

Clean Heat and Power Driven Desiccant Dehumidification and Absorption Air Conditioning

Prepared by the North Carolina Solar Center at North Carolina State University

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CHP-Driven Air Conditioning

Combined Heat and Power (CHP) is an integrated energy system located at or near the point of use at a facility to provide at least a portion of the electrical or mechanical load while utilizing the waste/reject heat from the power application to provide heating, process steam, cooling, and/or dehumidification. (DOE, 2003)

Conventional electricity production as it exists today in the United States is only about 33% efficient. (SERAC, 2007) The waste of nearly two-thirds of internal energy from a fuel is generally accounted for by thermal losses resulting from the thermodynamic cycle used in standard electricity production. CHP systems capture and utilize these heat losses by applying thermal energy to existing needs.

As energy costs increase and owners of commercial buildings seek ways to become more energy efficient, CHP will become a more attractive option. When CHP is used onsite to provide electrical, thermal, and cooling requirements of a facility, system efficiencies can surpass 90 percent. (Goodell) Common thermal loads for CHP technology applications can be cooling, heating, and humidity control systems for buildings; steam production for industrial processes; and hot water production where the need exists.

Absorption chilling and desiccant drying are thermally activated air conditioning technologies that can be used in conjunction with CHP. Absorption chilling systems operate similarly to an electric chilling system. The major difference is that the absorption chilling system uses heat rather than electric motors to compress refrigerant vapors to a high pressure for use in the refrigeration process. In the case of CHP-driven units, the heat is derived from a heat exchange process from the CHP unit's exhaust gas or engine coolant fluids.

Desiccant dehumidification equipment can also operate using a CHP unit's waste heat. The CHP unit's thermal energy recharges the desiccant agent, removing the moisture and allowing the agent to continue drying the air used to condition the building space. By removing moisture from the ventilation air, the air conditioning system is left to deal primarily with control temperature (sensible load) rather than moisture (latent load).

CHP-driven absorption chilling and desiccant drying can shift a facility's space conditioning from electric load to thermal load. This can have a substantial impact on energy expenditures by reducing fuel costs, electric peaks, and demand charges. Additionally, CHP can also utilize opportunity fuels such as LFG, biomass, and digester gas. Many industrial processes in the pulp and paper industry recycle waste heat from processes and utilize thermal energy elsewhere in production. Landfill and agriculture applications capture methane gas that fuels CHP generators. These systems can be utilized to meet power and thermal requirements of the facilities.

Due to the increased efficiencies of CHP systems and the minimized amount of fuel consumed, the amount of emissions from energy conversion is reduced. Since thermal energy loads are satisfied by the same instance of fuel used to produce necessary electricity, additional fuel is no longer utilized to supply heat loads. By reducing the amount of fuel consumed, fewer emissions are produced when compared to conventional electrical and heat production.

Major Design, Operating, Marketing, and Sales Issues

Thermal-Electric Ratio

One of the major issues with the CHP market is matching a facility's particular requirements with the appropriate CHP system arrangement. Many CHP applications differ with respect to thermal loads, the electrical needs of the facility, and siting requirements.

Generally, it is preferable to size the system based on thermal loads. Thermal loads are comparatively dynamic and greatly influence the size and type of heat recovery equipment required. Thermal requirements also vary in the type of thermal energy required. (Integrated, 2007) However, in addition to thermal loads, another major factor in determining system configuration is electric output requirements, and in turn, the thermal-electric ratio.

Electric generators and chillers are typically sized to meet only a portion of the load in order to create a high load factor. Typical buildings have a 100% load factor for generators that output approximately 30% to 40% of the buildings peak electric load. At this ratio the thermal output of the CHP system will typically also have a high load factor. (Integrated, 2005)

When thermal energy, either for use in heating, cooling, or dehumidification, is needed at the same time as electricity, the CHP-driven system will be more efficient. The better thermal and electrical energy production can be matched to energy requirements, the more economical the system will be to operate, and the shorter the payback period will be. If a facility is unable to coordinate the Thermal-Electrical Ratio, CHP-driven systems become far less economically feasible.

Power-Cooling Ratio

An important characteristic that must be considered when designing a CHP-driven chilling system is the Power to Cooling (P/C) Ratio. The P/C Ratio is the electric output of the generator (converted to BTU/hr) divided by the chiller output (BTU/hr). The result can then be compared to the building's P/C Ratio. If the building has a P/C Ratio that is similar to the CHP-driven system, the application has good potential for success. (Integrated, 2005)

In applications such as supermarkets, where refrigeration systems consume large amounts of electricity, and simultaneously cool the facility, thus lowering the cooling requirements, there will be a need to use thermal energy elsewhere. As in the discussion above, if the thermal energy can be used for some simultaneous function, in addition to cooling, it will create a more economically feasible application. (Integrated, 2005)

In some cases, the facility may not be able to utilize all of the electricity produced by the CHP system. Systems designed and engineered with the intention to sell energy back to the local utility differ from systems using all energy produced “inside the fence.” Thermal energy may also be exported from the facility, influencing the size and configuration of prime mover technology.

