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Gas Turbine World 1997 Handbook

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FOR PROJECT PLANNING, DESIGN & CONSTRUCTION

Turnkey Combined Cycle Budget Price Levels

Budgetary turnkey plant prices in 1997 US\$ for gas turbine combined cycle plants run from as low as \$320 per kilowatt to \$1,000 per kW, primarily as a function of plant size—the bigger plants cost less per kW, the smaller ones cost more. These are average turnkey plant prices, reflecting the median of the price range for a fairly basic, 'no-frills' plant.

The \$ figures are designed for scoping studies and preliminary project assessment. They are probably not the figures that you will actually end up paying for a new combined cycle.

The ratings are net plant at ISO conditions of 59°F (15°C) ambient air temperature, sea level and 60 percent relative humidity, base load, on natural gas fuel, no fluid injection for power augmentation. Equipment and services include:

- **Gas Turbine.** Packaged as enclosed cab or with very basic steel hall (for larger sets). Standard starting, fuel forwarding and control equipment, generally with dry low NOx combustors if available, and single fuel (gas) system. With standard inlet filtration, no heating or chilling. Enclosure ventilation included, reduction gearbox where required.
- **Steam turbine.** Condensing, subcritical, generally with two pressure levels or more; some larger units with triple pressure, others with triple pressure plus reheat. Axial or radial exhaust, water-cooled heat rejection, feedwater treatment and pumps.
- **Heat Recovery Boiler.** Outdoors-mounted unfired HRSG with ductwork but no bypass damper or stack. Generally multiple pressure level, some triple pressure, some with reheat as noted in the table. Minimum height exhaust stack. No catalytic converters for NOx or CO reduction.
- **Electric Generators.** Generally air-cooled on the smaller machines, mostly hydrogen cooled on the larger plants. Main step-up transformer, neutral grounding cubicle and non-segregated bus included.
- **Balance of Plant.** Standard controls (not DCS)

and auxiliaries; baseplate or basic foundation. Does not include electrical substation, or a pipeline to bring in gas fuel, or storage or treatment for liquid (if dual fuel). Administrative offices, workshops and storage buildings, operational spares and consumables are not included. No black start generator sets.

- **Services.** Basic services to allow for turnkey plant operability include engineering, project management, technical and start-up support, minimum inland transport, construction and installation, sub-contract labor.

Depending on the scope of equipment, site specific requirements, geographic location and competitive market conditions, these prices can vary considerably. One factor is fuel cost at the geographic site location. Construction costs can vary dramatically as a function of labor rates at different site locations.

There's a first-cost premium for efficiency, both on the gas and steam sides. For example, the more efficient the steam cycle and the more complex it is, the more the plant will cost. Triple pressure heat recovery boilers cost more. So do units with reheat, and the multi-casing steam turbines that match these boilers are also more expensive.

In mid-range to base load service, typically where these plants are operated, the higher efficiency units can produce equipment payback periods years faster than lower-efficiency competitors, justifying their greater initial cost.

In areas where fuel costs are high, figure that over the roughly 20-year life of a base load combined cycle, up to 70 percent of total plant costs—including acquisition, owning and operating costs and debt service—are for fuel alone, it's easy to see why efficiency can be so important.

In areas where fuel is cheap, obviously it's not worth it to pay extra for good thermal efficiency.

Competitive markets

Global competition among the suppliers of turnkey combined cycle power stations has reduced prices for these plants. In the large output CCGTs there has

been a serious price war. Big combined cycles, for example, have dropped as much as 40% in first cost over the last three to four years. The competition isn't quite as intense on the smaller scale plants—yet.

Independent power developers are creating a more competitive market that is affecting both the large and the smaller projects. Financial lenders and equity investors in IPP projects are forcing intense bottom line competition from equipment and service suppliers. These institutions want costs as low as possible to get maximum return on investment, and in some areas are forcing best available environmental controls along with lowest operating costs.

Another factor in the lower prices is EPC firms which have drastically cut building schedules, sometimes in half. Small, pre-engineered combined cycles can often be installed in under 12 months, cutting interest costs on construction loans and allowing plants to get on line and generate revenue much earlier.

