Results of Vertical Drain Water Heat Recovery Phase Two Lab Testing and Data Analysis

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Introduction

This project was undertaken as a continuation of Davis Energy Group's (DEG) and Pacific Gas and Electric Company (PG&E) Applied Technology Services (ATS) lab prior work on vertical drain water heat recovery (DWHR) units. The previous project focused on creating an initial algorithm, and estimating the potential savings if used in single family Californian homes. The objectives of this project were designed to assist NegaWatt Consulting in writing a Codes and Standards Enhancement (CASE) report for including vertical DWHR units in Title 24. The objectives of this project are listed below:

- Test multiple units and compare their performance,
- Create a generic algorithm for inclusion in Title 24, and
- Identify what installation characteristics ensure good performance.

Description of the Laboratory

Testing was performed in the ATS lab. The lab was modified from Phase 1 to enable better control of inlet water temperature, but most of the principles were the same. Figure 1 presents a schematic of the test apparatus.

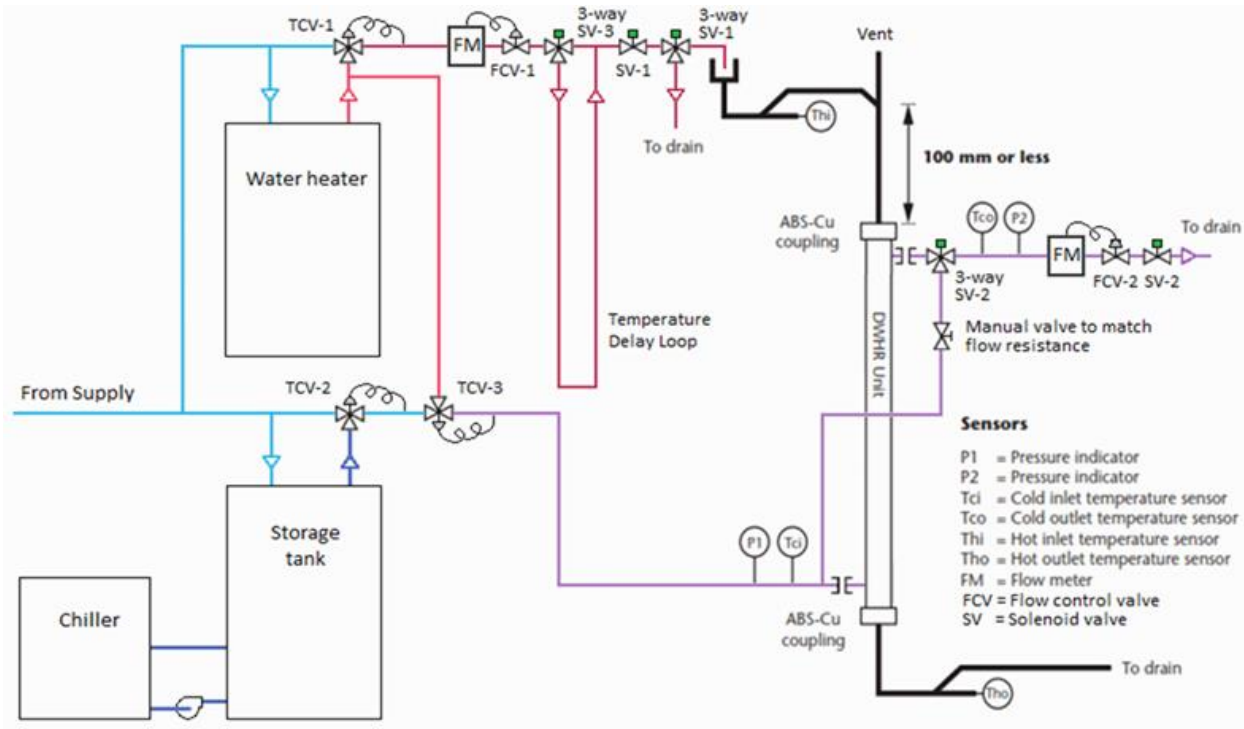

Figure 1: Schematic of the ATS DWHR Test Facility

Some characteristics of the test facility include:

- Tests are fully automated and scripted to run one after the other.
- Temperature conditions at the inlet of the drain and potable side are achieved through mixing of city water, chilled water and hot water. Three way modulating valves are used for mixing, with temperature feedback from RTDs. Chilled water is provided by a 7.5 ton chiller paralleled to a 80 gallon storage tank. Hot water is provided by a 200,000 btu/hr 100 gallon water heater.
- Flow conditions are maintained using modulating needle valves, provided feedback from nutating disc flowmeters.
- The test system demonstrates the ability to maintain steady state conditions at the heat exchanger applying these techniques.

Testing Individual Units

The main goal of this project was to compare the performance of four separate units, and compare their performance. The characteristics of the four units are shown in Table 1. Units were selected to include units with a number of different manufacturers, diameters, and lengths. Names of manufacturers and specific models have been removed.

Table 1: Characteristics of Four Tested Units

Unit	Manufacturer	Diameter (in)	Length (in)
Unit 1	Man. 1	3	48
Unit 2	Man. 2	4	60

Unit 3	Man. 3	4	42
Unit 4	Man. 4	2	60

To compare the performance of these units, their effectiveness under various conditions, as described in the test plan included in Appendix A, was identified.

