Discussion of Ventilation System Energy Performance and Cost

Research Report - 0912

1999

Armin Rudd

Abstract:

An hourly simulation study using DOE2.1E was conducted to determine the annual difference in energy consumption between various ventilation options in different climates.

Discussion of ventilation system energy performance and cost

An hourly simulation study using DOE2.1E was conducted to determine the annual difference in energy consumption between various ventilation options in different climates. Energy consumption and runtime was evaluated for the ventilation fan, and heating and cooling equipment. For the New Jersey climate, an average of the results for Chicago and Charlotte may be used. The simulated houses were insulated according to the ASHRAE Standard 90.2, and the heating and cooling systems were sized according to the ACCA Manual J procedure.

The focus here is a comparison between 1) a multi-port exhaust or supply system, continuously delivering 40 ft^3/min of ventilation air; and 2) a central-fan-integrated supply system, intermittently supplying 60 ft^3/min of ventilation air (33% duty cycle maintained with a fan recycling control). The central-fan-integrated system was simulated with ducts inside conditioned space (Table 1), and outside conditioned space (Table 2). In all cases, fan power was calculated as 0.35 W/cfm and 400 cfm per ton of cooling. The central system air handlers were 1000 cfm and 800 cfm for ducts in unconditioned and conditioned space, respectively. For multi-port supply systems, the outside air should be tempered with at least two parts inside air, which would increase ventilation fan energy consumption from what is shown here.

In summary, the central-fan-integrated system cost $24/yr more to operate with ducts in conditioned space and $65/yr more with ducts in unconditioned space. The difference in first-cost was estimated at $500 more for the multi-port exhaust or supply system due to installing a separate duct system. Thus, the multi-port exhaust or supply system has a simple payback between 8 and 21 years compared to the central-fan-integrated system. An added benefit of the central-fan-integrated system is periodic whole-house mixing, which takes place due to the fan recycling control, and serves to smooth temperature, humidity, and air quality conditions throughout the house providing improved comfort.

Table 1 Summary of DOE2.1E annual simulation data for ventilation systems with ducts in conditioned space for the central-fan-integrated system

	Chicago		Charlotte		Average	
Fan Energy	kW-h	$ @.11	kW-h	$ @.07	kW-h	$ @.09
Multi-port exhaust or supply w/o tempering: 40 cfm contin	750	82	755	53	753	68
Central-fan-integrated: 60 cfm intermittent @ 33%	1019	112	1284	90	1152	104
Difference	269	30	529	37	399	36
Cooling Energy						
Multi-port exhaust or supply w/o tempering: 40 cfm contin	2218	244	2786	195	2502	225
Central-fan-integrated: 60 cfm intermittent @ 33%	2290	252	2813	197	2552	230
Difference	72	8	27	2	50	4
Heating Energy	kW-h	$ @.02	kW-h	$ @.03	kW-h	$ @.025
Multi-port exhaust or supply w/o tempering: 40 cfm contin	11298	226	7533	226	9416	235
Central-fan-integrated: 60 cfm intermittent @ 33%	13553	271	7807	234	10680	267
Difference	2255	45	274	8	1265	32
Net Annual Cost		$		$		$
Multi-port exhaust or supply w/o tempering: 40 cfm contin		552		474		513
Central-fan-integrated: 60 cfm intermittent @ 33%		635		521		578
Difference		83		47		65
Central Fan Operational Hours		hours		hours		hours
Multi-port exhaust or supply w/o tempering: 40 cfm contin		2239		1808		2024
Central-fan-integrated: 60 cfm intermittent @ 33%		3639		3668		3654
Difference		1400		1860		1630
Central Fan Average Hourly Duty Cycle		Average duty cycle		Average duty cycle		Average duty cycle
Multi-port exhaust or supply w/o tempering: 40 cfm contin		0.26		0.21		0.24
Central-fan-integrated: 60 cfm intermittent @ 33%		0.42		0.42		0.42
Difference		0.16		0.21		0.18

Table 2 Summary of DOE2.1E annual simulation data for ventilation systems with ducts in conditioned space for the central-fan-integrated system

	Chicago		Charlotte		Average	
Fan Energy	kW-h	$ @.11	kW-h	$ @.07	kW-h	$ @.09
Multi-port exhaust or supply w/o tempering: 40 cfm continu	750	82	755	53	753	68
Central-fan-integrated: 60 cfm intermittent @ 33%	1004	110	970	68	987	89
Difference	254	28	215	15	235	21
Cooling Energy						
Multi-port exhaust or supply w/o tempering: 40 cfm continu	2218	244	2786	195	2502	225
Central-fan-integrated: 60 cfm intermittent @ 33%	2205	243	2665	187	2435	219
Difference	-13	-1	-121	-8	-67	-6
Heating Energy	kW-h	$ @.02	kW-h	$ @.03	kW-h	$ @.025
Multi-port exhaust or supply w/o tempering: 40 cfm continu	11298	226	7533	226	9416	235
Central-fan-integrated: 60 cfm intermittent @ 33%	12467	249	7207	216	9837	246
Difference	1169	23	-326	-10	422	11
Net Annual Cost		$		$		$
Multi-port exhaust or supply w/o tempering: 40 cfm continu		552		474		513
Central-fan-integrated: 60 cfm intermittent @ 33%		602		471		537
Difference		50		-3		24
Central Fan Operational Hours		hours		hours		hours
Multi-port exhaust or supply w/o tempering: 40 cfm continu		2239		1808		2024
Central-fan-integrated: 60 cfm intermittent @ 33%		3587		3463		3525
Difference		1348		1655		1502
Central Fan Average Hourly Duty Cycle		Average duty cycle		Average duty cycle		Average duty cycle
Multi-port exhaust or supply w/o tempering: 40 cfm continu		0.26		0.21		0.24
Central-fan-integrated: 60 cfm intermittent @ 33%		0.41		0.40		0.41

About the Author

Armin Rudd is a principal engineer at Building Science Corporation in Westford, Massachusetts. More information about Armin Rudd can be found at www.buildingscienceconsulting.com.

Direct all correspondence to: Building Science Corporation, 30 Forest Street, Somerville, MA 02143.

Limits of Liability and Disclaimer of Warranty: