AN INTEGRATED APPROACH FOR THE BEST SELECTION OF OFFSHORE POWER GENERATION

By

MOHD ZHAFRI BIN NASARUDIN

FINAL YEAR PROJECT
FINAL REPORT

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

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CERTIFICATION OF APPROVAL

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Mohd Zhafri Bin Nasarudin

ABSTRACT

This project is in collaboration with PETRONAS Carigali Sdn Bhd. and was selected for the **16th Engineering Design Exhibition (EDX 16) of UTP**. The main target or objective of this project is to develop a methodology and process to select the best and most suitable power generation technology specifically for remote or offshore facilities because currently, there is neither definitive methodology nor guideline for electrical engineers to select the type of generator suitably to meet the requirement of offshore applications. This is the first ever attempt to standardize the selection method. Studies on designing power generation and also on new and suitable technologies of power generators for offshore application have been conducted together with data collection from the internet. It can be conclude that there are two main factors have to be considered during the selection process. The factors are the technical parameter and the other one is the decision factor, which pretty much related to the structural limitations of a platform. As an addition, a system or selection tool software is developed as an aid to the engineers for selecting the best generator during the design stage. The software also serves the purpose as a database where all information and specifications from different types of generators can be safe-kept there.

ACKNOWLEDGEMENT

Using this opportunity, the author would like to express his gratitude to all who have been assisting during the execution of this project. Thank you Allah the Almighty for His will and guidance, this project is now complete. Profound appreciation and sincere thanks goes to my university supervisor Ir. N. Perumal for all the tremendous effort given in assisting and guiding throughout conducting the whole project. Million thanks to the industrial supervisor from PETRONAS, Principal Electrical Engineer Ir. Mohd Faudzi Bin Mohd Yasir, for his advices, information and co-operations. All of them are highly appreciated. My special gratitude goes to Mr. Mohd Khairul Zarir Bin Ahmed Lokman for his hand and expertise in the software development of this project. Not to forget all Electrical & Electronics Engineering lecturers and support staffs for being very helpful. Last but not least the author would like to thank all his colleagues, friends, and especially his family for all their endless support and motivations along the way; and keeps me going all the way. Again, thank you all!

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CHAPTER 1
INTRODUCTION

This project is initiated during the Industrial Internship Programme at PETRONAS Carigali Sdn. Bhd. (PCSB) KLCC from June 2004 to January 2005. It is offered by PCSB as the Final Year Project (FYP) for the university to explore new technology applications in offshore Oil & Gas industry. This FYP is a joint project, in-collaboration with PCSB. Principal Electrical Engineer Ir. Mohd Faudzi Mohd Yasir is the representative or industrial supervisor form PCSB together with Ir. N, Perumal as the lecturer supervisor from the university.

1.1 Project Background and Problem Statement

This project focuses on the selection of power generation technology for offshore facilities which requires electricity supply. Selection of power generation is part and parcel of facilities design for electrical engineers at PCSB. The design for offshore power generation offers many challenges. Among them are the changes in technologies (generators) and the varying load of facilities at different platforms. Recently, there are several numbers of technologies of power generators available in the market. A detailed study and analysis is required to determine the best offshore power generation types for all the facilities on-board. Currently, there is no establishing methodology for engineers to optimize the selection.

Different types of offshore platforms require different types of power generation depending on the size, facilities on-board, and load consumptions. For the time being, PCSB has 3 types of platforms which are 8-legged, 4-legged, and 3-legged. The bigger the platform means more power required to cater the loads such as drilling facilities, lighting, and Distributed Control System (DCS). Smaller platforms require smaller power which can be generated by smaller generators such as from Microturbine Generator (MTG) and Close-cycle Vapour Turbogenerator (CCVT). Besides producing self generation, few others satellite platforms tap electrical power from their mother or main platforms via Submersible Power Cable.

1.2 Objectives

The main objective of this project is to develop a methodology or process to select the best and most suitable power generation technology specifically for remote or offshore facilities in the oil & gas business. Currently, there is neither definitive methodology nor guideline for electrical engineers to select the type of generator suitably to meet the requirement of offshore applications.

CHAPTER 2
LITERATURE REVIEW

Because this is a collaborative project with PCSB, all historical data and information on the various types of offshore facilities together with its' type of power generator technologies and power requirements will be input by PCSB itself. Besides that, references from the internet, journal and product catalog from vendors will also be required. There are three main sources for literature which are:

- PETRONAS Technical Standards (PTS). PTS 33.65.11.32 (Package Unit AC Generator Sets) and PTS 33.64.10.10 (Electrical Engineering Guidelines).[1]
- Types of Offshore Platforms and Facilities
- Different Types of Small and Large Power Generation Technologies

2.1 Types of Offshore Platforms and Facilities

PCSB has many oil fields or wells throughout the Malaysian waters particularly at the South China Sea. Besides that, PCSB also has interests in other countries such as Vietnam and Indonesia, to name a few. To get the knowledge on typical offshore facilities, the ANGSI field has been selected as the main reference and example because it has a complete facilities for offshore applications within its' five platforms.

ANGSI field is situated at the South China Sea offshore of Kerteh, Terengganu. This field already has five operational platforms; whereby ANPG-A (process platform) and ANDR-A (drill riser platform) act as mother platforms with three satellite drilling platforms namely ANDP-B, ANDP-C and ANDP-E (*please refer appendix, ANGSI Field Development Plan*). For info, the ANGSI field produced about 100,000 barrels of crude oil per day, which justify that this field is the largest in production of crude oil for PETRONAS at South China Sea.

2.1.1 8-legged Central Processing Platform (ANPG-A)

Typical installed power capacity: 3 MW to 5 MW

Typical voltage rating: 6600 VAC

Frequency: 50Hz

Typical offshore facilities: Production, Processing and Living Quarters

2.1.2 8-legged Drill Riser Platform (ANDR-A)

Typical installed power capacity: 100 kW

Typical voltage rating: 400 V AC

Frequency: 50Hz

Typical offshore facilities: Drill Riser, Flare Tower

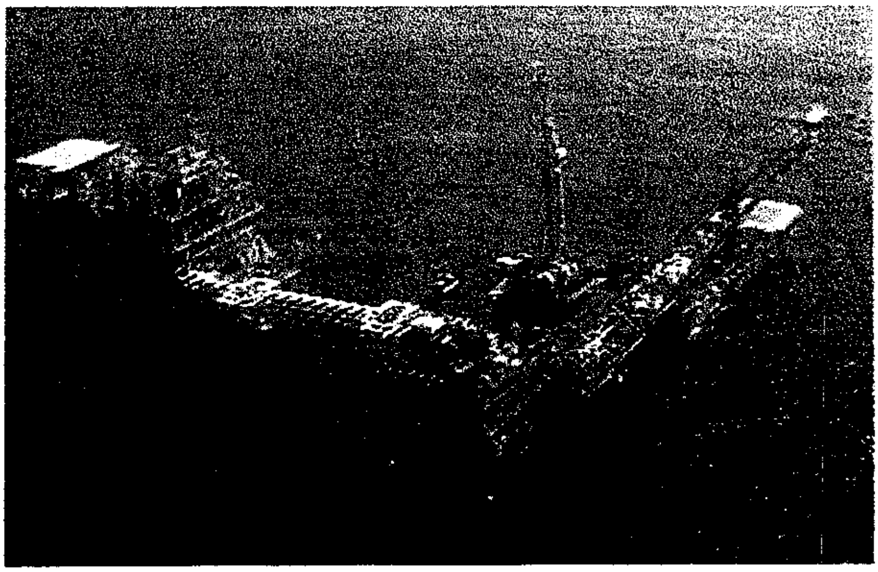

Figure 1: ANPG-A Process Platform and ANDR-A Drill Riser Platform

2.1.3 4-legged Drilling Platform (ANDP-B)

Typical installed power capacity: 100 kW to 150 kW

Typical voltage rating: 400 V AC

Frequency: 50Hz

Typical offshore facilities: Drilling Rig

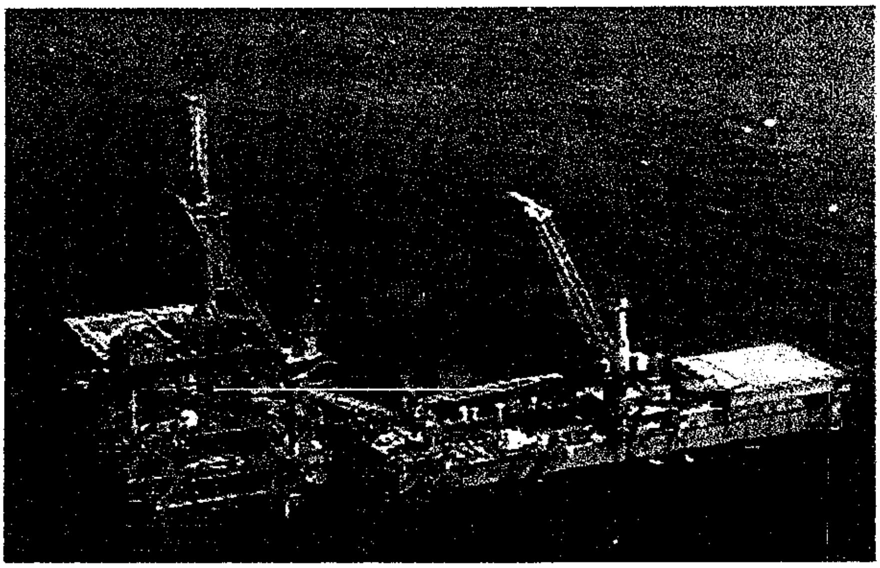

Figure 2: ANDP-B Drilling Platform

2.1.4 3-legged (Tripod) Drilling Platforms (ANDP-C & ANDP-E)

Typical installed power capacity: 2 kW to 4 kW

Typical voltage rating: 24 VDC

Frequency: -

Typical offshore facilities: Drilling Rig

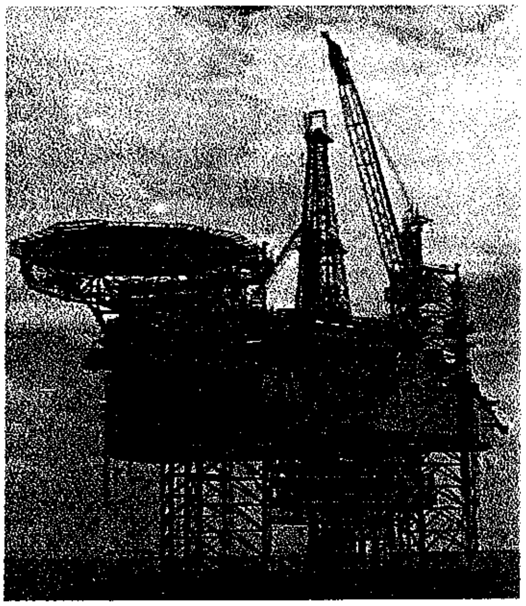

Figure 3: ANDP-C and ANDP-E Drilling Platform

2.2 Different Types of Small and Large Power Generation Technologies

Currently, there are many types of power generation technologies available in the market. Study on the characteristics, working principles and specifications are also necessary to make sure whether the equipment is viable for offshore practice. A power output is considered small when the rated power produced is below 1000 kW or 1 MW. Above that ranges is considered as large or high power output. These are a few examples of technologies which have been identified suitable for offshore usage.

2.2.1 *Microturbines* [6]

Microturbines are small combustion turbines that produce between 25 kW and 500 kW of power. Microturbines have a common shaft on which mounted a compressor, turbine, and generator. These components are mounted on air bearings, so no lubrication is required; because friction is eliminated, the cost of maintenance is significantly reduced. Most microturbines are single-stage, radial flow devices with high rotating speeds of 90,000 to 120,000 revolutions per minute. The frequency may vary from 1,300 to 1,600 Hz. This AC power may be converted to DC power and later re-converted via inverters into AC power at 240 or 480V and 50 or 60 Hz.

Microturbine generators can be divided into two general classes: (i) Recuperated microturbines, that recover the heat from the exhaust gas to boost the temperature of combustion and increase efficiency; and (ii) Unrecuperated (or simple cycle) microturbines, which have lower efficiencies, but also lower capital costs. While some early product introduced in the market has featured unrecuperated designs, the bulk of developers' efforts are focused on recuperated systems. The recuperator recovers heat from the exhaust gas in order to boost the temperature of the air stream supplied to the combustor.

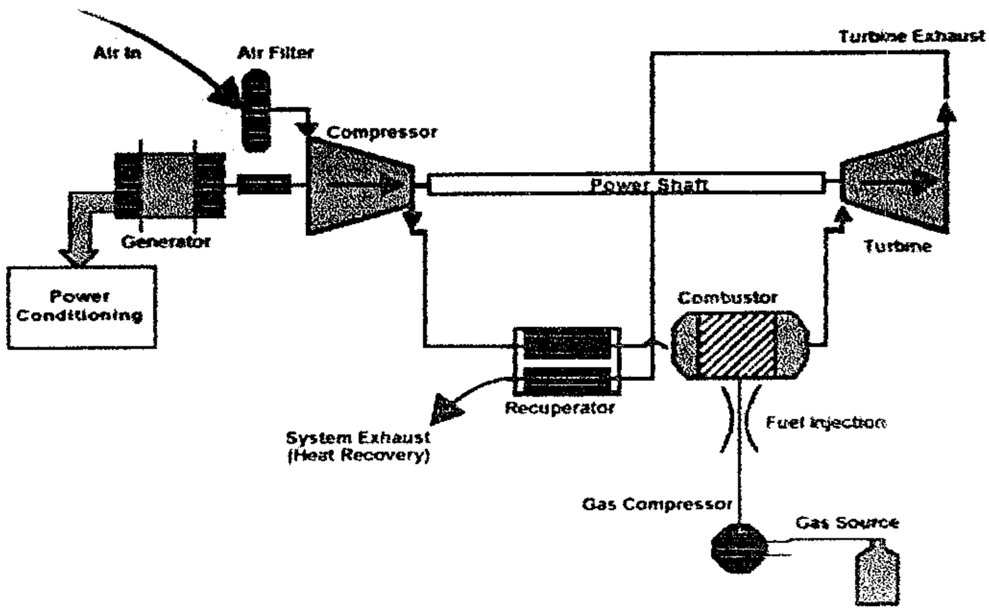

Figure 4: Recuperated Microturbine Systems

Further exhaust heat recovery can be used in a cogeneration configuration. The figure above illustrates a recuperated microturbine system. In the recuperated microturbine systems, units are air cooled, with air brought in through an inlet to cool the generator set. The air is then compressed before it is ducted through the regenerator into the combustion chamber. Once the air is compressed, it is sent to the recuperator to raise its temperature, passing to the combustion chamber, and mixing with fuel. Ignition of the mixture creates the combustion gases that enter the turbine, making it rotate. The gases leave the turbine at 1,100°F and return to the recuperator, which transfers a large fraction of the heat to the compressed air before the compressed air enters the combustion chamber. Exhaust gases at 450°F may be sent to a heat exchanger in order to heat water for industrial, commercial, and residential purposes, as well as for the production of steam.

2.2.2 Close-cycle Vapour Turbogenerator [8]

Closed Cycle Vapour Turbogenerator or CCVT is another of many types of power generating equipment offshore platforms. ORMAT is one of the manufacturers whom named its CCVT product as The ORMAT Energy Converter (OEC). This OEC unit is suitable for remote power system and certified for operations in Class 1, Division 2 (Zone 2, Group II) conditions in offshore applications.

Usually, a CCVT is only used to produce small power at an unmanned platform. For OEC, basically a self-contained power package consisting of a combustion system, a vapor generator, a turbo alternator, an air-cooled condenser, a rectifier, alarms and controls housed in a shelter. It will supply 200 to 3000 Watts of filtered DC power on a continuous 24-hour-per-day basis for periods of up to 20 years with virtually no maintenance or repairs.

