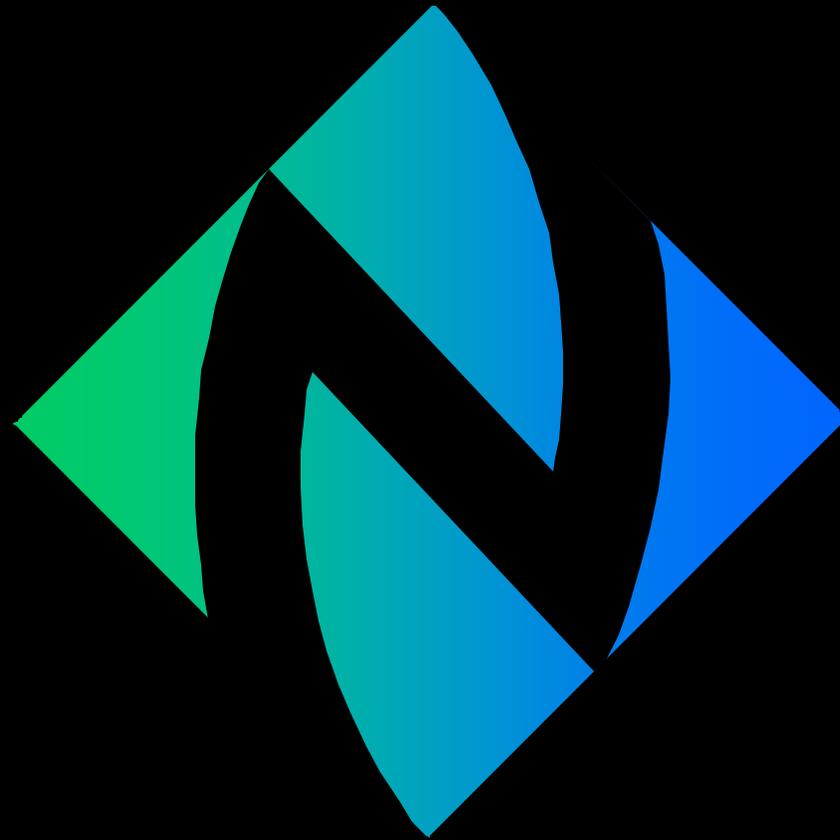




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BPA Conference:
Christopher F. Galati, P.E.



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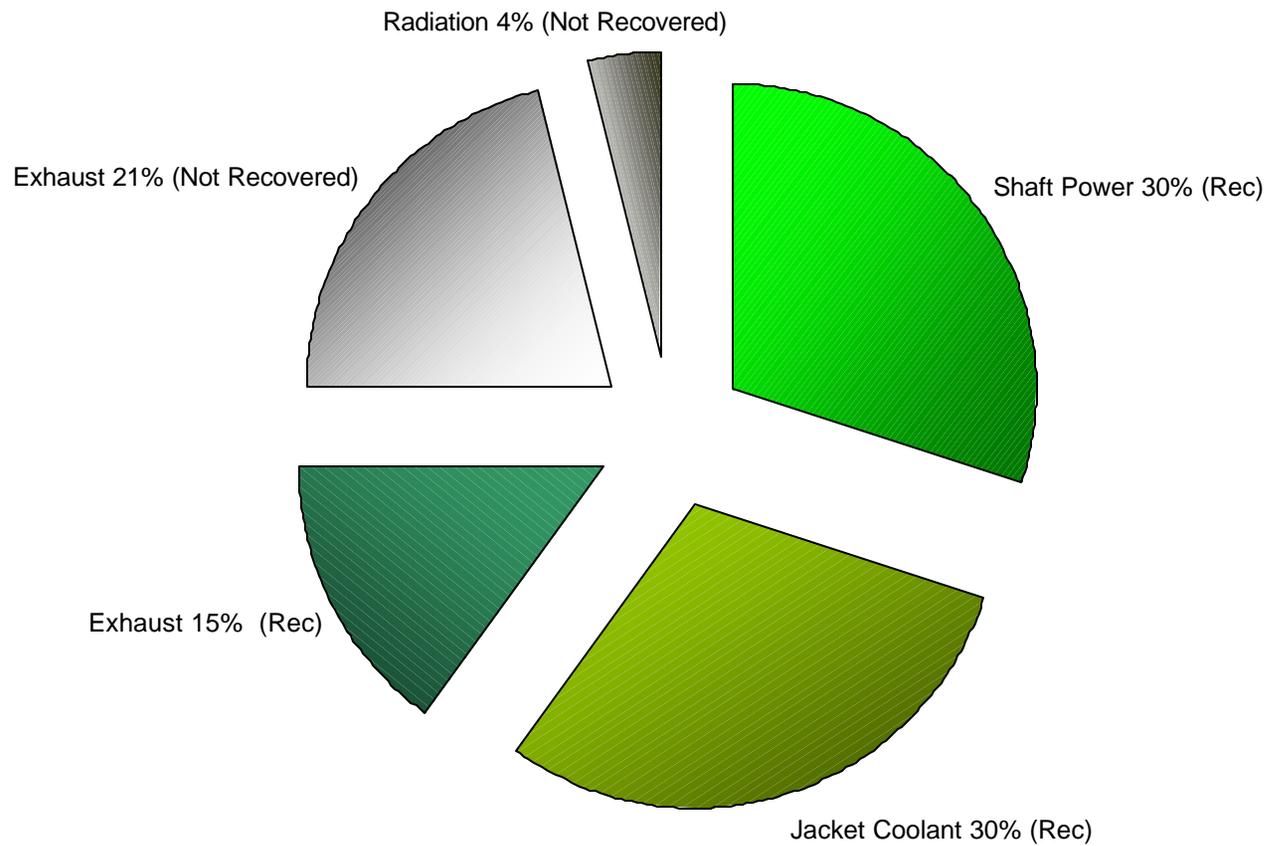
DISTRIBUTED GENERATION