Other factors, such as efficiency, emissions, cost, physical size, noise control, aesthetics, and maintenance requirements will also vary widely from system to system, and are taken into consideration when assessing a potential CHP application. (Integrated, 2005)

Identifying New Markets

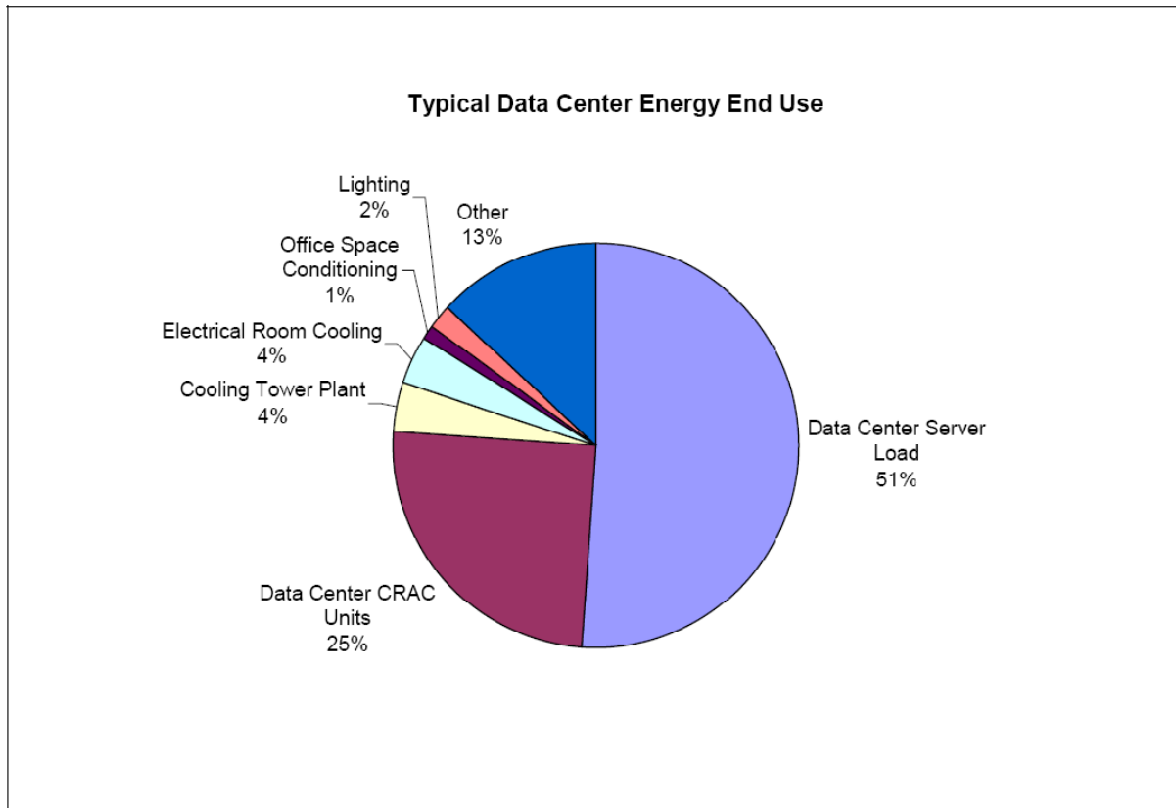
A significant factor in the expansion of the CHP-driven desiccant dehumidification and absorption chilling technologies is the identification of new markets. One specific market that shows great promise is the data center market. CHP-driven desiccant dehumidification and absorption chilling is poised to make a great impact on this industry, and the North Carolina Solar Center is making efforts to promote the application of the technology for this application.

Data centers house computer and telecommunication systems, as well as associated power supplies, controlling equipment, and security devices. As electronic technologies become more vital to companies around the world, the operation of data centers becomes more and more important to the basic operation of a business’s infrastructure.

Data centers have unique energy requirements, generally housing a high density of digital electronics and computer technology. Data centers require reliable power for computers, power supplies, power conditioning equipment, control electronics, and backup power systems. In addition to power required to operate these systems, power is also required to maintain air conditioning systems to keep the equipment cooled to optimum operating temperatures. These temperatures generally range from 68-70 °F. (Beck, 2001)

The computers used in data centers are generally known as servers. Multiple servers are contained on racks which are placed on a raised floor area. This serves as a plenum allowing cooled air to move below the racks, then up through perforated floor tiles to cool the system before returning to the HVAC system. (Beck, 2001)

According to the US EPA Combined Heat and Power Partnership, data centers may require from 20 to 100 watts per square foot, which is much higher energy utilization intensities than typical commercial buildings, which average 2 watts per square foot, based on annual consumption data for all commercial buildings. (EIA, 2006) Lawrence Berkley National Laboratory states that data centers represent approximately 1.2 percent of total U.S. power use —or about 5,000 MW (Kooimey, 2007).



