DISTRIBUTED ENERGY PROGRAM REPORT

# Targeted CHP Outreach in Selected Sectors of the Commercial Market

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By

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Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

# 1 Abstract

This report defines the opportunity for CHP in three specific commercial building market segments

- Smaller Educational Facilities,
- Smaller Healthcare Facilities, and
- Data Centers/Server Farms/Telecom Switching Centers

And focuses on the following questions

- Do Segments Need to be Focused Further?
- How Large Are These Segments in Terms of Power Needs?
- What Are Their Key Drivers That Can Be Used To Promote CHP in Each Segment?
- Who Are the Major Players in Each Segment?
- How Do They Make Major Equipment Purchase?

The chart on the next page summarizes the finding of this report. Ranking the resulting sub-markets by:

- Size
- Growth
- Applicability of CHP to Meet Market Concerns
- Market Concentration

And finds the best focused segments to be, in order of desirability:

- Larger Schools Over 400 kW – Particularly Secondary Schools (9-12)
- Nursing Care Facilities
- Server Farm/Data Centers
- Telecom Central Offices
- Medical Laboratories

Major issues affecting each of these markets are explored in the report in detail to provide guidance on the best manner to present the CHP concept to meet individual market concerns and needs.

| Original Target Market Segments | | | |
|---|---|---|---|
| Original Segment | Smaller Educational Facilities | Smaller Healthcare Facilities | Data Centers/ Server Farms / Telecom Switching |
| Original Definition | Smaller Schools than College Campus's which Commonly Use CHP Today | Smaller Facilities than Major Hospitals which Commonly Use CHP Today | Facilities Housing Large Electronics Systems & Having High Power & Cooling Loads |

| RESULTS - Focused Market Segment Findings | | | |
|---|---|---|---|
| First Focused Segment From This Study | K-12 Buildings >400 kW in Demand – Mainly High Schools | Nursing Care Facilities | Data and Internet Facilities Employing UPS Systems >100 kW |
| No. of Facilities | 7,400 | 15,600 | 14,000 |
| Focused Segment Size | 11.9 GW | 5.2 GW | 2.6 GW |
| Projected Growth | 350 MW/Yr. | 150-200 MW/Yr | Minimal – Near Term |
| Important Outreach Message | Emerg. Pwr/Safety<br>Public Disaster Shelters<br>Lower Operating Cost | Reliable Power/Cooling<br>Non-Evacuate Patients<br>Lower Operating Cost | Reliable Power/Cooling<br>Consistent Volt. & Freq<br>Lower Operating Cost |
| CHP Size Req. | 200-400 kW | 100-300 kW | 100-500 kW |
| Cooling Issues | Central Chilled Water | Rooftop Retrofits | Rooftop Retrofits |
| Market Concentration | High | Very High | High |
| Contacts List | Developed | Developed | Developed |

| | | | |
|---|---|---|---|
| 2nd Focused Segment From This Study | None | Laboratory Facilities | "Central Offices" |
| No. of Facilities | | 10,500 | 20,000 |
| Focused Segment Size | | NA | ~ 5 GW |
| Projected Growth | | 4% in Facilities | Moderate – Near Term |
| Important Outreach Message | | Reliable Power for Disaster Operations<br>Assured Refrigeration<br>Pathogen Containment<br>Lower Operating Cost | DC Power<br>Reliable Power/Cooling<br>Consistent Voltage<br>Red. Pwr Cond. Equip<br>Lower Operating Cost |
| CHP Size Req. | | NA | 100-250 kW |
| Cooling Issues | | | Low Cap. (30-50RT) |
| Market Concentration | | NA | Very High |
| Contacts List | | NA | Developed |

| Most Desirable States for CHP Systems | | |
|---|---|---|
| California | Illinois | Connecticut |
| Nevada | Vermont | Texas |
| Alaska | Massachusetts | |
| New York | New Jersey | |

Table 1: Summary Findings

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# 2 Introduction and Purpose

The objective of this report is to explore the desirability of three tightly focused market segments for Cooling Heating and Power systems (CHP). These segments:

- smaller educational facilities,
- smaller healthcare facilities, and
- data centers/server farms/telecom switching centers,

were selected to be compatible with the smaller CHP systems being developed under other DOE funded efforts. The first two segments, smaller education and healthcare facilities are a natural extension of the CHP market. Larger educational and healthcare campuses are currently the largest existing users of CHP systems.

The third category, data centers/server farms/telecom switching centers, are a new area which ultimately covers facilities responsible for housing, powering, and cooling large quantities of electronics equipment. The high power and cooling usage of such facilities and the potential for long term market growth makes this segment of significant interest for CHP applications.

This report:

- investigates the desirability of each segment as a market for CHP systems,
- develops the best message for reaching decision makers in each segment,
- develops the best method for reaching decision makers in each segment, and
- locates lists of the most appropriate companies to target in each segment.

With this information, truly effective outreach material can be developed and targeted to the correct potential customers.

# 3 Commercial CHP Systems - General Concepts and Economics Analysis

## 3.1 Description of CHP System

Two-thirds of all the fuel used to make electricity in the U.S. is wasted by venting unused thermal energy from power generation equipment into the air or into water streams. While there have been impressive energy efficiency gains in other sectors of the economy since the oil price shocks of the 1970's, the average efficiency of power generation within the U.S. has remained around 33% since 1960.

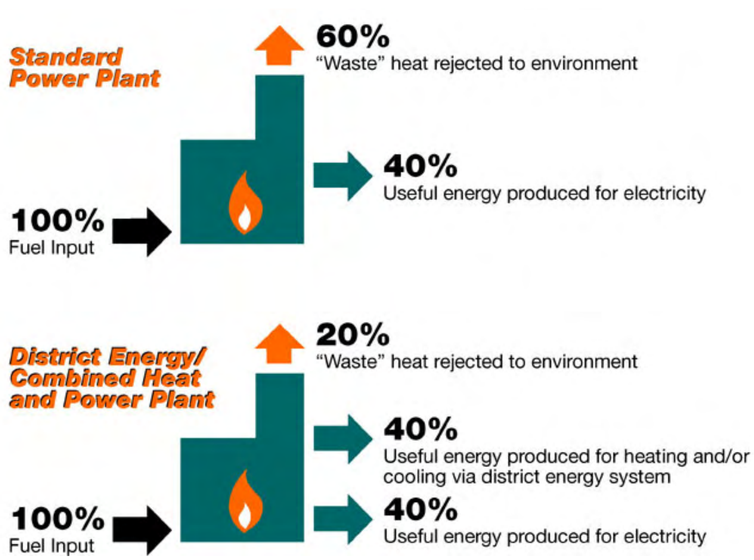


Figure 1: CHP Systems and Efficiency
*(Courtesy of the International District Energy Association)*

Integrated systems for cooling, heating, and power (CHP) production significantly increase efficiency of energy utilization by using thermal energy from power generation equipment to drive cooling, heating, and humidity control systems. These systems are located at or near the building using power and space conditioning, and can save 40% of the input energy required by conventional systems.

CHP systems for commercial buildings have to be built around the needs of those buildings. This means supplying electricity and using the recoverable heat from the system to supply some or all of the required space heating, space cooling, or domestic water hot. The systems shown in Figure 2 and Figure 3 are two ways of structuring such systems.

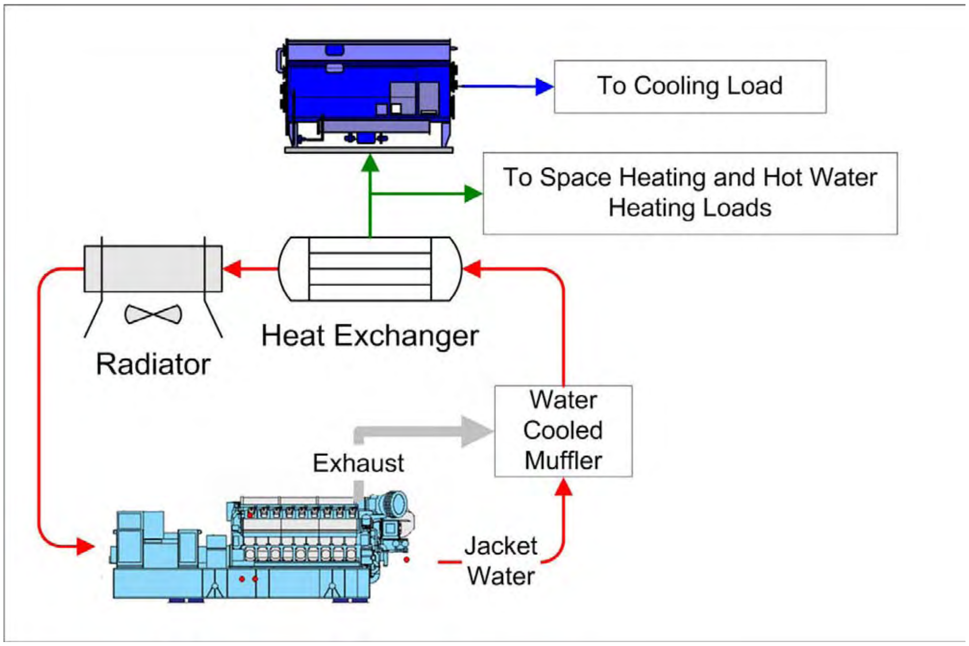


Figure 2: Simplified Engine Based CHP System for a Commercial Building
*The system shown uses an engine driven generator to provide electricity and collects heat from the engine jacket and the exhaust for space heating, water heating, and cooling. The chiller shown is a conventional hot water driven single effect absorption chiller.*

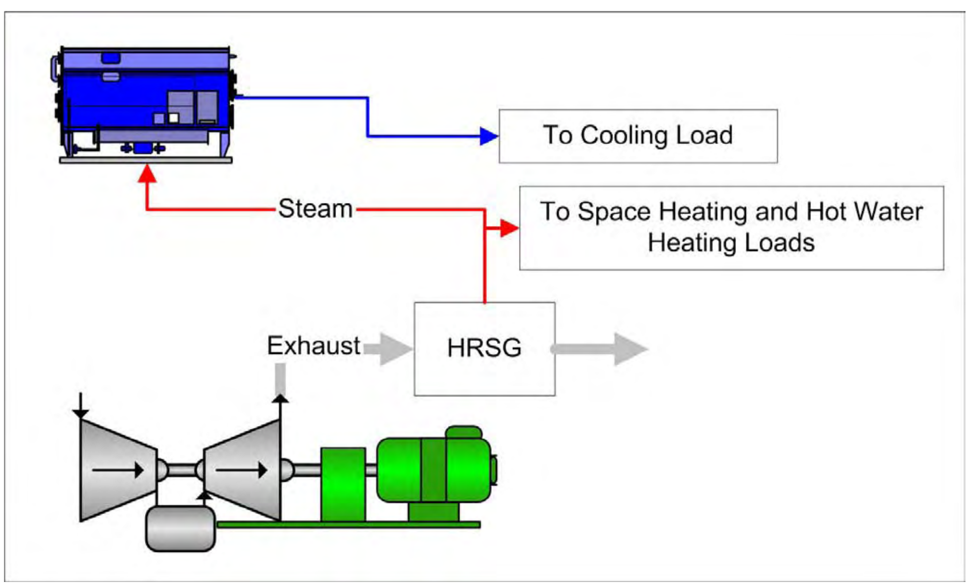


Figure 3: Simplified Turbine Based CHP System
*This system uses a gas turbine to provide electricity and collects waste heat from the exhaust stream with a Heat Recovery Steam Generator (HRSG) or a Heat Recovery Hot Water Generator. Gas turbine systems produce higher temperature waste heat, which can produce higher temperature hot water or steam. The chiller shown is a conventional steam driven absorption chiller.*

The engine-based system in Figure 2 is currently the most common arrangement. Continuous duty engine generators, and the associated heat recovery equipment, are widely available down to the 200 kW size range.

The turbine-based systems, shown in Figure 3 are used only for very large systems above at least 1 MW and often larger, generally for very large buildings or collections of buildings on a district energy system or campus.  However, the current evolution of microturbines to larger sizes may mean that turbine-based systems in the 200 kW range will be more affordable in the long run.

In addition, systems that operate double effect absorption chiller/heaters are also in development that may simplify CHP applications in the future.  However, this report assumes largely conventional equipment being used to build-up CHP systems.

## 3.2 Economics of Commercial CHP

### 3.2.1 Operating Cost of CHP Systems

The variable operating cost of a CHP system includes two major elements.

- The cost of the fuel being consumed by the engine or turbine generator
- A variable maintenance allocation generally based on the amount of power being produced by the CHP system

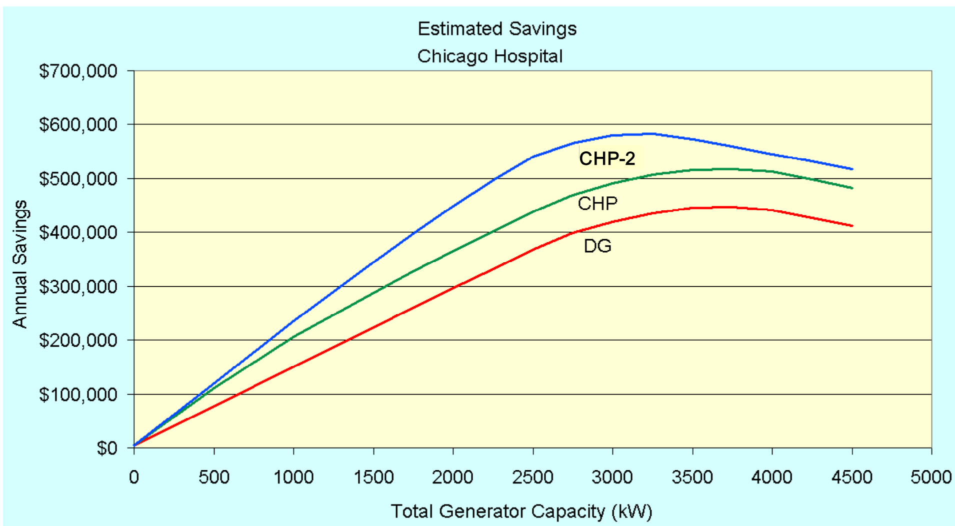


Figure 4: Operating Cost Savings[1]
*CHP uses recoverable heat for heating, whereas CHP-2 also uses recoverable heat for heating and cooling.*

Figure 4 shows the annual savings for CHP, CHP-2, and DG options in a large Chicago hospital. The calculation program resolves across a wide range of sizes. Note that savings rise to a point and plateau well below the building's peak load of 3800 kW. Declining savings on the right are due to utility stand-by charges.

A complete development of the operating economics, as in Figure 1 also includes:

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[1] Output from the UIC BCHP Engineering Model – a detailed model developed for assisting in the design of packaged BCHP systems for DOE and further developed for estimating economics for actual applications for the Midwest CHP Center.

- “stand-by or back-up” charges from the local electric utility to handle building electrical loads during CHP system downtime,
- supplemental power rates from the local utility to cover the portion of the electric load that is not handled by the CHP system, and
- as accurate a picture as possible of what the building electrical and thermal load will be, on an hourly basis if at all possible.
- With this information, a reasonable estimate of the operating cost and overall savings attributable to the CHP system can be made.

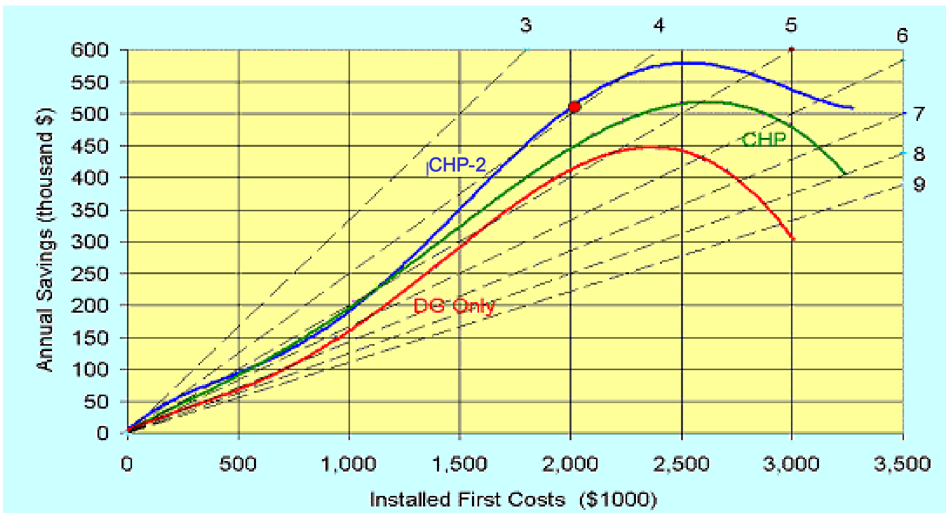


Figure 5: Finding the Economic Optimum[2]

*As the size of the system increases, the installed cost per unit of capacity decreases improving payback. Once the size reaches a level where further incremental capacity produces declining incremental operating cost savings, as seen in Figure 4, installed costs mount with lessening return and payback deteriorates producing the “S-curve” graph seen here with the optimum payback shown in red. Dashed lines are “iso-payback” lines.*

One important element in CHP design that needs to be solved from the economic analysis is the optimal size of the system. A system large enough to handle the entire electric load is generally not warranted, as the peak load occurs infrequently. However, as CHP components become smaller, the cost per unit of output increases. For any building load, there is an optimum point that will produce the shortest possible payback. This effect can be seen in

[2] Output from the UIC BCHP Engineering Model

Figure 5. The installed cost values used in Figure 5 are based on the cost data shown in Figure 6.

Notice that in the CHP system example shown in Figure 5, paybacks can be anywhere from 4 to 7 years depending on how well the system is optimized for the load. Accurately knowing where this optimum occurs can make the difference between a system that is or is not considered an acceptable investment.

### 3.2.2 Installed Costs of CHP Systems

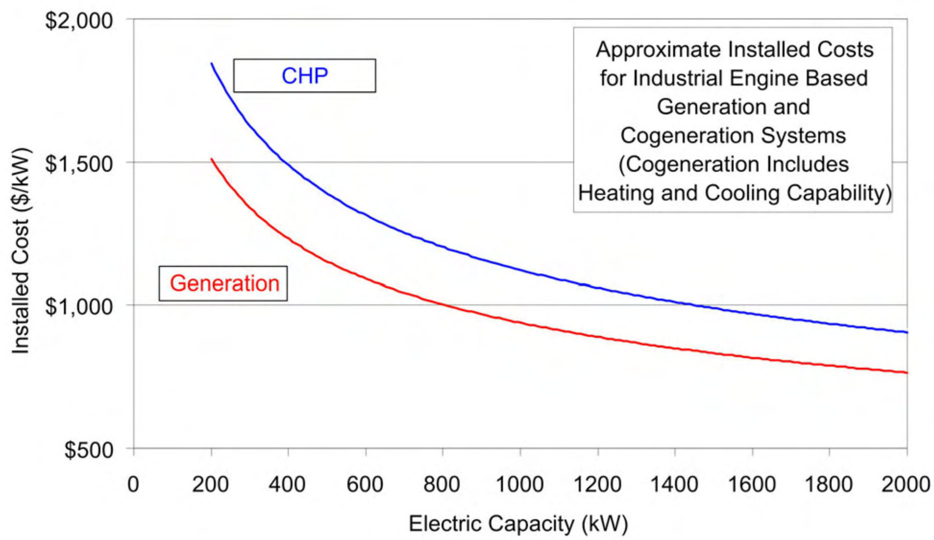


Figure 6: Approximate Installed Costs per kW for a Generation and a Commercial CHP System[3]
*The installed costs shown are approximate and do not include the cost of adding facility space for the CHP system. Costs include the incremental cost for an appropriately sizes single effect absorption chiller and all heat recovery equipment. Heat recovery is assumed to be as shown in Figure 1.*

The installed cost values shown in Figure 6 are to be used to provide guidance on the cost of DG and CHP systems. Many specific installations will involve added installation costs to handle issues such as multiple utility feeders, piping to transport heat to the point of use, or a new building to house the system. Conversely, the system may provide valuable user features that can be credited against the first cost of the CHP system, particularly back-up power capability in the event of a grid failure.

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[3] The installed cost values were developed from a collection of installation estimates and actual installations developed by the Gas Technology Institute and are used with permission.

## 3.3 Best Geographic Markets for CHP

### 3.3.1 Evaluation of CHP Economics Based on State Average Energy Costs

The CHP market is often geographically targeted by finding high electric cost areas. However, focusing entirely on regional or statewide average electric prices ignores the role that sufficiently low gas prices play in the economics. To examine the regional picture more closely, average electric and gas prices, by state were sorted by using a simple CHP graphical model.

First, a graphical model was assembled for the variable cost of generating electricity at differing gas prices. This chart is shown in Figure 7, and accounts for both fuel and maintenance cost. The top line is for simple distributed electric generation or "DG" with no heat recovery. The lower lines, moving downward, account for increasing levels of heat recovery by deducting the gas that is not required in a separate boiler, and, in a sense, crediting that gas savings to the cost of producing electricity.

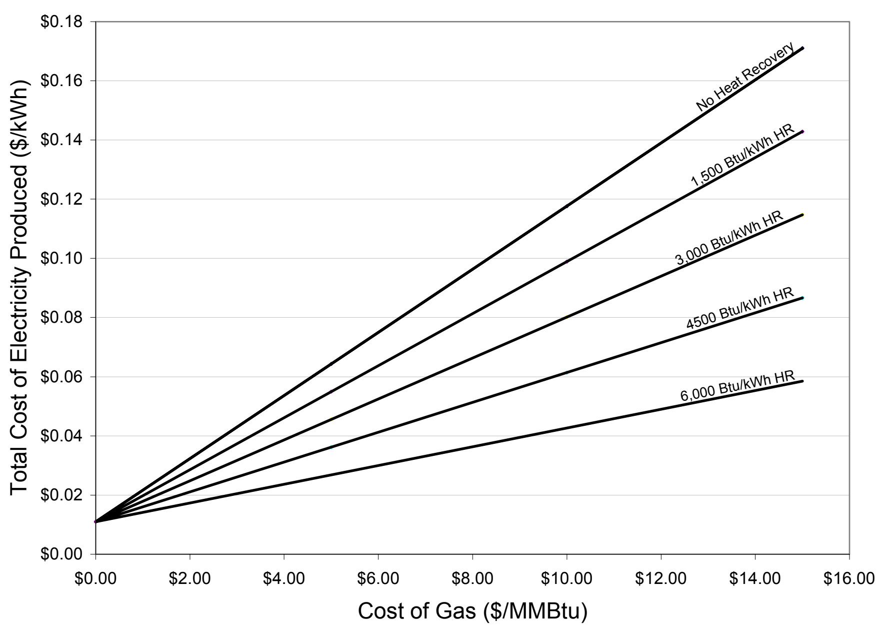


Figure 7: Variable Cost of Generating Electricity at Differing Gas Prices
*Cost includes fuel and maintenance from a 32% efficient engine generator with varying levels of heat recovery. The y-intercept is set by the $0.011/kWh. maintenance charge generally assumed for engines. Higher engine efficiencies will decrease the slope of these lines. Switching from engines to gas turbines generally lowers this maintenance charge to the $0.006-$0.008/kWh range.*

The various lines on the chart represent differing systems.

- The “No Heat Recovery” line is for an electric generation-only system.
- The 1,500 Btu/kW line is typical for engine cogeneration systems with high-pressure steam (125 psig) heat recovery from the exhaust heat only. Such a high temperature delivery systems are not needed in commercial buildings, except some hospitals, but may be appropriate for industrial loads.
- For engine cogeneration systems with typical hydronic heat recovery (180-250$^{o}$F) on the jacket and engine exhaust system, or for larger gas turbine prime movers, the useful heat recovery should be between 4,000 and 5,000 Btu/kWh. The 4,500 Btu/kWh line is a reasonable estimate.
- The 6,000 Btu/kWh is only for cogeneration systems feeding low temperature processes or hot water loads (140$^{o}$F and below).

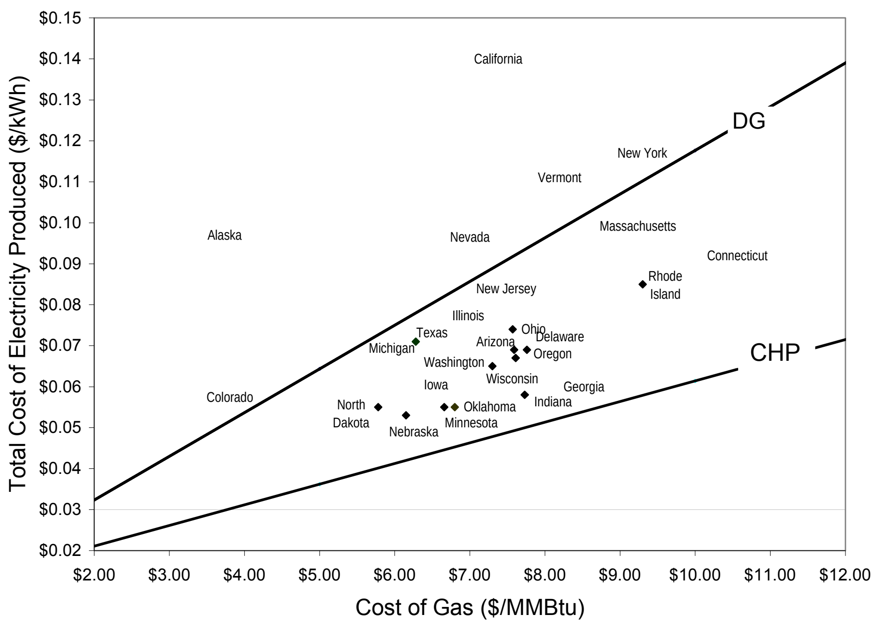


Figure 8: Average Energy Prices by State vs. Operating Cost Lines

*For CHP to be practical, the variable operating cost line must be below the energy cost point. This distance is the savings per kWh generated. The DG line is the “No Heat Recovery” line from Figure 7. The CHP line is the 4,500 Btu/kWh heat recovery line from Figure 7.*

At this point, the average prices of gas[4] and electricity[5] in various states can be plotted on the graph as shown in Figure 8. The "No Heat Recovery" line is also shown in Figure 8, marked as DG. The CHP line is for 4,500 Btu/kWh, typical of a commercial building heating and cooling system.

For CHP to be practical, the savings must be sufficient to payback the first cost of the equipment in a reasonable number of operating hours. In Figure 9, this DG line is eliminated, and "iso-savings" lines have been added for the CHP system.

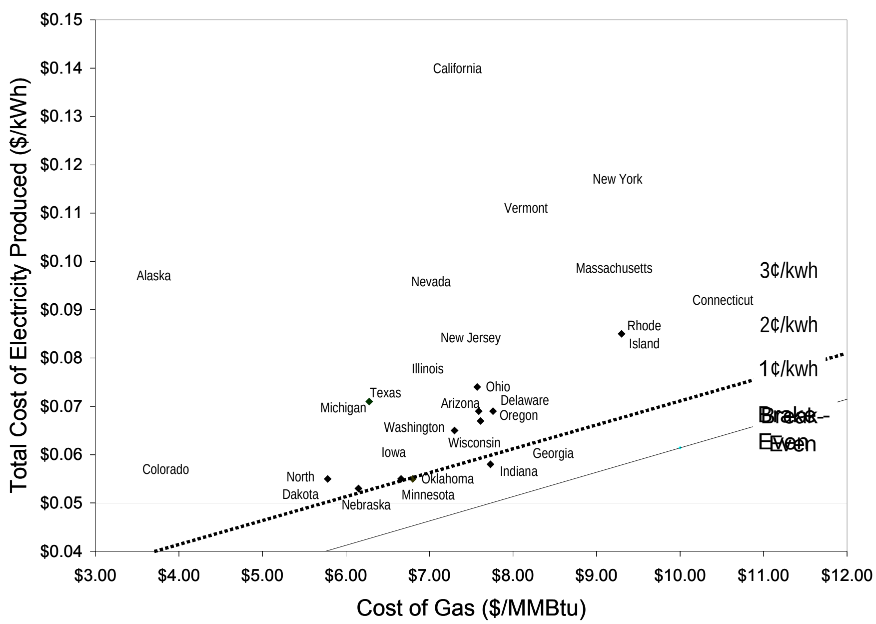


Figure 9: CHP Savings per Operating Hour for Differing Locations
*Note that these are average values for entire states. Specific large urban areas can have much different values. For instance New York City will be substantially higher on this chart than the overall state. However, we can see desirable regions on this chart.*

The most desirable areas for CHP are those above the 3¢ per kWh savings line, which are shown in Table 2. Theses states are currently of the greatest interest for CHP, but this does not imply that CHP is impractical in other areas. Due to large variations in actual delivered

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[4] Energy Information Administration/Natural Gas Monthly April 2003, Table 4, Selected National Average Natural Gas Prices, 1997-2003, and Table 22. Average Price of Natural Gas Sold to by State,2001-2003

[5] Energy Information Administration, Form EIA-826, "Monthly Electric Utility Sales and Revenue Report with State Distributions.", Values for December 2002

electric prices for differing loads, and the effect of demand charges, a properly designed system, taking into account factors in local rate structure, can often produce good economics even in other states.

| Most Desirable States for CHP Systems | | |
|---|---|---|
| California | Illinois | Connecticut |
| Nevada | Vermont | Texas |
| Alaska | Massachusetts | |
| New York | New Jersey | |

Table 2: States Currently Most Desirable for CHP

*Theses states are currently of the greatest interest for CHP, but this does not imply that CHP is impractical in other areas. Electric prices in Hawaii are too high to be seen on this chart. Also, No. 2 fuel oil prices may be lower than gas prices in the northeastern states making diesel engines an alternative. Diesel fuel will also be cheaper in Hawaii.*

### 3.3.2 Sensitivity to Application Types and Operating Strategies

Results shown in the last section have to be interpreted carefully. The use of average commercial revenues in evaluating various states can "wash away" the potential savings for specific applications. For example, the true cost of electric power for a specific application can vary widely depending on the magnitude of the demand charges and the load factor of the application.

The demand charge is a charge levied by the electric supplier on the peak electric consumption rate during any billing period, which is usually roughly one month. This is stated in $/kW per billing period. For instance, if a building consumed 100,000 kWh per month and the peak rate of consumption at any one time was 1,000 kW, the owner would pay the energy charge (in $/kWh) times 100,000 PLUS the demand charge in $/kW times 1,000.

The load factor is the result of dividing the monthly electric consumption by the monthly peak demand and then by the number of hours in the month. The result is a number between zero and one, and represents the average load divided by the maximum load. If the electric load were constant throughout the month, the load factor would be 1.0. For commercial buildings the load factors are well below 1.0. Note that the load factors discussed here are monthly load factors as this is the manner on which most demand charges are calculated. The load factor calculation can also be done on an annual basis.

The load factor ranges in Figure 10 are ranges based on the operating hours of differing building types. For example, most office buildings operate 10-12 hrs per day, 5 days per week, with some operating mechanical systems for 6 hours on Saturday or 23-30% of all hours within a month. In addition, the overall electric loads within the building are well below maximum in the morning and evening, which only serves to lower the factor further. A reasonable range of load factors below 28% is appropriate for offices.

Retail buildings operate longer hours, including full weekend schedules, making their load profiles higher. Hospitals have yet a higher load factor, as they are around-the-clock operations. However, occupancy and equipment loads drop dramatically at night, keeping load factors well below one. The highest load factors tend to be for industrial operations where the load profiles climb towards one for three-shift seven-day manufacturing.

Energy Charges are too often mistaken for the entire cost of electricity. Figure 10 shows how differing building functions will affect electric costs. Figure 10 is used to find the "Demand Charge Adder" which can be added to the electric energy charge to find the total average cost of electricity. For facilities such as office buildings, this adder will often be larger than the energy charge itself. The effective cost of electricity will therefore vary greatly by function.

The effect of this variation when compared to equivalent energy costs for a CHP system can be extreme. An example of this is shown for a Chicago office building in Figure 11. Notice that when the effects of the demand charge are put into the overall energy costs, the point is much higher on the chart than the average Illinois commercial revenue per kWh.

Conversely, when the off-peak energy charge is plotted (for which there is no demand charge), the number is below breakeven. This shows why cogeneration systems in the Chicago area generally run during the weekday, but are shut-off at night and on weekends. This is to prevent any "money-losing" off-peak operation from eating up the profits from the on-peak daytime plant operation.

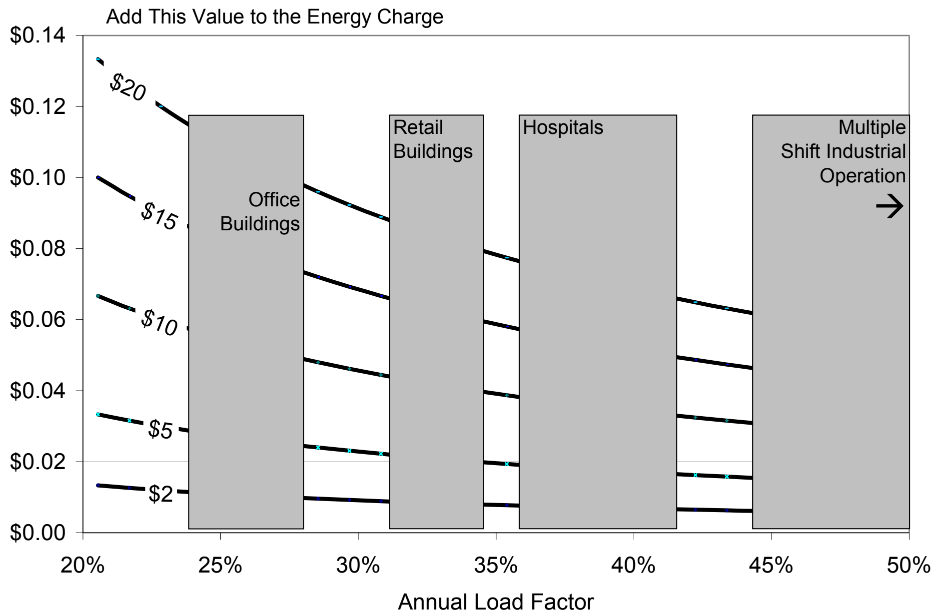


Figure 10: The Effect of Building Function on the Cost of Electricity
*The Demand Charge Adder should be added to the energy charge to find total cost. For example: a retail building with energy charge of $0.06/kWh and Demand Charge of $15/kW/Month. Using the "$15" line, the demand charge adder is $0.08. The overall cost of electricity is $0.06/kwh plus $0.08 for a total of $0.14/kW.*

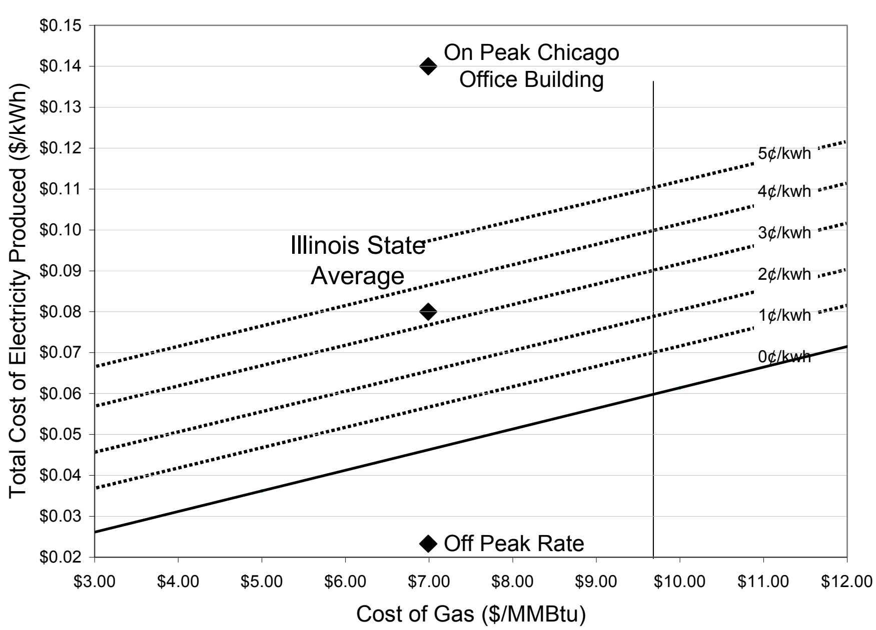


Figure 11: Total Cost Chart with Chicago time of day specifics
*The rate shown is the Chicago 6L large commercial rate.*

## 3.4 Best Market Sectors for CHP Today

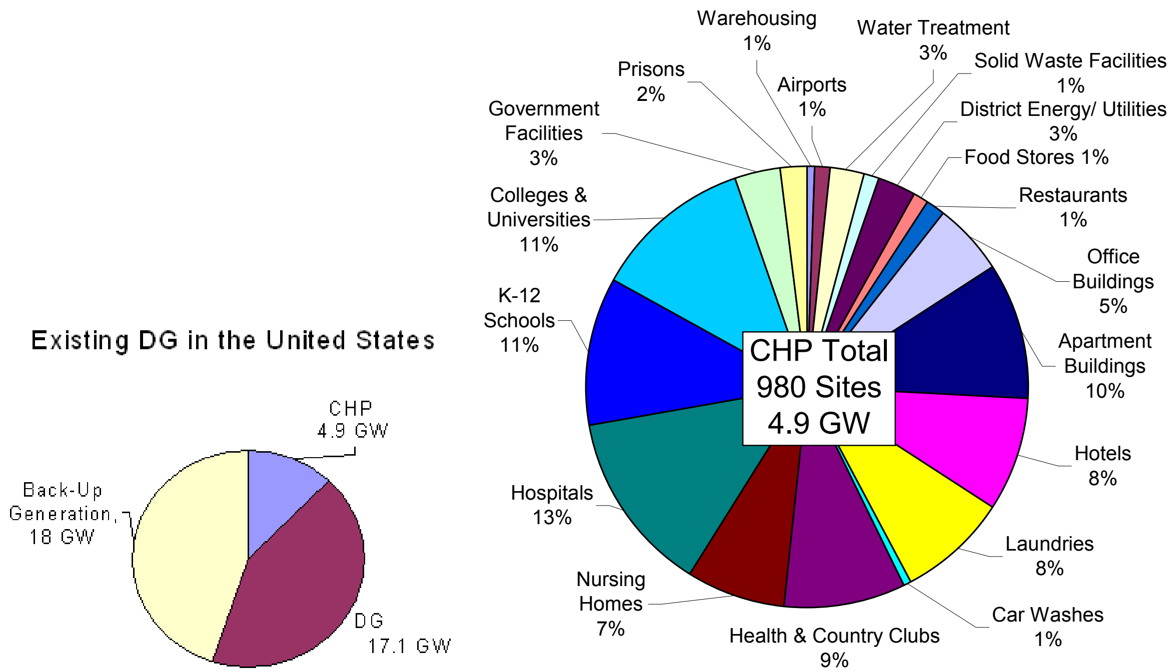


Figure 12: Existing Distributed Generation and Commercial Building CHP in the United States[6,7]
*CHP in Schools is a significant segment of the currently small CHP market (by number of sites) though the total power installed is small. These figures do not include industrial applications.*

A number of investigations have been done on CHP and DG applications in the United States. Figure 12 summarizes the results of two of these studies

A more recent report[8] places the total as high as 7 MW in 2000, as shown in Figure 13, but does not provide the detail seen in Figure 12. Although there are differences between the two charts, it is clear in both studies that colleges and hospitals are large markets for CHP.

The market sector targets for this report are to focus on smaller applications and new market sectors for CHP. New or "expansion" market sectors for CHP are best picked in areas on the periphery of existing established sectors. For this reason, smaller educational and healthcare

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[6] Establishing a Goal for DER: Challenging or Business As Usual, Paul L. Lemar, Jr., Vice President, Resource Dynamics Corporation, Distributed Energy Resources: The Power to Choose Conference and Peer Review, November 28, 2001.

[7] The Market and Technical Potential for Combined Heat and Power in the Commercial/Institutional Sector, ONSITE SYCOM Energy Corporation, Prepared for: U.S. Department of Energy, Energy Information Administration, 2000

[8] EEA CHP Installation Database: CHP Capacity in 2000, EEA, Presentation at the ACEEE - CHP Analysis Meeting, July 14, 2003, Washington DC

facilities were chosen for this study. Smaller education referring in general to K-12 schools. Smaller healthcare facilities simply mean anything smaller than general hospitals.

