Waldbaum's Supermarket Data Integrator Notes

The Waldbaum's Combined Heat and Power (CHP) system consists of a Capstone 60kW Microturbine and a Unifin Heat Exchanger for heat recovery. The heat recovered from the turbine exhaust is connected to a Munters air-handling unit (AHU) by a glycol loop. The Munters unit can use the heat recovered from the turbine as either the first-stage of heating for the store or to provide dehumidification. CHP data at this site is collected and managed by CDH Energy Corp.

[Note: Details about the data collection system, system outages and site events can be found in the Waldbaum's Supermarket Final Report]

Data Point Details

The data at this site is collected by a Campbell CR-10x and a Veris E-server Datalogger. The data is collected on a 15-minute interval and then made into hourly data for the online database. The data is summed, averaged or the maximum value is taken over the four 15-minute records constituting a single hourly record. Pages 9 through 11 of the Final Report summarize the Data Acquisition System.

The following data points are monitored directly on a 15-minute interval and then formed into hourly data:

- DG/CHP Generator Output (total kWh)
- DG/CHP Generator Output Demand (peak kW)
- DG/CHP Generator Gas Input (total cubic feet)
- Ambient Temperature (avg °F)

The following points are calculated:

Total Facility Purchased Energy (total kWh) and Demand (peak kW)
There are two power transducers installed on the main service of the supermarket. The 15-minute max demand is recorded for each transducer and summed for the Total Building Demand. The max 15-minute demand during an hour is used for the hourly online database. The energy is accumulated during the 15-minute interval for both transducers and is summed hourly for the Total Building Energy.

Other Facility Gas Use (total cubic feet)
Gas Use was measured for one large Munters Air-Handling Unit (AHU) at this site. Gas Use was not measured for Domestic Hot Water, the four smaller rooftop units and any cooking processes. These processes, which were not measured, have much lower gas use than the AHU therefore the AHU gas use is a reasonable approximation of the building gas use. The AHU gas use data was summed into hourly data for the Facility Gas Use in the online database.

Total Facility Energy (total kWh) and Total Facility Demand (peak kW)
These two data points are the sums of the DG/CHP Generator Output and Total Facility Purchased data points from the online database.

Useful and Unused Heat Recovery (total MBtu/h)
The Total Heat Recovery is integrated by the onsite Campbell Datalogger. The inlet and outlet temperature from the Unifin Heat Exchanger along with the flow rate of the Glycol Loop is integrated on a 5-second interval. The status of the regeneration wheel and the space heating coil are used to assign the heat recovery as useful or unused for the 5-second interval and then summed into the 15-minute data. The 15-minute data is summed into the hourly database.

Status/Runtime of DG/CHP Generator (total hrs)
The turbine is defined as being fully on for a 15-minute interval if the turbine output is greater than 45 kW for the period (the fully-loaded capacity is 60 kW). The status is given a value of 0.25 for the interval if the generator output is above 45 kW and the generator output is divided by 45 kW if it is below for fractional runtime. The 15-minute data is then summed into hourly data for the online database.

Total CHP Efficiency (%)
The Total CHP Efficiency is calculated from the online hourly database as the sum of the Useful Heat Recovery and the DG/CHP Generator Output, converted from kWh to MBtus, divided by the DG/CHP Generator Gas Input. The gas input is converted to MBtus using the Lower Heating Value (LHV) of the fuel which is 0.913 MBtu/cubic foot (Natural Gas) from testing conducted on Natural Gas samples at the site.

Electrical Efficiency (%)
The Electrical Efficiency is calculated from the online hourly database as the DG/CHP Generator Output, converted from kWh to MBtus, divided by the DG/CHP Generator Gas Input. The gas input is converted to MBtus using the Lower Heating Value (LHV) of the fuel which is 0.913 MBtu/cubic foot (Natural Gas) from testing conducted on Natural Gas samples at the site.

Data Quality Checks

The Data Quality Checks consist of three levels of verification: does the data exist, does the data pass reasonable range checking and does the data pass relational checks. The methodology for applying the data quality begins by creating a contiguous database. This is necessary to maintain compatibility between the many sites on the server. Next, the data received for this site is fit into the database, in this case we are using 15-minute data. For any period where there is data, the data quality level is set to 3 for “Passes Relational Checks”. We then work backwards to identify data that does not meet Relational and/or Range Checking.

