

## Ultraflex - MV2 Final Data Summary

The Ultraflex CHP site concluded MV2 on May 26, 2013. As a final check on the system measured data, overall trends in the fundamental temperature, flow, power and gas use data were compared between MV1 and MV2 to determine if a closeout verification of the field sensors are necessary. All field sensors were verified at the time of M&V installation in June 2011, when system flow, temperatures, and power generation were compared to independent readings from handheld sensors or manual meter readings. These initial verification measurements were documented in the revised M&V plan dated April 2011.

For the purposes of incentive evaluation, the following periods were examined.

Table 1. MV Periods

Period	Start Date	End Date
MV1	May 26, 2011	May 25, 2012
MV2	May 26, 2012	May 25, 2013

### Power Generation

Full load gross CHP generation for the system is 300 kW. The data logger measures net power (gross minus parasitic). Maximum net power generation across both MV1 and MV2 periods are consistently near 290 kW. At installation, the net generation measurement (WGnet) was determined to be within 0.8% of the manual power reading. With no change in the maximum power pattern observed in MV1 or MV2 indicating measurement deviation, the power data for both periods are considered valid.

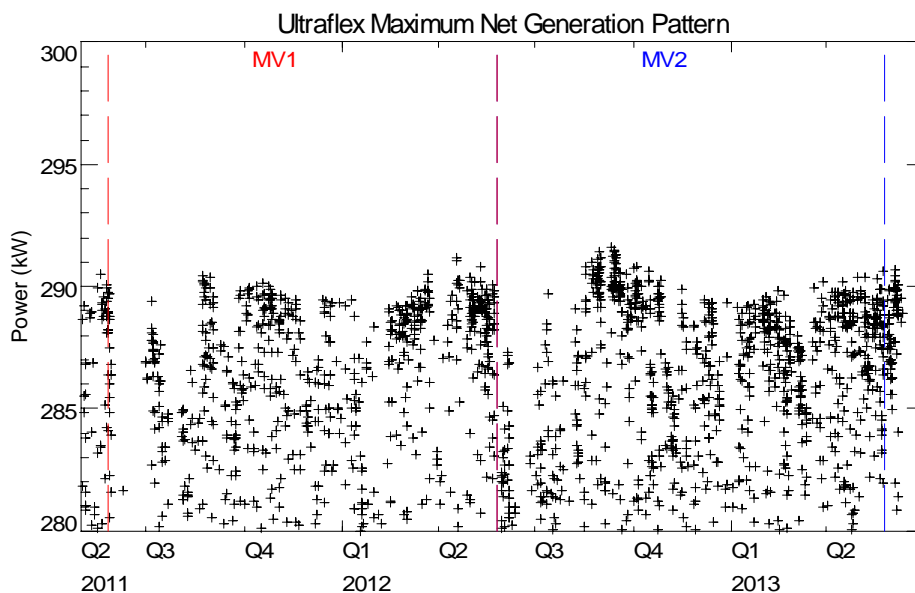


Figure 1. Maximum Net Power Generation

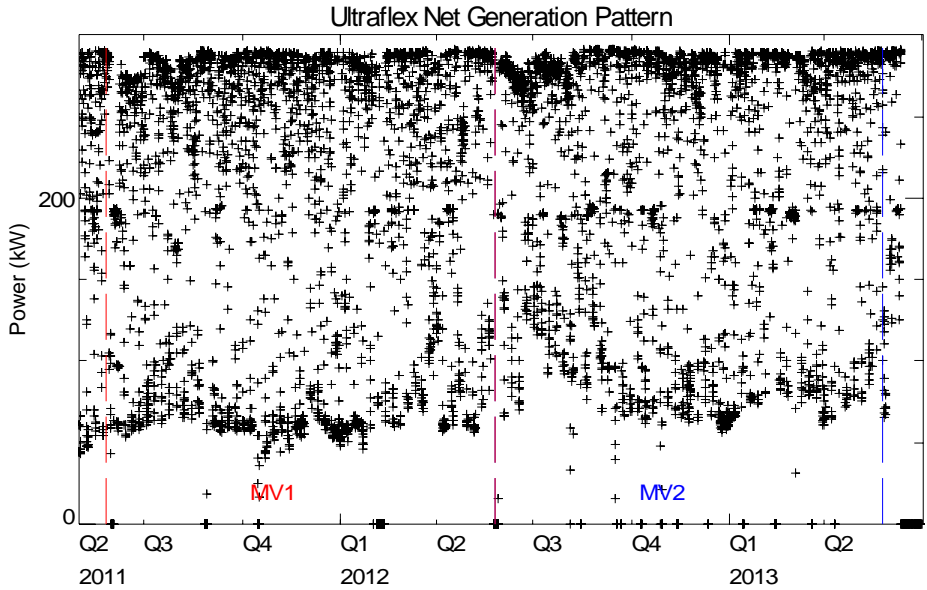


Figure 2. Overall Net Power Generation Patterns

**Gas Consumption**

Gas consumption for the three CHP units has a nominal rating of 3,900 CFH at full load. The monitored data has consistently displayed gas consumption levels at peak generation between 3,600 SCFH and 3,900 SCFH.

