ENERGY AND ENVIRONMENTAL ANALYSIS, INC.

Market Potential for Advanced Thermally Activated BCHP in Five National Account Sectors

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901 D Street, S.W.
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Submitted By:
Energy and Environmental Analysis, Inc.
1655 N. Fort Myer Drive, Suite 600
Arlington, Virginia 22209
(703) 528-1900

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1. INTRODUCTION

Potential distributed generation (DG) and combined heat and power (CHP) applications in the U.S. cover a broad spectrum of market segments, from nursing homes requiring a few hundred kilowatts (kW) of power and an economical hot water source to large chemicals plants requiring several hundred megawatts (MW) of power and thousands of pounds per hour of high-temperature steam. In the commercial buildings setting, integrating building CHP (BCHP) systems with advanced thermally activated equipment in integrated energy systems (IES) configurations can increase the efficiency and economic benefits available with onsite power systems. Thermally activated technologies (TAT) utilize waste heat to drive equipment that serves building air conditioning, refrigeration and dehumidification loads.

National account energy customers represent a potentially attractive market for BCHP-IES because they operate multiple sites and make many types of decisions on a centralized basis. The multiple project/unit marketing and sales approach that is possible with this structure is a much more efficient way to increase the penetration of energy systems than the labor-intensive site-by-site alternative. However, the drivers, technologies and economics of BCHP vary greatly across the spectrum of national account market segments. Developing appropriate technologies and devising effective market and policy strategies for BCHP-IES thus requires an understanding of the unique characteristics of each of these market segments.

This report assesses the applicability of innovative thermally activated technologies in integrated system configurations in the five target national account segments: healthcare (hospitals and nursing homes), supermarkets, lodging (hotels and motels), restaurants and "big box" retail. Our analysis looks specifically at smaller-scale systems (1.2 MW and under), as this is size range of typical applications in these five sectors. We identify and describe potential BCHP-IES target applications in the five segments, estimate the technical market potential for these applications, and provide insights into national account customers' perceptions about advanced thermally activated systems. Finally, we incorporate the findings of a sister report profiling national account segment energy loads, equipment and decision making to arrive at key conclusions about the potential markets for these systems.

2. EXISTING DG/CHP

2.1 INTRODUCTION AND SUMMARY

In this chapter, we characterize the existing capacity of CHP in five national account sectors. We developed the profile of existing CHP to understand the technologies and applications that comprise existing CHP capacity and to provide insight into projections of future market development in the national account sectors that have been the subject of this project: supermarkets, hospitals and nursing homes, hotels/motels, restaurants, and big box retail stores.

The following profile of existing CHP activity in the commercial sector is based on a CHP database developed by EEA with support by ORNL and DOE[1]. The database is based on a database developed by PA Consulting (formerly Hagler Bailly's *Independent Power Database)*. In the course of conducting several similar analyses in the past four years, we have not found any single database that contains a comprehensive listing of existing CHP and independent power facilities. While coverage of small systems in the Hagler Bailly (HB) database is notably incomplete, we consider the HB data as the best available, and have worked with it extensively to understand its content and to enhance its coverage and value. The database includes information for each CHP site including technology, fuel use, electrical capacity (MW), ownership and sales of power back to the grid. Since the HB database is incomplete in the coverage of small systems (less than one MW), the following analysis is a conservative estimate of existing CHP in the commercial market, including the sectors covered in this report.

The analysis of existing CHP in the five national account sectors leads to several conclusions regarding the scope of the CHP modeling and the technologies selected, as follows:

- To date, penetration in this market has been extremely limited. In the five sectors reviewed, we identified a total of 318 projects and over 500 MW of installed capacity.
- Nearly two-thirds of the CHP sites and over 90% of the installed capacity for the target sectors are in healthcare facilities (hospitals and nursing homes). Seven large hospital installations comprise over half of the total CHP capacity. These systems use large-scale technologies such as combustion turbines, combined cycle systems, and boiler/steam turbines.
- Lodging makes up the second largest existing CHP capacity. There are only limited applications in the three remaining sectors.
- Natural gas is the predominant fuel for existing CHP systems, serving 83% of installed capacity. All coal, wood and waste capacity is in the healthcare segment and concentrated in seven sites. With this in mind, we have used natural gas-fired technologies as the basis for defining future growth in the sector.

[1] EEA CHP 2000 database

- Existing CHP is concentrated primarily in five states (California, New York, New Jersey, Connecticut and Massachusetts).
- Most CHP installations are less than 500 kW. Hospital projects are typically much larger, with an average size of approximately 2 MW. The majority of installed capacity is in several large plants.

An understanding of existing CHP sites provides insights with respect to project sizes, prime mover technologies, locations, site applications, and the experience with onsite power. The following sections will provide more detailed data on existing CHP projects as a backdrop to the assessment of potential advanced CHP/IES market opportunities in the five segments profiled.

2.2 CHP INSTALLATIONS

2.2.1 Summary

Table 2-1 presents a summary of existing CHP in the segments reviewed. The summary is based on 318 CHP projects making up a total of 508.8 MW of electric capacity in the supermarket, healthcare, lodging, restaurant, and big box retail sectors.

TABLE 2-1
CHP CAPACITY BY NATIONAL ACCOUNT SECTOR

Segment	No. of CHP Sites	Total Capacity (MW)	Average Site Capacity (kW)	Median Site Capacity (kW)
Supermarkets	11	1.5	138.6	150.0
Healthcare	204	469.6	2,302.2	230.0
Lodging	84	30.5	362.7	100.0
Restaurants	13	1.2	96.0	23.0
Big Box Retail	6	6.0	994.2	362.5

Source: EEA CHP 2000.

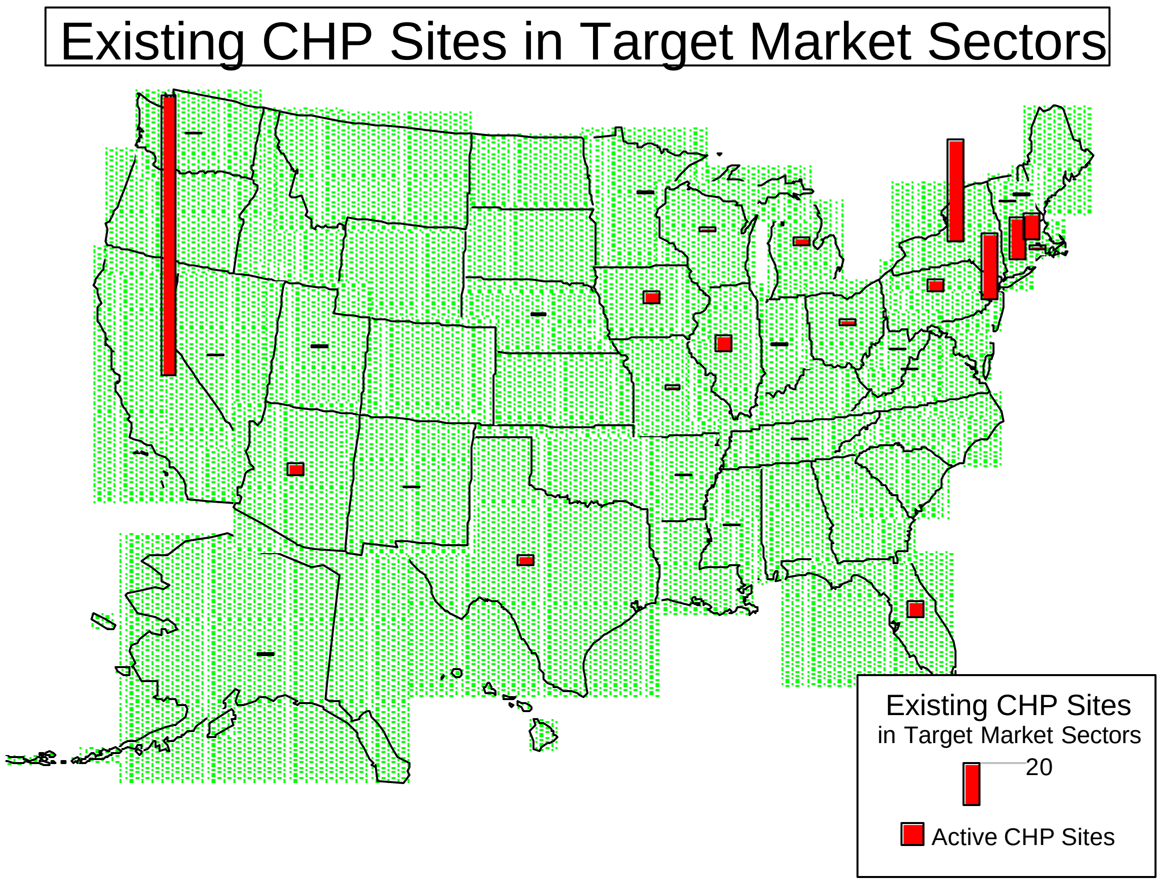
Nearly two-thirds of the CHP sites and over 90% of the installed capacity for the target sectors are in healthcare (hospitals and nursing homes). Seven large hospital installations comprise over half of the total CHP capacity. These systems use large-scale technology such as combustion turbines, combined cycle systems, and boiler/steam turbines. While the average capacity of CHP in healthcare is quite large (greater than two MW), the median healthcare CHP site is much smaller. This highlights the many small (less than 500 kW) healthcare CHP installations.

Hotels make up the next largest target segment with 84 sites and over 30 MW of total capacity. There has been limited application of CHP in the remaining national account sectors.

2.2.2 Geographical Breakdown of Existing CHP

Figure 2-1 illustrates the state-by-state breakdown of installed CHP in the five sectors profiled. Not surprisingly, CHP capacity is concentrated in five states (California, New York, New Jersey, Connecticut, and Massachusetts) that together account for 75% of all projects. In addition to large population and economic activity, these states typically have higher energy costs than the rest of the U.S. This is consistent with the overall commercial CHP market.

FIGURE 2-1
EXISTING CHP BY STATE



Source: EEA CHP 2000.

There are CHP projects in the target sectors in 31 states. California is the largest with 129 sites, followed by New York with 48.

