U.S. Environmental Protection Agency

Summary and Analysis Report of the BASE Study Building Selection Process Work Assignment V-01, Task 3 of Technical Directive 4 Contract 68D50164

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ABBREVIATIONS AND ACRONYMS

°F	Degrees Fahrenheit
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
AHU	air handling unit
BASE	Building Assessment Survey and Evaluation
BOMA	Building Owners and Managers Association
CBECS	Commercial Building Energy Consumption Survey
EH&E	Environmental Health & Engineering, Inc.
EPA	U.S. Environmental Protection Agency
HVAC	heating, ventilating, and air-conditioning
IAQ	indoor air quality
MSA	Metropolitan Statistical Area
PV	Preliminary Visit

1.0 INTRODUCTION

The U.S. Environmental Protection Agency's (EPA) Office of Radiation and Indoor Air has conducted a major study to fill a data gap that has existed regarding baseline indoor air quality (IAQ) in public and commercial office buildings. The goal of the Building Assessment Survey and Evaluation (BASE) Study has been to define the status of existing U.S. office buildings with respect to IAQ and occupant perceptions. Because much of the IAQ research in the U.S. prior to the BASE study had focused on buildings whose occupants had significant complaints about IAQ, the BASE study was designed as a cross-sectional study of office buildings without regard to IAQ complaints. As such, EPA conducted focus groups with over 40 IAQ experts to develop a sampling strategy that would gather information on randomly selected buildings. The protocol that developed out of these discussions[1] details a weeklong IAQ investigation in each building, providing general characteristics of the building and specific environmental and questionnaire measurements in a sampling space within the building. The purpose of the following report is to describe and evaluate the building selection process with regard to how well the sampled buildings represent U.S. office buildings.

To ensure that various climates would be represented in the study, a stratified random sampling method was devised across ten climate regions with similar heating and cooling requirements, based on the American Society of Heating, Refrigeration, and Air Conditioning Engineers' (ASHRAE) building design specifications. Within these climate regions, cities with a population of over 100,000 were randomly selected using a random number generator. Within these cities, tenants within buildings were contacted to determine building eligibility. The building manager/owner was then contacted and asked whether they would allow the study to be conducted in their building. Once it was determined that the building had not been highly publicized as a "sick" or "problem" building, a preliminary visit (PV) was scheduled to identify at least one sampling space within the building. If at least one study space could be identified as having more than 50

[1] *A Standardized EPA Protocol for Characterizing Indoor Air Quality in Large Office Buildings*. Indoor Air Division, Office of Radiation and Indoor Air, U.S. EPA and Atmospheric Research and Exposure Assessment Laboratory, Office of Modeling, Monitoring Systems, and Quality Assurance, U.S. EPA. Effective Date: June 1, 1994.

occupants and as being serviced by no more than two air handling units (AHUs), the building was considered acceptable for random selection.[2]

This report details the stratified random selection process for the 100 buildings and 100 study spaces studied between 1994 and 1998 (Section 2.0). It summarizes each level of this selection process (Section 3.0) and, wherever possible, provides reasons for rejecting buildings. Potential errors, uncertainties, and biases in the selection process are identified (Section 4.0). The BASE sample is then compared to the population of U.S. office buildings for a variety of common building characteristics (Section 5.0), and a summary of the analyses is provided (Section 6.0).

[2] *Developing Baseline Information on Buildings and Indoor Air Quality (BASE '94): Part I-Study Design, Building Selection, and Building Descriptions*. EH&E report to EPA on Work Assignment III-2, Contract No. 68-D2-0066, December 28, 1994.

2.0 DESCRIPTION OF BUILDING SELECTION PROCESS

The process undertaken by Environmental Health & Engineering, Inc. (EH&E) to recruit BASE buildings is detailed in three EH&E reports: *BASE Statistical Framework,*[3] *Building Recruiting for the Building Assessment Survey and Evaluation (BASE) Program*[4] and *Standard Operating Procedures for Building Recruiting*.[5] The first report outlines the proposed selection strategy. The second report describes the selection process that EH&E followed during the 1994 winter and summer seasons and during the 1995 winter season, as the study got under way. The third report is a detailed Standard Operating Procedure for selecting cities, buildings, and sampling spaces throughout the five-year study. A summary of these procedures is presented below.

2.1 SELECTING CITIES WITHIN CLIMATE REGIONS

EPA and EH&E divided the U.S. into 10 climate regions based on ASHRAE heating and cooling specifications.[6] Cities with populations over 100,000 were then randomly selected within each climate region.

