# Energy Demand System

## Automated Energy Management For Rooftop Units

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Syracuse, New York

September 2013

## TABLE OF CONTENTS



## INTRODUCTION

The ability to manage energy consumption and cost has become increasingly important in recent years. In addition to budget concerns and environmental pressures, building owners and facility managers face the negative effect that rapidly growing demand has had on the reliability of service provided by utilities. As HVAC (heating, ventilating, and air conditioning) equipment typically accounts for a large portion of a facility's electricity use, solutions for managing these systems are essential to achieving control of energy usage.

Building automation systems have progressed in their ability to manage loads, but they are not significant within the market that comprises 60% of the commercial and industrial floor space in North America. Defined by the U.S. Energy Information Administration's Commercial Buildings Energy Consumption Survey (EIA CBECS) as the middle market segment, this space typically consists of buildings of 10,000 to 200,000 sq ft.

This paper will explore the application of a new technology that can provide these facilities with the ability to control their energy demand. Designed for rooftop units (RTUs) with capacities of 3 to 30 tons, Carrier's energy demand system uses Swarm Energy Management* technology to wirelessly control rooftop operation and energy consumption. In addition, the energy demand system can record data and provide reports on energy usage, information critical to the process of evaluating and improving the efficiency of systems and equipment.

*Trademark of REGEN Energy Inc.

## BACKGROUND

Utilities are facing mounting pressure as they are tasked with reliably delivering energy to meet rapidly growing demand. This is further complicated by aging infrastructures of above and below-ground transmission lines, transformers, sub-stations and feeders, with no immediate upgrades evident. North America is subject to brown-outs and even black-outs. In fact, North American Electric Reliability Corporation (NERC) data shows that there were 856 events from 1984 through 2006.[1] Of these events, 438 were considered large blackouts – characterized as being larger than 300 MW or affecting more than 50,000 customers.

Unfortunately, updating the grid is an unrealistic solution as the cost far exceeds available resources. Instead, the focus should be on creating a smarter, more stable grid through the use of smart grid products and demand side management

Grid operators, known as Independent System Operators (ISOs) or Regional Transmission Operators (RTOs), grew by orders of the Federal Energy Regulatory Committee (FERC) issued in 1996. Their purpose is to pool energy for consistency in balancing of supply and delivery. Typically, an ISO or RTO exists to serve densely populated geographies (such as California, Texas, and the Atlantic seaboard) where delivery of electricity is, at times, very challenging. Providing automation and visibility through intelligent software solutions for the largest electrical loads, typically heating, ventilation and air conditioning, has proven to be key to driving on-demand reduction in energy usage.

According to the EIA CBECS, the facilities identified earlier as the middle market segment make up 60% of the commercial and industrial floor space in North America.[2] They are typically 10,000 to 200,000 square feet in size, with peak demands ranging from 50 kW to 1,500 kW.

Facilities in this segment include:

- Localized manufacturing
- Movie theaters
- Big box retail stores
- Warehouses/distribution centers
- Schools
- Office buildings
- Recreation centers
- Supermarkets

This large group of commercial and industrial facilities has been underserved, with few available solutions to control energy usage and demand.

## OBSTACLES TO ENERGY MANAGEMENT INTEGRATION

The "middle market" of energy customers is made up in large part by facilities that are also installation sites for high numbers of packaged rooftop units. Facilities of this size and type face several obstacles to energy management.

Building automation systems cannot economically serve this segment due to the high initial investment required, as well as the ongoing need for monitoring of the system by operational engineers. Many facilities in this space tend to use programmable thermostats to manage their loads. While programmable thermostats can be found in this market, they are often mismanaged. The method for programming schedules can be complex and tedious, and it is common for schedules to be set incorrectly from the very beginning. For example, in a large facility multiple thermostats exist, requiring each individual thermostat to be programmed independently by the facility manager. Even in cases where the schedules were set correctly, the thermostats do not communicate with each other within the facility and it is typical for the schedules to become erratic over time. This can be due to a number of reasons, including overrides being used to accommodate special circumstances or facility occupants changing thermostat settings in the interest of maintaining their own comfort.

