An Assessment of Cogeneration for the City of San Francisco

Department of the Environment
City and County of San Francisco

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Acknowledgments

In developing this cogeneration knowledge base from scratch, it was essential to speak with a diverse group of people experienced in the many different facets of cogeneration. Their assistance in understanding how cogeneration systems are implemented in the real world was invaluable, and will certainly help us to develop an effective program to promote cogeneration, and ultimately bring us closer to our goal of clean energy in the city of San Francisco.

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Foreword

The Department of the Environment for the City and County of San Francisco supports the use of efficient combined heat and power, or cogeneration power systems as an effective way to generate power, reduce pollution, and conserve natural resources. While our ultimate goal is a clean, sustainable, and carbon-neutral power system, it is important to take advantage of the technologies available today that can immediately improve our situation and aid us in our transition toward a renewable future.

This report has been developed to help solidify the City's stance on the promotion of cogeneration systems and how this promotion can work constructively with the City's long term goals of renewable energy and energy efficiency. Including the international airport, 70 MW of combined heat and power are currently being generated in the City. With several of these cogeneration facilities operating successfully in the City for close to two decades, this report is an attempt to learn from their experiences, as well as those of newly installed cogeneration systems and to evaluate and craft a plan which will promote the use of cogeneration in the most appropriate instances. In parallel, this is a study of the incentives, permitting processes and barriers to cogeneration deployment, to build a coherent understanding of the technology and its most effective use.

This report concludes with recommendations for the most effective ways in which cogeneration systems can be promoted in the near and longer term future, and how the City can expand its deployment.

Chapter 1 – Introduction To Cogeneration

Modern Power Production

The state of California generates its power from a diverse range of sources: natural gas (41.5%), large hydro (19.0%), coal (15.7%), nuclear (12.9%), and renewable resources (10.9%) [1]. Nearly all of this power is generated at large sites, and transmitted to the public through an extensive power grid tying together the entire state. While the system works, inefficient generation processes, polluting fossil fuel use, and large power losses during transmission through the grid leave large gaps for improvement.

Power production in the city of San Francisco differs somewhat from that of the state level, but suffers from the same inefficiencies. While all municipal buildings are powered by large hydro from the Hetch Hetchy power plant, PG&E provides the rest of the city with the following mix: natural gas (44%), nuclear (23%), large hydro (17%), coal (2%), and renewable resources (13%)[2].

What is Cogeneration?

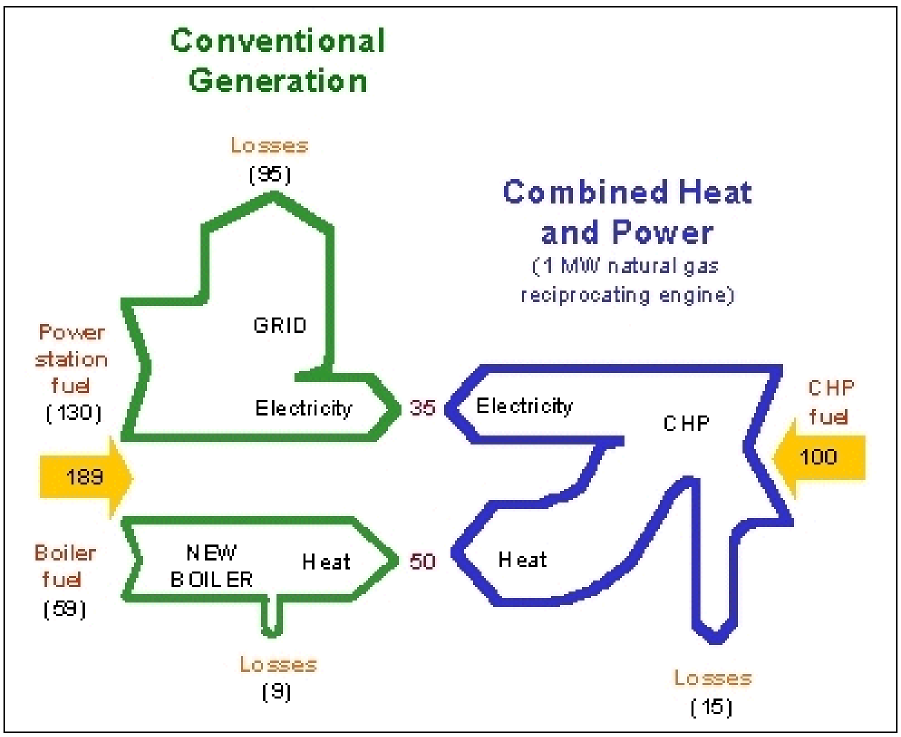
Cogeneration, also known as Combined Heat and Power (CHP), is the process of generating electricity and useful heat from the same power station. Modern power generators create electricity through the combustion of a fuel, or the nuclear processing of uranium, and give off large amounts of exhaust heat to the air, earth, or water that surrounds them. The waste of this excess heat is a fundamental inefficiency in these generators and the use of their fuel. Cogeneration systems are identical to these modern power generators, with the exception that they collect the exhaust heat from the electrical generation process and use this heat to perform other work. This heat can be used to heat the air in an office building, provide hot water or steam, drive a dehumidifier, or even drive an absorption chiller to provide refrigeration and cooling. With this large range of uses, a variety of buildings can benefit from the useful heat in a cogeneration system.

Efficiency

Cogeneration systems can be much more efficient in generating the heat and power used at a site than by generating electricity at a large power plant far away and generated heat on site by a gas powered boiler. In the large power plant model, power is typically created by the burning of natural gas or coal, or driven by the immense heat given off through a nuclear reaction. The burning of these fossil fuels is used to heat and expand air which drives a turbine and creates electricity, or in the case of nuclear power to make steam, again to drive a turbine to generate electricity. In each of these cases, only a little over a third of the energy is used to create electricity (up to 60% for fossil fuels if a modern combined cycle system is used), and the excess heat is dumped into the surrounding environment. To transport this electricity from the power plant to a building, it is sent through the power grid, again reducing energy through transmission losses by about 7% [3].

These inefficiencies can be avoided through the use of a cogeneration system. Further, cogeneration can reduce the need for extra equipment, such as an onsite boiler, to produce a building's necessary thermal load. A comparison between the heat and power efficiencies for conventional systems and cogeneration systems is shown in Figures 1 and 2. In Figure 1, one can compare the total amount of fuel necessary to generate equivalent amounts of heat and power from conventional generation and combined heat and power generation. A conventional power plant and onsite boiler would use 189 units of fuel to generate the same amount of heat and power produced by a CHP system using only 100 units of fuel. This makes a CHP system nearly twice as efficient as a conventional system. Figure 2 makes the same comparison, but with state-of-the-art systems for conventional generation that are just starting to enter the marketplace. Here, a conventional system uses 143 units of fuel to produce the same heat and power as a CHP system using only 100 units of fuel. CHP systems still average about 50% more efficient than state-of-the-art systems, and several real-world CHP systems do better than this.

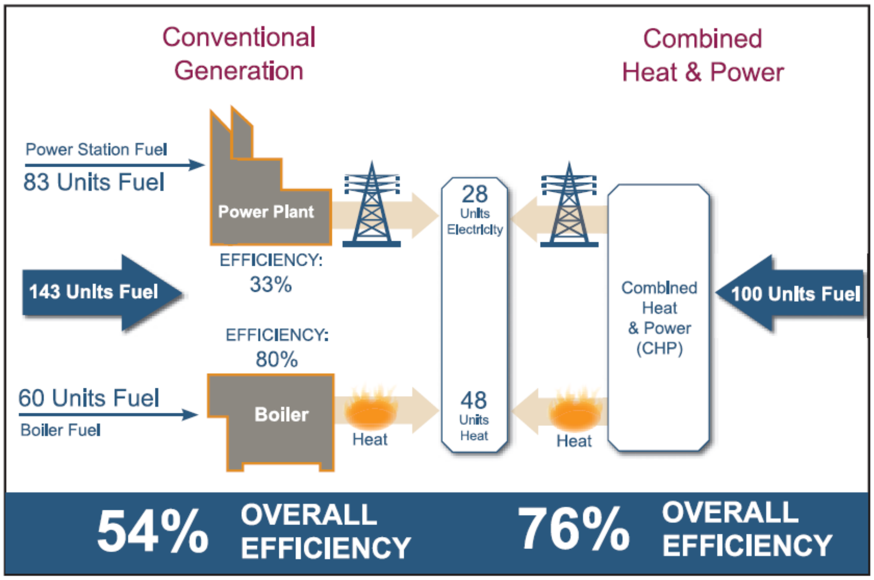
Conventional Generation vs. Combined Heat and Power



Source: USCHPA [4]

Figure 1: The amount of fuel used by conventional generation and cogeneration systems to generate the same amount of heat and power is shown above. Conventional generation require 189 units of fuel to generate the same heat and power as 100 units of fuel in cogeneration. This means cogeneration is nearly twice as efficient.

State-of-the-Art Conventional Generation vs. Combined Heat and Power



Source: US EPA[5]

Figure 2: The amount of fuel used by state-of-the-art power plants and boilers, compared with that of a typical cogeneration system is shown. State-of-the-art systems still require 143 units of fuel, versus 100 units of fuel for a cogeneration system, to produce the same amount of useful heat and power. This means typical cogeneration systems are still ~50% more efficient than state-of-the-art conventional systems [5].

How Cogeneration Can Be Beneficial

There are many reasons why cogeneration systems can benefit a host building, and why they are a great fit for many of the industries, businesses and public institutions in San Francisco.

Environmental

Cogeneration systems are much more efficient than the power plants that traditionally supply electricity. This efficiency translates to burning fewer fossil fuels for the same amount of heat and power, fewer pollutants being released into the atmosphere, and less ecological damage to the environment. The use of natural gas as a cogeneration system's fuel is a much more environmentally friendly choice than the burning of coal or the use of nuclear fuels. The use of a cogeneration system can reduce the level of pollutants released into the atmosphere by 50% or more, depending on the fuels and technologies being used. These values can even be quantified for a specific site using an Emissions Calculator, such as the one at the EPA's CHP website [4].

Economic

Cogeneration systems can significantly reduce the costs associated with a facility's electricity, water heating, and refrigeration or water chilling needs. By more efficiently using a fuel such as natural gas, a business can create heat and power below the cost of purchasing it through conventional methods. Additionally cogeneration can help mitigate against fluctuating electricity costs and peak-use rates. Currently, facilities are paying for their systems in 2 – 5 years, and thereafter reaping significant savings on their combined heat and power bills, with one example cutting them in half.

Energy Security

Adding a cogeneration system to a facility can greatly improve reliability in terms of having access to a continuous supply of heat and power. Onsite generation can keep vital systems running during a public utility blackout, and cogeneration systems remain connected to the power grid for instantaneous switching should a cogeneration system need to be halted for maintenance or in the event of system failure.

Grid Reliability

The introduction of cogeneration systems in the city can relieve stress on an already over-taxed power-grid. Producing power onsite can assist utility companies in maintaining and improving grid-reliability, and can lessen the need for costly upgrades to the electrical grid infrastructure. The city can reduce its need for larger amounts of central power, and the development of new power plants that would be necessary to provide this power.