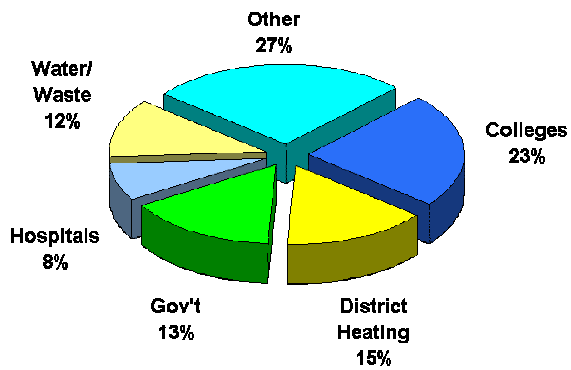


Figure 13: Existing Commercial CHP Capacity:
*Total of 7.1 GW*

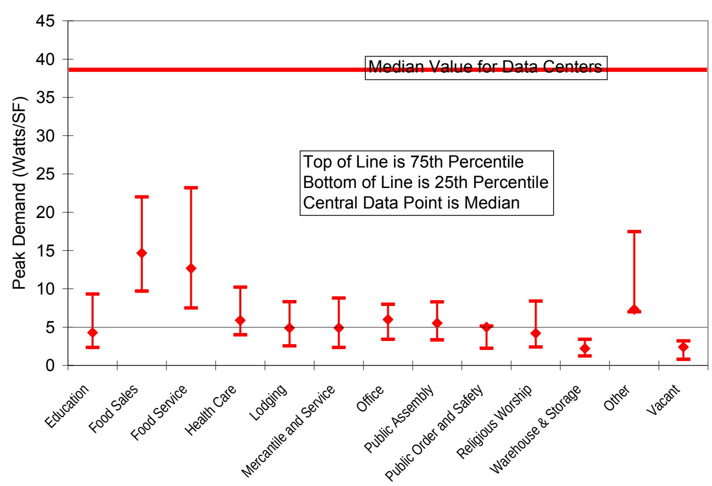


Figure 14: Energy Demand of a Typical Server Center and Other Commercial Building[9]

Internet server spaces, computer rooms, and telecom centers have very high power and cooling consumption, as seen in Figure 14, making these facilities good candidates for CHP. However, there is not much information available about the size of this market and information on how CHP can be applied to the needs of this market specifically needs to be developed. For this reason, this was selected as the third market sector to be explored here.

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[9] Internet Server Center value developed in this report. Values for other buildings are from the Energy Information Agencies CBECS Data Base

## 3.5 Summary

Although a large number of issues can play into CHP economics, including specific customer needs such as back-up power, and electric costs can vary widely by end-use application, average power prices can be used to establish best general geographic markets for CHP. Currently, these are, by state:

| Most Desirable States for CHP Systems | | |
|---|---|---|
| California | Illinois | Connecticut |
| Nevada | Vermont | Vermont |
| Alaska | Massachusetts | Texas |
| New York | New Jersey | |

# 4 Smaller Educational Facilities

Primary and secondary (K-12) education facilities have been put forward as a desirable new CHP market segment, based on the extensive use of CHP in larger educational facilities[10,1112] and the large number of back-up power systems found in K-12 facilities[13]. The following information is presented in this chapter

- The desirability of the K-12 facility market sector for CHP applications will be found. This determines IF this sector should be a focus for CHP outreach materials.
- The specific needs of this sector will be explored to determine the most important benefits that CHP can bring to all or perhaps specific portions of this building sector. This determines WHAT such CHP outreach materials should say by finding the most effective and market relevant message.
- Determine the decision makers in this market segment and how best to reach them. This determines the WHO and HOW for future outreach programs.

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[10] International District Energy Association, *Cooling, Heating, and Cooling, Heating, and Power in the Nation's Power in the Nation's Colleges & Universities Colleges & Universities: Census, Survey, and Lessons Learned Census, Survey, and Lessons Learned*, Presentation on a Report for Oak Ridge National Laboratory and Report for Oak Ridge National Laboratory and the United States Department of Energy, November 21, November 21, 2002

[11] *Combined Heat and Power (CHP): Applications of Distributed Power, Overview of Opportunities and Market Prospects*, Paul L. Lemar, Resource Dynamics Corp., Intertech Distributed Power Conference Washington, DC, September 25, 2000 .

[12] Census of Central Plant District Energy and CHP Systems at Colleges, Universities ,
http://www.districtenergy.org/CHP_Census/CHPCensusWebsitePhaseII/OtherCensusPages/census_homepage.htm

[13] *Commercial Market Segmentation Study, National Educational Sector*, AGA/GRI, January 1998 GRI 97/0385

## 4.1 Market Segment Desirability

For a specific market to be particularly desirable for CHP applications, it should be 1) sizable, 2) healthy or growing, and 3) have characteristics that will make CHP more highly desirable than for the average commercial building. In this section, the statistical background will be developed on this sector.

### 4.1.1 Market Size

For a market to be of interest, it has to be sizable. There are over 91,000 K-12 schools in the United States, comprising a very small segment of the overall 4.6 million commercial buildings. However, due to their large size, K-12 schools comprise 4.98 billion square feet of the overall 58 billion square feet of commercial floor space, or roughly 9% of the overall commercial floor space. The peak electric demand of these buildings is 25,580 MW.[14] However, many of these facilities are smaller than would be desirable for most CHP systems.

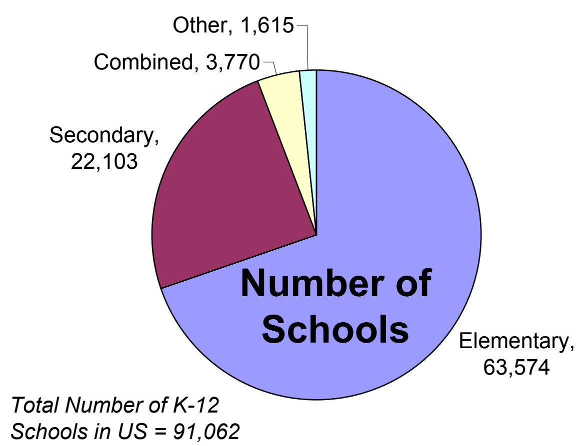



Figure 15-Number of Primary and Secondary Schools in the United States[15]

CHP systems, except for microturbines, produce better paybacks with a load of at least 400 kW.

[14] Source: Energy Information Administration, Office of Energy Markets and End Use, Commercial Buildings Energy Consumption Survey

[15] Data from *U.S. Census Bureau, Statistical Abstract of the United States: 2001*, *Section 4, Education*, No. 229. Public Elementary and Secondary Schools by Type and Size of School:1998-99

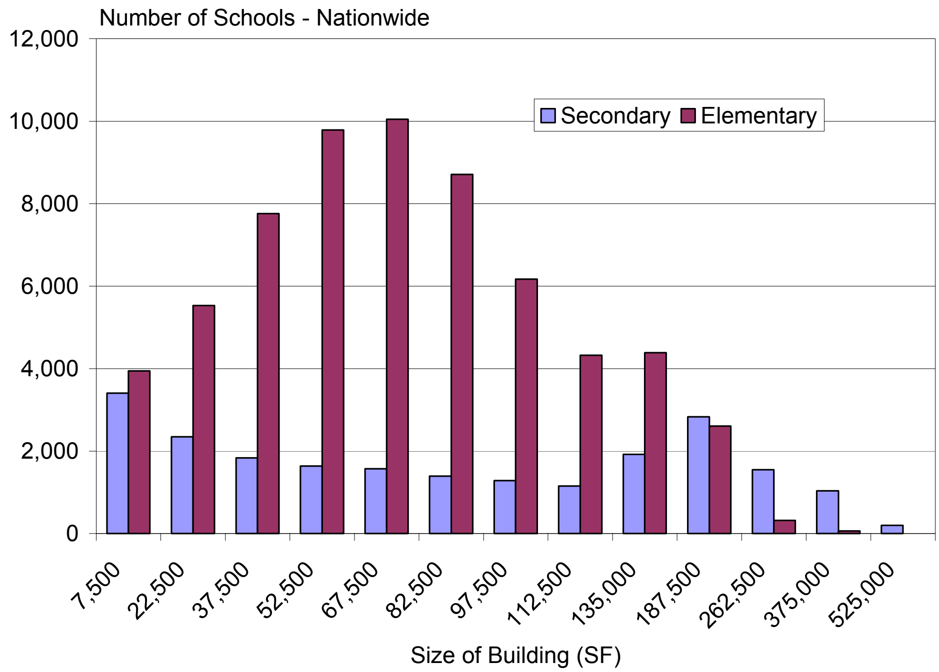



Figure 16: Size of Schools by Floor Space and Electric Demand

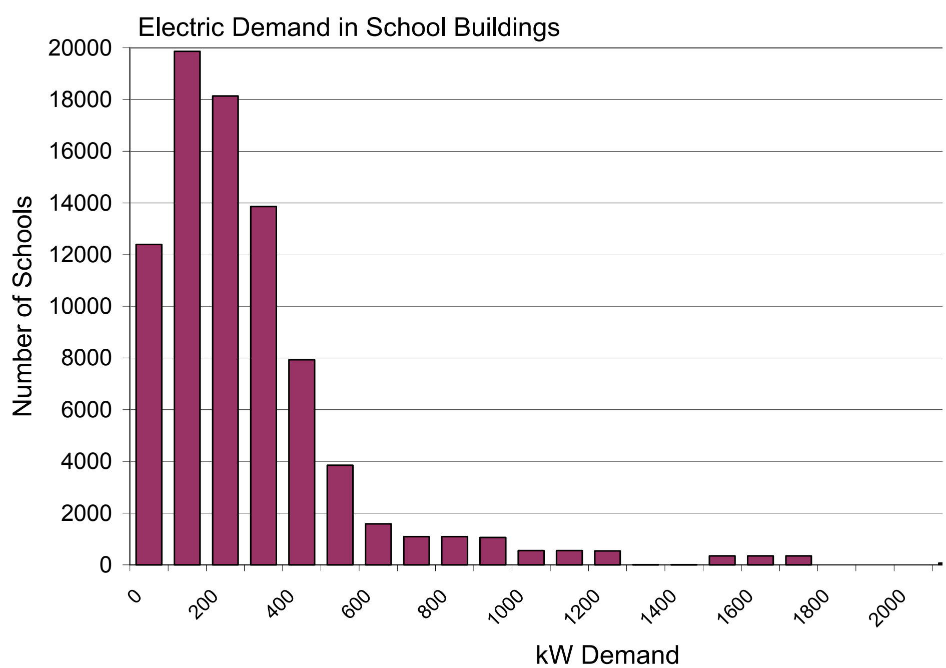
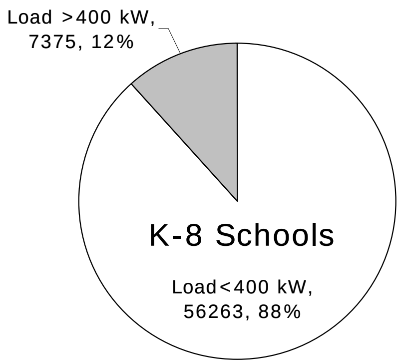
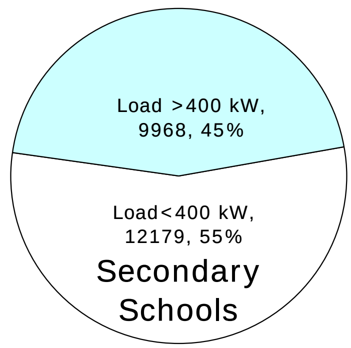



Figure 17: Size of Schools by Floor Space and Electric Demand

Available data on the distribution of enrollment in schools[16] was used to project school sizes from known values of floor space per student[17]. This is shown in Figure 16. National average values for power consumption in schools[18] were then used to project the distribution of peak power requirements for K-12 schools are shown in Figure 17. Only a minority of K-12 facilities exceed 400 kW. Figure 18 shows how these 400+ kW facilities break down between primary (K-8) and secondary (9-12) educational facilities. Secondary facilities are much more inclined to be over 400 kW.




| | Elementary | Secondary |
|---|---|---|
| All | 63,638 | 22,147 |
| All Over 400 kW | 7,375 | 9,968 |

Figure 18: Number of Schools above 400 kW[19,20]
*Nationwide, Elementary Schools Outnumber High Schools by Nearly 3-1. However, a Much Larger Portion of the High Schools are Over 400 kW in Electric Demand. Number of facilities total 85,785, which is lower than the 91,062 due to Combined and Unclassifiable specialty schools*

Clearly, secondary schools are more likely to employ CHP than primary schools. In addition, a market focus directly on secondary schools reduces the cost of the outreach

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[16] Based on U.S. Census Bureau, *Statistical Abstract of the United States: 2001, Section 4 Education*, No. 229. Public Elementary and Secondary Schools by Type and Size of School:1998-99

[17] Based on and 150 sq.ft./student for Secondary Schools and 110 sq.ft. for Primary Schools which are the National Average from *School Planning & Management*, 2002 Construction Report by Paul Abramson, Education Industry Analyst

[18] Source: Energy Information Administration, Office of Energy Markets and End Use, Commercial Buildings Energy Consumption Survey.

[19] Based on and 150 sq.ft./student for Secondary Schools and 110 sq.ft. for Primary Schools which are the National Average from *School Planning & Management*, 2002 Construction Report by Paul Abramson, Education Industry Analyst, TABLE 5 Profile of New Schools Currently Underway (School Construction Ending in 2002)

[20] Additional information on Floor Space per Student from: Topic Issue Trackers: Gross Square Feet per Student, Dr. Art Wohlers, November 1995 The Council of Educational Facility Planners, International

efforts as the target customers are reduced from all K-12 schools, which number 91,000 to only 9-12 schools which number 22,000. Secondary schools also have other advantages.

- Secondary schools are more likely to be operated 12 months of the year than primary schools, which may have little or no summer programs. Summer-school operation of CHP systems allows the facility to avoid high demand charges that would be incurred even during a short-day summer-school schedule.
- Secondary schools are far more likely to contain an indoor pool facility than primary schools. Indoor pools are a valuable heat load for CHP systems. Pools are low temperature heating loads that can absorb excess rejected heat as available, making overall operation more efficient. Although facility statistics are not available, over 5,500 high schools in the United States run intramural swim teams, a strong indication that at least 5,500 out of 22,000 high schools have indoor pools.[21]

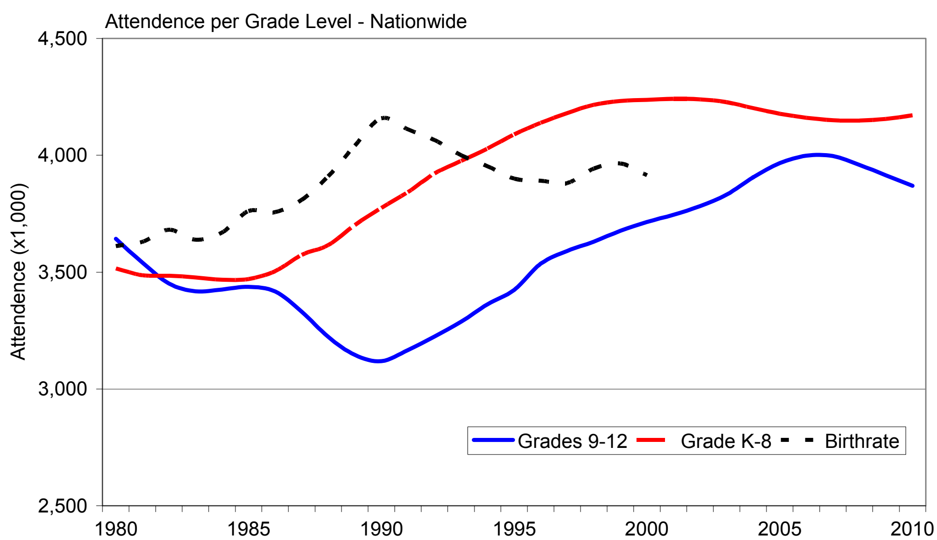


Figure 19: Birthrate Predicts School Population

- Secondary schools are more likely to be operated into the evening and on weekends than primary schools, allowing longer periods of power and heat generation.

[21] *Participation Survey, 2003*, National High School Athletics Association

- Secondary schools are far more likely to contain gymnasiums with shower facilities, adding considerably to the low temperature heating load for water heating.
- Current Census birthrate data shows the population of primary schools will plateau by 2005, whereas secondary school populations will not plateau until 2010.[22,23]

In summary, the electric demand for all 17,400 primary and secondary schools above the 400 kW size is 11,900 Megawatts. Notice that 17,400 schools are only 19% of the school facilities, but constitute 49% of the total electric demand.

[22] Source: Table No. 205. School Enrollment: 1965 to 2010, U.S. National Center for Education Statistics, Digest of Education Statistics, annual, and Projections of Education Statistics, annual.

[23] Original Graph. Projections of Education Statistics, annual and U.S. Department of Commerce, Bureau of the Census, Current Population Reports, Series P-25, Nos. 1092, 1095, and "National Population 'Estimates for the 1990s," Jan. 2001, and "Annual Projections of the Total Resident Population: 1999 to 2100," Jan. 2000.

### 4.1.2 Market Health and Growth

Overall construction expenditures in K-12 schools more than doubled between 1992 and 2001. The outlook for construction of new schools and the renovation of existing schools is strong throughout this decade. Figure 20 shows the regional projection of near term expenditures.

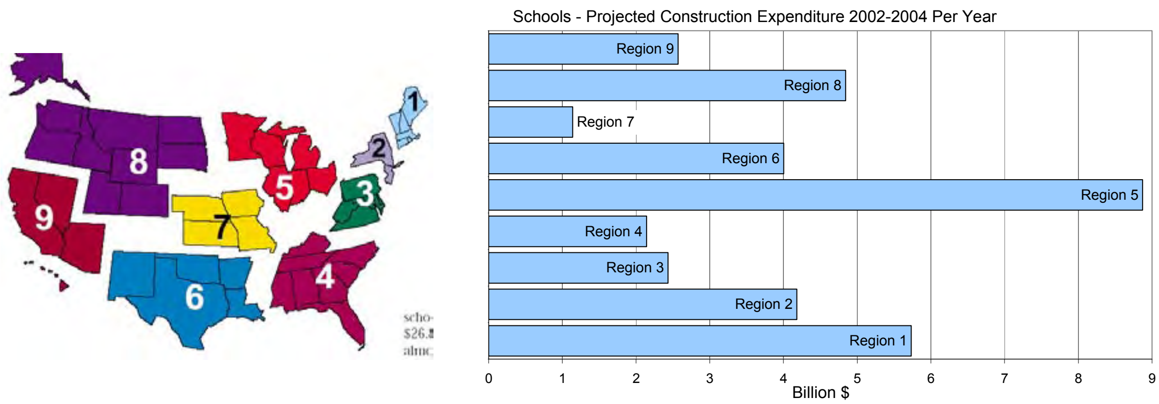


Figure 20: Near Term Construction Projections for Primary and Secondary Schools[24]
*Total Construction went from 11 Billion in 1992 to 27 Billion in 2001*

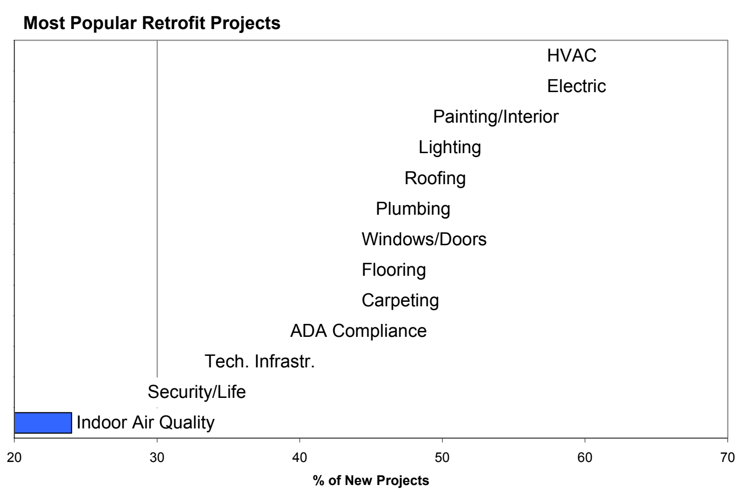


Figure 21: Most Popular Current 2002-2004 Projects[25]
*Prominence of HVAC and Electric Projects in Current Plans is Significant for the CHP Market*

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[24] Bucking The Trend, 28th Annual Official Education Construction Report, American School & University, May 2002

[25] *Bucking The Trend, 28th Annual Official Education Construction Report*, American School & University May 2002 www.Asumag.Com

This strong construction market is due to three ongoing issues in education: 1) expanding student populations, 2) inadequate existing facilities, and 3) growing new requirements in education.

#### 4.1.2.1 Expanding Student Populations

Expanding student populations will require more school floor space. 200,000 more secondary students per grade level will be added over the next 6 years. This suggests a near term expansion in the total floor space of secondary schools at 120,000,000 square feet. As CHP would be most conveniently and economically installed when schools are initially being built, this is a significant opportunity.

#### 4.1.2.2 Inadequate Existing Facilities

There is a widespread perception that current school facilities are inadequate to serve their traditional tasks for the existing student populations. A U.S. Department of Education report in 2000, estimated that $127 billion would be required to bring existing buildings into a condition rated as “adequate” or “good” in regards to basic functions such as structural integrity, heating, plumbing, and so on[26]. Even with the current student populations, 17% of schools reporting[27] make great use of portable classrooms for added instructional space and 36% make some use of such facilities. Figure 22 shows some of the systems most commonly felt to be inadequate in existing school facilities.

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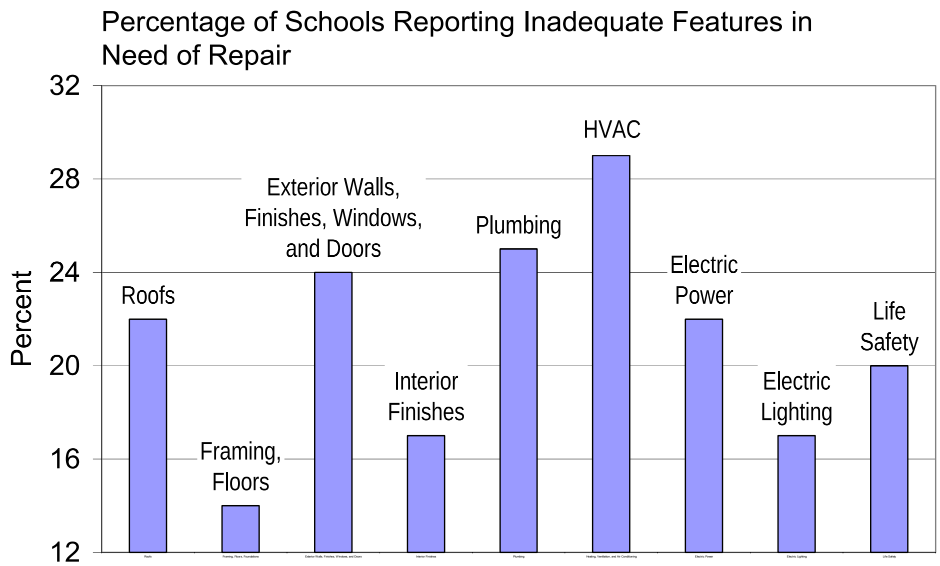
[26] *Condition of America’s Public School Facilities: 1999,* U.S. Department of Education Office of Educational Research and Improvement NCES 2000-032 Table 8

[27] *Condition of America’s Public School Facilities: 1999,* U.S. Department of Education Office of Educational Research and Improvement NCES 2000-032 Table 22



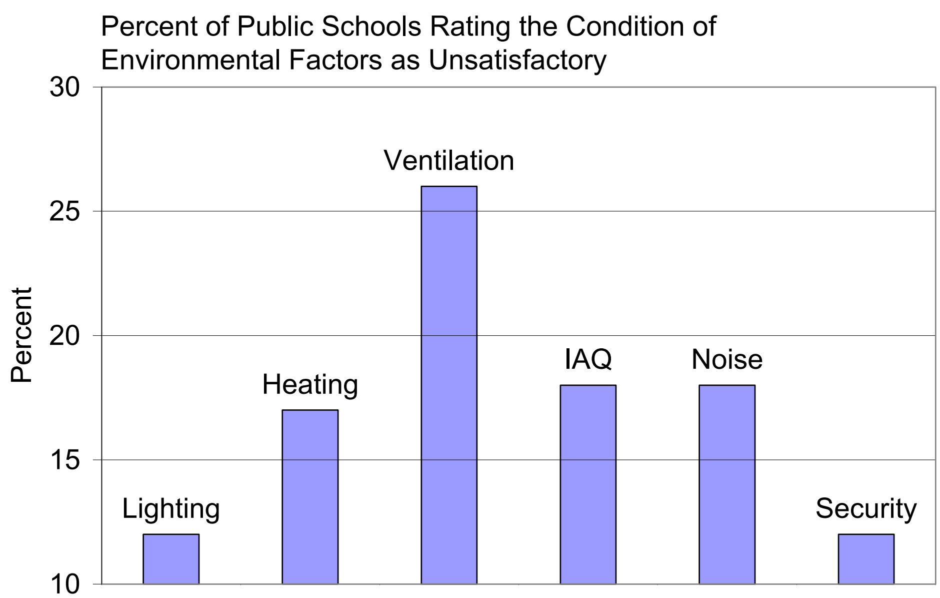




Figure 22: Renovation – Concerns and Dissatisfaction[28]
*HVAC and Power Issues, Which Can be Positively Effected by CHP Systems, are Significant or Leading Targets for Renovation. On Environmental Concerns, Ventilation and IAQ, which May be Aided by Some Types of CHP, are Important. Data is from before 2001. Low Ranking for the Security May Have Changed.*

[28] *Condition of America's Public School Facilities: 1999,* U.S. Department of Education Office of Educational Research and Improvement NCES 2000-032

#### 4.1.2.3 Growing New Requirements

Growing new requirements for education such as computer centers, Internet connections, reduced class sizes, and healthier indoor environments will increase the need for electric power. Of particular importance for CHP systems is computer proliferation in schools increasing future power demand. This is similar to that which occurred in office buildings in the 1990's. Although improvements in lighting efficiency will counteract some of this load, electric demand should be expected to increase. Reduced class sizes also tend to increase the floor space per student. Increasing emphasis on indoor air quality is generally dealt with by increasing fresh air ventilation rates, which also increases power, heating and cooling energy consumption.

### 4.1.3 Electric Demand from New Construction

Previously, it was determined that the existing stock of schools larger than 400 kW has an overall electric demand of 11.9 GW. With new construction currently underway, the growth in electric demand can also be estimated. The construction expenditures shown in Figure 20 include both new construction and renovation. In Figure 23, these expenditures are sorted in new buildings and "add/mod" which is addition and modifications projects.

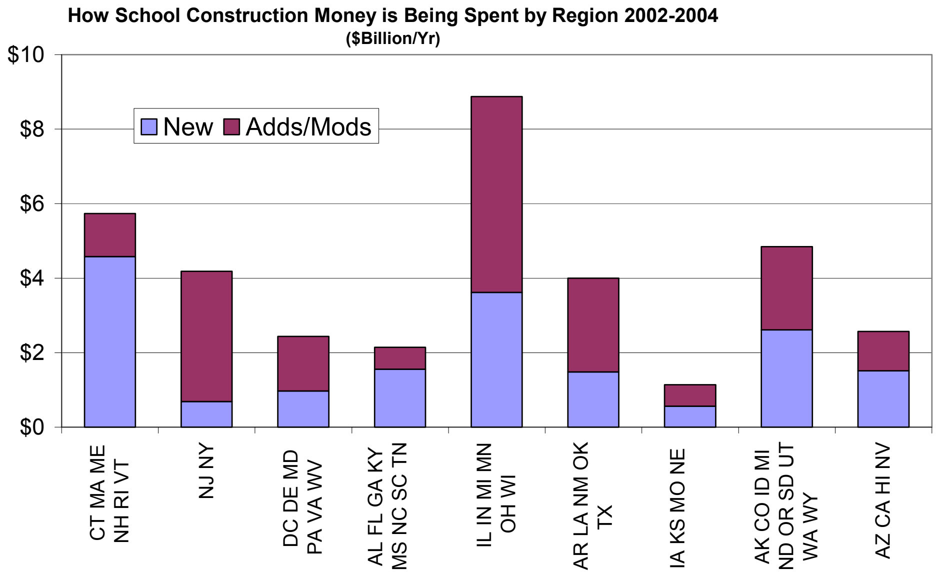



Figure 23: Expenditure Types in Schools[29]

Additions will add floor space to existing buildings and increase demand. Modification may also add demand. Overall, the amount is difficult to predict. However, statistics on new construction are available.

Figure 24 shows the considerable variation in the average cost of new school construction in differing regions of the country. Using the construction prices in Figure 24, the percentage of expenditure that are for new construction in Figure 23, and the current construction budgets in Figure 20, the floor space of new construction can be projected by region as shown in Figure 25.

[29] *Bucking The Trend, 28th Annual Official Education Construction Report*, American School & University, May 2002

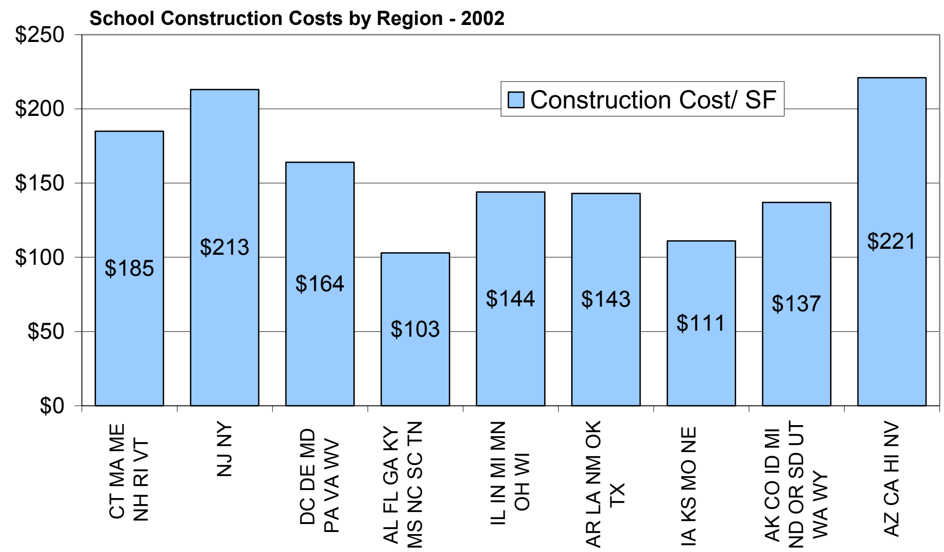



Figure 24: Differing Cost of Construction in US Schools[30]

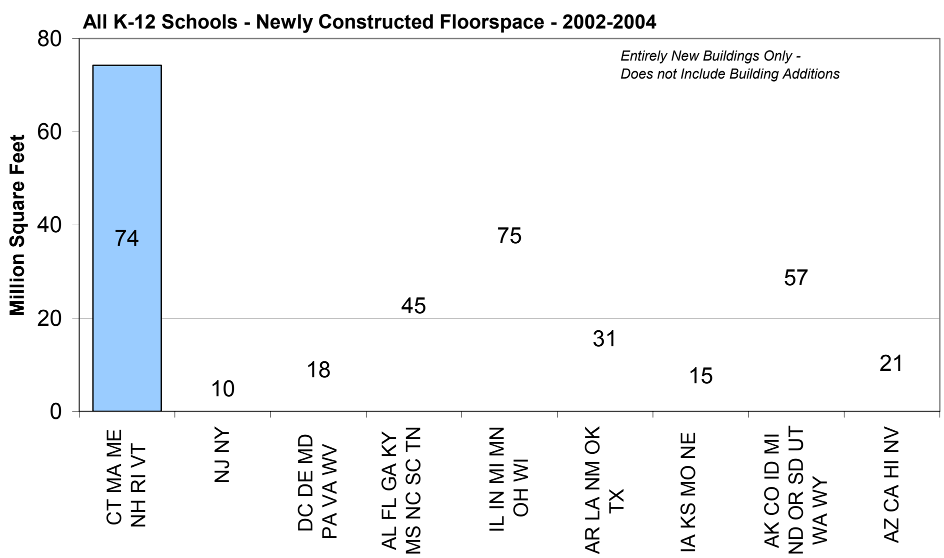



Figure 25: Square Footage added to School stock Due to New School Construction[31]
*New Square footage total to 346 Million Square Feet*

Using the median school power usage of 4.3 watts per square foot[32], the overall demand implications are as shown, by region in Figure 26. This projection is conservative for two

[30] *Bucking The Trend, 28th Annual Official Education Construction Report*, American School & University, May 2002

[31] Original Calculation Based on Figure 20, Figure 23, and Figure 24

[32] Peak Power Demand: Table 19. Distribution of Peak Watts per Square Foot and Load Factors, "U.S. Department of Energy, Energy Information Administration, "A Look at Commercial Buildings in 1995: Characteristics, Energy Consumption, and Energy Expenditures."

reasons: 1) an unknown amount of the renovation funds will be used for school additions, and 2) some renovations will be adding to internal equipment loads, such as new computer areas and so on. These two factors are not included in the electric demand growth estimate.

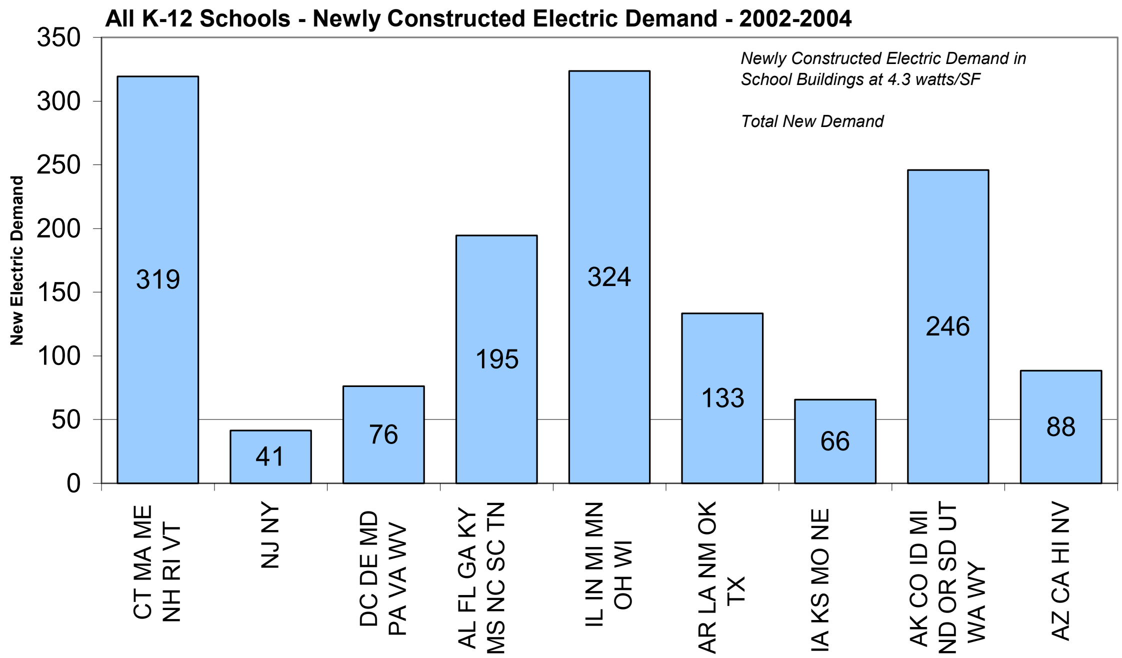



Figure 26: Added Electrical Demand for New Schools[33]
*New Demand Totals to 1,488 MW for the Two-Year Period*

The total demand growth due shown in Figure 26 is 1488 MW for the two-year period, making for a growth rate of 744 MW per year for the near term for all schools. However, to preserve the focus on larger facilities with over 400 kW of demand and remembering that this large facilities sub-sector comprises 49% of the overall current K-12 electric demand, the growth in larger K-12 schools with over 400 kW of demand is 350 MW/Yr.[34]

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[33] Original Calculation Based on Figure 25, and 4.3 watts per square foot.

[34] 49% of 744MW = 346 MW ~ 350 MW

### 4.1.4 The Compatibility of CHP with HVAC Currently Used in Schools

For CHP to be a practical retrofit in an existing facility there must be an opportune use for the waste heat being generated by the system. Facilities with centralized heating and hot water systems are more amenable to a CHP installation than a facility that uses localized or zone-by-zone heating systems, or local hot water systems.

In addition, facilities with centralized cooling systems also have a distinct advantage. Central cooling systems that dispatch chilled water to various areas of the building can be conveniently retrofit with an absorption chiller operating on the engine or turbine waste heat. Chilled water produced by the absorber can then be distributed by the same central chilled water system without any changes to the remainder of the facility.

Data on the types of systems currently used in K-12 schools is not widely available. However a survey carried out in 1998 by Gas Research Institute and the American Gas Association provides some information.

This survey was taken across the Education sector. Respondents were facility managers from 625 different facilities of which 433 were from K-12 facilities. Subdivision between elementary and secondary schools was not possible without discarding a large number of respondents as many respondents were responsible for school districts that operated both elementary and secondary schools.

| Summary of Survey Interviews and Projections | | | | |
|---|---|---|---|---|
| | Independents | System-Local Manager | System-Central Manager | Total |
| Number of Interviews | 192 | 224 | 209 | 625 |
| % Floor Space in K-12 | 3% | 100% | 91% | 73% |
| % Floor Space in Colleges | 97% | 0% | 9% | 27% |
| % Floor Space - Public | 76% | 92% | 98% | 92% |
| % Floor Space - Private | 24% | 8% | 2% | 8% |

Table 3: Description of Survey[35]

[35] *Commercial Customer Segmentation Study: National Education Sector*, GRI-97/0385, Gas Research Institute 1998

Although the survey did not break out K-12 from College responses, it is clear that the categories used could be so subdivided with little loss of accuracy. For this report, the results were reduced and K-12 facilities focused upon.

Survey responses were reduced in the original source by the area of floor space controlled by the respondent. Total facility values, shown in Figure 27 through Figure 32, project those results over all K-12 facilities in the United States.

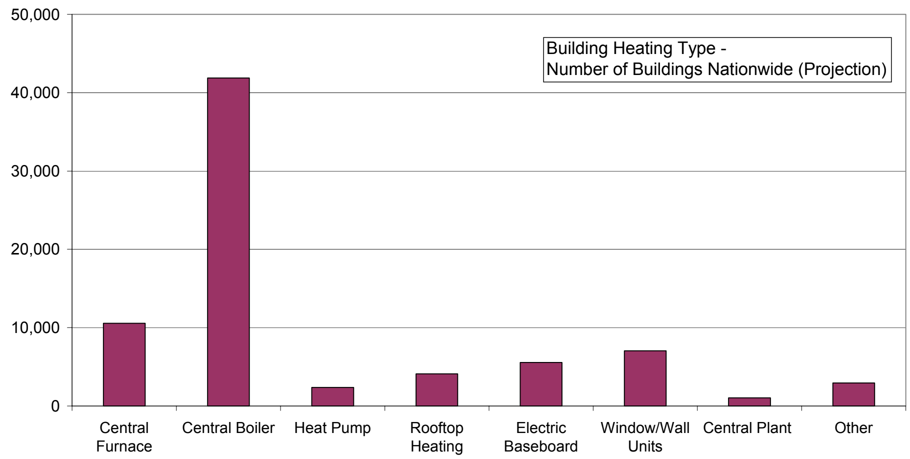


Figure 27: K-12 Building Heating System Types in K-12[36]

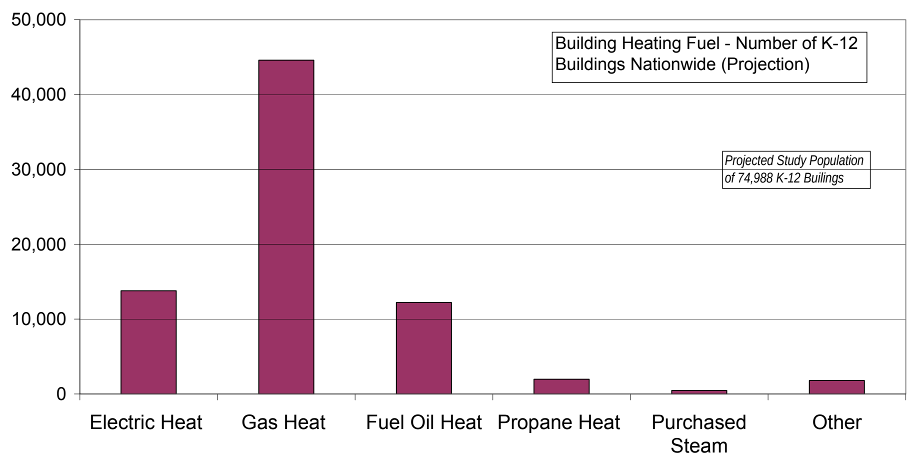


Figure 28: Building Heating Fuel Used in K-12[37]

[36] Original Projection and Chart, Data Taken from Table 4.4a, *Commercial Customer Segmentation Study: National Education Sector*, GRI-97/0385, Gas Research Institute 1998

[37] Original Projection and Chart, Data Taken from Table 4.9a, *Commercial Customer Segmentation Study: National Education Sector*, GRI-97/0385, Gas Research Institute 1998

Clearly central boilers dominate the heating system in this market nationwide and the most popular heating fuel is natural gas.  The favored equipment type will vary by region, but this was not broken out.  In all regions, gas was the dominant heating fuel with the lowest floor space percentage in the South at 57%

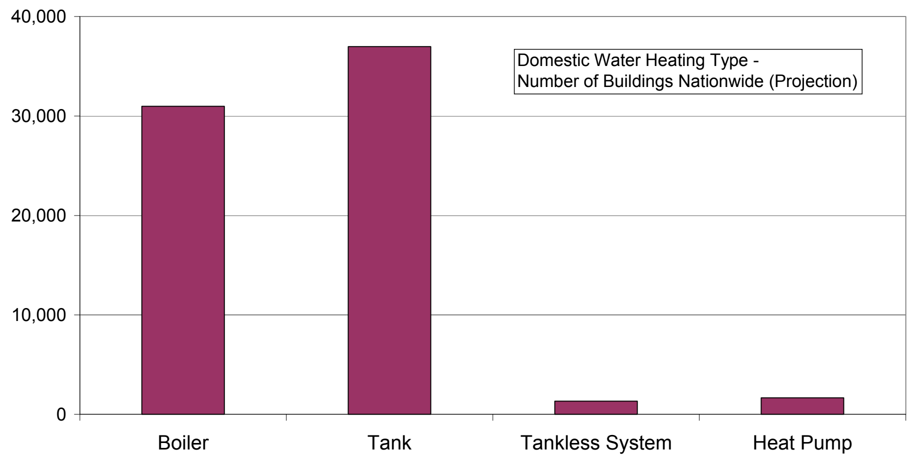


Figure 29: Equipment Types Used to Produce Domestic Hot Water in K-12[38]

Using the central boiler to produce hot water establishes that at least 30,000+ facilities have a centralized hot water system.  In addition, the "Tank and Tankless" systems shown may, or may not, also be centralized, with the tank in the central heating area of the building.