2.2.3 Size Breakdown of Existing CHP

Table 2-2 presents the estimated size distribution of existing CHP in the five sectors profiled. It is worth noting that two-thirds of the identified sites are less than 500 kW. Given that the HBI database, while still the best database that EEA has identified, may be incomplete in the coverage of small systems (<1 MW), the estimate of CHP is most likely conservative. This conservative under-counting of small CHP systems may not significantly affect total capacity, but the actual number of sites could be noticeably greater.

Most CHP installations are less than 500 kW, with a median size of 150 kW. Hospital projects are typically the largest, with an average size of over two MW. This is primarily a function of CHP systems sized to meet the thermal loads of the applications. Many of the very large projects export a large share of electricity generated. The small projects tend to provide energy to just a portion of the total facility.

TABLE 2-2
CHP BY FACILITY SIZE

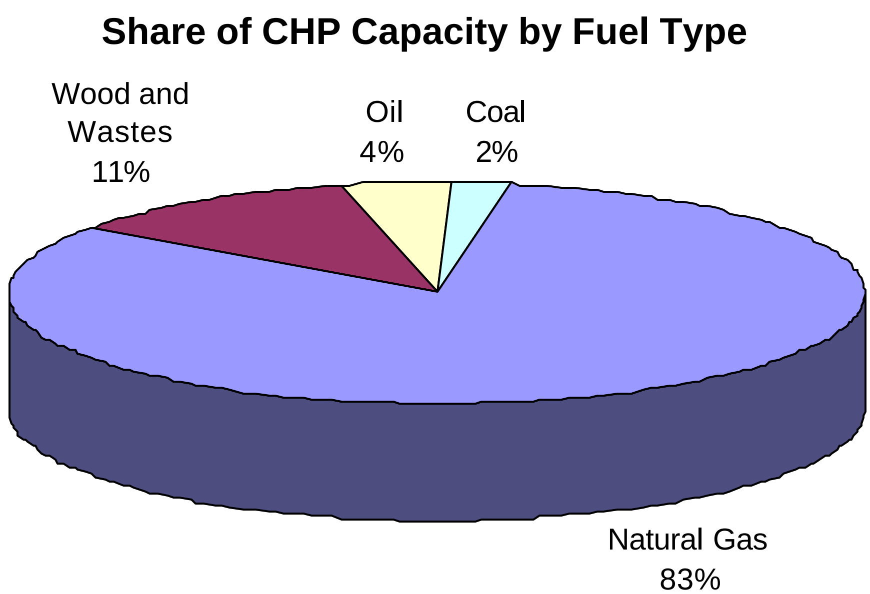
Size Range	Supermarkets	Healthcare	Lodging	Restaurants	Big Box Retail	Total
<100 kW	1	65	38	11	2	117
100-249 kW	10	39	26	0	0	75
250-499 kW	0	12	7	1	2	22
500-999 kW	0	26	8	1	0	35
1-2 MW	0	24	2	0	1	27
2-5 MW	0	23	1	0	1	25
5-10 MW	0	7	2	0	0	9
10-20 MW	0	3	0	0	0	3
20-50 MW	0	2	0	0	0	2
50-100 MW	0	3	0	0	0	3
Total	11	204	84	13	6	318
Average (kW)	138.6	2,302.1	362.7	96.0	994.1	1,600.1
Median (kW)	150.0	230.0	100.0	23.0	362.5	150
Range (kW)	85-150	20-80,000	9-5,200	10-650	30-4,100	9-80,000

Source: EEA CHP 2000

2.2.3 Breakdown of Existing CHP by Fuel Source

Figure 2-2 illustrates the estimated use of different fuel types that energize the installed CHP projects in the targeted national account sectors. Natural gas is the predominant fuel in existing CHP systems, serving 83% of capacity. In this report, we assume continuation of this trend, and have used natural gas-fired technologies as the basis for defining future growth in these five national account segments.

FIGURE 2-2
EXISTING CHP BY FUEL TYPE



Source: EEA CHP 2000

Seven projects comprise the total coal, wood and waste capacity. All of these sites are in the healthcare segment. Natural gas is used in all five segments. Oil-fueled projects are found only in healthcare, lodging and restaurant sites.

2.2.4 Breakdown of Existing CHP By Prime Mover

Table 2-3 presents the breakdown of CHP capacity in the five national account sectors by prime mover technologies. As expected, the preponderance of capacity is associated with the largest projects. The majority of capacity is in seven gas-fired combined cycle plants. Conversely, while there are many small projects (almost seven times more prevalent than the larger gas turbine- and combined cycle-based projects on a site basis), their total combined capacity is only one- third of the combined cycle dominated total. Most of these are reciprocating engine-based systems.

TABLE 2-3
EXISTING CHP BY PRIME MOVER TECHNOLOGY TYPE

Prime Mover	Capacity (MW)	No. of Sites
Combined Cycle	217.7	7
Reciprocating Engine	122.2	262
Combustion Turbine	89.9	32
Boiler/Steam Turbine	76.7	10
Fuel Cell	1.4	6
Unidentified	0.9	1

Source: EEA CHP 2000.

Natural gas-fueled combustion turbines are the third most common prime mover technology. Natural gas is utilized by all CHP technologies except boiler/steam turbines in the five target sectors. As noted in the previous section, boiler/steam turbines burn wood, wastes and coal. Liquid fuel use is split between reciprocating engines and steam boilers.

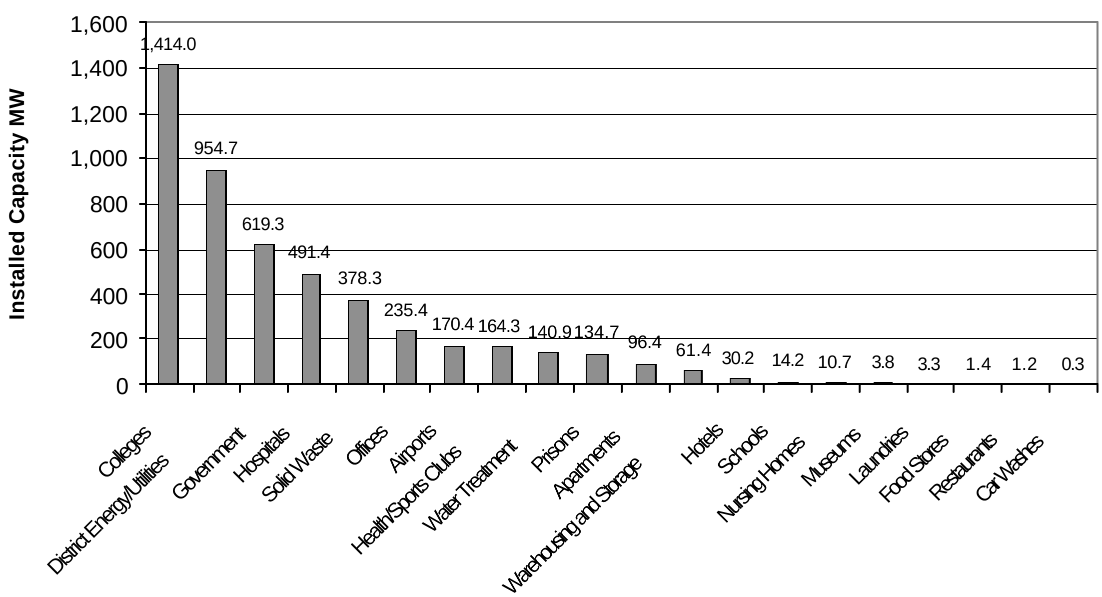
2.3 CONCLUSIONS

Similar to the overall commercial buildings CHP market, energy use in facilities in the five target market sectors serves as the basis for CHP applications. Unlike the industrial sector where, on balance, facility electric loads limit CHP, CHP in the commercial building sector is predominantly thermal load-limited. This limitation can occur in one of two ways: the thermal load is either inadequate, or it is highly seasonal (i.e., non-coincident with the electric load, as in thermal needs for space heating). Commercial applications may also be limited by fewer hours of operation, as compared to industrial process operations that are sometimes around-the-clock. The commercial applications where CHP has had some success exhibit high and fairly constant thermal loads and a high number of operating hours per year. The existing national accounts CHP base reflects this. The installed CHP systems are also typically sized to provide baseload power.

Because of this, the healthcare sector (specifically, hospitals) has historically been one of the primary commercial CHP markets. Hospitals are large facilities with around-the-clock operation and large, steady thermal and electric requirements. **Figure 2-3** shows the total commercial/institutional installed capacity of CHP by application.

Technology development efforts targeted at heat activated cooling/refrigeration and thermally regenerated desiccants could expand the application of CHP by increasing the base thermal energy loads in certain building types. Use of CHP thermal output for absorption cooling and/or desiccant dehumidification could increase the size and improve the economics of CHP systems in existing CHP markets such as lodging, nursing homes and hospitals. Use of these advanced technologies in applications such as supermarkets and large retail provides a base thermal load that potentially opens these applications to CHP. Segments that are currently marginal because of inadequate thermal loads could be future target applications based on the use of these advanced technologies.

FIGURE 2-3
CAPACITY OF COMMERCIAL CHP BY TYPE OF COMMERCIAL APPLICATION



Source: EEA CHP 2000

The major conclusions to be drawn from reviewing the existing CHP capacity in the five target sectors are as follows:

- The vast majority of existing CHP on both a site and capacity basis are in healthcare, specifically hospitals. Due to the steady thermal and electric load of hospitals they historically have been one of the largest commercial CHP markets.
- Hotel CHP installations make up a distant second. Market penetration to date in the other three target sectors has been extremely low. The other sectors are predominantly thermal load-limited.
- Most existing CHP installations in the five target sectors are less than 500 kW. Because the bulk of existing CHP capacity lies in several larger hospital CHP installations, the average installation size is skewed upward. The vast majority of the smaller-sized sites are natural gas-fueled reciprocating engines.
- CHP is concentrated in a handful of states. These states (California and the Northeast) typically have higher energy costs than the rest of the U.S.
- Historically, commercial CHP applications have focused on heat recovery for space and water heating.