Following testing, separate algorithms to identify their performance in Equal Flow and Unequal Flow configurations were created. A third algorithm, combining the Equal Flow and Unequal Flow data into a single data set was also created, and the resulting algorithm was compared to the two individual algorithms. Additionally, an algorithm estimating the impact of drain-side inlet water temperature was created. Some sample results are presented here, and the attached files contain detailed plots for all units.

Figure 2 shows both the tested and estimated steady state effectiveness of Unit 4. As shown in the test plan, the tests were performed ranging from 1 gal/min to 8 gal/min at intervals of 0.33 gal/min. This range of flow rates covers the expected flow rates in both single and multi-family buildings based on the anticipated number of simultaneous showers. The 0.33 gal/min frequency provided adequate resolution to create a fourth-order curve fit.

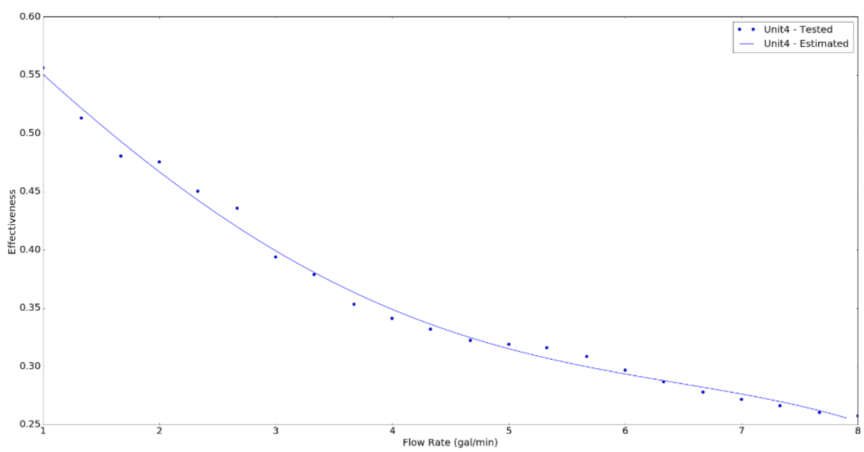

Figure 2: Measured and Estimated Effectiveness of Unit 4 in the Equal Flow Configuration

As can be seen in the results, the effectiveness of Unit 4 was at a maximum of 56% at 1 gal/min and decreased to 26% at 8 gal/min. The decrease in effectiveness as flow rate increased was non-linear though, in this case, it appears that a second order regression would have worked as well as the fourth order regression. The results in Figure 2 also show that the regression matches the measured results very closely.

Figure 3 shows the results for Unit 4 in the Unequal Flow configuration. In this case the drain-side and potable-side flows range from 1-8 gal/min, with all combinations of the flow rates tested. The results show very high effectiveness values when either flow rate is 1 gal/min, and decreasing effectiveness as the flow rates increase. Similarly to the Equal Flow case, Figure 3 shows that the regressed values closely match the measured results.

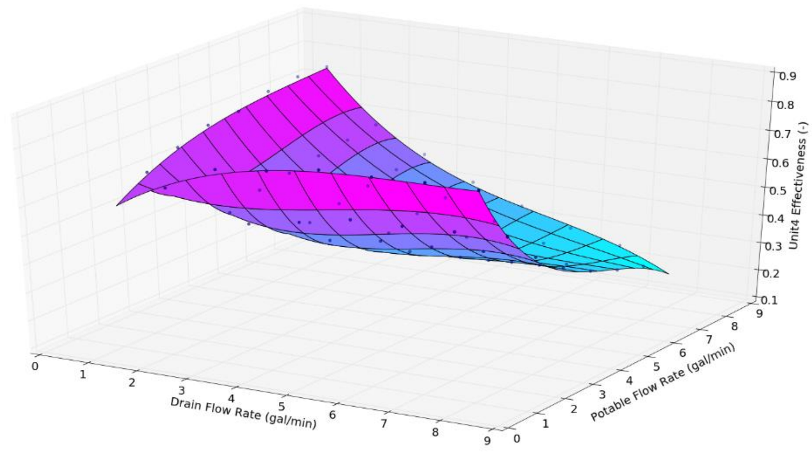

Figure 3: Measured and Estimated Effectiveness of Unit 4 in the Unequal Flow Configuration

Figure 4 shows the three dimensional effectiveness results for Unit 4, with both Equal Flow and Unequal Flow data combined in a single data set. It shows the same trends as in Figures 1 and 2, but the regression does not match the others as closely. This is particularly true in the case of low flow rate Equal flow conditions. Under these conditions, the effectiveness curve is very sensitive to changes in flow rate. The existing data set did not provide adequate data to force the regression to match the measured values, at these low flow rates. Due to the errors under these conditions, which are the most likely conditions, the decision was made to use the separate Equal Flow and Unequal Flow algorithms instead of the Combined algorithm.