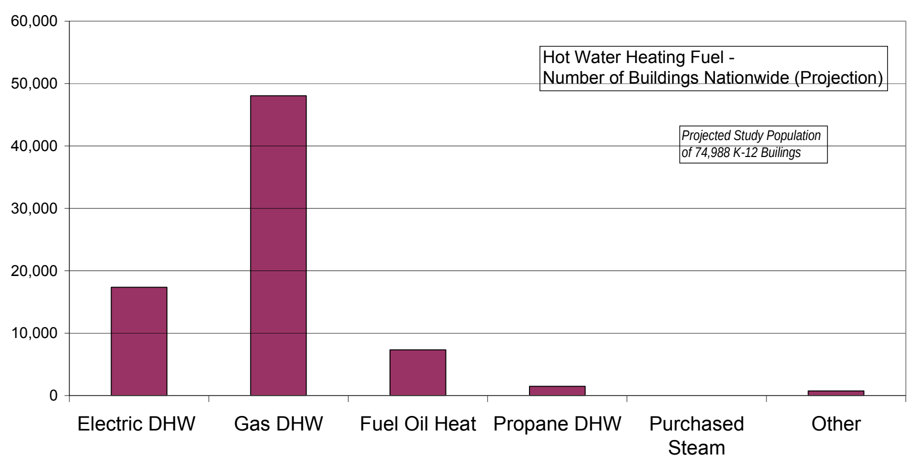


Figure 30: Fuel Types Used to Produce Domestic Hot Water in K-12

[38] Original Projection and Chart, Data Taken from Table 4.11, *Commercial Customer Segmentation Study: National Education Sector*, GRI-97/0385, Gas Research Institute 1998

Gas is even more dominant in the production of hot water with fully 48,000 facilities on gas water heating. This also establishes that at least 48,000 K-12 educational facilities have gas available at the facility. Even though the service may not be sized for a CHP system, having gas in the street outside the facility is important in installing CHP.

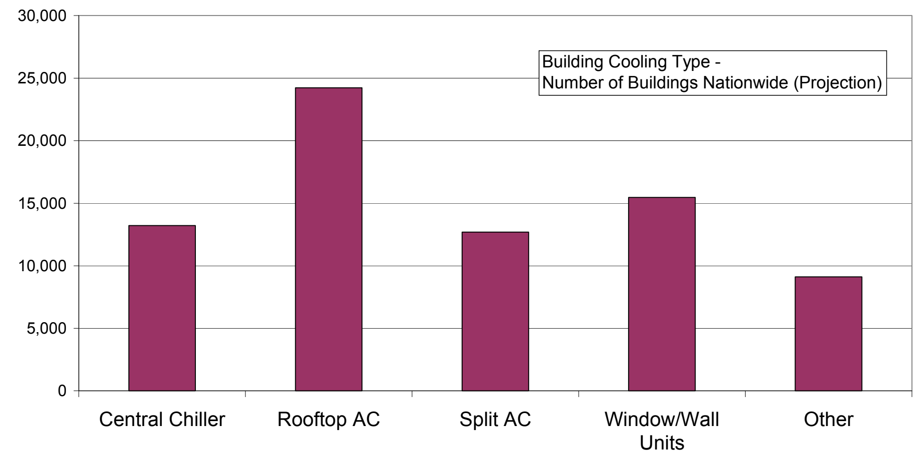


Figure 31: Equipment Types Used to Produce Domestic Space Cooling[39]

Air Conditioning or cooling equipment is less centralized than heating. Only 14,000 of the facilities use a central chiller system. 3% of the respondent floor space was cooled by natural gas, mainly consisting of older absorption chillers.

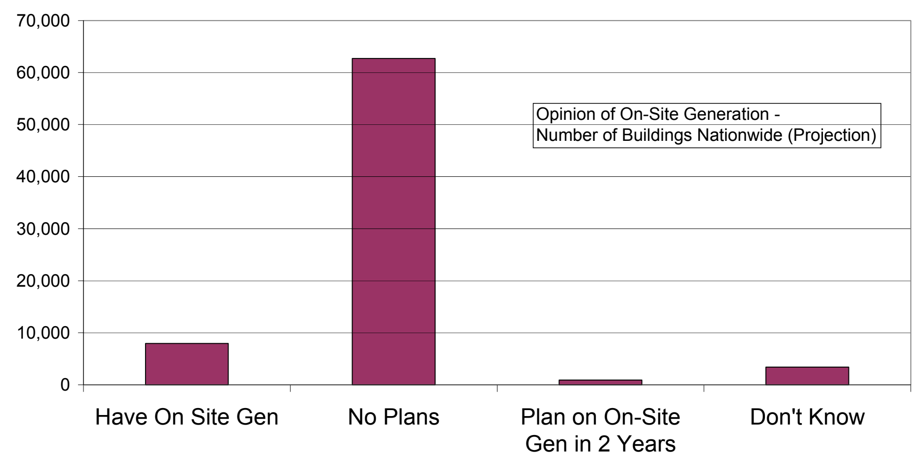


Figure 32: Facilities Interest in On-Site Power Generation[40]

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[39] Original Projection and Chart, Data Taken from Table 4.7, *Commercial Customer Segmentation Study: National Education Sector*, GRI-97/0385, Gas Research Institute 1998

A surprisingly large number of facilities claimed to have some form of On-Site generation, probably back-up generators.  These units may be required in some areas as a “life-safety” issue, as the school must be able to shelter students during outages caused by weather, and they may also be the public disaster shelter for sever weather disasters such as hurricanes.

These charts do more than tell us what type of equipment is being used in the market now and what the issues will be in retrofitting CHP systems to existing facilities.  These figures also indicate what type of equipment facility manager are familiar with in their existing building and are therefore to be most comfortable installing in new facilities

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[40] Original Projection and Chart, Data Taken from Table 4.15, *Commercial Customer Segmentation Study: National Education Sector*, GRI-97/0385, Gas Research Institute 1998

## 4.2 Targeting the Outreach Material

In order to develop outreach or educational materials, the audience is the first issue to define. To make outreach as effective as possible, it should be designed to meet the needs of the most influential decision-maker in this market. Effectively targeting the material means having information on:

- who make decisions on major equipment purchases in smaller educational facilities,
- what are their criteria are for those decisions,
- how do they get information to make these decisions, and
- what are the most important issues to that decision maker?

### 4.2.1 Who is the Target for Outreach Materials

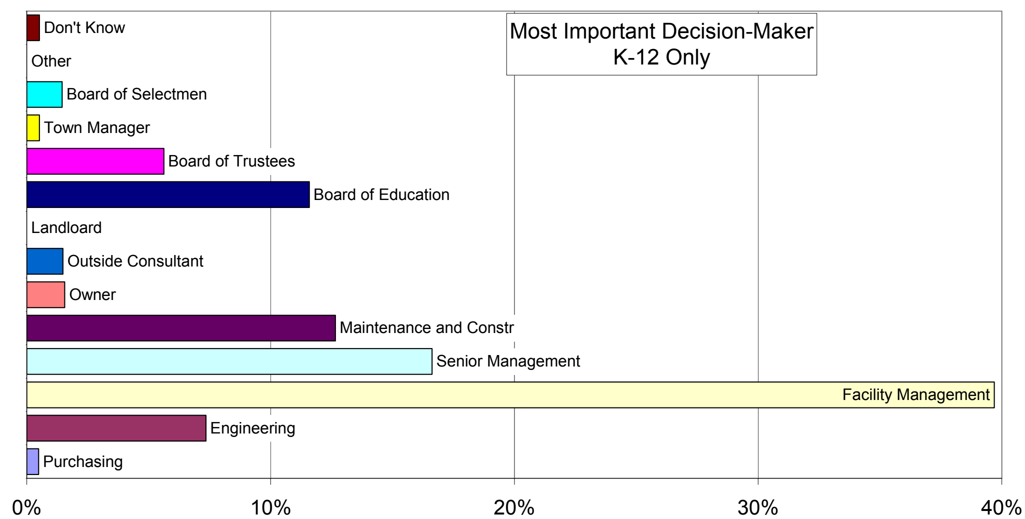


Figure 33: Most Important Decision Makers by Percent of Respondents[41]
*Local Facility Management Were Found to be the Most Important Decision Maker in this Sector when it came to Selecting Equipment. The Dominance Shown Here is Unusually High and Did Not Appear in Other Sector.*[42] *Conversely, in-house engineering staff were not important.*

[41] Original Projection and Chart, Data Taken from Table 4.15, *Commercial Customer Segmentation Study: National Education Sector*, GRI-97/0385, Gas Research Institute 1998 Table 5.5

[42] Other sectors available include Healthcare, Retail, Restaurant, Food Sales, and Hotels; *Commercial Customer Segmentation Study: National Education Sector*, GRI-97/0385, Gas Research Institute 1998

### 4.2.2 What are the General Decision Criteria?

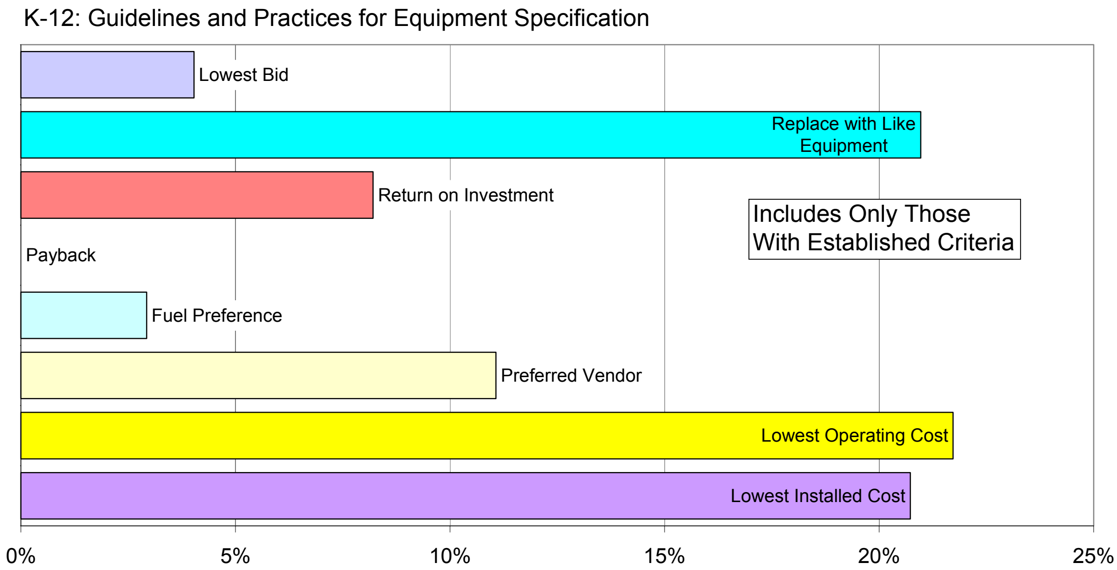


Figure 34: Perception of the Most Important Evaluation Criteria by Percent of Respondents[43]
*The "replace with like equipment" response shows conservatism in this market. Other segments did not rate that response as highly. The split between lowest first and lowest operating cost is common to many segments.*

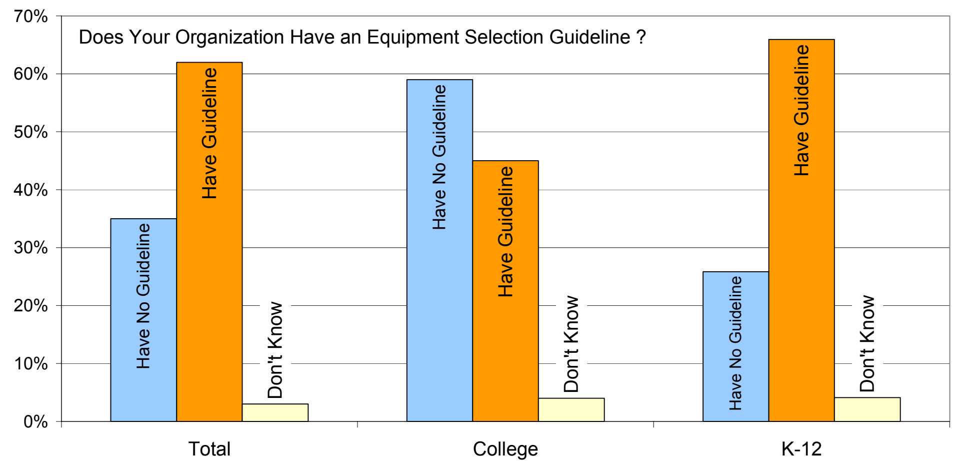


Figure 35: Commonality of Written Equipment Selection Guidelines[44]
*Numbers for Colleges have Been Included to Show the Comparison.*

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[43] Original Chart, Data Taken from Table 4.15, *Commercial Customer Segmentation Study: National Education Sector*, GRI-97/0385, Gas Research Institute 1998, Table 5.11

[44] Original Chart, Data Taken from Table 4.15, *Commercial Customer Segmentation Study: National Education Sector*, GRI-97/0385, Gas Research Institute 1998, Table 5.11

The use of written equipment selection guidelines is more common among K-12 school districts than college facilities.  This may be due to a greater level of school board over-site into the competitive bidding and evaluation process.

A good guideline may give owning and operating cost models, such as required payback or total life cycle cost calculations.  Others may only require operating cost submittals with the bids and provide little or no weighting guidance.  The values in Figure 34 are the respondents' perception of what their particular guideline has valued in previous equipment purchases.

### 4.2.3   Where Do the Decision Makers Get Their Information?

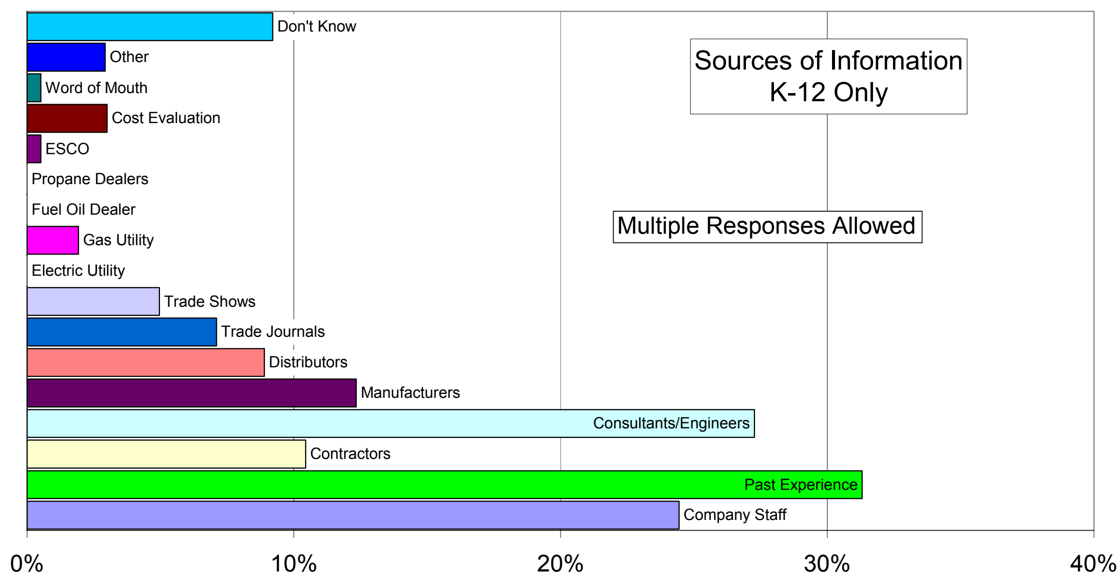


Figure 36:  Most Important Sources of Information[45]
*The use of Engineering Consultants as a Primary Data Source was Unique to This Market Segment, and May Indicate a Tendency for Facility Managers to Have Long Term Relationships with Consulting Engineers Rather than Incurring the Expense of Keeping Engineers on Staff.*

The way in which decision makers get their information is the most valuable insight into what channel of communication to use in getting outreach materials to them.  Figure 36 indicates that information from consulting engineers is more influential than even in-house

[45] Original Chart, Data Taken from Table 4.15, *Commercial Customer Segmentation Study: National Education Sector*, GRI-97/0385, Gas Research Institute 1998, Table 5.13b

staff in this market segment.  This is unusual to school facilities.  In other segments in-house staff, manufacturers, trade journals, and so on ranked much higher.  This seems to indicate that most school districts, except perhaps the largest, do not keep an engineering staff in-house.  Therefore, they rely on hired engineering consultants to advise them on major equipment purchases.

In this situation, the appropriate outreach channels should be those magazines and newspapers that reach these consulting engineers.  In addition, in recent years, consulting engineers have been found to rely more on the Internet for information than most professional groups.  As such, outreach through websites and direct e-mail may be most appropriate.

To maintain as tight a focus as possible, engineering firms who receive more specialized literature on schools such as from the Council of Educational Facility Planners (CEFPI), are more likely to have schools as a significant portion of their engineering practice.  Engineers in this market as likely to work in engineering, architectural, or planning firms.  The following pages show all the firms on the CEFPI Directory.

### 4.2.4 Architects/Planners/Engineers Listed in the CEFPI Directory

| Architects/Planners/Engineers Listed in the CEFPI Directory | |
|---|---|
| 3D/International | www.3di.com |
| ACI/Frangkiser Hutchens, Architects and Planners | www.aci-frangkiser.com |
| Adams Group Architects | theadamsgroup.com |
| Advanced Architecture Inc. | |
| Ambassador Technologies, Inc. | www.atisolutions.net |
| Armstrong, Torseth, Skold & Rydeen, Inc. | www.atsr.com |
| Ashley McGraw Architects, P.C. | ashleymcgraw.com |
| BCWH, Inc. | www.bcwh.com |
| BHDP Architecture | www.bhdp.com |
| BLRB Architects, p.s. | www.blrb.com |
| BMK, pc – Architects | bmkarch.com |
| BPLW Architects & Engineers, Inc. | www.bplw.com |
| Barr Ryder Architects & Planners | www.barr-ryder.com |
| Barton Malow Company | www.bartonmalow.com |
| Bay Architects | www.bayarchitects.com |
| BeeryRio | www.beeryrio.com |
| Benchmark Roof Consultants & Planners, Inc. | www.benchmark-inc.com |
| Boney Architects | www.boneyarchitects.com |
| Burt Hill Kosar Rittelmann Associates | www.burthill.com |
| C/V LAN, Inc. | www.cvlan.com |
| CLR Architects / Engineers / Surveyors | clri.com |
| CPMI | cpmi.com |
| Carruthers Shaw and Partners Limited, Architects | |
| Carter & Burgess, Inc. | www.c-b.com |
| Central City Construction | www.centralcc.com |
| Collins Cooper Carusi Architects, Inc. | www.collinscoopercarusi.com |
| Concordia, LLC | concordia.com |
| Coronado Builders | coronadobuilders.com |
| Cuningham Group Architecture, P.A. | www.cuningham.com |
| DBR Engineering Consultants, Inc. | www.dbrinc.com |
| DLR Group | www.dlrgroup.com |
| Dahlquist and Lutzow Architects, Ltd. | www.dahlquistandlutzow.com |
| David L. Adams Associates, Inc. | www.dlaa.com |
| DeJong, Inc. | www.dejonginc.com |
| Domingo Cambeiro Corp.- Architects | www.DCCArchitects.com |
| Drummey Rosane Anderson, Inc. Architects | www.DRAarchitects.com |
| Dull Olson Weekes Architects pc | www.dowa.com |
| Educational Systems Planning, Inc. | www.educationalsystemsplanning.com |
| Elert & Associates | www.elert.com |
| Eperitus | www.eperitus.com |
| F&S Partners Incorporated | www.fsarchitects.com |
| FPS Architects and Engineers, Ltd | www.fpsarchitectsengineers.com |
| Fanning/Howey Associates, Inc. | www.fhai.com |
| Flansburgh Associates, Inc. | www.faiarchitects.com |
| Fletcher-Thompson, Inc. | www.fletcherthompson.com |
| Franklin Hill & Associates, LLC | www.franklinhill.com |
| French Associates, Inc. | www.frenchaia.com |

| Architects/Planners/Engineers Listed in the CEFPI Directory | |
|---|---|
| GKKEDUCATION | www.gkkcorp.com |
| GPD Associates | www.gpdgroup.com |
| Greenhorne & O'Mara, Inc. | www.g-and-o.com |
| HMFH Architects, Inc. | www.hmfh.com |
| HTI INC., Architects | www.htiarchitects.com |
| Harriman Associates | www.harriman.com |
| Hayes Large Architects | www.hayeslarge.com |
| Horst, Terrill & Karst Architects, P.A. | www.htkarchitects.net |
| Ingraham Dancu Associates | |
| Integrated Design Solutions | www.ids-troy.com |
| Interface Engineering, Inc. | www.interfaceengineering.com |
| JAED Architects & Engineers | www.jaed.com |
| JAED Facilities Solutions | www.jaed.com |
| Jeter, Cook & Jepson Architects, Inc. | www.jcj.com |
| KBD Planning Group, Inc. | www.kbdplanning.com |
| KJM & Associates | www.kjmassoc.com |
| KTH Architects, Inc. | www.ktharch.com |
| Karlsberger Companies | www.karlsberger.com |
| Kitchell CEM, Inc. | www.kitchell.com |
| Klipp Coluss, Jenks DuBois Architects, P.C. | www.kcjd.com |
| L. Robert Kimball & Associates | www.lrkimball.com |
| Levin Porter Associates Inc. | www.levin-porter.com |
| MGT of America, Inc. | www.mgtofamerica.com |
| Mahlum Architects | www.mahlum.com |
| McDonough Bolyard Peck, Inc | www.mbpce.com |
| Meeks Technology Group | www.mtgedtech.com |
| Michael Hining Architects | www.mhaworks.com |
| Modular Technology, Inc. | www.modtechinc.com |
| Moseley Architects | www.moseleyarchitects.com |
| Moseley Wilkins & Wood | www.moseleyarchitects.com |
| Mount Vernon Group, Inc. | www.mvgarchitects.com |
| NJRA Architects | |
| NTD Architects | www.ntd.com |
| OWP/P | www.owpp.com |
| PC Associates, The Plan Check People | www.pcassoc.com |
| PDG Architects | www.pdgarchitects.com |
| PDT Architects | www.pdtarchs.com |
| Perkins & Will | www.perkinswill.com |
| Peter Hossack Architect Inc. | www.hossackarch.com |
| Planning Advocates, Inc. | www.planningadvocates.com |
| Planning Alliance | http://www.planning-alliance.com |
| Progressive AE | www.progressiveae.com |
| Quandel Group, Inc. , | The.quandel.com |
| R.P. Carbone Company | rpcarbone.com |
| Renaissance Design Group | www.rdgusa.com |
| SHW Group Architects | www.shwgroup.com |
| SSOE, Inc. | www.ssoe.com |
| Sandberg & Small Architecture, LLC | www.ssarch.org |

| Architects/Planners/Engineers Listed in the CEFPI Directory | |
|---|---|
| Shuller Ferris Lindstrom & Associates Architects www.sfla-architects.com | |
| Spencer Partnership Architects | www.sparchitects.com |
| Stanton Leggett & Associates | |
| Stevens & Wilkinson | www.stevensandwilkinson.com |
| Strada Architecture LLC | www.stradallc.com |
| TMP Associates, Inc. | www.tmp-architecture.com |
| TR,i Architekts | www.triarchitekts.com |
| Tate Snyder Kimsey Architects | www.tatesnyderkimsey.com |
| Tera Byte, Ltd. | www.terabyteltd.com |
| The Design Forum Inc. | www.thedesignforum.com |
| The Myers Group | |
| The Orcutt/Winslow Partnership | www.owp.com |
| The Ray Group | www.raygroup.com |
| The Ventin Group Ltd., Architects | ventingroup.com |
| Thomas & Williamson Program Management www.thomasandwilliamson.com | |
| Tower Pinkster Titus Associates, Inc. | www.tpta.com |
| WRA Architects | www.wraarchitects.com |
| Weber Murphy Fox | |

### 4.2.5 What are the Most Important Segment Issues that Relate to CHP?

Facility managers in any commercial or institutional building are always working under money, manpower, and time constraints. These concerns and limitations can be assumed. To develop customized outreach materials, those important issues that are unique to this market segment must be addressed. A survey of recent literature on K-12 education building brings up the following issues:

#### 4.2.5.1 Safety and Security

K-12 facilities are the only buildings in the commercial market entirely dedicated to the sheltering of large numbers of children. Schools were the leader in fire alarm system development, are often built to serve as the local severe weather shelter, and have become a point of national concern due to recent incidents of student violence. [46]

The State of Virginia Emergency Shelter website states "Each locality has a list of facilities (often public schools) that may be used as emergency shelters"[47]. Hurricane prone Volusia County in Florida notes 23 shelters, all in public schools[48]. Brevard county (FL) list 10, (all K-12 schools).[49] The State of Florida requires that all new schools have emergency shelters.[50] A check of emergency shelters for 3 nuclear power plants from Maine to Tennessee show that each lists a minimum of 13 locations, all K-12 schools.

No matter how likely or unlikely a disaster may be, from the inevitable hurricanes in Florida, to as unlikely a threat as a nuclear power plant accident, shelter preparations have requirements that often suggest but do not always require emergency power. Common disasters such a hurricanes, tornados, ice storms, heat waves, all tend to take out the electric grid but leave gas delivery largely unaffected. In areas of the country where these problems are a focus, mainly the east and Midwest, a CHP system may also fulfill the emergency

[46] Promoting Safety In Schools International Experience And Action, U.S. Department of Justice, 2001

[47] http://www.vaemergency.com/03hurr/shelters.htm

[48] http://b.orlandoweather.com/hurricanes/2245076/detail.html

[49] http://www.embrevard.com/prep_shelter.cfm

[50] http://www.firn.edu/doe/rules/memos/dpbm01_memo/dpbm0242.htm

power requirement, thereby lowering the proportion of the CHP first cost that must be justified entirely on operating cost savings. In areas of the country where earthquakes are a major threat, any CHP system also serving as an emergency power system should be dual fuel. Earthquakes will commonly take down both the power and the gas distribution system.

#### 4.2.5.2 Indoor Air Quality and Sufficient Ventilation

In February 1995 the US Government Accounting Office released a report[51] indicating that over half of our schools have problems that affect indoor air quality. The EPA has developed IAQ literature for schools and has identified a lengthy list of common indoor sources. Other than source removal, the EPA's first suggestion is increased ventilation[52]. Likewise, ASHRAE increased their ventilation guidelines in 1989 to drastically increase ventilation in crowded locations such as schools.[53]

#### 4.2.5.3 Expanding Student Populations

Expanding student populations and the need for expanding facilities will also be an issue for facility managers. The need to construct new facilities at a cost that will conform with capital budgets or voter governed bond authorizations may make extra cost features such as CHP difficult to install. Fortunately, many states now allow third party financing of energy options such as CHP systems, without penalty to the overall construction budget limits. In addition, many third party financers are particularly interested in K-12 facilities as new schools can be predicted to have a long useful life with much less business risk than facilities owned by private commercial or industrial operations.

#### 4.2.5.4 Expanding Educational Requirements

Expanding educational requirements often focus on new technologies, particularly computers. Greater use of on-line education, and the move to transform libraries into computerized databanks, will continue in the immediate future. This will expand power and cooling needs and make more dependable well-conditioned power more important.

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[51] "Conditions of America's Schools", U.S. General Accounting Office, Health, Education, and Human Services Division, Document#: GAO/HEHS-95-61, Report#: B-259307, February 1, 1995.

[52] Indoor Air Quality Tools for Schools, US Environmental Protection Agency

[53] ASHRAE Standard 62-1989 and later versions

## 4.2.6 Targeting the Outreach to Larger Players

Directly targeting school district facility managers can be challenging, as there are a surprising 14,981 separate school districts in the United States. However, many of these districts are quite small. Cost effective outreach should target the larger players, at least initially. Fortunately, there are a small number of large districts that dominate the market.

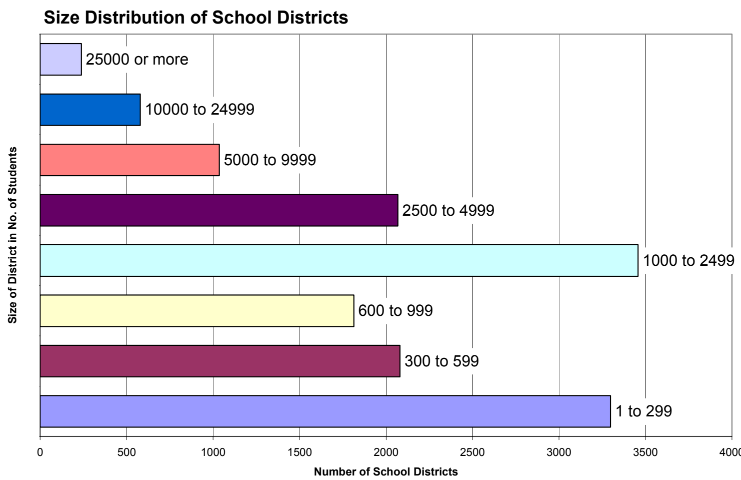


Figure 37: Number of School Districts by Size[54]

*The Largest 1.6% of School Districts have 32% of the Students Nationwide*

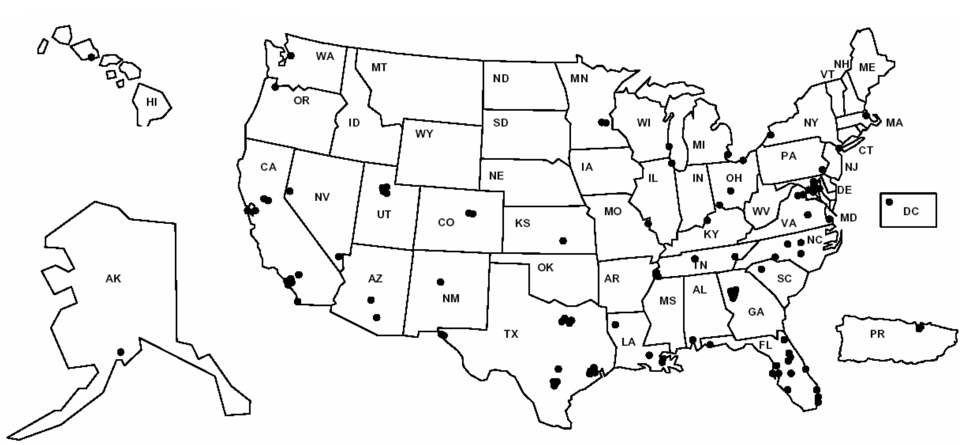


Figure 38: Location of the 100 Largest School Districts in the United States

*Appendix 1 has a complete list of these systems, including locations and number of students*

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[54] Table 89 and 90.—Public school districts and public and private elementary and secondary schools: 1869–70 to 1999–2000, Digest of Education Statistics, NATIONAL CENTER FOR EDUCATION STATISTICS, 2001

Of the 14,981 separate school districts in the United States, the 100 largest districts have a student population of nearly 11 million students, which is 24% of the national student count of 41 million.[55] These school districts are shown in Appendix 1 at the end of this chapter. Central or headquarters facility management in these districts will be extremely influential in getting new equipment introduced.

[55] U.S. Census Bureau, Statistical Abstract of the United States: 2001, Section 4 Education, No. 229. Public Elementary and Secondary Schools by Type and Size of School:1998-99

## 4.3 Determine the Best Channels for Information Outreach

### 4.3.1 Determine the Best Channels for Information Outreach

Outreach materials for K-12 educational facilities should be tightly targeted to two audiences: the critical decision makers, the facility managers, and their most influential sources of information, which are engineering consultants with significant school practices.

#### 4.3.1.1 Existing Professional Association Publications

Once the case for CHP in K-12 is packaged into articles that focus on the advantages to school facilities specifically, the most appropriate publication channel for facility managers is *American Schools and Universities* magazine or their facilities outreach operation - *SchoolDesign.com*. The same material could then also be used for CEFPI "*Breaking News*" website and potentially the Alliance to Save Energy's *Green School Program Website* (http://www.ase.org/greenschools/).

To be effective, this message must be repeated in literature appealing to Engineering Consultants that advise these facility managers. Here the publication market is less focused, but the most respected magazine is the *American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Journal*. Second choices include the *HVAC News*, *Heating, Piping, and Air Conditioning* magazine, and *Consulting Engineering* magazine.

The publication avenues into this market follow the HVAC industry. School facility manager or consultants will not commonly read power industry magazines. Most schools today do not generate power, but HVAC systems are universal. HVAC is also a significant portion of construction and operating costs for existing schools, and therefore an area of interest for existing facility managers.

#### 4.3.1.2 Internet Based Newsletters

Internet based newsletters may be a good mechanism to communicate with this diverse market. Internet based news letters are generally smaller word or PDF documents with some regular update of industry background information that is sent to a mailing list. To initiate this type of outreach, a sample newsletter is written and sent by unsolicited e-mail to a targeted group that should have a special interest in the area being covered.

To avoid the appearance of spam, the cover e-mail should look like a professional letter, mention that the material is being sent to a limited mailing list who may have an interest in the newsletter, that the newsletter is non-commercial in nature, include an attached recent issue, and should be set up to provide an e-mail response cancellation reply. Tight targeting of the material is important as many Internet service providers are cutting service to users who perform “mass-spamming” operations

In this market, the most important decision maker, the typical facility manager, will be involved in major facility equipment decisions fairly infrequently and therefore are a poor target for a regular newsletter outreach. However, the consulting engineers specializing in the school markets may be dealing with this type of decision frequently for multiple districts, and would be an appropriate target. In addition, facility management staff for some of the largest school districts will be frequently dealing with major power, heating, and cooling decisions across many facilities, and would be an appropriate target.

#### 4.3.1.3 Professional Association Alliances

Most appropriate professional organizations for this sector are

- CEFPI – Chartered Educational Facility Planners, International
- ASHRAE – American Society of Heating, Refrigerating, and Air-Conditioning Engineers

#### 4.3.1.4 Course Development and Delivery

Generally, development and on-site delivery of course material is an expensive operation which is being replaced by both distance learning conferences, which are live on-line presentations supported by conference call communications between teacher and students, or automated distance learning courses that students take by internet at their own pace. Materials developed for these new processes can also be used for live workshops. For this market, the national CEFPI meetings, for facility managers, and ASHRAE meetings, for engineering consultants would be most appropriate.

#### 4.3.1.5 Internet-Based Distance Learning Mechanisms

Rather than attempt to create the outreach channel, holding e-learning sessions on an existing targeted e-learning system is more effective. Developing a course for CEFPI's E-Conference series, begun this year, would directly target facility managers at schools, and deliver the course directly through CEFPI's web-site.

## 4.4 Summary

The K-12 schools market represents 9% of all the commercial floor space in the United States, is currently growing and projected to continue to grow until 2010. Targeting only individual buildings over 400 kW each, the market is currently 11.9 GW and is growing at 350 MW per year.

Unlike other sectors of the commercial buildings market, ownership and continued use of school buildings is extremely stable, leading to a willingness to undertake longer-term investments like CHP. In addition, back-up power is a significant benefit in buildings housing children, becoming more computer-intensive, and often serving as emergency shelters. The ability of CHP systems to affordably supply surplus heat to power desiccant dehumidification of ventilation air or heating of large quantities of ventilation air is also a plus in buildings where indoor air quality can be a major public concern. Lastly, systems used in larger school buildings today lend themselves to integration with CHP systems. For all of these reasons, secondary (9-12) schools should be an attractive growth market for CHP systems. In addition, these very same benefits, some of which are peculiar to this market, should form the core of the message being sent on CHP in outreach activities to this market.

## 4.5 *Appendix 1 – Largest School Districts by Number of Students*

| Name of District | City | State | County | Number of Students |
|---|---|---|---|---|
| | | | | 10,962,476 |
| New York City Public Schools | New York | NY | Kings | 1,075,710 |
| Los Angeles Unified | Los Angeles | CA | Los Angeles | 710,007 |
| Puerto Rico Dept of Education | Hato Rey | PR | San Juan | 613,019 |
| City of Chicago School District | Chicago | IL | Cook | 431,750 |
| Dade County School District | Miami | FL | Dade | 360,136 |
| Broward County School District | Fort Lauderdale | FL | Broward | 241,094 |
| Clark County School District | Las Vegas | NV | Clark | 217,526 |
| Houston Independent School District | Houston | TX | Harris | 209,716 |
| Philadelphia City School District | Philadelphia | PA | Philadelphia | 205,199 |
| Hawaii Department of Education | Honolulu | HI | Honolulu | 185,860 |
| Detroit City School District | Detroit | MI | Wayne | 167,124 |
| Dallas Independent School District | Dallas | TX | Dallas | 160,477 |
| Hillsborough County School District | Tampa | FL | Hillsborough | 159,517 |
| Fairfax County Public Schools | Fairfax | VA | Fairfax | 152,952 |
| Palm Beach County School District | West Palm Beach | FL | Palm Beach | 149,665 |
| Orange County School District | Orlando | FL | Orange | 144,231 |
| San Diego City Unified | San Diego | CA | San Diego | 140,743 |
| Prince Georges County Public Schools | Upper Marlboro | MD | Prince George's | 131,059 |
| Montgomery County Public Schools | Rockville | MD | Montgomery | 130,720 |
| Duval County School District | Jacksonville | FL | Duval | 126,362 |
| Memphis City School District | Memphis | TN | Shelby | 112,819 |
| Pinellas County School District | Largo | FL | Pinellas | 111,793 |
| Baltimore County Public Schools | Towson | MD | Baltimore | 106,465 |
| Gwinnett County School District | Lawrenceville | GA | Gwinnett | 104,552 |
| Baltimore City Public School System | Baltimore | MD | Baltimore | 103,000 |
| Charlotte-Mecklenburg Schools | Charlotte | NC | Mecklenburg | 100,553 |
| Milwaukee School District | Milwaukee | WI | Milwaukee | 99,729 |
| Jefferson (KY) County | Louisville | KY | Jefferson | 97,053 |
| De Kalb County School District | Decatur | GA | De Kalb | 95,283 |
| Wake County Schools | Raleigh | NC | Wake | 95,248 |
| Cobb County School District | Marietta | GA | Cobb | 93,657 |
| Long Beach Unified | Long Beach | CA | Los Angeles | 91,465 |
| Jefferson (CO) County | Golden | CO | Jefferson | 88,579 |
| Albuquerque Public Schools | Albuquerque | NM | Bernalillo | 85,381 |
| Orleans Parish School Board | New Orleans | LA | Orleans | 80,526 |
| Fresno Unified | Fresno | CA | Fresno | 78,766 |
| Polk County School District | Bartow | FL | Polk | 78,685 |
| Fort Worth Independent School District | Fort Worth | TX | Tarrant | 78,654 |
| Austin Independent School District | Austin | TX | Travis | 77,723 |
| Virginia Beach City Public Schools | Virginia Beach | VA | Virginia Beach Cit | 77,363 |
| Cleveland City School District | Cleveland | OH | Cuyahoga | 76,559 |
| Anne Arundel County Public Schools | Annapolis | MD | Anne Arundel | 74,663 |

| | | | | |
|---|---|---|---|---|
| Jordan School District | Sandy | UT | Salt Lake | 73,111 |
| Granite School District | Salt Lake | City | UT Salt Lake | 72,170 |
| Mesa Unified School District | Mesa | AZ | Maricopa | 71,894 |
| District of Columbia Pub Schools | Washington | DC | District of Columb | 70,762 |
| Nashville-Davidson County School District | Nashville | TN | Davidson | 70,176 |
| Denver County | Denver | CO | Denver | 69,693 |
| Brevard County School District | Melbourne | FL | Brevard | 69,661 |
| Fulton County School District | Atlanta | GA | Fulton | 67,025 |
| Columbus City School District | Columbus | OH | Franklin | 65,490 |
| Mobile County School District | Mobile | AL | Mobile | 65,067 |
| Boston School District | Boston | MA | Suffolk | 62,950 |
| Tucson Unified District | Tucson | AZ | Pima | 62,548 |
| Northside Independent School District | San Antonio | TX | Bexar | 62,536 |
| Guilford County Schools | Greensboro | NC | Guilford | 62,486 |
| El Paso Independent School District | El Paso | TX | El Paso | 62,306 |
| San Francisco Unified | San Francisco | CA | San Francisco | 60,896 |
| Volusia County School District | Deland | FL | Volusia | 60,688 |
| Cypress-Fairbanks ISD | Houston | TX | Harris | 60,370 |
| Davis School District | Farmington | UT | Davis | 59,486 |
| Atlanta City School District | Atlanta | GA | Fulton | 59,429 |
| Seminole County School District | Sanford | FL | Seminole | 59,326 |
| Greenville County School District | Greenville | SC | Greenville | 59,176 |
| Santa Ana Unified Santa | Ana | CA | Orange | 58,043 |
| San Antonio Independent School District | San Antonio | TX | Bexar | 57,565 |
| Arlington Independent School | Arlington | TX | Tarrant | 56,773 |
| Lee County School District | Fort Myers | FL | Lee | 56,109 |
| East Baton Rouge Parish School | Board Baton Rouge | LA | East Baton Rou | 55,652 |
| Oakland Unified | Oakland | CA | Alameda | 55,051 |
| Washoe County School District | Reno | NV | Washoe | 54,508 |
| Portland School District | Portland | OR | Multnomah | 53,587 |
| Knox County School District | Knoxville | TN | Knox | 52,840 |
| Fort Bend Independent School District | Sugar Land | TX | Fort Bend | 52,704 |
| Prince William County Public Schools | Manassas | VA | Prince William | 52,551 |
| Sacramento City Unified | Sacramento | CA | Sacramento | 51,898 |
| Jefferson Parish School Board | Harvey | LA | Jefferson | 51,835 |
| Cumberland County Schools | Fayetteville | NC | Cumberland | 51,300 |
| Aldine Independent School District | Houston | TX | Harris | 50,890 |
| Chesterfield County Public Schools | Chesterfield | VA | Chesterfield | 50,847 |
| San Bernardino City Unified | San Bernardino | CA | San Bernardino | 50,340 |
| Cincinnati City School District | Cincinnati | OH | Hamilton | 49,574 |
| Anchorage School District | Anchorage | AK | Anchorage | 49,382 |
| North East Independent Schools | San Antonio | TX | Bexar | 49,197 |
| Shelby County School District | Memphis | TN | Shelby | 49,078 |
| Garland Independent School District | Garland | TX | Dallas | 49,036 |
| Minneapolis | Minneapolis | MN | Hennepin | 48,688 |
| San Juan Unified | Carmichael | CA | Sacramento | 48,052 |
| Garden Grove Unified | Garden Grove | CA | Orange | 48,031 |

| | | | | |
|---|---|---|---|---|
| Seattle | Seattle | WA | King | 47,989 |
| Wichita | Wichita | KS | Sedgwich | 47,778 |
| Pasco County School District | Land  O Lakes | FL | Pasco | 47,691 |
| Ysleta Independent School District | El Paso | TX | El Paso | 46,950 |
| Buffalo City School District | Buffalo | NY | Erie | 46,370 |
| Caddo Parish School Board | Shreveport | LA | Caddo | 46,222 |
| Alpine School District American | Fork | UT | Utah | 45,842 |
| St. Louis City | St. Louis | MO | St. Louis City | 45,658 |
| Escambia County School District | Pensacola | FL | Escambia | 45,297 |
| Clayton County School District | Jonesboro | GA | Clayton | 45,266 |
| St. Paul | St. Paul | MN | Ramsey | 45,253 |
| | | | | |

# 5 Smaller Healthcare Facilities

The large hospital market has always been a significant market for Cogeneration or CHP systems. Figure 39 shows that both hospitals and nursing homes form a significant share of the current market. This has led to an interest in exploring further opportunities in this market sector, particularly for smaller CHP systems.