3. ADVANCED THERMALLY ACTIVATED TECHNOLOGIES

3.1 INTRODUCTION

As noted in the previous chapter, many commercial buildings have thermal use profiles that are very low compared to their electric load profile. For these types of buildings, it is either not possible to size a CHP system at all, or the economic size would be much lower than could be justified by meeting the base electric load alone.

Thermally activated technologies -- technologies that are able to use waste heat as a fuel -- offer the chance to replace electric air conditioning and/or dehumidification loads with thermal loads in commercial buildings. In this chapter, we explore the advantages of incorporating these technologies into CHP systems in commercial buildings; describe the technologies; and give examples of TAT applications in the target sectors.

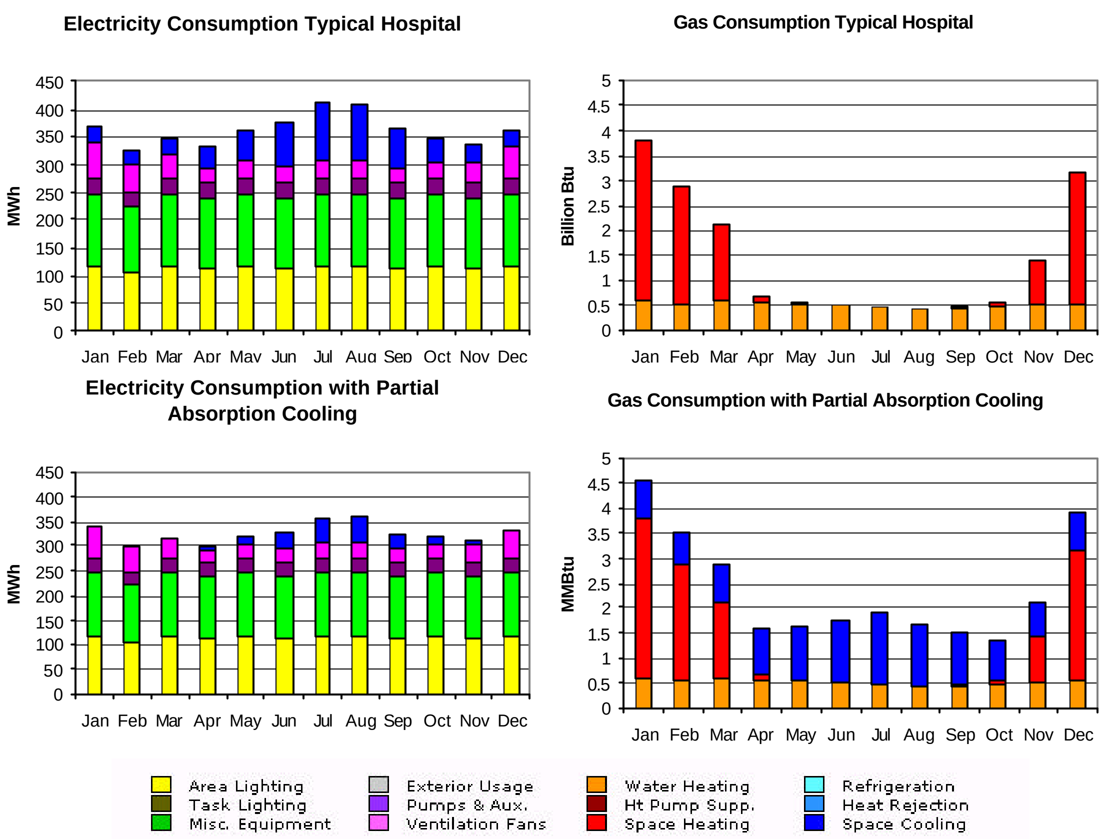
3.2 INTEGRATED ENERGY SYSTEMS

Converting building air conditioning and dehumidification electric loads to thermally based loads through the use of absorption chillers or desiccant dehumidification systems offers a number of advantages. First, the most expensive electric load, which is air conditioning during peak hours, is eliminated. Second, the remaining electric load has a better load factor, which reduces electric costs. Finally, the overall thermal load of the building increases, rendering it potentially economic to size a larger CHP system that can contribute to both winter heating and summer cooling. This approach is called an integrated energy system (IES), or building cooling, heating and power (BCHP).

Buildings such as retail stores and restaurants may have seasonal heating loads that are fairly substantial, but only a limited year-round water-heating load. Limited thermal load is a factor in supermarkets as well. These applications cannot provide adequate thermal utilization for CHP. Hospitals and hotels have a greater year-round thermal load than these other applications and have proven they can be good CHP candidates. However, even in these applications, an IES can increase the effective size of the CHP installation.

Figure 3-1 shows an energy load simulation for a 140,000 square foot hospital in Hartford, Connecticut. The standard hospital features electric chillers to meet the 400-ton peak load. In this configuration, the hospital uses about 500 million Btu per month during the summer months. A CHP system with 80% thermal utilization would be about 200 kW of capacity, about 30% of the hospital's peak electric load. By converting some of the chiller load to a thermally activated technology, in this case, waste heat-fired absorption chillers, the summertime thermal load can be increased four-fold and peak electric demand decreased by 10%. This thermal load increase supports a CHP-IES system of about 550 kW with 110 tons of absorption cooling. In this configuration, the CHP system can be effectively sized to 85% of the peak load with full thermal

FIGURE 3-1
COMPARISON OF ELECTRIC AND THERMAL LOADS FOR HOSPITAL WITH ELECTRIC AIR CONDITIONING VS. HOSPITAL WITH IES FEATURING ABSORPTION COOLING



Source: EEA; Energy Design Resources, eQuest2002 Database; Regional Economic Research, Inc., *eShapes, 2001 National Database.*

utilization. By integrating the chiller load with the CHP system, effective sizing can be increased from 200 kW to 550 kW, with an additional demand reduction of 80 kW provided by the absorption chillers.

IES as an economic driver for CHP is even more strongly indicated in applications with low thermal loads, such as retail facilities. On a per-square-foot basis, a big box retail store uses only about 6% of the amount of hot water used by the hospital described in the previous example. With this limited year-round thermal use, a CHP system with at least 80% thermal utilization could only be sized to meet 2.5% of the building peak load, not an economically meaningful share. By converting air conditioning load, it is possible to achieve a CHP-IES system that has a 75% thermal utilization factor and meets 15% of the building's peak load (for a 120,000 ft^2 store in Hartford, CT.). With the more constant air conditioning loads found in the Southwest, in locations such as Phoenix, Arizona, the shift of loads from an IES system is even more significant, allowing a 30% contribution to peak load for a CHP-IES system.

3.3 TAT COMPONENTS

3.3.1 Absorption Cooling

Absorption cooling relies on a chemical process to absorb and evaporate refrigerant rather than on the mechanical vapor compression cycle used by electric air conditioning equipment. The basic absorption cycle features two fluids, one refrigerant and one absorbent, that are separated and recombined in different stages of the cycle to produce chilled water. The absorption unit uses heat instead of an electric motor to compress refrigerant vapors to a high pressure level in the compression stage of the refrigeration cycle. The absorption chiller produces cold water that is circulated to air handlers in a building distribution system to provide air conditioning.

Because the absorption process is heat-driven, absorption cooling matches well with BCHP-IES. Commercially available indirect-fired absorption machines use hot water, steam, or exhaust gases as the heat source, while direct-fired machines feature natural gas burners. In IES configurations, direct-fired machines can be used to regenerate desiccant systems or provide hot water, while direct-fired units can use the rejected heat from onsite generation equipment or hot water from a direct-fired absorption chiller.

Equipment may also be single- or double-effect. In the single effect type, all of the heat that is released when the absorbent fluid stream absorbs the refrigerant vapors is rejected into the environment. Double effect chillers capture some of this heat and use it to generate more refrigerant vapor.

Absorption equipment in the context of IES has the following further characteristics:

- The most common refrigerant is water in a lithium bromide solution ($LiBr/H_2O$). Since water is the refrigerant, such systems are limited to evaporator temperatures of about 50°F.
- Single effect machines require only a low-temperature heat source. A typical small packaged absorption chiller is rated assuming 190°F water. Water at this temperature is

available from the jacket water of a reciprocating engine system or can easily be derived from the exhaust heat from a microturbine using an air-to-water heat exchanger. Single effect machines have a COP of about 0.7 (from hot water to chilled water). A 60 kW microturbine can provide 0.32 tons of cooling per kW of capacity, or just under 20 tons of cooling.[2]

- Double effect absorption machines provide COPs of 1.0 to 1.2 but require a high temperature heat source – either direct fuel firing or, more appropriately for IES, steam. Double effect systems, therefore, match up best with gas turbines. A 5 MW gas turbine with a heat recovery steam generator (HRSG) can provide 0.48 tons per kW due to the higher COP of the double effect system. Thus, a 5 MW turbine can provide 2,400 tons of waste-heat fired cooling, assuming 29% electrical efficiency (higher heating value, or HHV[3]).
- Lithium bromide/water absorption systems require a lower condenser temperature than can be provided by air alone. Therefore, these systems require a water-cooled condenser or a cooling tower. Many large electric chillers also use cooling towers, though most smaller direct expansion (DX) cooling systems do not. The cooling tower must exhaust both the heat from the space and the heat generated by the process. The cooling tower for an electric chiller (0.68 kW per ton) must exhaust 14,320 Btu per ton of cooling provided to the space. The cooling tower for a single effect absorption system must be more than twice as large to exhaust over 29,000 Btu per ton. Often, the cooling tower temperature differential is increased from 10 to 15 degrees when used with absorption systems to minimize the size and water pumping requirements.
- Ammonia/water absorption systems are also available and under development. In these systems, ammonia is the refrigerant, so evaporator temperatures as low as –40 °F are possible. Therefore, these systems are appropriate for large-scale refrigeration. Smaller packaged space conditioning systems using ammonia/water absorption are under development because they can work with an air-cooled condenser. Because ammonia is highly toxic, safety codes in many areas restrict its use as a refrigerant in residential and commercial applications.
- Absorption systems, unlike electric air conditioning systems, show part-load performance that is somewhat higher than full-load performance. However, lithium bromide systems are best operated under steady-state conditions rather than for peaking or with frequent cycling.