Source: William Tschudi, Tengfang Xu, Dale Sartor, and Jay Stein, “High-Performance Data Centers: A Research Roadmap,” Lawrence Berkeley National Laboratory, March 30, 2004. See reference 11 for alternative data (IT load 33%, cooling load 63%, UPS load 4% of data center power usage).

Reduced Electrical Demand

A CHP-driven dehumidification and cooling system would provide multiple benefits to the target market segment. Because of the importance of data centers to the operation of a business, there is a great need for reliable, uninterrupted power service. Likewise, it is essential to have reliable HVAC service to maintain the centers’ operations.

Data Centers currently utilize approximately 1.2% of the electrical energy in the US. (Modius, 2008) CHP-driven cooling technologies can provide dependable electricity production, while at the same time generating heat necessary to operate absorption chillers that can be used to produce the required cooling, replacing electrically driven HVAC equipment. Any electrical energy derived from the CHP-driven system which is not needed by the TES system will be used to reduce the data center’s electrical demand.

Utilization of Non-Performing Assets

Additionally, all data centers have some form of DG, typically reciprocating engines, located on site for back-up power. These systems represent non-productive capital expenditures. The CHP-driven system will allow data centers to utilize these non-performing assets to reduce energy costs and in some instances may see a positive cash flow from these systems. Since the electrical

demand of the data center will be reduced by the use of absorption technologies, the size of these DG systems will also be reduced, thereby saving the customer capital dollars.

Emissions Reduction

By generating electricity onsite, the inefficiencies of utility-generated electrical distribution can be avoided, and the efficiency of the facility is further increased by capturing the waste heat from the proposed CHP unit for use in the absorption chiller. Displaced emissions and grid loss directly reduces the production of greenhouse gases, as well as reducing other air pollutants, including carbon monoxide, nitrogen oxides, and sulfur dioxide.

Power Quality and Reliability

Data centers are uniquely sensitive to power quality and reliability. They often have extensive power conditioning equipment, back-up power systems, batteries, flywheel storage, ultra-capacitors, as well as onsite backup power such as diesel. Many data centers also have multiple redundancies built into their power and HVAC systems to ensure that electricity and air conditioning are continuously maintained. These redundancies are necessary because even brief power outages can lead to significant revenue loss, and elevated temperatures can cause costly damage to heat-sensitive equipment.

A CHP system can provide insurance against utility outages that extend beyond the capabilities of UPS and battery systems. A report by Oak Ridge National Laboratory in 2003 (Energy and Environmental Analysis, 2004) found that reciprocating engine powered CHP showed availability factors averaging 97 percent. This reliability can be increased by using parallel utility feeds along with the onsite CHP generation. Since the utility service feed availability is approximately 99.7 percent, by combining the CHP system with utility service, the availability could approach 99.97 percent, resulting in only about 43 minutes of expected outages per year. (US EPA, 2007)

Green Marketing

With the increase in public awareness regarding environmental and economic sustainability, businesses are finding it more important to market their green efforts. Demonstrating corporate responsibility is now at the forefront of advertising, marketing, and public relations strategies. Incorporating CHP-driven systems in a facility is a great way of practicing energy efficiency methods by capturing and utilizing waste heat that would otherwise be lost. Additionally, if renewable fuels such as landfill gas, biomass, etc, can be used, the CHP energy production is considered renewable energy.

Facility Expansion

A CHP-driven system provides a user increased flexibility in expanding existing facilities and designing new facilities. Onsite electricity and thermal energy production provides data centers the ability to plan expansion without concern of the ability of the existing utility grid to meet their increased power demand. The utility grid's ability to provide reliable service in the face of

ever-increasing load, especially during periods of heavy demand such as summertime, creates greater incentive for facilities to look for sources of energy that can be produced onsite.

Energy Efficiency

Conventional electricity production as it exists today in the United States is only about 33% efficient. (SE CHP Application Center, 2007) The waste of nearly two-thirds of internal energy from a fuel is generally accounted for by thermal losses resulting from the thermodynamic cycle used in standard electricity production. CHP systems capture and utilize these heat losses by applying thermal energy to existing needs. Additionally, by incorporating renewable technologies the user takes advantage of free sources of power. A CHP-driven system can use available waste heat to operate a dehumidification or absorption chiller, further reducing the electrical load that would otherwise be needed for the electrically driven HVAC system.

Installations in the Southeast 2003 - 2008

Three installations of CHP-driven Absorption Chilling or Desiccant Dehumidification in the Southeastern United States since 2003 were identified. These sites were the National Transportation Research Center in Knoxville, Tennessee, Fort Bragg Army Base, in North Carolina, and Pepperell High School in Rome, Georgia. Below is a description of each installation. Fact sheets can be found in the Appendix.

National Transportation Research Center, Knoxville, TN

Oak Ridge National Laboratory (ORNL) installed a phosphoric acid fuel cell at the National Transportation Research Center (NTRC) in Knoxville, TN in 2003. The project was funded through the U.S. Department of Energy's (DOE's) Office of Distributed Energy and Electric Reliability Program and a Department of Defense (DoD) National Energy Technology Laboratory (NETL) grant.