In addition to problems with directly managing energy usage, facility owners in this segment also face challenges in monitoring consumption and collecting data. This data can provide insight into the operational efficiency of equipment and provide the knowledge required for energy budget management.

Recent communications from the U.S. Department of Energy have emphasized the importance of economical metering systems that enable the collection and use of data and lead to actions that improve efficiency.[3]

Facility owners often have little understanding of how they are charged for peak electrical demand. The method by which a facility owner is charged for peak demand may vary depending on the utility district. Under the most common billing structure, peak demand charges are billed according to the highest 15-minute demand seen in the billing month. However, variations to this billing structure can be seen. These variations may include:

- Higher rates during summer months
- Longer time periods may be metered for peak demand. For example, peak demand may be measured over a 30-minute or daily window instead of a 15-minute window
- A trailing 11-month "ratchet," in which facility owners are penalized for their facility's worst-case summer peak with the effect felt all the way through the following fall, winter, and spring

Typically the HVAC equipment consumes the largest amount of energy in a facility, so the ability to analyze HVAC usage data can lead to great savings in energy and cost.

These facts add up to an emerging need for a solution that enables logical control over energy-using assets. For this market segment, it is especially critical that the solution be easy to use (automated) and cost-effective.

## CARRIER'S ENERGY DEMAND SYSTEM

### Emergence in Nature

A colony of simple insects, such as ants or bees, exhibit complex behavior patterns which reflect a greater intelligence than the sum of the intelligence capabilities of the individual members. Ants and bees themselves have very simple brains that are programmed with a very simple set of instructions. These instructions allow the colony to build nests, gather food and defend, all without any semblance of a centralized leadership structure. Each individual will change its function, from food gathering to nest maintenance to nest defense, solely based on what it can deduce about its surroundings from pheromone trails left by its peers. Such behavior is known as emergence or swarm logic.

As described earlier, a principal obstacle to energy management of equipment using programmable thermostats is that they do not directly communicate with each other, and therefore cannot organize their use of energy in an intelligent manner that is beneficial to the entire network. Carrier's energy demand system with Swarm Energy Management technology overcomes this challenge by attaching a simplistic intellect to each RTU, along with a method by which the unit can convey critical information to all other units in the network.

## Optimizing Energy Usage in Rooftop Units

Designed for rooftop units, Carrier's energy demand system provides reliable and automated processes to manage the costs of energy consumption. Carrier's energy demand system uses low-cost, wireless devices incorporating patented algorithms to create a powerful network of rooftop units that are coordinated to reduce and optimize their energy usage.

The natural duty cycle is the percentage of time over a given time interval that a unit must run in order to satisfy the temperature set point. The system takes advantage of the natural duty cycle concept across the network to ensure that the minimum number of units is allowed to run at any point in time.

The ideal application for the Carrier energy demand system is an installation consisting of 6 or more rooftop units, each controlled by a thermostat. An energy demand system network of up to 50 units can be created for each energy demand gateway. (See Fig. 1.) When an energy demand load controller is attached to each rooftop unit in the network, the load controller deduces the operating characteristics of the unit, including:

- The natural duty cycle
- The maximum power draw of the unit
- The length of time it has been allowed to run
- The length of remaining time required to meet its duty cycle

When this information is communicated to all other load controllers in the network, each individual load controller can decide independently whether or not it should allow its unit to run. The load controller is a simple device with a relay that can break the connection between the rooftop unit and the thermostat; the load controller either disables the unit from running or control of the unit reverts back to the rooftop thermostat. When the relay connection is restored, the RTU will turn on at the next call for cooling received by the thermostat. (Note that the time period set for cycling the unit meets requirements for compressor protection.) By communicating through the gateway, units are prevented from running simultaneously when it is not necessary, thereby smoothing out peak demand over time.