Absorption cooling is appropriate for any commercial or industrial facility that needs air conditioning, including all five national account target sectors that are the focus of this study.

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2 Capstone.

3 HHV includes the heat of condensation of the water vapor in the combustion products. In engineering and scientific literature the lower heating value (LHV) is often used, which does not include the heat of condensation of the water vapor in the combustion products. Fuel is sold on an HHV basis.

3.2.2 Desiccant Dehumidification

Desiccant dehumidification systems remove moisture from the air. As the desiccant removes the moisture, the air heats up. Therefore, a desiccant system does not provide cooling per se. Instead, it converts latent heat (moisture) load to sensible heat (temperature) load. The added sensible heat is typically removed by a heat exchanger, heat wheel or heat pipe, using the building exhaust air or outside air. An electric system, evaporative cooler, or absorption system can perform post-cooling of the air downstream of the heat exchanger

The moisture absorbed by the desiccant is removed in a step called regeneration. Regeneration is accomplished by passing heated air over the desiccant bed and exhausting the hot air and moisture to the outside, at temperatures in the 200-350 °F range. Desiccant dehumidification technology is another potential match for a BCHP-IES system because regeneration can be accomplished using a low-grade heat that is available from virtually any prime mover or from a direct-fired absorption chiller.

Desiccant systems in the context of BCHP-IES have the following further characteristics:

- Adding a desiccant system allows facility air conditioner capacity to be reduced and the efficiency increased.
- In a typical commercial application, desiccant regeneration requires 45 Btuh per cubic foot per minute (cfm). A 60 kW microturbine could support a desiccant system to dehumidify at the rate of 9,000 cfm.[4]
- An IES could be designed in which a larger DG system provided waste heat for both the desiccant and an absorption chiller.

The benefits of a desiccant system are very site-specific. In "cold footprint" applications, such as supermarkets, ice rinks, and refrigerated warehouses, the use of desiccant dehumidification can result in a large decrease in energy consumption for the facility due to decreases in fogging, condensation, and icing of the refrigeration evaporator coils. Desiccants can also provide an economic advantage in facilities that require a high percentage of make-up air, or in facilities that require special conditions, such as hospitals, hotels, and restaurants. In addition to energy cost savings in these applications, desiccants can also provide value via enhanced customer comfort, improved indoor air quality, and removal of airborne bacteria and viruses.

3.2.3 TAT Application Descriptions

This section describes a number of applications of TAT in the target national account sectors. Here, the examples show the use of TAT in the target applications (but not necessarily the integration of CHP and TAT).

[4] Capstone.

Supermarkets

Supermarket characteristics include high refrigeration loads and limited heat or hot water loads. Reclaim heat is often recovered from the refrigeration compressors. The in-store refrigeration cases reduce the sensible air-conditioning loads, leaving mainly the latent (moisture) load of the makeup air. The opportunities for CHP with hot water heat recovery are virtually non-existent. However, CHP with IES can be configured to use waste heat from the prime mover to provide absorption sub-cooling of the refrigeration system, or to provide regeneration heat for a desiccant dehumidification system that dries and warms the incoming air. Sub-cooling reduces the energy required for refrigeration by lowering the condenser temperatures from the 85-115°F range to 55°F. A desiccant system can reduce the energy requirements for store air conditioning, reduce the energy used for defrost cycling, and provide a more comfortable shopping environment.

Below are several examples of TAT components in supermarket applications.

- A 57,000-ft^2 Big Bear supermarket in Westerville, Ohio uses a 5,600-cfm desiccant unit with a 60-ton rooftop air conditioning system to maintain comfort levels in the store. The unit saves about $10,000 per year in energy costs providing a three-year payback on the investment.
- The 55,000-ft^2 Clemens Market in Harleysville, Pennsylvania uses a 10,000-cfm desiccant system that provides both latent and sensible cooling for the store. The store saves in air conditioning and refrigeration loads by maintaining humidity control.
- Western Beef, a 70,000-ft^2 warehouse supermarket in Queens, New York, installed a prototype gas engine-driven parallel rack refrigeration system. The four engine-driven compressors total 180 tons of refrigeration. Energy savings are estimated at $160,000 per year.

Hotels

Hotels represent a good potential application for BCHP-IES systems featuring absorption air conditioning and/or desiccant dehumidification. They can also be attractive candidates for engine-driven chillers or CHP, as there is a good hot water load in addition to the need for cooling and dehumidification.

Examples of TAT in existing hotel applications are:

- A 275-room historic hotel in St. Petersburg, Florida was suffering from severe humidity and moisture problems until they installed desiccant wheels as part of their air conditioning system.
- A one million-square foot, 1,200-room hotel complex built in 1995 in Philadelphia installed a 1,000-ton double effect, direct-fired absorption chiller to take on the base load cooling for the facility. A 1,000-ton electric centrifugal chiller meets peak cooling loads.
- A 220,000-ft^2 hotel in Washington, D.C. uses a 20,000-cfm desiccant system combined with conventional electric chillers to provide conditioned air to the guest rooms.

Hospitals

Hospitals are a strong application for CHP, and there are additional opportunities to expand the capacity at a site by implementing IES. These systems may include absorption cooling, engine-driven cooling, and desiccant dehumidification.

Examples of hospital TAT and IES applications are:

- A Philadelphia hospital installed 400 tons of steam-fired absorption chillers to support facility expansion. The absorption chillers are now the base load cooling system and the existing 260 tons of electric chillers meet peak cooling needs. The absorption system was combined with a boiler upgrade that replaced older, inefficient oil-fired boilers with a modern dual fuel system. The hospital reduced its peak electric demand by 423 kW, with a corresponding drop in demand charges based on the year-round demand ratchet.
- A 750,000-ft^2 hospital in Pennsylvania installed 600 tons of absorption chillers and a natural gas-fired generator for peak shaving. The system saves on electric costs and provides additional reliability in case of power outages.
- A hospital in San Antonio, Texas needed to reduce the temperature in its operating rooms to 62 °F to accommodate modern medical requirements of staffing, protective clothing, and additional heat generating equipment. The existing chillers could not meet the load while simultaneously providing acceptable humidity conditions. The hospital installed a rooftop desiccant dehumidification system that dries 7,300 scfm of fresh air, removing 380 pounds of water per hour. The reduced humidity levels have increased comfort and reduced the growth of bacteria and viruses. The unit supports five operating rooms (2,500 ft^2).
- A medical college in Georgia installed a 600-ton desiccant-based cooling system that preconditions 140,000 scfm of air for the 250,000-ft^2 facility. The moisture removal from the makeup air reduces the electric chiller load. In addition to $200,000 per year in energy savings, the system has eliminated humidity problems that had interfered with medical experiments and had led to mold and mildew damage.

Big-Box Retail

Big box retail facilities feature high air conditioning loads to eliminate heat produced by high lighting levels and store traffic. There is very little hot water load and insignificant space heating requirements. The lack of thermal load limits the opportunities for traditional CHP systems. A variety of TAT systems could be integrated with CHP such as absorption cooling, engine driven cooling, and desiccant dehumidification.

Several examples of existing TAT in retail applications are as follow:

- A 200,000-ft^2 department store in White Plains, New York cut its summer electric demand by one-third by installing desiccant dehumidification. The system provides a comfortable shopping environment with a higher set point. Only one of the store's two chillers is required to meet the sensible cooling load.

- An existing 120,000-ft^2 mixed-use retail space in Jamaica, New York was fitted with a 400-ton gas-fired absorption chiller/heater. The system replaced older, inefficient electrical equipment and has reduced energy bills by about $60,000 annually. A unique feature of the system is the use of a deep water well to reject heat rather than a cooling tower.

Restaurants

Restaurants are typically smaller than the facilities in the other four target sectors. Applications with cooling loads of 10 to 30 tons and electric loads of 100 kW or less require the use of small-scale DG systems of 50 kW and under. Restaurants typically have high ventilation requirements that increase cooling loads and move the latent to sensible cooling ratio upward. Both desiccant systems and absorption cooling could be applied in this sector.

An example of existing TAT in the restaurant sector is:

- A Church's Fried Chicken in Atlanta uses a desiccant system with a 10-ton rooftop air-conditioner to replace a 17.5-ton electric system. Waste heat from the electric air conditioner regenerates the desiccant wheel. The reduced humidity provides better comfort for diners and workers, and allows a higher set point that reduces electricity consumption.

3.3 ADVANCED PROGRAM DEVELOPMENT

The U.S. Department of Energy (DOE) is active in both desiccant and absorption system development and in the integration of these systems with prime movers.

The Advanced Desiccant Dehumidifier and Chiller Program is working with industry, including the U.S. Air Quality (USAQ) Consortium, the Gas Technology Institute (GTI), the American Gas Cooling Center (now part of the Energy Solutions Center), and gas utilities around the country to identify and remove barriers to commercialization of advanced desiccants. The program will also investigate desiccant systems that use recuperated waste heat from distributed generation technologies (turbines, microturbines, and fuel cells), from refrigeration processes, and solar heat.

The National Renewable Energy Laboratory (NREL) and Oak Ridge National Laboratory (ORNL) are assisting industry in developing desiccant wheels, as well as testing emerging designs and materials. Diagnostic techniques, such as infrared thermal performance mapping and advanced tracer gas leak detection, will be used to assess equipment designs and concepts. The program is also working with York International in the development, testing, and commercialization of an advanced double condenser coupled (DCC) commercial chiller, which is expected to be 50 percent more efficient than imported chillers. This DOE-patented DCC technology, which uses a LiBr/H_20 refrigerant solution, is being pursued rapidly given its potential for near-term commercialization.

The Absorption Chillers for Buildings Program plans to continue its work with industry to make chillers more efficient in their engineering and more prominent in the marketplace. One general goal is to compare thermally activated chillers with conventional heating, ventilation, and air conditioning (HVAC) systems.