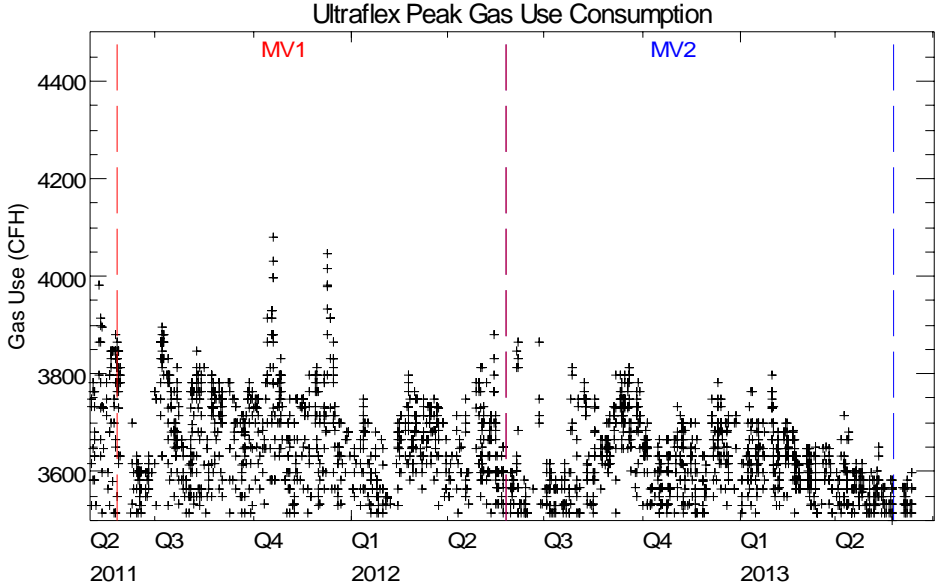
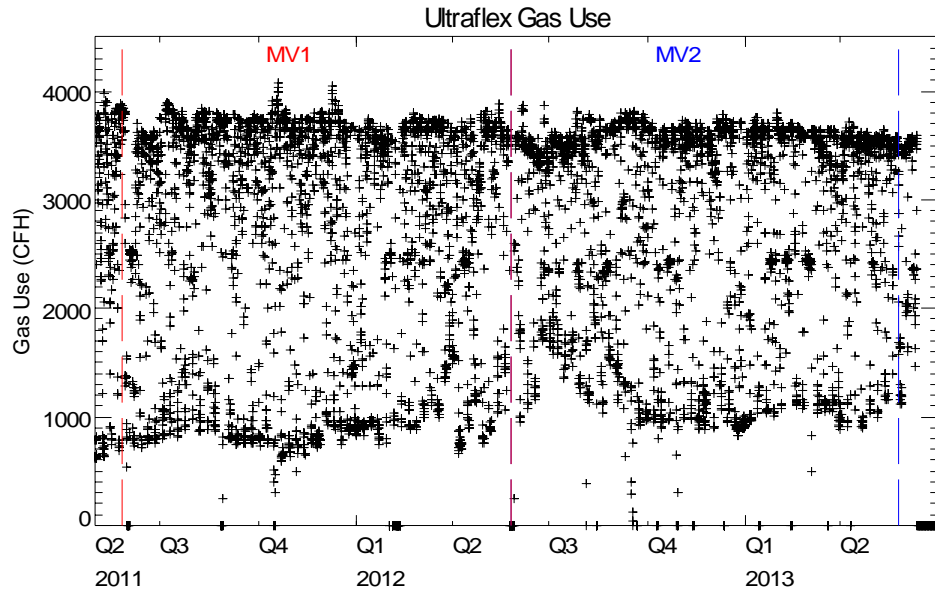
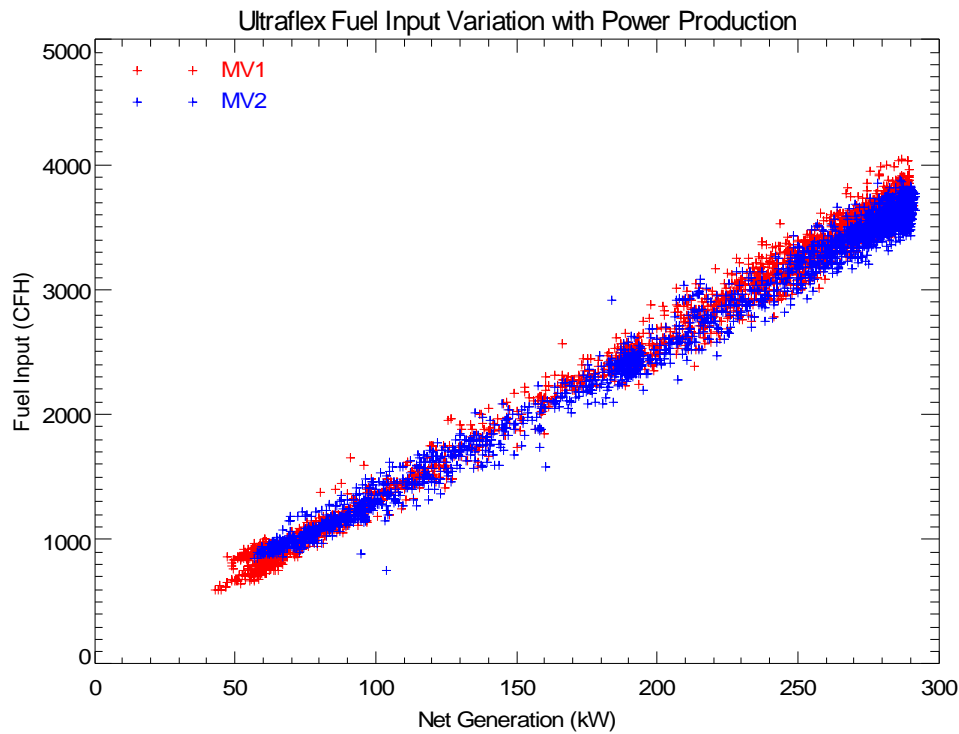


Figure 3. Maximum Gas Consumption



**Figure 4. Overall Gas Consumption Patterns**

Comparing CHP gas consumption to power generation for the two periods displays a linear trend of fuel consumption with power production. The trend is comparable between both MV1 and MV2 periods, validating gas use across both periods.