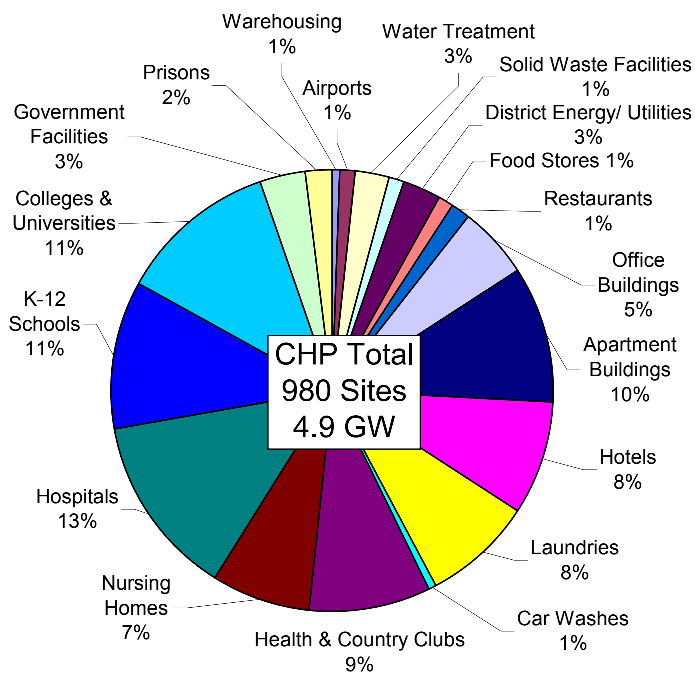


Figure 39: Existing CHP Systems [56]

However, "Healthcare" is a very wide market title. First the structure of this market needs to be investigated.

[56] Establishing a Goal for DER: Challenging or Business As Usual, Paul L. Lemar, Jr., Vice President, Resource Dynamics Corporation, Distributed Energy Resources: The Power to Choose Conference and Peer Review, November 28, 2001.and The Market and Technical Potential for Combined Heat and Power in the Commercial/Institutional Sector, ONSITE SYCOM Energy Corporation, Prepared for:U.S. Department of Energy, Energy Information Administration, 2000

## 5.1 Structure of the Healthcare Market

The Census Bureau NAICS system places Healthcare under NAIC Category 62 and breaks the market down into the following segments.

- 621 Ambulatory health care services
  - 6211 Offices of physicians
  - 6212 Offices of dentists
  - 6213 Offices of other health practitioners
    - 62131 Offices of chiropractors
    - 62132 Offices of optometrists
    - 62133 Offices of mental health practitioners (except physicians)
    - 62134 Offices of phys., occup, & speech therapists & audiologists
    - 62139 Offices of all other health practitioners
  - 6214 Outpatient care centers
    - 62141 Family planning centers
    - 62142 Outpatient mental health & substance abuse centers
    - 62149 Other outpatient care centers
  - 6215 Medical & diagnostic laboratories
  - 6216 Home health care services
  - 6219 Other ambulatory health care services
    - 62191 Ambulance services
    - 62199 All other ambulatory health care services
  - 6221 General medical & surgical hospitals
  - 6222 Psychiatric & substance abuse hospitals
  - 6223 Specialty (except psychiatric & substance abuse) hospitals
- 623 Nursing & residential care facilities
  - 6231 Nursing care facilities
  - 6232 Residential mental retardation/health & substance abuse facility
    - 62321 Residential mental retardation facilities
    - 62322 Residential mental health & substance abuse facilities
  - 6233 Community care facilities for the elderly
  - 6239 Other residential care facilities
- 624 Social assistance
  - 6241 Individual & family services
    - 62411 Child & youth services
    - 62412 Services for the elderly & persons with disabilities
    - 62419 Other individual & family services
  - 6242 Community food & housing/emergency & other relief services
    - 62421 Community food services
    - 62422 Community housing services
    - 62423 Emergency & other relief services
  - 6243 Vocational rehabilitation services
  - 6244 Child day care services

Table 4: Breakdown of the Total NAICS Code 62 “Healthcare and Social Assistance” Market

## 5.2 Desirability of the Market for CHP

For a specific market to be particularly desirable for CHP applications, it should be 1) sizable, 2) healthy or growing, and 3) have characteristics that will make CHP more highly desirable than for the average commercial building. In this section, the statistical background will be developed on this sector.

### 5.2.1 Complexity of the Market

The NAIC breakdown for Healthcare is far more complex than the educational market. Part of this is the combination of Healthcare with Social Assistance operations. This is unavoidable, as some of the functions of the healthcare industry overlap with Social Assistance. For instance, Nursing Homes may supply a true hospital-like function for some of their patients in "High Care" areas, while providing more of an "Assisted Living" function in other areas, of the same facility. The same is true of psychiatric and substance abuse treatment centers. Conversely, "Medical and Surgical Hospitals" will be almost entirely healthcare in function, where as "Individual & Family Services" will be largely Social Assistance

To sort this out, the categories that will be well suited for cogeneration need to be selected and focused upon. The following criteria were used for this selection:

- This study was predicated on looking at Healthcare facilities smaller than that seen in Major Hospitals. Therefore, only the smaller end of the Medical and Surgical Hospital Category will be considered.
- Only those facilities that can present a reasonably centralized electric and thermal load for cogeneration will make such systems practical.
- Generally, 24 hour, 7-day/week operation significantly improves the economics of cogeneration. A facility with full time residents is important.

### 5.2.2 Need for Emergency Power

CHP presents the best economics when the on-site generating system can also supply emergency power to a facility that needs such power. In the overall "Healthcare and Social Assistance" area, there are three reasons for needing back-up power.

- **Life-Safety**: The first is life-safety for patients depending on electrical machinery for life support or the completion of critical procedures, such as surgery. This is why hospitals are required to have back-up power.
- **Non-Evacuatable Patients**: The second, however, is quite different. Facilities where evacuating patients in a prolonged power outage is impractical or unsafe, such as Nursing Homes, should have back-up power. Extreme examples are psychiatric or drug facilities where some patients may be in "Locked-down" wards. This is the reason that prisons and jails generally have back-up power. However nursing homes and non-confined psychiatric or drug facility patients may simply present a situation where evacuation is largely impractical. These facilities have not traditionally had back-up power in the past. However, the recent power outage may cause this to be reconsidered.
- **Critical Equipment**: Some healthcare facilities have equipment that must be kept in operation even when not serving patients or where there are no on-site patients. These include diagnostic imaging equipment such as MRI scanners that depend on continuously cooled superconducting magnets. Loss of power will stop the cryo-coolers on such equipment and quench the magnet, leading to a costly restart.[57] Loss of power will also lead to loss of refrigeration and air handling systems at medical diagnostic laboratories. This can lead to serious situations such as spoiling of stored medical test samples, loss of frozen specimens, or losing containment on a dangerous pathogen. These pathogen concerns have been made more critical in recent years due to the appearance of antibiotic resistant bacteria for pneumonia and tuberculosis, and terror threats such as anthrax.

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[57] Personal communications with a Chicago based manufacturer of mobile MRI facilities, AK Systems

Given these criteria, the large list in Table 4 can be reduced as shown in Table 5.

- 621 Ambulatory health care services
    - 621493 Freestanding ambulatory surgical & emerg. Cntrs. Only
  - 6215 Medical & diagnostic laboratories
    - 621991 Blood & organ banks
  - 6221 General medical & surgical hospitals
  - 6222 Psychiatric & substance abuse hospitals
  - 6223 Specialty (except psychiatric & substance abuse) hospitals
- 623 Nursing & residential care facilities - All
- 624 Social assistance

Table 5: Selected Segments of the Total NAICS Code 62 "Healthcare and Social Assistance" Market

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Reasons for eliminating specific segments include:

- 6211-6214: Office and outpatient functions with little or no overnight operations. 621943 has been left in as it includes Freestanding Emergency Centers
- 6216 Home health care services and 62191 Ambulance services have minimal facilities
- 624 Social Assistance classes were eliminated as they presenting short daytime only schedules

The functional descriptions of the chosen segments in Table 5 makes the reasons for this selection clearer.[58]

#### 5.2.2.1 621493: Freestanding Ambulatory Surgical & Emerg. Centers Only

Provide (1) surgical services on an outpatient basis or (2) emergency care service to patients suffering injuries as a result of trauma. Outpatient surgical establishments have specialized facilities, such as operating and recovery rooms, and specialized equipment.

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[58] Market segment definitions taken from Census Bureau definitions.

#### 5.2.2.2 6215: Medical & Diagnostic Laboratories

Provide analytic or diagnostic services, including body fluid analysis and diagnostic imaging, generally to the medical profession or to the patient on referral from a health practitioner.

#### 5.2.2.3 621991: Blood & Organ Banks

Collect, store, and distribute blood and blood products and store and distribute body organs.

#### 5.2.2.4 6221: General Medical & Surgical Hospitals

Provide treatment to inpatients with a wide variety of medical conditions. These establishments maintain inpatient beds, provide patients with food services, and have an organized staff of physicians and other medical staff to provide patient care services. These establishments usually also provide other services, such as outpatient services.

#### 5.2.2.5 6222: Psychiatric & Substance Abuse Hospitals

Provide diagnostic, medical treatment, and monitoring services for inpatients that suffer from mental illness or substance abuse disorders. The treatment often requires an extended stay. They have an organized staff of physicians and other medical staff to provide patient care services. Psychiatric, psychological, and social work services are available. These hospitals usually provide other services, such as outpatient services.

#### 5.2.2.6 6223: Specialty (Except Psychiatric & Substance Abuse) Hospitals

Provide diagnostic and medical treatment to inpatients with a specific type of disease or medical condition. Hospitals providing long-term care for the chronically ill and rehabilitation services to the disabled. They have an organized staff of physicians and other medical staff to provide patient care services. These hospitals may provide outpatient services.

#### 5.2.2.7 623: Nursing & Residential Care Facilities – Entire Segment

Provide residential care combined with either nursing, supervisory, or other types of care as required by the residents. In this sub-sector, the facilities are a significant part of the production process and the care provided is a mix of health and social services with the health services being largely some level of nursing services.

### 5.2.3 The Size of the Selected Sectors

| | Number of Establishments | Number of Employees | Employees per Estab. |
|---|---|---|---|
| 621493 Freestanding ambul. surgical & emerg. Cntrs | 2,402 | 42,416 | 18 |
| 6215 Medical & diagnostic laboratories | 9,076 | 151,388 | 17 |
| 621991 Blood & organ banks | 1,230 | 42,997 | 35 |
| 6221 General medical & surgical hospitals | 5,487 | 4,526,591 | 824 |
| 6222 Psychiatric & substance abuse hospitals | 801 | 255,257 | 319 |
| 6223 Specialty (except psych & subs abuse) hospitals | 397 | 151,190 | 381 |
| 623 Nursing & residential care facilities - All | 57,359 | 2,470,723 | 43 |
| Total | 76,752 | 7,640,562 | 100 |

Table 6: Comparing the Size of the Initially Selected Sectors[59]

As mentioned in the segment on educational facilities, for a market to be desirable, it has to be sizable. In Table 6, the sizes of the selected sectors are suggested from the available Census data. Even after isolating those segments of the Healthcare and Social Assistance Market that would have both economic and emergency power rational for having CHP, these segments remain at nearly 7.7 million employees at over 75,000 sites.

Clearly the average size of an individual establishment varies widely with the average general hospital having nearly 40 times the staff of the average medical laboratory.

However, the outstanding market in number of facilities, NAICS 623: Nursing and Residential Care Facilities, has to be refined further. This category spans the gamut from facilities that provide high levels of care to the completely disabled to assisted living situations, for ambulatory patience in need of minimal care.

High-level care facilities should have a significant interest in back-up power capabilities, as the residents generally cannot be evacuated during a prolonged power outage. Conversely, assisted living facilities may have little interest. Therefore, this segment is refined further in Table 7.

[59] 1997 Economic Census, Health Care and Social Assistance, Issued in Stages from 1999 to 2001

The high level of care facilities are shown as "6231: Nursing Care Facilities", and the employee count per establishment indicates these as the larger facilities. Assisted living arrangements are under "6233: Community Care for the Elderly".

The large number of facilities under "6232: Residential Mental Retardation and Substance Abuse" are clearly smaller facilities and are more likely to be "Half-Way House" type arrangements. Facilities for severe substance abuse, psychiatric, and retardation patients are listed elsewhere (under the 6222 and 6223 category as shown in Table 6).

| | | Number of Establishments | Number of Employees | Employees per Estab. |
|---|---|---|---|---|
| 6231 | Nursing Care Facilities | 15,605 | 1,557,162 | 100 |
| 6232 | Residential Mental Ret. and Subs. Abs. | 20,233 | 356,015 | 18 |
| 6233 | Community Care Facilities for the Elderly | 15,588 | 422,078 | 27 |
| 6239 | Other Residential Care | 5,933 | 135,468 | 23 |
| | | | | |
| 623 | Total | 57,359 | 2,470,723 | 23 |

Table 7: Details on the Nursing and Residential Care Sector

A more focused listing is shown in Table 8 showing only those medical facilities that have at least one of the three motives for being interested in back-up power capabilities. Those three motives were defined earlier as Life-Safety Needs, Non-Evacuatable Patients, or Critical Equipment.

| | Number of Establish-ments | Number of Employees | Employee per Estab. |
|---|---|---|---|
| 621493 Freestanding ambul. surgical & emerg. Cntrs | 2,402 | 42,416 | 18 |
| 6215 Medical & diagnostic laboratories | 9,076 | 151,388 | 17 |
| 621991 Blood & organ banks | 1,230 | 42,997 | 35 |
| 6221 General medical & surgical hospitals | 5,487 | 4,526,591 | 824 |
| 6222 Psychiatric & substance abuse hospitals | 801 | 255,257 | 319 |
| 6223 Specialty (except psych & subs abuse) hospitals | 397 | 151,190 | 381 |
| 6231 Nursing Care Facilities | 15,605 | 1,557,162 | 100 |
| | | | |
| Total | 34,998 | 6,727,001 | 100 |

Table 8: Final Targeted List

Another source, CBECS data, allows the number of facilities by size to be seen. However, in this data, there is not the level of detail about the facility available in the Census data

| | All Buildings | 1,001 to 5,000 Square Feet | 5,001 to 10,000 Square Feet | 10,001 to 25,000 Square Feet | 25,001 to 50,000 Square Feet | 50,001 to 100,000 Square Feet | 100,001 to 200,000 Square Feet | 200,001 to 500,000 Square Feet | Over 500,000 Square Feet |
|---|---|---|---|---|---|---|---|---|---|
| All Buildings | 4,657 | 2,348 | 1,110 | 708 | 257 | 145 | 59 | 23 | 7 |
| Health Care | 127 | 64 | | 10 | 8 | 4 | 2 | 2 | 1 |
| Inpatient | 11 | | | | | | 2 | 2 | 1 |
| Outpatient | 116 | 64 | | | 7 | | | | |

Table 9: Number of Health Care Facilities by Size[60] (in Thousands)

To integrate the two databases takes some judgment. First, the Census data in Table 6 indicates 5,487 general medical and surgical hospitals, averaging 800+ employees, far larger than other facilities. As all the categories over 100,000 SF in the CBECS data in Table 9 add to 5,000, it seems clear that these are the large General Hospitals.

The CBEC data then indicates a collection of 22,000 facilities from 5,000 to 100,000 SF. The smaller average size for the psychiatric and specialty hospitals would indicate that they would mainly fall in the size range of 50,000 to 100,000 square feet, most likely at the upper end of this range. However, this class is only 1,198 facilities.

Looking at the breakdown in Table 9 immediately indicates that the only other sizeable facilities are the 15,605 Nursing Care Facilities (NAICS 6231). If Psychiatric and Specialty Hospitals and Nursing Care Facilities are totaled, the result is 17,603, which explains the majority of the 26,000 CBECS facilities between 5,000-100,000 SF.

| NAICS Class | Sector Name | Census Count | CBECS Size Range | CBECS Count |
|---|---|---|---|---|
| 6221 | General medical & surgical hospitals | 5,487 | 100,000+ SF | 5,000 |
| 6222, 6223, 6231 | | 16,803 | 5,000 – 100,000 SF | 22,000 |

Table 10: Cross-Comparison of Census and CBECS Data

[60] Source: Energy Information Administration, Office of Energy Markets and End Use, Form EIA-871A of the 1999 Commercial Buildings Energy Consumption Survey.

### 5.2.4 Overall Healthcare Market Health and Growth

Market growth is an important element in targeting CHP systems and not just because a growing market grows the CHP opportunity. CHP is a major system to be adding to an existing facility. CHP can be installed more inexpensively in new construction than in existing facilities, and growing markets require new construction.

Overall, there has been a steady "real" (corrected for inflation) growth in healthcare spending over the last 10 years as can be seen in Figure 40. However the health care market has been shown to be a complex collection of sub-markets, which may be faring quite differently. These will be examined in the following separate sections.

There is widespread awareness, due to public concerns, about the overall rising cost of healthcare. Statistics on this rise are shown in Figure 40, which indicates a 300% increase in inflation corrected (or real) healthcare expenses since 1980. Although this is a substantial increase, it does not mean that these increased expenses are spread over the healthcare sector uniformly. Figure 41 indicates where the recent cost increases have come from, and this has predominantly been from an increase in pharmaceutical expenditures and insurance administration. Pharmaceuticals expenditures have increased 600% in real terms between 1980 and 2000.

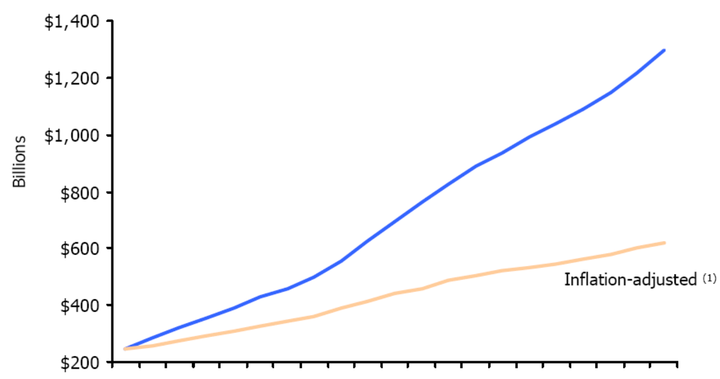


Figure 40: Total National Health Expenditures 1980 – 2000[61]

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[61] American Hospital Association Trends Affecting Hospitals and Health Systems, November 2002

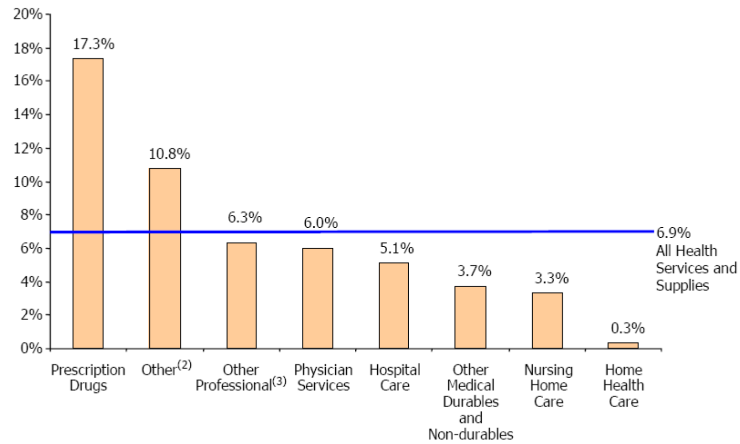


Figure 41: Percent Change in National Expenditures for Health Services and Supplies (1999 –2000)[62],[63]

#### 5.2.4.1 Health and Growth in the Hospital Market

Between 1980 and 2000, National healthcare expenditures in nominal terms grew from $233 Billion to $1,255 Billion. Over the same period, Hospital Care expenditure went from 40.5% of the total to 32% of the total. The central role previously played by major hospitals is declining and this is reflected in the declining number of hospitals seen in Figure 42.

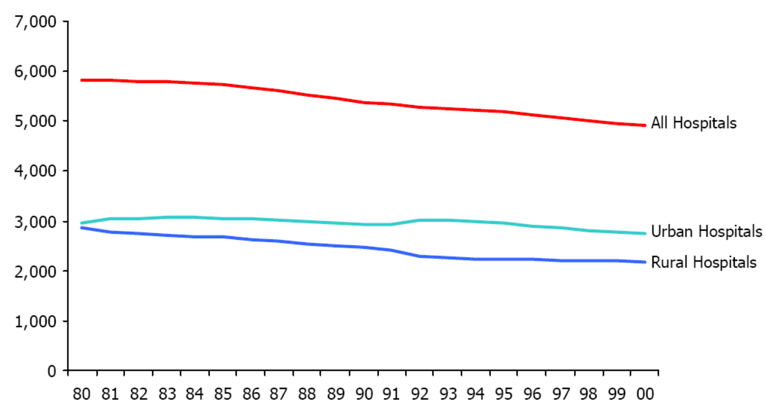


Figure 42: Number of Community Hospitals, Nationwide[64] 1980 - 2000[65]

[62] "Other" includes net cost of insurance and administration, gov. public health activities, and other personal health care

[63] American Hospital Association, *Trends Affecting Hospitals and Health Systems*, November 2002

[64] Community Hospitals are all nonfederal, short-term general, and special hospitals whose facilities & services are available to the public.

More dramatically is the change in the way hospitals are used. Nationally, inpatient days have declined dramatically as seen in Figure 43. The average inpatient stay has declined from 7.6 to 5.8 days from 1980 to 2000[66]. .

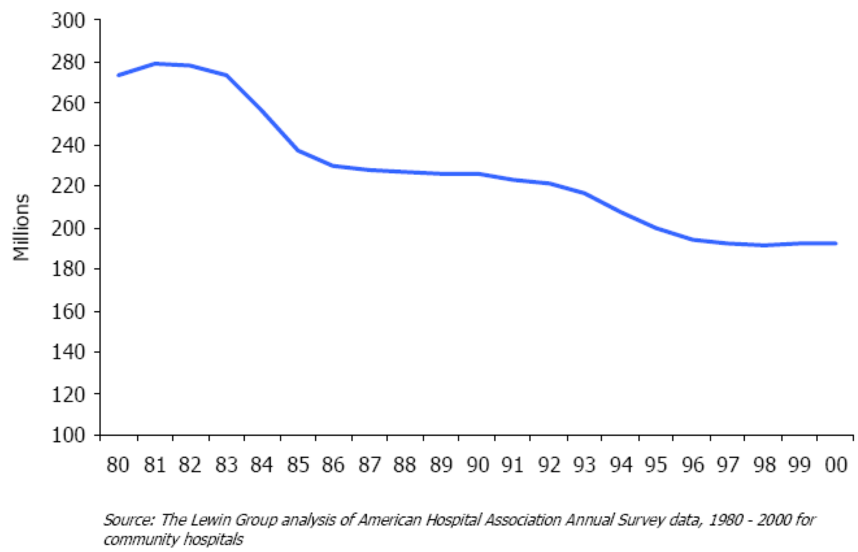


Figure 43: Declining Inpatient Days in All Hospitals[67]

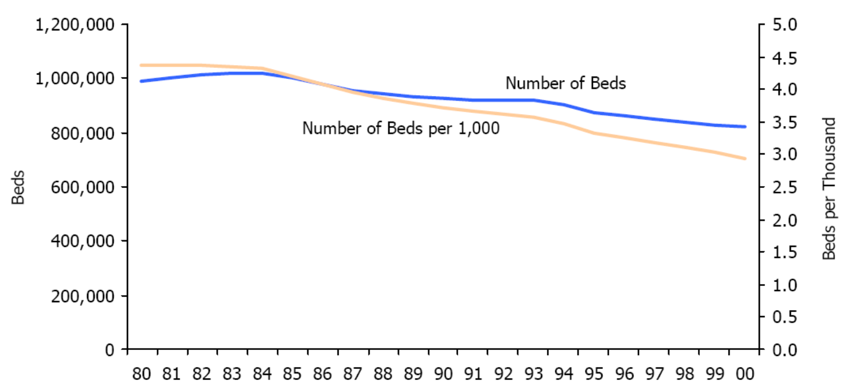


Figure 44: Number of Beds and Number of Beds per 1,000 Persons 1980 - 2000[68]

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[65] American Hospital Association Trends Affecting Hospitals and Health Systems, November 2002, Original Source: The Lewin Group analysis of American Hospital Association Annual Survey data, 1980 - 2000 for community hospitals

[66] American Hospital Association, *Trends Affecting Hospitals and Health Systems*, November 2002

[67] American Hospital Association, *Trends Affecting Hospitals and Health Systems*, November 2002

This has lead to a steady decline in the number of inpatient days per hospital. Interesting, much of this decline came in the 1980's with the decline in the number of beds not occurring until the 1990's

At the same time, a much larger portion of the hospital business is now being done on an outpatient basis, with Figure 46 and Figure 47 showing the growing outpatient admission numbers and the dramatic shift in the balance between in patient and outpatient surgeries. This indicates a greater emphasis is being placed on higher margin activities such as surgery itself, and a reduction in lower margin activities such as day-to-day patient care.

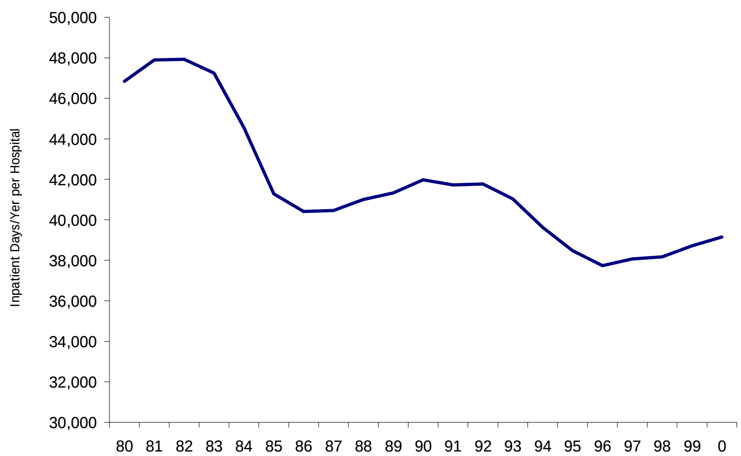


Figure 45: Inpatient Days per Year per Hospital[69]

Inpatient nights per hospital continue to decline, indicating that the national decline in in-patient nights is still outpacing hospital closures.

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[68] American Hospital Association, *Trends Affecting Hospitals and Health Systems*, November 2002, Original Source: The Lewin Group analysis of American Hospital Association Annual Survey data, 1980 - 2000 for community hospitals

[69] Original Graph, Basic data from American Hospital Association Trends Affecting Hospitals and Health Systems, November 2002

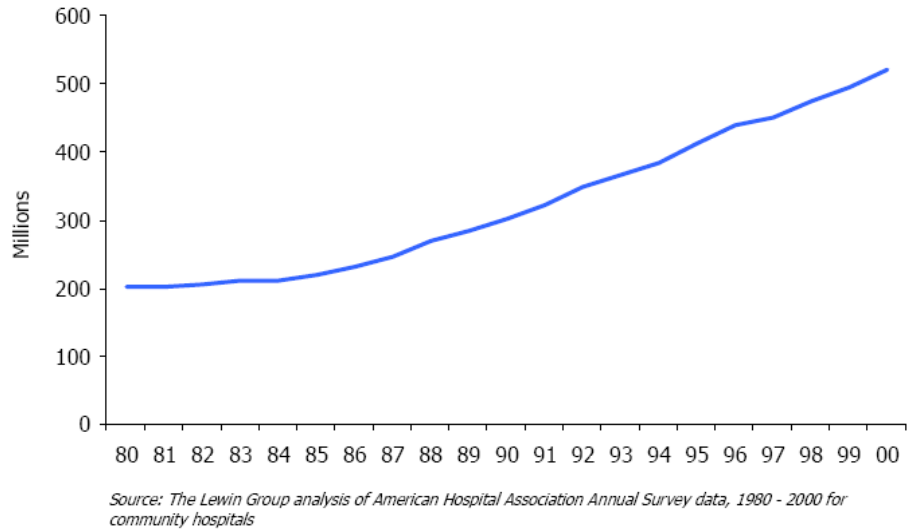


Figure 46: Total Hospital Outpatient Visits in Community Hospitals 1980 – 2000[70]

At the same time, hospitals as an organization, have diversified into a number of non-hospital services as shown in Figure 48, although none of these services seem to be showing any dramatic growth in the percentage of the hospitals involved.

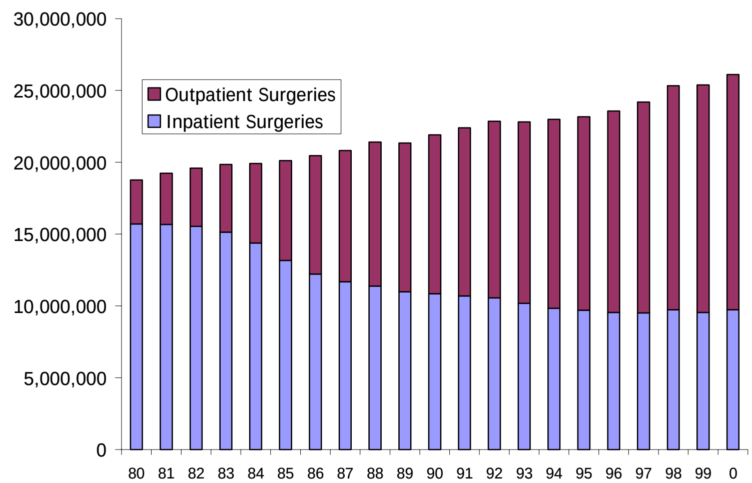


Figure 47: Number of Surgeries by Admission Type[71]

[70] Taken directly from American Hospital Association Trends Affecting Hospitals and Health Systems, November 2002

[71] Original Graph, Basic data from American Hospital Association Trends Affecting Hospitals and Health Systems, November 2002

Finally, in Figure 49, the margins in the hospital industry are not growing. Worse, nearly one-half of the Total Margin seen in the figure was from income on endowment investments. Considering the reversals in the investment market since 2000, the financial situation of hospitals is unlikely to have improved from 2000 to 2003.

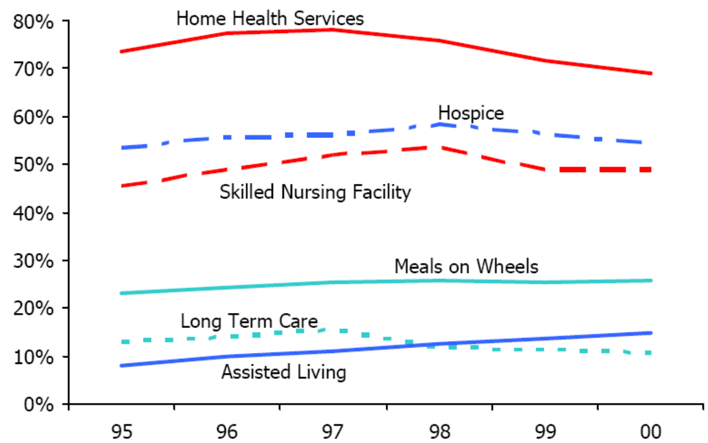


Figure 48: Percentage of Hospitals Offering "Non-hospital" Services 1995 - 2000[72]

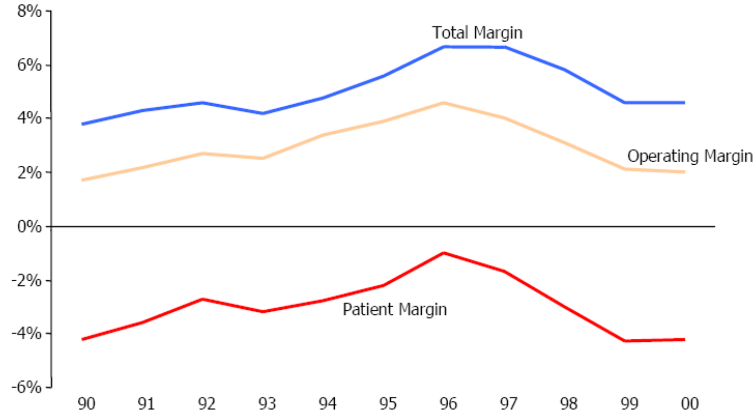


Figure 49: Aggregate Total Hospital Margins, Operating Margins, and Patient Margins 1990 - 2000 [73]

[72] American Hospital Association Trends Affecting Hospitals and Health Systems, November 2002

[73] Total Hospital Margin is calculated as the difference between total net revenue and total expenses divided by total net revenue. Operating Margin is calculated as the difference between operating revenue and total expenses divided by operating revenue. Patient Margin is calculated as the difference between net patient revenue and total expenses divided by net patient revenue. The difference between Operating Margin and Total Margin is almost entirely income on endowments.

With the overall aging of the American population, it would be easy to assume that the hospital market is looking forward to sustained growth. However, this is not indicated. Rather, due to the cost of operating major hospitals, hospital stays are becoming steadily shorter, and more of the healthcare dollar is going toward drug treatment and outpatient care than traditional hospital-based approaches, leading to an overall reduction in Community hospital numbers and in hospital bed numbers overall on a per capita basis. To survive, hospitals are following the trend and become more outpatient dependant.

Future growth of the hospital sector seems unlikely. The hospital industry is in a period of consolidation, suggesting that smaller hospitals will be absorbed into larger operations to control operating costs. Searching for a market for CHP in smaller hospital facilities does not seem to be attractive. For the overall sector, as hospitals consolidate, large operation will become larger, with added facilities strictly for outpatient care. These larger facilities will be even better candidates for large CHP systems, but this exceeds the focus of this report.

#### 5.2.4.2 Health and Growth in the Nursing Care Market

The number of nursing care facilities (NAICS 6231) has tripled over the 20 years between 1980 and 2000.

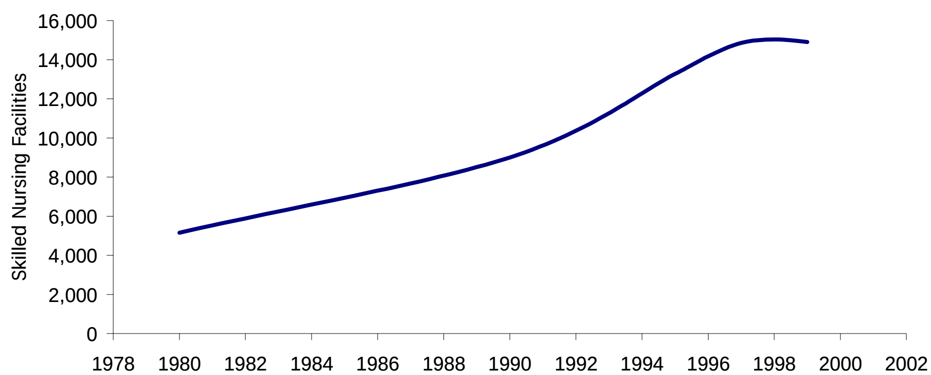


Figure 50: Growth in the Number of Nursing Care Facilities (NAICS 6231)[74]

[74] U.S. Census Bureau, Statistical Abstract of the United States: 2002, Table 164

This growth is significantly greater than the growth in the overall population and follows from the overall aging of the baby boom generation.

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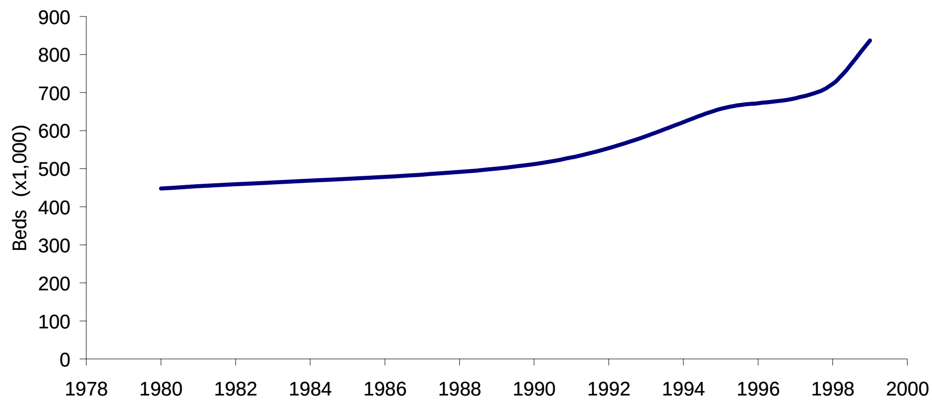


Figure 51: Census Data on Growth in the Number of Beds within Nursing Care Facilities (NAICS 6231) [75]

| | FACILITIES | DATA FOR YEAR |
|---|---|---|
| MANAGED CARE DIGEST DATA | 15,371 | 2001 |
| CENSUS DATA | 14,913 | 1999 |
| TYPE OF BED | Beds | Avg. Beds/NH |
| MANAGED CARE DIGEST DATA | | |
| Medicaid-certified | 837,792 | 54.7 |
| Medicare/Medicaid | 739,175 | 48.3 |
| Other | 101,477 | 6.6 |
| TOTAL/AVG. | 1,716,866 | 112.2 |
| CENSUS DATA | | |
| Yr 1999 Census Data | 837,000 | 56 |

Table 11: Number of Nursing Homes and Beds in 2002[76]

However, it cannot be assumed that the aging population will necessarily increase nursing care proportionally. There are currently 1,355,000 Americans in some form of home health care and a sizeable population in nearly 16,000 Community Care or assisted living facilities.