To allow comparison of the performance of the four units, Figure 5 shows the measured and estimated effectiveness of all four units in the Equal Flow configuration. The data in Figure 5 shows that Units 1, 3, and 4 all followed very similar patterns with low effectiveness at high flows and high effectiveness at low flows. Unit 2 was the outlier, with erratic effectiveness results below 3 gal/min. It is believed that this is a result of incomplete wetting, and poor performance, at low flows but there was not time to repeat the tests to determine if this was the case or not.

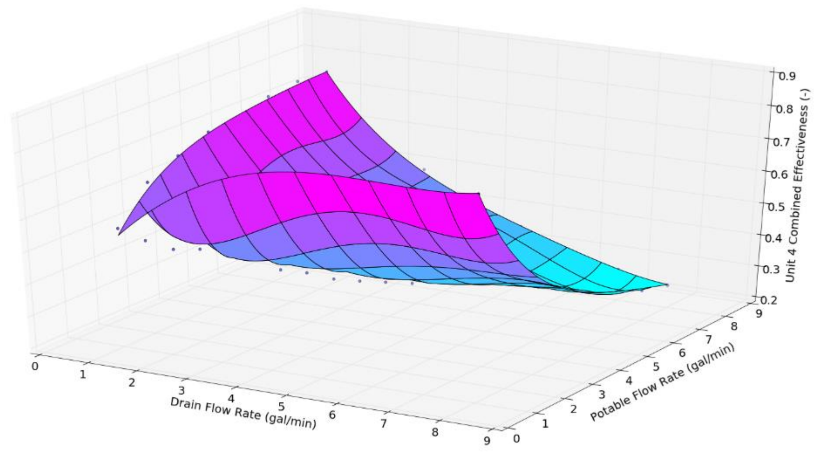

Figure 4: Unit 4 Measured and Estimated Effectiveness in Both the Equal Flow and Unequal Flow Configurations

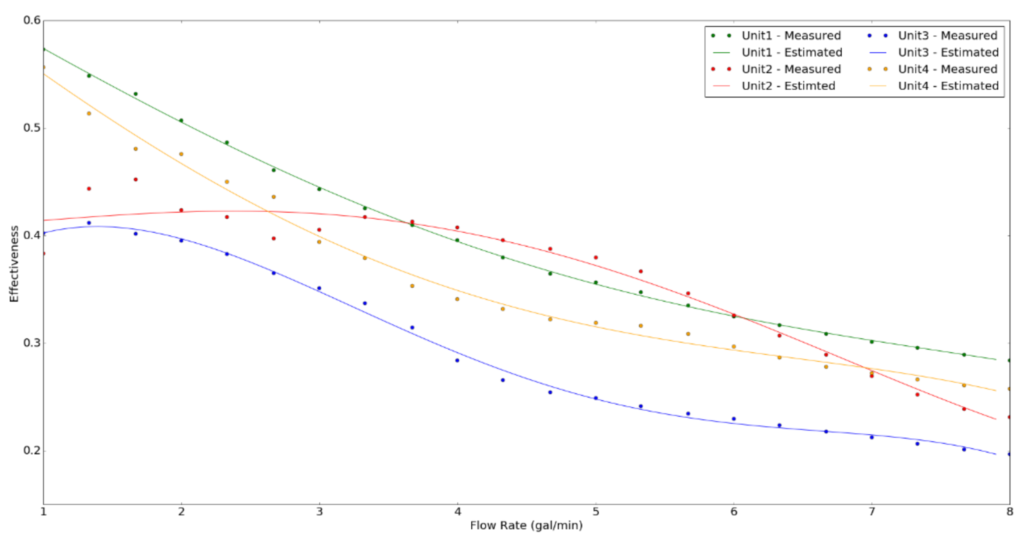

Figure 5: Measured and Estimated Effectiveness of all Units in Equal Flow Conditions

Figure 6 shows the data used to study the impact of drain-side inlet temperature on the effectiveness of all four units. As shown in the test plan in Appendix A, all tests used to create this algorithm were performed at 2.51 gal/min in the Equal Flow configuration. The results demonstrate that some units were more sensitive to drain-side inlet temperature than others; Units 1 and 4 showed very little change in effectiveness, while Unit 2 showed more, and Unit 3 showed high sensitivity. This data was later used to create a generic algorithm.