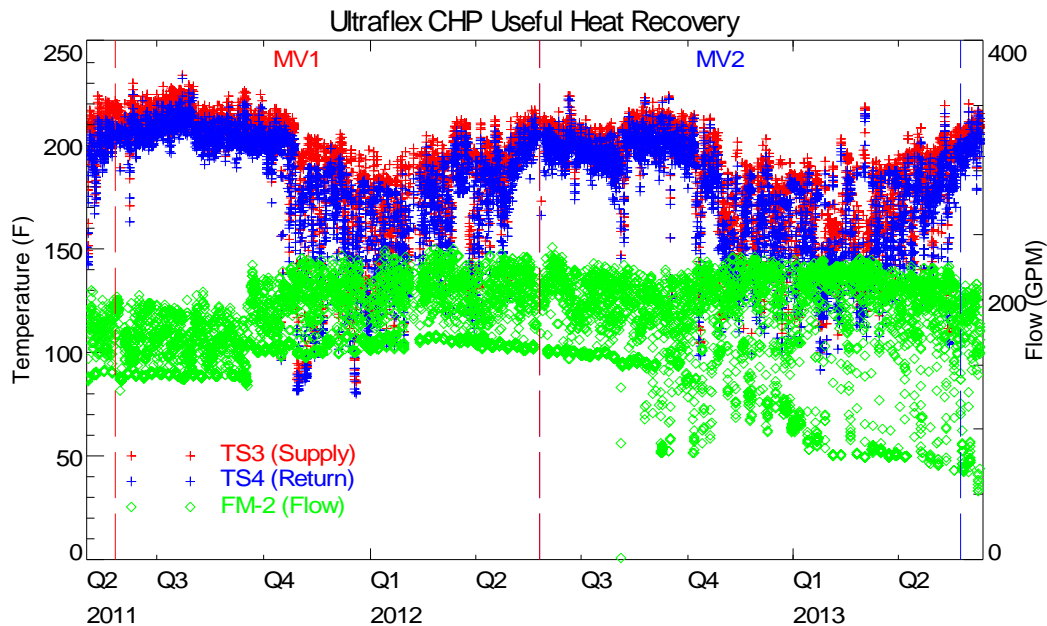


**Figure 5. Gas Consumption vs Power Generation Trend**

## Useful Thermal Measurements

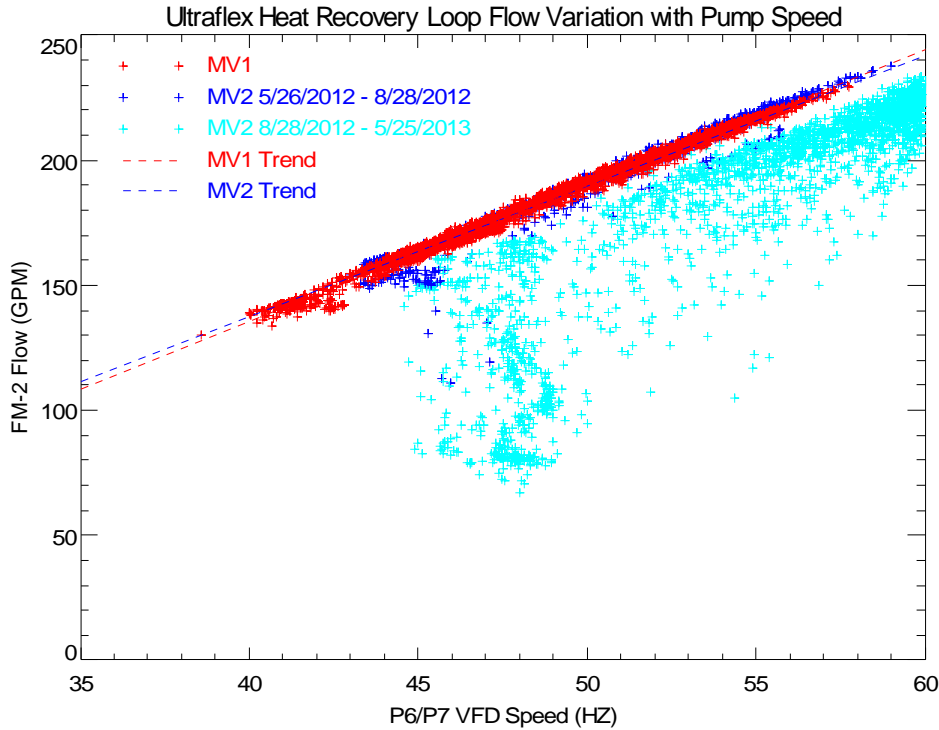
Useful thermal measurements are based on the flow and temperature difference measured at main CHP loop output to the thermal loads (FM-2, TS-3, TS-4 on Drawing M-301.00). The CHP system has typically provided up to a 220°F supply temperature for the heat recovery loads, at a variable flow rate. A distinct change in maximum system flow was observed in 2011-Q3 during MV1, and this increase in maximum flow has persisted into and throughout MV2. This increase in maximum flow may indicate additional heat recovery loads were added to the system during MV1.