The DOE programs are also focusing on IES. The following projects are being undertaken as part of this program:

- NiSource – Three microturbines in a hotel with heat recovery for heating, hot water, and pool heating. Later additions will include desiccant dehumidification and absorption cooling. The system includes advanced controls for energy savings and reliability.
- Ingersoll Rand – A single package, skid-mounted refrigeration system driven by a 75 kW PowerWorks microturbine integrated with an advanced GAX cycle absorption refrigeration system for supermarket refrigeration sub cooling.
- United Technologies Corporation – Mating a 400 kW miniturbine with a heat recovery absorption chiller for general commercial application.
- Gas Technology Institute – Engine driven CHP with an improved 90-ton absorption cooling system for general commercial application.
- Honeywell – 5 MW gas turbine generator matched with 1,000-ton Broad absorption chiller for application at a military base.
- Capstone – Matching microturbines with absorption cooling. Capstone is working on 30 and 60 kW integrated systems. The 30 kW system uses a 12- to 14-ton Takuma chiller. The 60 kW system is matched to a Broad 23- to 25-ton chiller. These systems achieve higher efficiencies at a reduced cost by using the turbine exhaust directly as the heat source for the absorption cycle.
- Burns and McDonnell – 4.6 MW turbine generator with 2,000 RT of waste heat-driven absorption with another 500 tons of waste heat- or direct-fired cooling capacity.

4. TECHNICAL MARKET POTENTIAL FOR THERMALLY ACTIVATED TECHNOLOGIES

4.1 INTRODUCTION

As suggested in the previous chapters, the market for CHP could be expanded in the five target national account sectors and the commercial/institutional market as a whole with advanced technologies that utilize thermal energy for non-traditional applications. CHP potential is limited in commercial/institutional applications due to the lack of adequate thermal energy needs in many building types. Advanced technologies such as heat-activated cooling and thermally regenerated desiccants can expand the economic applications of CHP by providing a base thermal load in building types that do not currently have adequate thermal needs. Cost effective CHP systems in smaller sizes would also expand the potential market and increase application of CHP.

In this chapter, we define and apply a methodology for estimating the technical market potential for BCHP-IES applications in the five target national account sectors.

4.2 RETROFIT APPLICATIONS

The technical market screen we conducted to estimate TAT market potential in the five target national account sectors covers the markets shown below in **Table 4-1.**

TABLE 4-1
MARKET SCREENING COVERAGE

Target Market	2-Digit SIC	Description
Retail	52	Building Materials, Hardware, Garden Supply & Mobile Home Dealers
	53	General Merchandise Stores
	56	Apparel and Accessory Stores
	57	Home Furniture, Furnishings and Equipment Stores
	59	Miscellaneous Retail
Supermarkets	54	Food Stores
Restaurants	58	Eating and Drinking Places
Hotels	70	Hotels, Rooming Houses, Camps, and Other Lodging Places
Hospital	80	Health Services

Based on the SIC targets and application requirements defined below, we searched MarketPlace, a comprehensive, proprietary database of over 14 million business facilities.[5] MarketPlace allows the sorting and selection of the business data employing a large number of screens. The

[5] D&B Solutions *MarketPlace July-September 2002*.

screens used for this analysis consisted of 2-digit SIC, electricity consumption, natural gas consumption, and state. The energy use estimations in the model are from the MarketPlace energy demand estimators. These estimators are derived from actual consumption data from a partnership alliance consisting of 10 utility firms, 12-month state temperature patterns, and D&B's demographic database of over 13 million U.S. businesses.

The energy data in the MarketPlace database consist of consumption ranges only. Therefore, we used the applications analysis to determine, for each consumption range in the MarketPlace database, what the facility peak load would be, and what size DG system could be supported.[6] We applied an additional screen for BCHP-IES systems: the facility had to have natural gas consumption large enough to show that the building had gas heat and gas hot water. Even though a significant share of the thermal energy from a BCHP-IES system goes to replace electric cooling, the existence of these other thermal loads is important to maintaining good thermal utilization on the system year-round.

The results of this screening of the MarketPlace data to estimate the potential for IES retrofit are shown in **Table 4-2.** The database contains 119,632 facility records in the target SICs that have electric consumption large enough to support a DG system between 50 and 1,200 kW. There are nearly three million facilities that have consumption less than that needed to support a 50 kW BCHP-IES system. There are 633 sites that could support a system larger than 1,200 kW. These very small and very large systems were not included in the technical market potential screening, as facilities in the target sectors would typically fall in the 50-1,200 kW system range. The total retrofit market potential identified for the target market segments in the screening range is 46,209 sites and 7,719 MW of capacity.

TABLE 4-2
SUMMARY OF MARKETPLACE SCREENING OF EXISTING FACILITIES BCHP-IES RETROFIT IN NATIONAL ACCOUNT TARGET SECTORS

Electric Cons. Bin		Data	Gas Cons.	CHP System Size kW*			CHP Potential	
MWh/year		Records	MMBtu/yr	Min.	Max.	Avg.	Sites	MW
No electric data		264,869	Outside of Screening Range					
Less than 500		2,904,221						
500	to 999	60,206	>500	60	to 120	86	27,437	2,347
1,000	to 2,499	38,330	>1,000	120	to 300	200	14,295	2,855
2,500	to 4,999	16,155	>2,500	300	to 600	428	3,075	1,316
5,000	to 9,999	4,941	>5,000	600	to 1,200	856	1,402	1,200
10,000 and over		633	Outside of Screening Range					
* Facility Load Factor 60%, CHP Sizing 60% of peak load					**Total Potential**		**46,209**	**7,719**

Source: D&B Solutions *MarketPlace July-September 2002*

[6] Applications analysis included calculation of typical load shapes and load factors, which we used for DG sizing purposes.

Table 4.3 on the following page breaks down the retrofit BCHP-IES potential by size of application. The **Appendix** provides a breakdown by state.

TABLE 4-3
BCHP-IES TECHNICAL MARKET POTENTIAL BY APPLICATION AND SIZE RETROFIT OF EXISTING FACILITIES

National Account Segment		Number of Potential Sites by Application Size Range				Potential IES Capacity (MW)
2-Digit SIC	**SIC Description**	**60-119 kW**	**120-299 kW**	**300-599 kW**	**600-1199 kW**	
52	Building Materials, Hardware, Garden Supply & Mobile Home Dealers	972	777	20	4	250
53	General Merchandise Stores	899	1,469	46	9	398
54	Food Stores	2,925	2,352	37	5	740
56	Apparel and Accessory Stores	140	41	101	1	64
57	Home Furniture, Furnishings and Equipment Stores	475	112	10	6	72
58	Eating and Drinking Places	8,463	608	30	10	867
59	Miscellaneous Retail	1,102	350	60	27	213
70	Hotels, Rooming Houses, Camps, and Other Lodging Places	5,479	2,857	1,191	450	1,934
80	Health Services	6982	5729	1580	890	3,180
	Total	**27,437**	**14,295**	**3,075**	**1,402**	**7,719**

Source: EEA.

4.3 NEW CONSTRUCTION APPLICATIONS

In the previous section, we used the MarketPlace data to estimate the potential for existing or retrofit IES applications. For new applications, we estimated a 20-year growth rate for each 2-digit SIC based on the five-year growth rate (1992-1997) as reported in the *U.S. Census of Manufactures,* as available. We used the average of growth in employment and real value of shipments combined with our knowledge of the markets. This growth rate does not represent a detailed analysis of industry trends, rather a generalized long-term growth forecast for purposes of this report.

Table 4-4 shows these data for the target SICs. In cases where data were missing or withheld, we estimated the 20-year market growth. In cases where the growth rate was negative, we assumed no new applications. We multiplied the 20-year estimates (final column) by the existing market in each 2-digit SIC to derive the new market estimate.

The breakdown of new construction technical market potential by target SIC is shown in **Table 4-5.** The breakdown by state may be found in the Appendix.

TABLE 4-4
ESTIMATE OF 20-YEAR NEW MARKET GROWTH BY SIC

National Account Segment		Value of Shipments ($Billion)			No. of Paid Employees (Millions)			20-Year Average Growth	20-Year Estimated Growth
2-Digit SIC	1987 SIC Description	1997	1992	Percent Change*	1997	1992	Percent Change		
52	Building Materials, Hardware Supply	1.46	.99	29.32%	8.3	6.66	24.7	160.22%	160.22%
53	General Merchandise Stores	n.a.	2.45	n.a.	>.1	20.8	n.a.	n.a.	82.46%
54	Food Stores	4.16	3.69	-1.49%	31.1	29.7	4.7	6.57%	6.57%
56	Apparel and Accessory Stores	1.17	1.02	0.22%	11.2	11.4	-2.5	-4.48%	0.00%
57	Home Furniture Stores	1.36	.93	27.64%	8.62	7.02	22.7	145.46%	145.46%
58	Eating and Drinking Places	n.a.	1.95	n.a.	>.1	65.5	n.a.	n.a.	82.46%
59	Miscellaneous Retail	3.66	2.61	22.35%	28.0	23.6	18.6	110.67%	110.67%
70	Hotels	0.98	.69	23.65%	16.9	14.9	13.2	96.69%	96.69%
80	Health Services	3.99	2.99	16.48%	55.2	44.5	24	71.74%	71.74%

* Real change.
Source: *http://www.census.gov/epcd/ec97sic/E97SUS.HTM.*

TABLE 4-5
NEW CONSTRUCTION BCHP-IES TECHNICAL MARKET POTENTIAL BY APPLICATION AND SIZE - NEW FACILITIES THROUGH 2020

National Account Segment		Number of Potential Sites by Application Size Range				Potential IES Capacity (MW)
SIC 2 Code	SIC Description	60-120 kW	120-300 kW	300-600 kW	600-1200 kW	
52	Building Materials, Hardware, Garden Supply & Mobile Home Dealers	1,558	1,243	36	8	404
53	General Merchandise Stores	745	1,212	38	9	330
54	Food Stores	189	155	0	0	47
56	Apparel and Accessory Stores	0	0	0	0	0
57	Home Furniture, Furnishings and Equipment Stores	686	160	12	6	101
58	Eating and Drinking Places	6,977	501	26	10	717
59	Miscellaneous Retail	1,217	386	64	28	233
70	Hotels, Rooming Houses, Camps, and Other Lodging Places	5,298	2,763	1,155	439	1,875
80	Health Services	5,007	4,111	1,133	639	2,281
	Total	21,677	10,531	2,464	1,139	5,998

Source: EEA

4.4 CONCLUSIONS

The key conclusions for the technical market potential screening may be summarized as follows:

- The total market potential within the five sectors studied is almost 14,000 MW at about 82,000 facilities. This capacity figure would provide from 4 to 7 million tons of air conditioning. About 56% of this potential is in existing facilities and the remaining share will be in new construction between now and the year 2020.
- Hospitals represent the largest market potential within the target applications followed by hotels. Together, hospitals and hotels account for about two-thirds of the potential by capacity. These two applications also represent about 90% of the target facilities above 300 kW. The geographical concentration of potential is in the largest states. The ten largest states account for 54% of the total technical market potential (CA, TX, OH, IL, PA, NY, MA, IN, NJ, GA).
- These market results represent an estimate of the facilities in which a BCHP-IES system can be sized to provide high electric and thermal utilization. This estimate is defined as the *technical market potential*. The actual market penetration for these systems will depend on the cost and performance of the IES-BCHP system, the cost of power and fuel to the facility with and without a CHP system, the investment decision criteria of the facility owner/manager, and resolution of a variety of institutional and regulatory barriers.