The ORMAT concept utilizes a hermetically sealed Rankine cycle generating set which contains only one smoothly rotating part – the shaft on which the turbine wheel and the brushless alternator rotor are mounted. The turbo alternator shaft is supported by working fluid film bearings, which eliminate any metal-to-metal contact, resulting in years of trouble-free operation. Unlike any other generators, this OEC unit can operate with natural gas with high NCG content and low LHV.

System Operation of a CCVT

The burner heats the organic working fluid in the vapour generator where some of it vaporizes and expands through a turbine wheel thereby producing shaft power to drive the alternator. The vapour then passes into a condenser where it is cooled, condensed back into the liquid state and driven back into the vapour generator, cooling the alternator on its way, and lubricating the bearings. The cycle continues as long as heat is applied to the vapour generator. Because the vapour/liquid stainless steel envelope is sealed, none of the organic fluid is loss during the process.

Furthermore, the working fluid is totally immune to climatic conditions outside the sealed envelope. The turbo-alternator produces three-phase AC power, which is then rectified and filtered. The DC power is regulated for varying load by automatically controlling the amount of fuel supplied to the burner. The system is equipped with a digital turbine control unit with safety controls to protect it against any abnormalities, including overheating.

General Specifications of CCVT:

- Output power: 200 to 3000 W (per unit)
- Output voltage: 24 or 48 or 125 VDC (nominal)
- Voltage variation: 3.5% of voltage setting
- Protections: short circuit, over voltage, low voltage, motive fluid over temperature
- Area of installation: Zone 2, Group II, Temperature Class T3 / Class 1, Division 2, Temperature Class T3

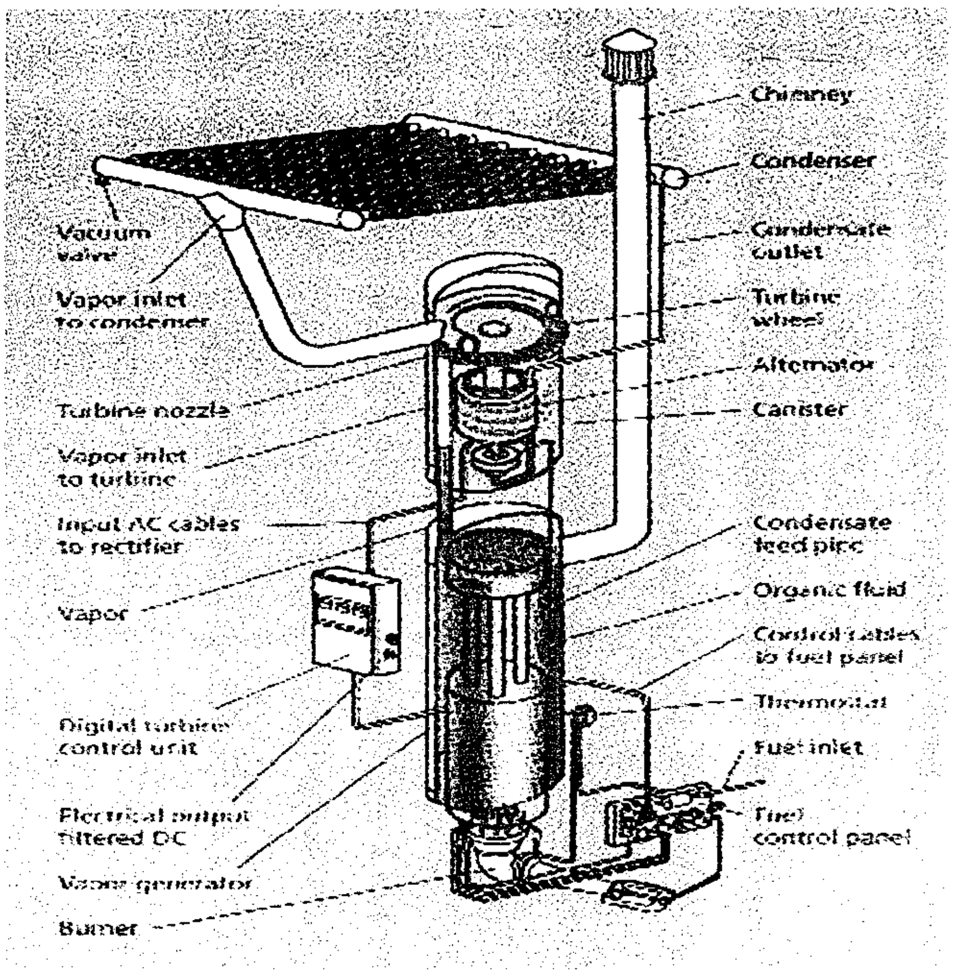

Figure 5: Inside a CCVT

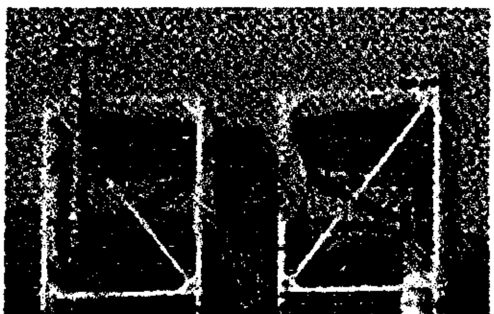

Figure 6 Actual CCVT Units

2.2.3 Thermal Electric Generators [9]

Known as TEG, is another highly robust and reliable product which produced electricity from the conversion of heat. It is low in maintenance as there are no moving or rotating parts inside this unit. Initially, this technology is develop by 3M for the Apollo space program, but later was commercialized by Global, as one of the main manufacturer and supplier worldwide. A standard TEG unit is designed for 20 years lifetime.

A TEG solid state comprises of 3 key components which are burner, sealed thermopile and heat sink. The burner acts as the main heat source of the unit. The sealed thermopile is the energy conversion device which converts the heat produced by the burner to electricity. The heat generated is cooled by heat sink in the form of cooling fins or heat pipes.

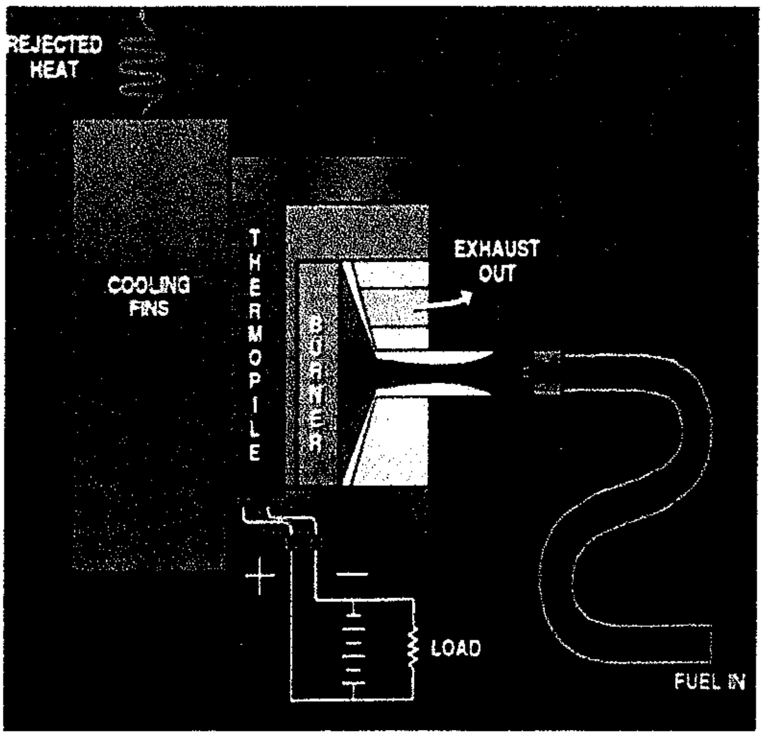

Figure 7: TEG Solid State Device

System Operation of a TEG

The main conversion unit of this TEG unit is the hermetically-sealed thermopile. This is where the heat is converted directly to electricity. DC current is produced when there is a difference in temperature across the thermopile, just like the concept of thermocouple. This small DC current is then amplified and regulated to produce the amount of power needed, in this case, according to the unit's rating. The elements of this thermopile are lead-tin-telluride.

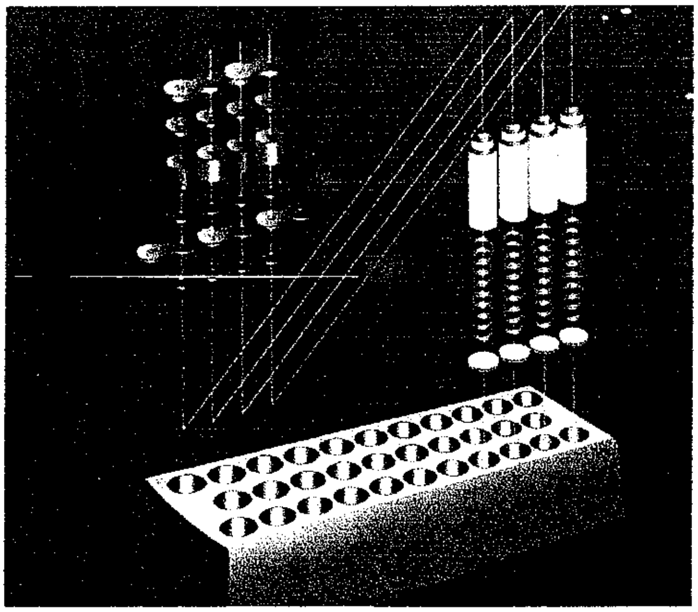

Figure 8: Thermopile

TEG Features

- Standard 12 VDC, 24 VDC
- Generators can be connected in parallel or series for larger loads
- Systems can be designed for load requirements from 10 W to 5000 Watts
- Gaseous Fuels – natural gas, propane

2.2.4 Reciprocal Engine

Reciprocating or internal combustion (IC) engines are part of our everyday life. There are over a million IC engines installed for electricity backup applications worldwide, and over 100 million engines in operation counting cars, trucks, planes, and boats. IC engines are best suited for backup, intermediate, peaking, and combined heat and power (CHP) applications where unit sizes with electrical output requirements range from a few kW up to roughly 10,000 kW. Besides applicable to offshore power generation, IC engines are installed in manufacturing facilities, office buildings, universities, hospitals, retail stores, distribution centers, and small utilities. IC engines are generally characterized as having:

- Low initial capital cost
- Proven reliability
- Strong maintenance support networks
- Rated output that is not impacted by higher ambient temperatures or elevations
- High partial load efficiency
- Heat recovery capabilities for combined heat and power
- No requirements for external inlet fuel compression

IC engines are divided into two basic types: spark ignition and compression ignition engines. The spark ignition engine is common in the form of gasoline powered car engines. Below 75 kW they are produced in large volumes, but are also seeing rapid acceptance above 300kW for natural gas fired power generation with heat recovery (CHP). Excluding the lowest output models, these engines typically have four-stroke combustion cycles, operate at medium to high speed, and are powered by liquid fuels or natural gas. Higher engine speeds allow for greater engine efficiency. Natural gas is often required for longer run hours to meet environmental regulations for applications with longer run hours.

Figure 9: Internal Combustion Engine Installation

The compression ignition engine, often called a diesel engine, is used in heavy trucks or buses. Diesel engines can have two- or four-stroke combustion cycles and can operate at any speed. Heavy fuels such as diesel are used extensively for power production in Africa, Asia, and many islands. IC engines provide the best combination of efficiency and cost effectiveness in smaller scale applications compared to other power generation technologies. IC engines are found in the following cycles:

1) Simple Cycle - This is the standard operational method of IC engines. Simple cycle indicates that cogeneration or combined heat and power is not being employed. They have high simple cycle efficiencies, low capital cost and start-up times typically of less than ten seconds. These attributes make IC engines well suited for back-up power.

2) Cogeneration or Combined Heat and Power - Combined Heat Power (CHP) is a leading configuration for supplying electricity while capturing thermal energy in the form of process steam or hot water for industrial and commercial applications. IC engines are not as efficient as combustion turbines in converting waste heat to steam

(less than 50% thermal energy can be converted to steam), but are very well suited for applications requiring small amounts of steam at low pressure or small to large volumes of hot water. Reciprocating engine CHP installations have been steadily increasing.

Technology of IC

IC engines and combustion turbine technologies both use the energy of combustion and convert it into rotating mechanical energy. The basic operation of an IC engine is similar to a combustion turbine in that both convert combustion gases into a rotating shaft (crank). However, combustion turbines use a continuous combustion process, whereas IC engines follow discrete steps in the energy conversion process. A typical four-stroke IC engine cycle consists of the following four steps:

- Intake
- Compression
- Power (Combustion)
- Exhaust

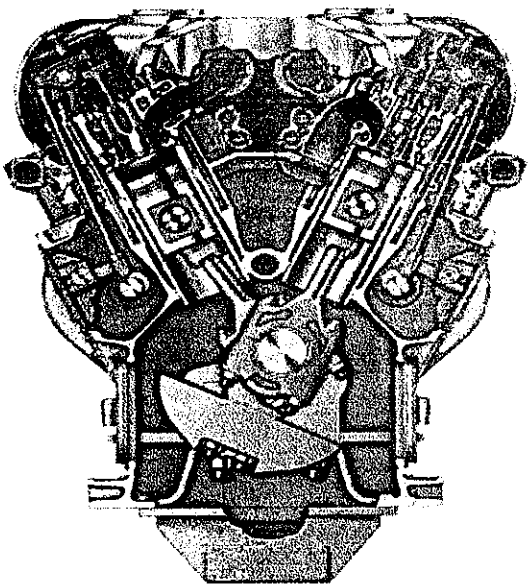

Figure 10: Cross Section of IC Engines

A four-stroke process requires two complete revolutions of the crank shaft to complete its cycle versus a two-stroke machine which completes the four cycles in one revolution of the crankshaft. During the Intake step, air and fuel are inducted into a cylinder when the piston is near or at its downward stroke (assumes a vertically oriented engine) and the intake valves or ports (located at the top of the engine block) open to draw in air. Intake air is always filtered to remove particles and extend the life of the engine. Once the air and fuel mixture is in the cylinder, the compression step occurs by an upward stroke of the piston that reduces the combustion volume and compresses the mixture. The piston is connected to the crankshaft by a connecting rod that pushes the piston upward as the crankshaft rotates. The piston travels upward until it reaches the end of its stroke.

The combustion or power step in the four-stroke cycle occurs when either compression is high enough (16:1) to cause the mixture to self ignite, or an external spark is introduced. The pressure ratio is the ratio of the pressure at full compression, or minimum volume, divided by the pressure of the cylinder at its maximum volume. The expanding exhaust gases push the piston downward, creating mechanical energy that causes the connecting rod to rotate the crank shaft. In the exhaust step, the valves or ports in the exhaust manifold open to allow hot exhaust gases to escape, completing the cycle.

In contrast to the four-stroke cycle, two-stroke machines complete their cycle in one revolution. For this reason, two-stroke air aspirated engines generate more mechanical power than their four-stroke counterpart with the same cylinder volume. Both types of engines go through the four steps listed above. When the piston moves downward, the two-stroke engine exposes an exhaust port that allows exhaust to escape and then introduces a fresh air/fuel mixture into the cylinder. The mixture is compressed with a subsequent upward stroke of the piston, followed by the combustion process that drives the piston back downward and creates mechanical power through the crankshaft. The exhaust valves or ports in the exhaust manifold open to allow hot exhaust gases to escape. Although two-strokes can generate more power than a four-stroke with equivalent displacement (cylinder volume), they are also less efficient and have higher emissions.

