Recent Reference Residence Studies

1) Wilson, AL; Colome, S; Tian, Y; et al. (1996) California residential air exchange rates and residence volumes. J Expo Anal Environ Epidemiol 6(3):311-326.

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Wilson et al. (1996) presented air exchange rate (AER) data and residence volume data from two California residential indoor air quality studies. In the first study, a broad range of residential characteristics in over 500 randomly chosen residences in southern California were measured for three one-week periods during three distinctly different seasons from 1984 to 1985. In the second study, data were collected from nearly 300 residences throughout the state of California in a two-day period during the winter of 1991-1992. A total of 1,700 air exchange rate measurements were taken in the two studies.

The data represents the AER measured during normal daily activities. The first study measurements were taken in the Los Angeles area, while in the second, measurements were taken throughout the entire state. A summary of the seasonal AER values in the Los Angeles area is presented in Table 1 and the median seasonal values by average outdoor temperatures are presented in Table 2. Figure 1 provides the log-probability plots of the distributions shown in Table 1.

The data in Table 2 show that, in the Los Angeles area, AER increases with average ambient temperature between 51° and 75°F and decreases as the ambient temperature rises above 76°F . The AER almost doubled when the temperature increased from the 61° to 65°F range to the 66° to 70°F range. The authors noted that people open their doors and windows more often when outside temperatures are in the range of 66° to 75°F.

Descriptive statistics were calculated for the 1991-1992 AER data to evaluate the geographical effect of AER. These data are presented in Table 3. The log-probability plots of the distribution data in Table 3 are presented in Figure 2. Based on the results of non-parametric tests, the average AER for the Los Angeles area is significantly higher than AERs for the other areas.

The relations between AER and appliance types in the home were also evaluated. Cooking appliances were grouped into three categories: electric, gas without a standby pilot light, and gas with a standby pilot light. Heating appliance categories were electronic, gas forced-air furnace, and gas wall furnace. Non-parametric test results indicated that AER distributions of gas with a standby pilot light is significantly higher than for electric and gas without a standby pilot. The AER distributions for residences with gas wall furnaces were significantly higher than for electric and gas forced-air furnaces and may be due to their design.

Table 4 is a cross tabulation of the median AER values for cooking and heating appliance type categories where there were more than 10 residences, combined for 1984-1985 and the 1991-1992 studies. The AERs in the wall (gas wall furnace) column are higher than for other heating types; AER is highest when wall is combined with GWP (gas with a standing pilot light).

Since resident volume is used to calculate air exchange, the authors evaluated the relations between home volume (F^3[35.31 ft^3 = 1 m^3] and appliance type. Figures 3 and 4 show the home volumes for the winter 1991-1992 study by major cooking and heating appliance categories.

Table 5 shows the median home volumes by cooking and heating appliance where there were more than 10 residences. These results are tabulated from the combined data for the 1984-1985 and 1991-1992 studies.

The results of the study showed that cooking and heating types, geographic locations, temperatures, and home volumes influence residential AERs. Home volume has the strongest effect and outdoor temperature has the weakest effect based on the multivariate and univariate regression analyses.

Indoor air quality and human exposure models can be improved by using data distributions for heating and cooking appliances as estimates of air exchange rates and residence volumes. The limitations of the study is that the data used are measurements taken from one state, California.

Table 1. Summary of Seasonal AER Values in the Los Angeles Area

Parameter	Residential AER, h^{-1}			
	One-week Sample		Two-day Sample	
	March 1984	July 1984	January 1985	Winter 1992
Number of measurements	571	426	372	75
Average	0.78	1.51	0.58	0.79
Geometric mean	0.62	1.05	0.47	0.63
Median	0.62	1.07	0.45	0.64
Arithmetic s.d.	0.63	1.47	0.47	0.57
Geometric s.d.	1.95	2.39	1.97	1.97

Source: Wilson et al., 1996.