The system minimum flow has decreased during MV2. Due to the variable flow nature of the heat recovery system, it is unclear if this indicates heat recovery loads have two-way valves that shut down flow when unneeded. It also may indicate that the flow meter turbine is starting to stick at low flows, and may need service.



**Figure 6. Heat Recovery Measurement Trends**

Further evidence of the flow meter degrading was observed when examining the variation of measured flow with pump speed. During all of MV1 and the beginning of MV2, flow varied linearly with pump speed, and produced similar trends during both periods. After August 28, 2012, flow begins to deviate from the tightly defined trend previously observed, particularly at lower pump speeds. This slow degradation of the flow meter at low flow rates mostly likely would not be detected by additional one-time measurements.



**Figure 7. Heat Recovery Loop Flow Variation with Pump Speed**

If the heat recovery flow had not displayed the observed flow reduction, useful heat transfer would have increased from 7,809 MMBtu in MV2 to 8,609 MMBtu. This increase in useful heat transfer would have increased the annual FCE for MV2 to 68.3% LHV. This change is mostly irrelevant, as the performance observed in MV2 met all program performance requirements. This change would not impact the MV1 performance observed.

**Table 2. Impact of Flow Reduction on FCE**

	<b>MV2</b>	<b>MV2 with increased flow</b>
WGnet (kWh)	1,850,423	1,850,423
QU (MMBtu)	7,809	8,609
FG (MMBtu HHV)	24,278	24,278
FCE (% LHV)	65.4%	68.3%

Comparison of the minimum temperature difference between TS3 and TS4 indicate that the temperature offset between the two sensors is stable across both the MV1 and MV2 periods, with a minimum temperature difference of  $\pm 1.5^{\circ}\text{F}$ . Periods where reverse heat transfer were measured ( $\text{TS4} > \text{TS3}$ ) are set to zero and occur less than 1% of all records across the entire two year MV1/MV2 duration. No adjustment to the temperature data are recommended in the final performance calculations.