CHAPTER 3
PROJECT OVERVIEW AND METHODOLOGY

3.1 Project Overview

In Malaysia, electricity or electrical power supply is obtained by two methods. First, the supply is received from the source that generates its own power and supplies it to consumers as their core business such as Tenaga Nasional Berhad (TNB) or other Independent Power Producers (IPPs). Secondly, the electricity required for own usage is produced by self generation using various types of power generators. For example, PETRONAS produced its own power for self utilization through their power plants from PETRONAS Gas Berhad (PGB) through its Central Utility Facilities (CUFs).

Offshore platforms and facilities generate its' own electricity. Currently, PCSB had spent an incurred high cost of investment on power generation systems offshore by undertaking substantial engineering activity and inventory to cater the changes of load. Therefore, PCSB is looking at an optimize method or philosophy in selecting the type of power generation technology for their facilities, hence reducing the front end cost of engineering works. Selecting of a power generator for offshore is normally based on these criteria:

i) *Load Demands*:

To cater all the required power on-board for process, instrumentation, drilling, accommodation and other equipment such as various types of pumps, lighting and also Distributed Control System (DCS).

ii) *Space*:

Whether the footprint of the power generator is able to fit in the space provided on-board.

iii) *Weight*:

To match the equipment's weight with the structural limitations of the platform.

iv) *Reliability*:

The reliability and performance of the generators must be taken into account during the design stage and technical evaluation. To check whether the generators comply with all the technical requirements and are robust enough to withstand the harsh offshore environment.

3.2 Project Methodology

The methodology on conducting this project is divided into four parts:

i) *Data gathering and collection*:

Information on types of power generations for offshore applications are searched and collected from PCSB's vendors and suppliers. The information on types of offshore platforms is to be obtained from PCSB through the project collaborator. Besides, other relevant information can be gathered from the PCSB's archive at KLCC [5] (*please refer appendix, Load Study*).

ii) *Study, research, and data analysis*:

Studies on how to determine offshore power generation design by referring to the PTS together with frequent consultation with the industry supervisor. All the data obtained are also analyzed in terms of suitability and cost effective.

iii) *Data compilation and arrangement*:

With the aid and advices from the project collaborator together with project supervisor, all the data had been arranged and compiled according to criteria that will be discussed later. A small database containing all the relevant information also being constructed as reference (*please refer appendix, Equipment Database and Specifications*).

iv) *Software development on power generation selection*:

This is just an extra, not an objective of the project. According to plan, the software or system should serve two main purposes, first as a 'mini library' or database whereby additional data can be stored into later. Second, it will act as the selector of the best power generator to assist the engineers during the designing stage in a project.

3.2.1 Software & System Development Tools Selection

After conducting some survey and readings on software, it is concluded that only two programs are more suitable to develop the system for this project; first is MATLAB and second is Microsoft Visual Basics.NET (VB). Comparing both of them in terms of data management and accessibility, is it decided that VB is the better selection of the two.

VB harnesses Microsoft Access (Access) to store data. In other words, a new database must be constructed using Access by transferring all the data obtained earlier. But after considering back all other factors such as time constrain and complexity, it is decided that the database should be created directly in the VB itself using the .txt format, and then be stored inside the bin folder.

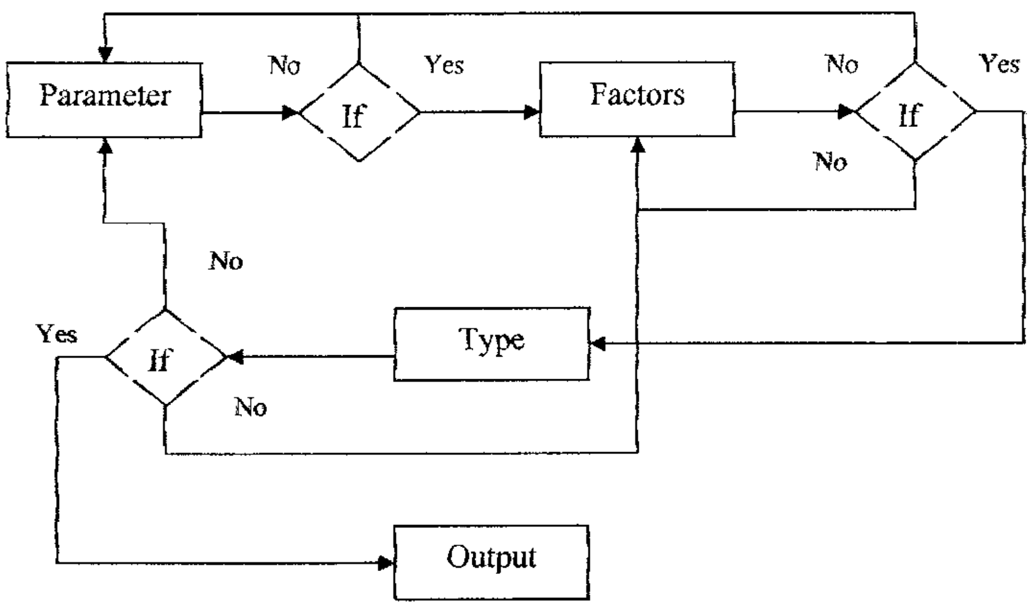

Figure 11: Programming Algorithm for the Software

CHAPTER 4
FINDINGS AND DISCUSSION

4.1 Results of study

From the study conducted, it is found that there are standard specifications and also variable specifications of a particular power generator for offshore or remote applications. The standard specifications or requirements for offshore installation are:

i) *Hazardous Area Classification:*

Although the power generator should be placed at safe area (according to standards IP Part 15, usually the equipment is required to be configured for Zone 1 adaptability.

ii) *Ingress Protection (IP):*

This is a protection against solid and water criteria. Normally, the generator has to comply with IP 56, which is the protection against medium size solid and jet spray of water.

Most of the manufacturers of these products can customize the standard specifications required. The variable specifications are the one where electrical engineers have to consider during the design stage. After further discussions with both supervisors and studies conducted, two things must be taken into account:

i) *Technical Parameters*:

Consist of which type of fuel source to be used, what are the ranges of output power needed, the voltage output whether AC or DC together with its frequency.

ii) *Factor Decision*:

This factor includes the maximum weight of the generator which the platforms can withstand and also the maximum footprint or size that can accommodate by the space limitation of the platform.

4.2 Software & System Development

Referring to the project planning before, the data are grouped according to types of generation such as gas turbines, diesel generators etc. Each of this group contained the following parameters of all the respective brands:

- power produces (output power)
- footprint (size)
- weight
- URL (website link)

This main objective of this system software is to assist the engineers to select the best generator according to the technical parameters and the decision factors. So the user interface should include the mentioned details or input:

i) *Technical Parameters*:

- fuel source – heat, gas, liquid
- power output – in kilowatts
- voltage output – AC or DC
- frequency – 50 or 60 Hz

ii) *Decision Factors*:

- maximum size or footprint – length, width, height
- maximum weight – in kilogram

4.3 *Software & System Demonstration*

This is the first page interface whereby the user needs to input all the parameters required in order to perform the selection

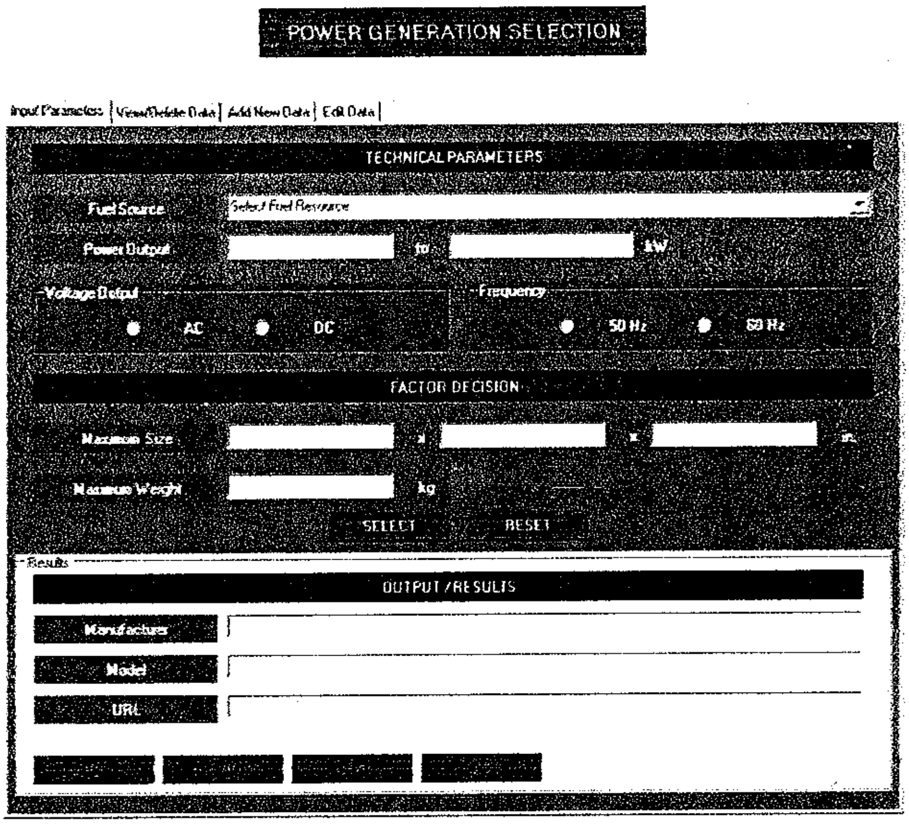

Figure 12: User Interface of the Power Generation Selection Software

The user will then fill out all the needed parameters of the generator (Figure 13). After that, the 'SELECT' button is push. The software then will filter out from its database and come out with the best matched equipment. The results will display the manufacturer's and model name, together with the website address or URL of the manufacturer for more detail descriptions and reference to the engineers (Figure 14).

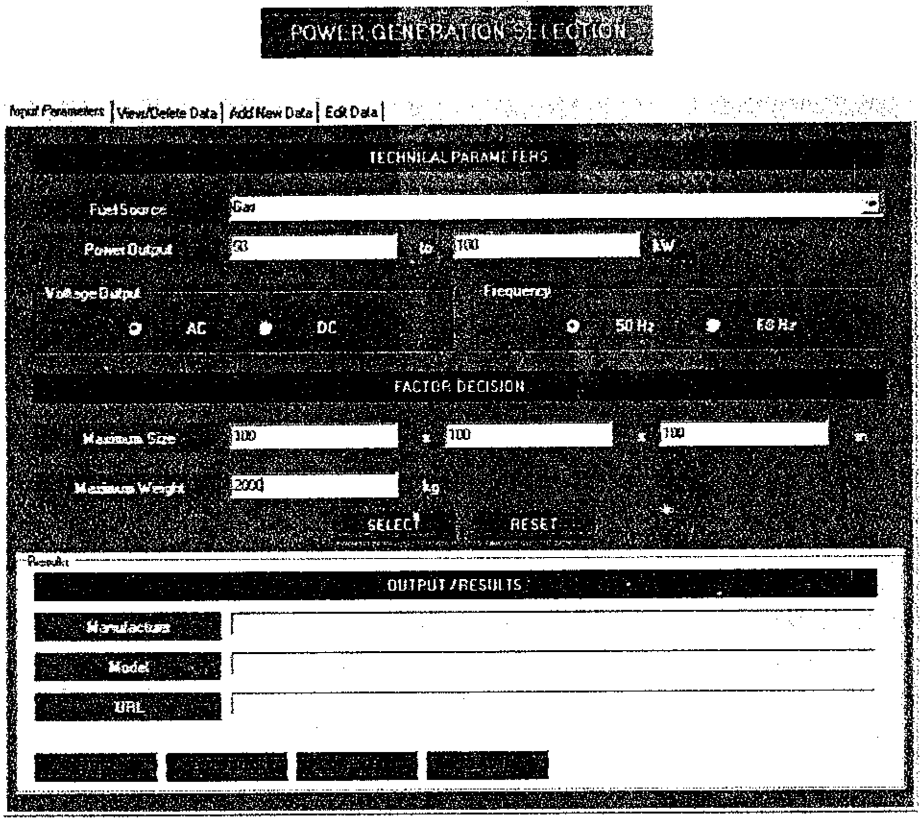

Figure 13: Example of Input Parameters

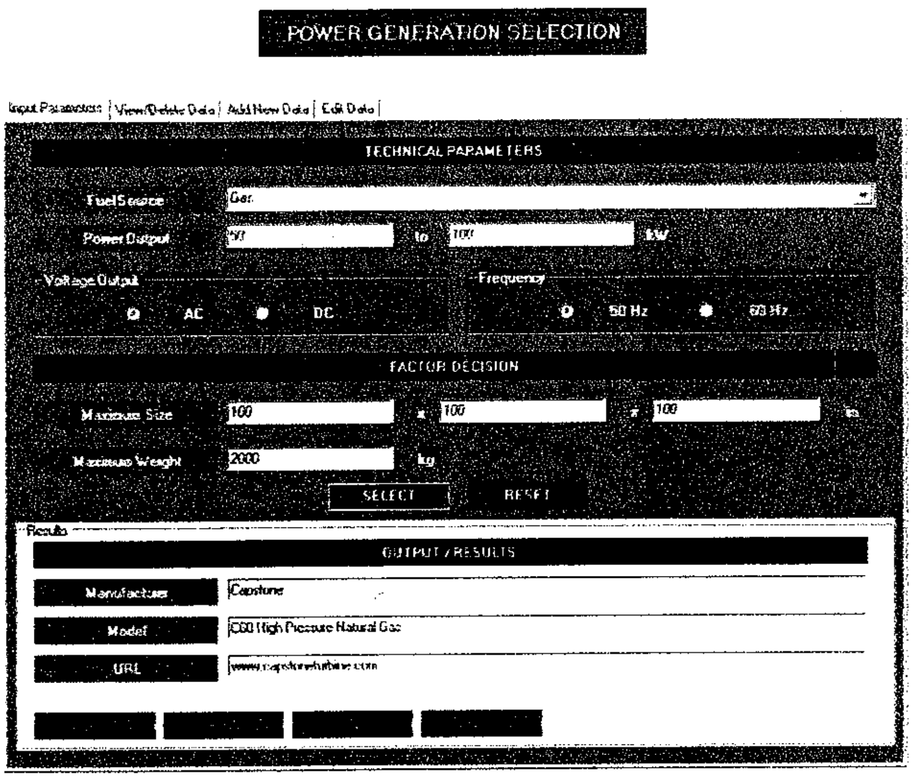

Figure 14: Example of Output Result

As an addition or extra for this software, some new functions are planned and develop to make the software more user-friendly and useful. Those functions are 'Add New Data' (Figure 15) where users can update the database with new models and types of generators in the future; and users or engineers can also modified current or existing data using the 'Edit Data' function (Figure 16).