Distributed Generation: On site generation, parallel and synchronous with the grid.

Combined heat and power: On site generation specifically using waste heat from the process.



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“200 Market Building Consortium”

Purpose: To install, study and publicize Combined Heat & Power in a commercial application.

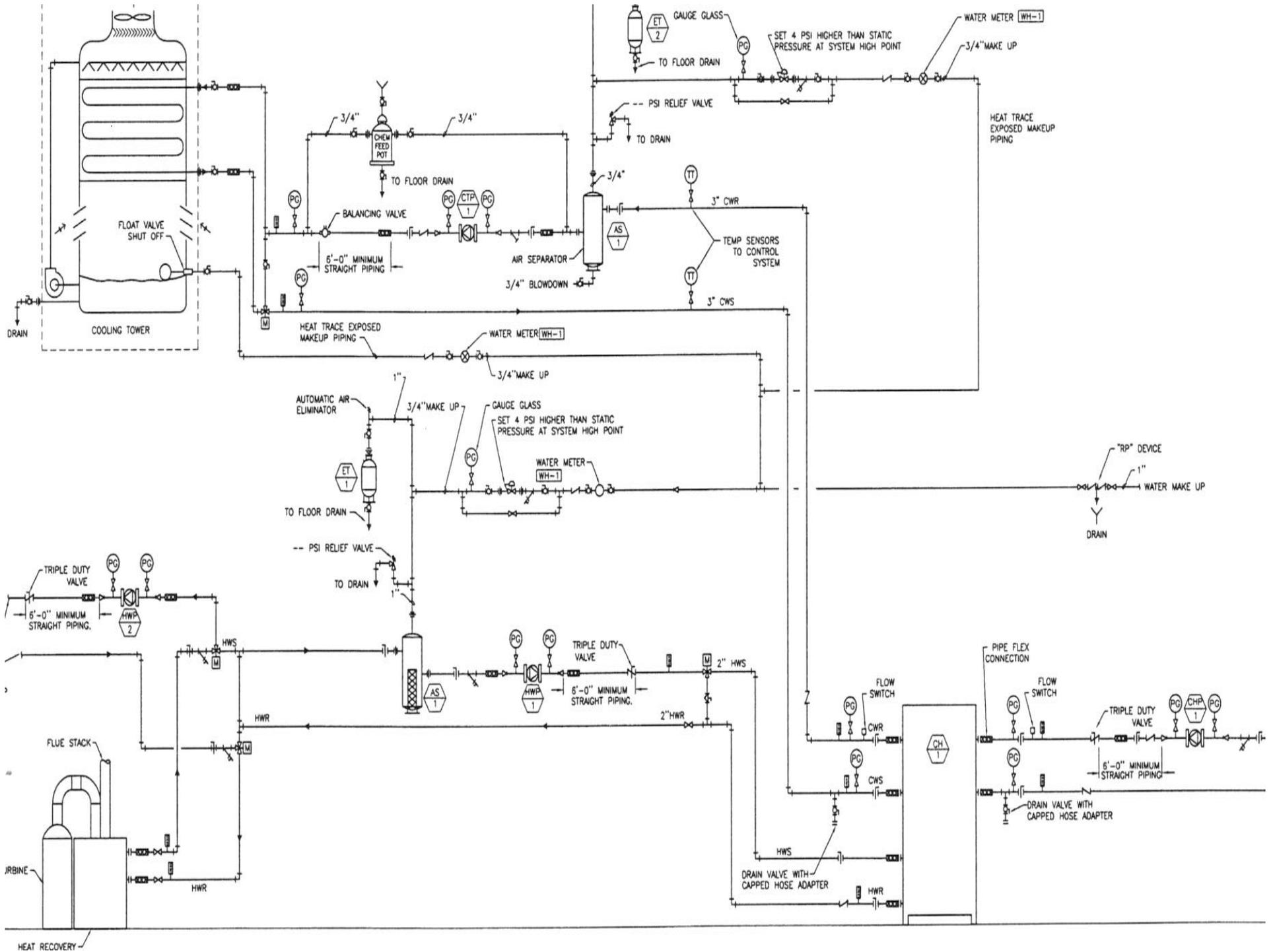
- ◆ Use waste heat 24/7
- ◆ Demonstrate reliability of technology
- ◆ Drive costs down.
- ◆ Inform customers of potential problems.
- ◆ Demonstrate boiler preheat for waste heat recovery.
- ◆ Demonstrate Absorption chiller for waste heat recovery.
- ◆ Create templates for analysis and share reports, drawings and key contacts to all on the internet.





