PROCEDURES FOR MODELING BUILDINGS TO MNECB AND CBIP
- PART 1 -

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Appendix F

Drainwater Heat Recovery Systems

In buildings and industry, substantial energy savings can be achieved through reclaiming heat from drainwater (or waste-water), a process commonly called drainwater heat recovery (DHR). The reclaimed heat is almost always used to preheat cold fresh water. The most cost-effective class of drainwater heat exchangers are counter-flow.

Many DHR systems are in operation in Multi-Unit Residential Buildings (MURBs), hotels, recreation facilities, restaurants, laundromats, industry, and homes. There are many other excellent applications including high schools and hospitals (cafeteria, laundry, showers, kidney dialysis, cart washers, and steam condensate).

In MURBs the overall savings on domestic water heating is typically 25-30%, but the potential range is 5% to 46%. The lower end of this range is for centralized systems that reclaim heat from a single building-wide drainwater source. In restaurants and health clubs the range of savings is 40-75%.

The following guidelines and procedures form an abbreviated methodology for drainwater heat recovery in buildings. For clarification and/or confirmation that your design staff are applying these procedures correctly, it is recommended that you contact a DHR manufacturer or experienced sales engineer.

Design Considerations

There is a range of design options for DHR systems. Design considerations include trade-offs between overall performance, system cost, and fresh water pressure drop. The design for DHR in a MURB typically calls for a heat exchanger for every 3-4 washrooms; however to maximize performance it could call for a heat exchanger for each washroom. Alternatively, one could use one centralized system for an entire building. Where maximum flows are above 34 litres per minute (9 usgpm) - such as those found in health clubs - or where it is best to maximize heat exchanger performance (in large restaurants for instance) multiple heat exchanger systems are preferred.

CBIP Credit Calculations: Hotels/Motels, and MURBs

The effect of DHR on the water heating load depends on a combination of a few design factors that are multiplied together. The following equation and subsequent sections detail how to determine these factors.

DHW Load Reduction = DHW Heating Load * DHRsavings * DHReff * DHRutil

DHW Heating Load = hot water heating load from EE4 calculation (DOE2 BEPU report)

DHRsavings = % savings due to DHR installation (see Table F-1)

DHReff = % effectiveness of DHR equipment

DHRutil = utilization factor of DHR in a building (0 – 100% coverage)

Potential DHW Savings from Drainwater Heat Recovery (DHRsavings)

In MURBs the fresh water that is heated by DHR unit(s) can be plumbed as the cold water stream (preferably washroom CW), the hot water stream to the boiler room, or both. With distributed DHR units, which are located throughout the building, it is not feasible (except in some small buildings) to preheat the HW stream. With a centralized system it is not practical to preheat the CW stream. Select the maximum savings from Table 1 depending upon your design. This number would be the estimated DHW load reduction if the DHR unit(s) have a 100% effectiveness and they serve all the washroom (WC) loads in the building.

Table F-1

Maximum Potential DWH Savings for Various Plumbing Schemes Options				
	Distributed DHR [1]			Centralized DHR
	1-2 WC/unit[2]	3-4 WC/unit[1]	5-6 WC/unit	>=7 WC/unit
HW and CW Heating	61.7%	56.0%	44.7%	18.0%
CW Heating*	46.7%	42.4%*	33.4%	13.6%
HW Pre-Heating	46.6%	42.3%	33.3%	13.6%
*most common method in MURBs W/C = washrooms installed per DHR unit HW = hot water CW = cold water				

Rated Effectiveness of DHR Unit(s) (DHReff)

Design, installation, heat transfer surface area, and fluid flow rates all contribute to the performance of any heat exchanger. The numbers in the Distributed DHR column of Table 1 are based upon a study in a real MURB with a counter flow heat exchanger that has a known rated effectiveness of 50.0%. This value shall be used for MURB and Hotel/Motel installations where test data has not been provided. The effectiveness of centralized DHR systems shall be 25% unless a detailed test report has been provided.

Rated Effectiveness for Distributed DHR

Heat exchange effectiveness shall be determined from bench-scale testing at an ISO certified independent laboratory (such as Bodycote-Ortech) and signed by a professional engineer.