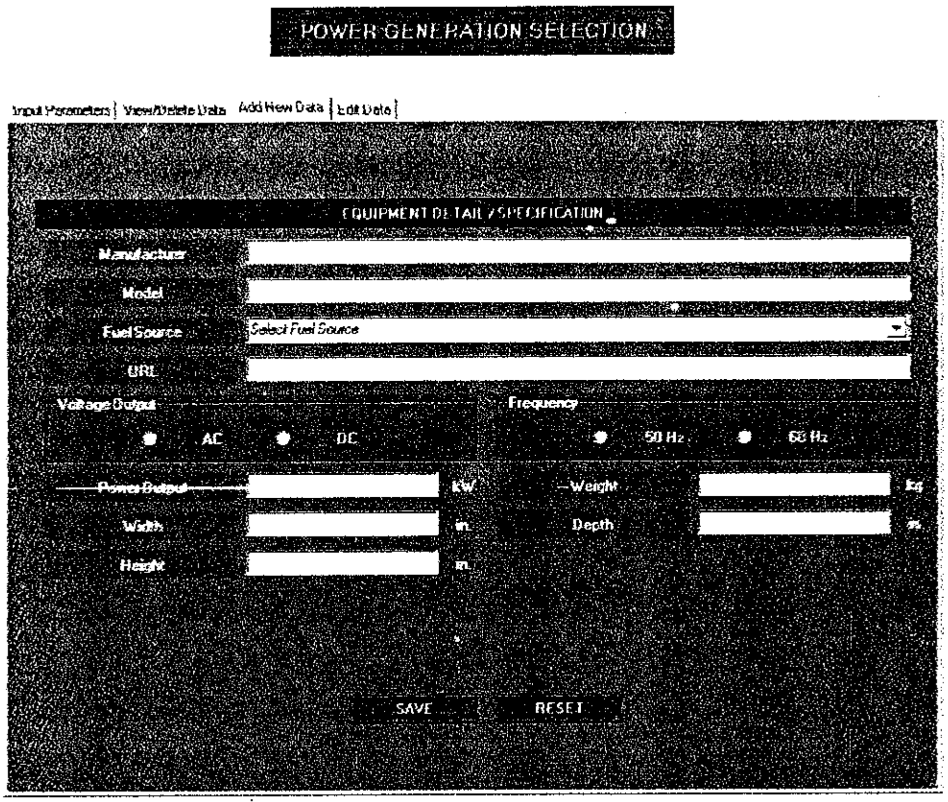

Figure 15: 'Add New Data' Function Page

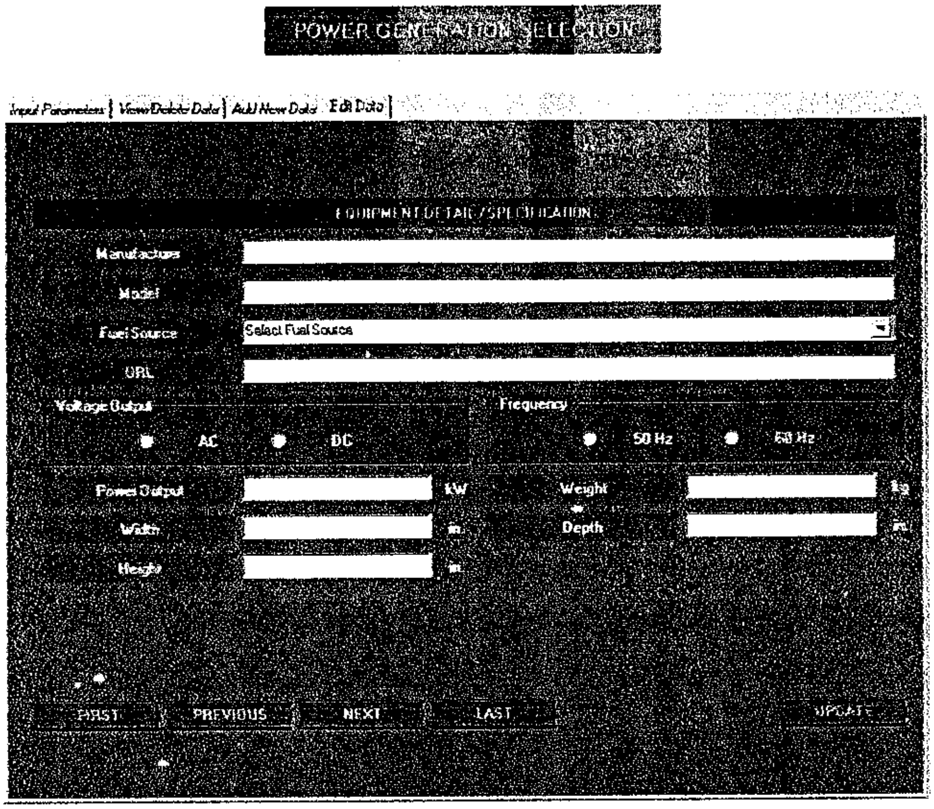

Figure 16: 'Edit Data' Function Page

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

All in all, this entire project has met its main objective. The objective of the exercise is to develop systematic approach and methodology to select the optimum generator on the offshore facilities. The methodology will facilitate engineer to identify and select the right generators for power source at any facilities and at anytime, therefore it could minimize the design time of power generation. In future, the electrical design engineers just need to input all the relevant parameter to get the right generators. After further discussions with both supervisors from the industry and the university, the two parameters which must be taken into consideration during the selection process that has been finalized are:

i) Technical Parameters - fuel source, power output, voltage output, and frequency.

ii) Decision Factors - the maximum weight and size

In addition to this, an integrated system using the Microsoft Visual Basics.NET software has been developed as an initiative to improve this project. This system can store all the different types of data together with its specifications in its database. Selection of the best selection of the offshore power generators can be done by this software by inputting all the above mentioned parameters. The software will filter out from its database and came out with the most suitable output of the required generator.

5.1.1 Benefits of This Project

From all the studies conducted and the results produced, this project will eventually benefit both the design engineers and also the company itself. Among those benefits are:

i) Reduce the man hour to select the most suitable generators during the design stage of a particular project development plan.

ii) *Reduce the front-end cost of the engineering works. This means that the* generators selected will be most efficient; not more or not less *that the required* rated output power. Thus, this will save the initial cost by minimizing the chance of selecting generators with excess power ratings.

5.2 Summary

Most of the offshore platforms generate its' own power from various types of generation units. Usually, the satellite platforms require power from as low as 3kW to 150kW. These types of platforms perform drilling operations. Whereas, the mother or main platforms can consume more power up to a few megawatts to cater for the load demands which include on-board crude oil & gas processing. The table is just a short summary on some examples of the types of offshore facilities platforms together with its power demands or requirements.

Table 1: Example of Types of Offshore Platforms and Its' Power Demands

Types of platforms	Functions and On-board Facilities	Approx.Power Consumption	Ex. of Generation Types
Central Processing Platform (8-legged)	Production, Process, and Living Quarters	3MW-5MW	Gas Turbine
Drill Riser Platform (8-legged)	Drill Riser, Flare Tower	100kW-150kW	Diesel Generator
Drilling Platform (4-legged)	Drilling Rig	100kW-150kW	Microturbine
Drilling Platform (3-legged)	Drilling Rig	2.5kW-4kW	Close-cycle Vapour Turbogenerator

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[11] Microsoft Visual Basics.NET online tutorials – Microsoft Studio.NET

[12] American Electrical Consumer Forum Website

APPENDIX A

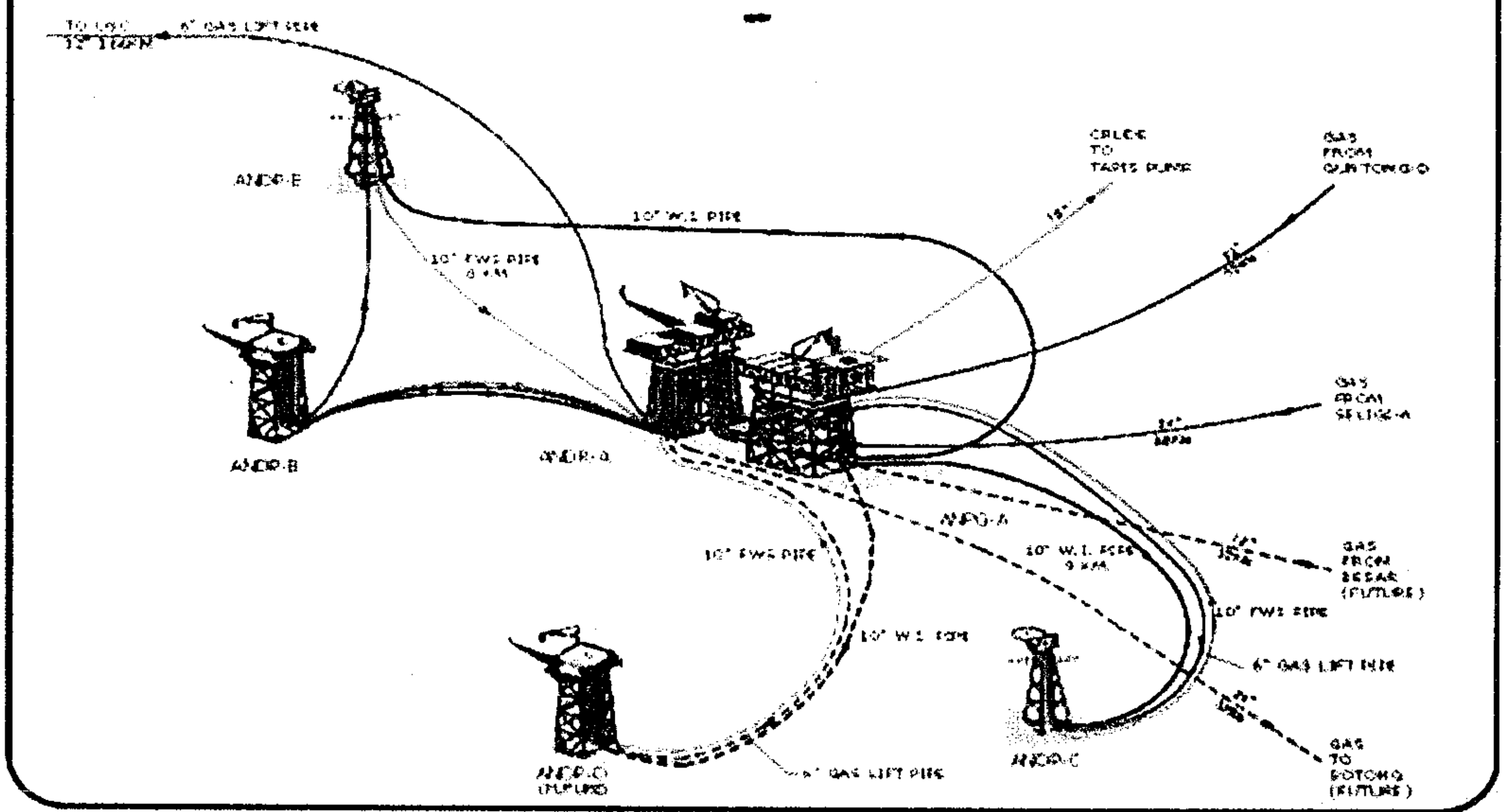
PCSB LOAD STUDY

Project Name	Designed Maximum Running Load	Unit	Designed Peak Load	Unit	Actual Maximum Running Consumpt	Unit	Access Generated Power	Variance (%)
MLNG 3 Pipeline Project - Slugcatcher III and Metering Area	371.61	kW	371.61	kW	N/A	kW	#VALUE!	#VALUE!
	182.04	kVar	182.04	kVar	N/A	kVar	#VALUE!	#VALUE!
	413.80	kVA	413.80	kVA	N/A	kVA	#VALUE!	#VALUE!
MLNG 3 Pipeline Project - BCOT & BSTABS 3 / 4 Areas	106.17	kW	108.02	kW	N/A	kW	#VALUE!	#VALUE!
	63.47	kVar	64.76	kVar	N/A	kVar	#VALUE!	#VALUE!
	123.69	kVA	125.94	kVA	N/A	kVA	#VALUE!	#VALUE!
Rehmat (Pakistan)	3.00	kW	3.00	kW	1.90	kW	1.10	63.33333333
	N/A	kVar	N/A	kVar	N/A	kVar	#VALUE!	#VALUE!
	N/A	kVA	N/A	kVA	N/A	kVA	#VALUE!	#VALUE!
CPOC - Secondary Platform	22.92	kW	31.71	kW	N/A	kW	#VALUE!	#VALUE!
	15.26	kVar	21.40	kVar	N/A	kVar	#VALUE!	#VALUE!
	27.54	kVA	38.26	kVA	N/A	kVA	#VALUE!	#VALUE!
Sumandak A - SUDPA Drilling Platform	260.90	kW	273.26	kW	N/A	kW	#VALUE!	#VALUE!
	170.93	kVar	180.85	kVar	N/A	kVar	#VALUE!	#VALUE!
	311.91	kVA	327.69	kVA	N/A	kVA	#VALUE!	#VALUE!
Dulang B (DL-B)	2,700.00	kW	2,700.00	kW	N/A	kW	#VALUE!	#VALUE!
	N/A	kVar	N/A	kVar	N/A	kVar	#VALUE!	#VALUE!
	N/A	kVA	N/A	kVA	N/A	kVA	#VALUE!	#VALUE!
Dulang (Overall)	9,000.00	kW	9,000.00	kW	N/A	kW	#VALUE!	#VALUE!
	N/A	kVar	N/A	kVar	N/A	kVar	#VALUE!	#VALUE!
	N/A	kVA	N/A	kVA	N/A	kVA	#VALUE!	#VALUE!
Duyong (Overall)	3,600.00	kW	3,600.00	kW	1,000.00	kW	2,600.00	27.77777778
	N/A	kVar	N/A	kVar	N/A	kVar	#VALUE!	#VALUE!
	N/A	kVA	N/A	kVA	N/A	kVA	#VALUE!	#VALUE!
Angsi (Overall)	16,000.00	kW	16,000.00	kW	7,000.00	kW	9,000.00	43.75
	N/A	kVar	N/A	kVar	N/A	kVar	#VALUE!	#VALUE!
	N/A	kVA	N/A	kVA	N/A	kVA	#VALUE!	#VALUE!
Resak (Overall)	10,500.00	kW	10,500.00	kW	1,200.00	kW	9,300.00	11.42857143
	N/A	kVar	N/A	kVar	N/A	kVar	#VALUE!	#VALUE!
	N/A	kVA	N/A	kVA	N/A	kVA	#VALUE!	#VALUE!

APPENDIX B

ANGSI FIELD DEVELOPMENT PLAN (LOCATION)

