
2018 FALL WORKSHOP
Gas Turbine Energy Systems:
Clean and Reliable Energy on Demand
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# TRAINING SESSION 5
# GAS TURBINE PRICING & PROJECT COSTS

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# 2018 Simple Cycle Genset Prices

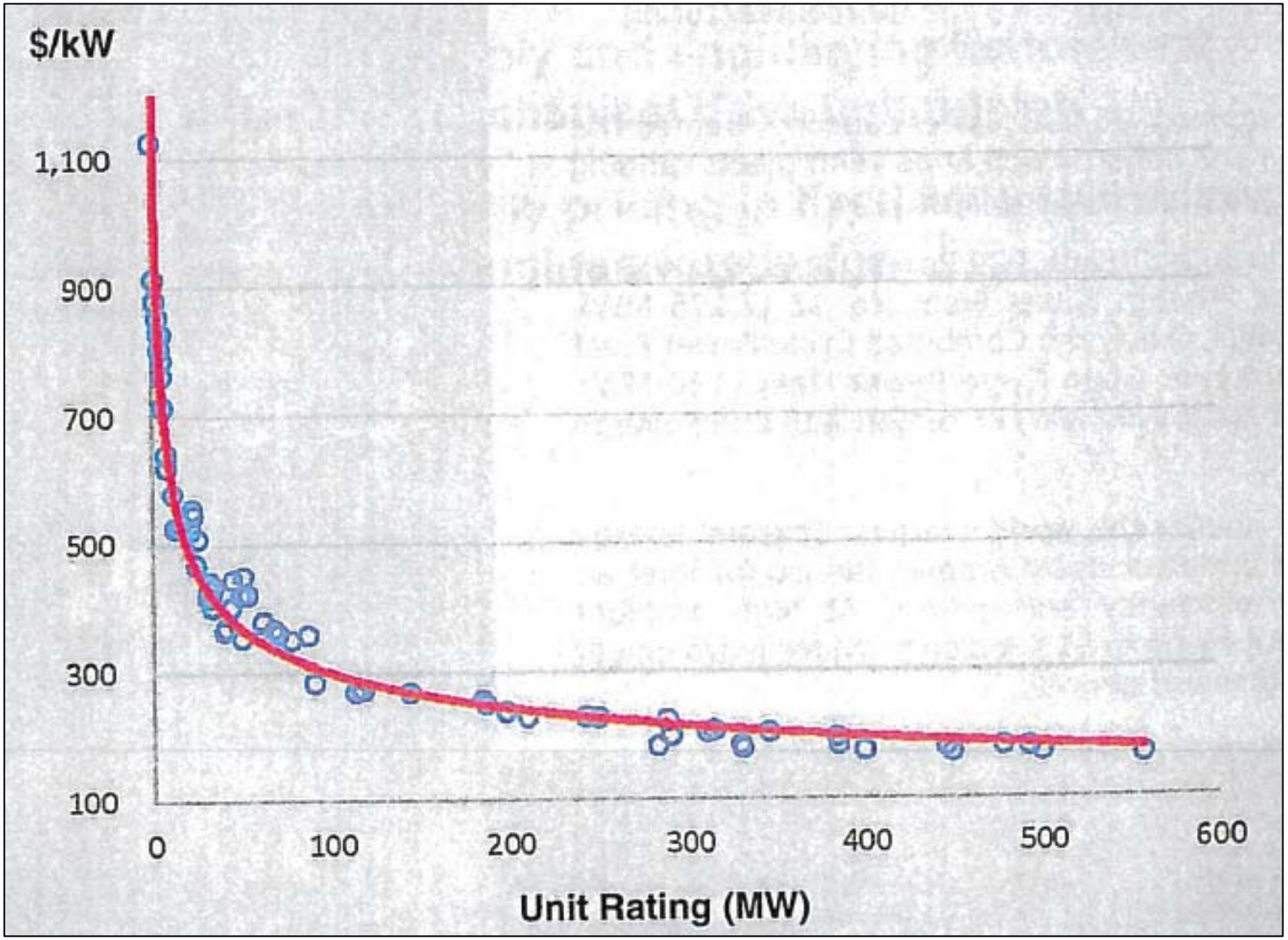
## Equipment-only budget pricing, in fixed 2018 US dollars, for standard bare bones design

| OEM Model | Freq Hz | Base Load Rating | Heat Rate Btu/kWh | Efficiency | Budget Price | $/kW |
|---|---|---|---|---|---|---|
| C200 | 50/60 | 200 kW | 10,300 Btu | 33.1 % | $225,000 | $1,125 |
| M1A-17D | 50/60 | 1,700 kW | 12,701 Btu | 26.9 % | $1,550,000 | $912 |
| OP16-3C | 50/60 | 1,876 kW | 13,585 Btu | 24.7 % | $1,650,000 | $880 |
| Centaur 40 | 50/60 | 3,515 kW | 12,240 Btu | 27.9 % | $3,000,000 | $853 |
| 501-KB5S | 50/60 | 3,980 kW | 11,504 Btu | 29.7 % | $3,300,000 | $829 |
| Centaur 50 | 50/60 | 4,600 kW | 11,630 Btu | 29.3 % | $3,700,000 | $804 |
| 501-KB7S | 50/60 | 5,380 kW | 10,570 Btu | 32.3 % | $4,450,000 | $827 |
| SGT-100 | 50/60 | 5,400 kW | 11,007 Btu | 31.0 % | $4,250,000 | $787 |
| Taurus 60 | 50/60 | 5,670 kW | 10,830 Btu | 31.5 % | $4,320,000 | $762 |
| Taurus 65 | 50/60 | 6,300 kW | 10,375 Btu | 32.9 % | $4,500,000 | $714 |
| SGT-300 | 50/60 | 7,901 kW | 11,158 Btu | 30.6 % | $4,900,000 | $620 |
| Taurus 70 | 50/60 | 7,965 kW | 9,955 Btu | 34.3 % | $5,100,000 | $640 |
| Mars 100 | 50/60 | 11,350 kW | 10,365 Btu | 32.9 % | $6,550,000 | $577 |
| GTU-12PG-2 | 50/60 | 12,300 kW | 10,469 Btu | 32.6 % | $6,460,000 | $525 |
| SGT-400 | 50/60 | 14,326 kW | 9,647 Btu | 35.4 % | $7,500,000 | $524 |
| Titan 130 | 50/60 | 16,450 kW | 9,605 Btu | 35.5 % | $8,750,000 | $532 |
| Titan 250 | 50/60 | 21,745 kW | 8,775 Btu | 38.9 % | $11,350,000 | $522 |
| LM2500DLE 50Hz | 50 | 22,400 kW | 9,626 Btu | 35.4 % | $12,400,000 | $554 |
| LM2500DLE 60Hz | 60 | 23,200 kW | 9,317 Btu | 36.6 % | $12,650,000 | $545 |
| SGT-600 | 50/60 | 24,480 kW | 10,161 Btu | 33.6 % | $11,450,000 | $468 |
| 1x FT8 SP25 DLN | 60 | 25,371 kW | 8,993 Btu | 38.1 % | $12,900,000 | $508 |
| 1 x FT8 SP30 | 60 | 30,892 kW | 9,327 Btu | 36.6 % | $12,875,000 | $417 |
| LM2500+ DLE 60Hz | 60 | 31,900 kW | 8,785 Btu | 38.8 % | $13,650,000 | $428 |
| RB211-GT61 DLE | 50/60 | 32,130 kW | 8,681 Btu | 39.3 % | $14,170,000 | $441 |
| SGT-700 | 50/60 | 32,820 kW | 9,170 Btu | 37.2 % | $13,650,000 | $416 |
| MS5002E | 50/60 | 33,310 kW | 9,517 Btu | 35.9 % | $13,400,000 | $402 |
| LM2500+ G4 DLE | 60 | 34,500 kW | 8,709 Btu | 39.2 % | $14,950,000 | $433 |
| SGT-750 | 50/60 | 39,810 kW | 8,456 Btu | 40.4 % | $14,525,000 | $365 |
| H-25 | 50/60 | 41,030 kW | 9,432 Btu | 36.2 % | $15,100,000 | $368 |
| 6B.03 | 50/60 | 44,000 kW | 10,180 Btu | 33.5 % | $17,650,000 | $401 |
| LM6000 DLE | 60 | 45,000 kW | 8,097 Btu | 42.1 % | $20,000,000 | $444 |
| LM6000 DLE Sprint | 60 | 50,000 kW | 8,097 Btu | 42.1 % | $21,000,000 | $420 |
| SGT-800 | 50/60 | 50,500 kW | 8,899 Btu | 38.3 % | $17,800,000 | $352 |