[75] U.S. Census Bureau, Statistical Abstract of the United States: 2002, Table 164

[76] Managed Care Digest 2001, 2001 Aventis Pharmaceuticals Inc., Developed by SMG Marketing Group Inc. http://www.managedcaredigest.com/edigests/is2001/is2001.shtml

Any major change in policies funding these various arrangements could move marginal patients from one type of facility to the other. As the Nursing Care sector is the most expensive to operate, pressure from the largest payer for these services, Medicare and Medicaid, could make a major difference in the future. Nursing care populations and therefore growth in this sector could be uncertain

To check with another source, “Managed Care Digest”, indicates a larger number of facilities and beds than those tracked by the Census bureau. However, comparing all of the details as shown in Table 11 indicates that the Census Bureau is only tracking certified beds.

Certified beds are beds eligible to be paid for by either Medicare or Medicaid. Therefore, the fact that the Census Bureaus number of beds in Figure 51 is growing more slowly than the number of facilities in Figure 50 most likely indicates that the percentage of beds being made eligible for Medicare or Medicaid recipients in Nursing Homes is declining.

Further, the “Managed Care Digest” data indicates 15,371 facilities in the US in 2001, whereas the Census Bureau lists 14,913 in 1999. These are in reasonable agreement and tend to indicate that almost all Nursing Homes have at least some Medicare/Medicaid beds, even if the percentage is declining. This also indicates that the growth over time in the number of facilities shown in Figure 50 agrees with the second data source.

Overall, the number of Nursing Care Facilities has grown from 5,500 to 15,271 over the period from 1980 to 2000, a 5.25% growth rate per year. From this it is clear that the nursing home market is large and growing, and should be a target market.

#### 5.2.4.3 Growth in Other Segments of Interest

This leaves a number of small sectors not yet examined. With the smaller size of these sectors, less information is available.

| | Number of Establishment 1997 Census | Number of Establishment 1992 Census | % Ch. |
|---|---|---|---|
| 621493 Freestanding ambul. surgical & emerg. Cntrs | 2,402 | Not Listed | NA |
| 6215 Medical & diagnostic laboratories | 9,076 | 8,434 | 7% |
| 621991 Blood & organ banks | 1,230 | 726 | 70% |
| 6222 Psychiatric & substance abuse hospitals | 801 | 919 | -13% |
| 6223 Specialty (expt psych & subs ab) hospitals | 397 | 577 | -31% |

Table 12: Comparison of the 1992 and 1997 Economic Census
*1992 Data was Collected by SIC Codes which are Not Entirely Compatible with the New NAICS System*

Due to the change in the Census data system between the 1992 and 1997 economic Census, many of these smaller segments have been reordered. The results seen above were found by using Census Bureau translation tools that help to reconstruct old SIC data into the new NAICS form, allowing some 1992 and 1997 data to be compared. Cleaner data will be available in the future when the 2002 economic Census data is published which, given the timetable of last Census, should begin in 2004.

Although the information is not completely clear, the categories not previously handled seem to break down as:

***Health and Diagnostic Laboratories Including Blood and Organ Banks***

There seems to be considerable growth in this sector. As both of these areas have the same motivation for back-up power, they can be viewed as one sector, with an overall positive outlook.

***Freestanding Ambulatory Surgery and Emergency Centers***

Information was not gathered on this sector in 1992, therefore growth figures are not known. However, given the emphasis on outpatient treatment in the hospital sector, it would not be surprising if a growing percentage of the outpatient surgical business was moving out of high cost environments like hospitals altogether. This small sector should be considered as positive.

***Psychiatric & Substance Abuse Hospitals And Specialty Hospitals***

These sectors, particularly psychiatric hospitals, are in extremely rapid decline in overall numbers. In general, this sector may be dwindling from the emphasis on outpatient treatment seen in the General Hospital sector. Overall, this segment should be viewed as negative.

### 5.2.5 Summary Results – Selected Sectors

Sectors of the healthcare market which have 1) a good reason to have an interest in on-site generation and CHP, and 2) a healthy growth out look can be seen in Table 13.

| | Recent Number of Establishments (Data Year) | Historical Number of Establishments (Data Year) | Annual Growth |
|---|---|---|---|
| 621493 Freestand ambul. surgical & emerg. Cntrs | 2,402 (1997) | NA | NA |
| 6215 & 621991 Medical Labs., Blood Banks | 10,306 (1997) | 9160 (1992) | 4% |
| 6231 Nursing Care Facilities | 15,371 (2001) | 5,500 (1980) | 5.25% |

Table 13: Final Short List of Attractive Sectors for Smaller CHP Systems

There does seem to be some growth in the laboratory and organ bank segment. As to the size of these facilities, they are most likely in the largely undifferentiated CBECS category of 5,000 square feet and below that also contain doctors offices and so on. Notice that the information in Table 12 records "Establishments" which are not necessary freestanding buildings.

### 5.2.6 Market Sizes in Power Terms

The overall size of the market in terms of peak power demand is the best indicator of potential cogeneration equipment sales.

#### 5.2.6.1 The Nursing Home Market

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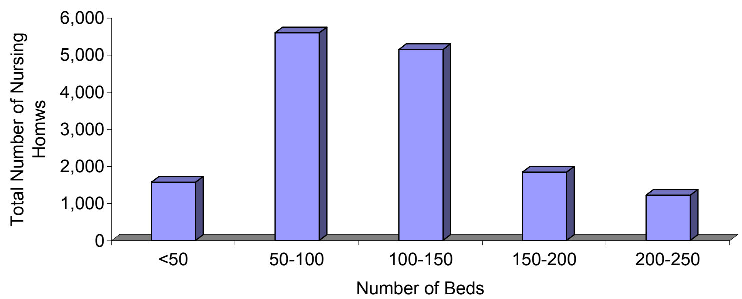


Figure 52: Profile of Facilities by Number of Beds[77]

The distribution of facility by patient bed count in the Nursing Care Facilities sector can be seen in Figure 53. As seen previously, the average facility is roughly 100 beds, but there is considerable variation across the market.

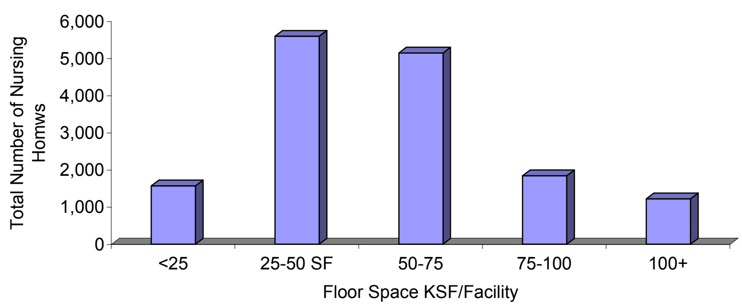


Figure 53: Profile of Facilities by Number of Beds and Roughly by Size[78]

Given that the main function of these facilities is to meet the needs of inpatient care, the assumption was made that facility size will vary linearly with the number of patient beds.

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[77] Values taken directly from Managed Care Digest 2001, 2001 Aventis Pharmaceuticals Inc., Developed by SMG Marketing Group Inc

[78] Assumes 500 square feet per bed for the entire facility

Therefore, the second graph assumes Nursing Facilities have 500 square feet for each patient bed. This covers not just the patient's room or portion of a room, but all other areas in the facility from corridors to kitchens. The CBEC data in Table 10 had placed Nursing Care facilities at between 5000-100,000 square feet. Using 500 square feet per bed, on the data in Figure 52 produces a spectrum of building largely between 5000 and 100,000 square feet, as shown in Figure 55.

Power consumption is often assumed to be proportional with building size. CBECS data indicates the average and diversity of power consumptions in the entire healthcare sector, but nothing specifically for nursing homes.

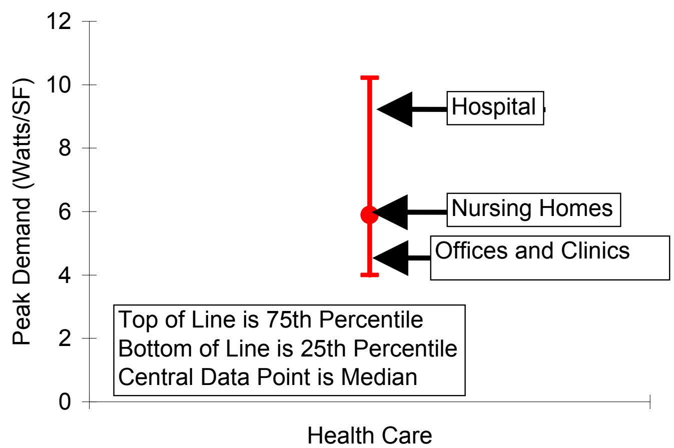


Figure 54: Range of Power Consumption per Square Foot for the Healthcare Segment[79]
*The top and bottom of the line is the 75th and 25th percentile respectively. The red dot is the median*

The range of peak electric consumption for the healthcare industry is shown in Figure 54. Overall, nursing homes will require more equipment than medical offices, but will be well below the power needs of a major hospital. On this basis, nursing homes will be assumed to have the median 6 watts per square foot of electric consumption, which allows the overall power consumption of nursing facilities to be estimated. Using the values in Figure 53, and 6 watts per square foot produces the spectrum of power demands shown in Figure 55.

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[79] Table 19. Distribution of Peak Watts per Square Foot and Load Factors, "U.S. Department of Energy, Energy Information Administration, "A Look at Commercial Buildings in 1995: Characteristics, Energy Consumption, and Energy Expenditures."

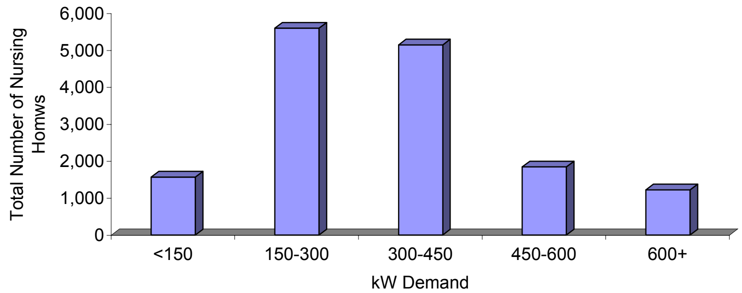


Figure 55: Number of Nursing Homes by Demand Size
*The total demand for all nursing homes is 5.2 GW*

Given that cogeneration systems tend to be best sized on the order of ~50% of the electric load and given the range of sizes of nursing facilities, packaged systems anywhere from 100-300 kW would seem most appropriate. This suggests that these systems would be on the small end of industrial engine systems and that cogeneration packages being developed with one or multiple Capstone 60 generators might be the most appropriate.

Overall, using the calculation outlined in this section, the overall 1,716,866 Nursing Care Facility beds represent an overall load of 5.15 GW, and the 5.25% growth rate suggests an annual growth rate of 275 MW.

### 5.2.7 Market Concentration

Some of the target healthcare facilities, particularly nursing homes, are subject to considerable market concentration. This means that a small number of owners control a substantial portion of the market. Appendix 1 contains a list of the 33 largest owners of Nursing Home facilities. This group owns over 4,200 Nursing Homes, which contain nearly 500,000 beds. This amounts to roughly one quarter of the market by facility count and nearly one-third of the market by overall bed count.

Such market concentration is an advantage in marketing a new concept like CHP, as this allows a very affordable marketing effort, as only a limited number of potential customers need to be approached. This makes the Nursing Care Facility an even more attractive introductory market for smaller CHP systems.

### 5.2.8 The Compatibility of CHP with HVAC Systems Currently Used in Healthcare

As mentioned previously for the educational sector, for CHP to be a practical retrofit in an existing facility there must be an opportunity to use the waste heat being generated by the system. In general, this means that facilities with centralized heating and hot water systems are more amenable to CHP installations than a facility that uses localized or zone-by-zone heating systems.

In addition, facilities with centralized cooling systems also have a distinct advantage. Central cooling systems which dispatch chilled water to various areas of the building can be conveniently retrofit with an absorption chiller operating on the engine or turbine waste heat. Chilled water produced by the absorber can then be distributed by the central chilled water system without any changes to the remainder of the facility.

Like education, data on the types of systems currently used in Healthcare is not widely available. Once again, the best source is another volume of the major markets survey carried out in 1998 by Gas Research Institute and the American Gas Association[80]. This survey was taken across the healthcare sector with the interviews equally dominated by hospital and nursing home responses. Respondents were facility managers from 1514 different facilities of which 472 were from nursing homes.

The interview responses were then reduced by facility ownership. Unfortunately, as can be seen from the response breakdowns, there is not a clean separation into hospital and nursing home sub-sectors. This will have to be kept in mind while examining the results. Fortunately some the results are reduced by facility size and this will help distinguish between nursing homes and hospital operations.

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[80] *Commercial Market Segmentation Study, National HealthCare Sector,* Prepared by Opinion Dynamics, GRI 97/0382, 1998

| Ownership of Facility | Independent | Local Control | HQ Control | Total |
|---|---|---|---|---|
| Actual Interviews | 964 | 474 | 76 | 1,514 |
| Number of Facilities Answered For | 1,024 | 522 | 2,465 | 4,011 |
| Facilities per Interviewee | 1.06 | 1.10 | 32.43 | 2.65 |
| Projected Number of Facilities | 28,386 | 5,336 | 4,809 | 38,531 |
| Projected Floor Space (Million Square Feet) | 1,600 | 231 | 926 | 2,757 |
| Floor Space by Facility | 56,366 | 43,291 | 192,556 | 71,553 |
| *Interviews by Sector* | | | | |
| Hospital | 415 | 256 | 48 | 757 |
| Nursing Home | 472 | 180 | 21 | 621 |
| Other | 77 | 38 | 8 | 136 |
| *Facilities Answered for by Sector* | | | | |
| Hospital | 440 | 282 | 1,553 | 2,006 |
| Nursing Home | 502 | 198 | 666 | 1,645 |
| Other | 82 | 42 | 247 | 361 |
| *Projected Facility Number* | | | | |
| Hospital | 12,206 | 2,881 | 3,030 | 19,266 |
| Nursing Home | 13,909 | 2,028 | 1,298 | 15,798 |
| Other | 2,271 | 427 | 481 | 3,468 |

Table 14: Healthcare Interviews

| Size | <5,000 SF | 5,000-10,000 SF | 10,000-30,000 SF | 30,000-50,000 SF | 50,000-75,000 SF | 75,000-150,000 SF | 150,000-300,000 SF | >300,000 SF |
|---|---|---|---|---|---|---|---|---|
| # Bldg Answered For | 533 | 291 | 289 | 885 | 467 | 276 | 1,071 | 193 |
| # by Size Breakdown | | 1465 | | | 2007 | | | |
| Facility Type | | Nursing Care | | | Hospitals | | | |

Table 15: Number of Facilities Answered for in the Interviews by the Size of Those Facilities as Reported

Note that the Range from 50,000 to 300,000 SF covers 2007 buildings which is nearly the same number of buildings as the hospital total (2,006) in Table 14, and the range from 5,000 to 50,000 SF covers 1,465 buildings which is about the same number of buildings as the Nursing Home “Answered For” (1,645) in Table 14. Therefore it will be assumed that, where results are available by size, the 5,000 to 50,000 SF respondents correspond to

Nursing Home respondents. The 5,000 to 50,000 SF size is slightly below what was found in the last section as shown in Figure 53, which may represent a skew in the interviewee selection.

Much of the data is given as a function of organizational type. Understanding the purchasing process was a major objective of the GRI study and therefore, organizational types were set by the ownership type and management control structure. These classes include:

- Facilities that are "*Independent*" that is independently owned and controlled.
- Facilities that are "*Part of a System*" with local decision making authority, but owned by a larger organization.
- Facilities that are in a "*System*" where all major purchasing decisions are made from headquarters

#### 5.2.8.1 Survey Results

CHP systems are major investments. For a healthcare operation to be interested in putting significant money into a facility, the operations ownership of the facility is important. Ownership indicates a plan to remain at the location over the long term and also control of the facility with rights to make the major modifications required by a CHP system. In addition, it is difficult to imagine such an investment being put into a rental building.

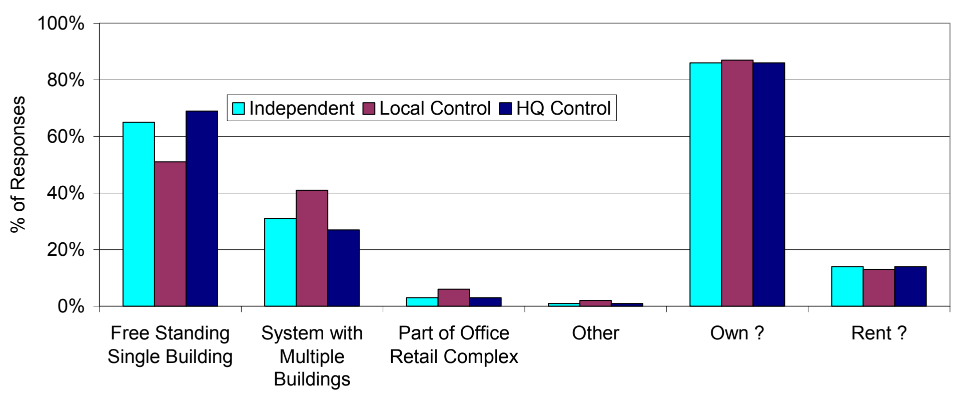


Figure 56: Building Structure and Ownership in Healthcare[81]

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[81] *Commercial Market Segmentation Study, National HealthCare Sector,* Prepared by Opinion Dynamics, GRI 97/0382, 1998

Healthcare buildings were found to be predominantly freestanding single or multi-building complexes and were generally owned by the healthcare operation. Note that only a few medical office buildings were included in the survey (in Table 14, under "Other")

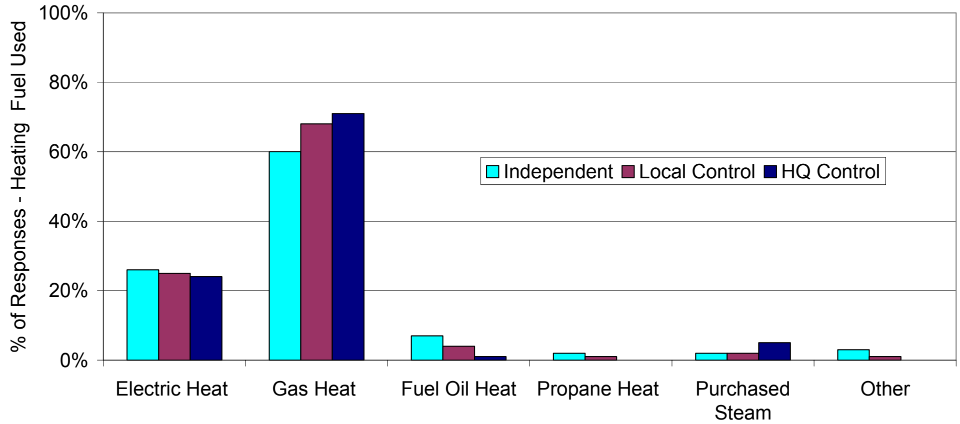


Figure 57: Heating Fuels Used in Healthcare
*60% to 70% of the buildings use gas for heating*

The respondents were asked which heating and water heating fuel they use. This result indicates the availability of gas service to the facility. As gas is the predominant fuel used for CHP systems, service availability is important. In the survey, 60% to 70% of the buildings use gas for heating and over 70% of all classes of healthcare buildings used gas for water heating, indicating that gas is available in over 70% of the buildings.

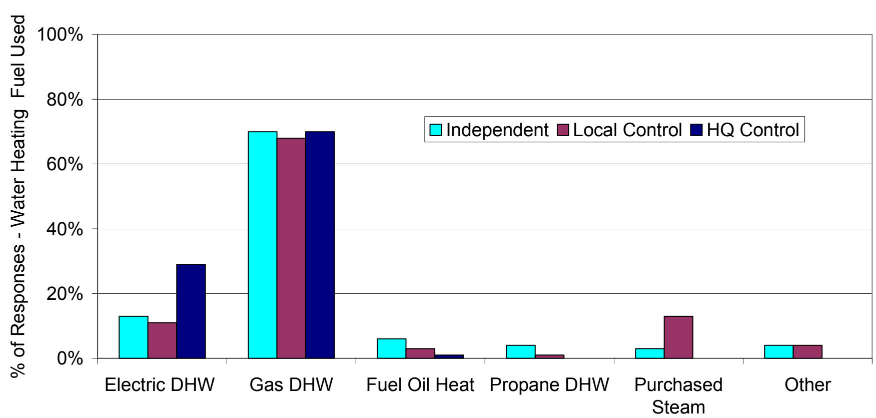


Figure 58: Water Heating Fuels Used in Healthcare
*Over 70% of all classes of healthcare building use gas for water heating indicating that gas is available in over 70% of the building.*

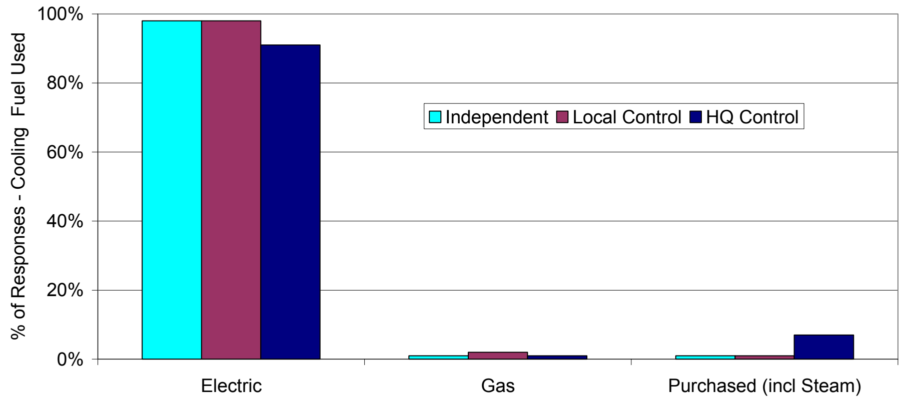


Figure 59: Energy Sources for Cooling Used in Healthcare
*The use of gas is comparatively rare in cooling, indicating that the operators may not have extensive experience with absorption chillers. Note, however, that this may not be true across all size classes.*

The type of fuel used for cooling, and most significantly, how commonly gas is used for cooling was an important question. Where gas is used for cooling in hospitals, this is generally done with absorption chillers operating on the steam system. As absorption chillers are an important element in CHP systems, the lack of familiarity with absorption cooling across the breadth of the healthcare segment is an important issue.

The survey found that the use of gas is comparatively rare in cooling, indicating that the operators may not have extensive experience with absorption chillers. Note, however, that this may not be true across all size classes.

At first, this result seems odd, as hospitals have always been a major market for absorption systems. This issue is explored in more detail in Figure 62.

The type of heating systems currently used in healthcare facilities is important in determining the difficulty in installing CHP in an existing building. Buildings with central boiler systems will be able to accept heat from the generator right at the boiler plant and then distribute this heat through the existing piping system. Buildings with other more scattered or "unitary" systems will have a greater difficulty in making use of heat from the generator. In that case, a CHP installation may either require the installation of a facility piping system, or the CHP package will have to be designed to work with a building structured for rooftop heating.

Fortunately, the survey found that centralized boiler heating systems are used across all size classes, and are significant or dominant in all size classes over 10,000 SF.

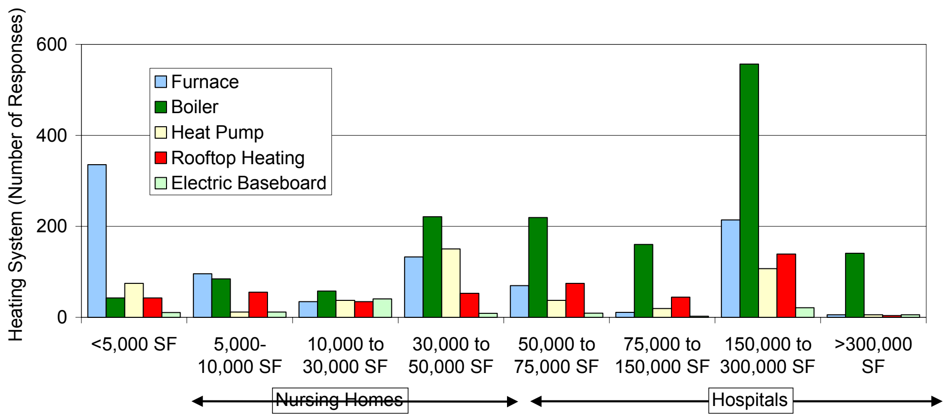


Figure 60: Types of Heating Systems Used in Healthcare by Building Size Class
*Centralized boiler heating systems are used across all size classes, and are significant or dominant in all size classes over 10,000 SF.*

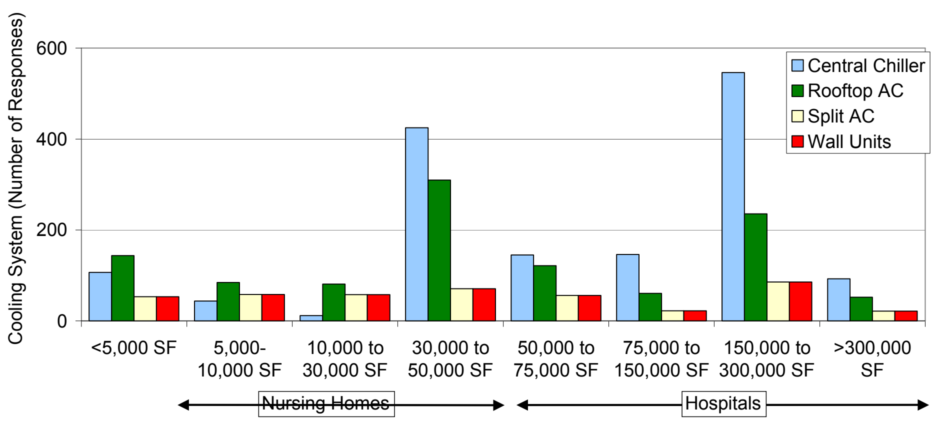


Figure 61: Types of Cooling Equipment Used in Healthcare by Building Size Class
*Central chillers play little role until the buildings are over 30,000 SF. Note that in the under 5,000 SF size, the respondent may have been confusing split systems with central chillers, as a single split system could handle such a small facility.*

The same situation between centralized and unitary systems exists for the cooling equipment. Once engine heat has been used to operate an absorber, cooling is produced as chilled water. If a facility is currently using chillers of any type, a complete distribution system for this chilled water is already available. However, the current use of rooftop systems for cooling would make CHP installation problematic. The survey found that central chillers play little role until the buildings are over 30,000 SF.

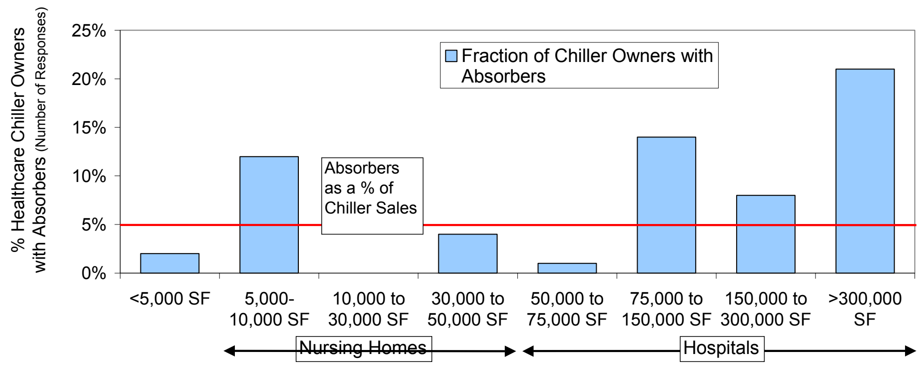


Figure 62: Fraction of Chiller Users Using Absorbers

If CHP can be most easily installed into facilities currently using chillers, then the familiarity in the healthcare market of absorption systems to chiller users is important. In Figure 62, the percentage of chiller users with absorbers in their facilities is shown. The line across the chart indicates the current percentage of national chiller sales taken by absorbers. Clearly, in the hospital end of the healthcare market, the familiarity with absorbers is substantially higher than in other markets. However, in smaller facilities, like nursing homes, familiarity will not be as high, making this an issue to be addressed in outreach activities.

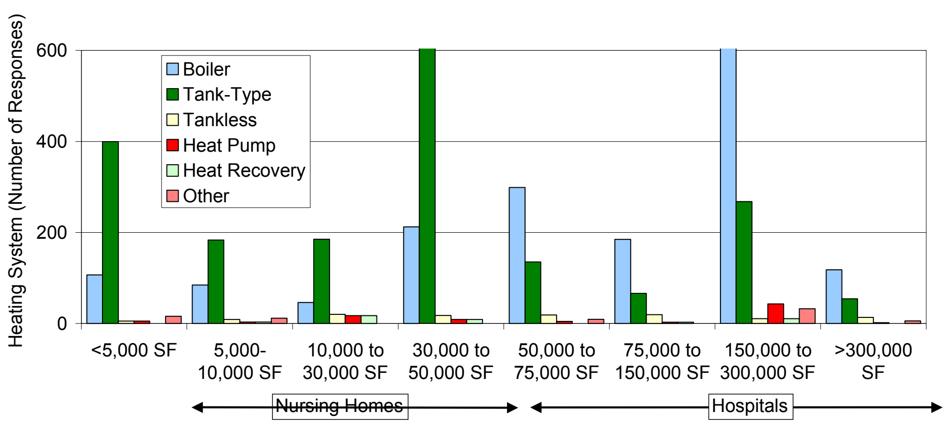


Figure 63: Types of Water Heating Equipment Used in Healthcare by Building Size Class
*Conventional tank type water heaters dominate the market up to 50,000 SF, where central boilers take over.*

The type of water heater used in a facility also has some effect on the difficulty of a CHP installation. Healthcare facilities tend to have appreciable water loads, and any facility that uses the central boiler for water heating will allow engine heat to be easily used for this purpose. If a tank-type water heater is used, it may be located in a centrally located or multiple units may be dispersed throughout the facility. The survey found that conventional tank type water heaters dominate the market up to 50,000 SF, where central boilers take over.

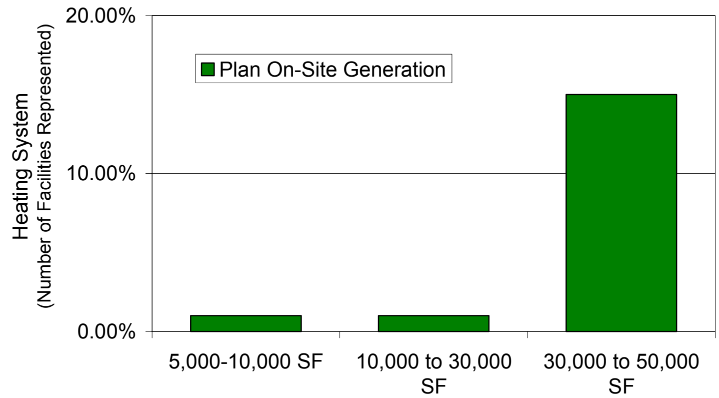


Figure 64: Number of Respondents Who are Planning on On-Site Generation
*As a Percentage of Those Facilities that Do Not Currently Have Generators On-Site*

Finally, the attitude of respondents to on-site generation is shown in Figure 64. Only facilities of a smaller size than hospitals are shown. Responses to this question in the hospital sector, where emergency on-site generation is universally required, are unclear in this study

Overall, the dominance of central heating systems in nursing homes is significant over 30,000 square feet in size and dominant over 50,000 square feet. This will make CHP retrofits to existing facilities easier and a focus on the larger end of this market is recommended.

### 5.2.9 Decision Making Process in the Health Care Industry

In designing outreach material for the CHP in the Healthcare market, the most important information to have is:

- Who is the most important decision maker to reach?
- How do they make their decisions?
- Who influences their decisions?
- Where do these decision makers go for information?

The study asked this question in enough detail to gain insight on how to reach out to this market.

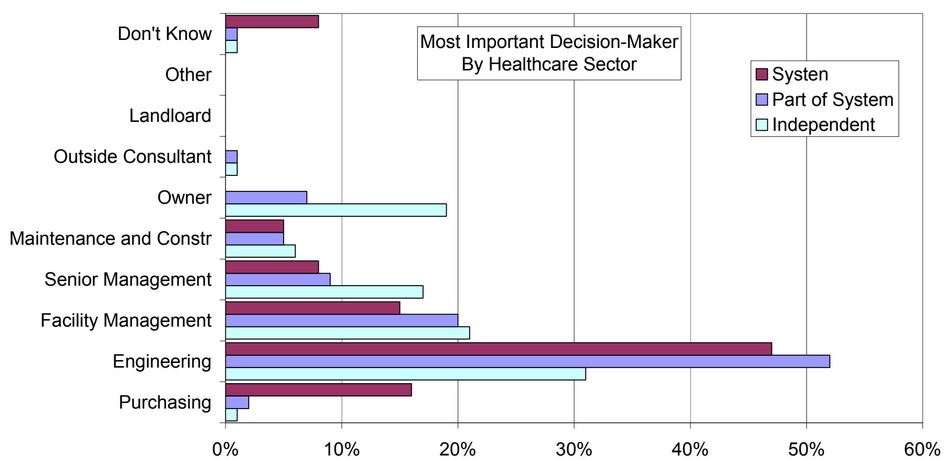


Figure 65: Who is the Decision Maker by Ownership Type

First, the organizational position of the most important decision maker is shown in Figure 65. These results are only available by ownership type as the decision making process will depend on the type of organization. Notice that an "Engineering " group was named as the most important decision maker across all organizational types, indicating a significant level of technical sophistication in this market sector. Other sectors studied in the same report[82]

[82] *Commercial Market Segmentation Study, National HealthCare Sector,* Prepared by Opinion Dynamics, GRI 97/0382, 1998 also covered Grocery, Lodging, Restaurants, Retail, and the Education Sector

showed a much greater level of control held by owners or facility managers with little influence from any in-house engineering capability

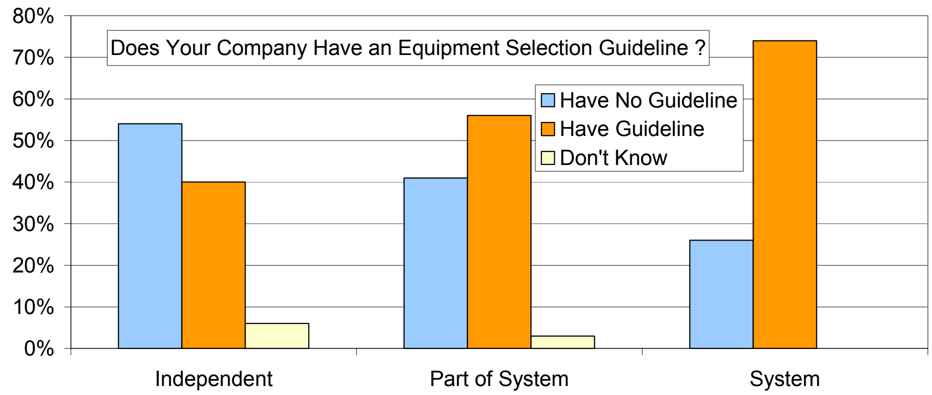


Figure 66: Does the Healthcare Organization Have a Written Equipment Selection Guideline?

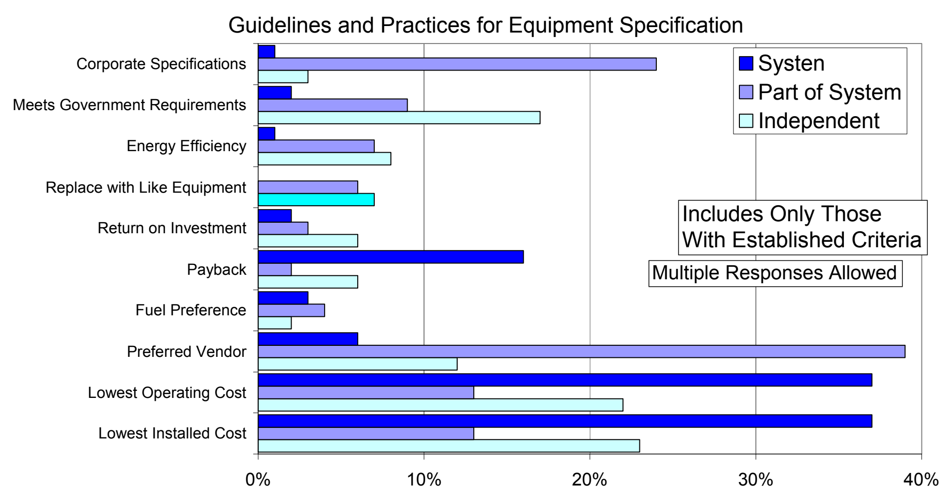


Figure 67: Decision Making Process
*What guideline or preference is most important in the owner's or manager's mind when deciding on a major HVAC purchase?*

Before asking about the most important issues in the decision making process, the organization was asked if they had a written equipment selection guideline. The existence of such a guideline document indicates an organization that has thought through the equipment decision-making process. Only organizations with such a guideline were asked to contribute their criteria to the study.

The criteria used in the healthcare market are shown in Figure 67 and vary substantially depending on ownership type.

In healthcare, those facilities that are controlled from a central location, the “System” organizations, report that they are significantly more concerned with financial calculations such as operating cost projections, first cost estimates, and paybacks than in other sectors. This indicates a central engineering department under significant pressure to implement technologies that improve the organizations financial position.

Those organizations that are centrally owned but make equipment decisions on the local level, the “Part of System” organizations, are most focused on preferred vendors and meeting corporate specifications. This indicates that, although they are responsible for decision-making, they are also under significant corporate scrutiny on any negative outcome of those decisions, potentially making them highly risk averse. Decision makers in “Independent” organizations seem to be somewhere in the middle of these two extremes.

Given this information, the centrally controlled “System” organizations would be the best initial market for CHP, working through their central Engineering departments, and leading with financial information, followed by technical background geared to Engineering professionals.

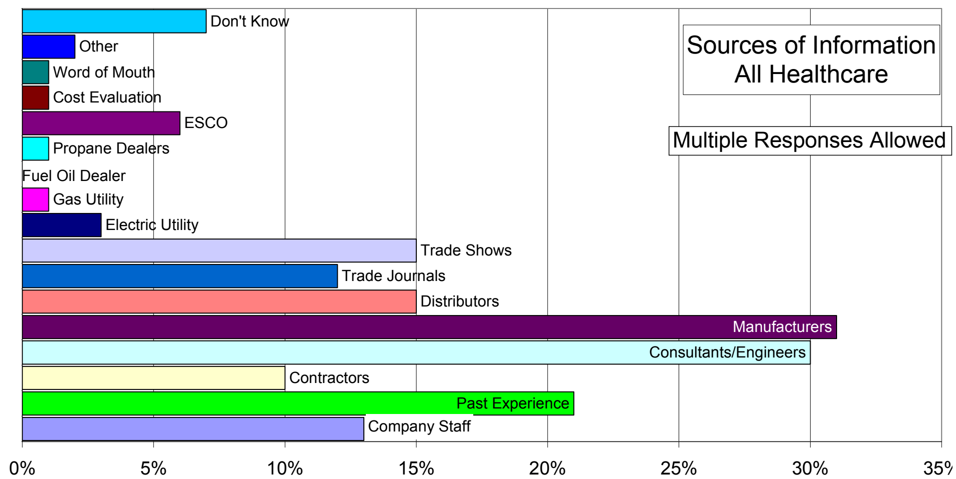


Figure 68: Sources of Information in the Decision Making Process

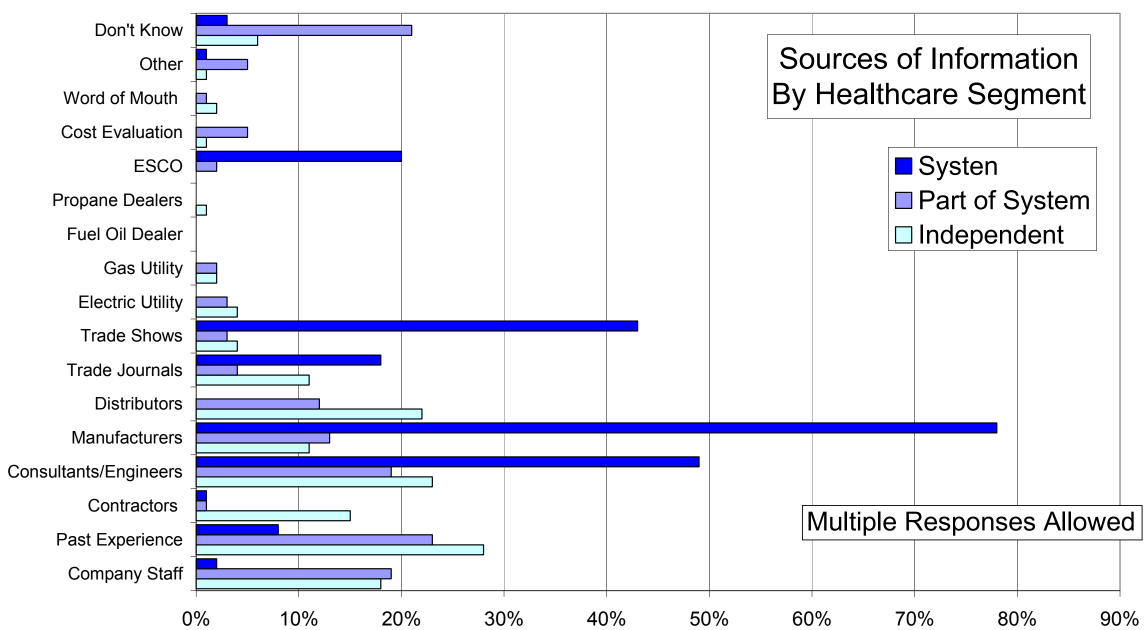


Figure 69: Sources of Information in the Decision Making Process by Ownership Type

The sources of information also show a wide diversity of responses depending on the type of organization. The responses for the entire sector are shown in Figure 68. However the responses for the individual sectors in Figure 69 display large variation between organization types and are more revealing.