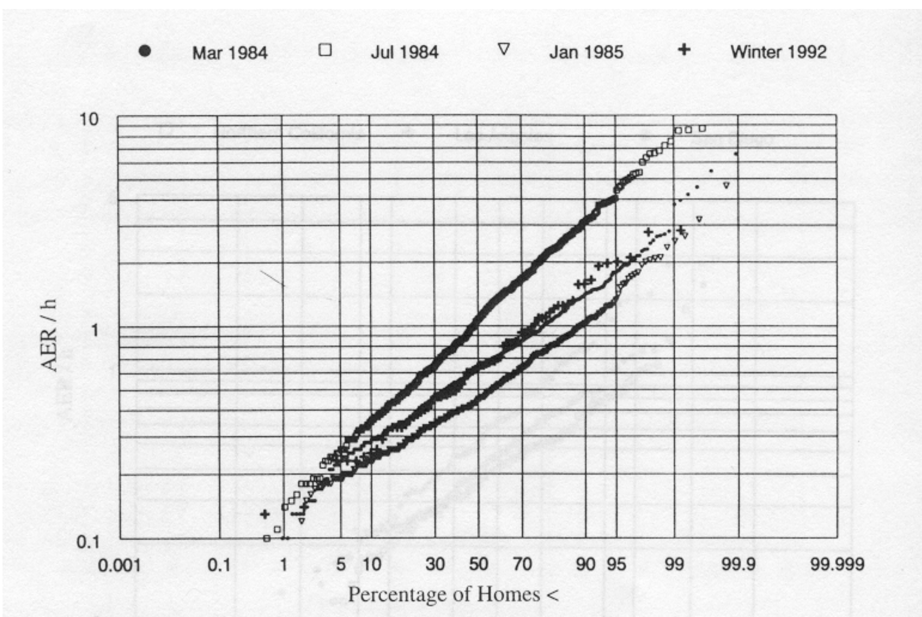

Figure 1. AER by sampling period measured in the Los Angeles area.

Source: Wilson et al., 1996.

Table 2. Median Seasonal AER Values in the Los Angeles Area
Summarized by Average Outdoor Temperatures

Average Outdoor Temperature Range (°F)	Median AER/h[1] Los Angeles Area			
	Seven-day Sample			Two-day Sample
	March 1984	July 1984	January 1985	Winter 1991-1992
51-55	–	–	0.45	–
56-60	0.54	–	0.48	0.50
61-65	0.63	–	–	0.66
66-70	1.22	–	–	–
71-75	–	1.35	–	–
76-80	–	0.88	–	–
81-85	–	0.98	–	–
86-90	–	0.81	–	–
All Temperatures[a]	0.62	1.07	0.45	0.64

Note: Bins with ≤10 samples were not included.

a Averaged across all homes.

Source: Wilson et al., 1996.

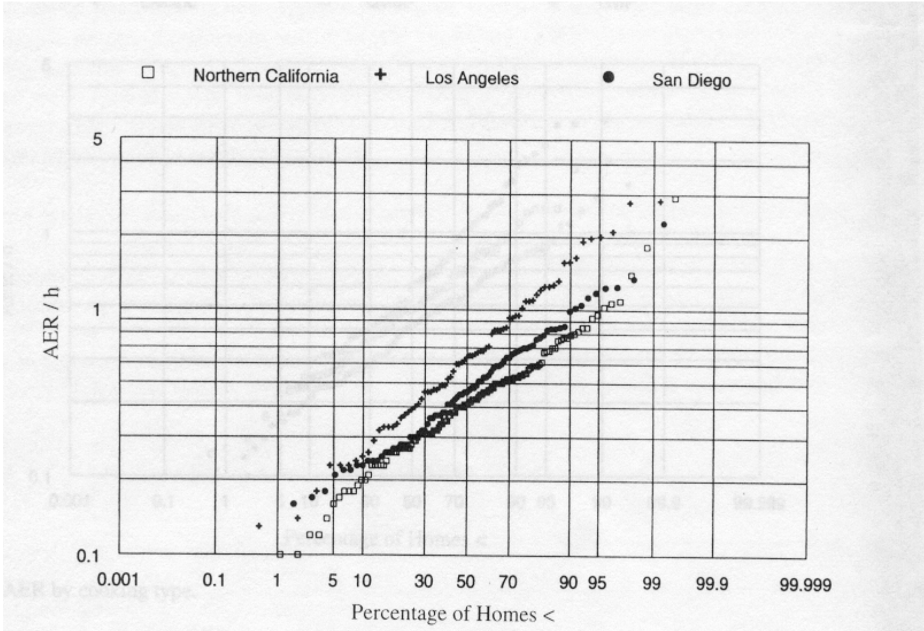

Figure 2. Air exchange rate by study area measured during the winter of 1991-1992.