The fuel cell generates 200 kW of electricity and 900,000 Btu/hr for hot water while consuming 2,050 cft/hr of natural gas. The electricity generated by the fuel cell is used to power the NTRC building and replaces approximately one-third of the building's load. Thermal energy from the fuel cell is used to augment the heating provided by the facility's existing gas-fired boilers. In the summer, the hot water produced by the fuel cell is used in conjunction with a 525-ton chiller that produces 55°F air for conditioning the facility. See Figure 1.

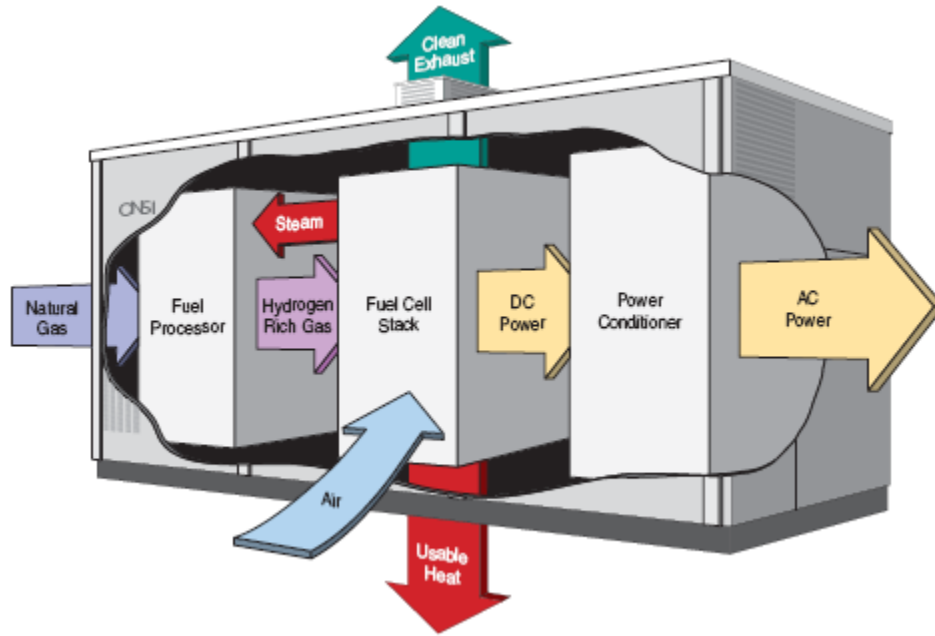


Figure 1: Fuel Cell Process at NTRC

The facility's efficiency is improved by using on-site electricity generation, as well as taking advantage of the fuel cell's usable heat to produce 250°F water from for temperature control. The efficiency is expected to increase from ~33% to 59% year. (ORNL, 2003)

U.S. Army, Fort Bragg, NC

The combined Cooling, Heating and Power (CHP) system installed at the Fort Bragg's 82nd Central Heating Plant represents a joint venture between the U.S. Army, the Department of Energy's Oak Ridge National Lab and Honeywell Labs. The 82nd Central Heating Plant serves a large number of barracks and other buildings on base. The plant provides steam for heat and domestic hot water, as well as chilled water for air conditioning. Through Oak Ridge National Lab, the Honeywell Energy Services Team is collaborating with DOE's Federal Energy Management Program (FEMP) to allow the 82nd Central Plant to serve as a showcase CHP site. The North Carolina Solar Center at N.C. State University is working in support of this effort. (NCSC, 2005)



Figure 2: Ft. Bragg CHP Installation

The project will reduce improve facility efficiency and reduce operating costs while illustrating the value of an integrated energy system capable of generating power, chilled water, and steam. The CHP system includes a 5.5 megawatt gas combustion turbine that is capable of operating on either natural gas or Number 2 fuel oil. Turbine exhaust fires an absorption chiller that produces up to 1,000 tons of chilled water or to fire a heat recovery steam generator that can produce up to 80,000 pounds of steam per hour. System efficiency is expected to approach 80 percent. (FEMP, 2004)

CHP system equipment specifications and a system schematic are shown below. (NCSC, 2005)

- Solar Turbines Taurus 60 gas turbine, rated at 5 MW
- Broad Air Conditioning 1000-ton heat recovery absorption chiller
- Coen natural gas-fired duct burner, capable of 55.2 MMBTU/hr
- Rentech Type “O” Heat Recovery Steam Generator, rated at 27,800 lb/hr of 125-psig steam unfired; or 81,200 lb/hr when fired with duct burner

