

National Fuel Gas Data Integrator Notes

This site is a residential fuel cell demonstration sponsored by National Fuel Gas. A 5 kW Natural Gas fuel cell provides electricity for use at the residence or export to the utility grid. Heat is recovered from the cell for domestic hot water and to boiler pre-heat. Data for this site is collected by Connected Energy and provided 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 301 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 a 15-minute average for fuel cell demand. The column of origin for this data point is labeled “Fuel Cell Power” in the data files received from Connected Energy. This 15-minute interval demand data is converted to energy and then summed into hourly data.

DG/CHP Generator Output Demand (peak kW)

The data for Generator Output Demand comes from a 15-minute average for fuel cell demand. The column of origin for this data point is labeled “Fuel Cell 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 a 15-minute total for gas. The column of origin for this data point is labeled “Natural Gas to Fuel Cell Flow” in the data files received from Connected Energy. The data in the column is in units of CFM and is converted to total cubic feet by multiplying the values by 15 minutes. The 15-minute interval gas data is then summed into hourly data.

Total Facility Purchased Energy (total kWh)

The data for Facility Purchased Energy comes from a 15-minute average for electric demand import. The column of origin for this data point is labeled “Electric Grid Feed” in the data files

received from Connected Energy. This 15-minute interval demand data is converted to energy and then summed into hourly data.

Total Facility Purchased Demand (peak kW)

The data for Facility Purchased Demand comes from a 15-minute average for electric demand import. The column of origin for this data point is labeled “Electric Grid Feed” in the data files received from Connected Energy. The maximum for a given hour is assigned to the hourly database.

Other Facility Gas Use (cubic feet)

The data for Facility Gas Use comes from a 15-minute total for gas. The column of origin for this data point is labeled “Total House Gas Consumption” in the data files received from Connected Energy. Based on calculations for fuel cell electrical efficiency, we believe all the gas data in the files requires a multiplier of 10 cubic feet. The 15-minute interval gas data is multiplied by 10 and then summed into hourly data.

Total Facility Energy (total kWh) and Total Facility Demand (peak kW)

These two data points are the sum 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 data for the Total, Boiler and Domestic Hot Water (DHW) heat recovery rate. The columns of origin for this data point are labeled “Total Recovery Rate”, “Boiler Heat Recovery Rate” and “DHW Heater Heat Recovery Rate” in the data files received from Connected Energy. The heat recovery rates are converted to energy for the 15-minute interval. The boiler and heat recovery values are subtracted from the total heat recovery to calculate the total unused heat recovery. This 15-minute energy data is then summed into hourly data.

Useful Heat Recovery (total MBtu/h)

The Useful Heat Recovery comes from 15-minute data for the Boiler and Domestic Hot Water (DHW) heat recovery rate. The columns of origin for this data point are labeled “Boiler Heat Recovery Rate” and “DHW Heater Heat Recovery Rate” in the data files received from Connected Energy. The heat recovery rates are converted to energy for the 15-minute interval. The boiler and heat recovery values are added to calculate the total useful heat recovery. This 15-minute energy data is then summed into hourly data.

Status/Runtime of DG/CHP Generator (hrs)

The fuel cell is defined as being fully on for a 15-minute interval if the fuel cell power is greater than 1.5 kW for the period (the fully-loaded capacity is 2.5-3 kW). The status is given a value of 0.25 if the generator output is above 1.5 kW and the generator output is divided by 1.5 kW if it is below. The 15-minute data is then summed into hourly data for the online database.

Ambient Temperature (avg °F)

The Ambient Temperature comes from 15-minute data. The column of origin for this data point is labeled “Temp. Outside Ambient” 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 0.930 MBtu/cubic foot (Natural 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 0.930 MBtu/cubic foot (Natural Gas).

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.

Table 2. Relational Checks for National Fuel

Evaluated Point	Criteria	Result
FG	$WG > 10$ and $FG \leq 0$	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 National Fuel

Data Point	Hourly Data Method	Upper Range Check	Lower Range Check
DG/CHP Generator Output	Sum	1.4 kWh	0 kWh
DG/CHP Generator Output Demand	Maximum	5.5 kW	0 kW
DG/CHP Generator Gas Use	Sum	25 cubic feet	0 cubic feet
Total Facility Purchased Energy	Sum	1.25 kWh	-2.5 kWh
Total Facility Purchased Demand	Maximum	5 kW	-10 kW
Other Facility Gas Use	Sum	30 cubic feet	0 cubic feet
Unused Heat Recovery	Sum	20 MBtu	0 MBtu
Useful Heat Recovery	Sum	20 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 adheres fully to the ASERTTI Long-Term Monitoring Protocol. All required performance parameters are being 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 22, 2005

We received data files from Connected Energy for the period from June 24 – July 28, 2004.

July 26, 2005

We received data files from Connected Energy for the period from July 29 – August 24, 2004.

July 27, 2005

We received data files from Connected Energy for the period from August 25 – September 21, 2004.

July 28, 2005

We received data files from Connected Energy for the period from September 22 – October 19, 2004.

July 29, 2005

We received data files from Connected Energy for the period from October 20 – November 16, 2004.

July 30, 2005

We received data files from Connected Energy for the period from November 17 – December 14, 2004.

July 31, 2005

We received data files from Connected Energy for the period from December 15, 2004 – January 11, 2005.

August 1, 2005

We received data files from Connected Energy for the period from January 12 – February 8, 2005.

August 2, 2005

We received data files from Connected Energy for the period from February 9 – March 8, 2005.

August 3, 2005

We received data files from Connected Energy for the period from March 8 – April 5, 2005.

August 4, 2005

We received data files from Connected Energy for the period from April 6 – May 4, 2005.