ANGSI FIELD DEVELOPMENT PLAN



APPENDIX C

VISUAL BASIC.NET PROGRAMMING CODINGS

```
Public Class Form1
    Inherits System.Windows.Forms.Form
```

```
'declaration'

Structure ProductDetails
        Public Manufacturer As String
        Public Model As String
        Public FuelSource As String
        Public PoworOutput As String
        Public VoltageOutput As String
        Public Frequency As String
        Public Width As String
        Public Depth As String
        Public Height As String
        Public Weight As String
        Public URL As String
    End Structure
```

```
Dim udtProductDetails(300) As ProductDetails
Dim intNumRecord As Integer
Dim intNumRecord2 As Integer
Dim intIndex As Integer
Dim intEntry As Integer
Dim udtRightRecord(100) As Integer
```

```
'reset'

[illegible]
    Public Sub Reset()
        cbxFuel.Text = "Select Fuel Resource"
        txtPower1.Text = ""
        txtPower2.Text = ""
        rbtAC.Checked = False
        rbtDC.Checked = False
        rbt50Hz.Checked = False
        rbt60Hz.Checked = False
        txtMaxWidth.Text = ""
        txtMaxDepth.Text = ""
        txtMaxHeight.Text = ""
        txtMaxWeight.Text = ""
        btnFirst.Enabled = False
        btnPrevious.Enabled = False
        btnNext.Enabled = False
        btnLast.Enabled = False
        txtManufacturer.Text = ""
        txtModel.Text = ""
        txtURL.Text = ""
    End Sub
```

```
                                                If
Val(udtProductDetails(intIndex).Height) <= Val(txtMaxHeight.Text)
Then
                                                    If
(udtProductDetails(intIndex).Weight) <= Val(txtMaxWeight.Text) Then

udtRightRecord(intNumRecord2) = intIndex
                                                        intNumRecord2 += 1
                                                    End If
                                                End If
                                            End If
                                        End If
                                    End If
                                End If
                            End If
                        End If
        Next

        LoadOutput()
    End Sub
```

```
[illegible]

Public Sub LoadOutput()
        intEntry = 0

        If intNumRecord2 = 0 Then
            MsgBox("No product found", MsgBoxStyle.Information,
"Search Result")
            Exit Sub
        End If

        LoadControl()
        LoadOutput2()

        [illegible]
[illegible]
        [illegible]
[illegible]
        [illegible]
[illegible]
    End Sub
```

```
[illegible]

Public Sub LoadOutput2()
        txtManufacturer.Text =
udtProductDetails(udtRightRecord(intEntry)).Manufacturer
        txtModel.Text =
udtProductDetails(udtRightRecord(intEntry)).Model
        txtURL.Text =
udtProductDetails(udtRightRecord(intEntry)).URL
End Sub
```

```
'Load control'

Public Sub LoadControl()
        If intNumRecordZ > 1 Then
            If intEntry = 0 Then
                btnPrevious.Enabled = False
                btnFirst.Enabled = False
                btnNext.Enabled = True
                btnLast.Enabled = True
            ElseIf intEntry > 0 And intEntry < intNumRecordZ - 1
Then
                btnPrevious.Enabled = True
                btnFirst.Enabled = True
                btnNext.Enabled = True
                btnLast.Enabled = True
            ElseIf intEntry = intNumRecordZ - 1 Then
                btnPrevious.Enabled = True
                btnFirst.Enabled = True
                btnNext.Enabled = False
                btnLast.Enabled = False
            End If
        End If
    End Sub
```

```
'Load'

Private Sub Form1_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load
        Reset()
        LoadProductDetails()
    End Sub


'Closing'

Private Sub Form1_Closing(ByVal sender As System.Object, ByVal e As
_
    System.ComponentModel.CancelEventArgs) Handles MyBase.Closing

        Dim intResponse As Integer
        intResponse = MsgBox("Do you really want to exit this
application?", 276, "Exit?")
        If intResponse = 6 Then
            End

        Else
            e.Cancel = True
        End If
    End Sub
```

```
'Reset'

Private Sub btnReset_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btnReset.Click
        Reset()
    [illegible]
```

```
Private Sub btnSelect_Click(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles btnSelect.Click
        Dim PowerTypeCheck As Boolean
        Dim FrequencyCheck As Boolean
        PowerTypeCheck = True
        FrequencyCheck = True

        If rbtAC.Checked = False And rbtDC.Checked = False Then
            PowerTypeCheck = False
        End If

        If rbt50Hz.Checked = False And rbt60Hz.Checked = False Then
            FrequencyCheck = False
        End If

        txtManufacturer.Text = ""
        txtModel.Text = ""
        txtURL.Text = ""

        If cbxFuel.Text = "Select Fuel Resource" Or cbxFuel.Text =
"" Or txtPower1.Text = ""
        Or txtPower2.Text = "" Or txtMaxWidth.Text = "" Or
txtMaxHeight.Text = ""
        Or txtMaxDepth.Text = "" Or txtMaxWeight.Text = "" Then
            MsgBox("Please enter all the necessary data before
proceed", MsgBoxStyle.Information, "Incomplete Parameters")
            Exit Sub
        End If

        If PowerTypeCheck = False Or FrequencyCheck = False Then
            MsgBox("Please check the required radio button before
proceed", MsgBoxStyle.Information, "Incomplete Parameters")
            Exit Sub
        End If

        FilterData()
    End Sub
```

```
Private Sub btnFirst_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btnFirst.Click
        intEntry = 0
        LoadControl()
        LoadOutput2()
    End Sub
```

```
Private Sub btnPrevious_Click(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles btnPrevious.Click
        intEntry -= 1
        LoadControl()
        LoadOutput2()
    End Sub
```

```
Private Sub btnNext_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btnNext.Click
        intEntry += 1
        LoadControl()
        LoadOutput2()
    End Sub
```

```
Private Sub btnLast_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btnLast.Click
        intEntry = intNumRecord2 - 1
        LoadControl()
        LoadOutput2()
    End Sub
End Class
```

APPENDIX D

DATABASE AND EQUIPMENTS SPEC (EXAMPLES)

Product	Rated Output	Fuel Source	Installed Cost (est.)
Capstone C30 Low Pressure Natural Gas	28 kW	Natural Gas	$8,400 - $30,800
Capstone C30 Liquid Fuels	29 kW	Diesel, Kerosene, Liquid Fuel	$8,700 - $31,900
Capstone C30 Biogas	30 kW	Biogas	$9,000 - $33,000
Capstone C30 High Pressure Gaseous Fuels	30 kW	Natural Gas. Propane, Alternative Gas	$33,000 - $33.000
Capstone C60 High Presure Natural Gas	60 kW	Natural Gas	$54.000 - $66.000
Ingersoll-Rand Energy Systems 70LM	70 kW	Natural Gas. Biogas	$21,000 - $77,000
Ingersoll-Rand Energy Systems 70SM	70 kW	Natural Gas. Biogas	$21.000 - $77.000
Bowman Power Systems TG80BG	80 kW	Natural Gas. LPG, Butane. Propane, Alternative Gas	$24,000 - $88.000
Bowman Power Systems TG80CG	80 kW	Natural Gas. LPG, Butane. Propane, Alternative Gas	$24.000 - $88.000
Bowman Power Systems TG80SC	80 kW	Natural Gas. LPG, Butane. Propane. Alternative Gas	$24.000 - $88.000
Elliott Energy Systems TA 80R	80 kW	Natural Gas	$24.000 - $88.000
Turbec T100	105 kW	Natural Gas	$31.500 - $115.500
Pratt & Whitney ST5 Recuperated	395 kW	Natural Gas	$256.750 - $355.500
Pratt & Whitney ST5 Simple Sycle	457 kW	Natural Gas	$297.050 - $411.300
Pratt & Whitney ST6L-721	508 kW	Natural Gas. Liquid Fuel	$330 200 - $457 200

Pratt & Whitney ST6L-795	678 kW	Natural Gas, Liquid Fuel	$440,700 - $610,200
Pratt & Whitney ST6L-813	848 kW	Natural Gas, Liquid Fuel	$551,200 - $763,200
Pratt & Whitney ST6L-90	1,175 kW	Natural Gas, Liquid Fuel	$763,750 - $1,057,500
Turbomach Industrial Energy Systems TBM-S20	1,204 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$782,600 - $1,083,600
Solar Turbines Saturn 20	1,210 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$786,500 - $1,089,000
Pratt & Whitney ST18A	1,961 kW	Natural Gas, Liquid Fuel	$1,274,650 - $1,764,900
Centrax KB3	2,682 kW	Natural Gas, Liquid Fuel, and Natural Gas/Liquid Backup	$1,743,300 - $2,413,800
Orenda Aerospace Corporation OGT 2500	2,720 kW	Natural Gas	$1,768,000 - $2,448,000
Pratt & Whitney ST30	3,340 kW	Natural Gas, Liquid Fuel	$2,171,000 - $3,006,000
Solar Turbines Centaur 40	3,515 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$2,284,750 - $3,163,500
Turbomach Industrial Energy Systems TBM-C40	3,515 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$2,284,750 - $3,163,500
Centrax KH5	3,811 kW	Natural Gas, Liquid Fuel, and Natural Gas/Liquid Backup	$2,477,150 - $3,429,900
Centrax KB5	3,902 kW	Natural Gas, Liquid Fuel, and Natural Gas/Liquid Backup	$2,536,300 - $3,511,800
Pratt & Whitney ST40	4,039 kW	Natural Gas, Liquid Fuel	$2,625,350 - $3,635,100
Solar Turbines Mercury 50	4,200 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$2,730,000 - $3,780,000

Alstom Typhoon	4,350 kW	Natural Gas, Liquid Fuel	$2,827,500 - $3,915,000
Centrax KN5	4,495 kW	Natural Gas, Liquid Fuel, and Natural Gas/Liquid Backup	$2,921,750 - $4,045,500
Turbomach Industrial Energy Systems TBM-C50	4,598 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$2,988,700 - $4,138,200
Solar Turbines Centaur 50	4,600 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$2,990,000 - $4,140,000
Alstom Typhoon	4,700 kW	Natural Gas, Liquid Fuel	$3,055,000 - $4,230,000
Alstom Typhoon	5,050 kW	Natural Gas, Liquid Fuel	$3,282,500 - $4,545,000
GE Power Systems, Oil & Gas PGT5	5,220 kW	Natural Gas, Liquid Fuel, Biogas	$3,393,000 - $4,698,000
Centrax KB7	5,240 kW	Natural Gas, Liquid Fuel, and Natural Gas/Liquid Backup	$3,406,000 - $4,716,000
Alstom Typhoon	5,250 kW	Natural Gas, Liquid Fuel	$3,412,500 - $4,725,000
GE Power Systems, Aero Energy GE5 (DLN)	5,500 kW	Natural Gas	$3,575,000 - $4,950,000
GE Power Systems, Oil & Gas GE5	5,500 kW	Natural Gas	$3,575,000 - $4,950,000
Solar Turbines Taurus 60	5,500 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$3,575,000 - $4,950,000
Turbomach Industrial Energy Systems TBM-T60	5,500 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$3,575,000 - $4,950,000
Centrax KN7	5,805 kW	Natural Gas, Liquid Fuel, and Natural Gas/Liquid Backup	$3,773,250 - $5,224,500
Alstom Tornado	6,750 kW	Natural Gas, Natural Gas/Liquid Backup Distillate Fuel, Liquid Fuel	$4,387,500 - $6,075,000

Turbomach Industrial Energy Systems TBM-T70	7,515 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$4,884,750 - $6,763,500
Solar Turbines Taurus 70 CED	7,520 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$4,888,000 - $6,768,000
Alstom Tempest	7,900 kW	Natural Gas, Liquid Fuel	$5,135,000 - $7,110,000
Turbomach Industrial Energy Systems TBM-M90	9,438 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$6,134,700 - $8,494,200
Solar Turbines Mars 90	9,450 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$6,142,500 - $8,505,000
GE Power Systems, Oil & Gas PGT10	10,220 kW	Natural Gas	$6,643,000 - $9,198,000
Turbomach Industrial Energy Systems TBM-M100	10,681 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$6,942,650 - $9,612,900
Solar Turbines Mars 100	10,690 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$6,948,500 - $9,621,000
GE Power Systems, Oil & Gas GE10	11,250 kW	Natural Gas, Distillate Oil, Liquid Fuel, Biogas	$7,312,500 - $10,125,000
GE Power Systems, Aero Energy GE10 (DLN)	11,300 kW	Natural Gas	$7,345,000 - $10,170,000
Mitsubishi Heavy Industries MF-111A Fuel Oil	12,220 kW	Fuel Oil, Liquid Fuel	$7,943,000 - $10,998,000
Mitsubishi Heavy Industries MF-111A Natural Gas	12,610 kW	Natural Gas	$8,196,500 - $11,349,000
Alstom Cyclone	12,900 kW	Natural Gas, Liquid Fuel	$8,385,000 - $11,610,000
[illegible]	13,500 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$8,775,000 - $12,150,000

GE Power Systems, Aero Energy LM1600PA	13,615 kW	Natural Gas	$8,849,750 - $12,253,500
GE Power Systems, Oil & Gas PGT16	13,735 kW	Natural Gas	$8,927,750 - $12,361,500
Turbomach Industrial Energy Systems TBM-T130	14,000 kW	Natural Gas, Diesel Oil, Landfill Gas, Propane, Naphtha, LPG, LNG, Refinery Gas, Liquid Fuel, Alternative Gas	$9,100,000 - $12,600,000
Mitsubishi Heavy Industries MF-111B Fuel Oil	14,210 kW	Fuel Oil, Liquid Fuel	$9,236,500 - $12,789,000
Mitsubishi Heavy Industries MF-111B Natural Gas	14,570 kW	Natural Gas	$9,470,500 - $13,113,000
Alstom GT35	17,000 kW	Natural Gas, Liquid Fuel	$11,050,000 - $15,300,000
GE Power Systems, Aero Energy LM2000PE	17,650 kW	Natural Gas	$11,472,500 - $15,885,000
GE Power Systems, Aero Energy LM2500PE	22,400 kW	Natural Gas	$14,560,000 - $20,160,000
GE Power Systems, Oil & Gas PGT25	22,417 kW	Natural Gas	$14,571,050 - $20,175,300
Alstom GT10B	24,770 kW	Natural Gas, Liquid Fuel	$16,100,500 - $22,293,000
GE Power Systems, Aero Energy LM2500PH	26,725 kW	Natural Gas	$17,371,250 - $24,052,500
Mitsubishi Heavy Industries MFT-8	26,780 kW	Natural Gas	$17,407,000 - $24,102,000
GE Power Systems, Oil & Gas MS5001	26,830 kW	Natural Gas	$17,439,500 - $24,147,000
Ishikawajima-Harima Heavy Industries LM2500 Plus	27,000 kW	Natural Gas	$17,550,000 - $24,300,000
Alstom GT10C	29,100 kW	Natural Gas, Liquid Fuel	$18,915,000 - $26,190,000
GE Power Systems, Aero Energy LM2500PK	29,250 kW	Natural Gas	$19,012,500 - $26,325,000

Product	Rated Output	Fuel Source	Installed Cost (est.)
Honda Power Equipment EM5000SXK1	4.5 kW	Gasoline, Liquid Fuel	$2,700 - $5,400
Honda Power Equipment EX5500K2	5 kW	Gasoline, Liquid Fuel	$3,000 - $6,000
Cummins DNAC 50 Hz	5.4 kW	Diesel, Liquid Fuel	$2,700 - $5,400
Honda Power Equipment EB6500SX	5.5 kW	Gasoline, Liquid Fuel	$3,300 - $6,600
Honda Power Equipment ES6500K2	6 kW	Gasoline, Liquid Fuel	$3,600 - $7,200
Generac SD008 with 1.0DN Engine	6.4 kW	Diesel, Liquid Fuel	$3,200 - $6,400
Cummins DNAC 60 Hz	6.8 kW	Diesel, Liquid Fuel	$3,400 - $6,800
Cummins DNAD 50 Hz	8.1 kW	Diesel, Liquid Fuel	$4,050 - $8,100
Generac SD010 with 3.0DN Engine	8.2 kW	Diesel, Liquid Fuel	$4,100 - $8,200
Honda Power Equipment EB11000	9.5 kW	Gasoline, Liquid Fuel	$5,700 - $11,400
Cummins DNAD 60 Hz	10.4 kW	Diesel, Liquid Fuel	$5,200 - $10,400
Deutz F2M 1008	10.7 kW	Diesel, Liquid Fuel	$5,350 - $10,700
Broadcrown BCY13P 50 Hz	10.8 kW	Diesel, Liquid Fuel	$5,400 - $10,800
Cummins DKAC 50 Hz	11 kW	Diesel, Liquid Fuel	$5,500 - $11,000
Cummins DNAE 50 Hz	11.3 kW	Diesel, Liquid Fuel	$5,650 - $11,300
Generac SD015 with 3.0DN Engine	11.8 kW	Diesel, Liquid Fuel	$5,900 - $11,800
Broadcrown BCY13P 60 Hz	13.3 kW	Diesel, Liquid Fuel	$6,650 - $13,300
[illegible]	13.5 kW	Diesel, Liquid Fuel	$6,750 - $13,500