Chapter 2 – Fuels and Technologies

A variety of technologies have emerged over the years to facilitate the distributed production of heat and power. From the oldest and most established technology, the reciprocating engine, to newer and more compact turbines and cutting-edge fuel cells, optimum cogeneration technologies can be selected to fit each facility's needs. In this chapter, a description of environmentally acceptable fuels is given first, and then a description of each technology, along with its merits and possible disadvantages.

Fuels

Cogeneration technologies can use a wide variety of fuels to generate heat and power. This report however focuses on three environmentally acceptable fuels: natural gas, biogas, and hydrogen.

Natural Gas

Natural gas (CH_4) is the primary fuel to be applied in the combined heat and power technologies to be discussed in the next section. The natural gas infrastructure is well established and provides gas effectively to most buildings in San Francisco. The combustion of natural gas is much cleaner than oil or coal, and is a locally abundant natural resource.

Biogas

Biogas is the gas produced by the anaerobic digestion of organic matter, typically created at waste management facilities. It is primarily composed of methane (CH_4) and carbon dioxide (CO_2), with trace amounts of nitrogen and hydrogen sulfide [12]. Biogas is produced and released into the atmosphere at these plants as a byproduct, so using this resource in a cogeneration system is an opportunity to take advantage of a fuel source that would otherwise be wasted. Emissions are comparable to that natural gas.

Hydrogen

While a hydrogen infrastructure does not yet exist, hydrogen gas would provide an extremely clean alternative for powering all of the cogeneration technologies to be described in the next section. Its combustion with pure oxygen results in only heat and water, and its combustion in air only adds NO_x emissions which can be controlled through standard catalytic converters. The use of hydrogen in a fuel cell requires a chemical reaction instead of combustion, and therefore only produces heat and water as byproducts.

Technologies

Reciprocating Engines

Reciprocating engines are perhaps the most familiar power generators, as they are the same piston and crankshaft models used in our automobile engines for nearly a century. A fuel is injected into the cylinder, where it is ignited and forces the expansion of hot gases, driving the piston's motion. This motion is directed into a crankshaft which can be connected to a generator to create electricity (Figure 3). The system can then work in a cogeneration mode by collecting the exhaust heat and directing it to a useful task.

Reciprocating engines have been designed in a wide range of sizes, generating from 0.5 kW – 10 MW of power (Figure 4). They have proven reliable for decades, benefiting from years of design, and are the most widely distributed engines in the world. While tried and true, the many moving parts of a reciprocating engine can lead to higher maintenance costs and downtime. These engines are about 37-40% efficient at generating electricity [7,9]. In San Francisco, reciprocating engines are the dominant technology used for cogeneration, and account for over 20 installations.

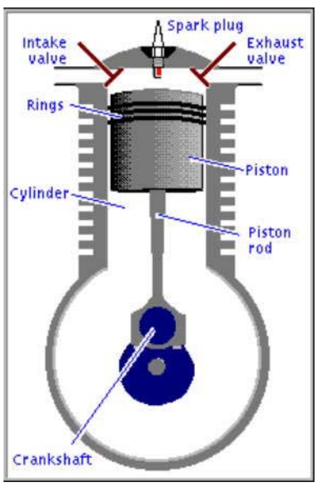
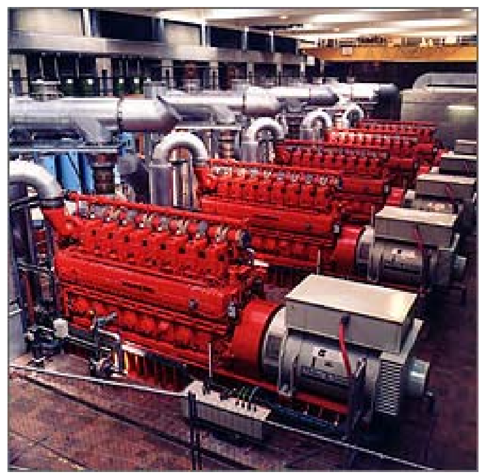


Figure 3: Cross section of reciprocating engine, highlighting key components.



Source: Waukesha Engines [8]

Figure 4: Picture of several 800 kW Waukesha reciprocating engines.

Combustion Turbines

Combustion turbines are electrical generation devices that use high-temperature, high-pressure gas to rotate a drive shaft, which is subsequently connected to an electrical generator to produce power. The gas is forced through one or more layers of blades connected to a central drive shaft, and the flow of this gas drives the system. Natural gas is typically used as the fuel, and is injected into the turbine at high pressure and then ignited. The large amounts of heat released in the combustion process greatly increase the pressure in the turbine, driving the flow of gas and the generation process.

Large amounts of heat are produced by a combustion turbine, and the continuous high-temperature exhaust gases can be used effectively in a cogeneration model. Many facilities use this high temperature gas to boil water and drive a steam turbine to produce even more power, operating in what is called a combined-cycle mode. Alternatively, the heat is used to drive an absorption chiller or provide varying grades of hot water.

Combustion turbines are in regular use at modern utility power plants, and their planned deployment in existing and new plants will lead to improvements and greater efficiencies in design over time. Research in combustion turbine technology is actively being pursued by several universities and government laboratories to increase system performance and lower emissions. Combustion turbines are currently available in the 500 kW to 500 MW range. Single cycle turbines can produce electricity at an efficiency of 35-40%, and up to 60% in a combined cycle arrangement [7,9]. There are currently two combined cycle systems utilizing this technology in San Francisco

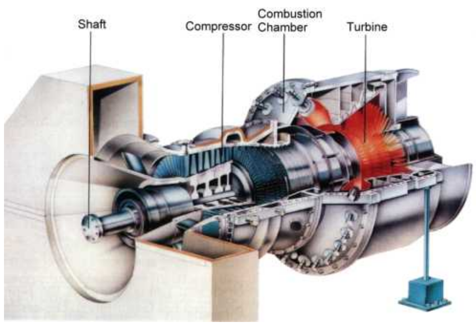


Figure 5: A cross section of a combustion turbine, highlighting the main components.

Source: USCHPA [9]

Figure 6: A picture of an installed combustion turbine at a facility

Microturbines

Microturbines are a relatively new form of combustion turbine that offer solutions for sites with limited space. Each unit can produce from 25 – 500 kW of power, and is about the size of a refrigerator. Natural gas powered microturbines with recuperators (a component used to recycle some of the exhaust heat to preheat the incoming gas) can achieve electrical efficiencies of 25-30%, and by using the exhaust heat in a cogeneration model, can reach total efficiencies of 80% and beyond. They have fewer moving parts than a reciprocating engine, and are much quieter than a full size combustion turbine or reciprocating engine [7,9]. There are currently three microturbine installations in San Francisco.

Source: Capstone Microturbines [10]

Figure 7: A picture of several 30kW Capstone microturbines.

Fuel Cells

Fuels cells are an emerging technology, being hotly pursued and improved in many research institutions around the world. They are similar in design to a battery, but instead of storing power, they create it with a fuel. Hydrogen gas (H_2) is fed into one side of the fuel cell, and an electrical current is generated between the positive and negative terminals of the cell. There are no polluting emissions given off in the process, and the only exhaust is heat and pure water. Harnessing this heat allows the fuel cell to function as a cogeneration system.

Currently, there are no efficient means to produce and transport hydrogen gas. To bypass this problem, natural gas is used and converted into hydrogen gas before running a fuel cell. The conversion process produces some emissions, but these levels are very low and allow the technology to still be installed and operated without any emissions or air quality permits.

Fuel cell systems are now available for both residential and business markets, ranging in size from 1kW-3MW. Fuel cells are still very expensive, but generous government grants and subsidies are helping to push them toward greater commercial availability in the next five to ten years [7,9]. There is currently one fuel cell system in operation in San Francisco.

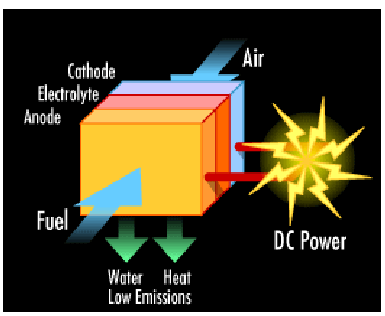


Figure 8: A diagram of a simple fuel cell illustrating the main components.

Figure 9: A 250kW FuelCell Energy fuel cell installed at a business [9].

Chapter 3 – Current Use In San Francisco

There are many existing cogeneration installations operating in San Francisco, some successfully for more than two decades. Together, these facilities generate a total of 60 MW of capacity, including the 30 MW industrial size system at San Francisco International Airport. These systems power a variety of industries and businesses, from residential complexes to large office buildings, hospitals, and hotels. Table 1 and Figure 10 show the distribution of cogeneration by industry. Table 2 presents a list of the known cogeneration facilities in the City and County of San Francisco

To better understand the unique operating characteristics and installation constraints of these facilities, site visits were conducted for a number of the systems listed in Table 2. Case studies were developed to summarize these visits, and can be found in Appendix B of this report.

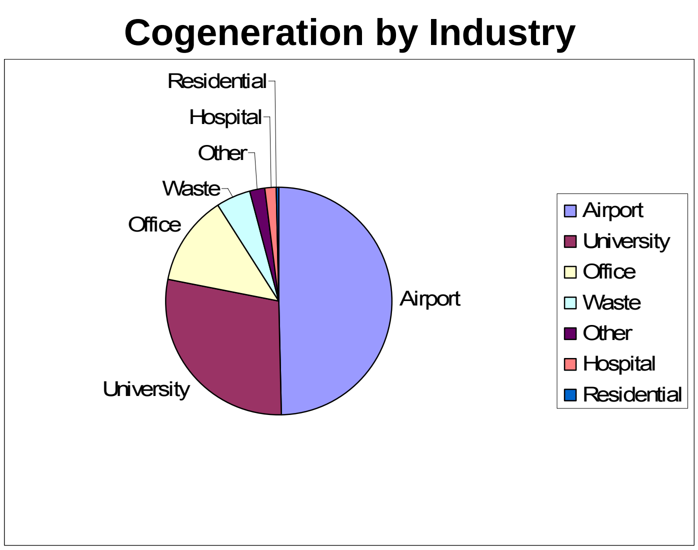


Figure 10: The distribution of cogeneration systems in San Francisco by industry.

Cogeneration by Industry

Industry	Power (MW)
Airport	30.0
Universities	17.0
Office Buildings	7.7
Waste Treatment	3.1
Other	1.3
Hospital	1.0
Residential	0.2

Table 1: The distribution of cogeneration systems in San Francisco by industry.

