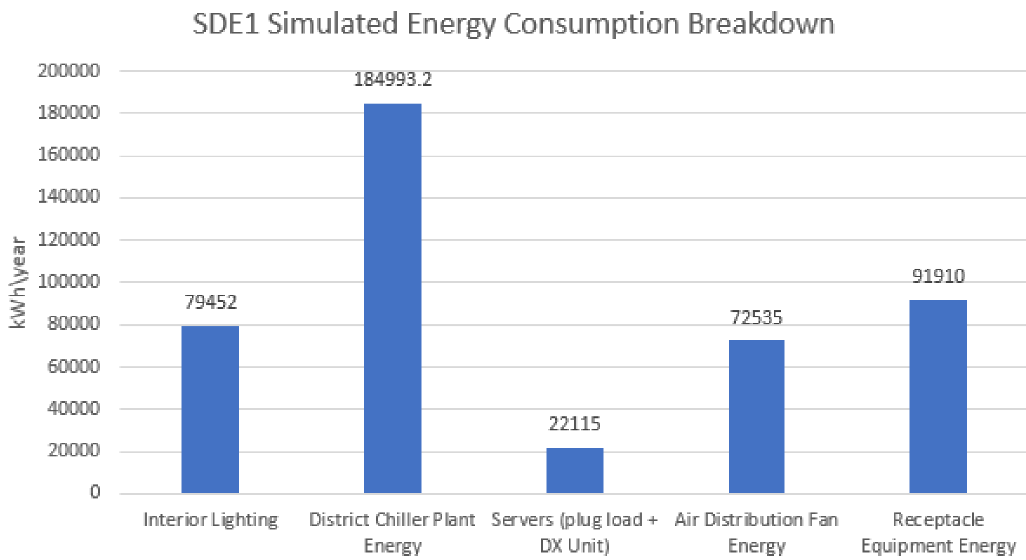
May 2024 ASHRAE Journal

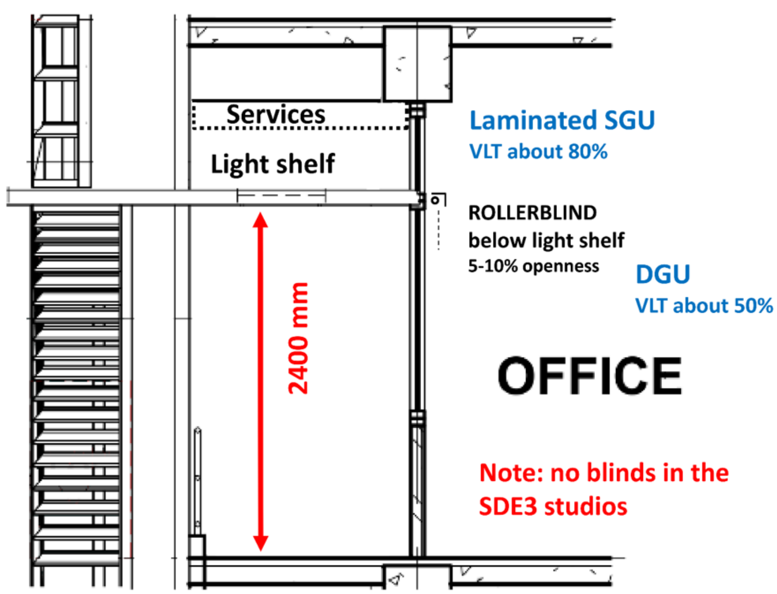
The following pages contain supplementary information for these articles in the May 2024 issue of ASHRAE Journal

Low-Carbon Academic Renovation Project in The Tropics
By Bertrand Lasternas, Member ASHRAE

Online Figure 1. Simulated Energy Consumption Breakdown of SDE1



Online Figure 2. Butterfly Shades.



Case 1 through Case 5

	Flow-to-kW	Speed-to-kW	
Bldg 1 PCHWP-1	2.6	2.9	50 HP
Bldg 1 PCHWP-2	2.5	2.8	50 HP
Bldg 1 PCHWP-3	2.5	2.7	50 HP
Bldg 1 PCHWP-4	2.4	2.8	50 HP
Bldg 1 PCHWP-5	2.7	2.8	50 HP
Bldg 2 PCHWP-2	2.8	2.8	20 HP
Bldg 2 PCHWP-3	2.4	2.7	20 HP
Average	2.5	2.8	
St Dev	0.2	0.1	

Case 1: Primary chilled water pumps (as part of a primary-secondary system).