| OEM Model | Freq Hz | Base Load Rating | Heat Rate Btu/kWh | Efficiency | Budget Price | $/kW |
|---|---|---|---|---|---|---|
| 2xFT8 SP50 DLN | 60 | 51,058 kW | 8,938 Btu | 38.2 % | $23,000,000 | $450 |
| LM6000 SAC | 60 | 53,000 kW | 8,175 Btu | 41.7 % | $22,250,000 | $420 |
| SGT-A65 TR DLE | 60 | 54,020 kW | 8,023 Btu | 42.5 % | $22,750,000 | $421 |
| 2xFT8 SP60 | 60 | 62,086 kW | 9,281 Btu | 36.8 % | $22,100,000 | $356 |
| SGT-A65 DLE ISI | 60 | 61,842 kW | 7,867 Btu | 43.4 % | $23,450,000 | $379 |
| LM9000 | 50/60 | 68,000 kW | 8,107 Btu | 42.1 % | $25,000,000 | $368 |
| 1xFT4000 SP60 | 60 | 70,836 kW | 8,269 Btu | 41.3 % | $25,500,000 | $360 |
| AE64.3A | 50/60 | 78,000 kW | 9,400 Btu | 36.3 % | $27,500,000 | $353 |
| 6F.03 | 50/60 | 87,000 kW | 9,340 Btu | 36.5 % | $31,100,000 | $357 |
| 7E.03 | 60 | 91,000 kW | 10,060 Btu | 33.9 % | $25,750,000 | $283 |
| M501DA | 60 | 113,950 kW | 9,780 Btu | 34.9 % | $30,500,000 | $268 |
| SGT6-2000E | 60 | 117,000 kW | 9,705 Btu | 35.2 % | $31,900,000 | $273 |
| LMS100 Wet | 60 | 118,000 kW | 7,628 Btu | 44.7 % | $40,000,000 | $339 |
| H-100 | 50 | 118,080 kW | 8,919 Btu | 38.3 % | $32,000,000 | $271 |
| M701DA | 50 | 144,090 kW | 9,810 Btu | 34.8 % | $38,600,000 | $268 |
| AE94.2 | 50 | 185,000 kW | 9,426 Btu | 36.2 % | $47,400,000 | $256 |
| M501F | 60 | 185,400 kW | 9,230 Btu | 37.0 % | $47,000,000 | $254 |
| SGT5-2000E | 50 | 187,000 kW | 9,426 Btu | 36.2 % | $46,500,000 | $249 |
| 7F.04 | 60 | 198,000 kW | 8,840 Btu | 38.6 % | $47,000,000 | $237 |
| GT13E2 | 50 | 210,000 kW | 8,980 Btu | 38.0 % | $48,000,000 | $229 |
| 7F.05 | 60 | 243,000 kW | 8,570 Btu | 39.8 % | $55,500,000 | $228 |
| SGT6-5000F | 60 | 250,000 kW | 8,682 Btu | 39.3 % | $56,750,000 | $227 |
| 9F.04 | 50 | 288,000 kW | 8,810 Btu | 38.7 % | $64,000,000 | $222 |
| M501GAC | 60 | 283,000 kW | 8,531 Btu | 40.0 % | $51,250,000 | $181 |
| 7HA.01 | 60 | 290,000 kW | 8,120 Btu | 42.0 % | $57,500,000 | $198 |
| SGT6-8000H | 60 | 310,000 kW | 8,530 Btu | 40.0 % | $63,000,000 | $203 |
| 9F.05 | 50 | 314,000 kW | 8,930 Btu | 38.2 % | $65,000,000 | $207 |
| SGT5-4000F | 50 | 329,000 kW | 8,322 Btu | 41.0 % | $60,000,000 | $182 |
| M501J | 60 | 330,000 kW | 8,105 Btu | 42.1 % | $58,500,000 | $177 |
| GT26 | 50 | 345,000 kW | 8,322 Btu | 41.0 % | $70,000,000 | $203 |
| 7HA.02 | 60 | 384,000 kW | 8,030 Btu | 42.5 % | $75,000,000 | $195 |
| M701F | 50 | 385,000 kW | 8,144 Btu | 41.9 % | $70,000,000 | $182 |
| M501JAC | 60 | 400,000 kW | 7,755 Btu | 44.0 % | $69,250,000 | $173 |
| SGT5-8000H | 50 | 450,000 kW | <8,322 Btu | >41 % | $76,500,000 | $170 |
| 9HA.01 | 50 | 446,000 kW | 7,910 Btu | 43.1 % | $80,000,000 | $179 |
| M701J | 50 | 478,000 kW | 8,067 Btu | 42.3 % | $86,000,000 | $180 |
| M701JAC | 50 | 493,000 kW | 7,954 Btu | 42.9 % | $88,000,000 | $178 |
| GT36 | 50 | 500,000 kW | 8,222 Btu | 41.5 % | $85,000,000 | $170 |
| 9HA.02 | 50 | 557,000 kW | 7,760 Btu | 44.0 % | $92,000,000 | $165 |

## GAS TURBINE PRICING - from the *2018 Gas Turbine Handbook*© ($USD)

**Simple-Cycle GTG Prices** – not total "project cost"



# 2018 Simple Cycle Genset Prices

## Scope of supply and engineering factors that enter into simple cycle genset equipment pricing

How much does a packaged simple cycle gas turbine plant cost? All depends on unit size, design technology and scope of equipment supply.