The steady-state heat exchange effectiveness at these conditions shall be used. The unit model number, heat transfer area, and pressure drops at the flowrates in table 1 shall be clearly reported. The summary test report must be submitted with the CBIP application.

It is common that model sizes vary from project to project. In this case, three options for selecting heat exchange effectiveness are allowed:

Have every model tested and reported.

Test at least 3 different heat exchanger models. Have the testing agency interpolate and/or extrapolate the heat exchange effectiveness for a wide variety of sizes with a recognized heat exchanger modelling method. The results shall be included in the test report in tabular form.

Use the reported heat exchanger effectiveness for a smaller model (by surface area).

Rated Effectiveness for Centralized DHR

It is recommended that the test report cover a wide flow rate range. If more than one heat exchanger is used then the design flow rate shall be divided between the heat exchangers and the rated effectiveness per unit at that flow rate shall be used.

Percent Utilization Adjustment (DHRutil)

Due to design constraints, in some buildings not every drainwater source is utilized for heat recovery. As a result, the rating must be reduced accordingly. This fraction will simply be:

Percent Utilization = Number of Washrooms feeding the DHR System(s) / Total Number of Washrooms in Building

CBIP Credit for Recreation Facilities, High Schools, Hospitals, and Restaurants

The key issue in estimating DHR energy savings in these building types is that there are many types of hot water loads. Furthermore, there is a wide variation in the proportion of these loads within a building. For this reason the accepted practice is to estimate the proportion of total drainwater that feeds the DHR system(s) by using fixture counts and peak hourly flow, as detailed by ASHRAE Fundamentals 1999 Table 9** for each fixture type. Where there is more than one DHR system within the building, the savings must be calculated separately for each one according to this procedure.

DHW Load Reduction = DHW Heating Load * DHRloadf * DHReff * Flowf

DHW Heating Load = hot water heating load from EE4 calculation (DOE2 BEPU report)
DHRloadf = % of hot water load connected to DHR saystem
DHReff = % effectiveness of DHR equipment at 50% flow
Flowf = flow balance correction factor

Proportion of Load Feeding the DHR system(s) (DHRloadf)

First, a count of all fixture types is made for the building. Next the total flow for each fixture type is calculated as the product of the total number of fixtures and the Peak Hourly Flow for each fixture type. The fixtures that can feed the one or more DHR systems are then used to calculate the total flow for each DHR system. Finally, the percent of the total HW load that is fed to each DHR system is calculated.

Estimated Service HW Load Breakdowns by fixture type for a Sample High School

	Table 9 Calculations from ASHRAE						
	Peak Hourly Flow	All Fixtures		DWHR Gym		DWHR Cafeteria	
	LitresHW/hour	Fixtures	Total Flow	Fixtures	Total Flow	Fixtures	Total Flow
Basin, Private Lavitory	7.6	21	159.6	2	15.2	2	15.2
Basin, Public Lavitory	57	26	1482	8	456	0	0
Dishwasher (average)	228	1	228	0	0	1	228
Foot Basin	11	1	11	0	0	0	0
Kitchen Sink	76	3	228	0	0	3	228
Pantry	38	3	114	0	0	2	76
Shower	850	11	9350	10	8500	0	0
Service Sink	76	0	0	0	0	0	0
Circular Wash Sink	114	0	0	0	0	0	0
Semi-circular Wash Sink	57	0	0	0	0	0	0
TOTALS			11572.6		8971.2		547.2
		Percent of Total HW Load			77.5%		4.7%

Sample Chart Showing Calculation of Load Proportion that could feed two DHR systems

Rated Effectiveness of DHR unit(s) at 50% flow (DHReff)

In reality it is rare that all fixtures will operate at once. The DHR system performance shall therefore be benchmarked at 50% of peak total flow, as calculate above and based upon test results from a testing agency. If test results are unavailable, the default is 50%.

Flow Balance Correction Factor (Flowf)

If the flow is balanced on both sides of the DHR system then this factor is 1.0; otherwise it is 0.75. For example, the DHR system might only preheat the CW supply to the showers. In this case the flow would not be balanced and the performance of the unit would be about 25% less than if it were to heat both HW and CW supply streams. In the case of a dishwasher where there is only HW supply this factor would be 1.0.