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COSTING INFORMATION		MARKET ST. CHP CONSORTIUM	
		Funds committed or being committed	
PROJECTED COSTS		PARTNERS	CAPITAL
MICRO TURBINE	\$39,000	NW NATURAL	\$25,000
UNIFIN HEAT EXCHANGER	\$10,000	OREGON OFFICE OF ENERGY	\$88,189
YAZAKI WATER FIRED	\$14,000	CITY OF PORTLAND	\$4,000
STRUCTURAL	\$5,000	BPA	\$25,000
ELCECTRICAL	\$20,000	PACIFIC POWER AND LIGHT	\$25,000
MECHANICAL	\$97,000	RUSSELL DEVELOPMENT	\$31,000
CONTROLS	\$28,000	INDUSTRIAL CENTER	\$2,000
DESIGN	\$10,000	AMERICAN GAS FOUNDATION*	\$106,000
TURBINE BUILDING	\$83,000	*(American Gas Association and the Gas Technology Institute)	
	\$306,000		\$306,189

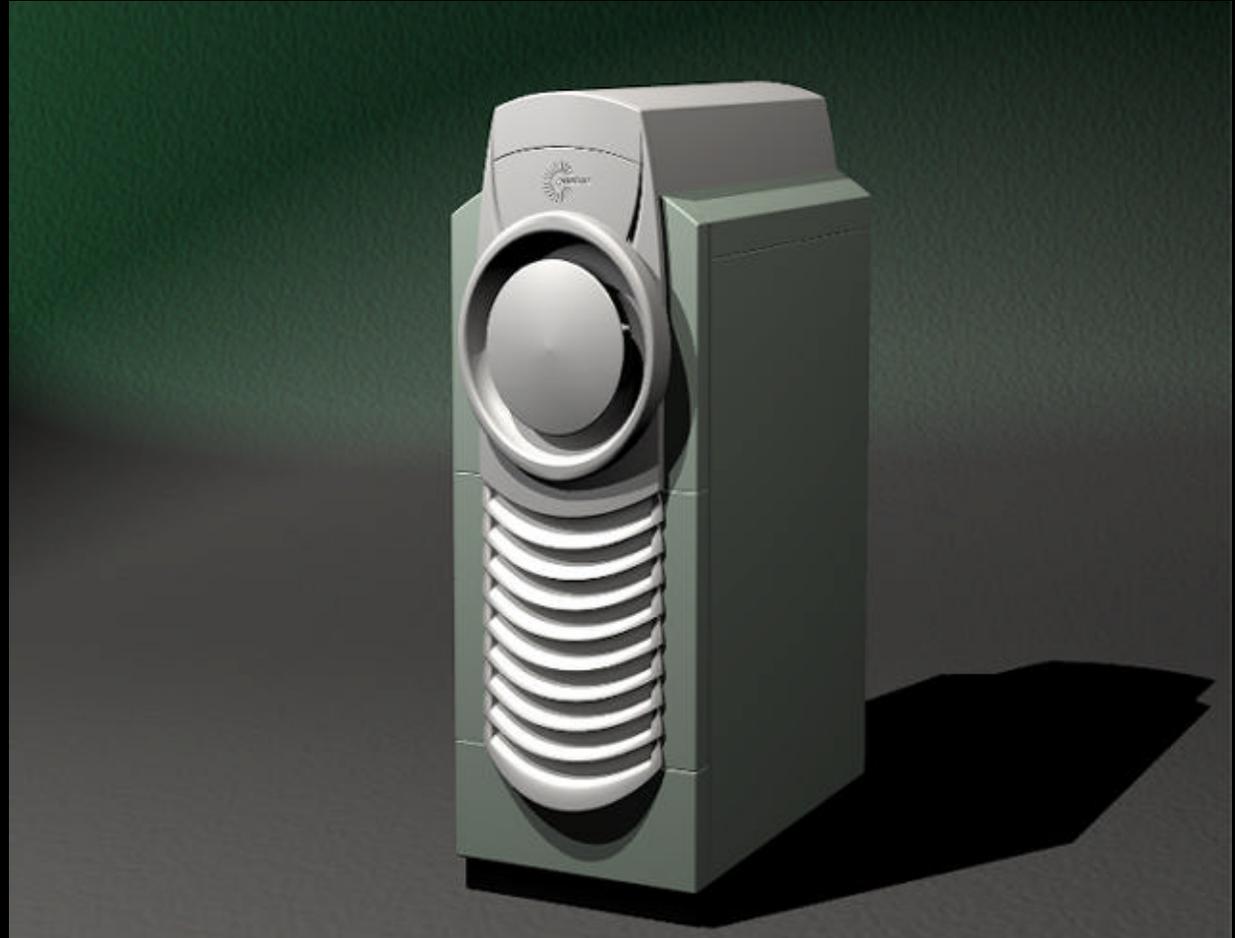




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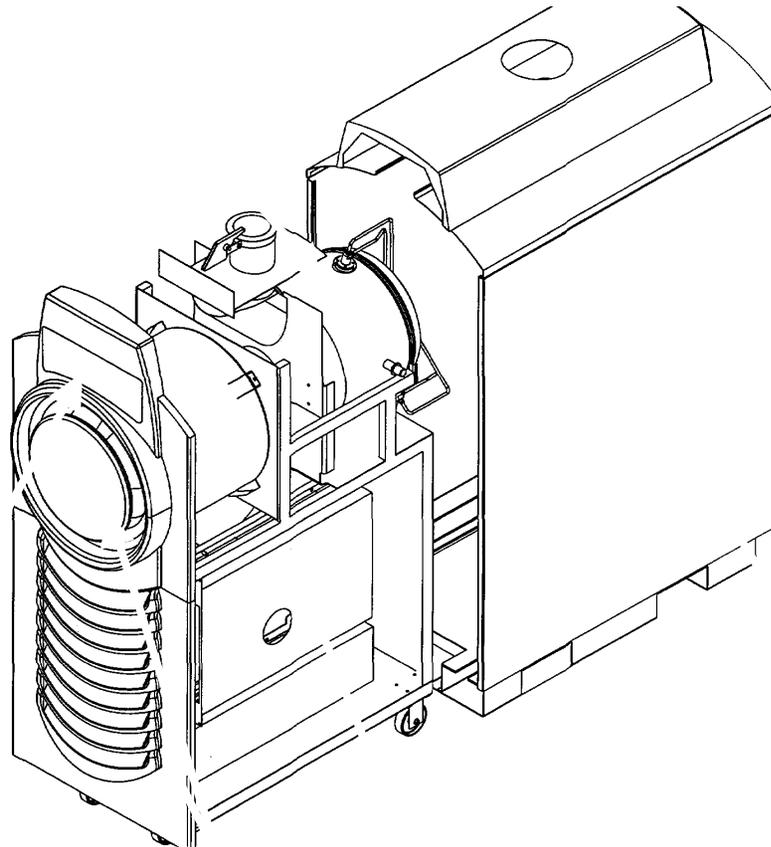
Wholesale Energy Prices