GTW's database covers a wide range of unit size and technology which shows that price ($) and unit price ($ per kW) depend strongly on unit size and type of gas turbine (aero vs frame).

GTW's simple cycle plant prices are based on standard bare bones single-fuel (gas only) packaged units. A myriad of add-on options and customized design features are provided by OEMs at additional cost.

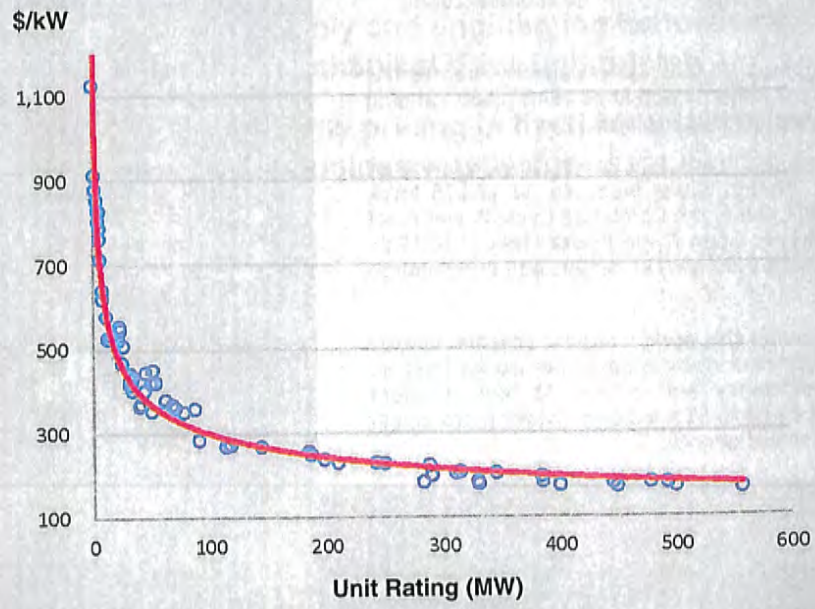
The prices are quoted in US dollars, FOB factory, for single-unit purchases. They are for equipment only, and do not cover transportation, plant engineering, construction, project-specific options or owner's project costs.

**Price update.** Except for some individual cases where new information from the marketplace has indicated otherwise, this year's estimated gas turbine prices reflect a slight upward trend (~3%) compared to last year's data.

Despite a softening market for large utility units in North America, this follows the observed movement of the cost indexes for industrial and power generation equipment (see https://www.ihs.com/info/cera/ihsindexes/).

2018 Simple Cycle Gensets

Pricing data for simple cycle gensets.
"Best Fit" curve plotted as: $/kW = 9650 x (kW)^-0.3




However, considering the significant over-capacity of manufacturing space for larger gas turbine units, the trend in pricing may very well turn downward.

A relatively flat US dollar relative to major international currencies during the current period has also meant little influence of currency exchange rates on price levels (in US$) for equipment manufactured in Europe and Asia.

**Equipment scope.** Limited to minimum scope of supply for a simple cycle power generating plant package built around a gas turbine, generator, associated mechanical and electrical auxiliary systems, including controls. Scope includes:

- Gas turbine. Skid-mounted gas turbine engine, starting motor, reduction gearbox (if any), lube oil and hydraulic fluid systems, compressor water wash, fuel forwarding and control, external turbine cooling (if any), interconnecting piping.
- Generator. Standard air-cooled generator package; hydrogen or enclosed water-air cooling (TEWAC) usually offered as options for larger units. Generator exciter is typically included in the standard package.
- Balance of plant. Standard auxiliaries such as air intake filter, inlet ducting and silencer, exhaust ducting and stack (short) with silencer, vibration monitoring, digital control system.

Packaged gensets typically include standard acoustic enclosures with ventilation and fire protection systems.

Mechanical and electrical auxiliaries for gas turbine operation are often

pre-packaged and supplied as separate enclosed auxiliary skids. Electrical auxiliaries include batteries, motor control center, voltage regulator and surge protection.

Auxiliary transformers needed to condition power supply for plant motors (starting, lube oil pump and cooling fans) are usually optional, as is main power step-up transformer.

Other OEM options include liquid or dual-fuel (gas and liquid) combustion, inlet air chilling (or deicing), isolated phase bus, fuel gas compression, etc.

**Price and performance.** Gas turbine model power output and efficiency ratings in GTW's simple cycle pricing tables are OEM specified design ratings for base load operation at ISO standard (59°F ambient and sea level) conditions on natural gas fuel.

Estimated unit price ($ per kW), based on base load ratings, makes it possible to review and evaluate differences in unit pricing of equipment cost of similarly sized units.

A best-fit relationship between $-per-kW and kW rating for listed models is provided and plotted to assist in calculating the cost of comparably sized models not listed.

Besides unit size, other factors that enter GT package price are gas turbine type (i.e., frame vs. aero) and engineering design factors such as firing temperature, pressure ratio, and mass flow.

Actual real-world OEM bid prices are quoted for customer-specified scope and with guarantees on net power and heat rate (efficiency) at site-specific conditions (i.e. ambient temperature, elevation and relative humidity) and specified fuel composition.

**Bid quotes.** OEMs strategically hedge project bidding with some performance margin, i.e. slightly lower power output and higher heat rate, to allow for normal variations in manufacturing tolerances and test uncertainties.

Quotes are always bid on the basis of "factory new and clean" performance without allowance for degradation in performance with usage. Contract language usually specifies a limit in operating time before performance testing must be conducted.

Typically, there is a margin of 0.5 to 1% on power and heat rate ratings. This explains why slightly better performance than expected may initially be realized.

Other factors that usually enter a project price quote include number of units ordered (i.e., quantity discounts), scope of equipment supply, site-specific requirements, duty cycle, geographic location and OEM's local market share position.