Source: Wilson et al., 1996.

Table 3. Summary of Winter 1991-1992 AER in California

Parameter	Residential AER/h^{-1} Two-day Sample		
	Northern California	Los Angeles	San Diego
Number of measurements	128	75	85
Average	0.47	0.79	0.54
Geometric mean	0.39	0.63	0.46
Median	0.41	0.64	0.46
Arithmetic s.d.	0.34	0.57	0.34

Source: Wilson et al., 1996.

Table 4. Median AER by Cooking and Heating Types

Cooking Type	Heating Type							
	Electric		FA[a]		Wall[b]		All	
March 1984, Los Angeles								
Electric	0.71	(19)	0.52	(102)	–	(7)	0.52	(139)
GwoP[c]	–	(1)	0.54	(46)	0.75	(16)	0.57	(81)
GwP[d]	–	(10)	0.60	(148)	0.80	(119)	0.70	(351)
All	0.72	(30)	0.56	(296)	0.79	(142)	0.62	(571)
July 1984, Los Angeles								
Electric	1.09	(11)	0.69	(68)	–	(4)	0.72	(93)
GwoP[c]	–	(1)	0.85	(39)	1.20	(12)	0.92	(66)
GwP[d]	–	(9)	0.77	(108)	1.59	(93)	1.29	(267)
All	0.98	(21)	0.76	(215)	1.57	(109)	1.07	(426)
January 1985, Los Angeles								
Electric	0.39	(11)	0.40	(63)	–	(4)	0.40	(88)
GwoP[c]	–	(1)	0.39	(38)	0.42	(14)	0.44	(63)
GwP[d]	–	(7)	0.44	(91)	0.47	(76)	0.46	(221)
All	0.34	(19)	0.42	(192)	0.46	(94)	0.45	(372)
Winter 1991-1992, California								
Electric	0.40	(39)	0.40	(71)	0.59	(11)	0.42	(135)
GwoP[c]	–	(7)	0.41	(41)	0.58	(15)	0.48	(71)
GwP[d]	–	(0)	0.44	(28)	0.72	(28)	0.61	(70)
All	0.42	(46)	0.41	(147)	0.61	(55)	0.46	(288)

Note: Counts of homes with valid AER data are listed in parentheses. AER median values were not computed for bins with $\leq$10 samples. Category "All" includes homes with infrequently encountered heating and cooking types that are not listed in the table.

a FA = gas forced-air furnace
b Wall = gas wall furnace
c GwoP = gas without a standing pilot light
d GwP = gas with a standing pilot light

Source: Wilson et al., 1996.

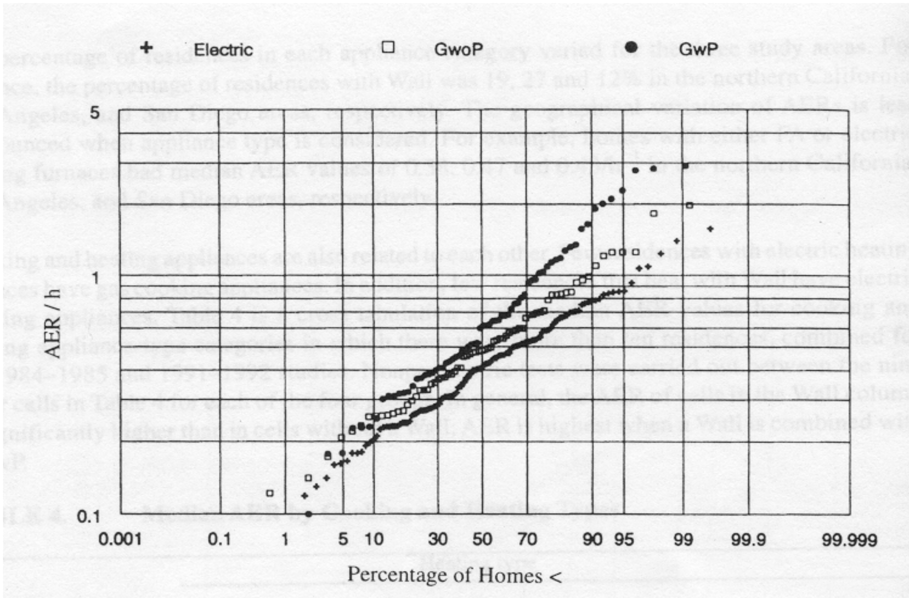

Figure 3. AER by cooking type.