2.1.1 Defining Climate Regions

To differentiate climate, EH&E compiled climate data for each of the 201 U.S. cities with populations greater than 100,000. After discussions with EPA, EH&E stratified the cities according to two variables: design temperature (for summer and winter) and dew point[7,8] (Table 2.1). Initially, eight regions were identified; however, EPA and EH&E judged the Pacific Northwest and the California coast to be sufficiently different (from D and G

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3 *BASE Statistical Framework*. EH&E report to EPA on Work Assignment II-5, Task 2 "Straw Man" Sampling Plan, Contract No. 68-D2-0066, December 1, 1993.

4 *Building Recruiting for the Building Assessment Survey and Evaluation (BASE) Program.* EH&E report to EPA on Work Assignment III-2, Contract No. 68-D2-0066, December 28, 1994.

5 Environmental Health & Engineering., Inc, *US EPA BASE Study Standard Operating Procedure for Building Recruiting*, November 1996.

6 *Region Definition for Sampling Plan,* EH&E report to EPA on Work Assignment #II-5, Contract No. 68D20066 dated February 15, 1994.

7 United States Department of Commerce, Weather Bureau, 1961. Climate Atlas of the United States, Washington, D.C.

8 ASHRAE, 1993. 1993 ASHRAE Handbook of Fundamentals; Atlanta, GA.

respectively) in terms of building design, construction and operation, that regions I and J were defined separately, creating a total of ten regions (Figure 2.1).

Table 2.1 Climate Regions for the BASE Target Cities

		Summer Design Conditions [a]			
		Dew Point < 53 °F		*Dew Point ³ 53 °F*	
		Temp. < 94 °F (Cool/Mod.)	*Temp. ³ 94 °F (Hot)*	*Temp. < 94 °F (Cool/Mod.)*	*Temp. ³ 94 °F (Hot)*
Winter Design Temp.	*Cool £ 10 °F*	A	A	B	C
	Mod. 11 °F – 32 °F	D	E	D or I	F
	Hot > 32°F	G	H	G or J	G or H

°F Degrees Fahrenheit

[a] 2.5% dry-bulb design temperature
[b] 97.5% dry-bulb design temperature

Figure 2.1 Climate Regions for the BASE Target Cities

2.1.2 Selecting Cities within Regions

Prior to each seasonal BASE study, EPA designated the regions from which the study cities were to be randomly selected (Appendix A). Table 2.2 shows the number of cities meeting the base study criteria, listed by climate region. The number of cities studied within each region was intended to reflect this distribution.

Table 2.2 Number of BASE Cities within Climate Regions

Region	Number of Cities
A	9
B	52
C	8
D	39
E	16
F	23
G	11
H	10
I	5
J	28

Random selection of a city within a region was accomplished by numbering an alphabetized list of the cities within the chosen region from 1 to the number of cities within the region. A random number between 0 and 1 was generated using a random number generator and was multiplied by the number of cities within the region and rounded to the nearest integer. The city with the corresponding number was then selected. This process was repeated for each region (Table 2.3).

Table 2.3 Cities within the BASE Climate Regions

Study Season	Climate Regions	State and City Number Selected Within the Given Region[a]
Winter 1994	B	Minnesota 1
Summer 1994	F	Texas 1
	J	California 1
	C	Missouri 1
	I	Oregon 1
Winter 1995	G	Louisiana 1
	D	South Carolina 1
	A	Nevada 1
	E	California 2
Summer 1995	H	Arizona 1
	G	Florida 1
	B	Pennsylvania 1
Winter 1996	F	Texas 2
	C	Nebraska 1
Summer 1996	E	California 2
	A	Colorado 1
	D	Tennessee 1
Winter 1997	B	Michigan 1
	B	Massachusetts 1
	H	Arizona 2
	J	California 4
	I	Washington 1
Summer 1997	D	Georgia 1
	D	Maryland 1
	J	California 5
	F	Tennessee 2
	D	New York 1
	B	New York 2
Winter 1998	D	North Carolina 1
	F	Arkansas 1
	J	California 6
	J	California 7
	B	South Dakota 1
	D	Florida 2
Summer 1998	E	New Mexico 1
	F	Texas 3
	B	New York 3
	B	Illinois 1
	G	Florida 3

[a] City names are not presented in order to preserve the confidentiality requirements of the study. Instead, each city is represented by the name of the state followed by a number to differentiate among multiple cities in the same state.

Typically, three to five cities were studied during each season, with up to three buildings studied in each city.