Cummins DNAE 60 Hz	14.4 kW	Diesel, Liquid Fuel	$7,200 - $14,400
Cummins DKAE 50 Hz	14.5 kW	Diesel, Liquid Fuel	$7,250 - $14,500
Cummins DNAF 50 Hz	15 kW	Diesel, Liquid Fuel	$7,500 - $15,000
Deutz F3M 1008	15 kW	Diesel, Liquid Fuel	$7,500 - $15,000
Broadcrown BCY20P 50 Hz	16.2 kW	Diesel, Liquid Fuel	$8,100 - $16,200
Generac SD020 with 3.0DN Engine	16.4 kW	Diesel, Liquid Fuel	$8,200 - $16,400
Broadcrown BCY22P 50 Hz	17.6 kW	Diesel, Liquid Fuel	$8,800 - $17,600
Broadcrown BCJD22P 50 Hz	18 kW	Diesel, Liquid Fuel	$9,000 - $18,000
Cummins DKAE 60 Hz	18 kW	Diesel, Liquid Fuel	$9,000 - $18,000
Cummins DKAF 50 Hz	18 kW	Diesel, Liquid Fuel	$9,000 - $18,000
Cummins DNAF 60 Hz	18 kW	Diesel, Liquid Fuel	$9,000 - $18,000
Broadcrown BCY20P 60 Hz	19.4 kW	Diesel, Liquid Fuel	$9,700 - $19,400
Deutz [illegible] 1011 F	20 kW	Diesel, Liquid Fuel	$10,000 - $20,000
Deutz [illegible] 1008	20 kW	Diesel, Liquid Fuel	$10,000 - $20,000
Generac SD025 with 3.0DN Engine	20.5 kW	Diesel, Liquid Fuel	$10,250 - $20,500
Broadcrown BCJD22P 60 Hz	22 kW	Diesel, Liquid Fuel	$11,000 - $22,000
Broadcrown BCJD28P 50 Hz	22 kW	Diesel, Liquid Fuel	$11,000 - $22,000
Broadcrown BCY22P 60 Hz	22 kW	Diesel, Liquid Fuel	$11,000 - $22,000
Cummins DKAF 60 Hz	23 kW	Diesel, Liquid Fuel	$11,500 - $23,000
Broadcrown BCJD30S 50 Hz	24 kW	Diesel, Liquid Fuel	$12,000 - $24,000
Cummins DGBB 50 Hz	25 kW	Diesel, Liquid Fuel	$12,500 - $25,000

Cummins DGGD 50 Hz	25 kW	Diesel, Liquid Fuel	$12,500 - $25,000
Generac SD030 with 3.0DT Engine	25 kW	Diesel, Liquid Fuel	$12,500 - $25,000
Deutz BF4M 1008	25.9 kW	Diesel, Liquid Fuel	$12,950 - $25,900
Broadcrown BCJD28P 60 Hz	26 kW	Diesel, Liquid Fuel	$13,000 - $26,000
Broadcrown BCJD30S 60 Hz	28 kW	Diesel, Liquid Fuel	$14,000 - $28,000
Generac SD035 with 3.0DT Engine	28.5 kW	Diesel, Liquid Fuel	$14,250 - $28,500
Cummins DGBC 50 Hz	29 kW	Diesel, Liquid Fuel	$14,500 - $29,000
Cummins DGHD 50 Hz	29 kW	Diesel, Liquid Fuel	$14,500 - $29,000
Deutz F3L912 E	29 kW	Diesel, Liquid Fuel	$14,500 - $29,000
Cummins DGGD 60 Hz	30 kW	Diesel, Liquid Fuel	$15,000 - $30,000
Deutz F3L 1011 F	30 kW	Diesel, Liquid Fuel	$15,000 - $30,000
Broadcrown BCJD40P 50 Hz	32 kW	Diesel, Liquid Fuel	$16,000 - $32,000
Cummins DGBB [illegible] Hz	32 kW	Diesel, Liquid Fuel	$16,000 - $32,000
Deutz F3M [illegible] F	32 kW	Diesel, Liquid Fuel	$16,000 - $32,000
Generac SD040 with 3.3DTA Engine	32 kW	Diesel, Liquid Fuel	$16,000 - $32,000
Generac SD040 with 4.8DT Engine	32 kW	Diesel, Liquid Fuel	$16,000 - $32,000
Broadcrown BCJD44S 50 Hz	35 kW	Diesel, Liquid Fuel	$17,500 - $35,000
Cummins DGBC 60 Hz	35 kW	Diesel, Liquid Fuel	$17,500 - $35,000
Cummins DGCA [illegible] Hz	36 kW	Diesel, Liquid Fuel	$18,000 - $36,000
[illegible]	36 kW	Diesel, Liquid Fuel.	$18,000 - $36,000
[illegible]	37 kW	Diesel, Liquid	$18,500 - $37,000

BCJD40P 60 Hz		Fuel	
Deutz F4L912 E	39 kW	Diesel, Liquid Fuel	$19,500 - $39,000
Cummins DGHE 50 Hz	40 kW	Diesel, Liquid Fuel	$20,000 - $40,000
Deutz F4L 1011 F	40 kW	Diesel, Liquid Fuel	$20,000 - $40,000
Generac SD050 with 3.3 DTA Engine	40 kW	Diesel, Liquid Fuel	$20,000 - $40,000
Generac SD050 with 4.8DT Engine	40 kW	Diesel, Liquid Fuel	$20,000 - $40,000
Deutz BF4M 1011 F	41.4 kW	Diesel, Liquid Fuel	$20,700 - $41,400
Broadcrown BCJD44S 60 Hz	42 kW	Diesel, Liquid Fuel	$21,000 - $42,000
Deutz F4M 1011 F	43.8 kW	Diesel, Liquid Fuel	$21,900 - $43,800
Cummins DGCA 60 Hz	45 kW	Diesel, Liquid Fuel	$22,500 - $45,000
Cummins DGCB 50 Hz	45 kW	Diesel, Liquid Fuel	$22,500 - $45,000
Cummins DGHE 60 Hz	45 kW	Diesel, Liquid Fuel	$22,500 - $45,000
Broadcrown BCJD60P 50 Hz	48 kW	Diesel, Liquid Fuel	$24,000 - $48,000
Deutz BF4L 1011 F	48 kW	Diesel, Liquid Fuel	$24,000 - $48,000
Generac SD060 with 3.9DTA Engine	48 kW	Diesel, Liquid Fuel	$24,000 - $48,000
Generac SD060 with 4.8DT Engine	48 kW	Diesel, Liquid Fuel	$24,000 - $48,000
Deutz BF4 M 1012 E	54 kW	Diesel, Liquid Fuel	$27,000 - $54,000
Cummins DGCB 60 Hz	55 kW	Diesel, Liquid Fuel	$27,500 - $55,000
Broadcrown BCJD60P 60 Hz	56 kW	Diesel, Liquid Fuel	$28,000 - $56,000
Broadcrown BCJD70S 50 Hz	56 kW	Diesel, Liquid Fuel	$28,000 - $56,000
Cummins DGDA 50 Hz	60 kW	Diesel, Liquid Fuel	$30,000 - $60,000

Deutz F6L912 E	60 kW	Diesel, Liquid Fuel	$30,000 - $60,000
Broadcrown BCJD80P 50 Hz	64 kW	Diesel, Liquid Fuel	$32,000 - $64,000
Generac SD080 with 3.9DTA Engine	64 kW	Diesel, Liquid Fuel	$32,000 - $64,000
Generac SD080 with 4.8DTA Engine	64 kW	Diesel, Liquid Fuel	$32,000 - $64,000
Broadcrown BCJD70S 60 Hz	66 kW	Diesel, Liquid Fuel	$33,000 - $66,000
Deutz BF4 M 1012 EC	67 kW	Diesel, Liquid Fuel	$33.500 - $67,000
Broadcrown BCJD80P 60 Hz	72 kW	Diesel, Liquid Fuel	$36,000 - $72,000
Broadcrown BCJD90S 50 Hz	72 kW	Diesel, Liquid Fuel	$36.000 - $72,000
Cummins DGDA 60 Hz	72 kW	Diesel, Liquid Fuel	$36,000 - $72,000
Broadcrown BCJD100P 50 Hz	80 kW	Diesel, Liquid Fuel	$40,000 - $80,000
Broadcrown BCJD90S 60 Hz	80 kW	Diesel, Liquid Fuel	$40,000 - $80,000
Cummins DGDB 50 Hz	80 kW	Diesel, Liquid Fuel	$40.000 - $80,000
Generac SD100 with 3.9DTA Engine	80 kW	Diesel, Liquid Fuel	$40.000 - $80,000
Generac SD100 with 4.8DTA Engine	80 kW	Diesel, Liquid Fuel	$40.000 - $80,000
Deutz BF4 M 1013 E	81 kW	Diesel, Liquid Fuel	$40,500 - $81,000
Broadcrown BCJD110S 50 Hz	88 kW	Diesel, Liquid Fuel	$44.000 - $88,000
Cummins DGDB 60 Hz	90 kW	Diesel, Liquid Fuel	$45.000 - $90,000
Cummins DGDK 50 Hz	90 kW	Diesel, Liquid Fuel	$45,000 - $90,000
Broadcrown BCJD100P 60 Hz	92 kW	Diesel, Liquid Fuel	$46.000 - $92,000
Broadcrown BCJD120P 50 Hz	96 kW	Diesel, Liquid Fuel	$48.000 - $96,000
Broadcrown	100 kW	Diesel, Liquid	$50.000 - $100.000

BCJD110S 60 Hz		Fuel	
Deutz BF4 M 1013 EC	100 kW	Diesel, Liquid Fuel	$50,000 - $100,000
Broadcrown BCJD120P 60 Hz	104 kW	Diesel, Liquid Fuel	$52,000 - $104,000
Broadcrown BCJD130S 50 Hz	104 kW	Diesel, Liquid Fuel	$52,000 - $104,000
Generac SD130 with 7 5DMTA Engine	105 kW	Diesel, Liquid Fuel	$52,500 - $105,000
Deutz BF6L913	106 kW	Diesel, Liquid Fuel	$53,000 - $106,000
Broadcrown BCJD140P 50 Hz	112 kW	Diesel, Liquid Fuel	$56,000 - $112,000
Cummins DGDK 60 Hz	113 kW	Diesel, Liquid Fuel	$56,500 - $113,000
Broadcrown BCJD150P 50 Hz	120 kW	Diesel, Liquid Fuel	$60,000 - $120,000
Broadcrown BCJD150S 50 Hz	120 kW	Diesel, Liquid Fuel	$60,000 - $120,000
Deutz BF6M 1013 E	122 kW	Diesel, Liquid Fuel	$61,000 - $122,000
Generac SD150 with 7 5DMTA Engine	123 kW	Diesel, Liquid Fuel	$61,500 - $123,000
Broadcrown BCJD130S 60 Hz	125 kW	Diesel, Liquid Fuel	$62,500 - $125,000
Cummins [illegible] 60 Hz	125 kW	Diesel, Liquid Fuel	$62,500 - $125,000
Broadcrown [illegible] 50 Hz	132 kW	Diesel, Liquid Fuel	$66,000 - $132,000
Cummins DGFA 60 Hz	135 kW	Diesel, Liquid Fuel	$67,500 - $135,000
Cummins DGFB 50 Hz	135 kW	Diesel, Liquid Fuel	$67,500 - $135,000
Deutz BF6L913 C	137 kW	Diesel, Liquid Fuel	$68,500 - $137,000
Broadcrown BCJD180P 50 Hz	140 kW	Diesel, Liquid Fuel	$70,000 - $140,000
Generac SD180 with 7 5DMTA Engine	147 kW	Diesel, Liquid Fuel	$73,500 - $147,000
Generac SD180with 13 3DT Engine	147 kW	Diesel, Liquid Fuel	$73,500 - $147,000

Deutz BF6M 1013 EC	148 kW	Diesel, Liquid Fuel	$74,000 - $148,000
Broadcrown BCJD165S 60 Hz	150 kW	Diesel, Liquid Fuel	$75,000 - $150,000
Broadcrown BCJD200P 50 Hz	160 kW	Diesel, Liquid Fuel	$80,000 - $160,000
Cummins DGFB 60 Hz	160 kW	Diesel, Liquid Fuel	$80,000 - $160,000
Cummins DGFC 50 Hz	160 kW	Diesel, Liquid Fuel	$80,000 - $160,000
Generac SD200 with 13.3DT Engine	163 kW	Diesel, Liquid Fuel	$81,500 - $163,000
Generac SD200 with 7.5DMTA Engine	163 kW	Diesel, Liquid Fuel	$81,500 - $163,000
Broadcrown BCJD220S 50 Hz	176 kW	Diesel, Liquid Fuel	$88,000 - $176,000
Cummins DFAB 50 Hz	180 kW	Diesel, Liquid Fuel	$90,000 - $180,000
Cummins DGFC 60 Hz	180 kW	Diesel, Liquid Fuel	$90,000 - $180,000
Broadcrown BCJD200P 60 Hz	184 kW	Diesel, Liquid Fuel	$92,000 - $184,000
Broadcrown BCJD230P 50 Hz	184 kW	Diesel, Liquid Fuel	$92,000 - $184,000
Generac SD230 with 12.0DTA Engine	185 kW	Diesel, Liquid Fuel	$92,500 - $185,000
Generac SD230 with 12.7DTA Engine	185 kW	Diesel, Liquid Fuel	$92,500 - $185,000
Broadcrown BCJD250P 60 Hz	192 kW	Diesel, Liquid Fuel	$96,000 - $192,000
Broadcrown BCJD220S 60 Hz	200 kW	Diesel, Liquid Fuel	$100,000 - $200,000
Broadcrown BCJD250P 50 Hz	200 kW	Diesel, Liquid Fuel	$100,000 - $200,000
Cummins DFAC 50 Hz	200 kW	Diesel, Liquid Fuel	$100,000 - $200,000
Cummins DOAD 50 Hz	200 kW	Diesel, Liquid Fuel	$100,000 - $200,000
Generac [illegible] with 12.0DTA Engine	205 kW	Diesel, Liquid Fuel	$102,500 - $205,000

Generac SD250 with 12.7DTA Engine	205 kW	Diesel, Liquid Fuel	$102,500 - $205,000
Broadcrown BCJD260S 50 Hz	208 kW	Diesel, Liquid Fuel	$104,000 - $208,000
Cummins DFAB 60 Hz	210 kW	Diesel, Liquid Fuel	$105,000 - $210,000
Deutz BF6M 1015	211 kW	Diesel, Liquid Fuel	$105,500 - $211,000
Broadcrown BCJD275S 50 Hz	220 kW	Diesel, Liquid Fuel	$110,000 - $220,000
Cummins DQAD 60 Hz	220 kW	Diesel, Liquid Fuel	$110,000 - $220,000
Broadcrown BCJD275S 60 Hz	225 kW	Diesel, Liquid Fuel	$112,500 - $225,000
Cummins DFAC 60 Hz	225 kW	Diesel, Liquid Fuel	$112,500 - $225,000
Cummins DFBF 50 Hz	227 kW	Diesel, Liquid Fuel	$113,500 - $227,000
Cummins DQAE 50 Hz	227 kW	Diesel, Liquid Fuel	$113,500 - $227,000
Generac SD275 with 12.0DTA Engine	233 kW	Diesel, Liquid Fuel	$116,500 - $233,000
Generac SD275 with 12.7 DTA Engine	233 kW	Diesel, Liquid Fuel	$116,500 - $233,000
Generac SD300 with 12.0DTA Engine	245 kW	Diesel, Liquid Fuel	$122,500 - $245,000
Generac SD300 with 12.7DTA Engine	245 kW	Diesel, Liquid Fuel	$122,500 - $245,000
Cummins DFBF 60 Hz	250 kW	Diesel, Liquid Fuel	$125,000 - $250,000
Cummins DQAE 60 Hz	250 kW	Diesel, Liquid Fuel	$125,000 - $250,000
Cummins DQAF 50 Hz	250 kW	Diesel, Liquid Fuel	$125,000 - $250,000
Broadcrown BCD315P 50 Hz	252 kW	Diesel, Liquid Fuel	$126,000 - $252,000
Deutz BF8M 1015	255 kW	Diesel, Liquid Fuel	$127,500 - $255,000
Generac SD350 with 12.7DTA	260 kW	Diesel, Liquid Fuel	$130,000 - $260,000