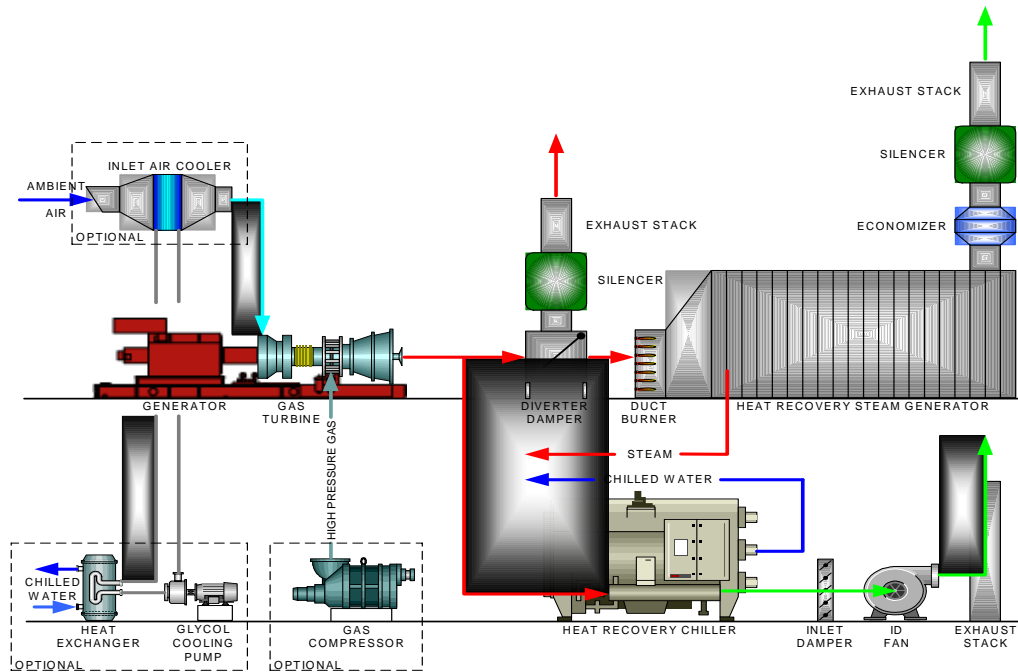


Figure 3: Ft. Bragg CHP System Schematic

Pepperell High School, Rome, GA

A distributed energy system has been installed at Pepperell High School in Floyd County, Georgia. The system consists of a 230 kW reciprocating engine generator and four Integrated Active Desiccant Rooftop (IADR) systems. The IADR systems were modified to include hot water coils to recover heat from heated engine jacket water for desiccant regeneration during the cooling season and heating during the heating season.

System specifications are detailed below. (Fischer, 2008)

- Continuous Output Power – 230 kW
- Mechanical Power - 322 bhp
- Rotating Speed - 1,800 rpm
- Actual Heat Rate - 10,204 Btu/kWh
- Fuel Consumption - 2,347 mmBtu/Hr
- Actual Electrical Efficiency - 33.4%
- Nominal Flow rate - 120.6 gpm
- Engine Inlet Temperature - 176.0 °F
- Engine Outlet Temperature - 190.0 °F
- Heat Energy - 844,875 Btu/hr

- Actual Thermal Efficiency - 36.0%
- Electrical plus Thermal 69.4%

The project involved four IADR units, operated as dedicated outdoor air systems, each capable of producing approximately 4,725 ft³/min. This is intended to be capable of delivering all ventilation air requirements to the main classroom areas of the Pepperell High School. See Figure 4. (Fischer, 2008)



Figure 4: Main Classroom Buildings at Pepperell High School

Using recovered heat from the cogeneration unit rather than using power from the electric grid for the IADR units during the peak cooling season reduces the connected load peak demand by approximately 145 kW. It also reduces the overall electrical demand by 21% and reduces the peak electrical demand associated with the HVAC system by 37%. Additionally, the waste heat source is even more beneficial during the heating season since it offsets approximately 234 kW of peak electrical demand that would otherwise be consumed by the electric reheat. (Fischer, 2008)

Identification of Manufacturers

Below is a list of manufacturers of distributed generation equipment, absorption chilling equipment, and desiccant dehumidification equipment. The list is not all-encompassing, and does not include every manufacturer in the respective technology fields.

- **Distributed Generation Equipment Manufacturers**
 - **Combustion Turbines**
 - **General Electric**
Phone: 866-770-5248
Email: extranetaccount@ps.ge.com
Website: <http://www.gepower.com>
 - **Siemens**
Phone: +49-180-524-7000
Fax: +49-180-524-2471
Website: <http://www.powergeneration.siemens.com>
 - **Solar Turbine**
Turbomachinery Sales/Service
10691 S.W. 88th Street
Suite 109
Miami, FL 33176
Phone: 305-279-6270
Fax: 305-595-2575
 - **Micro- and Mini-Turbines**
 - **Capstone Turbines**
21211 Nordhoff Street
Chatsworth, CA 91311
818-734-5300
1-866-4-CAPSTONE
Website: <http://microturbine.com/index.asp>
 - **DTE Energy Turbines**
30 New Hampshire Ave.
Portsmouth, NH 03801
Phone: 800-477-4747
Website: <http://www.dteenergy.com>
 - **Ingersoll Rand**