The next step is to apply the relational checks. Relational checks attempt to identify data which is uncorroborated by the rest of the data set. For instance, data received indicating a DG/CHP Generator output when the gas use is zero is suspect. For data failing a relational check, the data quality level is set to 2 for “Data Passes Range Checks”.

The last step is evaluating the range checks. The range checks consist of reasonable high and low values based on facility and DG/CHP Generator information. Data that falls outside the defined range for the database value has its data quality level set to 1 for “Data Exists.”

It is necessary to work backwards when applying data quality checks to insure that data gets set to the lowest applicable data quality level. It is possible for data to pass the relational check and fail the range check and such data will be set to a data quality level of 1 for "Data Exists."

Table 1. Data Quality Definitions

Data Quality Levels	Description	Definition
3	Passes Relational Checking	This data passes Range Checks and Relational Checks. This is the highest quality data in the data set.
2	Passes Range Checks	This data passes the Range Checks but is uncorroborated by Relational Checks with other values.
1	Data Exists	This data does not pass Range Checks. This data is found to be suspect based on the facility and/or CHP equipment sizing.
0	Data Does Not Exist	This data is a placeholder for maintaining a contiguous database only.

Details on the Range and Relational Checks are found below.

Relational Checks

These checks are applied to the 15-minute data before it is converted to hourly data. If any of the 15-minute data points fails the relational check, the data for the entire hour is marked as failed.

Table 2. Relational Checks for Waldbaum's Supermarket

Evaluated Point	Criteria	Result
FG	WG > 10 and FG <=0	DQ Level for FG set to 2
WG_KW	WG_KW > 5 and WG = 0	DQ Level for WG_KW set to 2

Notes: FG – DG/CHP Generator Gas Use
WG – DG/CHP Generator Output
WG_KW – DG/CHP Generator Demand

Range Checks

These checks are applied to the 15-minute data before it is converted to hourly data. If any of the 15-minute data points fails the range check, the data for the entire hour is marked as failed.

Table 3. Range Checks for Waldbaum's Supermarket

Data Point	Hourly Data Method	Upper Range Check	Lower Range Check
DG/CHP Generator Output	Sum	15 kWh	0 kWh
DG/CHP Generator Output Demand	Maximum	60 kW	0 kW
DG/CHP Generator Gas Use	Sum	300 cubic feet	0 cubic feet
Total Facility Purchased Energy	Sum	150 kWh	0 kWh
Total Facility Purchased Demand	Maximum	600 kW	0 kW
Other Facility Gas Use	Sum	500 cubic feet	0 cubic feet
Unused Heat Recovery	Sum	125 MBtu	0 MBtu
Useful Heat Recovery	Sum	125 MBtu	0 MBtu
Status/Runtime of DG/CHP Generator	Sum	0.25 hrs	0 hrs
Ambient Temperature	Average	130°F	-30°F

Notes: Data failing the Range Check has the data quality level set to 1 for "Data Exists"

ASERTTI Protocol Adherence

This data at this adhered fully to the ASERTTI Long-Term Monitoring Protocol from August 29, 2002 through June 9, 2004 when most of the monitoring equipment was removed. All required performance parameters were collected. The data was sampled in five second intervals and averaged or summed into 15-minute intervals as per the protocol. In addition, most of the optional parameters were available at this site.

After June 9, 2004, the sensors necessary for calculating thermal energy recovered were removed. This also does not allow for calculation of thermal efficiency.

Monitoring Notes

August 29, 2002

Installation of monitoring equipment complete.

April 18, 2003

Interconnection agreement with Long Island Power Authority is signed and the Microturbine CHP System can begin operation.

October 26, 2003

One of the two power transducers on the main building service feed begins malfunctioning. The transducer no longer records energy use and the demand for the period. The peak demand for the interval is now used in place of the energy.

November 1, 2003

One of the two power transducers on the main building's service failed. A relationship was determined from available data for the magnitude of the failed meter from the correctly working meter. This relationship is now used to calculate the building power on the second power transducer.

June 9, 2004

Monitoring equipment was removed at this site except for the turbine gas use, turbine power and building power. The following points no longer have updated readings:

- Other Facility Gas Use
- Useful Heat Recovery
- Unused Heat Recovery
- Ambient Temperature

Additionally, the Total CHP Efficiency can no longer be calculated properly due to missing the Useful Heat Recovery value.

August 25, 2004

The remaining power transducer on the building main service failed. There is no Total Facility Purchased Power or Demand data from this date forward. Also, the Total Facility Power and Demand data cannot be calculated properly due to this missing data.