Variation in currency valuations can also play a significant role depending on which countries (i.e., currencies) are involved in the gas turbine's manufacture, purchase, and installation.

Gas turbine gensets designed for onshore oil and gas pipeline operation typically are priced around 10% higher than industrial or utility power plants. That is due to the cost of compliance with special packaging and safety requirements such as found in API specifications.

Offshore platform gas turbine packages command an additional price premium to cover costs such as specialized mountings and housing, marine-resistant coatings or ultra-efficient intake filter systems designed to handle salt-water laden air.

**Benchmark.** This reference section of the GTW Handbook serves as a benchmarking tool for assessing the equipment cost of different size and type plants.

To allow for uncertainties, the estimated budget prices should be treated as having a plus or minus 10% range of accuracy.

The data plot and best-fit curve show the strong relationship of cost to unit size, especially with smaller units where the effect of size is most pronounced. 2MW plant may be priced at around $800 per kW compared to $500 per kW for a 10MW plant.

From around 20MW to 100MW cost per kW falls less steeply, from around $500/kW to $300/kW. This is displays the economies of scale which allow OEMs to reduce manufacturing costs (per kW) as unit physical size and power ratings increase.

Beyond 100MW, the $ per kW trend flattens, but still continues to decrease down to around $200/kW, or lower, for the largest G, H and J class units. Substantially lower $/kW prices (10%-20%) may be observed for these units, compared to earlier F-class technology.

This is despite the higher cost of more exotic materials, coatings and cooling techniques needed for machines operating in the 2700°F to 2900°F firing temperatures range, and is the apparent result of the significant gains in power output achieved with these large 400-500MW-class units.

**Data spread.** Note that the spread in the data of comparably rated units is due partly to effect of 50Hz vs. 60Hz direct drive machines, where the latter are more compact (increased power density) due to higher engine operating speed, and to differences in design technology (aero vs frame machines).

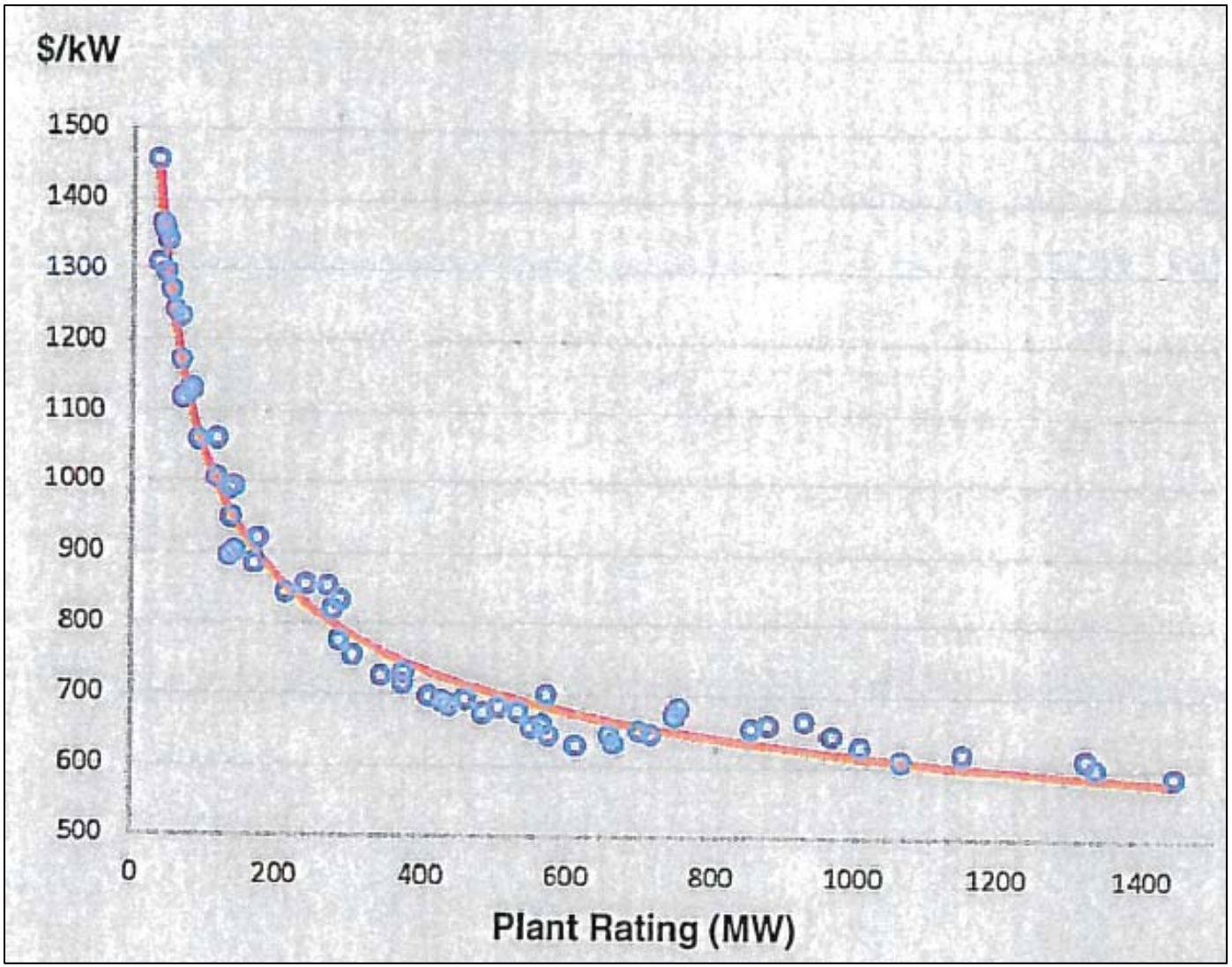
Aeroderivative units cost considerably more than heavy duty units. Also, note that the data plot excludes the LMS100 series since their inclusion of an intercooler puts them in their own price class (see table) where a premium is paid for even higher efficiency than the typical aeroderivative genset.

Regardless of gas turbine design and rating, however, remember that the cost of engineering, construction services and other project costs can add from 60% to 100%, and more, to the cost of the equipment alone.

For rough estimates, a useful rule of thumb is to double the equipment price for estimating total installed costs. ■

## GAS TURBINE PRICING - from the *2018 Gas Turbine Handbook*© ($USD)

**Combined-Cycle (CCGT) Prices** – approximately the project cost for a "reference plant" without typical options and site specific factors.



# 2018 Combined Cycle Plant Prices

## Scope of supply, engineering and construction factors that enter into combined cycle plant equipment pricing

How much does a combined cycle plant cost? Broadly speaking, it all depends on plant size and scope, and on engineering tradeoffs for the design and performance optimization for specific application and site location.