Standardized plants

Standardized combined cycle plant \$/kW prices are a function of size (output) of the gas and steam turbines, and vary according to multiples of units that

make up the plant—and the design configuration of both the plant and its components.

Multi-shaft plants, where each gas turbine and steam turbine drives its own generator, are generally more costly than single shaft designs. The single shaft combined cycle—with the gas and steam turbine driving one generator in a single power train—eliminates one complete electric generator and its attendant auxiliaries. Similarly, a plant design with twin gas turbines exhausting into a single HRSG is less costly than one with dual boilers. Any reduction in power equipment almost always reduces price.

Lower cost plants are not just a function of competitive market pressure. First costs have also dropped as manufacturers have improved both gas and steam turbine technologies and performance. More kW output is coming from uprated frames at the same (or lower) equipment cost. New machines pack much more power density than their predecessors of only a decade ago.

Computer design and network links have made concurrent engineering possible, drastically cutting product lead time, complexity and cost. The OEMs have also cut back on profit margins—sometimes significantly.



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Finally, OEMs and engineering companies have designed and created standardized, pre-engineered and easily replicated modules and packages to simplify combined cycle plant design and installation. Maximized factory production and packaging for minimum on-site work helps to bring down costs and speed up installation.

Excluded costs

These turnkey plant price levels, as noted, are for 'plain vanilla' plant equipment and services. Extended site work such as cogeneration process

steam or utility plant tie-ins are not covered, nor are extensive buildings, nor a large inventory of operational spares such as combustor baskets, blades and vanes, etc.

Also not included are the indirect, or so-called 'soft costs' that can significantly increase the overall project budget costs. These would include interest during construction, financing and legal fees, licensing and permitting, insurance and bonding, workman's compensation, sales tax, extensive inland freight, owner's cost and overhead, and finally, project contingency funds.

Project Prices for 107-MW Combined Cycle Cogeneration Facility

In 1995, CEA-Brooklyn Union Gas completed a gas-fired 107-MW combined cycle cogenerating station at John F. Kennedy International Airport in Brooklyn, New York. Power plant uses two 40-MW Stewart & Stevenson LM6000 gas turbine generators each exhausting into a triple pressure heat recovery steam generator raising steam for process and to power a nominal 27-MW steam turbine generator. HRSGs are complex-fitted with gas fuel duct burners and include selective catalytic reduction systems for both NOx and CO, driving up the price. Construction costs can vary dramatically, as shown, with JFK job at the top end of the scale. Budgeted prices are in 1995 U.S. dollars.

Budget Equipment Pricing	\$ Amount
Gas turbine generators	\$24,000,000
Heat recovery steam generators	10,000,000
Steam turbine generator set	4,000,000
Condenser	300,000
Cooling towers	800,000
Transformer and switchgear	8,000,000
Balance of plant equipment	7,500,000
Subtotal, equipment	\$54,600,000
Budget Services & Labor	
Mechanical & electrical construction	\$20-75,000,000
Engineering	4,000,000
Subtotal, services	\$24-79,000,000
Total Capital Cost	\$78,600,000-133,600,000

Turnkey Combined Cycle Plant Price Levels

Average standardized turnkey combined cycle power plant prices in 1997 U.S. dollars for a basic natural gas-fired combined cycle with gas turbine generator, unfired multi-pressure heat recovery boiler with no bypass stack, condensing multi-pressure steam turbine generator, step up transformer, water cooled heat rejection, standard controls, starting system and plant auxiliaries, and generally with dry low NOx gas turbine. Depending on scope of equipment, site specific requirements, geographic location and competitive market conditions, these prices can vary considerably.

