



Gas turbine manufacturers are driving toward simultaneously achieving low cost, high efficiency, and low emissions.

Gas Turbines (5 MW)

2003

- ▶ 27% electrical efficiency
- ▶ 25 ppm NO_x
- ▶ \$1000/kW CHP System @ 69% efficiency



2030

- ▶ 35% electrical efficiency
- ▶ 3 ppm NO_x
- ▶ \$900/kW CHP system @ 74% efficiency

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Manufacturers of stationary engines have pursued R&D related to reducing emissions, increasing engine efficiency and power, reducing engine costs, and extending maintenance intervals.

Reciprocating Engines (5 MW)

2003

- ▶ 37% electrical efficiency
- ▶ 0.5 g/bhp-hr NO_x
- ▶ \$890/kW CHP system @ 75% efficiency



2030

- ▶ 45% electrical efficiency
- ▶ 0.1 g/bhp-hr NO_x
- ▶ \$765/kW CHP system @ 80% efficiency

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Manufacturers of fuel cells are driving towards reducing costs.

Fuel Cells

2003 (PAFC/200kW)

- ▶ 36% electrical efficiency
- ▶ 0.04 lb/MWh NO_x
- ▶ 370-410 degrees F
- ▶ \$4,500/kW CHP System @ 75% CHP efficiency



2030 (PEMFC/200-250kW)

- ▶ 38% electrical efficiency
- ▶ 0.05 lb/MWh NO_x
- ▶ 150-180 degrees F
- ▶ \$1,100/kW CHP System @ 75% CHP efficiency

2030 (MCFC/250kW)

- ▶ 49% electrical efficiency
- ▶ 0.04 lb/MWh NO_x
- ▶ 1,200-1,300 degrees F
- ▶ \$1,565/kW CHP System @ 75% CHP efficiency
- ▶ Internal reforming

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Microturbine manufacturers are pursuing R&D related to achieving low cost, high efficiency, low emissions, and increased reliability.

Microturbines (100 kW)

2003

- ▶ 26% electrical efficiency
- ▶ 15 ppm NO_x
- ▶ \$1,770/kW CHP system @ 68% efficiency



2030

- ▶ 38% electrical efficiency
- ▶ 3 ppm NO_x
- ▶ \$845/kW CHP system @ 73% efficiency

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Thank you!

- You've met the panel
- Seen some numbers
- Now it's your turn...
 - Questions (stump the chumps)
 - or
 - Comments (join the chumps)

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	Availability %	Electric Efficiency (HHV) %	CHP System Efficiency %	Installed Cost w/wheat Recovery \$/kW	O&M Cost \$/kW-hr
Hedman: ICES					
100 kW	72-99%	30%	79%	\$1,350	0.018
300 kW	95-99%	31%	77%	\$1,160	0.013
1 MW	91-99% ^a	34%	76%	\$940	0.009
3 MW	91-99% ^a	35%	75%	\$935	0.0085
1 MW GT	88-99%	22%	68%	\$1,909	0.01
5 MW GT	86-99%	27%	69%	\$1,045	0.006
25 MW GT	97% ^b	34%	73%	\$800	0.005
Panora 75 kW Pckg	95%	28%	81%	1,800-2,600 \$/kw	-\$0.025 or \$15k/yr contracted
Garland, DOE/Industry 2030 Targets					
5 MW GT		35%	74%	810 \$/kW	0.0047
25 MW GT		40%	76%	680 \$/kW	0.004
ICE systems:					
100kW		34%	80%	970 \$/kW	0.01
300kW		35%	79%	900 \$/kW	0.01
1MW		42%	85%	800 \$/kW	0.008
3MW		43%	82%	790 \$/kW	0.0075

	Availability %	Electric Efficiency (HHV) %	CHP Efficiency %	Installed Cost w/heat Recovery \$/kW	O&M Cost \$/kW-hr
Crank/Navy					
PV 750 kW Case	~99%	N/A	N/A	\$10,213 /kW	Minimal
Micro Turbines (2 x 60 kW)	up to 99%	mfg: 23.4% meter: 34.7%	mfg: 53.3% meter: 80.9%	\$648,460 (incl HTHW syst, VFD pumps)	contract w/supplier \$26.6k/yr
GT (M&V) 5.2 MW	82%-100%	30%	76%	1,245 \$/kW	0.0075 \$/kWh
Thornton					
Hospital 5 MWhr	98%	26% HHV	63%	1,129 \$/kW	\$.025 or \$167k/yr
Campus 7.4 MW	96%	30%	69%	1,058 \$/kW	0.025/0.028 \$/kwh
City 20 MW	98%	31%	71%	1,030 \$/kW	\$0.028
DeGroat					
225 kW Wind	94%	NA	NA	1,500/kW	\$0.01-\$0.02
PV 1 kW flat w/o storage	94%	NA	NA	10,000 /kW	\$0.001-\$0.004
PAFC Fuel Cell 200 kW	88-96	40	Up to 90%	4,000 /kW	\$0.013-\$0.016
PEM Fuel Cell 3 kW	90-98	27-40%	Up to 90%	5,000 /kW	\$0.01-\$0.04