GTW's combined cycle plant prices are based on standard bare-bones plants designed for single-fuel operation (gas-only) with conservative steam cycle design and without HRSG duct firing or other performance enhancing options.

The prices are quoted in US dollars FOB factory for EPC turnkey scope, including major equipment supply, plant engineering and construction. They do not cover transportation, project-specific options, owner's project costs or project contingencies.

Except for some individual cases, where new information from the marketplace has indicated otherwise, this year's projected combined cycle plant prices reflect a slight upward trend (~ 3%) compared to last year.

This is based on a general uptick noted in the widely recognized HIS/CERA Power Projects Cost Index (see www.ihs.com/info/cera/ihsindexes/).

However, with the forecasted slowing of growth of gas-fired power generation, particularly in North America, and the over-capacity in large gas turbine manufacturing space, the pricing trend for larger combined cycle plants may very well turn downward in the near term.

With GTW prices quoted in US dollars, some year-to-year variation may also be attributed to fluctuation in the international value of the dollar in different markets. After a general strengthening of the dollar in 2015-2017, the value of the dollar has been relatively flat during the current period.

**Equipment scope.** Limited to minimum scope of supply for plants designed around one or more gas turbine gensets, one or more matching HRSGs (without SCR or CO catalyst for emissions reduction), single steam turbine genset with water-cooled condenser and mechanical draft cooling tower, integrated plant controls. Major equipment includes:

- Gas turbine. Skid mounted single-fuel unit with acoustic enclosure for outdoor installation, with standard starting and control systems. Includes standard mechanical and electrical auxiliaries normally supplied with simple cycle gas turbine package (no inlet air chilling or de-icing).
- Steam turbine. Condensing subcritical design, with single or dual-pressure levels for small plants, triple-pressure levels with reheat for large plants. Axial or radial exhaust, steam bypass and controls, enclosure, and water-cooled condenser. Includes all valves and controls (typically hydraulic).
- Unfired HRSG. Heat recovery steam generator for outdoor installation, along with ductwork and short exhaust stack with silencing. Dual or triple-pressure reheat units as dictated by gas turbine and steam turbine size and technology.
- Generator. Air-cooled generators for small gas turbines; hydrogen cooled for larger units. Large air-cooled generators for combined cycle application typically use enclosed water-to-air cooling (TEWAC) design. Neutral grounding cubicle and bus to main breaker included with generator packages.
- Control system. Distributed control system (DCS) for integrating gas turbine, HRSG and steam turbine controls with overall combined cycle plant control and operation.

**Balance of plant.** Standard balance-of-plant equipment for combined cycle plant construction and operation covers:

- Mechanical auxiliaries. Critical water handling systems with pumps and piping for boiler feed water, condenser cooling water and condensate.
- Electrical auxiliaries. Auxiliary power transformers and switchgear, voltage regulators, bus and breakers needed for plant operation. Main step-up transformers (one for each generator) for connecting plant output to the utility substation are excluded. Includes minimal control room installation.
- Engineering and construction. Allowance is made in EPC costs for plant design and engineering, foundations and installation of all equipment assuming non-union labor.

**Excluded options.** Popular customer-specified options considered outside combined cycle budget prices for a bare-bones combined cycle plant:

- Bypass stack. Allows independent operation of the gas turbine in simple cycle mode for quick start and flexible dispatch; option includes a mechanical damper in exhaust ducting to redirect flow.
- Inlet cooling. Evaporative and mechanical chilling systems that can boost plant output by up to 10% at 90°F hot day and 30% relative humidity operation.
- Duct firing. Supplementary duct firing to increase steam turbine output; also requires upgrades in steam and water handling systems.
- Catalysts. CO and SCR catalytic section for HRSG (to limit emissions) plus associated ammonia storage and feed systems.
- Back-up fuel. Storage and delivery of liquid fuel for back-up to natural

gas supply. Usually includes fuel unloading station and alternative provisions for NOx control, such as water injection.

**Boundary limits.** The defined scope of supply narrowly sets boundary limits such that they do not include utility grid interconnections, transmission lines, natural gas fuel pipelines, or service/access roads external to the plant site.

Within the plant site, such project specific balance-of-plant equipment such as fuel gas booster compressors, water treatment systems, waste water systems and cooling towers are also excluded.

Price estimates reflect overnight costs and exclude time-dependent costs such as escalation and interest during construction and highly variable project-specific owner expenses such as land, plant site preparation, project development, financing, permits, insurance, taxes, etc.

Nor do they cover the "first fill" of operating consumables such as lube oil, chemicals, catalysts, special tooling and replacement parts and spares, which, although not a significant percentage of total costs, is worth noting by cost estimators.

**Pricing scope.** GTW's budget cost estimates for combined cycles are based on OEM reference plant designs and EPC contractor costs. They include cost of equipment and construction, but exclude customized EPC services, project-specific options and owner's project costs.

In the real world, total plant costs for combined cycle plants powered by identical gas turbines can vary by as much as 25% depending on differences in engineering, design choices and add-on plant options and facilities.

Marketplace plant price quotes are invariably higher than GTW estimated budget prices. Result of extended scope of supply and project-specific costs related to site location and greater project complexity.

Given the uncertainty on scope of supply, even for a bare bones plant, we attach a plus or minus accuracy of 15% to the estimated price of combined cycle plants.

On the accompanying tables, combined cycle plant power and efficiency values are based on OEM ratings for optimized reference plant designs at ISO standard (59°F ambient and sea level) site conditions.

**Size matters.** As one might expect, prices for combined cycle power plants strongly exhibit the cost advantages of economies of scale.

The plot of combined cycle plant price versus power output shows how $-per-kW prices sharply decrease with increasing plant size, although they level off at the upper end of the size spectrum. (Note: the $/kW values are based on the net plant power ratings as listed in the performance specs section. As described there, some variation in these ratings exists depending on whether the OEM has accounted for plant auxiliary loads in the data.)

Compared to simple cycle plants, the leveling off in the price vs. size curve is delayed somewhat with combined cycle plants due to the large percentage of total plant cost attributed to the steam bottoming cycle and balance-of-plant equipment.