Plant Model	Net Plant Output	LHV Heat Rate	Net Plant Efficiency	No. Gas Turbines	No. Steam Turbines	Price Millions	\$ per kW
GT5 Cogen	2.65 MW*	n/a	n/a	1xGT5	0	\$2.2	\$825
GTM7 Cogen	5.72 MW*	n/a	n/a	1xM7A-01	0	\$4.1	\$715
<small>*w. process steam, no steam turbine</small>							
GPCS 80	7.9 MW	8470 Btu	40.3%	1xM7A-01	1x2.4 MW, 1P	\$5.5	\$1000
SB60C	17.7 MW	8230 Btu	41.5%	1xSB60C	1x5.4 MW, 2P	\$13.8	\$778
CC1-1600	17.9 MW	7125 Btu	47.9%	1xLM1600	1x4.8 MW, 2P	\$14.9	\$830
KA35-1	22.8 MW	7880 Btu	43.3%	1xGT35	1x8.2 MW, 2P	\$19.1	\$840
THM1304	27.8 MW	8125 Btu	42.0%	2x1304D	1x9.0 MW, 2P	\$22.2	\$799
CC-201	28.3 MW	7670 Btu	44.5%	2xPGT10	1x10 MW, 2P	\$24.1	\$852
IPS30	28.7 MW	7750 Btu	44.0%	2xMars 100S	1x7.3 MW, 2P	\$25.0	\$845
CC1-2500	30.9 MW	6850 Btu	49.8%	1xLM2500	1x8.4 MW, 2P	\$23.0	\$744
FT8	32.3 MW	6925 Btu	49.3%	1xFT8	1x8.4 MW, 2P	\$25.8	\$799
KA10-1	35.5 MW	6760 Btu	50.5%	1xGT10	1x12 MW, 2P	\$27.9	\$785
1x1 RB211	37.4 MW	6745 Btu	50.6%	1xRB211	1x12 MW, 2P	\$30.3	\$810
CC1-2500+	38.4 MW	6570 Btu	51.9%	1xLM2500+	1x12 MW, 2P	\$27.0	\$703
CC105P	38.5 MW	8180 Btu	41.7%	1xFr.5PA	1x13 MW, 2P	\$24.0	\$623
IPS40	43.1 MW	7730 Btu	44.1%	3xMars 100	1x11 MW, 2P	\$32.8	\$762
CC1-5000	44.5 MW	7095 Btu	48.1%	1xLM5000PC	1x11 MW, 2P	\$35.9	\$806
CC1-6000	55.0 MW	6500 Btu	51.5%	1xLM6000PA	1x13 MW, 2P	\$35.5	\$645
IPS50	57.4 MW	7720 Btu	44.2%	4xMars 100S	1x15 MW, 2P	\$44.2	\$770
S106B	59.8 MW	7005 Btu	48.7%	1xFr. 6B	1x23 MW, 2P	\$37.0	\$619
1x1 Trent	64.4 MW	6603 Btu	51.7%	1xTrent	1x16 MW, 2P	\$52.0	\$808
FT8 Twin	67.0 MW	6800 Btu	50.2%	2xFT8	1x18 MW, 2P	\$41.0	\$612
KA10-2	71.3 MW	6730 Btu	50.7%	2xGT10	1x24 MW, 2P	\$48.5	\$680
1x1 251B11/12	74.8 MW	6930 Btu	49.2%	1x251B11/12	1x26 MW, 2P	\$51.0	\$681
2x1 RB211	75.7 MW	6665 Btu	51.2%	2xRB211	1x24 MW, 2P	\$61.0	\$806
KA8C-1	77.7 MW	6640 Btu	51.4%	1xGT8C	1x25 MW, 2P	\$54.0	\$695
CC205P	77.8 MW	8110 Btu	42.1%	2xFr.5PA	1x27 MW, 2P	\$47.9	\$615
Cobra 1.64.3	90.4 MW	6615 Btu	51.6%	1xV64.3	1x32 MW, 2P	\$58.5	\$647

Turnkey Combined Cycle Plant Price Levels (Continued)

Average standardized turnkey combined cycle power plant prices in 1997 U.S. dollars for a basic natural gas-fired combined cycle with gas turbine generator, unfired multi-pressure heat recovery boiler with no bypass stack, condensing multi-pressure steam turbine generator, step up transformer, water cooled heat rejection, standard controls, starting system and plant auxiliaries, and generally with dry low NOx gas turbine. Depending on scope of equipment, site specific requirements, geographic location and competitive market conditions, these prices can vary considerably.