30 New Hampshire Ave.
Portsmouth, NH 03801
Phone: 877-477-6937
Website: http://energy.ingersollrand.com/index_en.aspx

○ **Reciprocating Engines**

- **Caterpillar**
100 North East Adams Street
Peoria, Illinois 61629
Phone: 309-675-1000
Website: <http://www.cat.com>
- **Cummins, Inc.**
3700 Jeff Adams Drive
Charlotte, NC 28206
Phone: 704-596-7690
Fax: 704-596-3038
Website: <http://www.cummins.com>
- **Kohler**
Phone: 800-544-24444
Website: <http://www.kohlerpower.com>
- **Marathon Engines**
2050 Energy Drive
East Troy, WI 53120
Phone: 262-642-6436
Website: <http://www.marathonengine.com>
- **Waukesha**
15455 Dallas Parkway
Addison, TX 75001
Phone: 972.361.9800
Fax: 972-361-9903
Website: <http://www.waukeshaengine.com>

● **Absorption Chiller Manufacturers**

- **Yazaki Energy Systems**
701 E. Plano Parkway, Suite 305
Plano, TX 75074
Phone: 469-229-5443

Fax: 469-229-5448
Website: www.yazakienergy.com

- **Broad USA**
401 Hackensack Ave., Suite 503
Hackensack NJ 07601
Phone: 201-678-3010
Fax: 201-678-3011
Email: info@broadusa.com
Website: <http://www.broad.com>

- **Carrier Corporation**
Phone: 800-227-7437
Website: <http://www.commercial.carrier.com>

- **Dunham Bush**
43000 Kajang
Selangor Darul Ehsan, Malaysia
Phone : 603-8733 9898
Fax : 603-8734 2178/6178
Email : info@dunham-bush.com.my
Website: www.dunham-bush.com

- **Robur Corporation**
Via Parigi 4/6
24040 Verdellino/Zingonia (Bg) – Italy
Phone: 39-035-888111
Fax: 39-035-888272
Website: <http://www.robur.com>

- **The Trane Corporation**
Phone: 800-524-4822
Website: <http://www.trane.com>

- **Desiccant Systems Manufacturers**
 - **Bry-Air**
10793 St. Rt. 37W
Sunbury, OH 43074
Phone: 877-379-2479
Fax: 740-965-5470
Email: info@bry-air.com
Website: <http://www.bry-air.com>

- **Munters Corporation**
MCS - Norfolk District Office
1700 B South Park Court
23320 Chesapeake, VA
Phone: 800-686-8377
Fax: 757-366-4428
E-mail: mcsinfo@munters.com
Website: <http://www.munters.us>

- **ATS**
1572 Tilco Drive
Frederick, MD 21704
Phone: 301-620-2033
Fax: 301-662-5487
Email: info@stulz-ats.com
Website: <http://ats.stulz.com>

- **Kathabar**
370 Campus Dr
Somerset, NJ 08873
Phone: 732-356-6000
Fax: 732-356-0643
Email: sales@kathabar.com
Website: <http://www.kathabar.com/contact.html>

Works Cited

Department of Energy. "Combined Heat and Power (CHP) Regional Application Center Guidebook." Midwest CHP Application Center. January, 2003.

South East CHP Application Center. "Basics." CHP Basics and Benefits.
http://www.chpcenterse.org/03-00_chp.html. 27 July, 2007.

Goodell, Monty. "The Advantages of Cogeneration and Trigeneration." Renewable Energy Institute.

Integrated CHP Systems Corp. "Thermal Design Approach." <http://www.ichps.com/index.html>. 27 July, 2007.

Integrated CHP Systems Corp. "Initial Market Sector Report: Potential for CHP-based Chillers 100 RT in North America" <http://www.ichps.com/PDF/Market%20Sector%20Report.pdf>. 2005.

Oak Ridge National Laboratory, "Unique Fuel Cell Installation Showcased at the National Transportation Research Center (NTRC)". 2003.

NC Solar Center, "Performance Analysis of Integrated Energy System at 82nd Airborne Plant Site in Fort Bragg, NC." November, 2005.

FEMP, US DOE Energy Efficiency and Renewable Energy Federal Energy Management Program, "FEMP FOCUS: Army Completes Advanced Combined heat and Power Plant." http://www1.eere.energy.gov/femp/newsevents/fempfocus_article.cfm/news_id=7475. 2004.

Fischer, John, "Design, Installation, and Field Verification of Integrated Active Desiccant Hybrid Rooftop Systems Combined with a Natural Gas Driven Cogeneration Package." January, 2008

Beck, Fred. Renewable Energy Policy Project. "Energy Smart Data Centers: Applying Energy Efficient Design and Technology to the Digital Information Sector". November 2001.

Energy Information Administration. "Commercial Building Energy Consumption Survey: 2003." December 2006.

Koomey, J.G. "Estimating total power consumption by servers in the U.S. and the world." Lawrence Berkeley National Laboratory. February, 2007.

Modius. "The Data Center Energy Problem" <http://www.modius.com/datacenterenergy.htm>. 2008.

US EPA. "The Role of Distributed Generation and Combined Heat and Power (CHP) Systems in Data Centers". August 2007.