Once again the "System" sector reveals their in-house capabilities in Engineering by noting manufacturers as their principle source of information, as well as the importance of trade shows. Generally, an organization will only reach directly to manufacturers for information if there is an in-house Engineering staff capable of interpreting information from multiple competing manufacturers. The responses do show some dependence on outside "Consultants/Engineers", probably for special issues. Notice that these "System" organizations also place a low emphasis on "Past Experience" which is also natural for organizations with in-house engineering capability.

Responses from the other organizational types, the "Independents" and the "Part of System" organizations, are mixed with only "Past Experience" and "Don't Know" as leading responses. The "Past Experience " response is another indication that these organizational types are risk averse. The "Don't Know" response indicates organizations that do not have a formalized process for considering or evaluating major new investments in infrastructural equipment.

All of these responses were in regard to making decisions on a major investment in HVAC equipment, a decision process that most facilities, including healthcare, do not have to engage in frequently. The results to not carry over to their decision making on medical equipment, which would not be the domain of the facility management people who were interviewed for this survey.

Overall, the interview responses indicated that the "System" organizations were better equipped with in-house engineering talent, were more focused on concepts that would reduce operating costs, and were less risk averse, making these centrally controlled organizations more attractive as an opportunity for smaller packaged CHP systems.

### 5.2.10 Determine the Most Important Segment Specific Facility Power and HVAC Issues

The American Society of Healthcare Engineers is the professional organization of facility engineers for hospitals and other healthcare facilities. As such ASHE present a series of regular training seminars on subjects that have been recommended to them by their membership. The seminars are then presented on an as needed basis, depending on the attendance of their membership[83]. At present, the seminars that are being repeatedly offered are:

- Emergency Management Planning: On the development of action plans to deal with major emergencies particularly including acts of terrorism.
- Healthcare Construction Certification Program: To train construction contractors on the needs of healthcare buildings particularly life safety system issues and medical equipment technology and hospital construction
- The Environment of Care: Dealing with patient safety, emergency management, security, infectious control, and indoor air quality.

As these have been the courses that have recently drawn the interest and attendance of the ASHE membership, it is clear that, after the 9/11 attacks, security is a major concern. Tying CHP into that concern depends on promoting CHP as a source of back-up power that also produces useful operating cost savings. This is a different "order-of-message" than used in the past where CHP has been promoted by focusing on operating cost savings and mentioning back-up power capability as an ancillary benefit.

As hospitals are larger employers of facility managers, the membership of ASHE is inclined to be more hospital dominated. In concentrating on the smaller healthcare building, such as nursing homes, outpatient operations, and medical laboratories, the need for back-up power

[83] Private conversations with Dale Woodin, Deputy Executive Director of the American Society of Healthcare Engineers

may have to be established more strongly in the operators mind. For example, the Standard Emergency Guideline for Blood Bank operations states[84] only:

> In preparation for power outages, the blood collector should
>
> - ✓ Determine the rules in the local community regarding priority status for return of power
> - ✓ Check with the local power company as to its procedures for deeming an entity top priority for restoration of power in the event of an outage (Note: the power company may direct BC to a city/local government)
> - ✓ Review all power backup plans for its facility. Ideally, a BC should have alternative sources of power.
> - ✓ Communicate with its vendors to determine procedures for obtaining back-up power in case of an emergency. Alternative sources of power/light that may be necessary include generators, batteries, and flashlights.

.

This is an amazingly weak emphasis on any form of electric back-up for facilities that may find themselves collecting and typing blood by "alternative sources of light such as flashlights" in the event of even high probability disasters such as hurricanes or tornados.

However, even in these markets, given current events, promoting CHP and Security together would pose a more gripping message than leading with operating cost savings alone.

[84] Disaster Operations Handbook – Coordinating the Nation's Blood Supply During Disasters and Biological Events, American Association of Blood Banks, InterAgency Task Force on Domestic Disasters and Acts of Terrorism 2003

## 5.3 Determine the Best Channels for Information Outreach

### 5.3.1 Existing Professional Association Publications

There are such a large number of professional publications in the medical industry, that the need to focus down on the most relevant publications is essential. The Facility Managers are clearly the most important decision makers in the acceptance of CHP systems.

ASHE does print it's own magazine "Healthcare Engineer" and also communicates with members over the Internet[85] through a members only service called "ASHE Flash". These are the most targeted method of outreach on CHP issues for healthcare facilities staff. Recent articles have included issues on power generating systems.

In addition ASHE, along with their parent organization, AHA, cooperate in "HospitalsConnect"[86], a large on-line resources system that publishes information on a wide spectrum of issues, but with more of a focus on hospitals.

One organization focused entirely on Nursing Homes for the Aged, Retarded, or Disabled is the American Health Care Association, AHCA, which carries a few issues briefs on their website. Although focused on Nursing Homes, the direction of the organization is mainly on the nursing function, rather than on the facilities.

Finally new construction and remodeling of Hospitals, Nursing Homes, and Health Care facilities involves the hiring of an engineering design firm. As most of these firms have multiple employees who are members of the American Society of Heating, Air Conditioning, and Refrigeration Engineers (ASHRAE), the ASHRAE Journal remains a excellent method of outreach but is not focused specifically on the Healthcare Industry.

Other magazines supplied to this market, generally for free are HPAC, Consulting Engineer, and the HVAC News. However, these no-fee magazines seem to have a very set publication agenda that relates closely to the products of their advertisers.

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[85] www.ashe.org

[86] http://www.hospitalconnect.com/DesktopServlet

### 5.3.2 Internet Based Newsletters

Internet newsletters on CHP are an option for reaching out to both the facility owners and to design engineers. For such materials to actually be read, they should be as targeted as possible to the needs of the recipient. Otherwise they will be viewed as mass advertising and disregarded.

For an effort in Internet marketing to be successful, the material must be

- Highly targeted to the recipients specific market sector
- Carry a message that corresponds to the current needs of the sector
- Be presented in a non-manufacturer specific manner
- Allow the reader to access supporting material on a web site, without having to contact any manufacturer's sales office. However, the web-site should provide contact points for a user who wishes to discuss a CHP feasibility study on his facility
- Be repeated with new information on a regular but not too frequent basis

The Steaming Ahead newsletter supported by DOE's Industrial program is a particularly good example of this type of outreach.

In reaching major nursing home owners, this approach may be the most successful way to introduce them to the CHP concept, as the major owners can be identified.

Unfortunately, unlike the schools market, no resource has been found to date that indicates facility design firms that specialize in the overall healthcare field, much less specific segments like Nursing Homes. Professional societies like ASHE may have this on a confidential basis, but unlike the CEFPI directory, it is not published. Therefore, newsletters for design engineers would have to be less market segment specific, perhaps covering CHP information for healthcare and other sectors together.

Overall Internet communications should be a most cost effective way to reach a large number of potential users with a new concept like smaller CHP systems and packages, where the message can be made intriguing and the material can be viewed as educational. Conversely, marketing an existing widely used product on the Internet is often viewed as simply spam

### 5.3.3 Course Development and Delivery

In 2001, ASHE had developed a complete two-day workshop course for their Educational series. The course was intended to tour the U.S., with a presentation scheduled for each of the 10 ASHE regions. Unfortunately, the course was initially presented in October of 2001, and in the post 9/11 atmosphere, ASHE was asked by their members to refocus their course series on security issues relating to terror/disaster scenarios. However, in recognition of the security implications of CHP, ASHE did hold a session of the course at their national meeting in 2002 and 2003.

As ASHE members consider the implications of the grid failure in August of 2003, electric supply security should be of greater interest. However, some updating and refocusing of the original material may be needed, but this material is available should a program of workshops be chosen as an outreach method.

### 5.3.4 Internet-Based Distance Learning Mechanisms

Given that significant material has already been developed for an ASHE course on CHP, a conversion to an Internet Based Distance Learning format is less elaborate than if the material had to be developed. To reach the appropriate customers, having the course housed on an existing distance learning system that appeals to this customer group is extremely helpful. Although at present, ASHE does not have such a facility on their website system, they have expressed on interest in setting such a system up.

This material could also be handled on a Distance Learning system through the CHP outreach centers. However, having trade allies like ASHE aiding in promoting the courses would help in gaining acceptance.

The entire area of distance learning is still in a process of evolving. However, some approaches have been more successful than others. On-line courses that are well scripted, structured, and graphically interesting attain a higher level of student attention and content absorption. Courses that have on-line support systems that allow questions to be presented and answered, and some give and take between students are reputed to help. No detailed statistics on Distance Learning Features Versus Educational Outcomes have been found.[87]

[87] Personal conversations with Raymond Matthes, Director, Media Services - Distance Learning, UIC

Appendix 1 – The Largest Nursing Home Chains in the United States

| CHAIN / HEADQUARTERS | Current Rank | Tax Status | Total NHs | Total Lic. Beds | Avg. Beds/NH | # of States |
|---|---|---|---|---|---|---|
| Beverly Enterprises / Fort Smith, Ark. | 1 | FP | 541 | 59,963 | 110.8 | 30 |
| Mariner Post-Acute Network / Atlanta, Ga. | 2 | FP | 425 | 50,830 | 119.6 | 29 |
| Integrated Health Services / Owings Mills, Md. | 3 | FP | 335 | 40,096 | 119.7 | 34 |
| ManorCare / Toledo, Ohio | 4 | FP | 296 | 40,046 | 135.3 | 31 |
| Sun Healthcare Group / Albuquerque, N.M. | 5 | FP | 285 | 32,074 | 112.5 | 25 |
| Vencor / Louisville, Ky. | 6 | FP | 281 | 36,288 | 129.1 | 31 |
| Genesis Health Ventures Inc. / Kennett Square, Penn. | 7 | FP | 269 | 34,515 | 128.3 | 17 |
| Life Care Centers of America / Cleveland, Tenn. | 8 | FP | 209 | 27,179 | 130 | 28 |
| The Evangelical Luth. Good Samar. Soc. / Sioux Falls, S.D. | 9 | NFP | 204 | 16,674 | 81.7 | 25 |
| Extendicare Health Services / Milwaukee, Wis. | 10 | FP | 169 | 17,920 | 106 | 13 |
| Centennial Healthcare / Atlanta, Ga. | 11 | FP | 103 | 10,996 | 106.8 | 22 |
| National Healthcare Corporation / Murfreesboro, Tenn. | 12 | FP | 102 | 13,366 | 131 | 9 |
| Texas Health Enterprises / Denton, Texas | 13 | FP | 99 | 10,942 | 110.5 | 4 |
| Complete Care Services / Horsham, Penn. | 14 | FP | 89 | 9,998 | 112.3 | 4 |
| Servicemaster—Diversified Health / Memphis, Tenn. | 15 | FP | 60 | 11,167 | 186.1 | 17 |
| Marriott Senior Living Services / Washington, D.C. | 16 | FP | 59 | 4,297 | 72.8 | 17 |
| Lenox Healthcare / Pittsfield, Mass. | 17 | FP | 52 | 5,181 | 99.6 | 12 |
| Advocat Diversicare / Franklin, Tenn. | 18 | FP | 49 | 5,370 | 109.6 | 8 |
| Britthaven Inc. / Kinston, N.C. | 19 | FP | 46 | 5,583 | 121.4 | 3 |
| Harborside Healthcare / Boston, Mass. | 20 | FP | 46 | 5,556 | 120.8 | 9 |
| Evergreen Healthcare / Vancouver, Wash. | 21 | FP | 45 | 4,493 | 99.8 | 6 |
| Care Initiatives / West Des Moines, Iowa | 22 | NFP | 45 | 3,795 | 84.3 | 1 |
| Life Care Services Corporation / Des Moines, Iowa | 23 | FP | 45 | 3,351 | 74.5 | 22 |
| Fountain View / Burbank, Calif. | 24 | FP | 43 | 5,784 | 134.5 | 3 |
| Covenant Care / San Juan Capistrano, Calif. | 25 | FP | 39 | 4,461 | 114.4 | 7 |
| Tutera Group / Kansas City, Mo. | 26 | NFP | 37 | 4,895 | 132.3 | 8 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Delta Health Group / Pensacola, Fla. | 27 | FP | 35 | 4,303 | 122.9 | 3 |
| American Health Centers / Parsons, Tenn. | 28 | FP | 34 | 3,624 | 106.6 | 2 |
| Northport Health Services / Tuscaloosa, Ala. | 29 | FP | 33 | 4,058 | 123 | 4 |
| Raintree Healthcare / Scottsdale, Ariz. | 30 | FP | 33 | 3,486 | 105.6 | 6 |
| Millers Health System / Warsaw, Ind. | 31 | FP | 32 | 3,450 | 107.8 | 1 |
| Horizon West / Rocklin, Calif. | 32 | FP | 32 | 3,333 | 104.2 | 2 |
| Health Systems Inc. /Sikeston,Mo. | 33 | FP | 32 | 2,879 | 90 | 1 |
| TOTAL / AVERAGE | | | 4,204 | 489,953 | 116.5 | |

## Appendix 2 – Nursing Homes by State

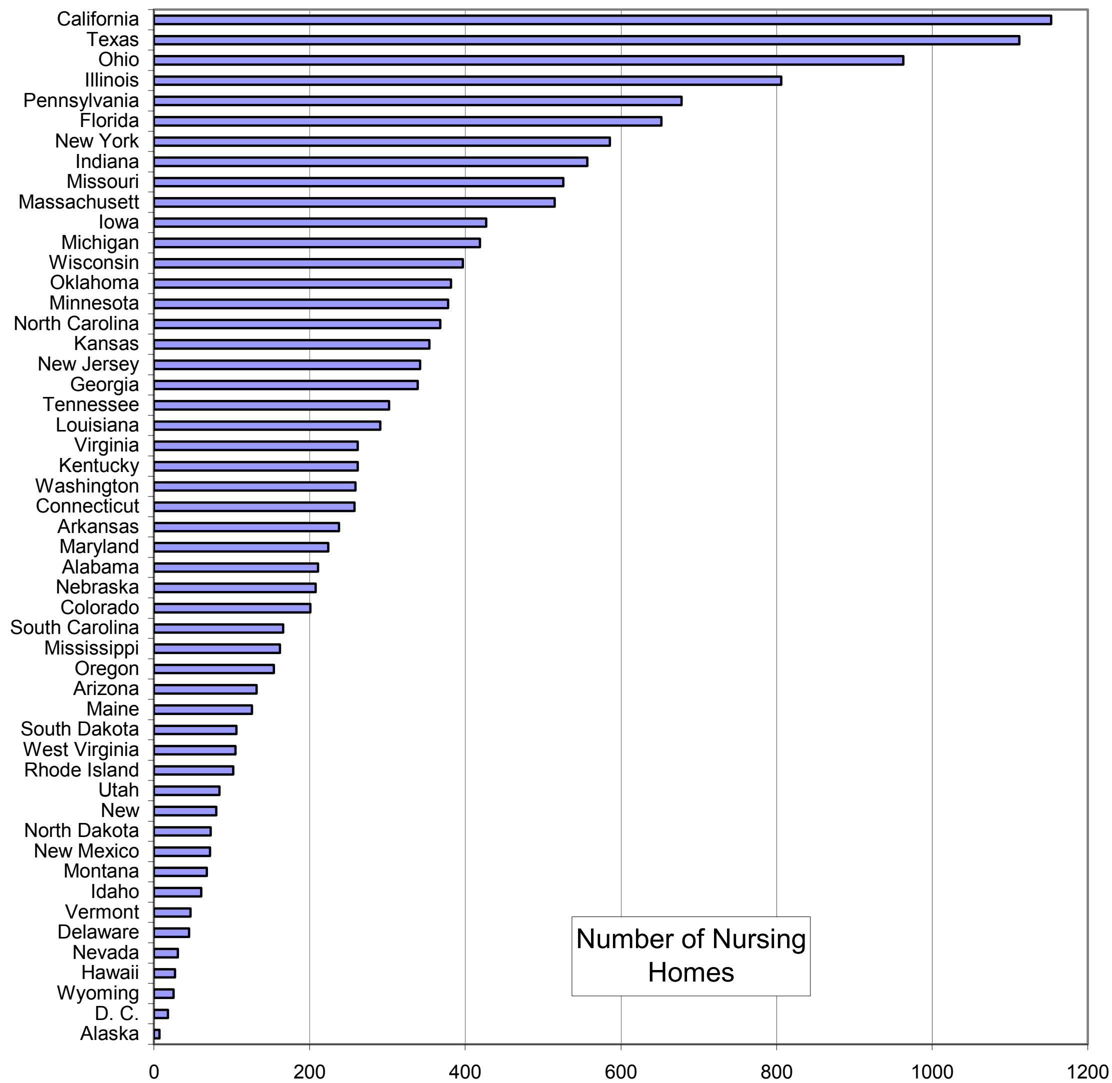


Figure 70: Number of Nursing Homes by State[88]

[88] Data source: SMG Marketing Group Inc. © 2001

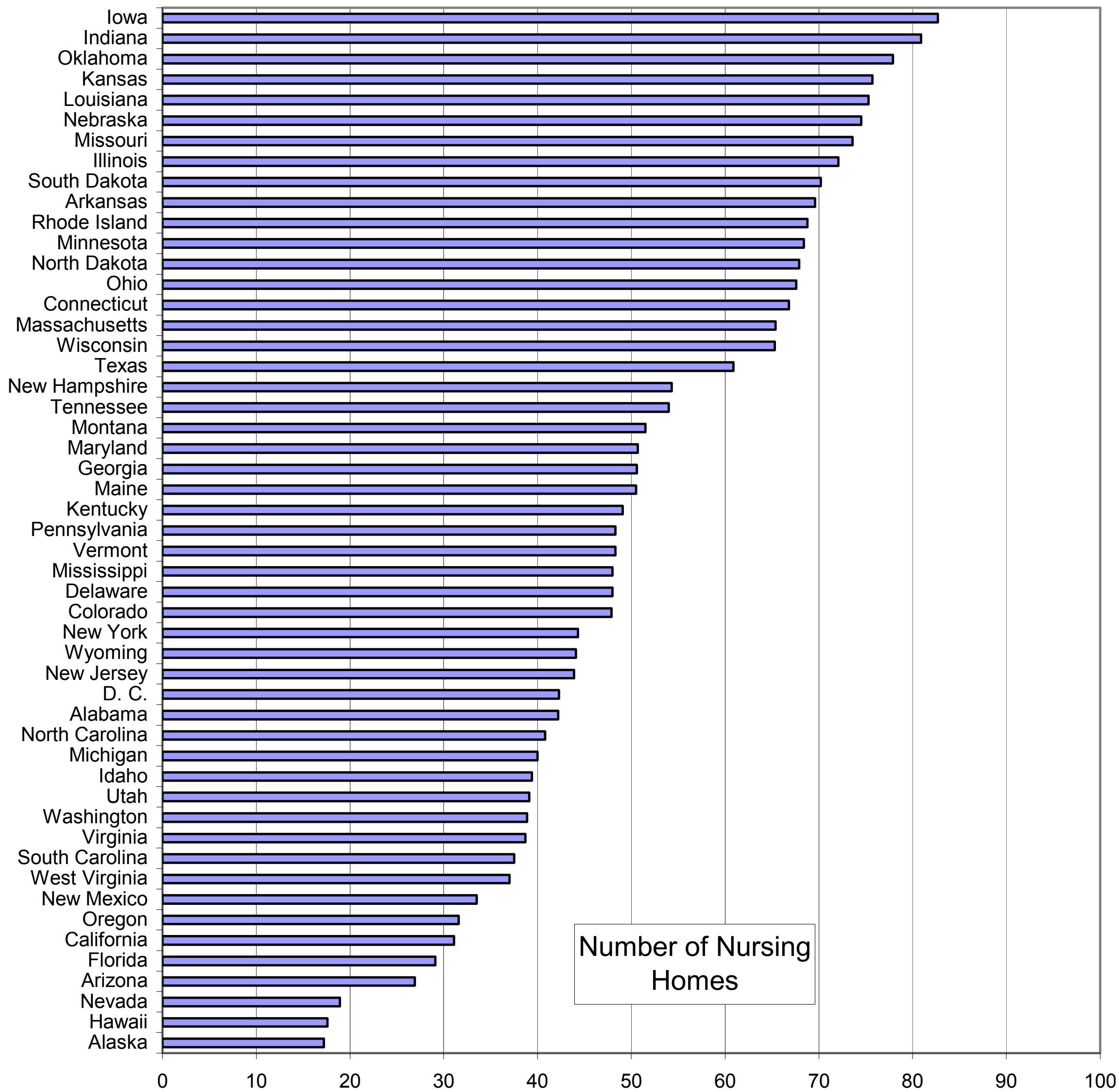


Figure 71: Number of Nursing Home Beds per 1,000 of State Population[89]

[89] Data source: SMG Marketing Group Inc. © 2001

# 6 Data Centers/Server Farms/Telecom Switching Facilities

This chapter was originally envisioned to scope CHP opportunities in the computer-based electronic communication service centers. However, as the market was explored, differences began to emerge between differing areas of the market. The distinctions that arose were these:

- Data Centers include central computer systems that may serve an individual business or provide multi-business customers with data handling functions. This business has been in existence since the early 1960's, when computers were exclusively large mainframes and continues today to serve everything from centralized accounting functions, massive record keeping duties, high speed engineering simulation functions, and so on. Often these systems are separated from Internet service for data security purposes.
- Server Farms are the newest element. Servers generally providing the switching and content management of the Internet. Unlike proprietary data centers, these servers will often be located into massive Server "Farms" where Internet content will be located and internet communications switching handled.
- Telecom Switching Facilities are another distinct category, at present. Currently telephone systems work far differently than the Internet. Telecom Switching Facilities are sites from which telephone communications systems are both directed and powered. These facilities have a far longer history, going back to the 1880's, and have gone through multiple generations of technical change. However, they serve the telephone business in the same manner as in the $19^{th}$ century by providing very local telephone system control. Today, these facilities tend to be unmanned, small, and extremely numerous.

There is at present a continuing process of technical convergence in these three sectors as, for example, server systems are beginning to be used to replace mainframe computers and telephone systems are projected to transition to Internet-like operation by 2020. However, the business functions may remain distinct.

## 6.1 Data Centers/Internet Servers - Market Segment Desirability

### 6.1.1 Definitions

Server Farms as a distinct commercial segment largely arose in the 1990's, and due to the newness of widespread Internet service. Technical term definitions are yet to be universally accepted. Some recently suggested definitions are shown in Table 16 [90]:

| | |
|---|---|
| Telecoms | Telecommunication switches. These are known as telecoms or telcos. These are more energy demanding than typical Internet data centers.[91] |
| ISP's | Internet service providers |
| CoLos | Co-located server hosting facilities, also known as CoLos, where rack space is leased by tenants and the actual computer equipment is owned and operated by tenants. Because tenants may move in and out, upgrade their computers frequently, and have a disconnect between the energy-using facility and the billing department, energy demands tend to have greater fluctuations and to be less well characterized than corporate data centers. |
| Server Farms | Data storage and hosting facilities ("internet hotels"). These facilities are built specifically for data storage, and often are maintained by a single company (even if it is a company that rents out servers to outsourcing groups), and therefore the whole building can be built or retrofitted to the owners needs, including energy needs. |
| Internet Hotels | Same as Server Farms |
| Corporate Data Centers | Corporate data centers, include both servers and mainframe computers. These are the oldest types of data centers. |

Table 16: Terms in the Internet Server Market

[90] *ACEEE: Overview of Data Centers and Their Implications for Energy Demand*, Elizabeth Brown, R. Neal Elliott, and Anna Shipley, American Council for an Energy-Efficient Economy, Washington, DC, September 2001

[91] *Energy Smart Data Centers: Applying Energy Efficient Design And Technology To The Digital Information Sector*, by Fred Beck*Renewable Energy Policy Project, November 2001,No. 14

### 6.1.2 Market Sizing Issues

Estimating the size of this market in number of centers or in power usage is difficult. In the 1999-2000 period, during the electric supply crisis in California, a number of reports pointed to the "The Internet" generically as being a major culprit in electric demand growth. This controversy was triggered by a 1999 study by Mills[92], which received extensive press coverage.

The Mills study was contradicted by later studies[93]. In the server area, later studies suggested that Mills over-predicted power consumption by ~4,000% and server power demand by ~1,000%. In addition, office equipment, such as PC's, were lumped into "The Internet" as a category. Confusing Internet infrastructure power usage with local office based power usage producing huge demand estimates.

Another author notes[94] that projections done in 2000 suggested a very large total Internet Server market of 15 GW by 2003. This was later greatly corrected downward. The original projection had been based on the size and number of electric service requests for new Internet Server Farms. Many of these requests were later dropped due to the downturn in the Internet market. Also, most requests for service had been dramatically oversized to take care of future growth, which largely has not yet arrived. Interestingly, another reason for oversized service requests was a perception in this new industry that over sized service would be somehow more reliable, which is, in general, incorrect. The same report was then unable to define the market in size.

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[92] Mills, M.P., 1999, "The Internet Begins with Coal: A Preliminary Exploration of the Impact of the Internet on Electricity Consumption", A Green Policy Paper for the Greening Earth Society, May, 1999

[93] *Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings*, Kurt W. Roth, Fred Goldstein, Jonathan Kleinman, Arthur D. Little, Inc., For Department of Energy, Office of Building Technology State and Community Programs, January, 2002

[94] ACEEE: Overview of Data Centers and Their Implications for Energy Demand, Elizabeth Brown, R. Neal Elliott, and Anna Shipley, American Council for an Energy-Efficient Economy, Washington, DC, September 2001

### 6.1.3 Defining the Data Center Market Suitable for CHP Applications

Clearly, care must be taken in developing the market size for this "Data Center" and "Internet Server" market sectors. The specific sector must be clearly defined, keeping in mind that the objective is to find loads that are individually large enough to warrant a CHP system. This means defining what type of facility is or is not large enough to be included in the market.

| Market Definition | |
|---|---|
| Loads Included | Loads Not Included |
| Large Collections of Servers at One Site with over 100 kVA in Total Load | Small Individual PC Based Servers |
| Mainframe Equipment at One Site with over 100 kVA in Total Load | Free Standing Routers, LAN, WAN Switches Used on Office Networks |
| Telecom Switching Centers | Any Office Equipment (PC's, Printers, etc.) |

Table 17: Market Definition

A search of existing US Census and Energy Information Agency data finds no information on facilities broken down in this manner. Therefore, some common element that can serve to trace both large Data Centers and Internet Servers facilities was required. The best indicator found is statistics on the sales and current usage of Uninterruptible Power Supplies (UPS) systems. These statistic break out systems by size, and note systems over 100 kVA are intended for large Data Center and Server Farm facilities. Therefore, this distinction was used to define the market as shown in Table 17.

| UPS Power Range | kVA Typical Applications |
|---|---|
| <1 kVA | PCs, Workstations |
| 1 - 5kVA | Multiple Computers Servers |
| 5 – 100kVA | Telecom Switching Centers, ISP, Data Networks |
| >100kVA | Larger Telecom Centers, Data Centers |

Table 18: Applications for Differing Sizes of UPS Systems[95]

[95] Table 5-65, *Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings*, Kurt W. Roth, Fred Goldstein, Jonathan Kleinman, Arthur D. Little, Inc., For Department of Energy, Office of Building Technology State and Community Programs, January, 2002

UPS systems are sold in a wide variety of sizes for a many applications. UPS systems above 100 kVA in size shown in Table 18 are used for the large facility types listed as "Included Loads" in Table 17. This coordination makes large UPS systems a good market-tracking device for data centers and server farms.

There are other distinctions between UPS systems as well.

- Smaller UPS systems are of the more affordable "Stand-By" type.
- Larger units are of the more expensive highly reliable "On-Line" type.

These types are explained in detail in a later section. This distinction also tends to separate out large data centers and server farms, as a composite arrangement of multiple smaller "Stand-By" systems cannot be used to serve large high reliability loads. This makes UPS systems an even better indicator of Data Center/Server Farm market size.

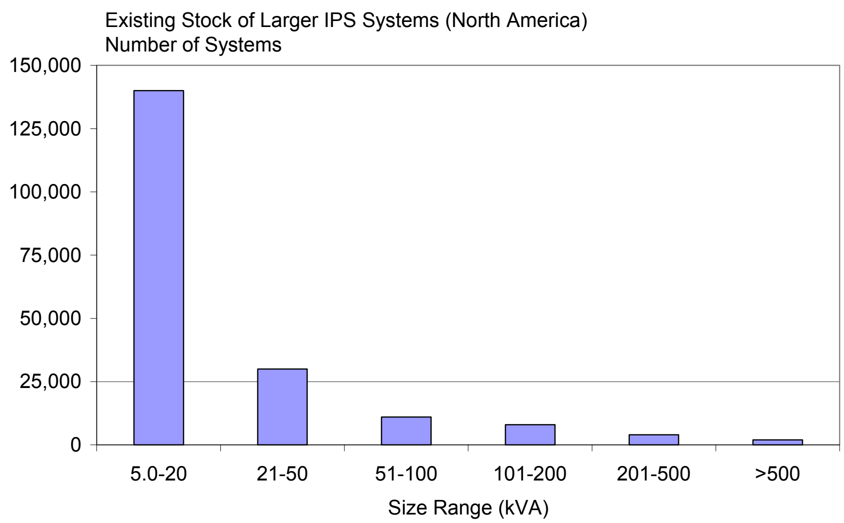


Figure 72: Existing Stock of UPS Systems in Number of Units[96]

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[96] Original Chart. Data from *Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings*, Kurt W. Roth, Fred Goldstein, Jonathan Kleinman, Arthur D. Little, Inc., For Department of Energy, Office of Building Technology State and Community Programs, January, 2002

Later information indicated strongly that the principal power sources in Telecom switching operations are custom systems that are not included in these figures. Therefore, Telecom Switch Centers are handled in a later analysis in this chapter.

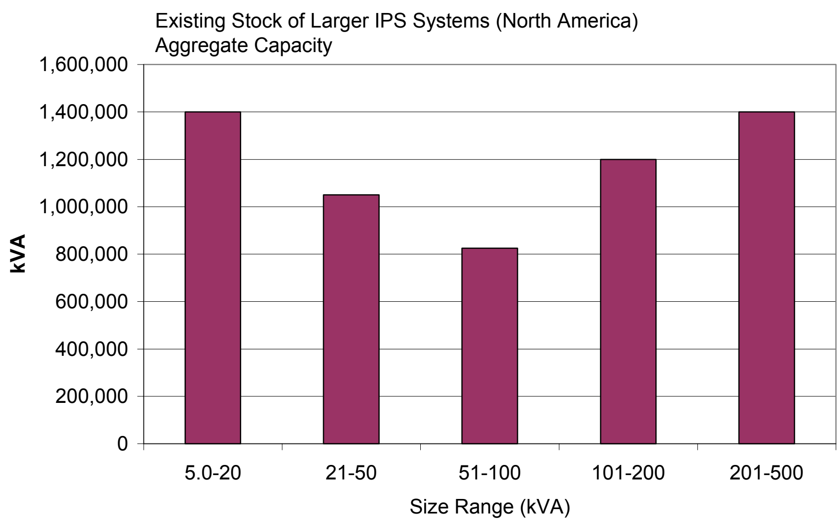


Figure 73: Existing Stock of UPS Systems in Electrical Capacity[97]

*Information taken from sales volume and assumed life calculations. The total of demand for all UPS systems over 100 kVA is 2.6 GW from a total of 14,000 systems.*

In order to check the values in Figure 73, Census data from 1997 was pulled together for NAICS subdivisions that are closest to the class of establishment in this sector. This comparison is shown in Table 19. The most recent available Census Data comes from 1997. Given the growth in the industry between 1997 and 1999, these numbers seem in agreement.

| NAICS Code | | |
|---|---|---|
| 5142 | Data processing services | 7,588 |
| 514191 | Online information | 4,165 |
| | 1997 Census Total | 11,753 |
| | 1999 UPS System Count | 14,000 |

Table 19: Comparison of UPS and Census Data[98]

*The most recent available Census Data comes from 1997. Give the growth in the industry between 1997 and 1999, these numbers seem in reasonable agreement*

[97] Original Chart. Data from *Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings*, Kurt W. Roth, Fred Goldstein, Jonathan Kleinman, Arthur D. Little, Inc., For Department of Energy, Office of Building Technology State and Community Programs, January, 2002

[98] INFORMATION: SUBJECT SERIES SUMMARY 39, U.S. Census Bureau, 1997 Economic Census, Apr. 30, 2001

### 6.1.4 Market Health and Growth

Since the end of 1999, the decline in the value of Internet company stocks has been dramatic. However, much of the value of these companies was overestimated in the 1990's, based on unrealistic growth and profit projections. The period since the beginning of 2000 has seen more realistic valuations and substantial consolidation in the industry.

Although the use of the Internet for business-to-business and business-to-consumer marketing may have been overestimated in the past, current valuations place this industry in a position to grow based on actual financial progress. Therefore, the best estimate of market health in the future is current revenue growth. The best information on revenue is based on data from the Economic Census Reports. Although the last complete Economic Census was done for 1997, making it out of date for this rapidly changing market, the Census Bureau has developed extensive updated information for this market.

Census classifications that apply to the area of server farms and data centers are shown in italics below. Table 20 shows the definition of these segments.

NAICS Outline

- 51 – The "Information" Sector
    - 511 Publishing Industries
    - 512 Motion Picture and Sound Recording Industries
    - 513 Broadcasting & Telecommunications
    - 514 Information and Data Processing Services
        - 5141 Information Services
            - 51411 News Syndicates
            - 51412 Libraries and Archives
            - 51419 Other Information Services
                - 514191 Online Information Services
                - 514199 All Other Information Services
        - 5142 Data Processing Services

When the NAICS definitions are checked, the only sections that apply directly to the Internet Server/Data Center market are 514191, and 5142. The Census definitions are in Table 20

| NAICS Code | Name of Sector | Description of Sector |
|---|---|---|
| 514191 | Online Information Services | Internet access providers, Internet service providers, and similar establishments engaged in providing access through telecommunications networks to computer-held information compiled or published. Server Farms Fall In This Area |
| 5142 | Data Processing Services | Establishments providing electronic data processing services. These establishments may provide complete processing and preparation of reports from data supplied by customers; specialized services, such as automated data entry services; or may make data processing resources available to clients on an hourly or timesharing basis |

Table 20: NAICS Codes – Specific Definitions[99]

*Code 414191 is the closest to the Internet server farms but also covers facilities for housing modems without server equipment. 5142 are the much more established data processing firms.*

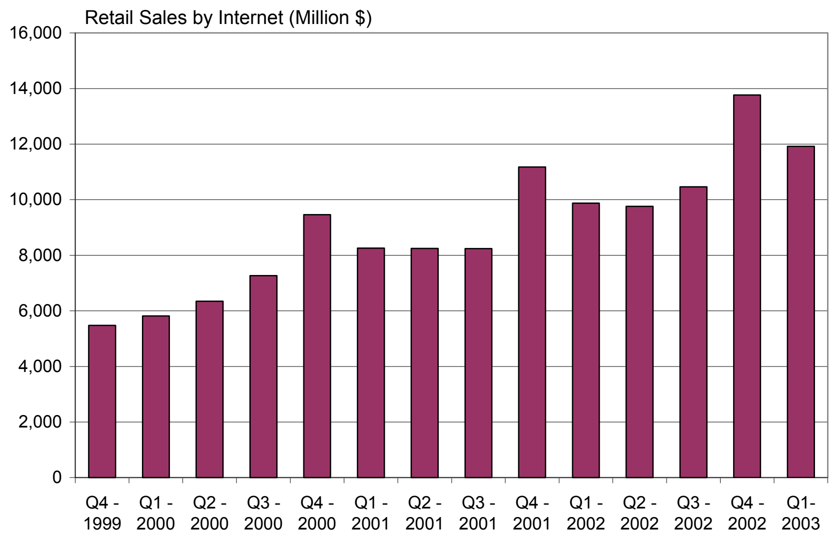


Figure 74: Internet Commerce Totals[100]

*These values indicate that Internet Commerce is continuing to grow even during the economic downturn beginning in 2000.*

#### 6.1.4.1 Health of the Internet Sector

Given the stock reversals and corporate consolidations, this area deserves considerable scrutiny, by focusing on the market fundamentals.

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[99] 1997 INFORMATION SUBJECT SERIES SUMMARY 39 U.S. Census Bureau, 1997 Economic Census Apr. 30, 2001

[100] United States Department of Commerce News – Last Updated Friday, May 23, 2003.

Was Internet  commerce a 1990's fad or is this continuing to grow, and how fast?

- Internet commerce is essential if Internet service providers are to be charging profitable service rates to customers.  The customer must find a financially productive use to justify the expenditure.  The Internet's predecessor, the DARPANET provided nothing but free information and was operated largely by libraries and universities for a decade or more without significant economic impact.  Only when the system began to carry significant business volume, did rapid growth in promotion and use begin.  Figure 74 indicates that retail sales are continuing to increase, even during the economic downturn.

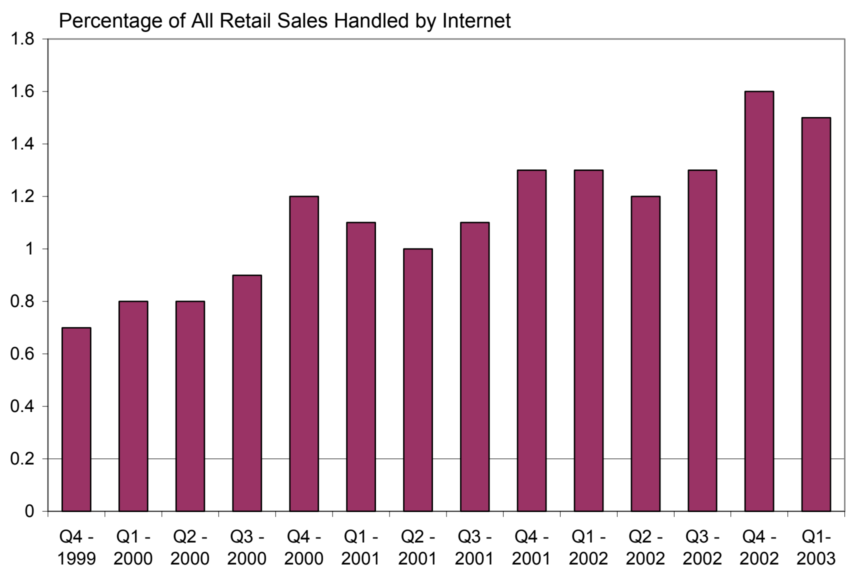


Figure 75:  Internet Share of Retail Sales[101]

*To date, the percentage of all retail sales handled by the Internet is very small.  There is some limited saturation level of all retail sales that the Internet can hope to achieve.  However, even though this saturation level is unknown, the current very low percentage indicates there is considerable room to grow*

Conversely, how saturated is the economy with Internet marketing?  Does Internet commerce still have room to grow?

[101] United States Department of Commerce News – Last Updated Friday, May 23, 2003.

- Figure 75 indicates that there is still considerable room to grow. Internet sales are still less than 2% of overall retail sales. There is some limited saturation level of all retail sales that the Internet can hope to achieve. However, even though this saturation level is unknown, the current very low percentage indicates there is considerable room to grow

Is the customer base of Internet service providers continuing to grow?

