Matlink Farm Data Integrator Notes

Matlink Farm's combined heat and power (CHP) system consists of a 145 kW Waukesha engine running on biogas. Heat is recovered from the engine using plate and frame heat exchangers. The heat recovery is used for hot water and to heat the digester. Data for this site is collected by Connected Energy and provided daily to CDH Energy.

Data Point Details

The data at this site is provided by Connected Energy in the form of comma-separated value (CSV) files. There is one file for each day containing 15-minute timestep data for 91 data points. From these 15 minute values, the hourly database is formed. It is unclear whether the 15-minute data is sampled or averaged across the interval. It is also unclear whether the heat recovery rates are integrated across the 15-minute interval, averaged or sampled. The details for each individual data point are outlined below.

The timestamp in the raw data files is in Eastern Local Time. This means it obeys the Standard to Daylight savings times rules for the Eastern timezone. For display purposes, we convert the timestamp from Local Time to Eastern Standard Time for all graphical figures on the website. This means that during the Daylight Savings Time period from the first Sunday in April until the last Sunday in October the monitored data plots, CSV output and standardized PDF reports are in Eastern Standard Time and do not obey Daylight Savings time rules. Presenting data in Standard Time throughout the year is common practice for graphical time series plotting because it eliminates skipping an hour in April and duplicating an hour in October.

DG/CHP Generator Output (total kWh)
The data for Generator Output comes from an accumulator of energy use throughout the day. The column of origin for this data point is labeled "Generator Cumulative Power" in the data files received from Connected Energy. The difference between consecutive records is calculated for the energy use during the interval. This 15-minute interval energy data is summed into hourly data.

DG/CHP Generator Output Demand (peak kW)
The Generator Output Demand comes from 15-minute data. The column of origin for this data point is labeled "Generator Real Power" in the data files received from Connected Energy. The maximum for a given hour is assigned to the hourly database.

DG/CHP Generator Gas Input (cubic feet)
The data for Generator Gas Input comes from an accumulator of gas use throughout the day. The column of origin for this data point is labeled "BioGas to Engine Bldg Cumul" in the data files received from Connected Energy. The difference between consecutive records is calculated for the gas use during the interval. This 15-minute interval gas data is summed into hourly data.

Total Facility Purchased Energy (total kWh)
The data for Facility Purchased Energy comes from two accumulators of energy use throughout the day. The columns of origin for this data point are labeled "Grid Energy to Farm Cumul" and "Grid Energy from Farm Cumul" in the data files received from Connected Energy. The

difference between consecutive records is calculated for the energy use during the interval. The difference between the energy to the farm and from the farm is calculated for the 15-minute interval energy data, which is then summed into hourly data.

Total Facility Purchased Demand (peak kW)
The Facility Purchased Demand comes from 15-minute data for demand from the grid to the farm and from the farm to the grid. The columns of origin for this data point are labeled "Grid Power to Farm" and "Grid Power from Farm" in the data files received from Connected Energy. The difference between the demand to the farm and from the farm is calculated for the 15-minute interval demand data and then maximum for a given hour is assigned to the hourly database.

Other Facility Gas Use (cubic feet)
There is no data available for this data point from the Connected Energy data.

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.

Unused Heat Recovery (total MBtu/h)
The Unused Heat Recovery comes from 15-minute. The column of origin for this data point is labeled "Dump Cooler Heat Dump Rate" in the data files received from Connected Energy. The heat recovery rate is converted to energy for the 15-minute interval. The heat recovery values from the 15-minute data during an hour are summed for the Unused Heat Recovery Rate in the online database.

Useful Heat Recovery (total MBtu/h)
The Useful Heat Recovery comes from 15-minute data. The column of origin for this data point is labeled "Utilized Heat Recovery Rate" in the data files received from Connected Energy. The heat recovery rate is converted to energy for the 15-minute interval. The heat recovery values from the 15-minute data during an hour are summed for the Useful Heat Recovery Rate in the online database.

Status/Runtime of DG/CHP Generator (hrs)
The generators are defined as being fully on for a 15-minute interval if the generator output is greater than 100 kW for the period (the fully-loaded capacity is 145 kW). The status is given a value of 0.25 for the interval if the generator output is above 100 kW and the generator output is divided by 100 kW if it is below. The 15-minute data is then summed into hourly data for the online database.

Ambient Temperature (avg °F per hour)
The Ambient Temperature comes from 15-minute data. The column of origin for this data point is labeled "Ambient Temp" in the data files received from Connected Energy. The values from the 15-minute data are averaged across the hour for the Ambient Temperature in 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 0.600 MBtu/cubic foot (Digester Gas).

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 0.600 MBtu/cubic foot (DigesterGas).

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" or 1 for "Data Exists".

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. At this site we know that there are two separate pieces of equipment involved in the monitoring data. Columns from "BioGas Pct Methane" through "Cogen % of Farm Bldg Power" represent one piece of equipment that contains information for most of the data points. Columns from "Generator Voltage Ph. A" through "Count of Sub Intervals" represent data for the Engine Controller and contain data for the Generator Output and Generator Output Demand. When there is a failure to obtain new data, the data set repeats the old value. We can identify this bad data through a relational check for repeating data on the two pieces of equipment separately. We are using thresholds of 50% and 80% because some value reset to zero during the repeating periods.

Table 2. Relational Checks for Matlink Farm

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
WG, WG_KW	> 80% of columns "Generator Voltage Ph. A" through "Count of Sub Intervals" repeat previous data record	DQ Level for WG_KW and WG set to 1
FG, WT, WT_KW, QHR, QHD, SG, TAO	> 50% of columns "BioGas Pct Methane" through "Cogen % of Farm Bldg Power" repeat previous data record	DQ Level for FG, WT, WT_KW, QHR, QHD, SG and TAO set to 1

Notes: FG – DG/CHP Generator Gas Use
WG – DG/CHP Generator Output
WG_KW – DG/CHP Generator Demand
WT – Total Facility Purchased Energy
WT_KW – Total Facility Purchased Demand

QHR – Useful Heat Recovery
QHD – Unused Heat Recovery
SG – Status/Runtime of the DG/CHP Generator
TAO – Ambient Temperature

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 Matlink Farm

Data Point	Hourly Data Method	Upper Range Check	Lower Range Check
DG/CHP Generator Output	Sum	40 kWh	0 kWh
DG/CHP Generator Output Demand	Maximum	160 kW	0 kW
DG/CHP Generator Gas Use	Sum	1200 cubic feet	0 cubic feet
Total Facility Purchased Energy	Sum	125 kWh	0 kWh
Total Facility Purchased Demand	Maximum	500 kW	0 kW
Other Facility Gas Use	Sum	N/A	N/A
Unused Heat Recovery	Sum	450 MBtu	0 MBtu
Useful Heat Recovery	Sum	450 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 site adhered fully to the ASERTTI Long-Term Monitoring Protocol. All required performance parameters were collected. The data is sampled and then averaged or summed into 15-minute intervals as per the protocol. In addition, most of the optional parameters are available at this site.

Monitoring Notes

July 13, 2005

We begin receiving data files from Connected Energy.

July 16, 2005

A thunderstorm damaged some equipment at the site, including the engine controller. We are continuing to receive data daily however the data has not updated since this date.