30 KW Capstone Turbine



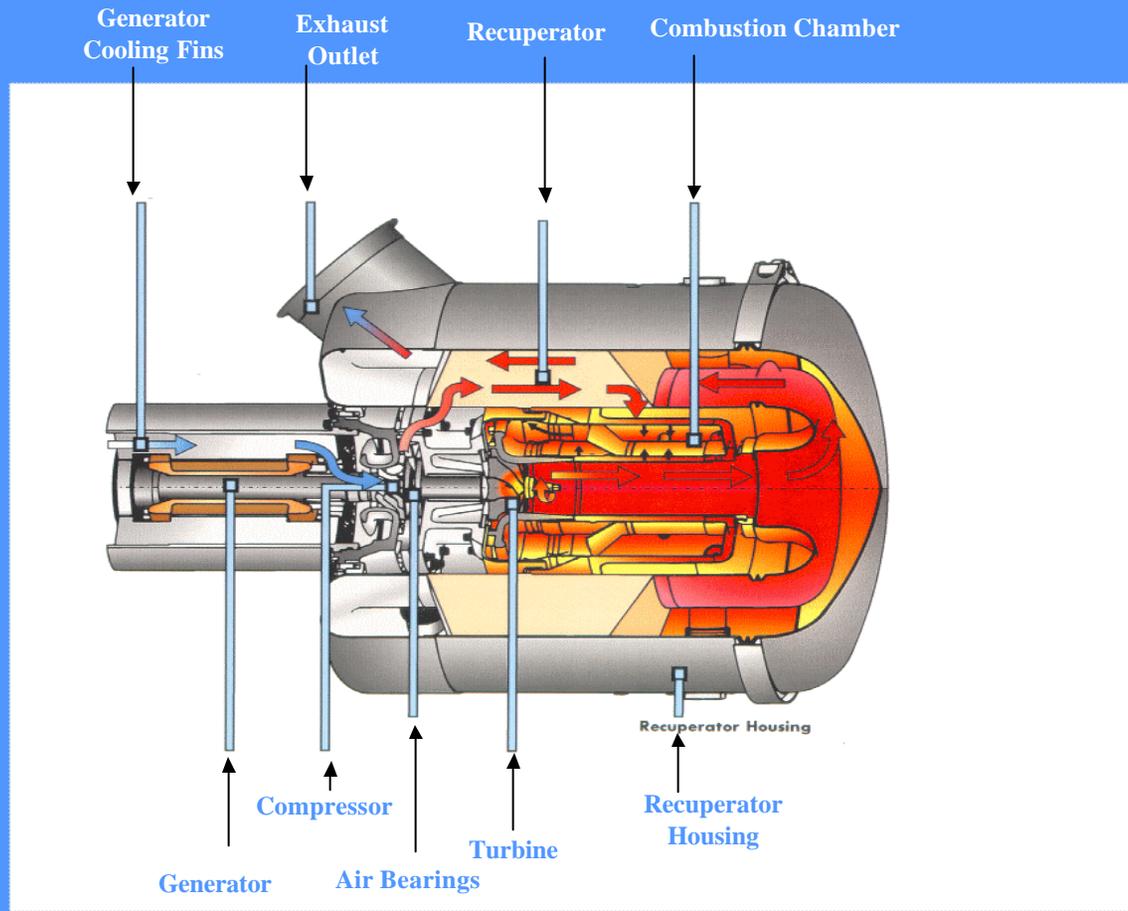


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The Capstone MicroTurbine™ has patented air bearings that eliminate the need for liquid lubricants



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POWER OUTPUT FUEL INPUT									
DG	OUTPUT	FACTOR	EFF	HEAT	BTUH	TH/HR	RUNTIME	POWER	TOTAL
DEVICE	KW	BTU/HR/KW	M:E	RATE	INPUT	INPUT	EST	KWH	THERM
TURBINE	27	3412	0.28	12186	329014	3.29	8760	236520	28822