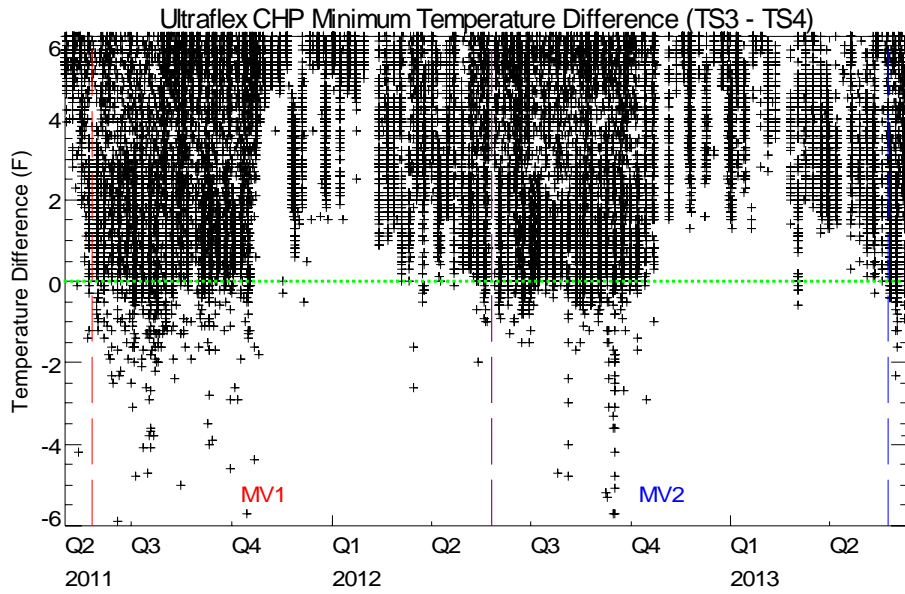


Figure 8. Minimum Heat Recovery Temperature Difference

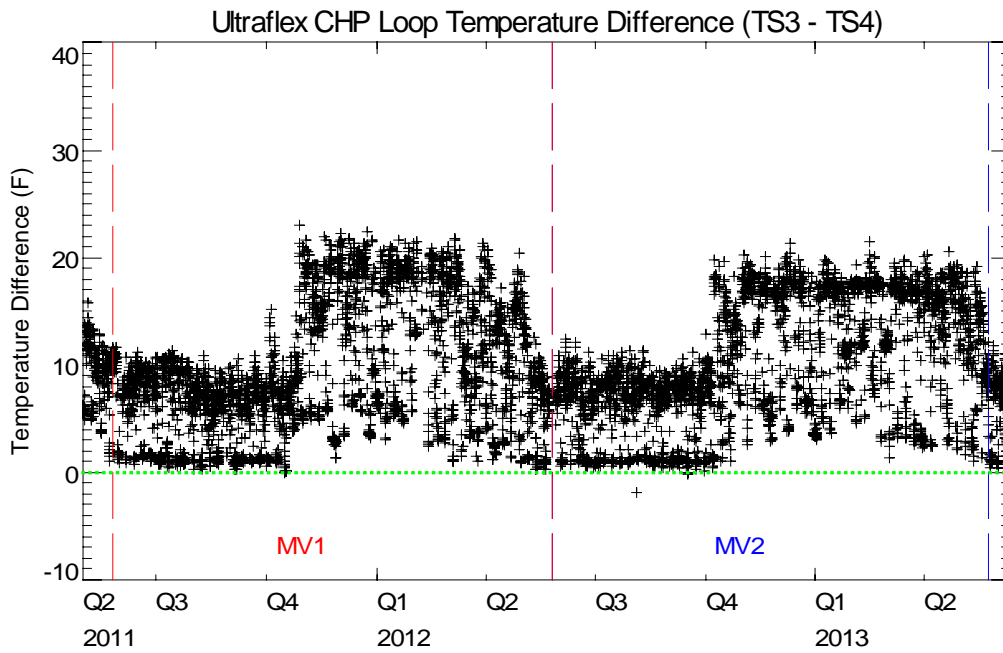


Figure 9. Overall Heat Recovery Temperature Difference

## **Conclusions**

The data collected across both MV1 and MV2 accurately capture the performance of the CHP system. Data from the heat recovery flow meter during MV2 indicated that this flow meter may be in the early stages of fouling, and requires service for continued use. The discrepancy in the flow measurement resulted in an estimated 10% reduction in the heat recovery measurement during MV2. This reduction in heat recovery did impact the measured FCE of the CHP system during MV2, but did not have an impact on the system meeting the overall program goals of  $PR > 0.6$ , and  $FCE \%LHV > 60\%$ .