- Internet Service Providers started in business with a focus on supplying Internet connections to subscribers. As shown in Table 22, 62% of the revenue in 1997 was from service subscriptions. However by 2002, the number of households with Internet subscription services has grown as shown in Table 21. At the current rate of growth of nearly 9 percentage points per year, the market for basic Internet access services will soon be saturated. Notice that the growth actually increased during the financial downturn from 7.8 percentage points in 1998-1999 to 9 percentage points in 2001-2002.
- Other data from 1998 to 2000 indicates that the threat of saturating the Internet subscription market was successfully met by diversifying the focus of the business to include web hosting and, most prominently advertising, as shown in Table 23. Given the ability of these providers to continue diversification of services, the number of households on-line should provide expanding revenues once the current economic downturn has passed.

| Households with Internet Subscription | |
|---|---|
| 1998 | 18.60% |
| 1999 | 26.20% |
| 2000 | 33.85% |
| 2001 | 41.50% |
| 2002 | 50.50% |

Table 21: Subscription Growth for Service Providers
*At the current rate of growth of nearly 9 percentage points per year, the market for basic Internet access services will soon be saturated. Notice that the growth actually increased during the financial downturn from 7.8 percentage point in 1998-1999 to 9 percentage points in 2001-2002.*

| Sources of Revenues for Internet Service Providers NAICS 514191 | |
|---|---|
| Data from 1997 | % of Revenue |
| Custom programming services | 1% |
| On-line access fees, except Internet access only | 21% |
| Internet access fees | 62% |
| Merchandise sales | 2% |
| Computer hardware | 1% |
| All other merchandise | 1% |
| All other receipts | 11% |

Table 22: Sources of Revenues of Internet Providers During the Last 5-Year Census [102]

| ON-LINE INFORMATION SERVICES (NAICS 514191) | Actual Values (in $Million) | | | Percent Change per Annum | | |
|---|---|---|---|---|---|---|
| | 2000 | 1999 | 1998 | 2000 | 1999 | 1998 |
| | $MM | $MM | $MM | % | % | % |
| Total Revenue | 26,577 | 18,012 | 10,882 | 100% | 100% | 100% |
| Sources of Revenue | | | | | | |
| Internet access fees | 12,345 | 8,966 | 5,499 | 46% | 50% | 51% |
| Advertising | 3,507 | 1,355 | 725 | 13% | 8% | 7% |
| Web hosting and design | 1,136 | 520 | 261 | 4% | 3% | 2% |
| Other revenues | 9,421 | 7,038 | 4,322 | 35% | 39% | 40% |

Table 23: Changes in the Industries Sources of Revenues[103]

Overall, the customer base and the sales volume of the Internet have continued to grow right through the current downturn. Undoubtedly, some of this growth was due to discounting service prices. Even with discounting, showing growth during an economic downturn is a significant show of market strength

[102] Table 2. Major Sources of Receipts for the United States: 1997 - 30 SUMMARY INFORMATION SUBJECT SERIES U.S. Census Bureau, 1997 Economic Census Apr. 30, 2001

[103] Information Services and Data Processing Services (NAICS 514)—Estimated Revenue for Employer Firms: 1998 Through 2000, 2000 Service Annual Survey, US Census Bureau

### 6.1.5 Geographic Layout of the Market

Contrary to popular opinion, there is a physical roadmap of the Internet, or more properly of the high-speed cables that form the backbone of Internet service delivery in the U.S. This is shown in Figure 76. Notice the major hubs in the San Francisco/San Jose/Silicon Valley region, New York, Boston, and the Orlando/Tampa area.

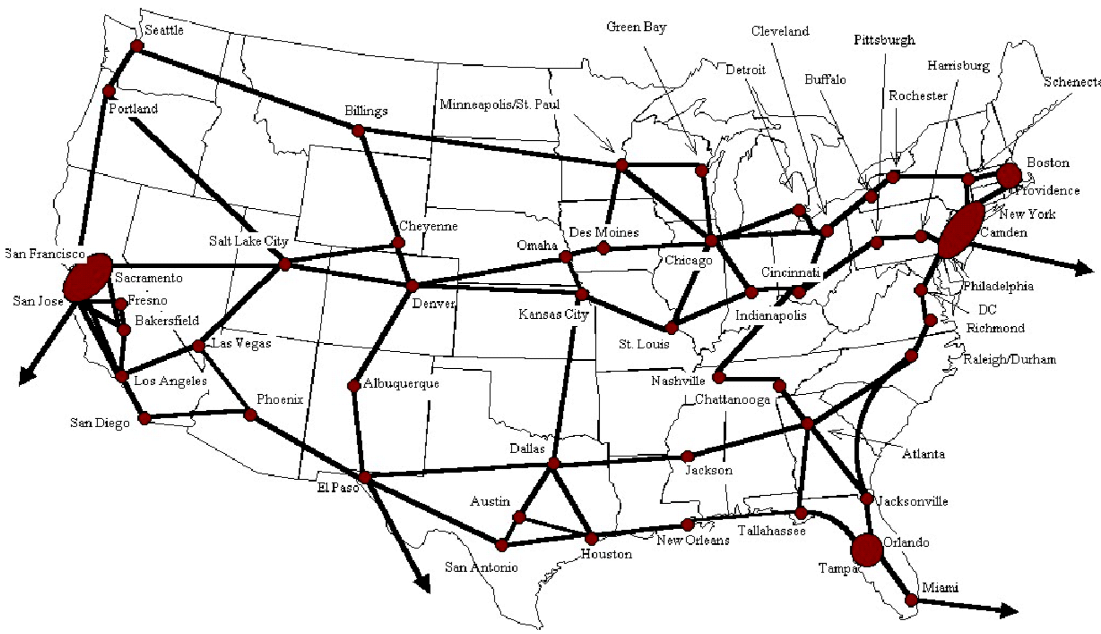


Figure 76: Map of the Internet Backbone Showing Primary Nodes[104]

All of the nodes shown are linked by high speed cabling that handles the majority of the traffic. In order to gain access to this system at the highest possible speeds, server facilities are generally located near nodes or along the high speed cabling.

Conversely, centers that handle modem connections and routers to allow telephone access for subscribers will be much more widely scattered. This allows telephone access for Internet users without having the user incur local toll charges. Such modem facilities will be much

[104] ACEEE: Overview of Data Centers and Their Implications for Energy Demand, Elizabeth Brown, R. Neal Elliott, and Anna Shipley, American Council for an Energy-Efficient Economy, Washington, DC, September 2001. Original Data from [FCC] Federal Communication Commission. 2000. Deployment of Advanced Telecommunications Capability. Washington, DC: FCC.

smaller than server farms, may be in facilities dedicated to other uses, and are not the focus of this market segment.

Major Co-Location facilities, where users locate their servers for protection, power supply, and conditioning purposes are more inclined to be coordinated with centers of business. As can be seen in Figure 77, these facilities are located in major metropolitan areas.

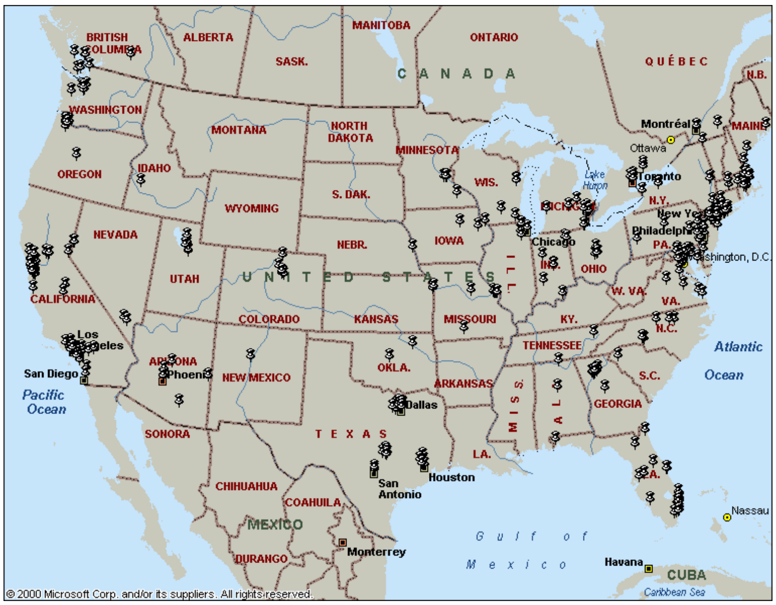


Figure 77: Location of Collocation Faculties[105]

Some of the locations are substantially in excess of what would be expected of cities of their size such as Portland, Oregon, the San Jose region in California, Madison, Wisconsin, and Huntsville, Alabama. However, these are all education or technical centers that have tended to give rise to high technology firms. In addition, such locations as Green Bay, Wisconsin, Des Moines, Iowa, and Omaha, Nebraska are likely to have collocation facilities due to their proximity to a major node in the Internet backbone and ability to handle very high-speed service for clients in other areas.

General-purpose data centers, which may or may not provide Internet access service or collocation hosting are shown in Figure 78, showing a very similar pattern.

[105] www.colosource.com

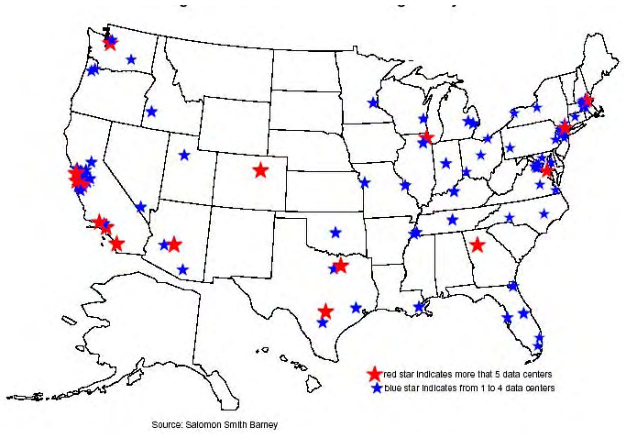


Figure 78: Locations of Data Centers Overall

Census data also provides some indication of the geographic distribution of establishments that provide Internet Service, as shown in Figure 79. Many of these States also have good CHP potential including California, New York, New Jersey, Illinois, and Texas.

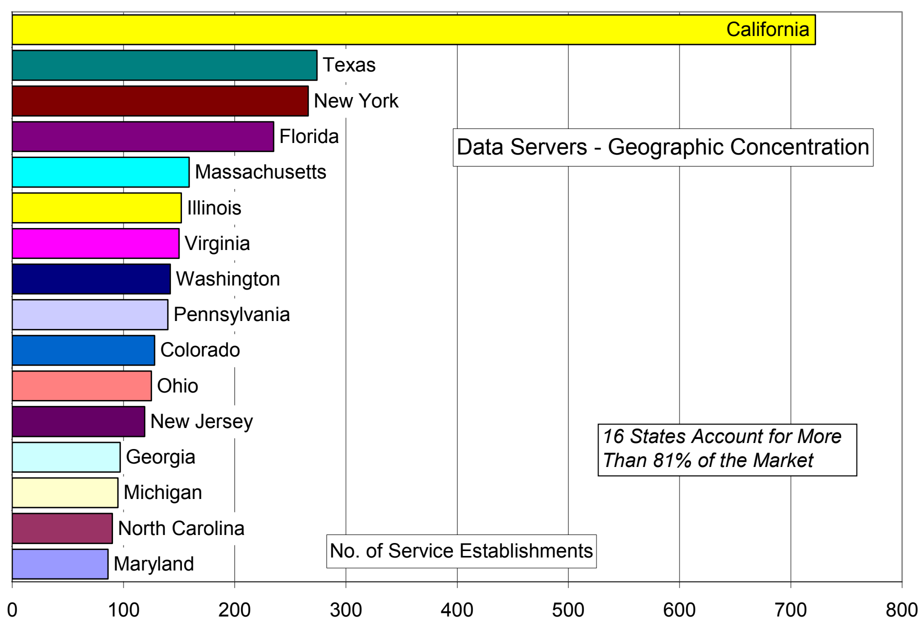


Figure 79: Geographic Distribution of ISP Establishments[106]
*Note the importance of States that were established in as states with good CHP potential including California, New York, New Jersey, Illinois, and Texas*

[106] Table 2, INFORMATION SUBJECT SERIES - MISCELLANEOUS SUBJECTS, U.S. Census Bureau, 1997 Economic Census Feb. 27, 2001

## 6.2 Advantages of CHP Systems in Data Centers/Server Farms/Telecom Facilities

Future development of outreach programs for this market sector depends on delivering a message that is relevant to the main concerns of facility operators. This is a varied market, spanning older data center operations to the latest in Internet providers. There is not a large database of operator opinion surveys available. However, a substantial amount of literature was unveiled from industry organizations. Interestingly, the most quoted source found on issues regarding buildings and infrastructure, was the "Uptime Institute" (http://www.upsite.com/TUIpages/tuihome.html), which focuses on continuous operation as the major issue in the industry. This theme is echoed throughout the literature.[107]

The realities in server, telecom, and data facilities are these.

- The equipment being operated within these facilities is significantly more expensive that the construction cost of the building itself.
- Customers usually pay for service as it is received, whether from user access fees or direct on-line time fees. Continuous operation means continuous revenue production.
- Internet, telephone, and data customers have an extremely high expectation of reliability and a growing desire for speed, as witnessed by the recent growth in broadband service.

The need for uninterrupted operation is very great, and the industry has gone to great lengths to attempt to achieve it. Higher end facilities today have duplicate power sources, redundant wiring systems, emergency generator backed UPS systems, dual cooling systems including, in some cases, dual chilled water lines. With all of these additional systems, costs for the overall facility can range up to $1,600 square feet, 15 times higher than for other commercial buildings. Clearly, reliability is the major market driver in the design of facilities

The internal power and HVAC loads for these facilities are unique, including such issues as:

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[107] Industry Standard Tier Classifications Define Site Infrastructure Performance, W.P. Turner and K. G Brill, 2001, The Uptime Institute

- Intense Electrical Loads per Square Foot
- Intense Cooling Loads per Square Foot
- Need for Continuous Power During Grid Power Failures
- Need for Continuous Cooling During Grid Power Failures
- Need for Continuous Electrical Voltage Support without Fluctuation

### 6.2.1 Intense Use of Power and Cooling per Foot of Floor Space

The intense use of power and cooling on a square foot basis is the most distinguishing feature of this market. Figure 80 shows a typical layout indicating how closely packed racks of equipment can be in these facilities.

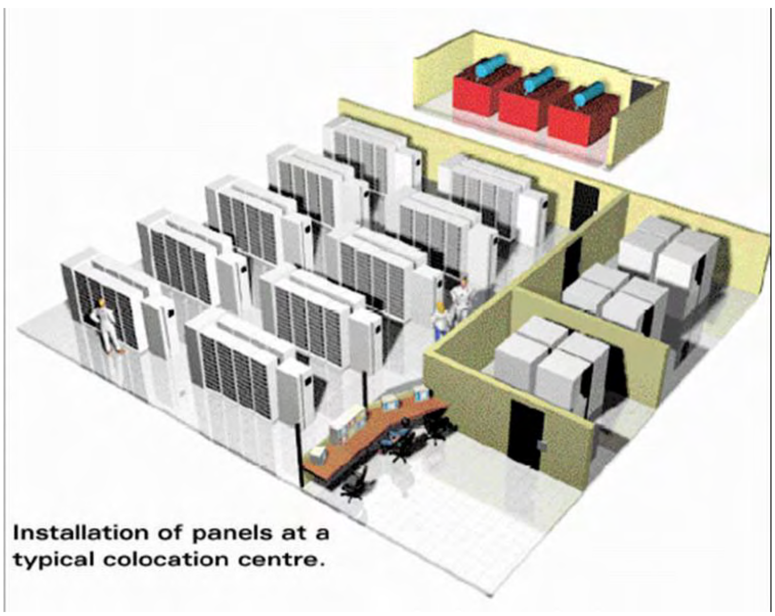


Figure 80: Typical Rack Layout for Server/Telecom/Computer Equipment Installations[108]

Not only are the power and cooling needs intense, but also they are projected to become steadily worse. Figure 81 shows how current developments in more powerful and smaller electronics are projected to increase power usage and heat release rates over the next few years.

[108] Illustration from *Power to the Internet*, Shri Karve, Electrical and Mechanical Contractor Magazine, Dec. 2001

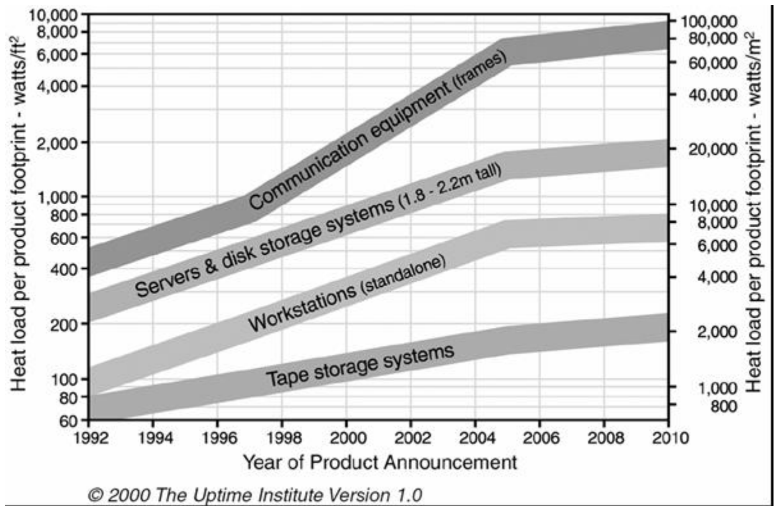


Figure 81: Future Heat Load Projections for Servers, Communications Frames, Workstations and Storage[109]

Information available on the power and cooling requirements for computer facilities has presented a confused picture that recent authors have attempted to clarify. To do so, a number of issues need to be handled carefully including how power densities are defined, the structure of typical computer facilities, the difference between nameplate and actual power consumption, and a look at actual measured power usage.

| Differing Definitions of Power Density | |
|---|---|
| Rack (or Product) Power Density | Power drawn by an individual rack (or product such as a server or tape backup device), divided by it's footprint |
| Simple Computer Room Power Density | Power drawn by computer equipment installed on the raised floor of a computer room, divided by the raised floor area under the equipment |
| Total Computer Room Power Density | Power drawn by computer equipment and all supporting equipment such as power distribution units (PDUs), uninterruptible power supplies (UPSs), HVAC, and lighting, divided by the raised floor area |
| Building Power Density | Total power drawn by the entire building, divided by the total floor area of the building |

Table 24: Differing Definitions of Power Density in Computer Equipment Spaces[110]
*Quotations in the press on power density must be interpreted carefully. Rack power density values are too often taken as applying to the entire facility.*

---

[109] *Heat Density Trends in Data Processing, Computer Systems, and Telecommunication Equipment*, The Uptime Institute,

[110] From Table 3, *Energy Smart Data Centers: Applying Energy Efficient Design And Technology To The Digital Information Sector*, by Fred Beck*Renewable Energy Policy Project, November 2001,No. 14

| Approximate Usage of Total Building Floor Space | |
|---|---|
| Function | Area Usage (%) |
| Core and common area (hall, stair, elevator, electrical & mechanical) | 20-25% |
| Generators, batteries, power supply and conditioning equipment | 25-30% |
| Raised floor area | 50-60% |

Table 25: Typical use of Floor Space in a Dedicated Data Center[111]
*Raised floor computer equipment areas are typically only one-half of the facility*

| Approximate Usage of Raised Floor Space | |
|---|---|
| Function | Area Usage (%) |
| Computer hardware footprint (servers, rack-mounted equipment) | 25-30% |
| Service clearances (allows for movements of cooling air and personnel) | 30-35% |
| Infrastructure support equipment (in-room UPS, power distribution (PDUs), cooling systems, air handling equipment, and other support electronics) | 20% |
| Main aisles, support columns, other non-electrified areas | 20% |

Table 26: Approximate Usage of Raised Floor Space Area[112]
*In addition to raised floors being only one half of the facility, the intense heat producing rack mounted equipment occupies only 25-30% of the raised floor areas and therefore only ~15% of the overall facility*

Table 24 through Table 26 indicate that the rack mounted server or mainframe equipment occupy only a small fraction, roughly 15%, of the overall building floor space. Therefore, large rack heat load numbers must not be applied to entire facilities.

In addition, there is a danger in estimating the power input and therefore also the heat output from equipment racks by using the nameplate data. Nameplates often substantially overstate the amount of power actually used by the equipment for a number of reasons:[113]

- Most devices use less electricity while running than they do at their peak, which is often during start-up. In addition, for safety reasons, most computer equipment never draws more than 80% of the rated power even at its peak.

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111 From table 1, *Energy Smart Data Centers: Applying Energy Efficient Design And Technology To The Digital Information Sector*, by Fred Beck*Renewable Energy Policy Project, November 2001,No. 14

112 From Table 2, *Energy Smart Data Centers: Applying Energy Efficient Design And Technology To The Digital Information Sector*, by Fred Beck*Renewable Energy Policy Project, November 2001,No. 14

113 Bullets quoted directly from: *Energy Needs In An Internet Economy: A Closer Look At Data Centers*, by Jennifer D. Mitchell-Jackson, July, 2001, Energy and Resources Group of the University of California, Berkeley

- Devices like computers, routers and switches can have slots for add-in cards. The power supply rating, and therefore nameplate power rating, must be sized as if all slots were full with cards that draw the maximum amount of power. If all of the slots are not full, or if the slots are designed for more than the cards that are in use require, the power requirements of the equipment will be overstated.
- For convenience, manufacturers standardize power supplies across multiple product lines in order to minimize the number of different power supplies that they have to produce. For some equipment, therefore, this would lead to larger power supplies than required.
- Power supplies are often oversized in anticipation of future upgrades.

Recorded measurements of the electricity consumption of network components (routers, switches, multiplexers, micro repeaters, media converters) in two modern networks with 82 and 1200 users respectively[114], found that the measured power was approximately 30% of the nameplate specifications.

Measured power has been recorded from a number of existing data centers across the United States. Quantities, shown in Table 27, are for overall computer room power divided by computer floor space. On an overall facility basis, these power uses would tend to be reduced by roughly one half. Notice that, although the numbers are high, they are not the tremendous power usage rates too often quoted for these facilities.

These measured power densities in Table 27 should be much more reliable than nameplate based design values. For a dedicated computer facility, the overall facility energy usage would then be about one-half of these values to account for non-computer areas. 20-25 watts per square feet for the overall facility internal electric usage and resulting heat load is realistic. This value would not include power use for cooling, lights, and fans.

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[114] As quoted in *Energy Needs In An Internet Economy: A Closer Look At Data Centers*, by Jennifer D. Mitchell-Jackson, July, 2001, Energy and Resources Group of the University of California, Berkeley from an original source: Basler and Hofman, "Energieverbrauch von Netzwerkkomponenten (English Version),"Bundesamt für Energiewirtschaft Forschungsprogramm Elektrizität, 26 November 1997.

| Measured Data Center Energy Demand Data from Various Sources<br>Power Density for the Total Computer Room | | |
|---|---|---|
| | (W/ft2) | Comments |
| Infomart | 50 | Based on six months of monitoring by a Texas-based data center developer |
| Energy Information Administration | 50 | Annual Energy Outlook 2001 |
| Jennifer Mitchell-Jackson and Lawrence Berkeley National Laboratory | 35-50 | Measured energy demand of U.C. Berkeley data centers |
| Commonwealth Edison | 40 | Utility data |
| Pacific Gas & Electric | 35 | Utility data, fully occupied facility, actual load 33% of requested capacity |
| Edison Electric | 25-40 | Utility data, requested capacities 150-200W/ft2 |
| Jennifer Mitchell-Jackson: Case Study | 32 | Detailed case study, actual load 25% of design load |

Table 27: Measured Data Center Energy Demand Data from Various Sources[115]

Standard HVAC calculations were then done for this internal load to find an estimate of the entire buildings load. These calculations are shown in Table 28. This was done on an entire building basis with a realistic 25 watts per square foot value is being used for the overall computer loads. Added to this were realistic lighting loads, which occur throughout the building and a fan power load, which is sufficient to deliver the large quantities of air needed to cool this facility. Once this was totaled, the internal loads and cooling airflow were found and the fan power rechecked. Finally, the power required to run the central cooling equipment was calculated and the overall consumption for the facility, including all cooling functions was found to come to nearly 40 watts per square foot.

[115] Table 4 from *Energy Smart Data Centers: Applying Energy Efficient Design And Technology To The Digital Information Sector*, by Fred Beck*Renewable Energy Policy Project, November 2001,No.14

| Total Facility Power Usage | | |
|---|---|---|
| **Internal Loads** | | |
| Computer Loads | 25 | watts/sq. ft. |
| Lighting Loads | 2.5 | watts/sq. ft. |
| Fan Power | 4.33 | watts/sq. ft. |
| Total Electric Loads | 31.83 | watts/sq. ft. |
| Internal Heat Loads | 108.65 | Btu/sq.ft./Hour |
| Internal Heat Loads | 0.00905 | tons/sf |
| Air Flow Required* | 4.69 | cfm/sq. ft, |
| Theoretical Fan Power** | 0.00261 | hp/sq. ft. |
| Actual Fan Power*** | 0.00523 | hp/sq. ft. |
| Fan Motor Power **** | 4.33 | W/sq. ft. |
| **Cooling System** | | |
| Chiller System Power Usage***** | 7.24 | W/sq. ft. |
| Total Facility Usage | 39.08 | W/sq. ft. |

* Air Flow Based on Air Supplied at 55F and Leaving at 80 F
** Theoretical Fan Power Based on 5 inches of Water Column Pressure Drop
*** Actual Fan Power Based on 50% Fan Efficiency
**** Fan Motor Power Based on 90% Efficient Motor – Agree with Original Estimate on Third Line
***** Chiller System Power Usage is .8 kW/ton times the Internal Heat Loads in Tons/sq. ft. The 0.8 total includes chiller (0.55 kW/ton) + Cooling Tower and Pumps (0.15 kW/ton) and Chilled Water pumps (0.1 kW/ton). If Rooftop Units are Used the 0.8 goes to 1.1 kW/ton, after netting out fan power.

Table 28: Overall Dedicated Computer Facility Electric Load Calculation[116]
*Including Lights, Fans and Chilled Water Cooling System. Power usage is based on the typical load and heat loss seen with computer system. A much higher connected load may be common due to nameplate oversizing.*

The typical internal cooling load of nearly 32 watts per square foot, including lights and fans is very high. For most buildings this would be in the 5-15 watts per square foot range. However, this is not the astronomical 100+ watts per square foot often projected from server rack space and nameplate ratings.

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[116] Original Calculation for this report.

### 6.2.2 Need for High Quality and Reliability Power and Cooling

High quality and reliability electric power are essentially two separate issues.

*High quality power* is, at a minimum, power free of momentary fluctuation, even of less than one second in length. Brief fluctuations are not caused by electric grid failures but by electric equipment switching in the utility distribution grid. This involves a switch on the grid momentarily leaving one source of power and, to prevent cross circuiting, traveling a pre-set distance before connecting into another power source.

This may be noted as a slight flickering of lights and generally causes little harm in conventional applications. However these fluctuations can cause computer equipment to cut-off, sending essential computers and servers into a re-boot that can take them off-line for minutes, and may cause work in progress to be lost. High quality power can also imply power of very consistent voltage and clean 60-cycle waveform with little harmonics or noise

*High reliability power* is a power system that is properly backed up to keep utility grid failures from taking the facility down.

There are a number of systems used to protect computers from power fluctuations and grid failures, including uninterruptible power supplies, back-up generators, flywheel systems, and double ended grid connections wherein the facility is fed by two independent radial feeders. Each has advantages and problems.

*Uninterruptible Power Supplies* or UPS systems involve battery back-up units to feed the computer(s) whenever a grid failure occurs. Due to the finite storage of any battery system, the period of back-up has to be specified when the system is ordered. Many smaller UPS systems provide only enough battery storage to operate computers through a safe shutdown. Given the needs of both Internet Servers and Telecom Facilities to operate entirely through a blackout, batteries must be sized for some perceived predictable blackout period. These battery systems can become quite large and expensive, and may require maintenance. For example, one supplier[117] will provide a battery system for a nominal 225-kVA critical load.

[117] Galaxy PW Brochure, MGE UPS SYSTEMS, http://rep.mgeups.com/3ppdf/pwbro.pdf

The battery package weights over 19,000 lbs and will provide 44 minutes of full load operation. This is not a great deal of power for a server center, nor can the center be kept on line without cooling, which would use a good one-half of the critical power output. Therefore, UPS systems in server farms are generally used in concert with emergency generators

*Back-Up or Emergency Generators* are engine generator systems, usually featuring a high-speed lower cost diesel engine, which can be started in the event of a blackout. These systems can generally be started in as little as 10-20 seconds, to meet life safety code requirements on starting speed for medical applications. In computer facilities, back-up generators must be used in concert with UPS systems, as a 10-20 second loss of power will, once again, drop computers off-line and require the computers to restart.

With emergency generators, the UPS system need only have minimal battery back up to carry the system for a few minutes. The downside of back-up engines is the substantial investment in engines, generators, and switchgear that are never used productively to save operating costs. Emergency engines should also be frequently tested. These engines require on-site storage of a large supply of diesel fuel, which limits maximum operating time, tends to biodegrade over time, and, if leaking, can cause serious groundwater damage.

*Double Ended Grid Connections* involve connecting the facility to two different radial feeders. Often seen in hospitals, this type of connection will be hard to acquire in major urban areas, and may not provide any real protection unless the feeders are sourced at differing substations. Even then, a regional blackout will typically drop both feeders.

*Flywheels* are being packaged with UPS equipment today. The momentum of the flywheel coupled to a motor-generator, carries the facility through short momentary power fluctuations. To date, flywheels are not useful in storing large quantities of energy for blackout protection, although progress is being made in that direction.

Overall, server farms, telecom centers and high reliability electronic loads in general will require both UPS and generators. Looking more closely at UPS systems reveals two basic types: 1) Stand-By UPS and 2) OnLine UPS.

Stand-By systems, of the type shown in Figure 82 maintain charge on a battery pack and switch the load over to the battery pack in the event of grid failure. Inexpensive PC back-up systems work in this way and units of this type are widely used up to 20 kVA. This type of unit would, in general, not be used in server farms applications as the switching process will produce a momentary voltage fluctuation that can take down critical systems.

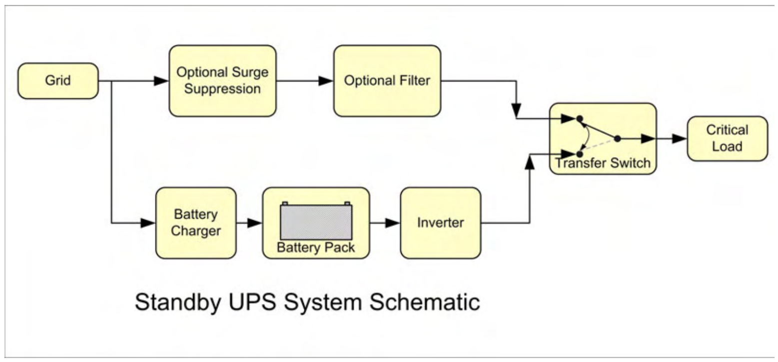


Figure 82: Stand-By Type UPS System
*This is the typical layout of UPS systems below 20 kVA, smaller than the centralized systems used in server market. Upon loss of grid power, the system must switch to stand-by power, causing a momentary interruption.*

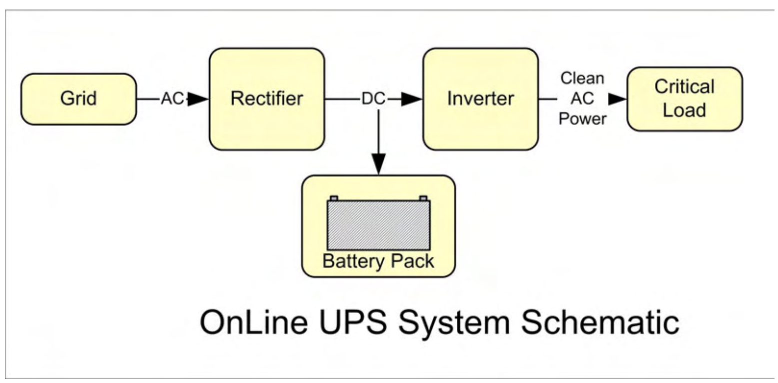


Figure 83: On-Line UPS System
*Systems above 20 kVA are typically on line systems that provide battery voltage support on a continuous basis as the grid goes off-line without any switching or momentary fluctuations. Newer systems provide a power "by-pass" to avoid the rectifier/inverter power loss during normal on-grid operation.*

Figure 83 shows an OnLine system used for larger more critical applications. The battery pack remains in the power supply circuit at all times and immediately supports the voltage as the grid goes into failure. In this way, there is no momentary voltage loss for switching.

As shown, the rectifier and inverter are in the power circuit at all times. However, newer systems feature a by-pass line, allowing power to avoid rectifier and inverter losses during normal grid operation. During a grid failure, the battery takes over immediately and a switch in the bypass opens to avoid feeding battery power back to the grid.

A high reliability load will require both UPS systems and emergency generators. These systems must work together as shown in Figure 84 and Figure 85.

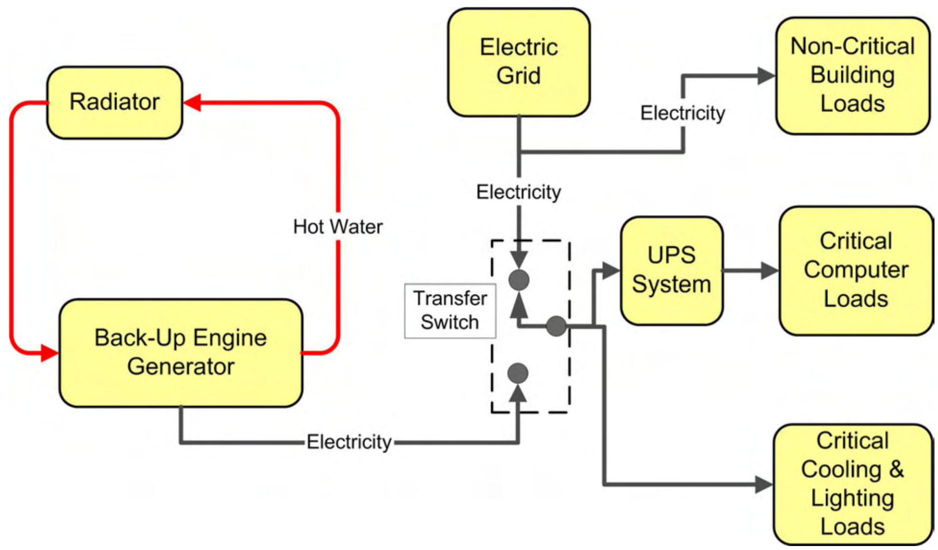


Figure 84: Typical Emergency Generator/UPS Operating Normally on the Grid

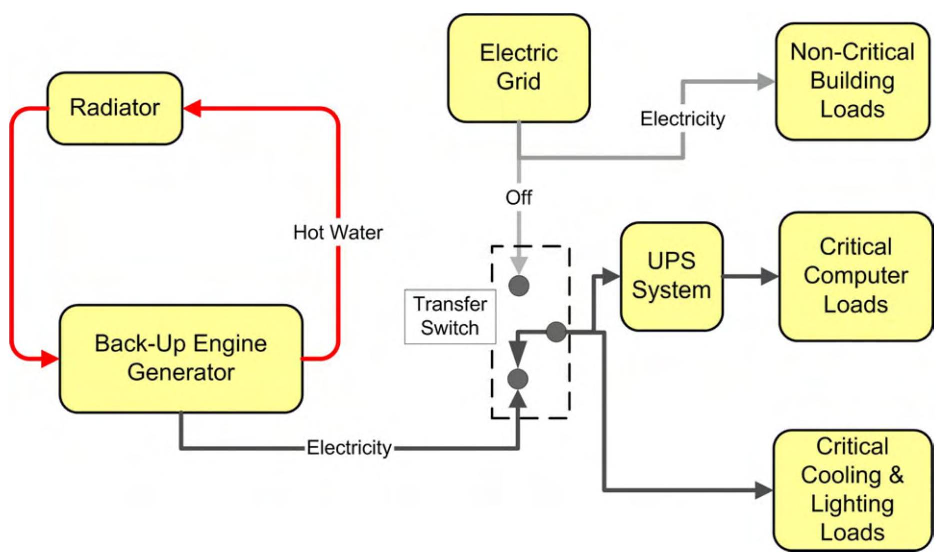


Figure 85: Typical Emergency Generator/UPS Operating During a Grid Outage
*Cooling must be provided during a grid outage, and therefore must add to the load on the generator. There is no need to add cooling onto the UPS systems, as the chillers can wait a few minutes for the engines to start.*

If a CHP system is used instead of an emergency generator, the system can operate during periods of normal grid operation as show in Figure 86

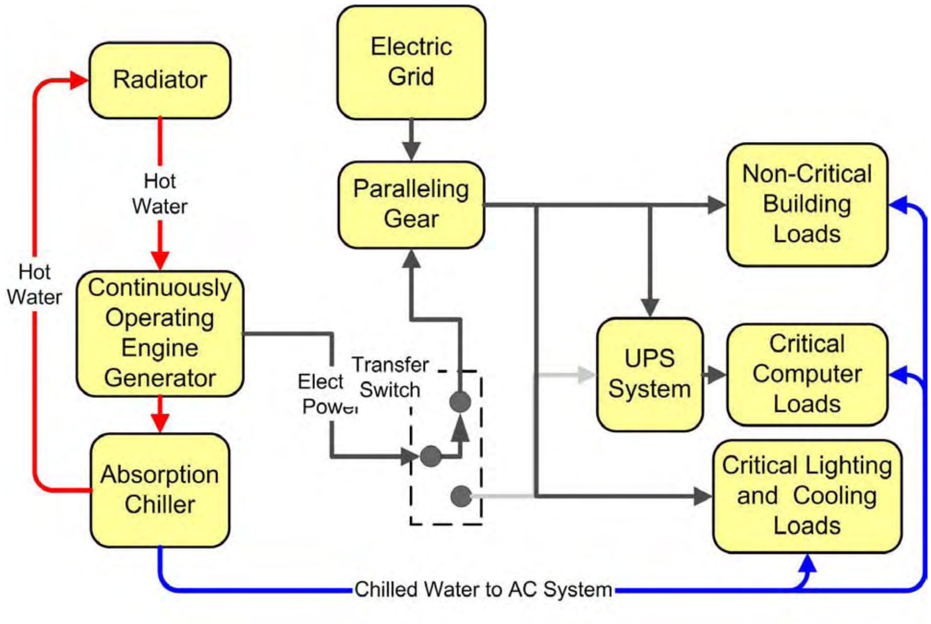


Figure 86: CHP/Back-Up System Operating WITH Normal Grid Power

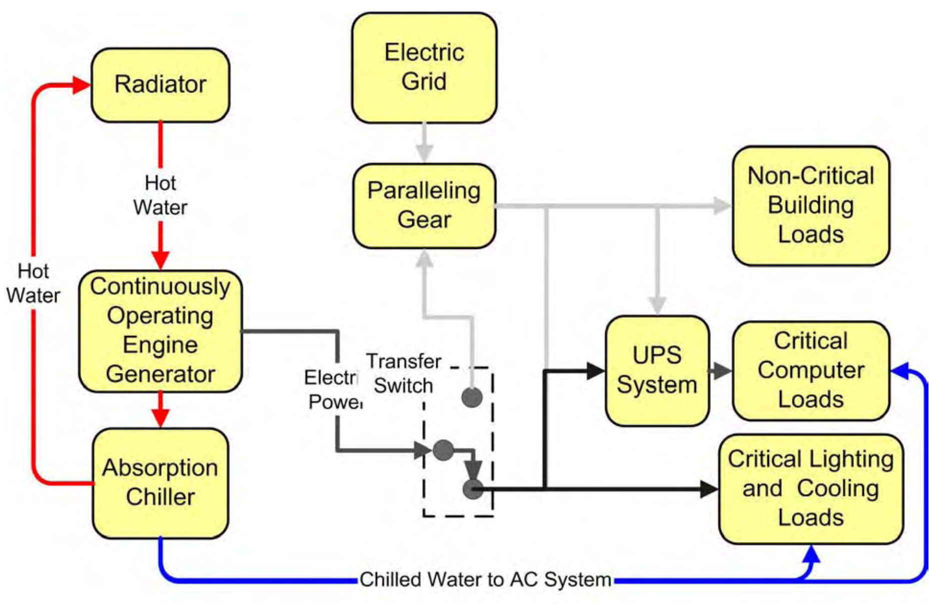


Figure 87: CHP/Back-Up System Operating WITHOUT Normal Grid Power

*When the grid fails, the CHP generators output is switched to the electric riser that feeds emergency loads only. The absorption chiller continues to produce cooling, which is directed only to critical loads.*

During a power failure, this same system would convert to the operating mode shown in Figure 87. When the grid fails, the CHP generators output is switched to the electric riser that feeds emergency loads only. The absorption chiller continues to produce cooling, which is directed only to critical loads.

| Cost for Electrical and Cooling System for 1,000 kW Critical Load Server Farm | | | |
|---|---|---|---|
| | Conventional | CHP | |
| Sizing | | | |
| Critical Load Power Required | 1000 | 1000 | kW |
| Cooling Required During Outage | 350 | 350 | Tons |
| Cooling Power Required | 332.5 | 122.5 | kW |
| Generator Size Required | 1332.5 | 1122.5 | kW |
| | | | |
| Costs | | | |
| Emergency Generator | $533,000 | $0 | |
| Continuous Duty Generator | $0 | $898,000 | |
| UPS System | $300,000 | $300,000 | |
| Gen Heat Recovery Equipment | $0 | $250,000 | |
| Cooling Equipment | $166,250 | $192,500 | |
| | | | |
| Total | $999,250 | $1,640,500 | |
| | | | |
| Incremental Cost for Adding CHP per kW Required by Conventional System | | $481 | /kW |

Table 29: Installed Cost Comparison Between CHP and Conventional Systems
*Two elements make CHP more competitive for high reliability applications. First, the CHP acts as the back-up generator and the cost of the back-up generator can be credited to the CHP system. Secondly, the generator used is smaller as power needs for cooling are reduced*

Finally, in Table 29 are preliminary numbers for a simple first cost comparison between conventional systems and a CHP system for a server center with a critical load of 1,000 kW. In most CHP applications, the operating cost savings must be sufficient to justify the entire first cost of the CHP systems, which in this size range will be $1,000 to $1200 per kW.