Engine			
Generac SD350 with 14.0DTA Engine	260 kW	Diesel, Liquid Fuel	$130,000 - $260,000
Generac SD350 with 16.0DTA Engine	260 kW	Diesel, Liquid Fuel	$130,000 - $260,000
Cummins DQAF 60 Hz	270 kW	Diesel, Liquid Fuel	$135,000 - $270,000
Deutz BF6M 1015C	271 kW	Diesel, Liquid Fuel	$135,500 - $271,000
Broadcrown BCD345S 50 Hz	276 kW	Diesel, Liquid Fuel	$138,000 - $276,000
Broadcrown BCD315P 60 Hz	280 kW	Diesel, Liquid Fuel	$140,000 - $280,000
Broadcrown BCD350P 50 Hz	280 kW	Diesel, Liquid Fuel	$140,000 - $280,000
Cummins DFCC 50 Hz	282 kW	Diesel, Liquid Fuel	$141,000 - $282,000
Generac SD400 with 14.0DTA Engine	300 kW	Diesel, Liquid Fuel	$150,000 - $300,000
Generac SD400 with 16.0DTA Engine	300 kW	Diesel, Liquid Fuel	$150,000 - $300,000
Broadcrown BCD345S 60 Hz	304 kW	Diesel, Liquid Fuel	$152,000 - $304,000
Broadcrown BCD350S 50 Hz	304 kW	Diesel, Liquid Fuel	$152,000 - $304,000
Cummins DFCC 60 Hz	315 kW	Diesel, Liquid Fuel	$157,500 - $315,000
Cummins DFEG 60 Hz	320 kW	Diesel, Liquid Fuel	$160,000 - $320,000
Deutz BF6M 1015CP	320 kW	Diesel, Liquid Fuel	$160,000 - $320,000
Detroit Diesel R1637K05-G50	330 kW	Diesel, Liquid Fuel	$165,000 - $330,000
Broadcrown BCD430P 50 Hz	344 kW	Diesel, Liquid Fuel	$172,000 - $344,000
Cummins DFEH 60 Hz	350 kW	Diesel, Liquid Fuel	$175,000 - $350,000
Cummins DFEH 50 Hz	352 kW	Diesel, Liquid Fuel	$176,000 - $352,000
Generac SD450 with 16.0DTA	360 kW	Diesel, Liquid Fuel	$180,000 - $360,000

Engine			
Deutz BF8M 1015C	362 kW	Diesel, Liquid Fuel	$181,000 - $362,000
Detroit Diesel R0837K08-G60	365 kW	Diesel, Liquid Fuel	$182,500 - $365,000
Detroit Diesel R0837K38-G60	365 kW	Diesel, Liquid Fuel	$182,500 - $365,000
Broadcrown BCD430P 60 Hz	372 kW	Diesel, Liquid Fuel	$186,000 - $372,000
Broadcrown BCD475 50 Hz	380 kW	Diesel, Liquid Fuel	$190,000 - $380,000
Broadcrown BCD500P 50 Hz	400 kW	Diesel, Liquid Fuel	$200,000 - $400,000
Cummins DFCE 60 Hz	400 kW	Diesel, Liquid Fuel	$200,000 - $400,000
Cummins DFEJ 50 Hz	400 kW	Diesel, Liquid Fuel	$200,000 - $400,000
Cummins DFEK 50 Hz	400 kW	Diesel, Liquid Fuel	$200,000 - $400,000
Generac SD500 with 16.0DTA Engine	400 kW	Diesel, Liquid Fuel	$200,000 - $400,000
Broadcrown BCD475 60 Hz	408 kW	Diesel, Liquid Fuel	$204,000 - $408,000
Cummins DFEJ 60 Hz	410 kW	Diesel, Liquid Fuel	$205,000 - $410,000
Detroit Diesel R0837K16-G81	410 kW	Diesel, Liquid Fuel	$205,000 - $410,000
Generac SD500 with 18.0DTA Engine	416 kW	Diesel, Liquid Fuel	$208,000 - $416,000
Deutz BF8M 1015CP	426 kW	Diesel, Liquid Fuel	$213,000 - $426,000
Broadcrown BCD500P 60 Hz	428 kW	Diesel, Liquid Fuel	$214,000 - $428,000
Deutz TBD 616 V8	432 kW	Diesel, Liquid Fuel	$216,000 - $432,000
Broadcrown BCD55LS 50 Hz	440 kW	Diesel, Liquid Fuel	$220,000 - $440,000
Broadcrown BCD550P	442 kW	Diesel, Liquid Fuel	$221,000 - $442,000
Cummins DFEK 60 Hz	455 kW	Diesel, Liquid Fuel	$227,500 - $455,000
Detroit Diesel	455 kW	Diesel, Liquid	$227,500 - $455,000

R0837K35-G70		Fuel	
Detroit Diesel R0837K36-G80	465 kW	Diesel, Liquid Fuel	$232,500 - $465,000
Broadcrown BCD550S 60 Hz	468 kW	Diesel, Liquid Fuel	$234,000 - $468,000
Broadcrown BCP600P	480 kW	Diesel, Liquid Fuel	$240,000 - $480,000
Detroit Diesel R1237K05-G50	489 kW	Diesel, Liquid Fuel	$244,500 - $489,000
Broadcrown BCC625S	500 kW	Diesel, Liquid Fuel	$250,000 - $500,000
Cummins DFGB 50 Hz	500 kW	Diesel, Liquid Fuel	$250,000 - $500,000
Broadcrown BCC630P	506 kW	Diesel, Liquid Fuel	$253,000 - $506,000
Broadcrown BCP650P	520 kW	Diesel, Liquid Fuel	$260,000 - $520,000
Broadcrown BCC670S	536 kW	Diesel, Liquid Fuel	$268,000 - $536,000
Broadcrown BCP670S	536 kW	Diesel, Liquid Fuel	$268,000 - $536,000
Broadcrown BCC650P	540 kW	Diesel, Liquid Fuel	$270,000 - $540,000
Cummins DFGB 60 Hz	545 kW	Diesel, Liquid Fuel	$272,500 - $545,000
Detroit Diesel R1237K08-G60	545 kW	Diesel, Liquid Fuel	$272,500 - $545,000
Detroit Diesel R1237K[illegible]8-G60	545 kW	Diesel, Liquid Fuel	$272,500 - $545,000
Generac SD600 with 22.0DTA Engine	547 kW	Diesel, Liquid Fuel	$273,500 - $547,000
Cummins DFHA 50 Hz	560 kW	Diesel, Liquid Fuel	$280,000 - $560,000
Detroit Diesel R0837K36-G81	571 kW	Diesel, Liquid Fuel	$285,500 - $571,000
Broadcrown BCP700S	572 kW	Diesel, Liquid Fuel	$286,000 - $572,000
Broadcrown BCP720P	576 kW	Diesel, Liquid Fuel	$288,000 - $576,000
Broadcrown [illegible]S	600 kW	Diesel, Liquid Fuel	$300,000 - $600,000
Generac [illegible] 24.0DTA	600 kW	Diesel, Liquid Fuel	$300,000 - $600,000

Engine			
Detroit Diesel R1237K35-G70	614 kW	Diesel, Liquid Fuel	$307,000 - $614,000
Detroit Diesel R1237K06-G21	619 kW	Diesel, Liquid Fuel	$309,500 - $619,000
Broadcrown BCC800P	638 kW	Diesel, Liquid Fuel	$319,000 - $638,000
Broadcrown BCP800P	640 kW	Diesel, Liquid Fuel	$320,000 - $640,000
Broadcrown BCP800S	640 kW	Diesel, Liquid Fuel	$320,000 - $640,000
Cummins DFHB 50 Hz	640 kW	Diesel, Liquid Fuel	$320,000 - $640,000
Deutz TBD 616 V12	648 kW	Diesel, Liquid Fuel	$324,000 - $648,000
Detroit Diesel R1637K05-G50	668 kW	Diesel, Liquid Fuel	$334,000 - $668,000
Cummins DFHA 60 Hz	680 kW	Diesel, Liquid Fuel	$340,000 - $680,000
Broadcrown BCC880S	703 kW	Diesel, Liquid Fuel	$351,500 - $703,000
Broadcrown BCP880S	704 kW	Diesel, Liquid Fuel	$352,000 - $704,000
Detroit Diesel R1637K08-G60	720 kW	Diesel, Liquid Fuel	$360,000 - $720,000
Detroit Diesel R1637K38-G80	720 kW	Diesel, Liquid Fuel	$360,000 - $720,000
Cummins DFHB 60 Hz	725 kW	Diesel, Liquid Fuel	$362,500 - $725,000
Cummins DFHC 50 Hz	725 kW	Diesel, Liquid Fuel	$362,500 - $725,000
Broadcrown BCP900P	728 kW	Diesel, Liquid Fuel	$364,000 - $728,000
Broadcrown BCC900P	729 kW	Diesel, Liquid Fuel	$364,500 - $729,000
Broadcrown BCC1000P	800 kW	Diesel, Liquid Fuel	$400,000 - $800,000
Broadcrown BCC1000S	800 kW	Diesel, Liquid Fuel	$400,000 - $800,000
Broadcrown BCC1010P	800 kW	Diesel, Liquid Fuel	$400,000 - $800,000
Broadcrown BCP1000P	800 kW	Diesel, Liquid Fuel	$400,000 - $800,000
Broadcrown	800 kW	Diesel, Liquid	$400,000 - $800,000

BCP1000S		Fuel	
Cummins DFDG 50 Hz	800 kW	Diesel, Liquid Fuel	$400,000 - $800,000
Generac SD1000 with 32.0DTA Engine	800 kW	Diesel, Liquid Fuel	$400,000 - $800,000
Detroit Diesel R1637K35-G70	810 kW	Diesel, Liquid Fuel	$405,000 - $810,000
Detroit Diesel R1637K06-G61	814 kW	Diesel, Liquid Fuel	$407,000 - $814,000
Cummins DFHC 60 Hz	818 kW	Diesel, Liquid Fuel	$409,000 - $818,000
Detroit Diesel R1237K36-G81	836 kW	Diesel, Liquid Fuel	$418,000 - $836,000
Deutz TBD 616 V16	864 kW	Diesel, Liquid Fuel	$432,000 - $864,000
Broadcrown BCC1100P	880 kW	Diesel, Liquid Fuel	$440,000 - $880,000
Broadcrown BCC1100S	880 kW	Diesel, Liquid Fuel	$440,000 - $880,000
Broadcrown BCP1100S	888 kW	Diesel, Liquid Fuel	$444,000 - $888,000
Generac SD800 with 33.9DTA Engine	890 kW	Diesel, Liquid Fuel	$445,000 - $890,000
Broadcrown BCC1125S	900 kW	Diesel, Liquid Fuel	$450,000 - $900,000
Cummins DFHD 60 Hz	900 kW	Diesel, Liquid Fuel	$450,000 - $900,000
Cummins DFLE 60 Hz	900 kW	Diesel, Liquid Fuel	$450,000 - $900,000
Broadcrown BCC1130S	905 kW	Diesel, Liquid Fuel	$452,500 - $905,000
Broadcrown BCC1020F	915 kW	Diesel, Liquid Fuel	$457,500 - $915,000
Detroit Diesel R1637K36-G80	915 kW	Diesel, Liquid Fuel	$457,500 - $915,000
Deutz TBD 620 V8	960 kW	Diesel, Liquid Fuel	$480,000 - $960,000
Broadcrown BCC1250S	1,000 kW	Diesel, Liquid Fuel	$500,000 - $1,000,000
Cummins DFLC 50 Hz	1,000 kW	Diesel, Liquid Fuel	$500,000 - $1,000,000
Generac	1,000 kW	Diesel, Liquid	$500,000 - $1,000,000

SD1250 with 49.0DTA Engine		Fuel	
Broadcrown BCP1250P	1,016 kW	Diesel, Liquid Fuel	$508,000 - $1,016,000
Broadcrown BCC1250P	1,021 kW	Diesel, Liquid Fuel	$510,500 - $1,021,000
Cummins DFMB 50 Hz	1,070 kW	Diesel, Liquid Fuel	$535,000 - $1,070,000
Detroit Diesel T1237K38-G21	1,070 kW	Diesel, Liquid Fuel	$535,000 - $1,070,000
Broadcrown BCP1350P	1,080 kW	Diesel, Liquid Fuel	$540,000 - $1,080,000
Cummins DFEC 60 Hz	1,100 kW	Diesel, Liquid Fuel	$550,000 - $1,100,000
Cummins DFLE 50 Hz	1,100 kW	Diesel, Liquid Fuel	$550,000 - $1,100,000
Detroit Diesel R1637K36-G81	1,115 kW	Diesel, Liquid Fuel	$557,500 - $1,115,000
Broadcrown BCP1400S	1,122 kW	Diesel, Liquid Fuel	$561,000 - $1,122,000
Broadcrown BCC1400P	1,132 kW	Diesel, Liquid Fuel	$566,000 - $1,132,000
Broadcrown BCC1430S	1,150 kW	Diesel, Liquid Fuel	$575,000 - $1,150,000
Broadcrown BCP1500S	1,188 kW	Diesel, Liquid Fuel	$594,000 - $1,188,000
Broadcrown BCC1500P	1,200 kW	Diesel, Liquid Fuel	$600,000 - $1,200,000
Broadcrown BCP1500P	1,200 kW	Diesel, Liquid Fuel	$600,000 - $1,200,000
[illegible] SD1500 with 49.0DTA Engine	1,200 kW	Diesel, Liquid Fuel	$600,000 - $1,200,000
Cummins DFLE 60 Hz	1,250 kW	Diesel, Liquid Fuel	$625,000 - $1,250,000
Cummins DFMB 60 Hz	1,250 kW	Diesel, Liquid Fuel	$625,000 - $1,250,000
Detroit Diesel T1237K36-G41	1,255 kW	Diesel, Liquid Fuel	$627,500 - $1,255,000
Broadcrown BCC1600P	1,287 kW	Diesel, Liquid Fuel	$643,500 - $1,287,000
Broadcrown BCC1600S	1,288 kW	Diesel, Liquid Fuel	$644,000 - $1,288,000
Broadcrown	1,326 kW	Diesel, Liquid	$663,000 - $1,326,000

BCP1650S		Fuel	
Detroit Diesel T1237K38-G60	1,330 kW	Diesel, Liquid Fuel	$665,000 - $1,330,000
Broadcrown BCC1670	1,341 kW	Diesel, Liquid Fuel	$670,500 - $1,341,000
Cummins DQKB 50 Hz	1,350 kW	Diesel, Liquid Fuel	$675,000 - $1,350,000
Deutz BV6M 628	1,350 kW	Diesel, Liquid Fuel	$675,000 - $1,350,000
Broadcrown BCC1700P	1,368 kW	Diesel, Liquid Fuel	$684,000 - $1,368,000
Broadcrown BCP1750P	1,400 kW	Diesel, Liquid Fuel	$700,000 - $1,400,000
Generac SD1750 with 65.0DTA Engine	1,400 kW	Diesel, Liquid Fuel	$700,000 - $1,400,000
Broadcrown BCP1800P	1,440 kW	Diesel, Liquid Fuel	$720,000 - $1,440,000
Deutz TBD 620 V12	1,440 kW	Diesel, Liquid Fuel	$720,000 - $1,440,000
Detroit Diesel T1237K36-G60	1,490 kW	Diesel, Liquid Fuel	$745,000 - $1,490,000
Broadcrown BCC1850P	1,500 kW	Diesel, Liquid Fuel	$750,000 - $1,500,000
Broadcrown BCC1875S	1,500 kW	Diesel, Liquid Fuel	$750,000 - $1,500,000
Cummins DQKC 50 Hz	1,500 kW	Diesel, Liquid Fuel	$750,000 - $1,500,000
Detroit Diesel T1637K38-G21	1,533 kW	Diesel, Liquid Fuel	$766,500 - $1,533,000
Broadcrown BCC1920S	1,536 kW	Diesel, Liquid Fuel	$768,000 - $1,536,000
Broadcrown [illegible]	1,543 kW	Diesel, Liquid Fuel	$771,500 - $1,543,000
Broadcrown BCC1950P	1,597 kW	Diesel, Liquid Fuel	$798,500 - $1,597,000
Broadcrown BCC2000P	1,600 kW	Diesel, Liquid Fuel	$800,000 - $1,600,000
Broadcrown BCP2000S	1,600 kW	Diesel, Liquid Fuel	$800,000 - $1,600,000
Cummins [illegible]QKB [illegible] Hz	1,600 kW	Diesel, Liquid Fuel	$800,000 - $1,600,000
Generac [illegible] with 65.0DTA	1,600 kW	Diesel, Liquid Fuel	$800,000 - $1,600,000