	Flow-to-kW	Speed-to-kW	
Bldg 1 CDWP-1	2.4	2.9	100 HP
Bldg 1 CDWP-2	2.1	3.1	100 HP
Bldg 1 CDWP-3	1.9	2.9	100 HP
Bldg 1 CDWP-4	2.0	2.8	125 HP
Bldg 1 CDWP-5	1.9	2.8	125 HP
Bldg 2 CDWP-2	3.0	3.1	40 HP
Bldg 2 CDWP-3	2.1	3.1	40 HP
Average	2.2	3.0	
St Dev	0.4	0.1	

Case 2: Condenser water pumps serving open cooling towers.

	Flow-to-kW	Speed-to-kW
Bldg 3 MAH-1	2.1	2.6
Bldg 3 MAH-2	2.1	2.7
Bldg 3 MAH-3	2.7	3.0
Bldg 3 MAH-4	1.9	2.9
Bldg 3 MAH-5	2.2	2.7
Bldg 3 MAH-6	1.8	2.6
Bldg 3 MAH-7	2.4	2.7
Bldg 3 MAH-8	2.4	2.5
Bldg 3 MAH-9	2.5	2.8
Bldg 3 MAH-10	2.4	2.8
Bldg 3 MAH-11	2.7	2.8
Bldg 3 MAH-12	2.3	2.8
Bldg 3 MAH-51	2.7	2.9
Bldg 3 MAH-52	2.5	2.8
Bldg 3 MAH-53	2.6	2.9
Bldg 3 MAH-54	2.6	2.8
Bldg 3 MAH-55	2.7	3.0
Bldg 3 MAH-56	2.2	2.8
Bldg 3 MAH-57	1.8	2.9
Bldg 3 MAH-58	2.3	2.8
Bldg 3 MAH-59	2.4	2.7
Bldg 3 MAH-60	1.9	2.9
Bldg 3 MAH-61	1.6	2.7
Bldg 3 MAH-62	2.3	2.9
Average	2.3	2.8
St Dev	0.3	0.1

Case 3: Clean room make-up air handlers with 150 HP supply fan motors. VFDs modulate to maintain clean room space pressure setpoint (~0.04" WC).

	Flow-to-kW	Speed-to-kW
Bldg 4 MAH-2	2.2	2.7
Bldg 4 MAH-4	2.1	2.6
Bldg 4 MAH-5	2.0	2.7
Bldg 4 MAH-6	1.8	2.7
Bldg 4 MAH-7	2.3	2.8
Bldg 4 MAH-11	2.2	2.9
Bldg 4 MAH-51	2.2	2.8
Bldg 4 MAH-52	2.1	2.8
Bldg 4 MAH-53	2.8	3.0
Bldg 4 MAH-54	1.6	2.5
Bldg 4 MAH-55	2.3	2.5
Bldg 4 MAH-56	1.8	2.7
Bldg 4 MAH-59	2.2	2.7
Bldg 4 MAH-60	2.6	2.8
Bldg 4 MAH-61	2.4	2.6
Bldg 4 MAH-62	2.4	2.7
Average	2.2	2.7
St Dev	0.3	0.1

Case 4: Clean room make-up air handlers with 150 HP supply fan motors. VFDs modulate to maintain clean room space pressure setpoint (~0.04" WC).

	Speed-to-kW
10 HP evap fan	2.5
10 HP evap fan	2.7
10 HP cond fan	2.6
3/4 HP evap fan	1.7
3/4 HP evap fan	1.8
2 HP evap fan	2.6
1/2 HP evap fan	3.1
40 HP cond fan	2.7
3 HP evap fan	2.6
Average	2.5
St Dev	0.4

Case 5: Refrigeration system evaporator and condenser fans. Flow data not available.