Cogeneration Facilities in San Francisco

Industry	Location	Technology	Fuel	Power (kW)	Began
Air Transportation	United Cogen, Inc., SFO	CombCycle	NatGas	30,000	1985
College/Hospital	University of California, SF	CombCycle	NatGas	13,500	1998
College/Univ.	University of San Francisco	Recip Engine	NatGas	1,500	1988
College/Univ.	San Francisco State University	Recip Engine Recip Engine	NatGas DuelFuel	725 1,250	1984 1998
Schools	High School	Recip Engine	NatGas	300	2005
Schools	High School	MicroTurbine	NatGas	240	2005
Printing/Publishing	Arden Wood Benevolent Assoc.	Recip Engine	NatGas	90	1987
Residential Highrise	1080 Chestnut Street	Recip Engine	NatGas	60	1988
Residential Highrise	Nihonmachi Terrace	Recip Engine	NatGas	75	1992
Residential Highrise	Pacific Height Towers	MicroTurbine	NatGas	60	2005
Office Buildings	One Market Street	Recip Engine	NatGas	1,500	2003
Office Buildings	595 Market Street	Recip Engine	NatGas	1,130	2004
Office Buildings	DG Energy Solutions	Recip Engine	NatGas	1,200	2002
Office Buildings	201 Mission Street	Recip Engine	NatGas	750	2005
Office Buildings	TransAmerica Building	Recip Engine	NatGas	1,100	2007
Office Buildings	California Public Utilities Commission	Recip Engine	NatGas	400	2003
Office Buildings	Civic Center	Recip Engine	NatGas	800	
Office Buildings	Fremont Group	Recip Engine	NatGas	800	
Laundries	Fulton Fabricare Center	Recip Engine	NatGas	14	1991
Nursing Homes	Northern California Presbyterian Homes	Recip Engine	NatGas	240	1997
Postal Center	U.S. Postal Service	FuelCell	NatGas	250	2005
Hotels	Ritz Carlton	MicroTurbine	NatGas	240	2005
Waste Treatment	Oceanside Waste Management Facility	Recip Engine	BioGas	1160	
Waste Treatment	Southeast Waste Management Facility	Recip Engine	BioGas	1950	
Hospital	St. Francis Memorial	Recip Engine	NatGas	240	1996
Hospital	St. Mary's Medical Center	Recip Engine	NatGas	750	2006
			Total Power:	**60,324 kW**	

Table 2: A list of all known facilities in San Francisco operating cogeneration systems. The DuelFuel system at San Francisco State University mixes a gallon of diesel with natural gas per operating hour.

Chapter 4 – Cogeneration Markets In San Francisco

Identifying Potential Markets

Ideal candidates for cogeneration have a demand for both the electricity and heat produced by a generator. A system is optimally designed (mechanically and economically) when 100% of the heat is put to secondary use, and the system is able to run continuously throughout most of the year. A system can be very cost-effective running only during business hours, or as a demand-response solution generating power during peak-load hours, thus allowing businesses to avoid peak electrical rates. Several buildings in the city have applied this generation approach, but the dominant fraction of the City's systems have been designed to operate continuously.

The following markets have already found success with cogeneration systems; each of their distinguishing features will be discussed. Case studies for several markets can be found in Appendices B and C. Table 3 at the end of this chapter summarizes the cogeneration potential in all markets of the city.

Potential Cogeneration Markets

- Hotels
- Hospitals
- Data Centers
- Airports
- Office Buildings
- Universities
- Schools
- Others
- Residential Highrises
- Waste Treatment Plants
- Health/Fitness Centers

Hotels: Hotels with greater than 100 rooms generally have the electrical and thermal loads necessary to benefit greatly from a cogeneration system. If they have additional thermal loads through on-site pool heating, laundry facilities, or restaurants, they can be very well suited. Larger hotels in the several hundred room category are excellent cogeneration candidates. Currently, only one hotel in downtown San Francisco is operating a cogeneration system, but its success stresses the potential of this market (see Appendix B). Typically hotel systems range between 100 kW – 1 MW. Over 45 well qualified candidates have been identified in the city and are listed in Appendix E. The calculation in Appendix E estimates about 20 MW of potential in this market.

Hospitals: Hospitals also make excellent candidates for cogeneration systems. They have large power demands twenty-four hours a day, large kitchens for sizeable numbers of staff and patients, and use thermal loads for hot water, sterilization, and to operate absorption chillers for refrigeration. Several hospitals in San Francisco have installed cogeneration systems and report few difficulties navigating the enhanced permitting requirements for hospitals mandated by the Office of Statewide Health Planning and Development (OSHPD). Typical hospital systems range from 100 kW – 1 MW. There are currently three active cogeneration systems at hospitals in San Francisco, and large potential for the six other large hospitals in the city, and eight smaller medical centers. A calculation of the remaining hospital potential yields approximately 4 MW. The calculation and locations are given in Appendix F,

Data Centers: Data centers require large amounts of power to run their computer servers, and require cooling to keep these servers at an operational temperature. These centers operate twenty-fours a day, processing, receiving and sending data around the world. While the thermal loads applied towards cooling may not be large enough on their own, data centers that reside in a larger office complex can make good candidates for cogeneration.

Airports: Airports, particularly international airports, run continuously and may receive many benefits from cogeneration. This opportunity is enhanced if one or more airlines have a maintenance operations base at the airport. This potential has already been tapped by United Airlines at San Francisco International airport through a 30 MW system. In addition to supplying the United Airlines operations base with heat and power, excess electricity is sold to the local utility company. There may be an opportunity for another airline to install a cogeneration system if they also have an operations base at the airport, otherwise this market is saturated.

Office Buildings: The potential for office buildings varies greatly, depending on the overall size, the inclusion of data centers, and operating hours. Electric loads are particularly high during business hours, but drop significantly during the night in most buildings. This operating pattern should not discourage the installation of systems as the savings from peak electrical rates can be significant and can justify a project economically even if the system does not run during non-business hours. Typical thermal loads in office buildings include space and water heating, and absorption chillers for cooling. Generators can be sited on the roof, in basement level equipment rooms, or in parking structures. Typical cogeneration system sizes for office buildings range from 500 kW – 1.5 MW. This market has the largest segment of active systems in San Francisco, with eight distributed around the downtown area. The office building market also has the largest potential for growth in the city, with well over a hundred potential office buildings in the city, capable of producing in excess of 80 MW. The calculation for this estimate, and a list of potential locations is given in Appendix C.

Universities: Universities often make ideal locations for cogeneration facilities. Their large faculty, staff, and student populations require vast amounts of heat and power. Many parts of a campus operate with early morning to late night hours, and some continuously. Many laboratory experiments also run 24 hours a day, and have large thermal requirements. Universities with their own medical centers combine the needs of both a university and hospital, and often see significant energy savings from cogeneration. Universities that are part of a larger system, such as the UC system or the

State system, can also benefit from the negotiating power of this system in the purchase of natural gas.

Universities throughout the country have operated cogeneration systems for decades, and all three universities in San Francisco have already taken advantage of the technology. There may be an opportunity in one of the smaller colleges, but the market is otherwise saturated. Typical university cogeneration systems are very large, falling in the 1-15 MW range. A list of universities and colleges is given in Appendix G.

Schools: Schools with larger student populations and swimming pools have proved to be good candidates for cogeneration in several cities around California. Their thermal generation is typically directed to heating the pool, but can also provide hot water and refrigeration. System sizes tend to be in the 50-100kW range. There are currently two such systems operating in San Francisco.

Residential High Rises: Residential apartment or condominium complexes with at least 50 apartments or 100,000 total square feet usually have enough residents and a sufficiently large thermal load to benefit from a cogeneration system. Cogeneration heat can be directed toward water-heating , allow systems to run near continuously, with only short down periods during the late night when thermal and electric loads are minimal. During extreme periods of thermal use, these complexes can use their already existing boiler to generate the extra heat. Three residential high rises in San Francisco have taken advantage of cogeneration systems, with one of these successfully operating for close to 20 years. There are 13 large residential high rises, and many smaller residential high rises in the city that would make good candidates for cogeneration and these are listed in Appendix G. Typical system sizes range from 50 –200 kW, and this market is expected to have greater than two megawatts of potential.

Waste Treatment Plants: Waste treatment plants make exceptional candidates for cogeneration because their fuel, biogas, is usually just released into the atmosphere. Additionally, they have large heat and power needs and run 24 hours/day. San Francisco has installed large cogeneration systems at both of its waste treatment facilities, with an 1160 kW system at the Oceanside Plant, and a 1950 kW system at the Southeast Plant.

Health/Fitness Centers: Fitness centers may prove good candidates for cogeneration if they have a heated swimming pool to absorb the thermal load. These centers may already have large electrical demands from the exercise equipment, lighting and air conditioning they operate during their long business hours. There are no fitness centers in San Francisco that have installed a cogeneration system yet, but typical system sizes would range from 50 – 100 kW.

Others: A number of other types of facilities in the City can also effectively use cogeneration. Warehouses with long hours and either large thermal loads or a need for cooling or refrigeration are one example. Large commercial laundries or dry-cleaning facilities are another. An example of such a system in San Francisco includes the 250 kW fuel cell system at the U.S. Postal Service distribution center at 1300 Evans.

Cogeneration Potential in San Francisco

Market	Power (MW)
Office Buildings	> 80
Hotels	~ 20 MW
Residential High Rises	> 2 MW
Hospitals	~ 4 MW
Other (Commerical Retail and Misc, Data Centers, Schools/Fitness Centers with pools, Warehouses)	Several MW (to be studied)
	Total: > 106 MW

Table 3: The cogeneration potential of San Francisco's various markets. Calculations are described in Appendices C – G.

Chapter 5 – Incentive Programs and Regulations

Several federal, state, and local government incentive programs are in place to support the use of cogeneration for its environmental benefits through reduced emissions, efficient use of limited fossil fuels, and to lessen the electric load on an already overextended power-grid which is costly to maintain. A summary of the current programs and regulations is given below. Regularly updated databases of federal, state and local cogeneration incentive programs and regulations are available at the Environmental Protection Agency's Combined Heat and Power Partnership, http://www.epa.gov/chp/funding_opps.htm, and the Database of State Incentives for Renewables and Efficiency (DSIRE), http://www.dsireusa.org/.

Incentive Programs

State Incentives

Self-Generation Incentive Program (SGIP): The California Public Utilities Commission created this program to promote distributed generation facilities in the state of California. PG&E has been charged with distributing $32.4 million in 2007 to offset a portion of the costs of installing eligible systems. Fuel cells can receive $2.50/W, microturbines and small gas turbines $0.80/W, and reciprocating engines and large gas turbines $0.60/W.

The SGIP program began in March 2001 and is scheduled to last until January 2011. However natural gas powered systems are being disqualified from eligibility at the beginning of 2008. There is currently a debate to reinstate eligibility for natural gas systems (see California legislative bills AB 1064 and AB 1470). Current SGIP information is available from Pacific Gas and Electric at http://www.pge.com/selfgen/, and the California Public Utilities Commission (CPUC) at http://www.cpuc.ca.gov/static/energy/electric/051005_sgip.htm.

California Loans for Energy Efficiency Program: A pot of $26 million has been allocated to provide preferential loans for the development of any cogeneration facility being run on cleaner fuels, including natural gas and biogas. These are 15-year loans with a 3.95% fixed interest rate and a maximum loan of $3 million. The current term of the program began in April 2007 and will expire when all allocated funds have been distributed. For more information, go to the California Energy Commission (CEC) at http://www.energy.ca.gov/contracts/efficiency_pon.html.

