



Ingersoll Rand

Proven source. Proven solutions.

Market Leading Brands

Climate Control

Thermo King, Hussmann

Infrastructure

Ingersoll-Rand,
Bobcat, Blaw-Knox,
Club Car



Industrial Solutions

Dresser-Rand, ARO,
IR ASG,
PowerWorks

Security and Safety

Schlage, Von Duprin, Steelcraft

Why Ingersoll-Rand at the Landfill?

- Industrial pedigree
- Outstanding engineering expertise
- Organization size and strength
- Product design & performance
 - Military-grade recuperator
 - High efficiency performance
 - Low emissions combustor
- Extensive service capabilities

IR's US Service Coverage



How did we get here?



- 1989 • Demonstrated proof-of-concept
- 1994 • Developed breakthrough technology recuperator
- 1996 • Began development of commercial units in cooperation with SoCal Gas, New York Gas, and GRI
- 2000 • Shipped first Alpha field test unit
 - Began shipping Beta field test units
- 2001 • First commercial units



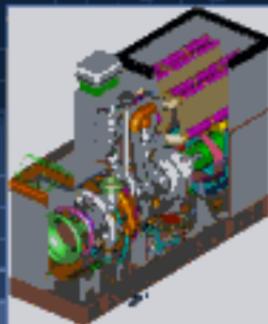
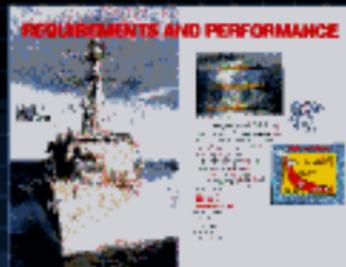
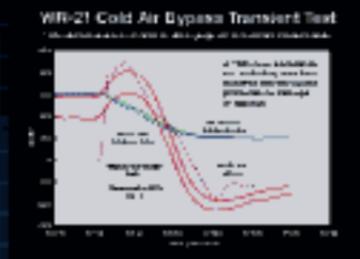
A Better Microturbine By Design



- Reliable commercial / industrial-grade design
- Robust, military-grade recuperator
- Industry qualified fuel-gas booster
- Rugged oil-lubricated bearings
- Proven generator design
- 10-year design life
- Long service intervals

The Recuperator Is Vital

- Unique combination of:
 - very high durability
 - better efficiency
 - compact packaging
 - competitive first cost
 - attractive life-cycle cost
- Destructive pressure
 - burst strength in excess of 3 times operating pressure
- Endurance
 - 1000 hours (steady state) at peak temperature and exaggerated differential temperature - no measurable or visible degradation
 - 500 rapid thermal cycles (1500 hours total) - no measurable or visible degradation
- Direct impact on system performance and life:
 - 80,000 hour product life
 - A costly component that cannot cost-effectively be replaced during the life of the system