5. MARKET ASSESSMENT OF CUSTOMERS AND OTHER STAKEHOLDERS

5.1 INTRODUCTION

The preceding chapters of this report have detailed the installed CHP base in the five target national account sectors, described TAT technologies in IES settings and provided example installations, and developed an estimate of the technical potential for advanced BCHP-IES systems in the target sectors. In this chapter, we examine awareness and perceptions of BCHP technologies, decision-making behaviors, and other characteristics of customers and other stakeholders in these sectors that influence how technical potential is translated into actual BCHP-IES installations.

5.2 HOSPITALS

A 1998 Opinion Dynamics Corp. study of decision-makers in the target sectors[7], called *TargetProfile*+, explored levels of familiarity among hospital decision makers with several types of equipment that can be components of an integrated energy system, with results as shown in Table 5-1. Among centralized chains, decision makers for about 40% of floor space reported current use of absorption chillers and engine-driven chillers. Decision makers responsible for more than half of all floor space had no experience with either of these technologies. Of those without experience, one-fourth to one-third were not familiar with the technologies.

TABLE 5-1
USE/FAMILIARITY WITH SELECTED IES TECHNOLOGIES IN HOSPITALS

Chains with Centralized Decision Making					
Technology	**% of National Floor Space**			**If never used:**	
	Use Now	**Used Formerly**	**Never Used/DK**	**Not familiar**	**Very/some-what familiar**
Absorption chiller	43%	1%	56%	22%	78%
Engine-driven chiller	39%	-	61%	32%	68%
On-site generation	Don't have: 62% - No plans to install: 64% - Plan to install w/in 2 years: 27%			Have: 38% - Natural gas: 74% - Fuel oil: 28%	
Chains with Individual Location Decision Making					
Absorption chiller	4%	4%	90%	65%	35%
Engine-driven chiller	1%	--	99%	62%	38%
On-site generation	Don't have: 93% - No plans to install: 89% - Plan to install w/in 2 years: 7%			Have: 7% - Natural gas: 37% - Fuel oil: 26%	

Source: Opinion Dynamics Corp.

[7] Opinion Dynamics Corporation, *TargetProfile*+. Gas Research Institute, American Gas Association, 1998.

On the generation side, decision makers for over one-third of floor space reported use of some type of on-site generation. At the time of the survey, over one-quarter of those without on-site generation indicated they had plans to install it within two years. Among chain locations where decisions are made at individual sites, levels of use and familiarity were significantly lower in all categories.

5.2.1 Insights

A number of information-gathering efforts conducted since the ODC study reveal information about priorities and outlooks affecting decisions about BCHP-IES in the health care sector. A 2002 survey of national account industry participants[8] showed that the hospital sector is focusing on the need for clean, reliable and high quality power, lower hospital operating costs, and contained and predictable energy costs. With respect to DG and other new technologies, survey respondents expressed the desire for emergency generation that can come on line in 10 seconds or less. Their concerns about energy system installations include:

- the high cost of new energy equipment
- time-consuming and costly environmental permitting and utility interconnection processes
- the high cost of testing and verifying new technologies
- the “hassle” surrounding energy system installations, and
- the lack of qualified technicians for advanced energy systems.

Our research in this sector showed that on the business side of hospitals, energy systems compete for funding with medical technologies that are much more visible to patients and doctors. Also, the ongoing consolidation of the industry has CFOs continually looking to minimize financial liabilities. CFOs and others on decision-making bodies such as executive committees most likely are not familiar with CHP or integrated CHP systems, and even relatively knowledgeable staff may not have enough specific information to understand the benefits completely and be able to calculate paybacks accurately.

On the other hand, hospitals have experience with absorption cooling and steam plants that match up well with CHP, and energy cost savings is a big motivator. Also, there are many examples of CHP in this sector, making adoption less of a perceived risk to hospital administrators. Industry participants indicated that the best time for introduction of DG/BCHP-IES is during facility expansion, when all systems are being evaluated and upgraded. Hospital capital decisions that take place in a public environment, where perceptions of benefits such as energy efficiency carry and environmental friendliness are important, is helpful for BCHP-IES. However, in most cases a champion on the inside who understands the benefits and is able to articulate them clearly is key. Interviewees also mentioned that the involvement of architect and

[8] Energetics, Inc., *National Account Segment Survey Results.* American Gas Association, May 2002.

engineering (A/E) firms with expertise and experience in CHP installations is another ticket to success in getting integrated CHP systems into hospitals.

Some national hospital chains have their own A/E and construction staff. One chain with whom we spoke is coming up with an innovative digital hospital design that incorporates the state-of-the-art in information access and electronic control. This design also incorporates gas/electric hybrid cooling and desiccant dehumidification systems – both thermally activated technologies that match up well with CHP. The goal of this design is a hospital with significantly lower operating costs than previous designs have offered.

Unlike some restaurant and supermarket chains that enter into exclusive equipment agreements with suppliers, hospitals prefer to use a spec-bid approach on equipment selection.

To summarize, our research suggests that the following factors can play an important role in the penetration of integrated CHP systems into health care facilities:

First, it is important for the facility to solicit proposals and work with firms that specialize in CHP systems, and ideally, in CHP systems in hospitals. Other types of firms are likely to propose cookie-cutter, non-CHP systems they have already designed and installed in other facilities, as this is the best way to maximize their profit from a new project. Without the participation in the proposal stage of a CHP firm, many of the key questions will not be asked and the potential benefits of integrated CHP never explored.

Another key to getting BCHP-IES installations is for the right information to be available when expansion and renovation projects are in the planning stages, as these types of projects provide some of the best opportunities for IES system consideration.

Finally, especially when an executive committee is involved, there needs to be an IES "champion" on the inside who is able to express clearly the benefits of CHP to non-technical board and committee members, and to challenge points made by those supporting non-CHP solutions.

5.3 SUPERMARKETS

The *TargetProfile*$^{+}$ study investigated levels of familiarity among supermarket decision makers with several types of equipment that can be components of an integrated energy system, with results as shown in **Table 5-2.** Among centralized chains, a small percentage of the floor space featured absorption chillers, none featured engine-driven chillers, while some engine-driven refrigeration was in use and a significant amount of desiccant dehumidification. Decision makers responsible for upwards of 80% of all floor space had no experience with engine-driven or absorption equipment, with somewhat more experience with desiccant technology. Of those without experience, 35 to 65% were not familiar with these technologies.

On the generation side, almost none of the floor space was served by on-site generation, and at the time of the survey, little was planned.

TABLE 5-2
USE/FAMILIARITY WITH SELECTED IES TECHNOLOGIES IN SUPERMARKETS

Technology	% of National Floor Space			If never used:	
	Use Now	Used Formerly	Never Used/DK	Not familiar	Very/some-what familiar
Absorption chiller	6%	11%	83%	44%	56%
Engine-driven chiller	0%	11%	89%	43%	57%
Engine-driven refrigeration	9%	0%	91%	65%	35%
Desiccant dehumidification	32%	2%	66%	35%	65%
On-site generation	*Don't have: 98%* - No plans to install: 81% - Plan to install w\in 2 years: 3%			*Have: 2%* - Natural gas: 83% - DK: 17%	

Source: Opinion Dynamics Corp.

5.3.1 Insights

Several interview/survey efforts conducted within the past six months among national account customers in the supermarket sector reveal additional information about their priorities and outlooks on energy technologies and markets. Top of mind for these customers are the need to gain empowerment at the individual store level to manage power demand, operating costs and onsite power capability. High priority concerns include energy price levels and volatility, uncertain regulatory framework, lack of corporate priority for reducing energy costs, lack of competition among energy suppliers, and lack of understanding of their own energy cost drivers. With respect to DG and other new technologies, supermarket customers' concerns include the high cost of testing and verifying new technologies, the "hassle" of operating on-site systems, time consuming and costly utility interconnection processes, and management's lack of understanding of the benefits of onsite energy systems.

Some companies are aggregating standby capacity in supermarkets to save on peak power costs. Others have tried DG/IES on a pilot basis, with engine and microturbine systems and both desiccant and absorption subcooling systems. Supermarket chain energy managers with whom we spoke indicate that commercial systems will have to be marketed as an integrated package (IES and refrigeration) to be attractive to them. They prefer to develop a direct relationship with suppliers, at least for refrigeration equipment, rather than issue specifications and invite bids. Supermarket decision makers report receiving a lot of support from manufacturers in this type of arrangement, with manufacturer representatives often on the floor of their stores. Large chains may be involved in a hundred or more projects a year and want to control product supply and specifications. Stores are also working on developing a "bid package" to get quotes on systems for evaluation.