Plant Model	Net Plant Output	LHV Heat Rate	Net Plant Efficiency	No. Gas Turbines	No. Steam Turbines	Price Millions	\$ per kW
1xP200-PFBC	100.0 MW	8030 Btu	42.5%	1xGT35P	1x83 MW, Cond.	\$120.0	\$1200
GUD 1S.64.3A	101.0 MW	6355 Btu	53.7%	1xV64.3A	1x31 MW, 3P*	\$74.7	\$740
S-106FA	107.4 MW	6420 Btu	53.2%	1xFr.6FA	1x40 MW, 3P*	\$79.6	\$741
CC2-6000	111.0 MW	6400 Btu	53.3%	2xLM6000PA	1x27 MW, 2P	\$73.0	\$658
S-206B	121.7 MW	6930 Btu	49.3%	2xFr. 6B	1x46 MW, 2P	\$65.0	\$534
2x1 Trent	127.2 MW	6575 Btu	51.9%	2xTrent	1x32 MW, 2P	\$89.0	\$700
S-107EA	130.2 MW	6800 Btu	50.2%	1xFr. 7EA	1x48 MW, 3P	\$58.6	\$450
KA13D-1	147.1 MW	6920 Btu	48.6%	1xGT13D	1x53 MW, 1P	\$74.9	\$510
2x1 251B11/12	149.7 MW	6930 Btu	49.2%	2x251B11/12	1x52 MW, 2P	\$78.5	\$524
GUD 1.84.2	163.0 MW	6630 Btu	51.5%	1xV84.2	1x60 MW, 2P	\$74.7	\$458
KA11N2-1	171.0 MW	6600 Btu	51.7%	1xGT11N2	1x56 MW, 2P	\$77.9	\$455
1x1 501D5A	179.0 MW	6570 Btu	51.9%	1x501D5A	1x60 MW, 2P	\$76.5	\$427
GUD 1.94.2	238.0 MW	6550 Btu	52.1%	1xV94.2	1x88 MW, 2P	\$101.5	\$426
S-107FA	258.8 MW	6090 Btu	56.0%	1xFr. 7FA	1x95 MW, 3P*	\$112.9	\$436
GUD 1S84.3A	260.0 MW	5885 Btu	57.0%	1xV84.3A	1x84 MW, 3P*	\$113.9	\$438
S-207EA	263.6 MW	6750 Btu	50.6%	2xFr. 7EA	1x101 MW, 3P	\$105.8	\$401
KA24-1	267.0 MW	5940 Btu	57.4%	1xGT24	1x97 MW, 2P	\$114.8	\$430
1x1 501F	268.1 MW	5980 Btu	56.9%	1x501F	1x97 MW, 3P*	\$111.0	\$414
GUD 1S.94.2A	285.0 MW	6095 Btu	56.0%	1xV94.2A	1x95 MW, 3P	\$112.3	\$394
S-109FA	376.2 MW	6060 Btu	56.3%	1xFr. 9FA	1x139 MW, 3P*	\$137.7	\$366
GUD 1S.94.3A	380.0 MW	5885 Btu	58.0%	1xV94.3A	1x120 MW, 3P*	\$142.9	\$376
KA26-1	396.0 MW	5830 Btu	58.5%	1xGT26	1x133 MW, 3P*	\$150.5	\$380
KA11N2-3	517.0 MW	6550 Btu	52.1%	3xGT11N2	1x172 MW, 2P	\$178.4	\$345
S-507EA	620.0 MW	6800 Btu	50.2%	5xFr. 7EA	3x68 MW, 3P	\$207.7	\$335
GUD 3.94.2	719.5 MW	6490 Btu	52.6%	3xV94.2	1x270 MW, 2P	\$244.7	\$340
KA13E2-3	727.5 MW	6380 Btu	53.5%	3xGT13E2	1x250 MW, 2P	\$244.4	\$336
S-209FA	757.5 MW	6020 Btu	56.7%	2xFr. 9FA	1x283 MW, 3P*	\$240.8	\$318
GUD 2.94.3A	760.0 MW	5883 Btu	58.0%	2xV94.3A	1x260 MW, 3P*	\$258.4	\$340

* with reheat