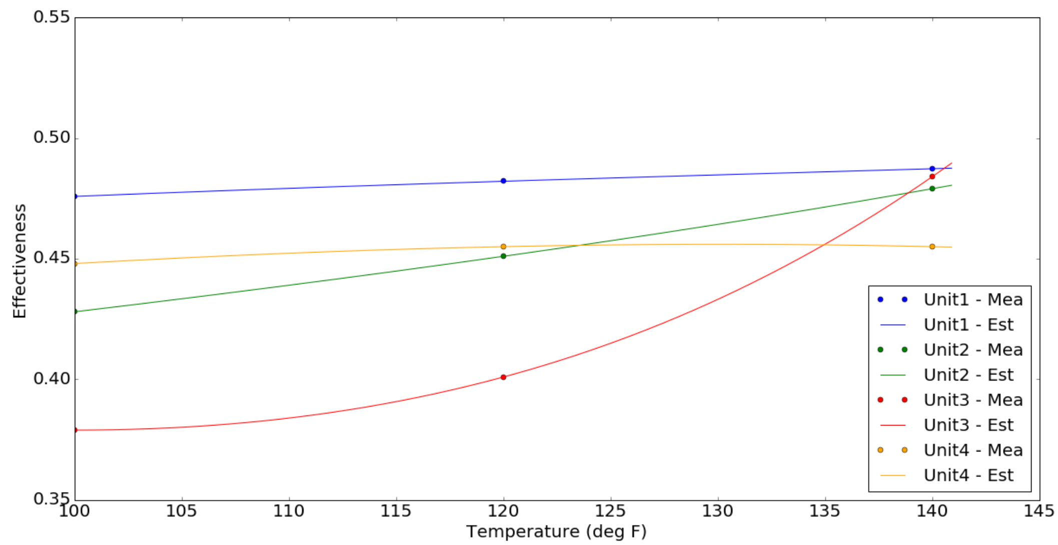

Figure 6: Effectiveness of all Four Units at 2.51 gal/min Equal Flow with Varying Drain-Side Inlet Temperature

Appendix B provides the coefficients for the Equal Flow, Unequal Flow and Drain-Side Inlet Temperature algorithms.

Generic Algorithm Development

To facilitate including an algorithm for DWHR in Title 24, a generic algorithm by combining the algorithms from the tested units. The measured effectiveness at each flow rate was divided by the CSA rating for the specific unit, creating a curve of the correction factors as a function of flow for each unit. These values were then averaged to create the generic algorithm. This method was used because it removes the necessity to use the effectiveness of the generic model at 2.51 gal/min in the algorithm, simplifying the implementation. Note that, because some of the test results for Unit 2 implied incomplete wetting, it was not included in the data set. The generic algorithm is used to identify the performance coefficients described in the Phase 1 report[1], then the result is multiplied by the CSA rated effectiveness of the simulated unit. Separate algorithms were created for the Equal Flow configuration, Unequal Flow configuration, and changes in drain-side inlet temperature.

Figure 7 presents the effectiveness of each unit estimated using the generic algorithm in the Equal Flow configuration. The data points represent the measured effectiveness for each unit at each flow rate, while the lines represent the effectiveness predicted by the generic algorithm for a given unit and flow

[1] Grant, Peter; Huestis, Eddie. "Development of a Title 24 Compliance Model for Residential Drain Water Heat Recovery Devices". July 2016

rate. The generic algorithm matches closely for Units 1 and 4, as well as for Unit 3 at low flow rates. The questionable results at low flow rates for Unit 2 caused significant inaccuracy in the generic algorithm when predicting the effectiveness for that unit at most flow rates. Retesting Unit 2 at the low flow rates would potentially provide a better data set and allow that unit to be included in creation of the generic algorithm.

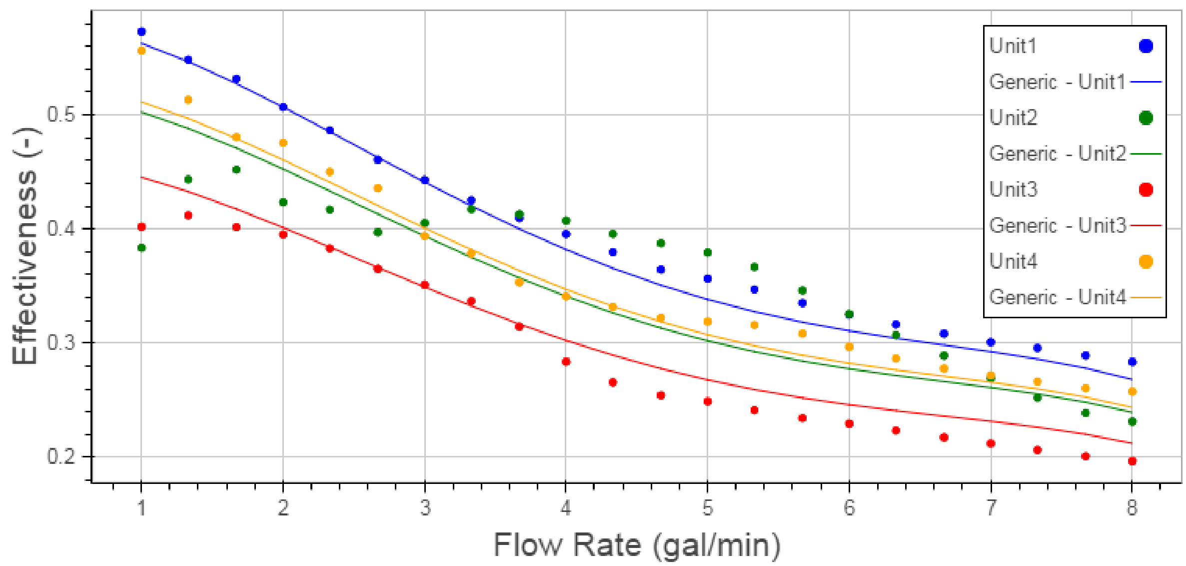

Figure 7: Predicted Effectiveness of Four Tested Units Using Generic Algorithm

Figure 8 shows the generic algorithm for drain-side inlet water temperature. The generic algorithm represents an average of the results from the four tested units, and can be used to estimate the response of a simulated DWHR unit to changes in drain-side inlet temperature.