5.4 HOTELS/MOTELS

The *TargetProfile*+ study explored levels of familiarity among lodging decision makers with several types of equipment that can be components of an integrated energy system, with results as shown in **Table 5-3.** Among centralized chains, a small percentage of the floor space featured absorption chillers, and engine-driven chillers served an even smaller subset. Desiccant dehumidification appeared in about one-quarter of floor space. Decision makers responsible for almost all floor space had no experience with engine-driven chillers, with somewhat more experience with absorption chillers, and significantly more with desiccant technology. Of those without experience, 40 to 50% were not familiar with these technologies. On the generation side, none of the decision makers reported operating any on-site generation, although almost 10% said they had plans to install systems within two years. Levels of use and familiarity were much lower among individual chain locations (those with responsibility for making their own energy decisions).

TABLE 5-3
USE/FAMILIARITY WITH SELECTED IES TECHNOLOGIES IN HOTELS

Chains with Centralized Decision Making					
Technology	**% of National Floor Space**			**If never used:**	
	Use Now	**Used Formerly**	**Never Used/DK**	**Not familiar**	**Very/some-what familiar**
Absorption chiller	12%	10%	70%	39%	61%
Engine-driven chiller	4%	1%	95%	40%	60%
Desiccant dehumid.	24%	9%	58%	50%	50%
On-site generation	Don't have: 100% - No plans to install: 75% - Plan to install w/in 2 years: 9%				
Chains with Individual Location Decision Making					
Technology	**% of National Floor Space**			**If never used:**	
	Use Now	**Used Formerly**	**Never Used/DK**	**Not familiar**	**Very/some-what familiar**
Absorption chiller	1%	8%	91%	61%	39%
Engine-driven chiller	2%	3%	95%	59%	41%
Desiccant dehumid.	1%	6%	93%	71%	29%
On-site generation	Don't have: 92% - No plans to install: 92% - Plan to install w/in 2 years: 4%			Have: 8% - Natural gas: 34% - Fuel oil: 23% - Other: 37%	

Source: Opinion Dynamics Corp.

5.4.1 Insights

With respect to DG and other new technologies, hotel/motel decision makers' concerns include the high cost of testing and verifying new technologies, the lack of corporate priority for reducing energy costs, and the "hassle" of installing, operating and maintaining on-site systems (with accompanying concern about lack of technicians to provide these functions). There is also some concern about environmental permitting and emissions controls. Based on our conversations, third-party turnkey installations with operating agreements appear to be an attractive avenue for addressing the concerns of larger development and operations companies. In fact, interviewees expressed directly the desire to work with companies who could install and operate a CHP system, so they could turn their attention to increasing energy efficiency in other, more familiar ways.

Large hotel chains with whom we spoke rely on centralized management services including energy management. The focus of these energy departments tends to be rate analysis and commodity purchasing, not energy efficiency and productivity. Experience with CHP, absorption cooling and desiccant dehumidification is limited. Some hotel chains have responded to the high costs of electric air conditioning by installing ice storage systems and even geothermal heat pumps, though studies seem to point to hotels as a very good application for desiccant technologies. DG/IES is most likely to take root in the full service hotel sector, as these facilities tend to have in-house energy managers and larger thermal loads than limited service facilities, and HVAC equipment that is more conducive to these technologies.

An executive committee may make decisions. However, the driving force behind DG/IES must come from innovative ESCO/engineering firms. Current financing methods, especially in real estate investment trust arrangements, leave few funds for energy projects, so owner/operator contracts would be attractive.

5.5 RESTAURANTS

While the *TargetProfile*+ study did not ask restaurant respondents about DG and TAT equipment, several interview/survey efforts conducted in the past year reveal information about their priorities and outlooks on energy technologies and markets. Restaurateurs are thinking about their capabilities to manage energy demand and indoor air quality, and to remain open during grid failure conditions so that guest service is maintained under all conditions. With respect to DG technologies, they are most concerned about the high cost of new equipment, the "hassle" of operating on-site energy systems, and the lack of technicians to install and maintain DG and DG-based systems.

5.5.1 Insights

Larger restaurant chains have in the past centralized at least some portion of energy management and equipment decisions in an energy services department. The trend, however, has been a focus on energy buying and utility relations rather than on energy productivity. As one interviewee mentioned, his company's energy services group was merged into the purchasing department in recognition of the similarity of the core function performed. Energy costs typically comprise

from 3 to 4.5% of total operating costs, so energy cost management is not a high priority for the restaurant sector.
Many restaurant chains deal with a limited number of different store designs. The typical restaurant load – less than 150 kW – means that restaurants have only a limited range of packaged DG equipment from which to select. Typical energy investment criteria are quite restrictive, with required paybacks of one to two years. Internal decision makers do, however, seem to be interested in ongoing education on energy technologies and savings potential.

We project that DG/IES projects in this will not be readily embraced, for the following main reasons. First, capital project impact on profit and loss is closely scrutinized. Second, even routine maintenance on equipment is often not performed, partly as a result of the way in which individual restaurant managers are evaluated. Managers typically attempt to keep operating costs at a minimum so profits (and bonuses linked to profits) are maximized. Maintenance expenditures reduce profit, while new equipment purchases do not count against unit profitability. Finally, DG/IES systems do not impact the item of topmost focus in restaurant management: menu item preparation and service.

5.6 BIG-BOX RETAIL STORES

The *TargetProfile*+ study explored levels of familiarity among retail chain operators with several types of equipment that can be components of an integrated energy system, with results as shown in **Table 5-4.** About 10% of retail floor space in the study featured absorption chillers and engine-driven chillers served a like amount. However, decision makers responsible for about 90% of total floor space had no experience with these technologies. Of these, about two-thirds were familiar with absorption chillers and about half were familiar with engine-driven chillers. On the generation side, decision makers for 70% of floor space indicated that their facilities had no on-site generation, and almost all said they had no plans to install it.

TABLE 5-4
USE AND FAMILIARITY WITH SELECTED IES TECHNOLOGIES IN CENTRALIZED RETAIL CHAINS

Technology	% of National Floor Space			If never used:	
	Use Now	Used Formerly	Never Used/DK	Not familiar	Very/some-what familiar
Absorption chiller	10%	1%	89%	33%	67%
Engine-driven chiller	9%	1%	90%	51%	49%
On-site generation	Don't have: 70% - No plans to install: 93% - Plan to install w/in 2 years: 2%				

Source: Opinion Dynamics Corp.

5.6.1 Insights

Several survey efforts conducted within the past year among national account customers in the retail sector reveal additional information about their priorities and outlooks on energy technologies and markets. They are concerned with containment and predictability of energy costs; assurance of power quality and reliability; ability to compare utility usage and rates across the nation; and more cost-effective methods for capturing, monitoring and analyzing their stores' energy usage information. Customers expressed most anxiousness about the level and volatility of energy prices and understanding their own energy use patterns.

With respect to DG and other new technologies, retail customers are most concerned about the high cost of testing and verifying new equipment, the "hassle" of operating on-site energy systems, and the lack of uniformity and standardization of system requirements. However, the specter of lost revenues associated with delays in product shipping and drops in productivity due to energy outages is a driver for consideration of DG technologies and systems. Retail managers report no experience with DG other than small emergency generators. They are concerned about noise and unit placement due to limited space. Lack of a qualified maintenance staff is also a concern.

As our research has shown, national retail chains construct a large number of new stores and undertake numerous remodeling efforts each year. Store sizes can vary widely depending on the particular retail market. Firms typically work from a limited number of set designs. Store lighting is a big load, which also leads to a large air conditioning load. One interviewee mentioned that most of their stores rarely operate space heating equipment, except in the northernmost U.S. locations when outside temperatures are well below freezing. Water heating is also minimal; in fact, uses are so few that instantaneous (tankless) electric water heaters are not uncommon.

Payback of three years or less is required, with sensitivity around how to quantify the benefits that some of these technologies provide. For example, one department store chain actually installed desiccants and tried them over a summer, but was disappointed when there was no demonstrated increase in sales over the test period. Interviewees report that interconnect fees have hurt project economics.

Big-box retailers would thus potentially be interested in integrating cooling with a CHP system, though stores typically use multiple rooftop units (1.5-20 tons). There is also potential and demonstrated interest in dehumidification. One respondent had looked at microturbines for peak shaving and rejected the idea. They have also looked at heat wheels for sensible heat recovery of make-up air. Another chain described their plan for developing a project to install DG in their stores. Originally, waste heat was going to be used in a bottoming cycle to generate more power. This idea was changed when the developers realized they would be subjected to higher standby charges than if they were a CHP qualifying facility. So they looked for just enough waste heat utilization to qualify. The chain is now considering liquid desiccants with DG – a system using 10 units has an equivalent of 100 tons of cooling.

6. CONCLUSIONS

The following paragraphs summarize key information and present our conclusions about the potential for integrated CHP in the five national account target sectors, based on the detailed information we collected, produced and analyzed in this report and in the companion *National Account Sector Energy Profiles* report. We have arranged these in descending order from most promising to least promising.

6.1 HOSPITALS AND NURSING HOMES

Despite a trend toward outsourcing of the laundry function, there are still very good thermal loads in the healthcare sector. The sector features the largest installed CHP base of any of the five target sectors, providing plenty of experience with CHP technologies to be shared. There is less experience with absorption cooling, but relatively high levels of awareness of the technology among those with no direct experience. Decision makers are used to relying on outside sources such as consulting engineers and manufacturer representatives for information, which can be a plus when there is no direct experience.

We found targeted opportunities for desiccant dehumidification in operating suites and nursing homes, along with the best overall opportunity for BCHP-IES among the five sectors. Chains featuring some centralized energy equipment decision making are much better prospects than chains in which individual locations make their own decisions. Expansion projects provide excellent opportunities for integrated CHP, as whole systems are evaluated for replacement with a larger system. With the high level of projected new construction, there will also be good opportunities if health care companies are working at the outset with firms knowledgeable about CHP. In fact, it's clear that A/E firms with specialization in CHP/TAT are a key to increasing penetration in both renovation and new construction. Having a project champion on the inside who is able to convey the benefits of BCHP-IES clearly to board members, financial and other non-technical decision makers is also important.

The opportunities in this sector may best be pursued through industry/customer partnerships to ensure that specific needs are met. It would be desirable to identify packaged system design features and the business arrangement that offers the most promise in terms of increasing integrated CHP installations. Demonstration projects with documented performance could help convince both end-users and A/E firms of the benefits to be gained.