Appendix

National Transportation Research Center, Knoxville, TN

U.S. Army, Fort Bragg, NC

Pepperell High School, Rome, GA

Unique Fuel Cell Installation Showcased at the National Transportation Research Center (NTRC)

Oak Ridge National Laboratory (ORNL), through funding sponsored by the U.S. Department of Energy's (DOE's) Office of Distributed Energy and Electric Reliability Program and a Department of Defense (DoD) National Energy Technology Laboratory (NETL) grant, has installed a United Technologies Company (UTC) phosphoric acid fuel cell at the National Transportation Research Center (NTRC) in Knoxville, TN. Installation of this fuel cell is unique for a DOE-leased building in a region with low electric rates, as well as for provision of thermal recovery for the building.

Background on Fuel Cells

A fuel cell is an electrochemical device that combines hydrogen fuel, such as natural gas and oxygen from the air to produce electricity and hot water (see Figure 1). Fuel cells operate without combustion, so they are virtually pollution free. Since the fuel is converted directly to electricity, a fuel cell can operate at much higher efficiencies than internal combustion engines, extracting more electricity from the same amount of fuel. The fuel cell itself has no moving parts, making it a quiet and reliable source of power.

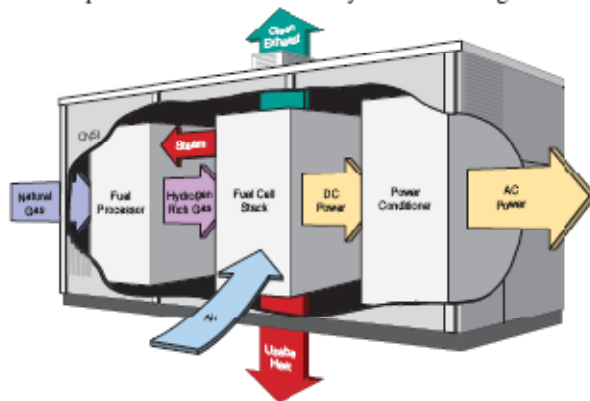


Figure 1. Fuel Cell uses Natural Gas to Produce Electricity.



Figure 2. The NTRC Fuel Cell.

The NTRC Fuel Cell

The NTRC fuel cell was purchased commercially from International Fuel Cells, which sells about 40 units per year, with the majority installed in the Western United States. The fuel cell (see Figure 2) consumes 2,050 cft/hr natural gas to generate 200 kW electricity while creating 900,000 Btu/hr hot water. The NTRC uses the electricity generated by the fuel cell to supply about one-third of the building's electricity. Thermal energy created by operation of the fuel cell is used to supplement the heating provided by seven gas-fired boilers. In the summer, the building is cooled using a 525-ton chiller that produces 55°F air. Hot water produced by the fuel cell will also be used in the summer to reheat this 55° air for temperature control.

Contribution to Operational Efficiency

In operation, this fuel cell combines heating, cooling and power generation to improve building efficiency. Efficiency is expected to increase from ~33% to 59% year round by using 250°F water for temperature control. Knoxville Utility Board (KUB) approved a lower gas rate to support favorable operating costs. The project is expected to reduce utility bills.

Independence from the Grid

Though the fuel cell normally operates connected to the electric grid, it is designed to automatically disconnect from the grid when either the grid fails or is out of tolerance. If out of tolerance, a fuel cell "grid enabled circuit" is opened. The local utility, Lenoir City Utilities Board (LCUB), required installation of a reverse power relay to prevent power from feeding the grid during grid outage. If the fuel cell fails to disconnect from the grid during a power outage, the reverse power relay disconnects the fuel cell from the grid.

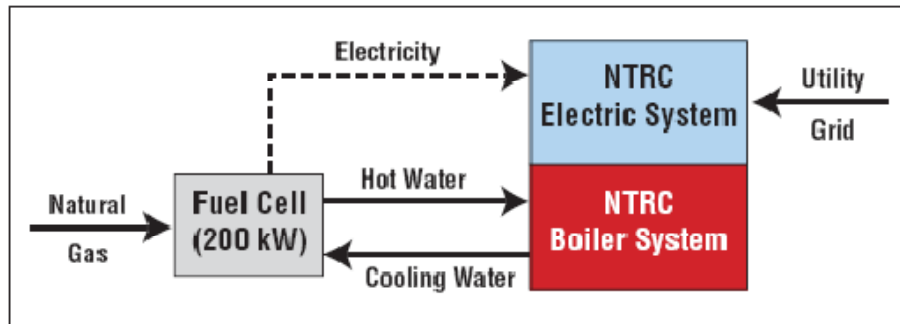


Figure 3. Fuel Cell Supplies Electricity and Heating.

Research on Advanced Relays

In addition to improving energy-efficient operation of the NTRC facility, the fuel cell is central to a research project on advanced relays. The grid disconnect relays of the LCUB substation are being compared with those of the UTC fuel cell. The "load tracking" control loop interaction is being evaluated in comparison with the reverse power relay. Research partners on this project include ORNL, EPRI Power Electronics Application Center (PEAC) Corporation, and Tennessee Valley Authority (TVA), with involvement from Construction Research Engineering Laboratory (CERL) and Institute of Electrical and Electronic Engineers, Inc. (IEEE).