CLIENT INFORMATION

REVISIONS

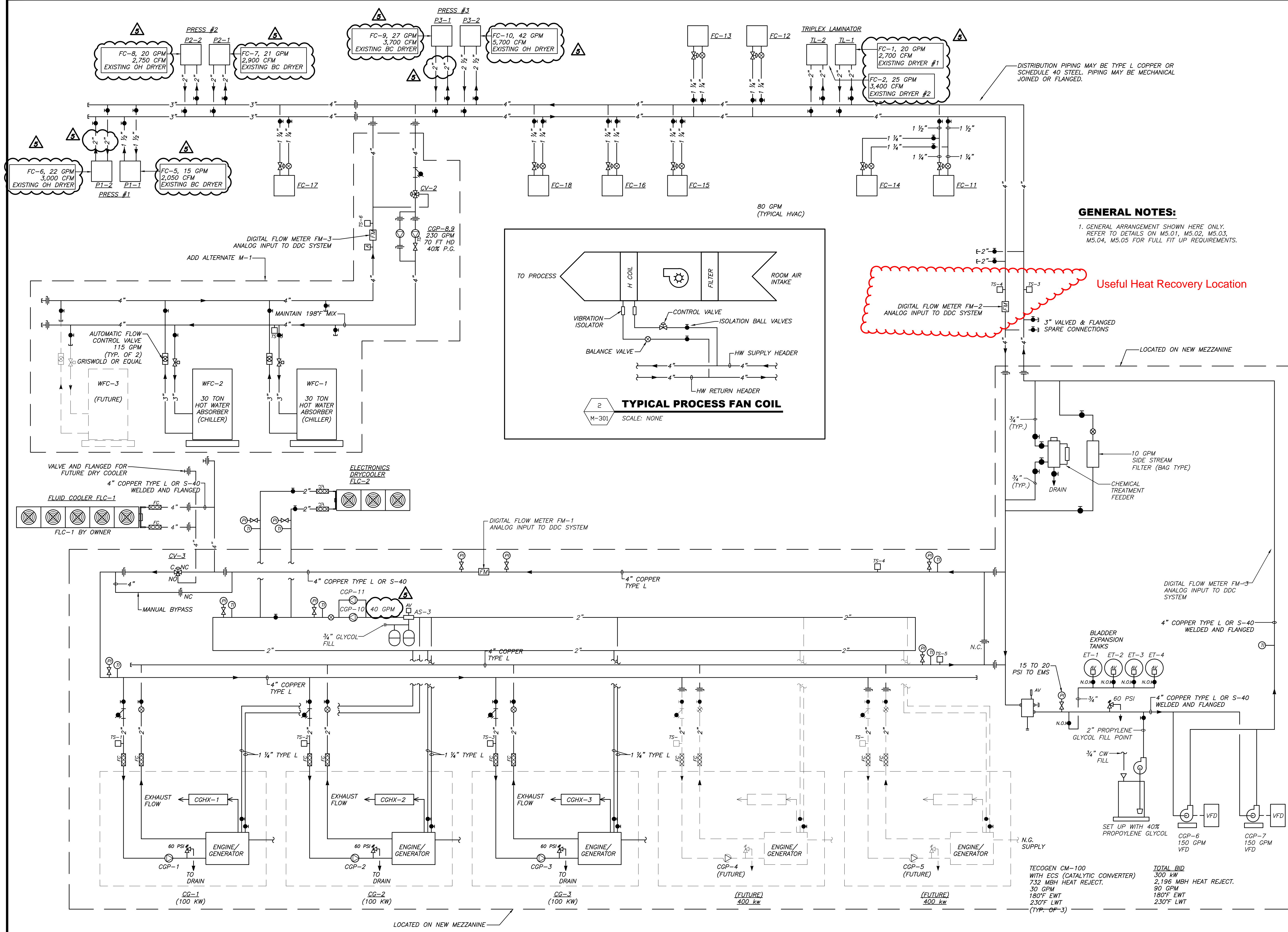
NO.	DATE	DESCRIPTION
1	3/11/09	ISSUED FOR BID
2	3/18/09	ADDENDUM #1
3	8/31/09	ISSUED TO DOB
4	11/13/09	UPDATED ELECTRONICS COOLER
5	12/22/09	UPDATED GPM AND CFM

ULTRA FLEX PACKAGING CORP.  
COMBINED HEAT AND POWER PLANT

PROJECT NAME  
SCALE PHASE  
**CHP PLANT FLOW SCHEMATIC**

DRAWING TITLE

DATE: 3-6-2009
PROJECT No.: 08017
DRAWING BY: CLK
CHK BY: CV
DWG No:
<b>M-301.00</b>
CADD FILE No:
1 of 1



**GENERAL NOTES:**  
1. GENERAL ARRANGEMENT SHOWN HERE ONLY. REFER TO DETAILS ON M5.01, M5.02, M5.03, M5.04, M5.05 FOR FULL FIT UP REQUIREMENTS.

DISTRIBUTION PIPING MAY BE TYPE L COPPER OR SCHEDULE 40 STEEL. PIPING MAY BE MECHANICAL JOINED OR FLANGED.