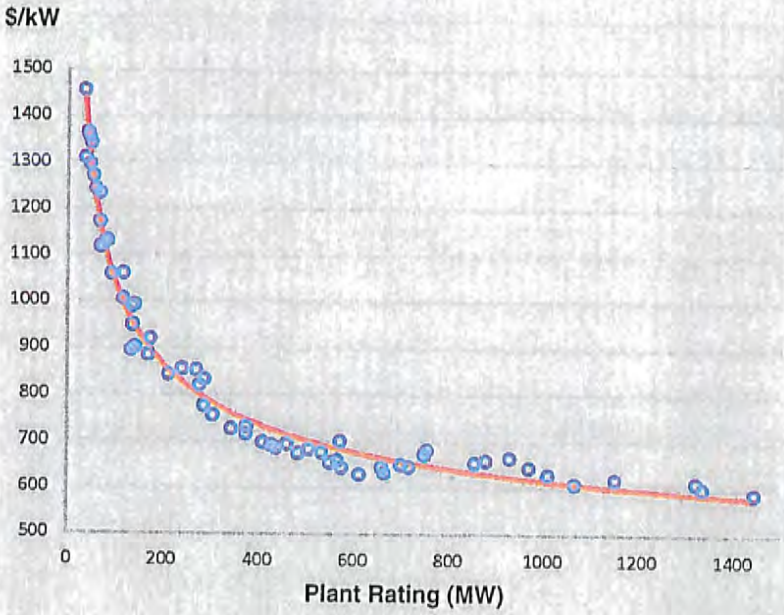
There is also an associated rise in the cost of more advanced steam turbine cycle equipment to match advanced technology gas turbine designs for new generation combined cycle plants in the 500MW-plus size that operate at better than 60% net plant efficiencies.

On the gas turbine side, new materials and manufacturing processes (such as single crystal and directionally solidified castings) and thermal barrier coatings for nozzles and blades to withstand higher firing temperature, add substantially to costs. However, this is countered to a large extent, and even overcome, by the large gains in power output with the latest technology advances.

The global growth in wind power and solar generation has also spurred the introduction of costly upgrades and more flexible gas and steam turbine designs for combined cycles capable of fast startup and ramping, operational flexibility and high part-load efficiencies and emissions control.

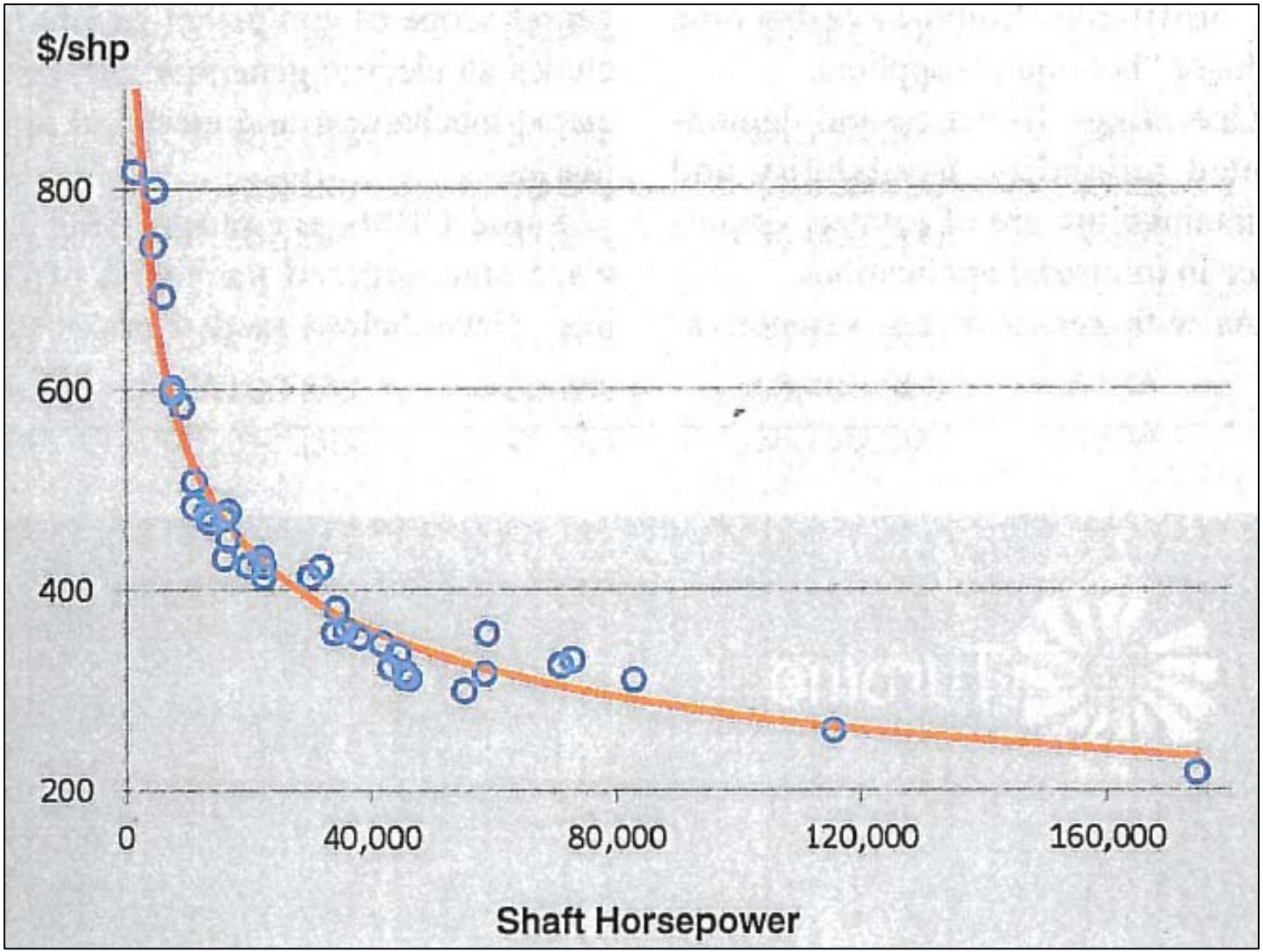
**2018 Combined Cycle Plants**

Pricing data for combined cycle plants.
"Best Fit" curve plotted as $/kW = 370 + (10.3 x 10^4) x (kW)^-0.438



## GAS TURBINE PRICING - from the *2018 Gas Turbine Handbook*© ($USD)

**Mechanical Drive Gas Turbine Prices** – gas turbine only and does not include driven equipment nor, the total "project cost".



# 2018 Mechanical Drive Prices

## Scope of supply and engineering factors that enter into skid-mounted mechanical drive equipment pricing

GTW's mechanical drive prices are based on the typical supply scope of packaged gas-only (not dual fuel) gas turbine prime movers designed to meet the widely varying demands of industrial applications.

Primary application is for compressor drives employed in the oil and gas and petrochemical industries, which are characterized by a lack of the standardization found in the power industry. This is generally reflected in their relatively higher unit prices.