Point of Contact:

Jan Berry
Oak Ridge National Laboratory
Phone: 865-241-1939
berryjb@ornl.gov



Broad Exhaust Fired Absorption Chiller

The Honeywell CHP System Team

Benefits of Packaged CHP Systems

Capital Cost Reduction

Packaged integrated energy systems are anticipated to cut CHP system capital costs by 15% to 30%.

Shorter & Less Expensive Installation

IES can reduce CHP system installation time by as much as two-thirds, and provide corresponding installation cost savings.

Replicability

System designs are suitable for multiple applications in facilities around the country.

Optimize Facility Energy Use

Packaged systems allow facility operators to manage power generation, cooling and heating to optimize energy use as well as reduce electricity use during peak periods.

Simplified Systems

The use of exhaust-fired absorption chillers eliminates the need for steam/hot water generation equipment.

Optimized Benefits

The packaged CHP system with supervisory controls can be a key component in maximizing the cost effectiveness of your entire site's energy choices.

Program Contact

Jan Berry
Oak Ridge National Laboratory
(865) 241-1939 • berryj@ornl.gov

<http://www.eere.energy.gov/del/>

Project Overview

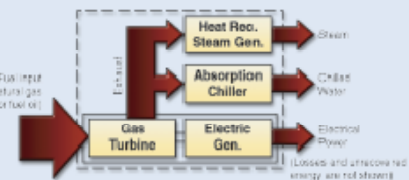
Honeywell Labs has teamed with Broad USA, Chelsea Group and I.C. Thomasson to fill technology voids for Integrated Energy Systems (IES). The team is developing a set of reference designs to improve economics and simplify installation, and developing supervisory control systems with on-line optimization. In collaboration with Honeywell Energy Services and the Federal Energy Management Program, the team is installing a prototype system at the Ft. Bragg Army Base in North Carolina. The prototype features a 5-MW turbine generator supplying electricity to the base and a 1,000-ton Broad USA absorption chiller with advanced waste heat-fired or direct gas-fired design to meet air conditioning needs. Turbine exhaust can also be used to produce steam.



Objectives

Optimize the integration of power generation and the mechanically activated cooling technologies for large (2-to 5-MW) IES, and field test a prototype design

- Develop a set of reference computer-based modular system designs
- Develop a supervisory control system with on-line optimization
- Install and monitor the performance of a prototype modular CHP system



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OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY





SEMCO's Hybrid Active Desiccant Rooftop

Integrated Energy System in High School (SEMCO, Inc.)

Benefits of Integrated Energy Systems

Capital Cost Reduction

Pre-engineered systems can cut CHP system capital costs by 15% to 30%.

Shorter & Less Expensive Installation

IES can reduce CHP system installation time by as much as two-thirds, and provide corresponding installation cost savings.

Replicability

System designs are suitable for multiple applications in facilities around the country.

Optimize Facility Energy Use

Pre-engineered systems allow facility operators to manage power generation, cooling, and heating to optimize energy use as well as reduce electricity use during peak periods.

Simplified Systems

Peak shedding power, cooling, heating, dehumidification, and continuous ventilation provided in one package.

Versatility

Combines strengths of advanced DX cooling, desiccant dehumidification, and waste heat utilization technologies in a packaged rooftop format.

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Project Overview

SEMCO, Inc., of Columbia, Missouri, has teamed with C&M Engineering, Southern Engineering, and Deutz Corporation to package a 200 kilowatt reciprocating engine generator, coupled with an integrated active desiccant (IADR) system, at the new Pepperell High School, in Floyd County Georgia. This project work will encourage further widespread adoption and implementation of integrated distributed energy systems consisting of electrical generators combined with desiccant dehumidifiers regenerated by engine heat to provide power and dry air.

Benefits of an Integrated Active Desiccant Rooftop (IADR):

- Unit achieves precise performance/load sensible/latent matching with variable speed compressors and blowers, modulating regeneration control, and direct digital control (DDC) logic algorithms.
- IADR applicable as dedicated outdoor air system (DOAS) or total air conditioning system with 100% to 0% outdoor air (0% to 100% return air) handling capability.
- SEMCO hybrid system delivers independent space temperature and humidity control for any fresh air fraction ventilation rate, which constitutes ideal rooftop air conditioning performance.
- Positioning the desiccant wheel after the DX cooling coil allows dry ventilation air at cool temperatures, lower desiccant regeneration temperatures, smaller component weights and footprint, and better waste heat utilization capability.
- Cool, dry ventilation air from IADR prevents mold and mildew risk in carpets, ceiling tiles, inside furnishings, and interior space.
- Hybrid system allows integration with building exhaust air energy recovery exchangers for exceptionally efficient performance and convenient integration with waste heat recovery applications.



Objectives

- Develop an integrated CHP System to optimize performance for a variety of energy customers in the most popular air conditioning package.
- Define prototype system(s) in one of the most demanding applications.
- Demonstrate energy-saving and enhanced comfort/IAQ features.

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