In this application, using the CHP generator for both continuous power and emergency capacity AND using the absorption chiller to allow the on-site generating capacity to be downsized, the incremental cost for the CHP system is under $481/kW. This means that the local operating cost savings for CHP must merely justify a $481/kW first cost. Adding this to the highly continuous nature of the server load, and paybacks in server applications can be quite short

### 6.2.3 Compatibility of CHP Systems with Electronics Installations

CHP systems may be based on a number of differing technologies but generally share some common elements.

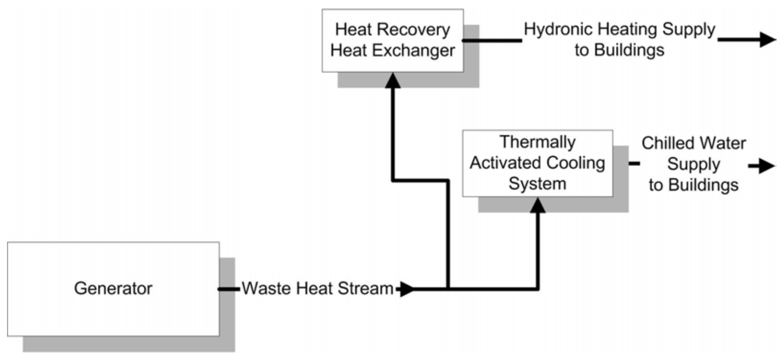


Figure 88: Completely Generic CHP System
*The generator may be a gas engine, turbine, or fuel cell, the thermally activated cooling system may be a single or multi-effect absorber, adsorber, or steam turbine driven system. Desiccant applications would differ.*

In general, CHP systems should be as centralized as possible with one generation, heating and cooling package serving as much of the entire facility as possible. Facilities are most compatible if the electric, heating, and cooling distribution systems can be served in this manner. This means that the facility should have a single point electrical service, and be cooled by centralized chilled water.

All electronic facilities from server farms to telecom switching, share common attributes:

- The principal loads will be cooling. Even in cold climates, the high internal loads will generate substantially more heat than is needed to meet heating loads.
- In cold climates, winter cooling loads cannot be met with outdoor air. The dehumidification of the facility that would result would either have to be made up by humidification or dry conditions could destroy electronic quickly. In general, ventilating to meet cooling loads is considered too risky. The standard cooling system must operate all winter.
- Chilled water systems have been uncommon in server farm facilities. However, other high-end electronic applications have used chilled water for years.

#### 6.2.3.1 Chilled Water – An Issue and an Opportunity

Chilled water has been used in electronics processing facilities, clean rooms, and all manner of sensitive facilities in the past. However, during the Internet boom of the late 1990's, server farms were largely assembled with all-air systems, and a myth arose that this was because of the concern about water leaks affecting electronic equipment. Some comments from recent reports:

ACEEE suggests[118]:

*Historically, centrifugal and absorption chillers are generally not used* (in internet server facilities) *for cooling because of the 180-240 day ordering lead-time. In the attractive market of the late 1990's, the rush to build data centers led to the use of direct expansion (DX) packaged cooling in these facilities because of the short lead-time (30-60 days) required by these units.*

Another suggests[119]:

*At 0.5-0.7 kW/ton, central chilled water systems are approximately twice as efficient as direct expansion air-cooled systems that draw 1.2 kW/ton. Concerns that water near computer equipment may cause problems can be ameliorated through proper chilled water system design.*

In looking to the future, another report[120]:

*If projected trends continue over the next 3-6 years, The Uptime Institute (Santa Fe, NM) predicts that cooling air from under the floor will not be enough to remove the heat being generated. At some time in the not so distant future,* (they say), *hardware manufacturers are going to have to consider a return to water cooling or other methods for removing heat from their boxes.*

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118 Page 5 of *ACEEE: Overview of Data Centers and Their Implications for Energy Demand*, Elizabeth Brown, R. Neal Elliott, and Anna Shipley, American Council for an Energy-Efficient Economy, Washington, DC, September 2001

119 *Energy Smart Data Centers: Applying Energy Efficient Design And Technology To The Digital Information Sector*, by Fred Beck*Renewable Energy Policy Project, November 2001,No.14

120 Cooling and Power Requirements for Collocated Hardware, by Kevin Facinelli, http://crystalpc.com

To understand these electronic facilities cooling needs, we need to see what has been done in the past. The following progression shows how intensely loaded electronic rooms, whether for large mainframe computers, server farms, or telecom switchgear have been handled since the 1970's, through today and some projection for the future.

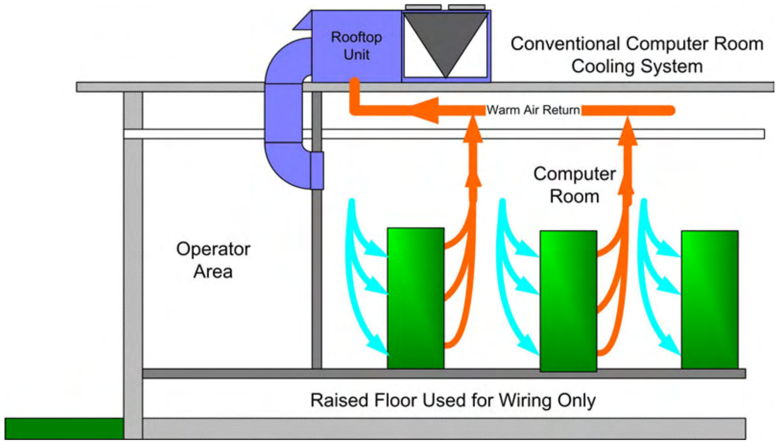


Figure 89: Conventional Computer Room from the 1980's
*Racks contain individual cooling fans (not shown) that draw air in the front and out the back. Racks are cooled by pulling in room air. System employs a very cold room environment. Cold air was supplied either from rooftop,(as shown) DX, or central chiller systems, often assisted by special computer room cooling packages.*

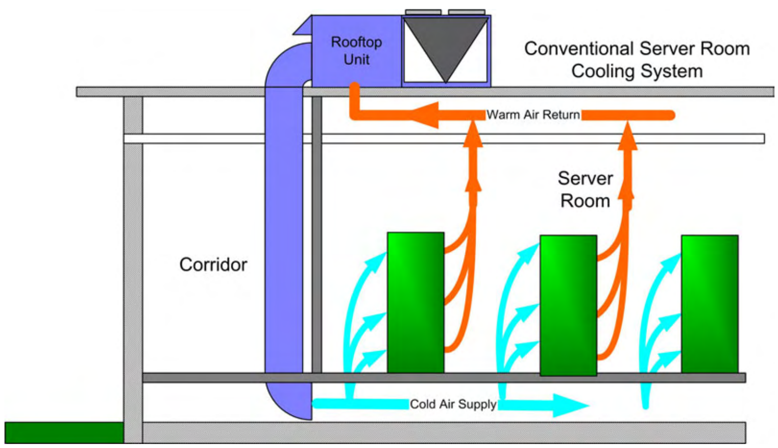


Figure 90: Addition of Under Floor Air Flow Allowing Aisles of Racks to be Packed More Closely
*An improvement on previous systems. Cold air from the under floor area is dumped in front of each rack and rack fans induce a cooling flow. Distribution to the rack is still haphazard.*

The classic "computer room" system, originally used for mainframes computers and still commonly used where loads are not extremely dense, is shown in Figure 89. As loads become more densely packed, the under floor space, originally used for wiring, became used as the supply duct for cooling air as shown Figure 90. In order to increase density further, it is now recommended[121] that racks be positioned back-to-back as shown in Figure 91. This allows the rack fans to discharge to a "warm aisle" and intake from a "cold aisle", which improves cooling as cold and warm air are less likely to mix.

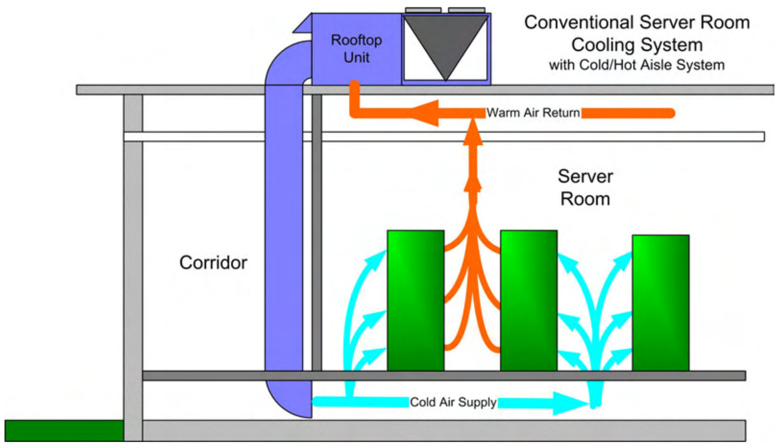


Figure 91: Recent System Organizing More Closely Packed Rack Aisles into Hot and Cold Aisles
*To pack rows of rack more closely together, racks are arranged back-to-back to separate cold air in front of the racks from hot air between rack backs.*

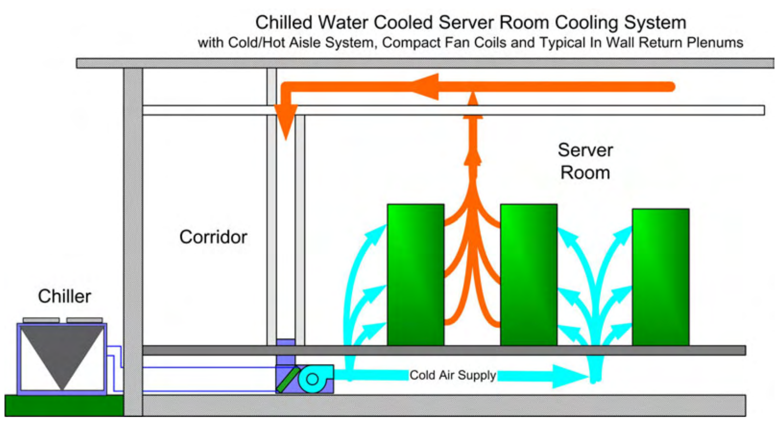


Figure 92: Any Layout Can Use Chilled Water as Well

All of the airflow layouts shown in Figure 89 through Figure 91 can use chilled water rather than rooftop units, for cooling. As shown, the chilled water is isolated away from the server

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[121] Alternating Cold and Hot Aisles Provide More Reliable Cooling for Server Farms, Robert Sullivan, Ph.D., The Uptime Institute, 2001

room. Chilled water eliminates running large ductwork from rooftop air conditioning units. This saves space in a single story building and may be the only way to make multi-story server facilities possible. Multiple fan coils can be used for a single server room if desired, and a simpler in-wall plenum can be used to feed return air to multiple compact fan coils.

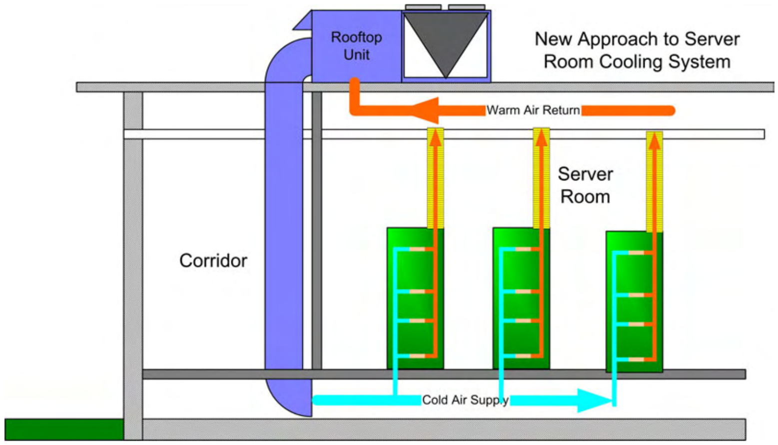


Figure 93: For Denser Loads – Passing the Air Directly Through the Rack is More Effective
*There is no real need to run cold air through the entire server room when the load is internal to the equipment rack. The equipment rack can be made part of the HVAC system. This system can also be driven by chilled water as shown in Figure 92.*

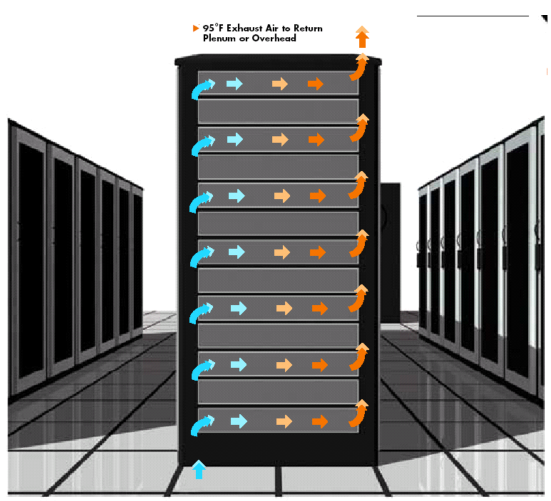


Figure 94: New Internally Air Cooled Equipment Rack Recently Introduced to the Market[122]

[122] Wright Line, Paramount Enclosure Systems, www.wrightline.com

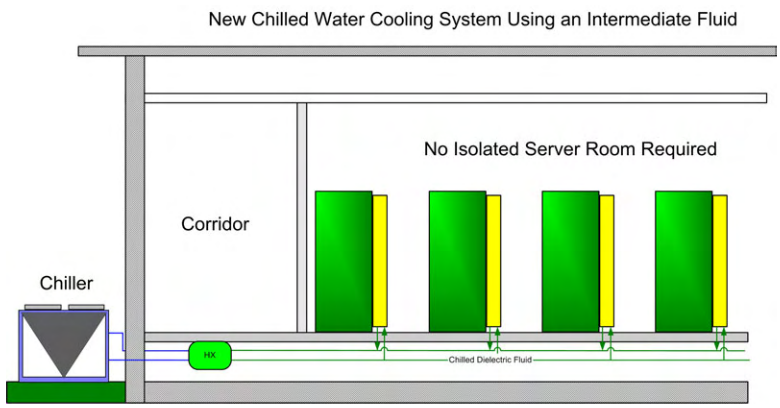


Figure 95: To Move to Higher Power Densities Chilled Water Becomes Essential
*In this system, recently introduced to the market, chilled water is used to cool ultra-high powered equipment racks. A dielectric fluid is used in the loop between the chilled water and the electronics racks. Rooftop units or direct expansion units are not adaptable to this system.*

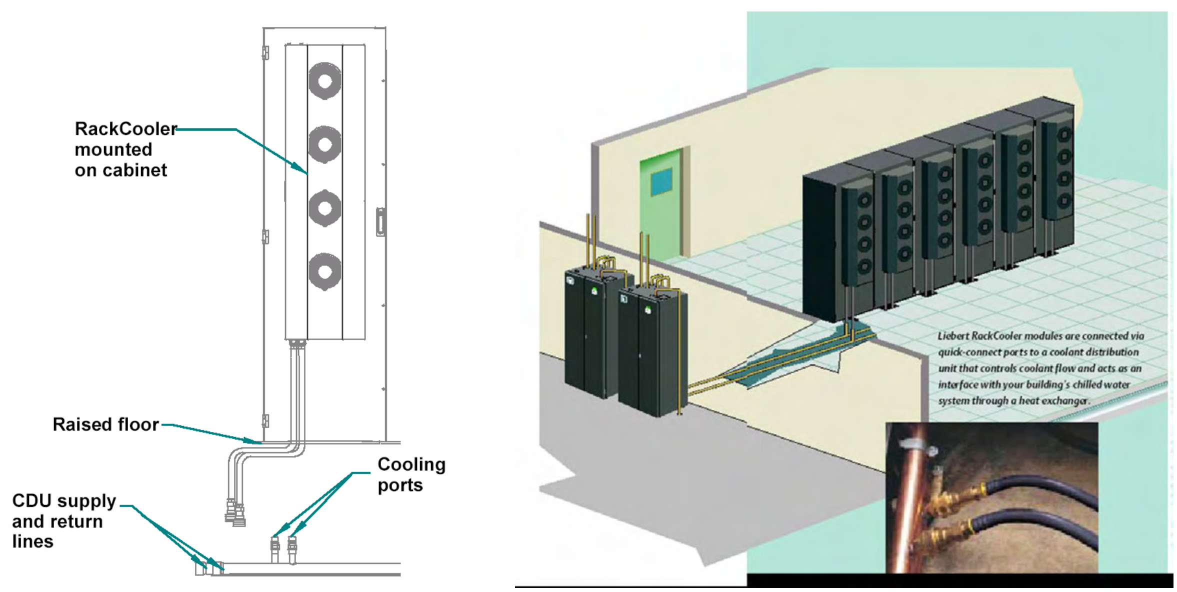


Figure 96: Liquid Cooled RackCooler™ System[123]

The next step in cooling higher power racks have recently come onto the market. In one, the cold under-floor air is ducted up directly through the electronics enclosure and then directly into the ceiling return plenum. This airflow never enters the room and can be heated to a

[123] Heat Removal RackCooler™, A Cool Solution For X-Treme Density Rack Enclosure Systems, 2001 Liebert Corporation, http://www.liebert.com

higher temperature before being returned to the cooling system. This allows each cubic foot of air to remove more heat and prevents any misdirection of the air within the room.

Another method is removing the air cooling and ducted recirculation system entirely. In this system, shown in Figure 95, rack fans pull air from the room through the electronics to be cooled and then through a liquid filled cooling coil which returns the air to room temperature before discharging the air to the room. This removes the entire server load from the rooms air conditioning system. Extremely intense and dense cooling loads can be handled in this manner and, the air conditioning system for the general room air need handle no special loads. This means that the liquid removes the rack load, and the racks do not have to be stored in an overly cooled room. This may allow servers to move to less specialized locations.

The cooling liquid is then re-cooled by chilled water in a remotely located heat exchanger. As the cooling liquid is in very close proximity to the electrical gear, a less conductive fluid is used to prevent water damage. This cooling system requires that the building be equipped with chilled water and this chilled water may also be used in the conventional manner to cool other areas of the building.

In summary, chilled water systems are not locked out of the Server Farm for any technical reason. Therefore, the chilled water production of CHP should not be a hindrance in applying CHP systems to these facilities, and there are a number of positive attributes of chilled water systems that can be pointed to as added features.

## 6.3 NAICS 513 – Broadcasting and Telecommunications

Areas of interest for CHP systems include facilities where the reliability of the power supply is essential and where there are a large number of facilities to pose an interesting market. High power reliability requirements should apply to any of the segments in NAICS 513: Broadcasting and Telecommunications.

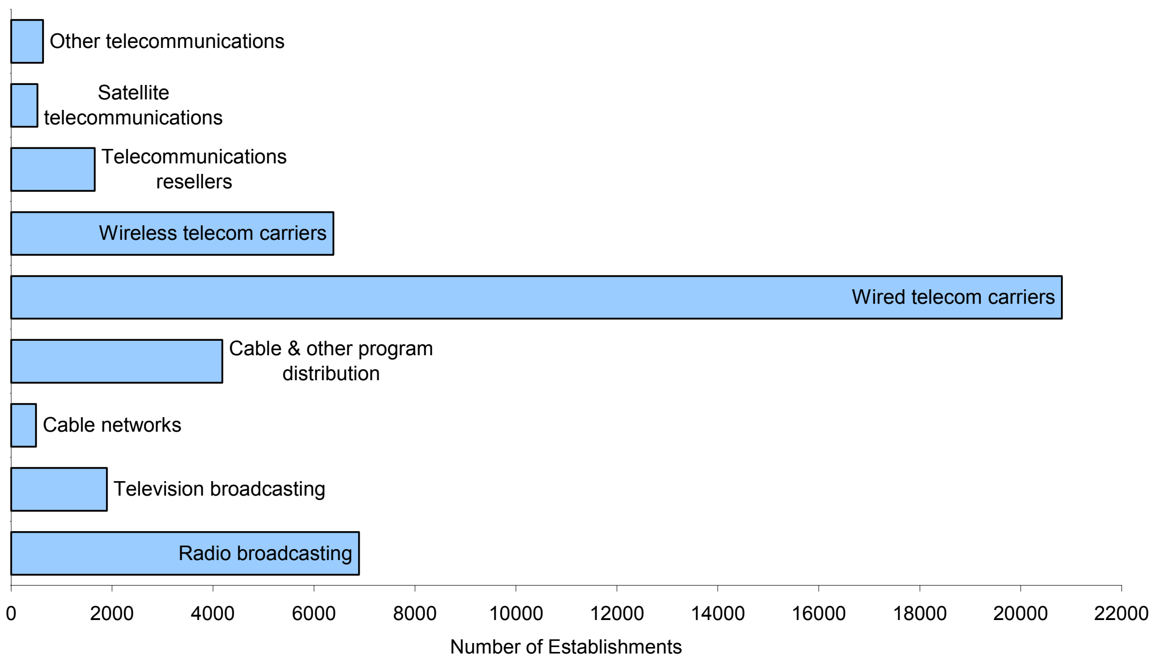


Figure 97: Detailed Segments under Broadcasting and Telecommunications[124]

The number of facilities can be seen in Figure 97. Clearly, wired telecommunication carrier facilities are the most common.

### 6.3.1 Definitions

The following are the Census definitions of the market segments shown in Figure 97.

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[124] 1997 Economic Census: Information Sector, United States, Information by Industry, http://www.census.gov/epcd/ec97/us/US000.HTM

*NAICS 51311: Radio Broadcasting*

This industry comprises establishments primarily engaged in broadcasting audio signals. These establishments operate radio broadcasting studios and facilities for the transmission of aural programming by radio to the public, to affiliates, or to subscribers. The radio programs may include entertainment, news, talk shows, business data, or religious services.

*NAICS 51312: Television Broadcasting*

Establishments engaged in broadcasting images together with sound. These establishments operate television broadcasting studios and facilities for the programming and transmission of programs to the public. These establishments also produce or transmit visual programming to affiliated broadcast television stations, which in turn broadcast the programs to the public.

*NAICS 51322: Cable and Other Program Distribution*

Establishments engaged as third-party distribution for broadcast programming. Establishments deliver visual, aural, or textual programming received from cable networks, local television stations, or radio networks to consumers via cable or direct satellite systems.

*NAICS 51331: Wired Telecommunications Carriers*

Establishments engaged in (1) operating switching and transmission facilities to provide direct communications via landlines, microwave, or a combination of landlines and satellite linkups or (2) furnishing telegraph and other non-vocal communications.

*NAICS 51332: Wireless Telecommunications Carriers (Except Satellite)*

Establishments engaged in operating switching and transmission facilities that provide direct communications via airwaves. Included in this industry are establishments providing wireless telecommunications network services, such as cellular telephone or paging services.

## 6.4 Specific Issues on Telecom Switching Systems

Telecom switching systems handle the establishment of telephone connections. The actual switching functions started in the 19th century as a physical circuit established by hand by one or a series of operators. This transformed into a complex system of mechanical switching, which operated throughout the first half of the 20th century, and then into electronically controlled mechanical switches by the 1970's.

Since the 1970's, the switching has become completely electronic with call direction being handled as a series of information packets flashed between computers, in a manner similar to Internet communications.

However, to date, once a connection is made, a continuously operating circuit exists between the two callers until the call is broken. This is quite different from an Internet connection in which all communications are "packetized" and sent over the network in a discontinuous manner, with information between any two users in packets being continuously re-routed.

Telephone connection is increasingly handled by more sophisticated electronics, effectively "converging" into arrangements similar to the server banks seen in server farms. However, the overall structure of these facilities differs in a number of ways.

### 6.4.1 System Structure

A highly simplified structure of the telephone system is shown in Figure 98. The Most Common Facility is a Central Office (CO) connecting subscribers to the system. Local calls are sent directly by the Central office from one subscriber to another. Calls outside the Central Office's coverage area are sent up to the Toll Office and then sent down to the recipients Central Office.

Long distance calls are transferred to the Toll Office and sent to an IXC (Independent Exchange Carrier), which can be any of the long distance companies. The signal from the subscriber indicates which long distance company is appropriate. The IXC transfers the call to the Toll Office of the recipient, which may be in another City or State, and the call passes through the Toll and Central office of the recipient to the recipients phone. Both the Central

Office and Toll offices will be the property of the local regulated telephone company where the IXC will be owned by one of the competitive long distance companies. In this way, long distance competition has been achieved without any duplication of local wiring.

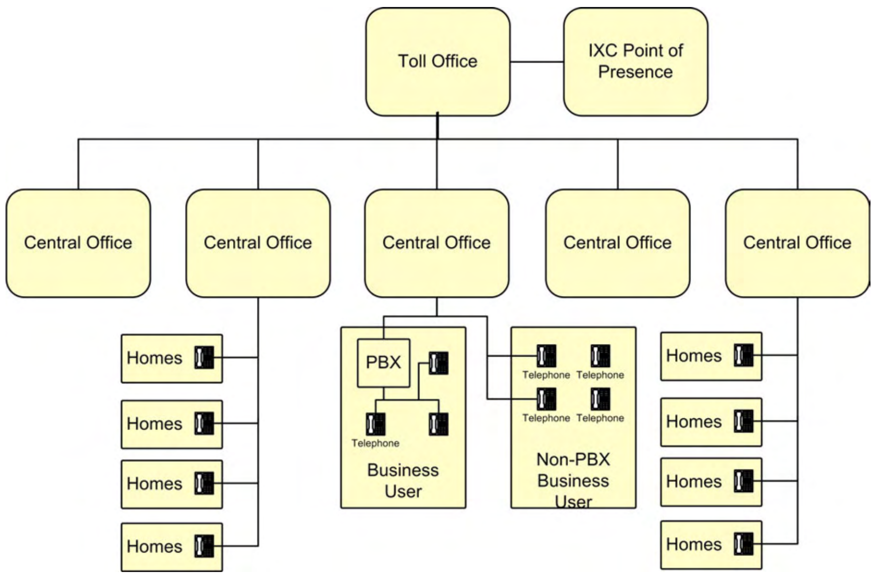


Figure 98: Telecom Switching System[125]
*The Most Common Facility is a Central Office (CO) connecting subscribers to the system. Long distance call are transferred to the Toll Office and sent to an IXC (Independent Exchange Carrier), which can be any of the long distance companies.*

### 6.4.2 Central Office Facilities

These are smaller facilities than the server farms previously examined.[126] A typical facility referred to as a "Central Office" or CO, is roughly 10,000 square feet. There are a very large number of these Central Offices (CO). As the distance that can be covered between the CO and the most distant telephone user is limited, these facilities are scattered all over the United States, with a best estimate of roughly 20,000 such facilities being used nationwide. These

[125] Original drawing. Information from Fundamentals of Telecommunications, The International Engineering Consortium

[126] Overall description of Central Office Facility operation and Power Uses from private communications with Jon Chestnut, Verizon.

Central Office facilities are the most numerous buildings of all the facilities owned by telephone systems and dominate NAICS 51331 Establishments.

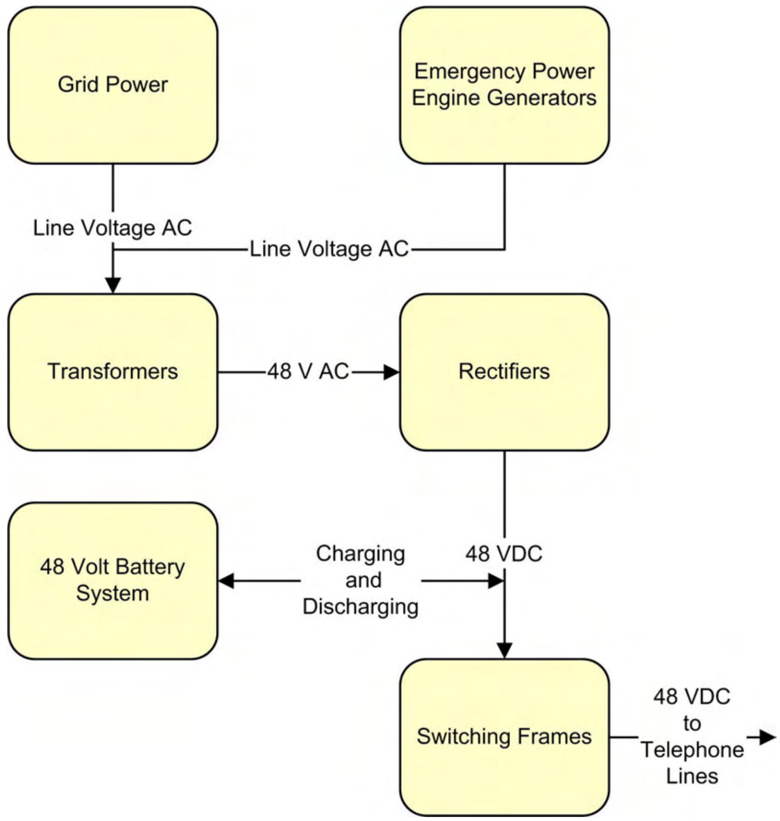


Figure 99: Power System in a Central Office

These small 10,000 square foot CO facilities are generally unoccupied, with no continuous human supervision. Overall power requirements are in the 250 kW range. The central business districts of major urban areas will tend to have larger Central Offices, due to the large number of users in a limited geographical area. In those cases, the Central Office facility may be a portion of a corporate office structure.

The Central Offices actually provide 48V DC supply power to the telephone wiring system. Some of the 250 kW of required power is used to power the wiring system and consumed by voltage drops throughout system. Therefore, unlike server farms, only a portion of the 250 kW is utilized, or generates heat, within the building.

In their role as a power source, a portion of the Central Office is occupied by transformers, used to step line power down to the proper voltage, and rectifiers used to convert this power to direct current.  Another area of the Central Office contains a battery bank, which is used to maintain consistent voltage on the telephone system and to provide back-up power in the event of a power supply outage.  Yet another section of the facility contains one or more back-up engine generators that recharge the battery system in the event of any prolonged utility power outage.  At present, these engines are used strictly as electric power back up and are generally diesel engines operating on oil.

The switchgear or telecom frames are an intense user of power and source of heat, running up to 100 watts/square foot.  However, frames occupy only a minor portion of the Central Office.  Estimated cooling requirements for a typical 10,000 square foot Central Office is on the order of 30 to 40 tons, only twice as intense per square foot as a typical office building.  These facilities are generally cooled by packaged rooftop units or occasionally DX systems (rooftop condenser with an indoor coil).  Only the largest metropolitan Central Offices use chilled water.  Rooftop systems are used due to their low maintenance requirements.  The industry appreciates that these units are not highly efficient.

Central Office buildings do require some heating.  Currently, this is accomplished by a heating unit in the rooftop system.  Economizer (outdoor air) cooling is done in cold weather, even though the very low indoor humidity conditions that can result are recognized as a problem

Many of these Central Office facilities were built in the era of electromechanical switching.  With the introduction on electronic switching, these buildings were actually oversized.  These facilities are now filling up again with growth in the number of telephone lines and new equipment required to provide high speed data service (DSL) to telephone systems.  In addition, Central Office facilities are now also being used to provide rentable “collocation” floor space as a service for Internet companies.  As the Internet industry recovers, the growth in collocated equipment will increase the power and cooling loads.

### 6.4.3 Overall Load

Given the estimate of 250 kW for a typical Central Office, and 20,000 CO’s in the United States, an overall load of 5 GW is identified. However, this is spread over 20,000 sites. Due to the centralized ownership of these facilities, generally by the local regulated phone service supplier, or the “telco”, reaching this market should be straightforward and limited in communication or advertising costs. However, the right system for this Central Office facility will have to be developed in cooperation with some of these “Telco’s”, to pull together a package that meets the needs of this market.

### 6.4.4 The CHP Potential for Central Offices

Due to the need for a large amount of DC power to run these facilities, transformers and rectifiers occupy a significant amount of interior space. An on-site generator that produced DC power such as fuel cells or high-speed generator microturbines, like Capstone. could save significant internal space and first cost by supplying DC power directly to the batteries. Actual supply power to the battery is ~52 VDC to drive recharging of the 48 VDC nominal power system. Supplying DC directly from the on site generator would also eliminate the power loss associated with transformers and rectifiers, improving operating efficiency.

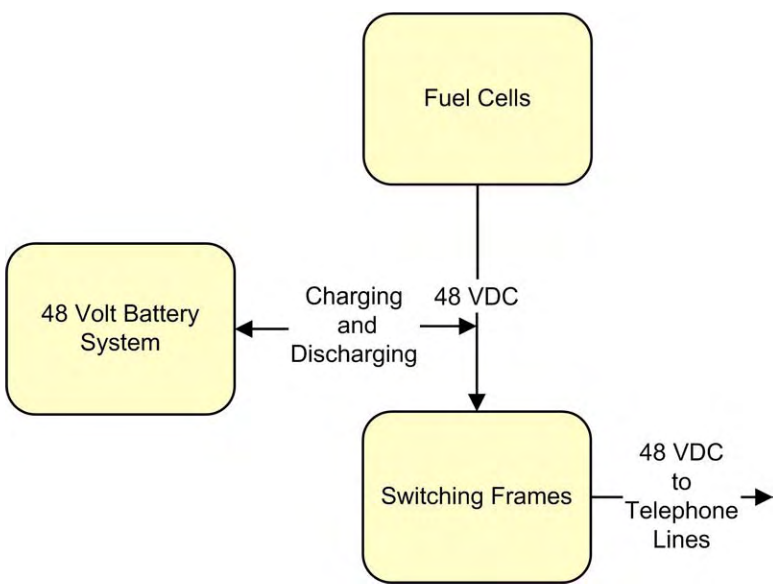


Figure 100: Potential Arrangement of a Fuel Cell Driven Central Office
*Grid connection may still be required as back-up.*

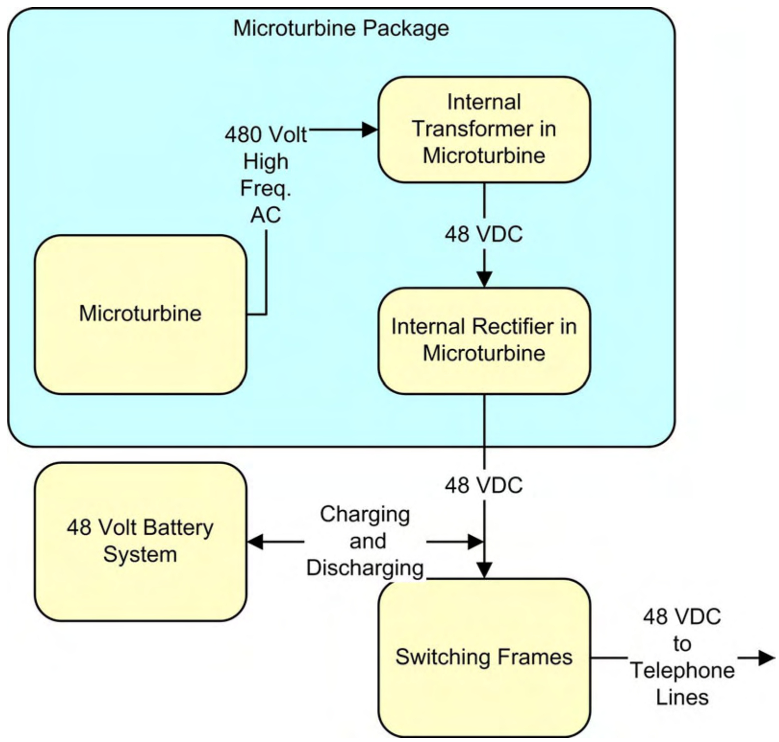


Figure 101: Potential Arrangement of a Microturbine Driven Central Office
*Grid connection may still be required as back-up.*

In residential areas, the offices are often located very near homes. The noise level of equipment must be minimal, and the building acceptable in appearance. For these reasons, back-up engines are located indoors and well silenced, and transformers and power conditioning systems are put indoors. Even conventional rooftop air conditioning equipment may cause noise complaints. The silent operation of a fuel cell system would be an asset.

Unlike Internet server operations, the load on telecom Central Office facilities is fairly level throughout the day and week, which can make a distributed generator or cogeneration much more economically attractive, depending on local grid power prices.

Given the smaller cooling loads in these facilities, a heat recovery cooling system would need to be practical in the 30-40 ton size range. Sealed air cooled ammonia water air conditioners run on fuel cell or microturbine heat rejection may be more practical than lithium bromide equipment that requires an open cooling tower and ongoing water treatment and other maintenance.

## 6.5 Determine the Best Channels for Information Outreach

This Internet Server/Data Center/Telecom Switching sector is unique in this report in that

- There have been few applications of CHP systems.
- The sector is in a process of rapid technological change, which tends to change the needs of the sector.
- The Internet Server and portions of the Telecom sector are in a state of financial disarray. Following a period of overestimated growth potential and rampant over-expansion, this industry came in for a "hard landing", which is forcing consolidation. Once consolidation is complete, the industry will be concerned about over-expansion and looking for ways to pull greater profits out of existing operations. CHP will be one potential avenue.
- When this sector is back to profitable operation, rates of return on capital investments in servers, switching equipment, and facilities in general will most likely be above those seen in CHP analyses. Therefore, third party CHP developers/owners may play a major role in financing and owning CHP of these facilities.

### 6.5.1 Demonstrations and Alliances Partners

CHP for this sector is so undeveloped that sensible first steps would include the following:

- Assembling case studies of any existing applications
- Alliances with existing facility owners to more fully understand the industries current and projected future requirements and desires for a CHP system
- Demonstration projects leading to Case Study documentation

Until this stage is complete, outreach in whatever form would have little commercial experience to work with, making an effective message difficult. The current Department of Energy demonstrations with Verizon and Sure Power are a step in this direction for fuel cell systems. Demonstrations with less expensive nearer-term technologies such as engine systems and microturbines may be a useful addition.

### 6.5.2 Professional Association Alliances

To date, no professional organization of facility planners, designers, or managers has been found for this market sector. With industry growth, such an organization will undoubtedly emerge. However, at present, outreach activities will have to be focused on facility owners directly.

### 6.5.3 Direct Outreach to Facility Owners

A list of major Internet Server facility owners is shown in the Appendix to this chapter. The local regulated telephone companies will own telecom switching systems, particularly Central Office.

Outreach material to facility owners and managers is best structured in the Internet Newsletter format with information centered on the main concerns of the industry. CHP would be laid out as an operating asset (reliable power) and revenue opportunity (reduced energy cost). Descriptions should be on a financial and not a technical level. Only if this should succeed in drawing interest will training for design professionals be needed, and this can be set up at a later time.

## 6.6 Summary

The Data Centers/Server Farms/Telecom Switching Facilities market is ~2.6 GW in 2002 (Data Centers and Server Farms) and ~5 GW for Telecom Switching Facilities, with substantial strength for new growth after the current period of consolidation. The key element in outreach materials for this market will be the relationship between CHP systems, reduced operating cost, and reliability. The ability for CHP systems to produce a rate of return and act as emergency power back-up is as interesting in this market as it is in hospital facilities, where CHP has already made significant headway.

This market does not require life safety start-up times, and therefore back-up generators can be allowed 1-2 minute start-ups while the facility is carried by the UPS system. This means that purely natural gas engines or microtubines could be used. With generally unmanned facilities like Telecom switching centers, there is also an interest in fuel cells, due to their DC output, quiet operation, and long term potential for low maintenance.

Due to high internal heat gains, this market will not need to use significant recovered heat for space heating. In addition, water heating loads are also not significant. Due to the need to maintain humidity in spaces with no humidity sources, dehumidification loads are non-existent. Rather, the essential use of recovered heat is for sensible cooling, and the essential component is the absorption chiller, feeding chilled water either to direct rack coolers or to air handlers that then use cold air to provide electronics cooling in the conventional manner. As an additional plus, there may be significant benefit incorporating chilled water reset in this "Server Center CHP" layout, as elevated chilled water temperatures will both increase the amount of cooling and avoid unintended dehumidification, a problem in computer rooms.

The ability of CHP to produce emergency power and emergency cooling driven by the generator's rejected heat is attractive in an application where cooling is absolutely essential to operation during an outage. CHP should have an opportunity with both Internet and Telecom facilities as these sectors recover from their current financial troubles, consolidate, and look for new avenues to increase net revenues from their existing business base.

## *Appendix 1 - List of the Major Internet Server Facility Owners*.

| Company | Subscribers (Millions) |
|---|---|
| America Online | 26.5 |
| MSN | 7.7 |
| United Online [NetZero + Juno Online] | 4.8 |
| EarthLink | 4.7 |
| SBC/Prodigy | 3.5 |
| CompuServe [AOL Owned] | 3 |
| Road Runner [AOL Owned] | 2.5 |
| AT&T Broadband | 1.8 |
| Verizon | 1.5 |
| AT&T WorldNet | 1.4 |
| Comcast | 1.2 |
| Cox | 1.1 |
| Charter | 0.9 |
| BellSouth | 0.8 |
| Cablevision | 0.61 |
| Qwest | 0.51 |
| RCN | 0.46 |
| Covad | 0.36 |
| CoreComm [Formerly Voyager.Net] | 0.29 |
| Hughes | 0.22 |
| Volaris Online | 0.24 |
| Bluelight | 0.17 |
| Other U.S. ISPs | 86.2 |

Table 30: Major Internet Service Providers as of 3Q/2002[127]

[127] http://www.isp-planet.com/research/rankings/usa.html

The Distributed Energy Program would like to acknowledge Oak Ridge National Laboratory for its Technical Project Input of this Report.

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