6.2 HOTEL/MOTEL

After hospitals, the hotel/motel sector offers the next best opportunities for BCHP-IES. There are some attractive thermal loads, especially among upper-tier properties, with a trend toward adding new thermal load in the form of spa facilities. While decision making emphasizes capital investments in projects that are highly visible to guests, larger properties have expressed strong interest in working with ESCOs to implement DG/CHP, primarily for the purpose of stabilizing energy costs. There is some experience with CHP and TAT technologies, with good levels of awareness among non-users, in chains with some centralized energy equipment decision making. There is also widespread reliance on outside sources for information, along with in-house experience.

Good opportunities for absorption chilling exist for peak electric demand reduction. Desiccants also appear to be a good application for mold, mildew and comfort control, but the low level of use to date reported by industry participants means education of decision makers is needed. Drawbacks in the sector continue to be the separation of ownership and management, the complexity of ownership/management/operating structures and entities, significant year-to-year turnover in property ownership and management contracts, and lack on central HVAC in most small hotels.

Our discussions with national account customers clearly indicate that they consider information and analysis by segment (full service, limited service, luxury) as applicable and valuable when considering their own properties, as there are many similarities in design and construction within those three segments and significant differences among them. A productive next step towards getting BCHP-IES systems into hotel facilities would be to conduct in-depth analyses of each of the three major segments, including detailed profiles, market potential estimates, and exploration of what specific system(s) and configurations would provide the most benefits to facilities within the segment.

6.3 SUPERMARKETS

On the positive side, national account decision makers in this sector have shown strong preliminary interest in DG and TAT, with pilot projects currently testing microturbine-based IES. Supermarkets are already a target for desiccant dehumidification to prevent frost buildup on refrigeration equipment and for comfort of shoppers. There is a very targeted opportunity for absorption to perform subcooling in refrigeration systems. Slim margins mean energy cost savings can be a critical factor in profitability. With energy cost savings very sensitive to how stores are designed and operated, pilot projects in customer stores appear to be a promising method for demonstrating BCHP-IES benefits.

On the downside, there is relatively little experience with CHP and TAT, along with relatively low levels of awareness among those with no experience. Supermarket decision makers have in the past tended to rely on in-house experience in making equipment decisions, so they may not be as receptive to education from outside sources as decision makers in other sectors.

National account customers have indicated that they would like the industry to work with refrigeration system manufacturers to integrate IES with refrigeration systems. This appears practicable, since supermarkets prefer to have a direct relationship with refrigeration system suppliers, who become intimately familiar with their needs. Thus, the ideal next step in this sector would be to identify specific IES equipment configurations. Developing a detailed concept in partnership with an individual national account chain may offer the best route to identifying one or more configurations.

6.4 RESTAURANTS

There has been some interest demonstrated in DG technologies in this sector, primarily for the ability for a restaurant to remain open to the community during electricity outages, and to reduce electricity costs. However, lack of thermal load in restaurants means limited CHP opportunities. Decision making processes, personnel, and criteria such as one-year payback further restrict opportunities. Even in cash-laden companies, the focus on short-term profitability impacts means that even projects with attractive cash flows after a two- or three-year payback period will not be implemented.

The priority for capital expenditures in this sector is food preparation equipment and projects visible to patrons. With energy costs comprising just 3 to 4% of typical operating budgets, much more attention goes to budget categories such as labor that claim much larger percentages of the total. Restaurant decision makers have tended to focus on achieving energy cost savings on the commodity side in the past few years, merging previously independent energy management departments with purchasing departments, for example.

Lack of skilled maintenance on-site, along with disincentives for having routine maintenance performed, further discourages investment in BCHP-IES. Even when a company has in-house maintenance staff, technologies beyond what they are currently familiar with are likely not to be adopted if manufacturers cannot promise and deliver on field support and maintenance services.

6.5 BIG-BOX RETAIL

Big-box stores feature even more limited thermal loads than restaurants, and appear to attach less value to the ability to remain open to the community during power outages ("people are not likely to want to congregate in our stores when the power's out," as one manager put it). Space heating needs are very low, with lighting and equipment in some stores such that heating is not needed until outside temperature are below freezing. The big push for big-box retailers and the primary use for capital is opening new locations, which the industry has done at a rapid pace in the last few years and plans to continue. Their reliance on a limited set of prototype store designs would be helpful in promulgating integrated CHP, once it was incorporated into store designs.

With virtually all big-box structures featuring roof top equipment, decision makers are not used to planning for equipment sited elsewhere. And, unlike the other four sectors examined, the engineering group seldom plays the lead role in energy equipment decision making, which is probably a drawback when trying to introduce more complicated systems. While we have observed active interest among some department stores in desiccants, decision criteria may restrict their application. On the other hand, with cooling loads often year-round, opportunities for absorption cooling exist. There is also awakening ESCO interest in serving this sector with BCHP-IES.

Appendix

TABLE A-1
BCHP-IES TECHNICAL MARKET POTENTIAL BY STATE AND SIZE
RETROFIT OF EXISTING FACILITIES

State	Number of Potential IES Sites by Size Range of Application*				Potential IES Capacity (MW)
	60-119 kW	120-299 kW	300-599 kW	600-1199 kW	
Alabama	412	175	41	21	106
Arizona	669	405	57	12	173
Arkansas	436	217	23	7	96
California	2,517	1,297	400	196	813
Colorado	32	42	7	2	16
Connecticut	429	231	32	14	109
Delaware	89	41	5	4	21
Florida	625	666	226	82	353
Georgia	753	382	104	48	226
Idaho	6	18	1	0	5
Illinois	1,808	1,039	142	72	485
Indiana	1,212	475	70	50	271
Iowa	715	380	46	24	177
Kansas	509	259	39	4	115
Kentucky	631	263	59	20	149
Louisiana	561	256	73	24	151
Maine	2	6	2	0	2
Maryland	536	328	56	27	158
Massachusetts	1,012	469	99	49	265
Michigan	37	57	10	2	21
Minnesota	165	65	7	4	34
Mississippi	303	171	44	20	96
Missouri	915	458	78	25	225
Montana	0	11	0	0	2
Nebraska	433	220	29	6	99
Nevada	305	197	60	57	140
New Hampshire	7	1	0	0	1
New Jersey	792	383	77	62	230
New Mexico	335	167	29	6	80
New York	448	517	209	114	329
North Carolina	657	342	61	53	196
North Dakota	59	12	0	0	7
Ohio	2,429	879	133	62	493
Oklahoma	488	272	29	5	113
Oregon	57	114	52	31	76

TABLE A-1 (Continued)

State	Number of Potential IES Sites by Size Range of Application*				Potential IES Capacity (MW)
	60-119 kW	120-299 kW	300-599 kW	600-1199 kW	
Pennsylvania	1,500	686	178	90	419
Rhode Island	163	63	8	10	39
South Carolina	372	192	38	20	104
South Dakota	42	13	0	0	6
Tennessee	888	377	75	38	216
Texas	2,645	1,249	208	23	584
Utah	272	127	6	0	51
Vermont	2	4	0	0	1
Virginia	661	327	102	50	208
Washington	125	197	86	38	119
Washington, D.C.	97	73	38	14	51
West Virginia	233	107	24	16	65
Wisconsin	50	51	11	0	19
Wyoming	2	14	1	0	3
Total	**27,436**	**14,295**	**3,075**	**1,402**	**7,719**

*Applications between 60 kW and 1199 kW only.
Source: EEA.

TABLE A-2
BCHP-IES TECHNICAL MARKET POTENTIAL BY STATE AND SIZE FOR NEW FACILITIES THROUGH 2020

State	Number of Potential IES Sites by Application Size Range*				Potential IES Capacity (MW)
	60-120 kW	120-300 kW	300-600 kW	600-1199 kW	
Alabama	334	143	32	16	85
Arizona	543	244	46	11	124
Arkansas	267	127	17	6	61
California	2,132	1,075	327	165	678
Colorado	29	41	5	2	15
Connecticut	355	170	28	11	86
Delaware	72	35	4	3	17
Florida	548	566	190	67	299
Georgia	646	331	85	39	191
Idaho	6	16	1	0	4
Illinois	1,382	690	112	57	353
Indiana	925	308	58	38	198
Iowa	511	203	35	19	116
Kansas	334	156	30	3	75
Kentucky	442	185	47	15	108
Louisiana	436	187	58	22	118
Maine	2	6	1	0	2
Maryland	456	242	46	21	125
Massachusetts	835	372	84	39	215
Michigan	29	50	8	2	18
Minnesota	145	60	6	3	30
Mississippi	228	135	37	17	77
Missouri	666	292	61	21	159
Montana	0	10	0	0	2
Nebraska	317	129	22	5	67
Nevada	268	134	50	54	117
New Hampshire	6	1	0	0	1
New Jersey	672	309	64	49	189
New Mexico	269	101	25	5	58
New York	375	423	172	90	267
North Carolina	568	293	47	40	161
North Dakota	48	11	0	0	6
Ohio	1,977	650	97	49	382
Oklahoma	296	147	22	4	68
Oregon	51	96	35	24	59

TABLE A-2 (Continued)

State	Number of Potential IES Sites by Application Size Range*				Potential IES Capacity (MW)
	60-120 kW	120-300 kW	300-600 kW	600-1199 kW	
Pennsylvania	1,253	525	147	72	337
Rhode Island	133	51	5	7	30
South Carolina	322	162	32	15	86
South Dakota	36	11	0	0	5
Tennessee	713	277	57	31	167
Texas	1,817	837	156	20	407
Utah	231	69	5	0	36
Vermont	2	4	0	0	1
Virginia	572	288	82	40	176
Washington	101	164	64	32	96
Washington, D.C.	81	61	35	13	45
West Virginia	196	88	18	12	52
Wisconsin	48	44	10	0	17
Wyoming	2	12	1	0	3
Total	**21,677**	**10,531**	**2,464**	**1,139**	**5,988**

* Applications between 60 kW and 1199 kW only.
Source: EEA