2.2 SELECTING BUILDINGS WITHIN CITIES

To obtain eligible buildings, an intensive selection process, normally over the course of weeks for each city, put EH&E in contact with thousands of tenants and building managers/owners. The goal was to find office buildings that had at least one study space with more than 50 occupants and that was serviced by no more than two AHUs (normally this meant that the study space was on no more than two adjacent floors). Buildings that had been highly publicized as "sick" or "problem" buildings were excluded from the selection process. The following report sections detail each step in this selection process. Table 2.4 summarizes the steps in the selection process and their possible outcomes.

Table 2.4 Building Selection Process

Step Number	Step	Possible Outcomes[a]
1	Call Attempted	• Listing not called by preliminary caller • *Listing called by preliminary caller*
2	Tenant Contact	• Contact w/ tenant not fully established • *Contact w/ tenant established*
3	Prior Contact	• Tenant previously contacted • *Tenant not previously contacted*
4	Office Space	• No office space according to tenant • *Office space according to tenant*
5	Number employees	• Fewer than 50 employees according to tenant • *More than 50 employees according to tenant*
6	Tenant interested	• Tenant not interested – Not interested: wary of EPA – Not interested: tenant concerns – Not interested: liability concerns – Not interested: no time to participate – Not interested: other • *Tenant willing*
7	ID bldg mgr/owner	• Tenant unable/unwilling to identify building manager/owner • *Tenant identified building manager/owner*
8	Bldg mgr/owner contact	• Building manager/owner not contacted by preliminary caller • *Building manager/owner contacted by preliminary caller*
9	Number employees	• Fewer than 50 employees according to building manager/owner • *More than 50 employees according to building manager/owner*
10	Bldg mgr/owner interest	• Building manager/owner not interested – Not interested: wary of EPA – Not interested: tenant concerns – Not interested: liability concerns – Not interested: no time to participate – Not interested: other • *Building manager/owner willing*
11	Technical call contact	• Building manager/owner not contacted by technical caller • *Building manager/owner contacted by technical caller*
12	Technical call eligibility	• Technical caller determines building to be ineligible (HVAC, publicity, or occupancy reasons) • *Technical caller determines building to be eligible*
13	Bldg mgr/owner interest	• Building manager/owner not interested – Not interested: wary of EPA – Not interested: tenant concerns – Not interested: liability concerns – Not interested: no time to participate – Not interested: other • *Building manager/owner interested – Preliminary Visit scheduled*
14	Preliminary Visit	• Scheduled Preliminary Visit but building not visited • *Scheduled Preliminary Visit and building visited*

Table 2.4 Continued

Step Number	Step	Possible Outcomes[a]
15	Post-Preliminary Visit eligibility	• Preliminary Visit-determined building ineligible • *Preliminary Visit-determined building eligible*
16	Random selection	• Building not randomly selected for study • *Building randomly selected for study*
17	Study building	• Building not studied • *Building studied*

HVAC heating, ventilating, and air-conditioning

[a] The second item of each possible outcome (or last item of each cluster) is the outcome that was required to continue the process. These c*ontinue recruitment* outcomes are indicated by italic type.

2.2.1 Generating Randomized Telephone Lists

For each selected city, EH&E developed business listings from either of two business telephone databases. The Cole Directory[9] was used for the 1994 cities, while two CD-ROM directories from ProCD,[10] *DirectPhone* (1995) and *SelectPhone* (1996-1998), were used for the remainder of the study.

For the 1994 winter study, Cole Directory provided EH&E with a bound directory of business addresses and telephone numbers. In order to develop a list of random telephone numbers, EH&E manually randomized the business telephone numbers. This method was extremely time consuming, so for the 1994 summer study, EH&E requested that Cole Publications electronically randomize the calling list and provide EH&E with a subset of telephone numbers from this randomized list. However, as part of a validation of this process, EH&E discovered that Cole Publications had used an algorithm that selected business listings based on certain consonants in the second letter of the listings. Because this algorithm may have biased the subset of listings by grouping certain business titles together, EH&E requested that Cole Publications generate another, unbiased list. The potentially biased list was used for selecting buildings within Texas 1, while the unbiased list was used for California 1, Missouri 1, and Oregon 1.

9 1994 Cole Directory. Cole Publications, Inc., Lincoln, NE.

10 ProCD Inc., Danvers, MA.

By the end of 1994, CD-ROM directories were publicly available; each year the quality of these CD-ROMs improved. Business listings were compiled from these CD-ROMs for each selected city, exported to a Microsoft Access® file (and in later years, to a Microsoft Excel® file), and then randomized using a random number function.