Federal Incentives

Tax Credit for Fuel Cells and Microturbines: A tax credit is being offered for the installation of fuel cells with a minimum of 0.5 kW capacity and no maximum. These systems are eligible for up to $500/0.5 kW of capacity. A tax credit is also being offered for the installation of microturbines with a capacity of less than 2,000 kW and offers a maximum return of $200/kW of capacity. This program began in January 2006 and will continue until the end of 2007. For more information, go to ENERGY STAR at http://www.energystar.gov/index.cfm?c=products.pr_tax_credits#s5.

United States Department of Energy – Climate Change Technology Program (CCTP): All cogeneration facilities using cleaner fuels (including natural gas and biogas) may be eligible for a grant from the $3 billion in federal funding set aside to reduce greenhouse gas emissions. This program was initiated on September 20, 2006 and has no set expiration date. More information is available at: U.S. Climate Change Technology Program, http://www.climatetechnology.gov/index.htm.

Renewable Energy Production Incentive: A rebate of 1.5 cents/kWh (1993 dollars) is being offered for all cogeneration systems using clean, renewable sources of fuel, including biogas. The operating time of this program is October 1992 – September 2026. For more information, go to the U.S. Department of Energy at http://www.eere.energy.gov/wip/repi.html.

Clean Renewable Energy Bond Program: A pot of $800 million has been set aside by the IRS to grant "tax-credit" bonds for all cogeneration facilities using cleaner fuels, including biogas. This offer is valid from the end of December 31, 2005 until January 1, 2008. For more information go to the Internal Revenue Service (IRS) at http://www.irs.gov/pub/irs-drop/n-05-98.pdf.

Regulations

California Distributed Generation Certification Program: As of 2003, all distributed generation systems, including cogeneration systems, must be certified according to the California Air Resource Board (CARB) emissions standards. Those passing receive pollution compliance credits on the scale of 1 MWh/3.4 MMBtu. As of January 1st, 2007, emissions standards have become more stringent, but the same credit scale applies. Eligible systems must be at least 60% efficient. More information can be found at the California Air Resource Board website, http://www.arb.ca.gov/energy/dg/dg.htm.

California Interconnection Standards: As of December 21st, 2000, all cogeneration systems up to 10 MW in size have the right, as described by California's interconnection standard Rule 21, to connect to the local utility grid so that they can generate all or a portion of a facility's electricity. This rule allows for the sale of power back to the utility each month, but sales may not exceed the amount of power that was purchased from the utility that month. This allows a cogeneration site to have an electric bill of $0.00, but not to make any revenue from power sales. In order to sell power back to the grid for profit, a Power Purchase Agreement would have to be made. A complete description of Rule 21 can be found at the California Energy Commission website, http://www.energy.ca.gov/distgen/interconnection/california_requirements.html, and PG&E's Rule 21 website, http://www.pge.com/suppliers_purchasing/new_generator/retail_generators/.

California Natural Gas Rates: Since 1981, all natural gas powered cogeneration systems that are at least 42.5% efficient are eligible to pay a reduced rate for natural gas. Gas utilities are required to sell gas to qualified cogenerators at the same price they bill larger electric utilities.

As this relates to San Francisco, PG&E charges natural gas customers as described by the rate schedules GNR-1 and GNR-2, for small and large customers respectively. These rates include three different charges: a customer charge, a procurement charge, and a transportation charge. Customer charges are calculated by the average amount of natural gas used on a daily basis. The procurement charge is the cost of natural gas per therm. The transportation charge is the cost per therm to bring natural gas from a supplier to a business via the natural gas infrastructure PG&E maintains.

Cogeneration customers may switch, to the G-EG rate schedule, for a significant reduction (> 90%) in the cost of transportation of natural gas. They may continue to purchase gas from PG&E for their cogeneration system if their generator is less than 500kW in size and it uses less than 250,000 therms of fuel per year. They are then placed on the G-CP rate schedule, which calculates its procurement rates from the GNR-1 and GNR-2 schedules. Customers who still use natural gas for other needs will pay for this gas in the standard method, through the GNR-1 and GNR-2 rate schedules.

While PG&E can provide gas for cogeneration systems, most customers find it more cost effective to purchase gas from a third party, and they have the right by law to do so. Depending on the amount of natural gas a system will consume, they may negotiate a better deal. More information on PG&E's gas tariffs can be found at their website, http://www.pge.com/tariffs/GRS.SHTML#GRS, and options for third party natural gas can be found at http://www.pge.com/customer_service/customer_choice/gas/. Information on natural gas in California can be found at the California Energy Commision website, http://www.energy.ca.gov/naturalgas/index.html, and at the California Public Utilities Commission website, http://www.cpuc.ca.gov/static/energy/gas/index.htm.

Bay Area Air Quality Management District (BAAQMD) Standards: The emissions from all cogeneration systems in San Francisco must meet air quality standards enforced by BAAQMD. More information about these standards can be found at the BAAQMD internal combustion engine website, http://www.baaqmd.gov/pmt/air_permit_programs/engine_instructions.htm, and the permitting process in further discussed in Chapter 6, Step 4: Permitting.

Chapter 6 – Installing a Cogeneration System in San Francisco

This chapter describes the steps involved in installing a cogeneration system in San Francisco, from the inception of a system to its operation.

Step 1: Assessment of Site Potential

Elements should be identified which can make effective use of the thermal load from a cogeneration system, including air and water heating, use of steam, refrigeration, and dehumidifiers. Information on the site's electrical and thermal (natural gas) usage, including the demand throughout the day, should be analyzed. Based on electrical usage in kWh per month, the maximum system size can approximated through Table 4. An optimum system may be much smaller than this to maximize the use of the thermal load, and will depend heavily on a site's unique characteristics.

After identifying the relevant electrical and thermal characteristics, a site should contact a professional consultant to conduct an assessment of site potential. The Department of the Environment for the City of San Francisco can offer a preliminary discussion over the phone, and point to other resources that can aid in the assessment. The Environmental Protection Agency's Combined Heat and Power Partnership has developed a mature program for the promotion of cogeneration, and can offer various levels of assistance. In a 15 minute phone call they can determine if cogeneration is sensible, and if so, guide you through a "Level 1" and "Level 2" Feasibility Analysis. More information can be found at the EPA website, www.epa.gov/chp/, and from the list of cogeneration firms that serve San Francisco, given in Appendix A.

Total kWh Generated per Month* for Various Cogeneration System Sizes

System Size (kW)	**Power Generated per month (kWh)**
50	36,000
100	72,000
250	180,000
500	360,000
750	540,000
1000	720,000

*assuming 24 hour/day operation and a 30 day month

Table 4: The total number of kWh produced by a cogeneration system in a 30-day month of operation is shown.

Step 2: Economic Analysis

While reducing the amount of polluting emissions a facility is responsible for is an important motivator for pursuing cogeneration, the economic savings resulting from the efficiency of a cogeneration system are a building manager's true driving force. Savings will vary greatly from location to location, and can most accurately be determined via a professional assessment. However, Table 5 gives several examples of the savings currently being experienced by installations in the city of San Francisco.

Cogeneration System Savings in San Francisco

Industry	System Size	Savings/Month	Pay-back Time
Residential High-rise	60 kW	$3,600	< 4 years
Hotel	240 kW	$13,000	< 2 years
Hospital	750 kW	$23,000	~ 4 ½ years
Office High-rise	1100 kW	$80,000	~ 4 years

Table 5: The savings being experienced by several cogeneration systems recently installed in the city of San Francisco are shown.

Step 3: Selection of a Technology & Installation Contractor

Once cogeneration has been deemed appropriate for a given location, the generator technology and installer must be selected. Technology choices depend on the size of the system, the initial capital a business is willing to invest, usage, environmental and other goals. A list of contractors that have previously worked in the City, as well as a list of cogeneration installers that have joined the EPA's Combined Heat and Power Partnership, can be found in Appendix A. After reviewing bids from several installers, a facility can choose the best technology and installation company for their needs.

Step 4: Permitting

There are four separate permitting processes that must be navigated to install a combined heat and power system in San Francisco. These processes are described below and can often be dealt with in parallel to speed the installation of a project. The respective permitting agencies should be contacted before the purchase of any equipment to ensure each permit can be obtained for the designed location.

San Francisco Department of Building Inspection (DBI)

All cogeneration installations in the City must obtain construction permits from the San Francisco Department of Building Inspection (DBI), whose website can be found at www.sfgov.org/site/dbi_index.asp. The initial plans for a project will be reviewed by DBI and approval can take up to several months. DBI offers a useful feature online that allows the permit applicant to follow the status of their permit request as it is passed through the various stages within DBI. Tracking the permit applications progress and inquiring with the right people during this process can help to expedite the issuance of a permit. With many historic buildings in the city, it may also be necessary to get a historical building permit for construction at these sites.

Bay Area Air Quality Management District (BAAQMD)

Due to the emission of pollutants through the burning of natural gas or biogas in generation equipment, steps must be taken to ensure that air quality within and around the site is held to safe levels. Thus an Authority to Construct and Permit to Operate for a cogeneration system, classed as an internal combustion engine, must be obtained from the Bay Area Air Quality Management District (BAAQMD), www.baaqmd.gov. Standard catalytic converters on cogeneration systems can remove many pollutants and cogeneration systems with appropriate pollution controls should have no problem meeting BAAQMD requirements. If the new system is within 1,000 feet of a school, public notice must be given to the school and parents, who are given 30 days to raise any issues regarding the installation. BAAQMD permitting times typically range from 5 to 8 months.

BAAQMD Fees are described by Regulation Three, Schedule B in the BAAQMD rules and regulations database [13] and are summarized below:

Fee Name	Description	Min Fee
Initial Fee	$37.66 per MM BTU/hour	$201
Risk Screening Fee	$286 + $37.66 per MM BTU/hour	$487
Permit to Operate	$18.83 per MM BTU/Hr	$144
Nearby School	Fee to inform school and parents	~ $2,000

As an example, a small cogeneration system (85 kW) burns natural gas at a rate of about 1 MM BTU/hour, and a large system (1.2 MW) burns natural gas at about 17 MM BTU/hour.

The process for application of a permit for an internal combustion engine is described at: http://www.baaqmd.gov/pmt/air_permit_programs/engine_instructions_permit.htm

Fuel cell systems use a chemical reaction to generate power and do not burn natural gas, and therefore are considered clean technologies and do not require any permitting by BAAQMD.

Pacific Gas and Electric (PG&E) Electrical Interconnection

Electrical interconnection between a cogeneration system and the local utility power grid is described thoroughly by California's Rule 21 for utility interconnection. While businesses have the right to connect their system, it may decrease the stability, and safety of the utilities local equipment and infrastructure and it may take time to solve these issues. Issues may arise with systems >1MW, but not by default. For buildings within a secondary network, such as the downtown electrical network, the number of cogeneration systems in proximity to the proposed site and the load on the local electrical substation may affect interconnection issues.

The interconnection process will follow these steps (taken verbatim from the PG&E distributed generation website), and the initial application fee will be $800.