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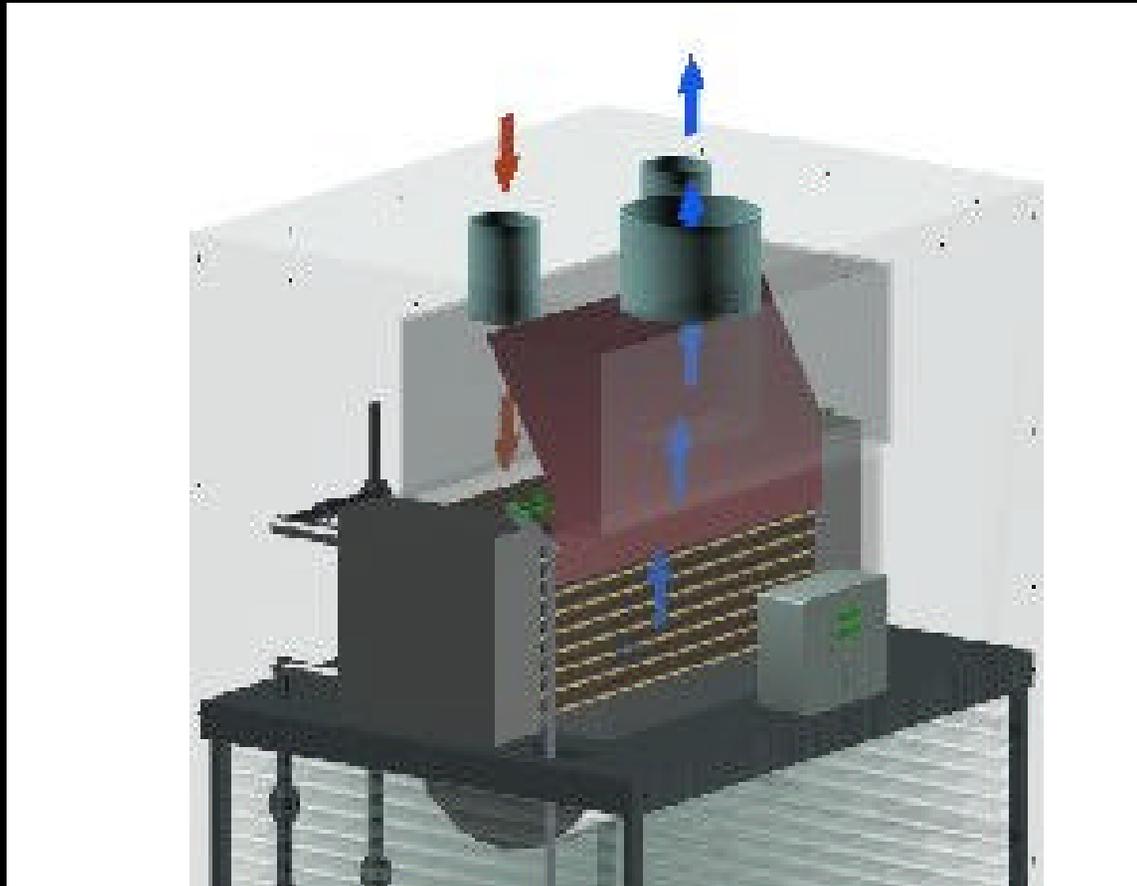
Heat Recovery





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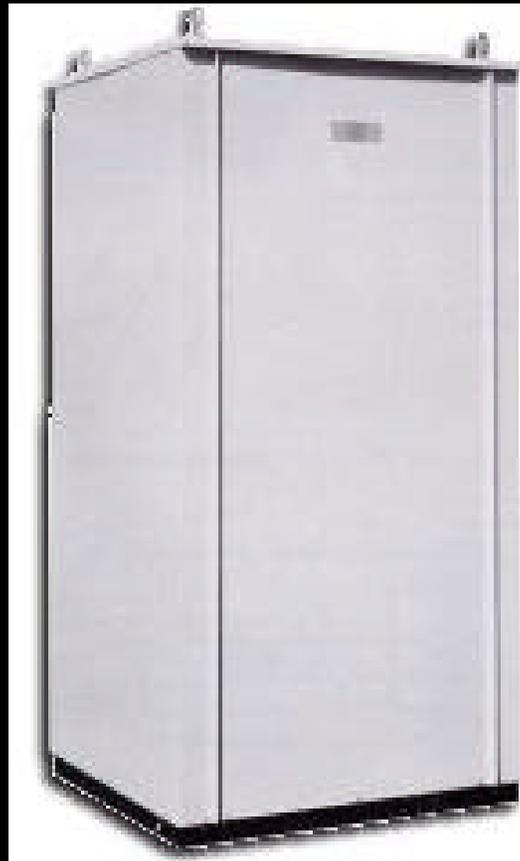
Air to Water Heat Exchanger