**TYPICAL PROCESS FAN COIL**  
SCALE: NONE

Useful Heat Recovery Location

LOCATED ON NEW MEZZANINE

DIGITAL FLOW METER FM-3  
ANALOG INPUT TO DDC SYSTEM

BLADDER EXPANSION TANKS  
ET-1 ET-2 ET-3 ET-4  
N.O. N.O. N.O. N.O.

2" PROPYLENE GLYCOL FILL POINT  
3/4" CW FILL

TECOEN CM-100 WITH ECS (CATALYTIC CONVERTER)  
732 MBH HEAT REJECT.  
30 GPM 180°F EWT 230°F LWT (TYP. OF-3)

TOTAL BID  
300 kW  
2,196 MBH HEAT REJECT.  
90 GPM 180°F EWT 230°F LWT

**CHP PLANT FLOW SCHEMATIC**  
M-301.00



## Ultra Flex CHP Performance Summary

<b>System Description</b>	<b>DEA</b>	<b>PIR</b>	<b>M&amp;V 1 (Year Ending 5/26/12)</b>	<b>M&amp;V 2 (Year Ending 5/26/13)</b>
Nameplate kW	300 kW	300 kW	300 kW	300 kW
Applicable Incentive Cap	\$750 /kW	\$750 /kW	\$750 /kW	\$750 /kW
Reported Project Cost	\$1,141,350	\$1,141,350	\$1,141,350	\$1,141,350

<b>System Performance</b>	<b>Energy Flow</b>	<b>Incentive Value</b>	<b>Energy Flow</b>	<b>Incentive Value</b>	<b>Energy Flow</b>	<b>Incentive Value</b>	<b>Energy Flow</b>	<b>Incentive Value</b>
Fuel Consumption (MMBtu - HHV)	22,640		22,640		22,919		24,278	
Heat Recovery (MMBtu)	7,350		7,350		7,105		7,809	
Generated Energy Output (kWh)	1,663,910	\$166,391.00	1,663,910	\$166,391.00	1,697,710	\$169,770.96	1,850,423	\$185,042.29
Fuel Conversion Eff (% LHV)	63.9%		63.9%		63.7%		65.4%	
kWp Achieved (kW)	n/a		n/a		260	\$195,000.00	256	\$184,396.80
Specified kWspc (kW)	260	\$195,000.00	260	\$195,000.00	260		260	
Power Ratio (kWp/kWspc)	n/a		n/a		1.00		0.98	
Total Performance Based Incentive		\$361,391.00		\$361,391.00		\$364,770.96		\$369,439.09
Maximum Incentive (with Cap)		\$570,675.00		\$570,675.00		\$570,675.00		\$570,675.00
Applied Incentive		\$361,391.00		\$361,391.00		\$361,391.00		\$361,391.00

<b>PIR Payment (40%)</b>		\$144,556.40		\$144,556.40		\$144,556.40
<b>MV1 Payment</b>		\$0		\$108,417.30		\$108,417.30
<b>MV2 Payment</b>		\$0		n/a		\$108,417.30
<b>Total Incentive Payment</b>		\$144,556.40		\$252,973.70		\$361,391.00
<b>Balance Remaining</b>		\$216,834.60		\$108,417.30		\$0.00

### Comments (Year 1):

- Actual demand reduction (kWp) based on 768 hours in period and recorded electrical output of 199,437 kWh (96.6% level 3 data).
- FCE reported on 91.4% coincident level 3 data for net electric output, useful heat recovery and fuel input.

### Comments (Year 2):

- Actual demand reduction (kWp) based on 774 hours in period and recorded electrical output of 198,411 kWh (95.7% level 3 data).
- FCE reported on 93.5% coincident level 3 data for net electric output, useful heat recovery and fuel input.

<b>Final Incentive Breakdown</b>	
<b>PIR</b>	\$144,556.40
<b>MV1</b>	\$108,417.30
<b>MV2</b>	\$108,417.30
<b>Total</b>	\$361,391.00
<b>Unclaimed</b>	\$0.00