1. Application Review: The application will normally be acknowledged and reviewed for completeness within 10 business days of PG&E's receipt of the application. The application must be complete before PG&E can move on to the initial review.
2. Initial Review: The review shall be completed, absent any extraordinary circumstances, within 10 business days of PG&E's acceptance of the completed application. This review will determine if the generation facility qualifies for a simplified interconnection or if a supplemental review is required.
3. Supplemental Review: The review, if required, should be completed within 20 business days of deeming the application complete. Payment of $600 by the applicant for the supplemental review must be submitted to us within 10 days of issuance of review. The review will determine if the generation facility can be interconnected or if a Detailed Interconnection Study is required first.
4. Detailed Interconnection Study: The applicant must enter into an agreement with Pacific Gas and Electric Company to perform additional studies, facility design/engineering, and cost estimates for required interconnection facilities. The study is at the applicant's expense.

Typical times reported by PG&E are:

Type of Interconnection	Timeline
Simplified Interconnection	3 to 6 months
Supplemental Review	3 to 7 months
Detailed Interconnection Study	4 to 10 months

The costs for a Detailed Interconnection Study can vary greatly, as well as the incurred costs to an applicant for redesign and materials in a project.

Further Information can be found at the PG&E website, http://www.pge.com/suppliers_purchasing/new_generator/retail_generators/#topic2, and a list of equipment certified to meet Type Testing and Production Testing requirements for Rule 21 interconnection can be found at http://www.energy.ca.gov/distgen/interconnection/certification.html.

Pacific Gas and Electric (PG&E) Natural Gas Permitting

Depending on the size of the proposed system, an increase in natural gas pressure may be required at the installation site and permits will be necessary to route this gas from the local gas main to the cogeneration system. Even the extension of a buildings internal gas line several feet will require a permit, though requiring less evaluation and time to permit.

Step 5: Installation

Once the technology and a contractor have been identified, the system designed, and the equipment delivered, a system can be installed in a relatively short amount of time, from several weeks to several months.

Step 6: Operation & Maintenance

After the initial installation, systems may be adjusted for up to a year to further optimize the electrical and thermal loads and provide increased savings for location. The starting and stopping of load-following systems can be programmed and controlled automatically, and there are several plans for system maintenance: a dedicated building engineer or team of engineers, or a system contractor with roving engineers in the area. Many systems run at the 99% or greater reliability level, and only require scheduled maintenance at one or more points throughout the year. Building and property managers will have to negotiate the terms of maintenance and system warranties themselves.

Chapter 7 – Opportunities and Barriers

Opportunities

The potential for cogeneration in San Francisco is large, and there are a number of factors that could create sudden and steady growth. This report gives a first assessment of the power that can be offset by cogeneration, coming to greater than 106 MW, or more than 10% of the city's peak power consumption. There are many factors that can help the City tap into this potential and each will be discussed in turn.

<u>Positive Economics</u>
The greatest asset to the promotion of cogeneration is its efficiency. This efficiency leads to tremendous savings for the combined heat and power costs at a facility. Systems are finding an outstanding return on investment (ROI) of 20-50% and paying for themselves in 2-5 years. Employing a cogeneration system can also shield one from the rising and fluctuating costs of natural gas that would be felt through the use of a traditional boiler. The efficiency of cogeneration systems qualifies them for the purchase of natural gas at a significantly reduced rate.

<u>Large Potential Markets</u>
The greatest opportunity for San Francisco comes through the several large markets ready for the adoption of cogeneration. The office building and hotel markets are relatively untapped, with less than 1% of these markets utilizing combined heat and power systems. Further potential lies in the relatively untapped residential high-rise market and the remaining hospital market.

<u>Environmental Benefits</u>
The global environmental consciousness is growing, and many companies are supported because of their environmentally friendly choices. Installing a cogeneration system reduces the amount of pollutants a company produces from the power they consume, in turn reducing their impact on climate change. These systems are much "greener" than the current power structure, and can show that a company cares about the environment. Installing a cogeneration system can enhance a company's image as well as their value.

<u>Incentive Programs</u>
Many state and federal programs are in place to promote cogeneration. These programs should be taken full advantage of to help businesses defray the large initial costs of an installation, and decrease the pay-back period of a system. Making potential businesses aware of these programs is a crucial step in helping them make the decision to invest in cogeneration.

Potential Barriers

There are several potential or perceived barriers inhibiting the growth of cogeneration, including the downtown steam loop and electrical network, fluctuating incentive programs, public awareness, and permitting processes. Most of these are surmountable, and each will be discussed in this section.

Downtown Steam Loop

There are several perceived barriers that simply require sharing the correct set of facts to remove. One instance involves the downtown steam loop, and the misinformed belief that a cogeneration system could not operate in this region or a building could not opt out of the steam loop and produce its own steam. Any building in the steam loop can install a cogeneration system and produce its own steam, and several have already done so.

Downtown Electrical Network

A real barrier to cogeneration in the downtown area is interconnection with the PG&E run electrical network. In addition to a lengthy Detailed Interconnection Study by default, the density of cogeneration systems in the immediate area can have an impact on the time necessary for PG&E to prepare the grid for the new system. Issues arise because PG&E is charged with supplying back-up for a system should it fail, and this becomes more complicated as more systems are installed in the area. While interconnection in the downtown network may take time, any building is capable of installing a cogeneration system, and several have successfully done so already.

Fluctuating Incentive Programs

The fluctuation or loss of incentive programs can hamper the deployment of new systems. A current issue is the loss of the Self-Generation Incentive program offered by the state of California. The eligibility of natural gas powered systems ends this year, removing a rebate that typically offsets 15% of the cost of a project. It is important for the city to locate the right figures working in state legislature and show support in reinstating the SGIP and other cogeneration or distributed generation programs.

Lack of Awareness About the Benefits of Cogeneration

A large factor inhibiting the use of cogeneration is a lack of understanding and familiarity with the technology in the public eye. Specifically, building and property managers in charge of green-lighting such projects are unfamiliar with the technology and afraid to put a large investment into an unknown item. Systems are typically championed by the building engineer, who often fights an uphill battle to convince management that it is a wise decision. An example of lack of awareness was the belief that cogeneration is not clean or reliable enough for a hospital setting, when in fact many hospitals have successfully relied on cogeneration for years. To combat this instance and other misunderstandings, more information and examples of successful systems running in San Francisco should be made available for the public.

Lengthy Permitting Processes

The duration of the four permitting processes necessary to install a system varies from case to case and can last from several months to over a year. Particularly lengthy can be the PG&E interconnection process and any buildings that require a Detailed Interconnection Study, including downtown network buildings by default, and other systems that are particularly large or in a unique electrical location. While this process is described in detail in Rule 21, varying circumstances can lengthen the overall duration. To improve the speed of all four permitting processes, it is essential to understand the typical hold ups and inevitable miscommunications between the site representatives and the permitting departments, and take steps to improve and avoid these situations.

Chapter 8 – Recommendations

In light of the findings of this report, several important steps have been identified to greatly increase the use of cogeneration systems in the city of San Francisco, and hasten their deployment. These key steps are highlighted below.

1) Aggressively contact important large potential markets.
Of the potential markets identified in Chapter 4, the greatest potential lies in the downtown city center and its dense number of office buildings and hotels. These two markets should be the primary target for the promotion of cogeneration systems and aggressively pursued. Secondary markets include the remaining hospitals in the city and a number of residential high rises. Together, all of the markets listed could provide the city with greater than 100 MW of cleaner and more efficient power.

Office buildings are by far the most important market in San Francisco for significant gains in cogeneration deployment. The city has eight existing systems in this sector, ranging in power from 400kW – 1.5 MW, and totaling to 7.7 MW. With well over 100 buildings in the city with similar potential, a calculation of new cogeneration capacity yields greater than 80 MW. Many of these buildings have simply never considered cogeneration, do not believe it will work for their location, or do not believe the hassle of this "new technology" will be worth the reward, and it is essential to show relevant building and property managers that cogeneration systems are a significant opportunity for them.

The hotel market is relatively untapped, with just one 240kW system currently installed in San Francisco. Over 50 candidates have been located that have several hundred rooms each, with some of these well beyond the 1,000 room level. If each of these hotels installed a 250kW cogeneration system, we would have a total generation power of 12.5 MW. Considering that each of the 1,000+ room hotels could consume closer to a megawatt each, and there are really in excess of 50 hotels with cogeneration potential, the total generation power lies closer to 20 MW.

Several of the hospitals in the City have already installed cogeneration systems, but there are at least nine more viable locations. Averaging 500kW for each of the six larger hospitals, and 333kW for the smaller ones, these could add another 4 MW of power.

Finally, the residential high-rise market can be pursued for its cogeneration potential. There are more than 10 large scale residential high rise locations that have been identified as good candidates, and probably 20 or more small to medium size locations as well. With system size from 50 – 200 kW, this sector could provide two or more megawatts of power.

2) Promote and disseminate cogeneration information.
In order to promote cogeneration systems, it will be essential to distribute information and help the public to become more familiar with the technology. An informational

event or meeting should be setup to inform specific markets of the existence of cogeneration, their potential for these systems, and the large benefits they could enjoy. Representatives from cogeneration companies, the EPA's CHP program or its partners, and especially those from existing installation sites in San Francisco should be asked to present at this event. Case studies on existing installations both in and outside the City can also be distributed to share the implementation and success of the various technologies.

3) Improve the permitting processes.

To better understand and speed up the permitting processes, detailed notes should be gathered from new and recent installations involving the duration of all steps in the permitting processes, as well as the costs. By developing a database of "real-world" examples, we can see if the permitting agencies are living up to their advertised turn-around time, and if not, highlight how the process can be improved. Such a data-base can also help new installations prepare for these permitting processes and learn from previous miscommunications and mistakes to hasten the permitting of their own installation.

4) Support the extension of cogeneration incentive programs.

It is crucial that the current incentive programs continue to support cogeneration in the future, and the City needs to stand behind these programs, and voice its support. An example of City support that is needed immediately is to reinstate natural gas fired cogeneration systems for eligibility in the SGIP program. As the program stands, natural gas fired systems lose eligibility at the end of the year.

Appendix A – Cogeneration Resources

This appendix contains a list resources for all aspects of cogeneration. The first section is a list of websites pertaining to cogeneration, divided by government agencies and public associations and educational websites. The second section contains lists of contractors and manufacturers who have previously worked in the city or are capable of doing so.