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Absorption by Yazaki



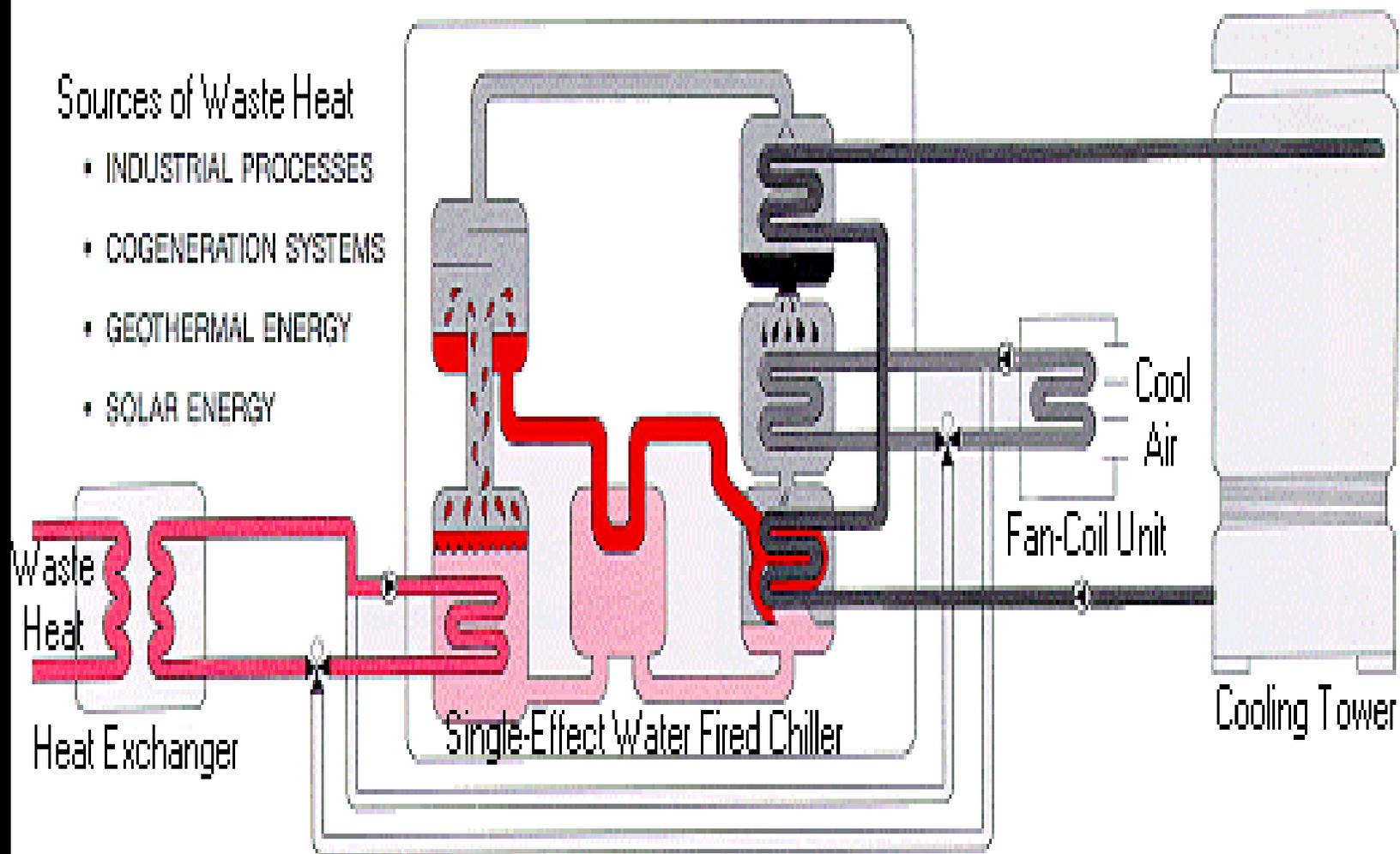


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Absorption Cycle

Sources of Waste Heat

- INDUSTRIAL PROCESSES
- COGENERATION SYSTEMS
- GEOTHERMAL ENERGY
- SOLAR ENERGY





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DG									
HEAT RECOVERY									
DG	OUTPUT	FACTOR	WASTE %	WASTE %	SPACE HEATING		HW	COOLING	COOLING
DEVICE	KW	BTU/HR/KW	TOTAL	RECOVER	HOURS	THERMS	THERMS	HOURS	KWH
TURBINE	27	3412	0.72	0.55	2190	3963		6570	52560



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ENERGY RATES AVERAGE		INPUT		DISPLACED
DG	RATE	DG RATE		VALUE
DEVICE	ELECTRIC	GAS		GAS
TURBINE	0.0442	0.42		0.76



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ENERGY ACCOUNTING YEAR 1									
	INPUT	DISPLACED	RECOVER	RECOVER	DISPLACE	TOTAL		DG POWER	FULL CHP
DG	FUEL	ELECTRIC	HEATING	H2O	COOLING			\$/KWH	\$/KWH
DEVICE	COST	VALUE	VALUE	VALUE	VALUE	VALUE		ELECTRIC ONLY	
TURBINE	-\$12,105	\$10,454	\$3,012	\$0	\$2,323	\$3,684		\$0.0512	\$0.0419