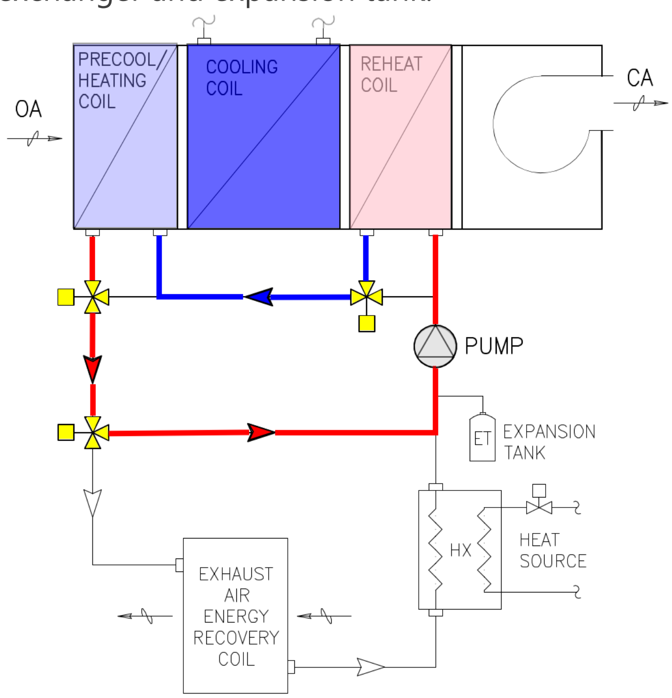
Hydronic Series Energy Recovery
By Christopher Scheck, P.E., Member ASHRAE

Online Sidebar 1: SER with Hydronic Exhaust Air Energy Recovery

If the exhaust and supply airstreams are in close proximity, exhaust air energy recovery can generally be accomplished more easily and more effectively with an energy wheel or a plate heat exchanger.

However, hydronic systems enjoy certain advantages. For instance, as depicted in Online Figure 1, both SER and EAER can be accomplished with just two coils in the outdoor airstream (discounting the cooling coil). On the other hand, when a heat pipe system is used for SER or EAER, additional coils (either electric or hydronic) are often required to provide supplemental heat and/or reheat, adding to the first cost and expending more fan energy. Furthermore, once the heating and reheat coils are installed in the DOA unit, hydronic exhaust air energy recovery can be retrofitted in the future, with minor impact to the DOA unit.

Online Figure 1 shows a hydronic heat recovery circuit with an isolation exchanger to inject heat into the closed aqueous-glycol circuit. In climates where freezing or coil frosting is not a concern, glycol can be eliminated from the energy recovery circuit, along with the heat exchanger and expansion tank.

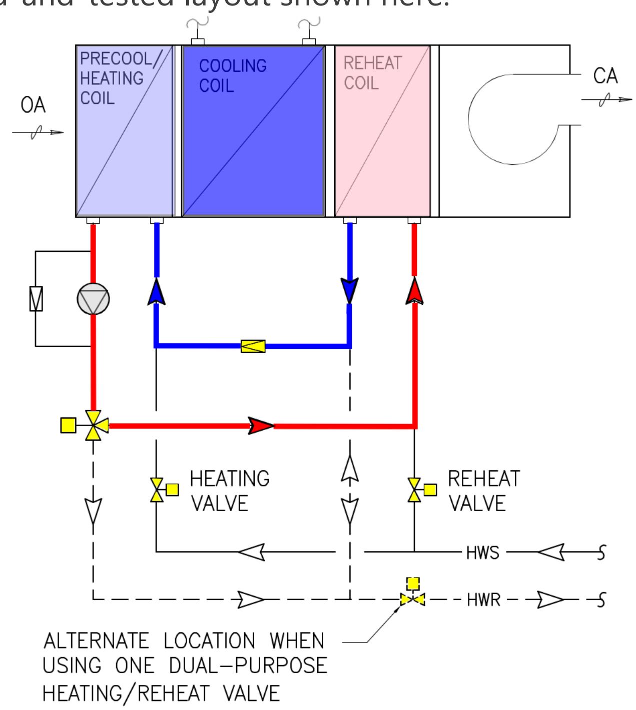


Note: Flow through Series Energy Recovery circuit is highlighted. (conceptual diagram courtesy of Heat Pipe Technology Inc., Tampa FL)

Online Figure 1: SER Piping Configuration incorporating Exhaust Air Energy Recovery
For a detailed discussion of EAER with runaround coils, see Online Reference 1. Compared to SER systems, EAER systems must meet higher effectiveness standards (see Standard 90.1, Section 6.5.6.1); thus, they require more robust coils (generally six or eight rows as opposed to four rows for a typical SER coil). For comparison purposes with SER, adding a coil in the exhaust airstream will increase the annual energy recovered by about 50% for Atlanta, by about 150% for New York City, and by about 300% for Denver. Of course, the additional energy recovery has to be weighed against the significant increase in first cost and complexity.