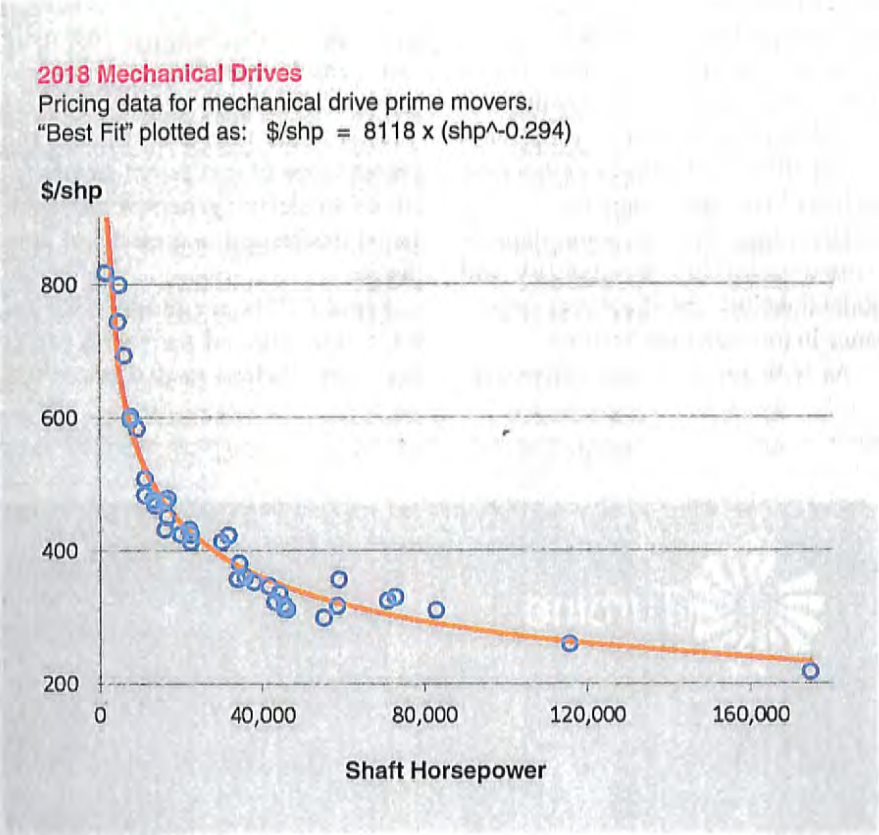
Although a growing number of OEMs now offer complete packages that include the compressor, GTW pricing estimates are for the gas turbine package only (through the driveshaft flange).

Prices are quoted in US dollars FOB factory for a single or two-unit buy as opposed to a multi-station order. They represent equipment-only prices that do not include transportation, site engineering, installation or add-on options.

Compared to last year's price levels, which reflected the general downturn in oil and gas industry business since 2014, prices for 2018 show a slight upward (~3%) trend.

This is based on the current movement of recognized cost indexes for industrial equipment (ref: https://www.ihs.com/info/cera/ihsindexes/0 )

Chart shows trend of unit price ($/shp) with output rating demonstrating typical economies of scale with steep drop-off in price starting around 40,000 shp.




**Equipment scope.** Standard scope of supply includes gas turbine, reduction gearbox (when needed), inlet air filter, auxiliaries, and dry low NOx combustion, when available:

- Packaged unit. Skid-mounted single-fuel gas turbine with driveshaft output coupling, starting motor (electric or hydraulic) and lube oil systems.
- Output gearbox. Parallel-shaft gearbox is usually standard for aero units. Epicyclic gearbox is more compact and efficient, but adds to the price. (Most heavy-frame gas turbines are direct drive.)
- Inlet and exhaust. Air inlet filter, ducting and silencer plus exhaust duct, silencer and stack. Options such as multi-stage inlet filtration, pulse-jet cleaning, anti-icing, air inlet chilling and water or steam injection for power augmentation are not included.
- Auxiliaries. Lube oil system (pump, cooler, etc), vibration monitoring, compressor washing, speed and temperature instrumentation, automated digital controls, typically including variable speed operation (for two-shaft designs), and fire protection systems.

**Market factors.** Estimated prices do not apply to large multi-unit orders (usually with phased delivery) where buyers gain bargaining leverage to negotiate sizeable discounts.

**EXAMPLE FICTITIOUS INDUSTRIAL CLIENT XYZ** Project: 18-473
**7.5 MW GTG-HRSG COGENERATION PROJECT - OPTION 4** Date: Oct 23-18
**PROJECT BUDGETARY COST ESTIMATE - $CAD (+/- 25%)** Issue: 04

| ITEM | DESCRIPTION | MAT'LS | LABOUR | TOTAL | |
|---|---|---|---|---|---|
| **1.0** | **MAJOR EQUIPMENT & VENDOR-ENGINEERED SYSTEMS - SUPPLY ONLY** | | | | |
| 1.1 | Gas Turbine Generator Package | 7,500,000 | | | gas-fired; 4160 VAC; incl'g site-support |
| 1.2 | Heat Recovery Steam Generator | 3,500,000 | | | duct-fired single-pressure; incl'g site-support |
| 1.3 | Fuel Gas Compressors | 450,000 | | | |
| 1.4 | Generator Step-Up Transformer | 225,000 | | | 4160V-27.6 kV |
| 1.5 | Auxiliary Supply Transformer | 120,000 | | | 4160-600V |
| 1.6 | High-Voltage Switchgear & Breakers | 175,000 | | | 4160V |
| 1.7 | Motor Control Centres (MCC) | 75,000 | | | 600V |
| 1.8 | Distributed Control System (DCS) | 450,000 | | | Including programming & site-support |
| 1.9 | Pre-Engineered Building | 350,000 | | | 40' x 65' |
| 1.10 | Relay Protection & Metering System | 145,000 | | | |
| 1.11 | HVAC & Ducting Systems | 150,000 | | | |
| | **Totals - Section 1.0** | **13,140,000** | **0** | **13,140,000** | |
| **2.0** | **CIVIL & STRUCTURAL** | | | | |
| 2.1 | Site Prep, Area Hydrovac and/or Investigations | 15,000 | 0 | 15,000 | |
| 2.2 | Major Equipment Foundations | 100,000 | 100,000 | 200,000 | |
| 2.3 | Existing Building Demolitions | 10,000 | 50,000 | 60,000 | As required |
| 2.4 | Asbestos Removals | 75,000 | | 75,000 | Subcontract |
| 2.5 | Acoustic Barrier Wall | 45,000 | | 45,000 | Subcontract |
| 2.8 | Misc. Project Concrete, Grout, Steel, Fencing | 25,000 | 10,000 | 35,000 | Allowance (disc'd w/ potential contractor) |
| 2.9 | Support Steel & Mods in Boilerhouse | 45,000 | 15,000 | 60,000 | Allowance (disc'd w/ potential contractor) |
| | **Totals - Section 2.0** | **315,000** | **175,000** | **490,000** | |
| **3.0** | **MECHANICAL** | | | | Riggers, Pipefitters, Welders & Millwrights |
| 3.1 | Maj. Equipment Erection & Installation | 150,000 | 225,000 | 375,000 | GTG, HRSG, Gas Comp'rs |
| 3.2 | Steam, Feedwater & Cond. Piping Int'con'tn | 65,000 | 100,000 | 165,000 | HRSG to-from boilerhouse |
| 3,3 | Natural Gas System | 25,000 | 55,000 | 80,000 | To new Big-Gas Metering & Regulation Station |
| 3,4 | Cooling Water Systems | 18,500 | 24,000 | 42,500 | |
| 3.5 | Instrument/Service Air System Interconnection | 8,000 | 12,500 | 20,500 | |
| 3.6 | Misc. Removals & Demolition | 5,000 | 10,000 | 15,000 | |
| 3.7 | Miscellaneous Mech Eqp'mnt, Insulation | 10,000 | 12,000 | 22,000 | Mat'ls & Labour |
| 3.8 | HVAC & Ducting Systems | 150,000 | | 150,000 | Subcontract |
| | **Totals - Section 3.0** | **431,500** | **438,500** | **870,000** | |
| | | | | | |