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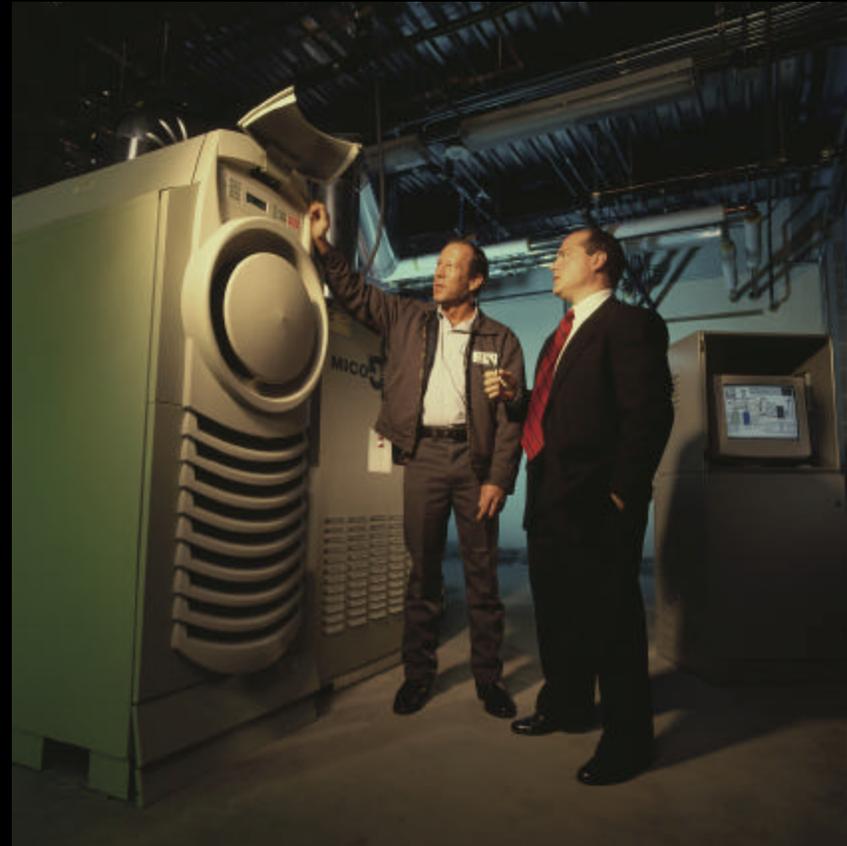
CUSTOMER PAYBACK STREAM									
CAPITAL/ 30KW TURE	LEASE 10	DEPREC STRAIGHT	ESTIMATED MAINT.	FUEL INPUT TO DG EQU	ELECTRIC AVOIDED	HEATING AVOIDED	HOT H2O AVOIDED	COOLING AVOIDED	TOTAL
YEAR 0	\$25,000	\$925	(\$946)	(\$17,005)	\$15,450	\$3,205	\$0	\$2,922	(\$25,000)
YEAR 1	(\$6,261)	\$925	(\$946)	(\$12,105)	\$10,454	\$3,012	\$0	\$2,323	\$3,663
YEAR 2	(\$6,261)	\$925	(\$946)	(\$12,105)	\$12,022	\$3,614	\$0	\$2,439	\$5,950
YEAR 3	(\$6,261)	\$925	(\$946)	(\$12,105)	\$13,826	\$4,337	\$0	\$2,561	\$8,598
YEAR 4	(\$6,261)	\$925	(\$946)	(\$12,105)	\$14,517	\$3,012	\$0	\$2,689	\$8,092
YEAR 5	(\$6,261)	\$925	(\$946)	(\$12,105)	\$15,243	\$3,012	\$0	\$2,824	\$8,952
YEAR 6	\$0	\$925	(\$946)	(\$21,904)	\$16,005	\$3,012	\$0	\$2,965	\$56
YEAR 7	\$0	\$925	(\$946)	(\$21,904)	\$16,805	\$3,012	\$0	\$3,113	\$1,005
YEAR 8	\$0	\$925	(\$946)	(\$21,904)	\$17,645	\$3,012	\$0	\$3,269	\$2,001
YEAR 9	\$0	\$925	(\$946)	(\$21,904)	\$18,528	\$3,012	\$0	\$3,432	\$3,046
YEAR 10	\$0	\$925	(\$946)	(\$21,904)	\$19,454	\$3,012	\$0	\$3,604	\$4,144
	(\$25,000)		(\$6,348)	(\$107,855)	\$99,711	\$21,778	\$0	\$19,012	\$1,298



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Conclusions

- Look for base loaded 30 KW 24/7 applications.
- Look for base loaded 1.5 Therms/hour 24/7 hot water applications.
- Locate outside if possible.
- Locate close to hot water loads served first.
- Get good design advice and controls engineer on board first.
- Pools, health care/clubs computer rooms.





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Looking Forward Stirling Engine

Key Features

- **Dual Shell Technology**
 - Higher Operating Temperature
- **Advanced Regenerator**
 - Further improves efficiency
- **Simplified Heater Head**
 - Dramatic cost savings



- ◆ **External Combustion Engine...The Stirling Engine**