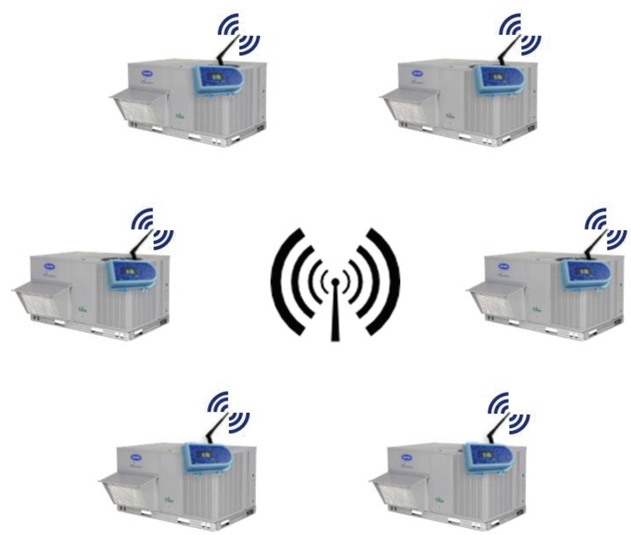

*Figure 1 – Energy Demand System Network of Rooftop Units*

## ENERGY MANAGEMENT WITH THE ENERGY DEMAND SYSTEM

### Demand Management

The goal of demand management is to encourage customers to use less energy during peak times, when overall electrical demand is high. With unmanaged demand, usage during the peak demand period is not controlled and the facility owner may pay a high cost for energy used. (See Fig. 2.) Carrier's energy demand system allows facility managers to realize the benefits of demand management savings even if the HVAC equipment is not connected to a networked control system or building automation system.

The energy demand system enables the equipment in buildings to communicate and coordinate to minimize the number of units unnecessarily running concurrently, thereby reducing peak electrical demand. (See Fig. 3.)

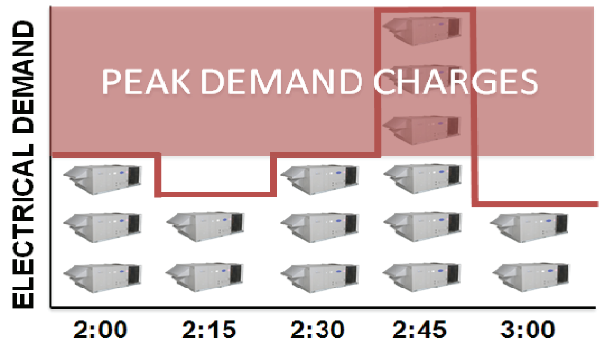


*Figure 2 – Unmanaged Demand*

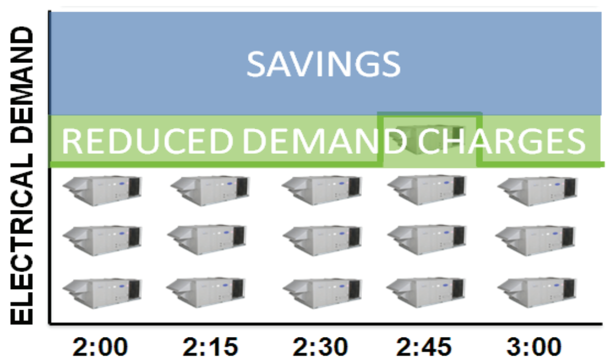


*Figure 3 – Demand Management with the Energy Demand System*

## Demand Response

The ability of the energy demand system to turn individual units on and off according to each unit's duty cycle is a unique feature that provides an advantage over other demand response methods.

Utilities frequently offer incentives to customers who are willing to enroll in demand response programs. Participating customers receive a request to reduce electrical demand at times when overall demand is high and grid reliability is in jeopardy. To achieve this reduction for RTUs using traditional demand response mechanisms, temperature set points are increased by several degrees or RTUs are entirely powered off. After the RTUs are powered off, a very quick rise in temperature and humidity is observed. Furthermore, when the demand response event has ended, all of the HVAC units are likely to turn on simultaneously once normal set points are resumed (known as a post-demand response event rebound). This can result in a new peak demand being set.

With the energy demand system, the energy demand gateway can receive information about grid events and take appropriate demand response action.

The energy demand system is OpenADR[4] compliant and can react directly to a signal dispatched from a utility, ISO/RTO or other entity using the OpenADR communication protocol. Each unit will experience a reduction in its duty cycle rather than all units turning off or on at the same time. Overall peak electrical demand and consumption will be reduced without a significant reduction in comfort. (See Fig. 4.) Following the event, the energy demand system enables the units to coordinate and provide an intelligent restoration of units, thereby reducing the change of a post-demand response event rebound. In addition, valuable sub-metered data can be conveyed to the cloud service or web portal.