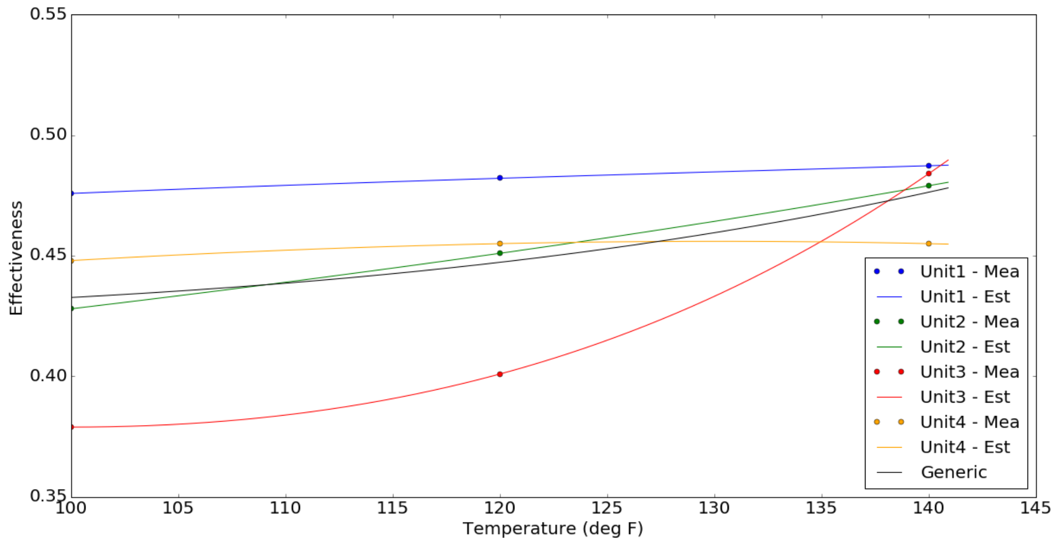

Figure 8: Generic Algorithm for Drain-Side Inlet Temperature

Estimates of Annual Savings

To both estimate the benefits of vertical DWHR units, and estimate the accuracy of the generic model, the annual savings from all four units were estimated. Simulations were performed using the individual regression for each unit, and using the generic model tailored to each unit (As would be done in the Title 24 ACM). Estimations were created for 1 – 5 bedroom houses in San Diego, San Francisco, and Sacramento.

Table 2 presents the maximum and minimum savings from each unit, as predicted using the algorithm for that unit and using the generic algorithm tuned to that unit (Denoted with a "G"), for all three climate zones. Note that the predicted savings are in therms, and do not account for inefficiencies at the water heater. Excluding Unit 2, most of the savings predictions from the generic model are within 7% of the individual models. Unit 2, as expected based on the previously discussed limitations, showed higher error when predicting savings using the generic model.

Detailed savings tables for each unit are presented in Appendix C.

Table 2: Sample Results Showing Annual Savings from DWHR (Therms)

	Unit							
	G-1	1	G-2	2	G-3	3	G-4	4
Min - San Diego	8.97	9.11	8.01	6.57	7.10	6.37	8.15	8.74
Max - San Diego	21.92	21.95	19.58	17.26	17.36	16.66	19.93	20.59
Min - San Francisco	11.28	11.43	10.07	8.32	8.93	8.09	10.25	10.93
Max - San Francisco	26.08	26.11	23.29	20.53	20.65	19.82	23.70	24.50

Min - Sacramento	9.85	10.00	8.80	7.24	7.80	7.03	8.95	9.58
Max - Sacramento	23.57	23.59	21.04	18.55	18.66	17.91	21.42	22.14

Impact of Installation Characteristics

Originally, the scope of the project included detailed testing to identify installation criteria that lead to high performance DWHR systems. However, this testing was dramatically reduced for two reasons:

1. The testing on length of vertical, or horizontal pipe leading to the inlet of the unit was removed due to the discovery that use of the DWHR unit itself reduced the incomplete wetting problem. During testing, the incomplete wetting observed during Phase 1 could not be replicated. Additionally, one of the manufacturers attested that used units tend to have reduced issues with incomplete wetting than new units.
2. The testing on tilt angle of the installed unit was removed because a previously published study had already addressed this issue[2]. The research showed that effectiveness of some units experienced significant degradation of effectiveness when tilted by 5 degrees or more. As such, 5 degrees is expected to be used as a qualification criterion in the Title 24 implementation.

Future Work

While this work represents a significant step forward in understanding and modeling DWHR systems, there are still some tasks which could be completed to improve the results in future projects. They include:

- Repeat tests on Unit 2 at low flow rates, to understand the reduction in effectiveness and obtain a better representation of its performance.
- Redevelop the generic model using new data from Unit 2, and check to ensure that it more closely matches the measured data for that unit.
- Perform more tests at low flow rates, close to Equal Flow conditions and redevelop the combined Equal Flow and Unequal Flow regression.