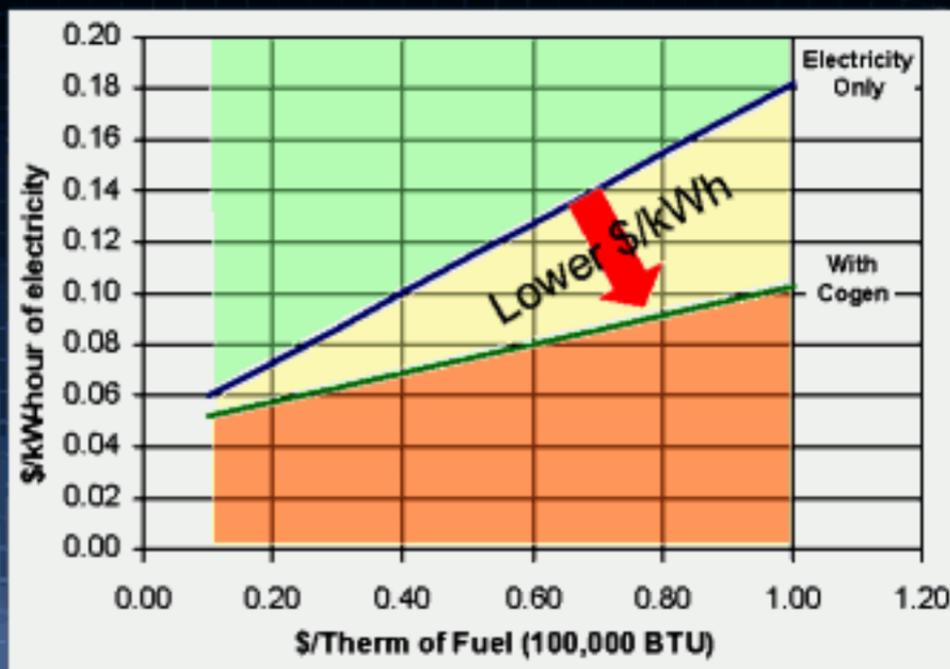


Initial Market Strategy

- Microturbines: a new way to supply facilities with continuous energy generated onsite
- Installed inside or near a building to provide electricity and optionally heat, similar to a boiler
- The value proposition is heavily dependent on "spark spread" -- the difference between the value of electricity and fuel



Cogeneration Reduces Cost of Electricity



Events Converge Against Cogeneration

- California energy crisis
 - Deregulation screeches to halt in most states
 - Market prices for power and fuel become increasingly unstable
- ENRON
 - Heightens uncertainty about long term pricing
- New Administration
 - Does not support Kyoto Protocol
 - Diminished advocacy for cogeneration & DG

LFG to Energy Issues

- Reciprocating engine LFG to energy requires too much attention in projects below 800 kW
- Standard maintenance costs severely affect economics of most small LFG to energy projects
- Existing technologies often contribute to:
 - Noise;
 - Odors; and
 - Pollution; all of which
 - Affect communities adjacent to landfills.

IR Recognizes Commonality of Needs...

- Landfill gas
- Digester gas
 - Municipal wastewater treatment
 - Agricultural anaerobic digestion
 - Food & beverage processing
- Oil field flare gas

Jamacha Microturbine Project

- Replaced Honeywell microturbines
- Installed in newly roofed area
- Low BTU fuel
- 24/7 electricity (baseload) exported to grid
- No heat recovery components (cogeneration)



Oil Microturbine Project



- OII (Operating Industries), Monterey Park, CA
- Inactive Superfund toxic waste landfill site
- Constant flaring at ~24% methane content
- Six PowerWorks units operating at 38-40%
- Exhaust gases are flared to ensure complete burning of gas
- Perimeter wells prevent landfill gases from affecting surrounding family dwellings



Many Lessons Learned

- Dirty air
- Fuel contaminants
- Effects of wind
- Challenges of common exhaust ducting
- Variability of LFG composition
- Ambient temp / power swings
- Cost of working in remote locations

Ongoing Tests

- H_2S -- levels versus effects
- Siloxanes -- levels versus effects
- Physical modifications to increase tolerance
- Gas conditioning and processing alternatives

Long term goal: minimize project cost vs. contaminants

New Options Are Coming in 2003

- Modular pre-engineered compressors to serve multiple units
- Pre-engineered, factory-built fuel treatment modules, tuned to the needs of our microturbines
- 250 kW units for larger projects

250 kW Package



- 250 kW_e model at ISO conditions
- Has 120% peaking power capacity
- Efficiency
 - 32% LHV electric w/booster
 - Up to 70% total with cogeneration
- Low emissions with natural gas
 - <9 ppmw NO_x @ 15% O₂
- 8,000 hour maintenance interval
- 10 year design life
- 3x footprint of 70 kW
- Grid-parallel or grid-isolated
- Closed transitions to grid-isolated mode during grid outages

The image features a black background with several bright, jagged lightning bolts striking horizontally across the center. The word "PowerWorks" is written in a white, outlined, sans-serif font, positioned directly in the middle of the lightning bolts. The bolts appear to be striking the letters, creating a sense of power and energy.

PowerWorks

1-877-IRPOWER

www.irpowerworks.com