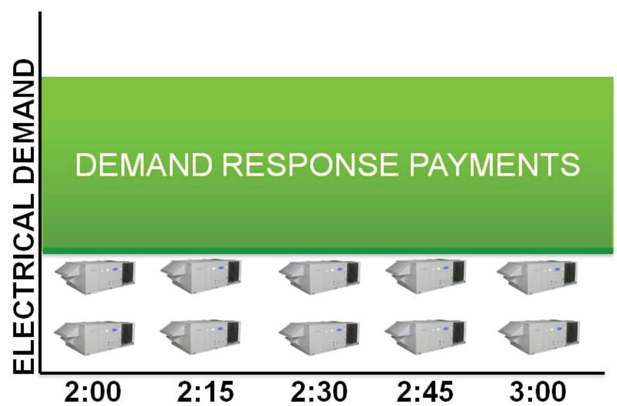


*Figure 4 – Demand Response with the Energy Demand System*

## Unit Scheduling

As mentioned previously, programmable thermostat schedules can be overridden and adjusted locally without the knowledge of facility managers, thereby causing units to operate during undesired periods. With the energy demand system, facility managers can generate customized schedules for individual RTUs via a user-friendly graphic calendar within a web portal. These schedules can eliminate unnecessary unit operation during overnight periods or simply reduce the unit duty cycle. This basic concept can provide additional savings and eliminate wasted energy consumption.

### Data Collection

A valuable feature of the energy demand system is the ability to collect consumption and peak operating data from each unit. A wireless signal uploads data from each unit to a cloud service or web portal. With this data, it is possible to profile the load over time to ascertain load failures or even load maintenance requirements.

Consider an RTU that normally consumes at a peak rate of 10 kW. Over time, if this peak consumption rate begins to increase, it may be an indication that the unit may require servicing due to a possibly failing compressor or clogged air filters. The availability of this data allows HVAC service firms to proactively manage their customer's HVAC assets and to take preventative actions before failures occur.

## ENERGY SAVINGS WITH THE ENERGY DEMAND SYSTEM

Energy savings is affected by several variables. Some of the basic elements we must take into consideration when calculating annual energy savings include:

- Operating condition of each RTU
- Existing operational cost of each RTU
- Existing utility costs, both supply (kWh) and demand (kW)
- Energy services including demand response, incentives, and similar ancillary services

Below is an example of the energy savings that may be achieved in 12 to 24 months.

**Table 1 – Sample Energy Savings Achieved with the Energy Demand System**

| SAMPLE FACILITY | | | |
|---|---|---|---|
| **SITE EQUIPMENT** | **Number of RTUs** | **Tonnage per RTU** | **Total Tonnage** |
| | 15 | 20 | 300 |
| **DEMAND MANAGEMENT SAVINGS** | **Annual Reduction** | **Annual Savings** | **Total Annual Savings: $10,940*** |
| | 20% or 234 kW | $3,510 | |
| **CONSUMPTION SAVINGS** | **Annual Reduction** | **Annual Savings** | |
| | 10% or 74,304 | $7,430 | |

*Based on 5-month cooling season and utility rates of $15/kW (peak demand) and $0.10/kWh (standard consumption).

## SUMMARY

Utilities are facing significant challenges with regard to reliable supply and delivery of energy. These challenges provide opportunities for energy and cost savings through demand management.

Carrier's energy demand system creates a wireless network of rooftop units with energy demand modules communicating through the energy demand gateway.

The energy demand system provides a unique solution for facilities with 6 or more rooftop units and positions building owners to take full advantage of demand response programs.

The features of the energy demand system are summarized below:

- No additional staff required to monitor system
- Addition or removal of a demand module will cause the network to rebalance in short term with no human intervention or oversight required
- Once installed and commissioned, no user intervention is required
- Reduction in peak demand and energy costs
- Consumption and peak data may be tracked and analyzed

By enabling an automated process for managing energy usage, Carrier's energy demand system provides cost benefits to facility owners while helping to reduce pressures on utilities and conserve resources.

References

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