Additionally, there are several tasks which must be completed to include the DWHR algorithm in Title 24. These include:

- Compare the savings using this algorithm to RESNET,
- Create a non-iterative solution to identify the potable flow rate through the DWHR device in the Unequal-Shower configuration,
- Work with Bruce Wilcox's team to integrate the algorithm into CBECC,
- Model the pipe heat loss representing the volume of water trapped in the pipes at the end of a draw, and

[2] Manoucheri, Ramin. "Impact of small tilt angles on the performance of falling film drain water heat recovery systems". Energy and Buildings, 2015

- Create a tool to estimate DWHR savings in multi-family buildings, using the Title 24 ACM multi-family building draw profile.

Appendix A: Performance Map Test Plan

Test Number	Configuration	Drain-Side Flow Rate (gal/min)	Potable-Side Flow Rate (gal/min)	Drain-Side Inlet Temperature (deg F)	Potable-Side Inlet Temperature (deg F)	Note
Equal Flow Testing						
1	Equal	1.00	1.00	100.4	50	
2	Equal	1.33	1.33	100.4	50	
3	Equal	1.67	1.67	100.4	50	
4	Equal	2.00	2.00	100.4	50	
5	Equal	2.33	2.33	100.4	50	
6	Equal	2.67	2.67	100.4	50	
7	Equal	3.00	3.00	100.4	50	
8	Equal	3.33	3.33	100.4	50	
9	Equal	3.67	3.67	100.4	50	
10	Equal	4.00	4.00	100.4	50	
11	Equal	4.33	4.33	100.4	50	
12	Equal	4.67	4.67	100.4	50	
13	Equal	5.00	5.00	100.4	50	
14	Equal	5.33	5.33	100.4	50	
15	Equal	5.67	5.67	100.4	50	
16	Equal	6.00	6.00	100.4	50	
17	Equal	6.33	6.33	100.4	50	
18	Equal	6.67	6.67	100.4	50	
19	Equal	7.00	7.00	100.4	50	
20	Equal	7.33	7.33	100.4	50	
21	Equal	7.67	7.67	100.4	50	
22	Equal	8.00	8.00	100.4	50	

Unequal Flow Testing						
23	Unequal	1	2	100.4	50	
24	Unequal	1	3	100.4	50	
25	Unequal	1	4	100.4	50	
26	Unequal	1	5	100.4	50	
27	Unequal	1	6	100.4	50	
28	Unequal	1	7	100.4	50	
29	Unequal	1	8	100.4	50	
30	Unequal	2	1	100.4	50	
31	Unequal	2	3	100.4	50	
32	Unequal	2	4	100.4	50	
33	Unequal	2	5	100.4	50	
34	Unequal	2	6	100.4	50	
35	Unequal	2	7	100.4	50	
36	Unequal	2	8	100.4	50	
37	Unequal	3	1	100.4	50	
38	Unequal	3	2	100.4	50	
39	Unequal	3	4	100.4	50	
40	Unequal	3	5	100.4	50	
41	Unequal	3	6	100.4	50	
42	Unequal	3	7	100.4	50	
43	Unequal	3	8	100.4	50	
44	Unequal	4	1	100.4	50	
45	Unequal	4	2	100.4	50	
46	Unequal	4	3	100.4	50	
47	Unequal	4	5	100.4	50	
48	Unequal	4	6	100.4	50	
49	Unequal	4	7	100.4	50	

50	Unequal	4	8	100.4	50	
51	Unequal	5	1	100.4	50	
52	Unequal	5	2	100.4	50	
53	Unequal	5	3	100.4	50	
54	Unequal	5	4	100.4	50	
55	Unequal	5	6	100.4	50	
56	Unequal	5	7	100.4	50	
57	Unequal	5	8	100.4	50	
58	Unequal	6	1	100.4	50	
59	Unequal	6	2	100.4	50	
60	Unequal	6	3	100.4	50	
61	Unequal	6	4	100.4	50	
62	Unequal	6	5	100.4	50	
63	Unequal	6	7	100.4	50	
64	Unequal	6	8	100.4	50	
65	Unequal	7	1	100.4	50	
66	Unequal	7	2	100.4	50	
67	Unequal	7	3	100.4	50	
68	Unequal	7	4	100.4	50	
69	Unequal	7	5	100.4	50	
70	Unequal	7	6	100.4	50	
71	Unequal	7	8	100.4	50	
72	Unequal	8	1	100.4	50	
73	Unequal	8	2	100.4	50	
74	Unequal	8	3	100.4	50	
75	Unequal	8	4	100.4	50	
76	Unequal	8	5	100.4	50	
77	Unequal	8	6	100.4	50	

