat can be put to excellent use to generate electrical power using the WOWGen® power plant. Benefits include:

- Use of waste industrial process heat as a fuel source that, in most cases, represents nothing more than thermal pollution.
- Generation of significant power with no incremental emissions; this generation typically offsets power currently being produced using fossil fuels. In the case of coal generated power, each MW of WOWGen® clean power generation effectively eliminates 21 tons of NOX, 59 tons of SO2, and 8,615 tons of CO2 emissions annually.

⁴ Annual Energy Outlook, Department of Energy, Energy Information Administration, 2007

- Stable, predictable generation capability on a 24x7 basis. This means that even when the sun has set, or the wind has ceased blowing, the facility can be generating clean, reliable power.
- Distributed generation; reducing transmission line congestion and losses. In addition, distributed generation eliminates the 4% to 8% transmission and distribution power loss associated with central generation.
- Reduced power costs.
- Potential for carbon credits.
- Potential for renewable energy credits (10 states recognize waste heat recovery power generation in their Renewable Portfolio Standards).

WOW's business model is to sell patented and proprietary technologies of WOWGen® and WOWClean® directly to end users. WOW envisions accomplishing its business model goals by pursuing either selling its system or licensing directly to end the user. Besides these, WOW will also generate revenue through royalty streams and studies/designs.

Sample Project Economics: Diesel Engine Waste Heat Recovery Power Generation

- Project Description
 - Capture waste heat from 18V32 diesel engine
 - Flue Gas Temp = 350°C
 - Flue Gas Flow Rate = 15.8 kg/sec
 - Project Impact
 - From Flue Gas = 1,168 kW
 - From CW Jacket = 433 kW
 - Plant Rating = 42 MW
 - WOWGen® = 6.4 MW (15.2% increase)
- 15.2% increase in power output
 - No additional emissions
 - Zero fuel consumption
 - Additional revenue @ \$ 0.132/kwh = \$ 5.4 Million
 - Simple Payback = 2.2 years
 - IRR (unleveraged) = 30%
- Reduced carbon footprint
 - CO2 emissions reduction = 29,000 tons per year
 - Value of CER @ \$ 30/ton = \$ 0.87 Million
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- Increase in yearly cash flow = **\$ 6.27 Million**