Source: Wilson et al., 1996.

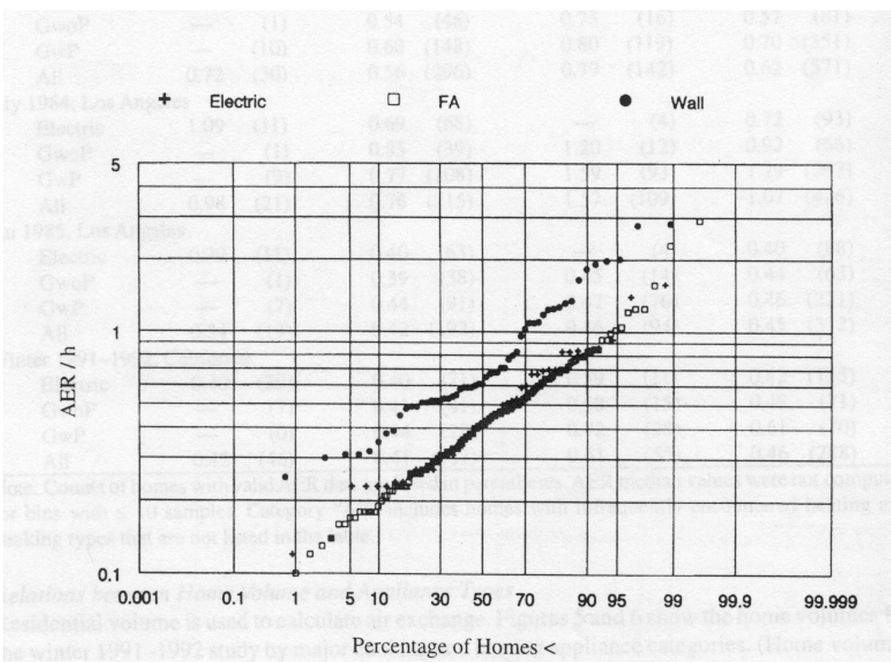

Figure 4. AER by heating type.

Source: Wilson et al., 1996.

Table 5. Median Residence Volume by Cooking and Heating Types (Cu Ft)

Cooking Type	Heating Type: Electric		FA[a]		Wall[b]		All	
Los Angeles, 1984-1995								
Electric	6,500	(20	13,600	(103)	–	(7)	12,800	(142)
GwoP[c]	–	(2)	13,000	(48)	8,100	(17)	11,200	(87)
GwP[d]	–	(10)	12,000	(164)	6,600	(125)	9,200	(380)
All	7,800	(32)	12,600	(315)	6,700	(149)	10,400	(609)
California, 1991-1992								
Electric	7,200	(41)	13,200	(73)	6,400	(11)	11,400	(139)
GwoP[c]	–	(7)	13,000	(42)	6,200	(15)	10,200	(72)
GwP[d]	–	(0)	10,600	(28)	5,400	(28)	7,000	(70)
All	7,300	(48)	12,800	(150)	5,800	(55)	10,000	(293)

Note: Counts of homes with valid AER data are listed in parentheses. AER median values were not computed for bins with ≤10 samples. Category "All" includes homes with infrequently encountered heating and cooking types that are not listed in the table.

a FA = gas forced-air furnace
b Wall = gas wall furnace
c GwoP = gas without a standing pilot light
d GwP = gas with a standing pilot light

Source: Wilson et al., 1996.

Table 6. AER Stepwise Regression Results

Independent Variables	Parameter Estimate	Partial R^2	Prob. >F
Home volume, cu ft	-0.000018	0.1679	0.0001
GwP	0.1672	0.0643	0.0001
Located in SoCal gas territory	0.1792	0.0360	0.0009
Gas wall heating	0.1437	0.0149	0.0303
Average outdoor temperature, °F	0.0521	0.0107	0.0630

Source: Wilson et al., 1996.