78	Unequal	8	7	100.4	50	
79	Unequal	1	0.5	100.4	50	
80	Unequal	1	0.75	100.4	50	
81	Unequal	1.25	0.625	100.4	50	
82	Unequal	1.25	0.9375	100.4	50	
83	Unequal	2	1.75	100.4	50	
84	Unequal	2	2.25	100.4	50	
85	Unequal	1.75	2	100.4	50	
86	Unequal	2.25	2	100.4	50	
Drain-Side Temperature						
87	Equal	2.51	2.51	100.4	50	
88	Equal	2.51	2.51	140	50	
89	Equal	2.51	2.51	120	50	
Ramp-Up Effects						
90	Equal	1.33	1.5	100.4	50	
91	Equal	2	2	100.4	50	
92	Equal	4	4	100.4	50	Use delay loop
Validation						
93	Equal	1.5	1.5	100.4	50	
94	Unequal	1.75	1.3	100.4	50	
95	Unequal	5.25	3.9	100.4	50	
96	Unequal	2.51	2.51	130	50	If drain temperature important

Appendix B: Algorithm Coefficients

Table 3: Equal Flow Coefficients for Each Tested Unit and the Generic Algorithm

Term	Unit1	Unit2	Unit3	Unit4	Generic
$Flow^4$	-6.85E-05	0.000154	-0.00062	-0.00013	-0.00070
$Flow^3$	0.001064	-0.00237	0.01217	0.001654	0.01285
$Flow^2$	-0.00071	0.005623	-0.07949	0.001242	-0.07024
Flow	-0.0728	0.005301	0.157037	-0.09685	-0.01336
Constant	0.64646	0.405332	0.313341	0.644567	1.23339

Table 4: Unequal Flow Coefficients for Each Unit

Term	Unit1	Unit2	Unit3	Unit4	Generic
Constant	-0.24005	-0.24179	-0.0155	-0.1162	-0.27287
Flow_Potable	0.753841	0.576698	0.351707	0.707474	1.39188
$Flow\_Potable^2$	-0.14548	-0.10539	-0.06872	-0.1356	-0.26864
$Flow\_Potable^3$	0.008779	0.006216	0.004126	0.008181	0.016191
Flow_Drain	0.936706	0.82002	0.625638	0.728912	1.78092
Flow_Drain * Flow_Potable	-0.80916	-0.61469	-0.47378	-0.72018	-1.54925
Flow_Drain * $Flow\_Potable^2$	0.165839	0.124106	0.099027	0.147118	0.31886
Flow_Drain * $Flow\_Potable^3$	-0.01031	-0.00767	-0.00617	-0.00915	-0.01984
$Flow\_Drain^2$	-0.18498	-0.15573	-0.11834	-0.13809	-0.34253
$Flow\_Drain^2$ * Flow_Potable	0.167535	0.125903	0.093504	0.147458	0.31541
$Flow\_Drain^2$ * $Flow\_Potable^2$	-0.03667	-0.02782	-0.02126	-0.03235	-0.0698
$Flow\_Drain^2$ * $Flow\_Potable^3$	0.00237	0.001813	0.001387	0.002104	0.00453
$Flow\_Drain^3$	0.011201	0.009236	0.007089	0.008241	0.02058
$Flow\_Drain^3$ * Flow_Potable	-0.01039	-0.0079	-0.00559	-0.00921	-0.01942
$Flow\_Drain^3$ * $Flow\_Potable^2$	0.002364	0.001842	0.001332	0.002113	0.00449
$Flow\_Drain^3$ * $Flow\_Potable^3$	-0.00016	-0.00012	-8.94E-05	-0.00014	-0.0003

Table 5: Drain-Side Inlet Temperature Coefficients

Term	Unit1	Unit2	Unit3	Unit4	Generic
$Flow^4$	1.07E-10	1.23E-10	1.25E-09	-2.64E-11	3.62E-10
$Flow^3$	-2.49E-08	-1.19E-08	-4.46E-08	-1.88E-08	-2.50E-08
$Flow^2$	-1.68E-06	-1.19E-07	-1.59E-05	3.11E-07	-4.34E-06
Flow	0.001015	0.00095	-0.00047	0.001108	0.00065
Constant	0.405258	0.333792	0.505145	0.355558	0.399939

Appendix C: Estimated Savings for Each Unit Using Both the Individual Models and the Generic Model

Table 6: Unit 1 Estimated Savings (Therms)

	San_Diego	San_Francisco	Woodland
OneBedroom_Equal	12.67	15.08	13.60
OneBedroom_UnequalWaterHeater	9.11	11.43	10.00
TwoBedroom_Equal	14.81	17.61	15.93
TwoBedroom_UnequalWaterHeater	10.65	13.36	11.72
ThreeBedroom_Equal	16.74	19.91	17.99
ThreeBedroom_UnequalWaterHeater	12.04	15.10	13.23
FourBedroom_Equal	19.05	22.66	20.47
FourBedroom_UnequalWaterHeater	13.71	17.19	15.06
FiveBedroom_Equal	21.95	26.11	23.59
FiveBedroom_UnequalWaterHeater	15.85	19.87	17.42

Table 7: Unit 1 – Generic Model Estimated Savings (Therms)

	San_Diego	San_Francisco	Woodland
OneBedroom_Equal	12.64	15.04	13.57
OneBedroom_UnequalWaterHeater	8.97	11.28	9.85
TwoBedroom_Equal	14.78	17.57	15.89
TwoBedroom_UnequalWaterHeater	10.49	13.18	11.55
ThreeBedroom_Equal	16.70	19.86	17.94
ThreeBedroom_UnequalWaterHeater	11.85	14.90	13.04
FourBedroom_Equal	19.01	22.61	20.43
FourBedroom_UnequalWaterHeater	13.50	16.97	14.85
FiveBedroom_Equal	21.92	26.08	23.57
FiveBedroom_UnequalWaterHeater	15.65	19.65	17.21