Cogeneration Websites

Government Agencies

1. Combined Heat and Power Partnership (U.S. Environment Protection Agency)
http://www.epa.gov/chp/index.htm

2. Distributed Energy Program (U.S. Department of Energy)
http://www.eere.energy.gov/de/

3. Federal Energy Management Program (U.S. Department of Energy)
http://www1.eere.energy.gov/femp/der/index.html

4. U.S. Case Study Database (U.S. Department of Energy)
http://www.eere.energy.gov/de/casestudies/index.asp

5. Distributed Energy Resource Guide (California Energy Commission)
http://www.energy.ca.gov/distgen/index.html

6. Self-Generation Incentive Program (California Public Utilities Commission)
http://www.cpuc.ca.gov/static/energy/electric/051005_sgip.htm

Public Associations and Educational Websites

1. U.S. Combined Heat and Power Association http://uschpa.admgt.com/

2. Combined Heat and Power Installation Database (supported by DOE and ORNL)
http://www.eea-inc.com/chpdata/index.html

3. California Regulations Database for Small Electric Generators
http://www.eea-inc.com/rrdb/DGRegProject/States/CA.html

4. CogenWorks http://www.cogenworks.com/index.html

5. Pacific Southwest CHP Initiative (supported by the DOE) http://www.pswchpi.org/

6. Cogeneration (Wikipedia) http://en.wikipedia.org/wiki/Cogeneration

7. Pacific Region CHP Application Center (funded by the DOE)
http://www.chpcenterpr.org/Index.aspx

8. American Council for an Energy-Efficient Economy
http://www.aceee.org/pubs/ie983.htm

Cogeneration Manufacturers and Engineering/Construction Firms

This is by no account an exhaustive list, rather a compilation of firms who have previously worked in the city, are based in California, or have come to our attention otherwise. A more complete database is held by the following:

1. EPA's Combined Heat and Power Partnership
   http://www.epa.gov/chp/chp_partners.htm

2. Combined Heat and Power Associations database
   http://uschpa.admgt.com/links.htm

Manufacturers

Reciprocating Engines
Tecogen
Waukesha

Turbines
Solar Turbines

Microturbines
Capstone Turbine Corporation
Ingersoll-Rand Energy Systems

Fuel Cells
Fuel Cell Energy

Engineering/Construction Firms

American Energy Assets
California Power Partners
CMC Engineering
Chevron Energy Solutions
Distributed Energy Systems (previously Northern Power)
Hawthorne Power Systems
Occidental Power
PowerHouse Energy
RealEnergy

UTC Power

Financiers

BAR Capital Group
NexGen Power
National City Energy Capital

Appendix B – Cogeneration Case Studies in San Francisco

Several case studies have been created from site visits to local businesses in San Francisco who have installed or are installing a cogeneration system. These studies are meant to aid businesses who are considering cogeneration for themselves and can highlight the solutions and economics that similar businesses have found. These studies can also be used to easily disburse information about cogeneration, making the public more aware and comfortable with the technology.

Case Studies:

1. St. Mary's Hospital, 750 kW
   Department of the Environment, Philip Perea and Johanna Partin

2. Ritz Carlton Hotel, 240 kW
   Department of the Environment, Philip Perea

3. U.S. Postal Service Distribution Center, 250 kW (To Be Completed)
   Department of the Environment, Philip Perea

4. TransAmerica Building, 1.1 MW (To Be Completed)
   Department of the Environment, Philip Perea and Johanna Partin

5. 1080 Chestnut St, 60 kW
   Tecogen
   [Available as a PDF at http://www.tecogen.com/pdf-docs.htm]

SF Cogeneration Business Leaders

Ritz-Carlton Hotel

Paul Savarino, the Director of Engineering at the Ritz-Carlton in San Francisco, works hard to reduce the energy consumption of the hotel and keep energy costs at a minimum. When he discovered he could create considerable savings by generating a portion of the hotel's heat and power on-site, he didn't hesitate to pursue the project.

At the Ritz-Carlton, the comfort and quality of their guests was of the utmost importance, so their cogeneration solution had to be reliable and unnoticeable to guests in its outdoor location. With limited installation space, the Ritz decided on a set of four 60-kW Capstone Microturbines. The 240-kW cogen system took about a year for UTC Power to design, acquire permits for, and install, and has been running seamlessly – and surprisingly quietly – since January 2006.

The system generates 240kW of electricity (25% of the hotel's electrical needs), and uses the exhaust heat to power a newly installed absorption chiller for refrigeration and cooling, saving the hotel an average of $13,000 per month. The system cost about $450,000 to install before rebates; after $150,000 in grants and rebates from the U.S. Department of Energy and PG&E, it only cost $300,000, which the Ritz expects to pay back in less than two years.

With such a high return on investment, Mr. Savarino has been tempted to upgrade the system, but admits he needs more space. For now, he is extremely happy with the system and is moving on to his next large energy saving and environmentally friendly project: recycling 90% of the hotel's laundry water.

Ritz-Carlton www.ritzcarlton.com
Capstone Turbines www.capstoneturbine.com
UTC Power www.utcpower.com

SF Cogeneration Business Leaders
St Mary's Medical Center


St. Mary's 750kW cogeneration system, providing heat, power, and savings.

Hospitals, like many businesses, run on very tight budgets and any opportunity to save money without reducing the quality of a patient's care is a welcome one. St. Mary's has found they could do just that, by generating their own heat and power at the medical center. They have installed a 750kW natural gas powered cogeneration system to provide 95% of their electrical needs, and more than 50% of their heating needs. The system uses a Waukesha reciprocating engine, and was designed and installed by American Energy Assets in just under a year. St Mary's was able to defray some of the cost of their $2.0 million system through California's Self-Generation Incentive Program, providing $450,000 in assistance.

The system began operation in September 2006, and is already providing drastic savings for the hospital. Even while the system is being optimized, the hospital is already saving an average of $23,000 per month during its first six months of operation. Sam Jayme, the Assistant Chief Engineer, is happy to report the system is on track to pay for itself in about 4 ½ years. Though dazzled by the savings, Sam believes there is more that can be done for the medical center's energy consumption, and is pushing for other energy efficiency measures, such as the replacement of all inefficient lightbulbs and exit signs.


Assistant chief engineer, Sam Jayme (left), displaying the computer software that monitors their heat and power system.

Waukesha Engines www.waukeshaengine.com
American Energy Assets www.americanenergyassets.com
St. Mary's Medical Center www.stmarysmedicalcenter.org

Appendix C – San Francisco Potential Office Building Market

A list of the largest commercial buildings in San Francisco has been compiled with the assistance of the Assessor's Office. This list has been used to derive a first estimate of the potential for cogeneration installations in the city. Using existing cogeneration systems in office buildings as a guide, a conservative calculation has been estimated as follows:

Building Size (Square Feet)	Average System Size (MW)	Number of Potential Buildings	Potential Power (MW)
> 800,000	1.5	14	21
450,000 – 800,000	1.0	28	28
250,000 – 450,000	0.5	49	24.5
200,000 – 250,000	0.25	22	5.5
		Total:	79

Not included in this estimate are buildings in the Commercial Retail or Commercial Miscellaneous classes, any of the new buildings being constructed in the city, or any buildings with less than 200,000 square feet of space. These omissions could each contribute multiple megawatts of power to the city.

The codes for the building report from the Assessor's Office are as follows:

Use Code	Description		Class Code	Description
COMH	Commerical Hotel		IW	Industrial Warehouse
COMM	Commerical Misc.		M	Motels
COMO	Commerical Office		N1	Hospitals
COMR	Commercial Retail		N2	Convalescent/Nursing Homes
GOVT	Government		O	Office
IND	Industrial		A	Apartment
MISC	Misc or Mixed-Use		AC	Apartment & Commerical Store
MRES	Mult-family Residential		C	Commerical Store
			G	Garage
			H1	Hotel
			OZ	Office - Condominium
			I	Industrial
			X	Miscellaneous
			C1	Shopping Center
			OC	Office with Major Retail
			OAT	Office – "Trophy" Class
			OAH	Office – High Class A

Largest Commerical Office Buildings in San Francisco

APN	SITUS	USECDE	CLASS	SQ_FT
3713 007	1 MARKET ST	COMO	O	1,534,312
0259 026	555 CALIFORNIA ST	COMO	OAT	1,471,929
3507 040	1455 MARKET ST	COMO	O	1,320,000
0263 011	101 CALIFORNIA ST	COMO	OAH	1,300,000
3708 056	525 MARKET ST	COMO	O	1,086,700
0233 044	4 THE EMBARCADERO	COMO	O	1,084,662
3709 014	425 MARKET ST	COMO	O	996,760
3709 015	425 MARKET ST	COMO	OZ	996,760
3709 016	425 MARKET ST	COMO	O	996,760
3709 017	425 MARKET ST	COMO	O	996,760
0232 016	3 THE EMBARCADERO	COMO	O	950,741
0230 028	1 THE EMBARCADERO	COMO	O	914,264
3709 019	50 FREMONT ST	COMO	O	914,037
0292 004	68 - 82 POST ST	COMO	O	816,735
0291 012	44 MONTGOMERY ST	COMO	O	750,491
3710 018	50 BEALE ST	COMO	O	730,136
0231 023	2 THE EMBARCADERO	COMO	O	725,000
3803 005	185 BERRY ST	COMO	O	710,581
3710 020	333 MARKET ST	COMO	O	694,334
3710 019	45 FREMONT ST	COMO	O	692,000
0235 022	50 CALIFORNIA ST	COMO	O	663,487
3506 001	1 SOUTH VAN NESS AVE	COMO	O	656,844
0269 001	235 MONTGOMERY ST	COMO	O	653,245
3712 025	101 MARKET ST	COMO	O	653,000
0204 021	300 CLAY ST	COMO	O	615,957
0289 004	1 SANSOME ST	COMO	O	611,000
0266 009	1 FRONT ST	COMO	O	605,459
0264 004	1 CALIFORNIA ST	COMO	O	570,000
3718 026	201 MISSION ST	COMO	O	547,960
0813 006	1390 MARKET ST	COMO	O	532,842
0207 032	600 MONTGOMERY ST	COMO	OAT	523,000
0288 033	333 BUSH ST	COMO	O	519,235
3708 058	575 MARKET ST	COMO	O	505,120
0289 001	225 BUSH ST	COMO	O	501,686
0311 015	1 POST ST	COMO	O	488,882
0228 039	475 SANSOME ST	COMO	O	483,425
3708 043	595 MARKET ST	COMO	O	476,189
3708 059	595 MARKET ST	COMO	O	476,189
0241 025	636 - 650 CALIFORNIA ST	COMO	O	461,138
3721 001	100 01ST ST	COMO	O	460,577
1032 003	3333 CALIFORNIA ST	COMO	O	460,232
3709 012	455 MARKET ST	COMO	O	459,696
0814 020	100 VAN NESS AVE	COMO	O	448,110
0238 001	275 BATTERY ST	COMO	O	447,372
3713 006	1 MARKET ST	COMO	O	434,396
0289 005	120 MONTGOMERY ST	COMO	O	428,295
3744 003	345 SPEAR ST	COMO	O	426,760

0239 026	464 CALIFORNIA ST	COMO	O	409,013
0241 027	600 CALIFORNIA ST	COMO	O	403,629
3740 033	211 MAIN ST	COMO	O	403,600
3717 022	123 MISSION ST	COMO	O	387,598
0262 020	100 PINE ST	COMO	O	365,809
0107 007	1155 BATTERY ST	COMO	O	360,713
3735 062	75 HAWTHORNE ST	COMO	O	360,000
3724 071	155 05TH ST	COMO	O	358,400
0240 007	580 CALIFORNIA ST	COMO	O	357,700
3508 039	875 STEVENSON ST	COMO	O	355,120
0227 007	505 MONTGOMERY ST	COMO	O	354,054
3740 034	221 MAIN ST	COMO	O	350,000
3708 028	71 STEVENSON ST	COMO	O	348,000
3735 059	201 3RD ST.	COMO	O	340,000
3708 057	555 MARKET ST	COMO	O	333,038
0240 020	550 CALIFORNIA ST	COMO	O	332,672
3738 011	301 HOWARD ST	COMO	O	328,501
0328 001	760 MARKET ST	COMO	O	327,339
3794 025	160 KING ST	COMO	O	323,983
0290 011	1 BUSH ST	COMO	O	319,234
3799 001	601 TOWNSEND ST	COMO	O	301,600
3741 032	201 SPEAR ST	COMO	O	296,075
0239 029	430 CALIFORNIA ST	COMO	O	295,783
0285 006	450 SUTTER ST	COMO	O	294,416
0258 032	601 CALIFORNIA ST	COMO	O	291,463
0238 008	350 CALIFORNIA ST	COMO	O	286,332
0292 001	111 SUTTER ST	COMO	O	286,182
0329 005	870 - 890 MARKET ST	COMO	O	285,570
0289 009	180 MONTGOMERY ST	COMO	O	281,527
0288 031	101 MONTGOMERY ST	COMO	O	277,895
0259 029	315 MONTGOMERY ST	COMO	O	270,497
0236 017	100 CALIFORNIA ST	COMO	O	266,237
0260 015	75 LEIDESDORFF ST	COMO	O	265,363
0262 021	201 CALIFORNIA ST	COMO	O	262,161
0227 048	555 MONTGOMERY ST	COMO	O	261,839
0311 007	88 KEARNY ST	COMO	O	260,624
0311 008	88 KEARNY ST	COMO	O	260,624
0311 009	88 KEARNY ST	COMO	O	260,624
0311 010	88 KEARNY ST	COMO	O	260,624
0311 011	88 KEARNY ST	COMO	O	260,624
3724 070	150 04TH ST	COMO	O	260,523
0237 014	353 SACRAMENTO ST	COMO	O	252,050
0268 008	220 MONTGOMERY ST	COMO	O	251,302
1052 025	2400 SUTTER ST	COMO	O	250,000
0236 019	150 CALIFORNIA	COMO	O	249,759
3774 067	501 02ND ST	COMO	O	248,888
0267 004	100 BUSH ST	COMO	O	246,458
0208 026	601 MONTGOMERY ST	COMO	O	245,733
3707 062	33 NEW MONTGOMERY ST	COMO	O	244,804
3751 112	765 FOLSOM ST	COMO	O	244,800

3751 155	315 - 327 04TH ST	COMO	O	244,800
0208 028	655 MONTGOMERY ST	COMO	O	242,197
3744 005	2 HARRISON ST	COMO	O	232,922
0766 002	400 MCALLISTER STREET	COMO	O	231,000
0267 010	114 SANSOME ST	COMO	O	224,651
3707 051	685 MARKET ST	COMO	O	219,831
3750 073	600 HARRISON ST	COMO	O	218,645
0671 009	1388 SUTTER ST	COMO	O	216,909
3512 008	1656 MISSION ST	COMO	O	216,712
0108 007	1160 BATTERY ST	COMO	O	215,359
3717 001	100 SPEAR ST	COMO	O	215,062
0695 005	1255 POST ST	COMO	O	214,422
0260 010	300 MONTGOMERY ST	COMO	O	211,947
0260 001	425 CALIFORNIA ST	COMO	O	206,191
0266 001	111 PINE ST	COMO	O	206,034
3717 020	180 HOWARD ST	COMO	O	205,690

Largest Other Buildings in San Francisco

APN	SITUS	USECDE	CLASS	SQ_FT
0666 030	1661 PINE ST	COMM	AC	524,271
3789 026	2 TOWNSEND ST	COMM	AC	433,191
1079 025	1410 - 1414 SITUS TO BE ASSIGNED ST	COMM	N1	420,000
3750 089	339 - 349 SAINT FRANCIS PL	COMM	AC	419,790
0277 025	900 HYDE ST	COMM	N1	400,598
0316 002	301 MASON ST	COMM	G	393,285
0253 020	1111 - 1175 CALIFORNIA ST	COMM	U	347,204
1077 027	1600 DIVISADERO ST	COMM	N1	346,570
3786 037	645 05TH ST	COMM	U	288,570
0318 005	525 JONES ST	COMM	G	285,584
3702 051	670 - 678 STEVENSON ST	COMM	AC	266,470
1539 002	4131 GEARY BLVD	COMM	N2	261,000
3516 019	255 12TH ST	COMM	G	248,550
0259 027		COMM	G	221,443
0344 010	201B - 201B TURK ST	COMM	AC	215,636
0762 026	601 VAN NESS AVE	COMM	G	203,866
3749 062	303 02ND ST	COMR	OC	809,986
3783 009	699 08TH ST	COMR	C	717,234
3910 001	2 - 98 HENRY ADAMS ST	COMR	C	328,508
7295 021	400 WINSTON DR	COMR	C1	278,930
0314 002	101 STOCKTON ST	COMR	C	264,780
0313 017	120 STOCKTON ST	COMR	C	263,640
3733 079	881 - 899 HOWARD ST	COMR	OC	255,000
0314 001	233 GEARY ST	COMR	C	243,612
0293 009	255 SUTTER ST	COMR	C	241,918
0142 001	815 BATTERY ST	COMR	C	233,609

0452 001	851 BEACH ST	COMR	C	232,700
3930A001	2300 16TH ST	COMR	C	226,487
3704 001	901 - 919 MARKET ST	COMR	C	217,707
3783 008	600 TOWNSEND ST	COMR	C	215,875
1094 001	2675 GEARY BLVD	COMR	C	205,196
3781 003	555 09TH ST	COMR	C	201,203
4042 002		IND	I	288,600
4232 010	435 23RD ST	IND	I	279,450
4764 002	1031 - 1062 QUESADA AVE	IND	IW	230,000
4315 008	3000 3RD ST	IND	I	224,502
3790 001	600 THE EMBARCADERO	MISC	X	236,885
3722 078	151 03RD ST	MISC	X	219,760

Appendix D – San Francisco Potential Hotel Market

A compilation of the largest hotels in San Francisco is given in the table below. They have been gathered by querying the Reference USA database for hotels, and have been ordered by number of employees. The number of rooms for a select few hotels was gathered through the Bay Area Book of Lists, 2002. The 46 largest hotels (100-5,000 employees) are definite candidates for cogeneration, and there are most likely a few candidates in the 50-99 employee category as well.

San Francisco Potential Hotel Market

1,000-4,999 Employees (4)			
NAME	**ADDRESS**	**PHONE**	**FACILITIES**
Hilton San Francisco	333 Ofarrell St	(415) 771-1400	1,896 rooms; 64 meeting rooms
Marriott San Francisco	55 4th St	(415) 896-1600	1,500 rooms; 52 meeting room
San Francisco Hilton Towers	333 Ofarrell St	(415) 771-0720	1,908 rooms;
Westin St Francis	335 Powell St	(415) 397-7000	1,195 rooms; 30 meeting rooms
500-999 Employees (6)			
NAME	**ADDRESS**	**PHONE**	**FACILITIES**
Grand Hyatt San Francisco	345 Stockton St	(415) 398-1234	685 rooms; 19 meeting rooms
Hyatt Hotels & Resorts	5 Embarcadero Ctr	(415) 788-1234	805 rooms; 34 meeting rooms
Radisson Miyako Hotel	1625 Post St	(415) 922-3200	
Ritz-Carlton San Francisco	600 Stockton St	(415) 296-7465	336 rooms
The Fairmont San Francisco	950 Mason St	(415) 982-6500	529 rooms; 19 meeting rooms
Renaissance Parc 55 Hotel	55 Cyril Magnin St	(415) 392-8000	1,008 rooms; 21 meeting rooms
250-499 Employees (17)			
NAME	**ADDRESS**	**PHONE**	**FACILITIES**
Argent Hotel San Francisco	50 3rd St	(415) 974-6400	667 rooms; 18 meeting rooms
Cathedral Hill Hotel	1101 Van Ness Ave	(415) 776-8200	
Clift	495 Geary St	(415) 775-4700	
Crowne Plaza San Fran-Union Sq	480 Sutter St	(415) 398-8900	403 rooms; 10 meeting rooms
Four Seasons HOTEL-Sf	757 Market St	(415) 633-3000	
Holiday Inn San Francisco	1500 Van Ness Ave	(415) 441-4000	499 rooms; 13 meeting rooms
Hotel Nikko San Francisco	222 Mason St	(415) 394-1111	532 rooms; 16 meeting rooms
Hyatt Hotels & Resorts	345 Stockton St	(415) 398-1234	
Hyatt Regency San Francisco	5 Embarcadero Ctr	(415) 788-1234	

Inter Continental Marc Hopkins	1 Nob Hl	(415) 392-3434	
J W Marriott San Francisco	500 Post St	(415) 771-8600	
Le Meridien San Francisco	333 Battery St	(415) 392-1234	
Palace Hotel	2 New Montgomery St	(415) 512-1111	550 rooms; 22 meeting rooms
Renaissance Stanford Court Htl	905 California St	(415) 989-3500	
Sir Francis Drake Hotel	450 Powell St	(415) 392-7755	417 rooms; 13 meeting rooms
St Francis Hotel A Westin	335 Powell St	(415) 774-0357	
W San Francisco	181 3rd St	(415) 777-5300	423 rooms; 8 meeting rooms
100-249 Employees (19)			
NAME	**ADDRESS**	**PHONE**	**FACILITIES**
Best Western Carriage Inn	140 7th St	(415) 552-8600	
Best Western Intl Inc	121 7th St	(415) 626-0200	
Campton Place Hotel	340 Stockton St	(415) 781-5555	
Handlery Union Square Hotel	351 Geary St	(415) 781-7800	
Hilton Hotel Corp Western Rgn	333 Ofarrell St	(415) 440-2685	
Hilton San Francisco Fisherman	2620 Jones St	(415) 885-4700	
Holiday Inn Civic Ctr	50 8th St	(415) 626-6103	394 rooms; 4 meeting rooms
Holiday Inn San Francisco	1300 Columbus Ave	(415) 771-9000	585 rooms; 5 meeting rooms
Holiday Inn Select Sf Chinatwn	750 Kearny St	(415) 433-6600	565 rooms; 9 meeting rooms
Hotel Huntington & Nob Hl Spa	1075 California St	(415) 474-5400	
Hotel Palomar	12 4th St	(415) 348-1111	
Hyatt At Fisherman's Wharf	555 N Point St	(415) 563-1234	
Mandarin Oriental Hotel	222 Sansome St	(415) 276-9888	
Pickwick Hotel	85 5th St	(415) 421-7500	
Radisson Hotel Fisherman's	250 Beach St	(415) 392-6700	
Ramada Plaza Downtown San Fran	1231 Market St	(415) 626-8000	446 rooms; 10 meeting rooms
San Francisco Marriott	1250 Columbus Ave	(415) 775-7555	
Sheraton Fisherman's Wharf	2500 Mason St	(415) 362-5500	521 rooms; 7 meeting rooms
YMCA	220 Golden Gate Ave	(415) 885-0460	
50-99 Employees			
NAME	**ADDRESS**	**PHONE**	**FACILITIES**
Best Western Tuscan Inn	425 N Point St	(415) 561-1100	
Broadmoor	1499 Sutter St	(415) 771-9119	
Chancellor Hotel	433 Powell St	(415) 362-2004	
Comfort Inn	2775 Van Ness Ave	(415) 928-5000	
Courtyard-Fisherman's Wharf	580 Beach St	(415) 775-3800	
Galleria Park Hotel	191 Sutter St	(415) 781-3060	
Granada Hotel	1000 Sutter St	(415) 673-2511	
Hotel Milano	55 5th St	(415) 543-8555	