Engine			
Broadcrown BCP2000P	1,640 kW	Diesel, Liquid Fuel	$820,000 - $1,640.000
Detroit Diesel T1637K36-G41	1,730 kW	Diesel, Liquid Fuel	$865,000 - $1,730.000
Detroit Diesel T1637K38-G60	1,760 kW	Diesel, Liquid Fuel	$880,000 - $1,760.000
Broadcrown BCC2200S	1,765 kW	Diesel, Liquid Fuel	$882,500 - $1,765.000
Broadcrown BCC2250S	1,800 kW	Diesel, Liquid Fuel	$900,000 - $1,800.000
Broadcrown BCP2250S	1,800 kW	Diesel, Liquid Fuel	$900,000 - $1,800.000
Deutz BV8M 628	1,800 kW	Diesel, Liquid Fuel	$900,000 - $1,800.000
Broadcrown BCC2250P	1,825 kW	Diesel, Liquid Fuel	$912,500 - $1,825.000
Cummins DQKC 60 Hz	1,825 kW	Diesel, Liquid Fuel	$912,500 - $1,825.000
Deutz TBD 620 V16	1,920 kW	Diesel, Liquid Fuel	$960,000 - $1,920.000
Detroit Diesel T1637K38-G80	1,990 kW	Diesel, Liquid Fuel	$995,000 - $1,990.000
Broadcrown BCC2500S	2,000 kW	Diesel, Liquid Fuel	$1,000,000 - $2,000.000
Deutz BV9M 628	2,025 kW	Diesel, Liquid Fuel	$1,012,500 - $2,025,000
Deutz BV12M 628	2,700 kW	Diesel, Liquid Fuel	$1,350,000 - $2.700 000
Deutz BV16M 628	3,600 kW	Diesel, Liquid Fuel	$1,800,000 - $3,600.000
Mitsubishi Heavy Industries 12MACH-30G	3,650 kW	Diesel, Liquid Fuel	$1,825,000 - $3.650.000
Mitsubishi Heavy Industries 12KU30A	3,750 kW	Diesel, Liquid Fuel	$1.875.000 - $3,750 000
Mitsubishi Heavy Industries 14MACH-30G	4,250 kW	Diesel, Liquid Fuel	$2,125,000 - $4.250.000
Mitsubishi Heavy Industries 14KU30A	4,350 kW	Diesel, Liquid Fuel	$2,175,000 - $4.350.000
Mitsubishi Heavy Industries	4,900 kW	Diesel, Liquid Fuel	$2.450.000 - $4.900.000

16MACH-30G			
Mitsubishi Heavy Industries 16KU30A	5,000 kW	Diesel, Liquid Fuel	$2,500,000 - $5,000,000
Mitsubishi Heavy Industries 12KU30B	5,180 kW	Diesel, Liquid Fuel	$2,590,000 - $5,180,000
Mitsubishi Heavy Industries 18MACH-30G	5,500 kW	Diesel, Liquid Fuel	$2,750,000 - $5,500,000
Mitsubishi Heavy Industries 18KU30A	5,650 kW	Diesel, Liquid Fuel	$2,825,000 - $5,650,000
Mitsubishi Heavy Industries 12KU34	5,900 kW	Diesel, Liquid Fuel	$2,950,000 - $5,900,000
Mitsubishi Heavy Industries 14KU30B	6,050 kW	Diesel, Liquid Fuel	$3,025,000 - $6,050,000
Mitsubishi Heavy Industries 14KU34	6,900 kW	Diesel, Liquid Fuel	$3,450,000 - $6,900,000
Mitsubishi Heavy Industries 16KU30B	6,910 kW	Diesel, Liquid Fuel	$3,455,000 - $6,910,000
Mitsubishi Heavy Industries 18KU30B	7,780 kW	Diesel, Liquid Fuel	$3,890,000 - $7,780,000
Mitsubishi Heavy Industries 16KU34	7,900 kW	Diesel, Liquid Fuel	$3,950,000 - $7,900,000
Mitsubishi Heavy Industries 18KU34	8,900 kW	Diesel, Liquid Fuel	$4,450,000 - $8,900,000
Mitsubishi Heavy Industries 12KU44	10,300 kW	Diesel, Liquid Fuel	$5,150,000 - $10,300,000
Mitsubishi Heavy Industries 14KU44	12,000 kW	Diesel, Liquid Fuel	$6,000,000 - $12,000,000
Mitsubishi Heavy Industries 16KU44	13,700 kW	Diesel, Liquid Fuel	$6,850,000 - $13,700,000
Mitsubishi Heavy Industries 18KU44	15,400 kW	Diesel, Liquid Fuel	$7,700,000 - $15,400,000

Product Info

Manufacturer :	Elliott Energy Systems
Model Name & Number :	TA 80R
Detail Description of Product :	Recuperated gas turbine. 4 pole permanent magnet generator. Synchronous output inverter.
Additional Information :	1.7 lbs/s exhaust gas flow rate at 450 degrees F.

Technical Description

Product Technology :	Gas Turbine
Rated Electrical Output AC (kW) :	80
Standard 3 Phase Voltages for 60 Hz AC Frequency :	480
Standard 3 Phase Voltages for 50 Hz AC Frequency :	
Heat rate (Btu/kWh) :	12200
Power GenerationEfficiency (%) :	
Can be used for Cogeneration :	Yes
Practical Load Duty :	Peaking, Intermediate, Baseload
Fuel or Source of Energy :	Natural Gas

Economics 1

Low Range for Installed Cost ($/kW) :	300
High Range for Installed Cost ($/kW) :	1,100
Estimated Low Range Installed Cost for Technology ($US) :	24,000
Estimated High Range Installed Cost for Technology ($US) :	88,000

Installation Info

Footprint by Area or Width x Depth :	110 x 32 in.
Height :	52 in.
Weight :	1890

Other

Pros of Technology :	Convenient size, low emissions, efficient, low maintenance, and well suited for cogen or combined heat and power. Natural gas is efficient, easy to use, and convenient in areas with a distribution network.
Cons of Technology :	High initial capital cost and operating cost is sensitive to gas price fluctuations.
Commercially Available :	Yes

Contact Info

Address and Contact Information :	2901 SE Monroe St. Stuart, FL 34997 Tel: (772) 219-9499 Fax: (772) 219-9448
URL :	www.elliott-turbo.com/new

Product Info

Manufacturer :	Pratt & Whitney
Model Name & Number :	ST5 Simple Sycle
Detail Description of Product :	Free turbine engine with single stage centrifugal compressor.
Additional Information :	5.1 lbs/s exhaust flow at 1089 degrees Fahrenheit. 563 kW peak power rating.

Technical Description

Product Technology :	Gas Turbine
Rated Electrical Output AC (kW) :	457
Standard 3 Phase Voltages for 60 Hz AC Frequency :	
Standard 3 Phase Voltages for 50 Hz AC Frequency :	
Heat rate (Btu/kWh) :	14510.52
Power GenerationEfficiency (%) :	23.5
Can be used for Cogeneration :	Yes
Practical Load Duty :	Peaking, Intermediate, Baseload
Fuel or Source of Energy :	Natural Gas

Economics

Low Range for Installed Cost ($/kW) :	650
High Range for Installed Cost ($/kW) :	900
Estimated Low Range Installed Cost for Technology ($US) :	297,050
Estimated High Range Installed Cost for Technology ($US) :	411,300

Installation Info

Footprint by Area or Width x Depth :	
Height :	

Weight :	800

Other

Pros of Technology :	Low cost, efficient and proven technology with established service channels. Well suited for cogen or combined heat and power. Natural gas is efficient, easy to use, and convenient in areas with a distribution network.
Cons of Technology :	Operating cost is sensitive to natural gas and liquid fuel price fluctuations. Decreased efficiencies when operated at partial load.
Commercially Available :	Yes

Contact Info

Address and Contact Information :	1166 Northchase Parkway, Suite 300 Marietta, GA 30067 Tel: (866) 723-6374
URL :	www.pratt-whitney.com

Product Info

Manufacturer :	Pratt & Whitney
Model Name & Number :	ST6L-721
Detail Description of Product :	4 stage turbine with single stage compressor and power turbines.
Additional Information :	6.6 lbs/s exhaust flow at 957 degrees Fahrenheit. 567 kW peak power rating.

Technical Description

Product Technology :	Gas Turbine
Rated Electrical Output AC (kW) :	508
Standard 3 Phase Voltages for 60 Hz AC Frequency :	
Standard 3 Phase Voltages for 50 Hz AC Frequency :	
Heat rate (Btu/kWh) :	14605.36
Power GenerationEfficiency (%) :	23.4
Can be used for Cogeneration :	Yes
Practical Load Duty :	Peaking, Intermediate, Baseload
Fuel or Source of Energy :	Natural Gas, Liquid Fuel

Economics

Low Range for Installed Cost ($/kW) :	650
High Range for Installed Cost ($/kW) :	900
Estimated Low Range Installed Cost for Technology ($US) :	330,200
Estimated High Range Installed Cost for Technology ($US) :	457,200

Installation Info

Footprint by Area or Width x Depth :	53 x 21 in.
Height :	21 in.

Weight :	229

Other

Pros of Technology :	Low cost, efficient and proven technology with established service channels. Well suited for cogen or combined heat and power. Natural gas is efficient, easy to use, and convenient in areas with a distribution network.
Cons of Technology :	Operating cost is sensitive to natural gas and liquid fuel price fluctuations. Liquid fuel units typically have lower reliability and higher cost than natural gas fired units. Decreased efficiencies when operated at partial load.
Commercially Available :	Yes

Contact Info

Address and Contact Information :	1167 Northchase Parkway, Suite 300 Marietta, GA 30067 Tel: (866) [illegible]23-6[illegible]74
URL :	www.pratt-whitney.com

Product Info

Manufacturer :	Ingersoll-Rand Energy Systems
Model Name & Number :	70LM
Detail Description of Product :	Grid parallel cogeneration system. Recuperated gas turbine with integrated, variable-output waste heat recovery system and fuel gas booster.
Additional Information :	1.6 lbs/s exhaust gas flow rate at 450 degrees F.

Technical Description

Product Technology :	Gas Turbine
Rated Electrical Output AC (kW) :	70
Standard 3 Phase Voltages for 60 Hz AC Frequency :	480
Standard 3 Phase Voltages for 50 Hz AC Frequency :	
Heat rate (Btu/kWh) :	13080
Power GenerationEfficiency (%) :	29
Can be used for Cogeneration :	Yes
Practical Load Duty :	Peaking, Intermediate, Baseload
Fuel or Source of Energy :	Natural Gas, Biogas

Economics

Low Range for Installed Cost ($/kW) :	300
High Range for Installed Cost ($/kW) :	1,100
Estimated Low Range Installed Cost for Technology ($US) :	21,000
Estimated High Range Installed Cost for Technology ($US) :	77,000

Installation Info

Footprint by Area or Width x Depth :	71 x 43 in.
Height :	87 in.
Weight :	4100

Other

Pros of Technology :	Convenient size, low emissions, efficient, low maintenance, can operate grid connected or stand alone, and well suited for cogen or combined heat and power.
Cons of Technology :	High capital cost. Biogas units require a source of biogas and output dependent on quality of fuel. Operating costs for natural gas units are sensitive to fuel price fluctuations.
Commercially Available :	Yes

Contact Info

Address and Contact Information :	[illegible]0-D Beaty Street Davidson, NC 28036 Toll Free:1-8[illegible]7-47[illegible]-[illegible] Tel: (704) 896-[illegible] Fax: (704) [illegible]-4[illegible]
URL :	www.irpowerworks.com

Product Info

Manufacturer :	Ingersoll-Rand Energy Systems
Model Name & Number :	70SM
Detail Description of Product :	Grid parallel cogeneration system with sunchronous generator. Recuperated gas turbine with integrated, variable-output waste heat recovery system and fuel gas booster.
Additional Information :	1.6 lbs/s exhaust gas flow rate at 450 degrces F.

Technical Description

Product Technology :	Gas Turbine
Rated Electrical Output AC (kW) :	70
Standard 3 Phase Voltages for 60 Hz AC Frequency :	480
Standard 3 Phase Voltages for 50 Hz AC Frequency :	
Heat rate (Btu/kWh) :	13500
Power GenerationEfficiency (%) :	28
Can be used for Cogeneration :	Yes
Practical Load Duty :	Peaking, Intermediate, Baseload
Fuel or Source of Energy :	Natural Gas, Biogas

Economics

Low Range for Installed Cost ($/kW) :	300
High Range for Installed Cost ($/kW) :	1,100
Estimated Low Range Installed Cost for Technology ($US) :	21,000
Estimated High Range Installed Cost for Technology ($US) :	77,000

Installation Info

Footprint by Area or Width x Depth :	71 x 43 in.
Height :	87 in.
Weight :	4850

Other

Pros of Technology :	Convenient size, low emissions, efficient, low maintenance, can operate grid connected or stand alone, and well suited for cogen or combined heat and power.
Cons of Technology :	High capital cost. Biogas units require a source of biogas and output dependent on quality of fuel. Operating costs for natural gas units are sensitive to fuel price fluctuations.
Commercially Available :	Yes

Contact Info

Address and Contact Information :	800-D Beaty Street Davidson, NC 28036 Toll Free:1-877-477-6937 Tel: (704) 896-5373 Fax: (704) 896-4327
URL :	www.irpowerworks.com

Product Info

Manufacturer :	Bowman Power Systems
Model Name & Number :	TG80BG
Detail Description of Product :	Single shaft engine rotor. Four pole permanent magnent alternator. Microporcessor controlled engine management and system monitoring.
Additional Information :	

Technical Description

Product Technology :	Gas Turbine
Rated Electrical Output AC (kW) :	80
Standard 3 Phase Voltages for 60 Hz AC Frequency :	380-480
Standard 3 Phase Voltages for 50 Hz AC Frequency :	380-480
Heat rate (Btu/kWh) :	
Power GenerationEfficiency (%) :	21
Can be used for Cogeneration :	Yes
Practical Load Duty :	Peaking, Intermediate, Baseload
Fuel or Source of Energy :	Natural Gas, LPG, Butane, Propane, Alternative Gas

Economics

Low Range for Installed Cost ($/kW) :	300
High Range for Installed Cost ($/kW) :	1,100
Estimated Low Range Installed Cost for Technology ($US) :	24,000
Estimated High Range Installed Cost for Technology ($US) :	88,000

Installation Info

Footprint by Area or Width x Depth :

Height :

Weight :

Other

Pros of Technology :	Low cost, efficient and proven technology with established service channels. Well suited for cogen or combined heat and power. Natural gas is efficient, easy to use, and convenient in areas with a distribution network.
Cons of Technology :	Operating cost is sensitive to natural gas and liquid fuel price fluctuations. Liquid fuel units typically have lower reliability and higher cost than natural gas fired units. Biogas units require a source of biogas and output is then dependent on quali
Commercially Available :	Yes

Contact Info

Address and Contact Information :	Ocean Quay Belvedere Road Southhampton, SO14 5QY England Tel: +44 (0)23 8023 6700 Fax: +44 (0)23 8022 1128
URL :	www.bowmanpower.com