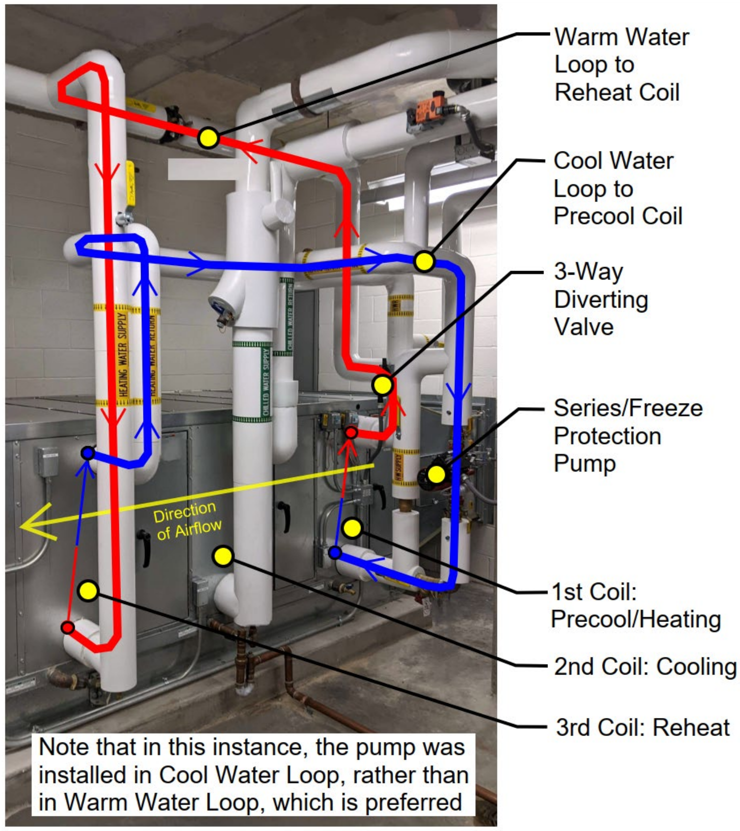
Online Sidebar 2: SER Piping/Pump Configuration
Online Figure 2 shows a suggested piping configuration for a hydronic SER circuit. It has been used by the author on several projects. Online Photo 1 shows a typical installation. This particular configuration uses two modulating control valves: one valve to modulate the flow of heating water to the heating coil and a smaller valve to modulate the flow of heating water to the reheat coil. This provides good control since the design water flow for heating is generally about an order-of-magnitude more than the design water flow for reheating.

However, as indicated, it is possible to relocate the heating water control valve so that one valve serves both functions, eliminating one of the modulating valves. Many other piping configurations are possible, and the reader is encouraged to investigate variations on the tried-and-tested layout shown here.



Flow through Series Energy Recovery circuit is highlighted.

Online Figure 2: Typical Piping Configuration for Series Energy Recovery



Online Photo 1: DOAS Installation showing Series Energy Recovery piping.

As can be seen in the piping diagram, when the 3-way diverting valve switches position, the energy recovery loop becomes a freeze protection loop. When used for freeze protection, the pump is energized when the outdoor air temperature drops to 38°F (3°C). When the pump is energized, the temperature of the water entering the heating coil will be significantly diluted (e.g., from 140°F [60°C] down to about 80°F [27°C]). As a result, the heating capacity of the coil (at this part-load condition) will drop by about 12% compared to what it would be with the pump turned off.

To compensate, the heating water flow rate will increase by about 15% to maintain the same leaving air temperature. This is not a significant concern because, as the OA temperature continues to drop and eventually approaches the site design heating condition, the proportion of heating water flow will increase and tempering of the recirculating water will diminish.

On the other hand, when the outdoor air temperature rises above the freezing threshold, the pump is turned off to save energy, as required by Standard 90.1. In that case, heating water will flow through the pump bypass line. In applications where heating of the incoming outdoor air is not required, the three-way diverting valve, the heating control valve and the pump bypass line are omitted. If supplemental reheat is not required, the reheat control valve can also be eliminated.

In the odd case where neither heating nor supplemental reheat is required, the diagram can be reduced to what is shown in Figure 1 (main article). Even with no external heat or reheat, it is recommended to connect the SER piping loop to a nearby hydronic system (heating water preferred) with a small-diameter tube. This obviates the need for a makeup water fill line, a safety relief valve, an expansion tank and separate water treatment. Where check valves are required for proper system operation, such as the two check valves shown in Online Figure 2, it is good practice to install a manually operated shutoff valve adjacent to each check valve for troubleshooting purposes.

Online References

Online Ref. 1 Nelson, G. 2021. "Optimizing coil loop energy recovery systems." *ASHRAE Journal* (11):10 – 20.