Hotel Monaco	501 Geary St	(415) 292-0100	
Hotel Rex	562 Sutter St	(415) 433-4434	
Hotel Triton	342 Grant Ave	(415) 394-0500	
King George Hotel	334 Mason St	(415) 781-5050	
LA Quinta Inn-Downtown	1050 Van Ness Ave	(415) 673-6400	
Maxwell Hotel	386 Geary St	(415) 986-2000	
Personality Hotels	440 Geary St	(415) 202-8700	
Prescott Hotel	545 Post St	(415) 563-0303	
The Donatello Hotel	501 Post St	(415) 441-7100	
Triton Hotel	342 Grant Ave	(415) 394-0500	
Villa Florence Hotel	225 Powell St	(415) 397-7700	
Warwick Regis Hotel	490 Geary St	(415) 928-7900	
White Swan Inn	845 Bush St	(415) 775-1755	
XYZ At West San Francisco	181 3rd St	(415) 817-7836	
York Hotel	940 Sutter St	(415) 885-6800	
20-49 Employees	Probably too small…		
NAME	ADDRESS	PHONE	
Adante Hotel	610 Geary St	(415) 673-9221	
Andrews Hotel	624 Post St	(415) 563-6877	
Beck Motor Lodge	2222 Market St	(415) 621-8212	
Beresford Arms Hotel	701 Post St	(415) 673-2600	
Beresford Hotel	635 Sutter St	(415) 673-9900	
Best Western Civic Ctr	364 9th St	(415) 621-2826	
Best Western Inn	1800 Sutter St	(415) 921-4000	
Britton Hotel	112 7th St	(415) 621-7001	
Cartwright Hotel	524 Sutter St	(415) 421-2865	
Courtyard By Marriott-Downtown	299 2nd St	(415) 947-0700	
Cow Hollow Motor Inn	2190 Lombard St	(415) 921-5800	
Cresleigh	433 California St # 7	(415) 982-7777	
Executive Hotel Mark Twain	345 Taylor St	(415) 673-2332	
Gaylord Apartments	620 Jones St	(415) 673-8445	
Great Highway Inn	1234 Great Hwy	(415) 731-6644	
Griffon Hotel	155 Steuart St	(415) 495-2100	
Grosvenor Suites	899 Pine St	(415) 421-1899	
Harbor Court Hotel	165 Steuart St	(415) 882-1300	
Heritage Marina Hotel	2550 Van Ness Ave	(415) 776-7500	
Holiday Inn Express-Fishermans	550 N Point St	(415) 409-4600	
Hotel Adagio	550 Geary St	(415) 775-5000	
Hotel Bijou	111 Mason St	(415) 771-1200	
Hotel Carlton	1075 Sutter St	(415) 673-0242	
Hotel Del Sol	3100 Webster St	(415) 921-5520	
Hotel Diva	440 Geary St	(415) 885-0200	

To complement this list of hotels, a second report was created by the Assessor's office to locate the largest commercial hotels in the city. These hotels are listed below, along with the size of each hotel (square feet). The description of codes in Appendix C applies to this table as well.

Largest Commercial Hotels in San Francisco

APN	SITUS	USECDE	CLASS	SQ_FT
0325 031	1 HILTON SQUARE	COMH	H1	1,424,230
0234 017	5 THE EMBARCADERO	COMH	H1	863,441
0244 001	950 MASON ST	COMH	H1	804,136
0330 026	55 CYRIL MAGNIN ST	COMH	H1	696,431
0295 016	345 STOCKTON ST	COMH	H1	610,645
3707 052	2 NEW MONTGOMERY ST	COMH	H1	591,732
0326 012	275 O'FARRELL ST	COMH	H1	574,080
0326 013	275 O'FARRELL ST	COMH	H1	574,080
0326 020	222 MASON ST	COMH	H1	574,080
0326 011	222 MASON ST	COMH	H1	574,080
0307 001	301 - 345 POWELL ST	COMH	H1	508,714
3706 074	50 03RD ST	COMH	H1	490,000
0307 013	455 POST ST	COMH	H1	475,679
0257 012	600 STOCKTON ST	COMH	H1	420,654
0695 006	1101 VAN NESS AVE	COMH	H1	416,333
0208 024	750 KEARNY ST	COMH	H1	323,435
3736 027	580 - 590 FOLSOM ST	COMH	H1	320,256
0255 002	1 NOB HILL	COMH	H1	310,000
0297 028	500 POST ST	COMH	H1	297,170
3722 081	185 - 187 03RD ST	COMH	H1	291,200
0646 016	1550 VAN NESS AVE	COMH	H1	282,783
0229 020	375 BATTERY ST	COMH	H1	281,581
0316 013	491 - 499 GEARY ST	COMH	H1	271,387
3701 059	1215 - 1231 MARKET ST	COMH	H2	257,526
0255 001	901 CALIFORNIA ST	COMH	H1	250,928
0023 005	1300 COLUMBUS AVE	COMH	M	249,352
0295 008	432 - 462 POWELL ST	COMH	H1	232,984
0014 001	91 - 97 JEFFERSON ST	COMH	M	220,932
3701 060	50 08TH ST	COMH	H1	202,661

Appendix E – San Francisco Potential Hospital Market

The hospital market has already been penetrated by cogeneration, but there are still several opportunities to saturate the market. A list of the city's largest hospitals is given as well as if they own a cogeneration system. As of this report, there are three active systems (H C Moffitt and UCSF Medical Center share the same UCSF system). There remains six hospitals with greater than 1,000 employees that would surely benefit from cogeneration systems, and eight smaller hospitals that could possibly benefit.

San Francisco Potential Hospital Market

5,000 - 9,999 Employees			
NAME	**ADDRESS**	**PHONE**	**Cogen System**
H C Moffitt Hospital (UCSF)	513 Parnassus Ave	(415) 476-1000	13.5 MW
San Francisco General Hospital	1001 Potrero Ave # 107	(415) 206-8000	
UCSF Medical Ctr	505 Parnassus Ave	(415) 476-1000	13.5 MW
1,000 - 4,999 Employees			
NAME	**ADDRESS**	**PHONE**	**Cogen System**
California Pacific Medical Ctr	3700 California St	(415) 600-6000	
Kaiser Permanente Medical Ctr	2425 Geary Blvd	(415) 833-2000	
Laguna Honda Hospital & Rehab	375 Laguna Honda Blvd	(415) 664-1580	
St Francis Memorial Hospital	900 Hyde St	(415) 353-6000	240 kW
St Luke's Hospital	3555 Cesar Chavez	(415) 647-8600	
St Mary's Medical Ctr	450 Stanyan St	(415) 750-5500	750 kW
UCSF Medical Ctr At Mount Zion	1600 Divisadero St	(415) 567-6600	
500 - 999 Employees			
NAME	**ADDRESS**	**PHONE**	**Cogen System**
California Pacific Medical Ctr	2360 Clay St	(415) 600-3395	
Kaiser Permanente Hospital	2200 Ofarrell St	(415) 833-2200	
Saint Francis Memorial Hosp	900 Hyde St	(415) 353-6230	
250 - 499 Employees			
NAME	**ADDRESS**	**PHONE**	**Cogen System**
Ca Pacific Medical Ctr	45 Castro St # 160a	(415) 600-6000	
Langley Porter Psychiatric	401 Parnassus Ave	(415) 476-7500	
100 - 249 Employees			
NAME	**ADDRESS**	**PHONE**	**Cogen System**
Chinese Hospital	845 Jackson St	(415) 982-2400	
Golden Gate Health Care Ctr	2707 Pine St	(415) 563-7600	
Nineteenth Avenue Healthcare	2043 19th Ave	(415) 661-8787	

Appendix F – San Francisco University and College Market

The cogeneration market in universities and colleges is nearly saturated in San Francisco. All three major universities already have large systems installed, but there may still be opportunities in some of the smaller schools. A list of all universities and colleges in San Francisco with student enrollment greater than 500 is given in the table below.

NAME	ADDRESS	PHONE	2004 Enrollment	Cogen System
Academy of Art University	79 New Montgomery	(415) 274-2200	5,995	
City College Of San Francisco	50 Phelan Ave	(415) 239-3000	39,386	
San Francisco State University	1600 Holloway Ave	(415) 338-1111	26,826	1,975 kW
University Of San Francisco	2130 Fulton St	(415) 422-5555	7,917	1,500 kW
Golden Gate University	536 Mission St	(415) 442-7000	5,322	
University Of California San Francisco	500 Parnassus Ave	(415) 476-1016	3,517	13,500 kW
California Culinary Academy	625 Polk St	(415) 216-4329	1,486	
University of California - Hastings College of Law	200 McAllister St.	(415) 565-4600	1,201	
Heald College	350 Mission St	(415) 808-3000	1,070	
California Institute	1453 Mission St	(415) 575-6100	951	
Fashion Institute Of Design	55 Stockton St # 5	(415) 675-5200	663	
San Francisco Art Institute	800 Chestnut St	(415) 771-7020	625	
New College Of California	777 Valencia St	(415) 437-3400	527	

Appendix G – San Francisco Residential High Rise Market

There is potential for the deployment of cogeneration in the residential high rise market. Three residential high rises have already successfully installed and operated cogeneration systems, one of them for nearly 20 years. The table below compiled by the Assessor's Office displays the largest multi-family residential buildings in the city. This list only shows the buildings with greater than 200,000 square feet of space. The bulk of multi-family residential buildings lies below this size, and it is expected that all locations with 100,000 – 200,000 square feet of space are viable candidates for cogeneration. Based on this table alone, an cogeneration estimate is calculate as shown below.

Building Size (Square Feet)	Average System Size (MW)	Number of Potential Buildings	Potential Power (MW)
400,000 – 520,000	0.2	3	0.6
200,000 – 275,000	0.1	10	1.3
		Total:	1.9

Largest Multi-Family Residential Buildings in San Francisco

APN	SITUS	USECDE	CLASS	SQ_FT
3537 090	25 SANCHEZ ST	MRES	A	517,232
3707 063	680 MISSION ST	MRES	A	482,781
0697 039	1400 GEARY BLVD	MRES	A	406,047
3773 100A	501 01ST ST	MRES	A	272,232
0337 020	350 TURK ST	MRES	A	247,100
3773 200A	500 BEALE ST	MRES	A	243,570
3773 300A	160 BRANNAN ST	MRES	A	243,570
0243 024	151 - 161 JOICE ST	MRES	A	220,000
0243 058	945 SACRAMENTO ST	MRES	A	220,000
0774 021	1234 MCALLISTER ST	MRES	A	216,468
0770 027	735 GOUGH ST	MRES	CO	206,860
2636 003	6 - 8 LOCKSLEY AVE	MRES	A	205,770
0697 037	1333 GOUGH ST	MRES	A	201,318

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