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| ITEM | DESCRIPTION | MAT'LS | LABOUR | TOTAL | |
|---|---|---|---|---|---|
| **4.0** | **ELECTRICAL & INSTRUMENTATION** | | | | Electricians & Instrument Techs |
| 4.1 | Major Equipment Electrical & Controls Ins'tn | 100,000 | 225,000 | 325,000 | |
| 4.2 | Generator & TF Output Cabling | 25,000 | 100,000 | 125,000 | |
| 4.3 | Power, Instrumentation & Control Cabling | 25,000 | 55,000 | 80,000 | |
| 4.4 | DCS Installation & Tuning | 10,000 | 60,000 | 70,000 | |
| 4.5 | Winterization / Heat-Tracing | 30,000 | 25,000 | 55,000 | |
| 4.6 | Miscellaneous Elect Eqp'mnt, Mat'ls & Labour | 25,000 | 20,000 | 45,000 | |
| | **Totals - Section 4.0** | **215,000** | **485,000** | **700,000** | |
| **5.0** | **PROJECT DIRECT & INDIRECT COSTS** | | | | |
| 5.1 | Site Legal Survey | 15,000 | 0 | 15,000 | Subcontract |
| 5.2 | Site Geotechnical Investigation | 35,000 | 0 | 35,000 | Subcontract |
| 5.3 | Project Detail-Design Engineering & Specification | 45,000 | 700,000 | 745,000 | |
| 5.4 | Site Engineering Support | 15,000 | 50,000 | 65,000 | Site eng'g presence / reviews during constr'tn |
| 5.5 | Construction Manager | 15,000 | 125,000 | 140,000 | |
| 5.6 | Permitting, Inspections & Related-Testing | 90,000 | 0 | 90,000 | |
| 5.7 | Electrical Interconnection Cost - CIA/CCA | 250,000 | 0 | 250,000 | |
| 5.8 | Gas Interconnection Cost | 250,000 | 0 | 250,000 | |
| 5.9 | Commissioning Manager, Eqp'mnt & Mat'ls | 5,000 | 75,000 | 80,000 | Power-Generation Commissioning Specialist |
| 5.10 | Trade Support Allow. for Commissioning | 5,000 | 15,000 | 20,000 | |
| 5.11 | First-Fills & Lubricants | 20,000 | 0 | 20,000 | Oils, greases, glycol, etc. |
| 5.12 | Shipping & Freight Allowance | 40,000 | 0 | 40,000 | for sections 2.0 to 4.0 |
| 5.13 | Contractor Site Indirects - Trailers & Facilities, Supplies, Vehicles, Laydown Prep/Storage, Permits, Bonds, etc. | 250,000 | 0 | 250,000 | |
| 5.14 | Contractor Site Supervision, Safety / QA / Environmental, Security & Admin | 50,000 | 100,000 | 150,000 | Site Management & Admin Staff |
| 5.15 | Contractor Site Mob/De-Mob; Rentals (Cranes & Lifts, Concrete Pumpers, Portable Welders, Scaffolding); Temporary Fencing, Safety Equipment, NDE, Consumables, Environmental Man'gmnt | 125,000 | 125,000 | 250,000 | included above |
| | **Totals - Section 5.0** | **1,210,000** | **1,190,000** | **2,400,000** | |

**EXAMPLE FICTITIOUS INDUSTRIAL CLIENT XYZ**
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**PROJECT BUDGETARY COST ESTIMATE - $CAD (+/- 25%)**

Project: 18-473
Date: Oct 23-18
Issue: 04

| ITEM | DESCRIPTION | MAT'LS | LABOUR | TOTAL | |
|---|---|---|---|---|---|
| **6.0** | **OWNER & RELATED COSTS** | | | | |
| 6.1 | Owner's Project Manag'mnt, Eng'g, Legal & Financial Costs | | | | by Owner |
| 6.2 | Spare Parts - Major Equipment | | | | by Owner |
| 6.3 | Training | | | | by Owner |
| 6.4 | Startup Fuel | | | | by Owner |
| 6.5 | Letter of Credit | | | | by Owner |
| 6.6 | Project Insurance (All-Risk and Boiler & Machinery) | | | | by Owner |
| 6.7 | Interest During Construction (IDC) | | | | by Owner |
| 6.8 | Contingency | | | | by Owner |
| | **Totals - Section 7.0** | **0** | **0** | **0** | |

| SUMMARY / TOTALS | MAT'LS | LABOUR | TOTAL | |
|---|---|---|---|---|
| 1.0 - Maj. Equipment & Vendor Systems | 13,140,000 | 0 | 13,140,000 | |
| 2.0 - Civil & Structural | 315,000 | 175,000 | 490,000 | |
| 3.0 - Mechanical | 431,500 | 438,500 | 870,000 | $CAD |
| 4.0 - Electrical & Instrumentation | 215,000 | 485,000 | 700,000 | +/- 25% |
| 5.0 - Project Direct / Indirect Costs | 1,210,000 | 1,190,000 | 2,400,000 | Escalation & Contingency not included |
| 6.0 - Owner & Related Costs | 0 | 0 | 0 | |
| **TOTAL COST** | **15,311,500** | **2,288,500** | **17,600,000** | |