Table 8: Unit 2 Estimated Savings (Therms)

	San_Diego	San_Francisco	Woodland
OneBedroom_Equal	9.81	11.68	10.54
OneBedroom_UnequalWaterHeater	6.57	8.32	7.24
TwoBedroom_Equal	11.48	13.65	12.35
TwoBedroom_UnequalWaterHeater	7.69	9.73	8.50
ThreeBedroom_Equal	12.97	15.43	13.95
ThreeBedroom_UnequalWaterHeater	8.69	11.01	9.59
FourBedroom_Equal	14.80	17.60	15.90
FourBedroom_UnequalWaterHeater	9.91	12.55	10.94

FiveBedroom_Equal	17.26	20.53	18.55
FiveBedroom_UnequalWaterHeater	11.56	14.64	12.76

Table 9: Unit 2 – Generic Model Estimated Savings (Therms)

	San_Diego	San_Francisco	Woodland
OneBedroom_Equal	11.29	13.43	12.12
OneBedroom_UnequalWaterHeater	8.01	10.07	8.80
TwoBedroom_Equal	13.19	15.69	14.19
TwoBedroom_UnequalWaterHeater	9.37	11.77	10.32
ThreeBedroom_Equal	14.91	17.73	16.02
ThreeBedroom_UnequalWaterHeater	10.58	13.30	11.64
FourBedroom_Equal	16.97	20.19	18.24
FourBedroom_UnequalWaterHeater	12.06	15.16	13.26
FiveBedroom_Equal	19.58	23.29	21.04
FiveBedroom_UnequalWaterHeater	13.97	17.55	15.37

Table 10: Unit 3 Estimated Savings (Therms)

	San_Diego	San_Francisco	Woodland
OneBedroom_Equal	9.53	11.34	10.23
OneBedroom_UnequalWaterHeater	6.37	8.09	7.03
TwoBedroom_Equal	11.15	13.25	11.99
TwoBedroom_UnequalWaterHeater	7.46	9.47	8.25
ThreeBedroom_Equal	12.59	14.98	13.53
ThreeBedroom_UnequalWaterHeater	8.43	10.70	9.31
FourBedroom_Equal	14.36	17.08	15.43
FourBedroom_UnequalWaterHeater	9.62	12.21	10.62
FiveBedroom_Equal	16.66	19.82	17.91
FiveBedroom_UnequalWaterHeater	11.24	14.25	12.41

Table 11: Unit 3 – Generic Model Estimated Savings (Therms)

	San_Diego	San_Francisco	Woodland
OneBedroom_Equal	10.01	11.91	10.74
OneBedroom_UnequalWaterHeater	7.10	8.93	7.80
TwoBedroom_Equal	11.70	13.91	12.58
TwoBedroom_UnequalWaterHeater	8.31	10.44	9.15
ThreeBedroom_Equal	13.22	15.72	14.21
ThreeBedroom_UnequalWaterHeater	9.38	11.80	10.32
FourBedroom_Equal	15.05	17.90	16.17

FourBedroom_UnequalWaterHeater	10.69	13.44	11.76
FiveBedroom_Equal	17.36	20.65	18.66
FiveBedroom_UnequalWaterHeater	12.39	15.56	13.63

Table 12: Unit 4 Estimated Savings (Therms)

	San_Diego	San_Francisco	Woodland
OneBedroom_Equal	11.93	14.20	12.81
OneBedroom_UnequalWaterHeater	8.74	10.93	9.58
TwoBedroom_Equal	13.95	16.59	15.00
TwoBedroom_UnequalWaterHeater	10.22	12.78	11.23
ThreeBedroom_Equal	15.76	18.75	16.94
ThreeBedroom_UnequalWaterHeater	11.54	14.44	12.67
FourBedroom_Equal	17.93	21.33	19.27
FourBedroom_UnequalWaterHeater	13.14	16.44	14.43
FiveBedroom_Equal	20.59	24.50	22.14
FiveBedroom_UnequalWaterHeater	15.16	18.96	16.65

Table 13: Unit 4 – Generic Model Estimated Savings (Therms)

	San_Diego	San_Francisco	Woodland
OneBedroom_Equal	11.49	13.67	12.33
OneBedroom_UnequalWaterHeater	8.15	10.25	8.95
TwoBedroom_Equal	13.43	15.97	14.45
TwoBedroom_UnequalWaterHeater	9.53	11.98	10.50
ThreeBedroom_Equal	15.17	18.05	16.31
ThreeBedroom_UnequalWaterHeater	10.77	13.54	11.85
FourBedroom_Equal	17.28	20.55	18.57
FourBedroom_UnequalWaterHeater	12.27	15.43	13.50
FiveBedroom_Equal	19.93	23.70	21.42
FiveBedroom_UnequalWaterHeater	14.22	17.86	15.64