2.2.2 Recruiting Calls (Steps 1-10)

EH&E recruited buildings for the study by telephoning businesses in sequential order on each randomized calling list. For the first city, Minnesota 1, EH&E used its own technical staff to contact building tenants. For all other cities, EH&E hired temporary employees. Following are the steps preliminary callers followed for identifying potentially eligible buildings.

- A preliminary caller contacted a business using the randomized business telephone list for the study city and started filling out the *Preliminary Caller Form* (Figure B1, Appendix B). This form was used to prompt the preliminary caller through a series of questions and to document contacts.

- The tenant was first asked if their business is located in an office building. If the answer was "no," the preliminary caller ended the call. If the answer was "yes," the preliminary caller continued the call with a brief explanation of the BASE study and proceeded with the other eligibility questions.

- The preliminary caller asked if there were 50 or more occupants in the building. If the answer was "no," the recruiter ended the call. If the answer was "yes," the preliminary caller asked the tenant for the name, phone number, and fax number of the building manager/owner.

- If the recipient of the initial call was not interested, the preliminary caller attempted to document the reason for this lack of interest. The methodology for tracking information during this step in the recruiting process was developed as the study progressed; thus some information on tenant interest (and later building manager/owner interest) is not available for cities studied during the first two or three seasons.

- A call was then made to the building manager/owner. If the building manager/owner was unavailable after two calls, the preliminary caller faxed a *BASE Study Fax Information Packet* to him/her (Appendix C). When the preliminary caller contacted the building manager/owner, he/she described the objectives of the study and asked whether they would be interested in participating in the study. If the building manager/owner was not interested, the preliminary caller asked if they would be willing to say why and ended the call. If the building manager was interested, the preliminary caller verified answers to the preliminary eligibility questions and asked more detailed questions about general building characteristics (number of stories, age of building, etc.). If the building manager did not already have the *BASE Study Fax Information Packet*, the preliminary caller faxed the information packet to the building manager/owner.

- If the eligibility criteria (buildings with office space accommodating greater than 50 employees) were not met, the preliminary caller explained the reasons why the BASE study could not be conducted in that particular building and ended the call.

2.2.3 Technical Calls (Steps 11-13)

- The technical caller, using the *Technical Follow-up Call Form* (Figure B2, Appendix B), verified if there were office areas in the building that had at least 50 occupants. In addition, they asked whether these spaces were served by a maximum of two air handling systems.

- If the technical caller determined the building to be eligible and if the building manager/owner was interested, the technical caller attempted to recruit the building by providing more detailed information about the BASE study. The technical caller explained that this was a scientific study and that the results would be used to improve IAQ in the U.S. The technical caller also emphasized the non-regulatory nature of the study and assured the manager/owner that, although EPA sponsored this study, EPA had no intention of identifying environmental violations. The building manager/owner was encouraged by the technical caller to ask questions about any aspect of the BASE study, such as how the study would be conducted, the details of

the study (HVAC measurements, environmental sampling, and questionnaire), and the intended analysis/use of the data.

- A technical call ended when information revealed the building to be ineligible or if the building manager decided that they were not interested in proceeding with the study.

- If the building met the eligibility requirements and the building manager/owner was interested in participating in the study, EH&E scheduled an on-site PV and sent a *Preliminary Visit Information Packet*. The technical caller explained to the building manager that the PV was a screening visit. The *Preliminary Visit Packet*, accompanied by a confirmation letter, contained a letter from EPA assuring the confidential nature of the BASE study, flyers describing the BASE study, and a description of the field schedule for distribution to the tenants by the building manager (Appendix D).

2.2.4 Preliminary Visits (Steps 14 and 15)

Preliminary Visits (PV) for eligible buildings in a given city were conducted over the course of a week. At the PV, an EH&E investigator conducted an introductory overview with the building manager/owner about the BASE study and the logistics of the sampling schedule during the field study week. Study objectives were stated and the manager/owner was told that they would have the option of either receiving a formal report of the sampling results or not receiving any results. All managers/owners chose to receive a formal study report.

The managers/owners were encouraged to ask questions and discuss special concerns. A computer software-based survey[11] was conducted with the manager/owner with special emphasis placed on space use, occupancy, HVAC system, and potential study areas. During a walkthrough of the building, the investigator verified potential study areas by carefully reviewing the building design drawings, if available. If no space within the building met the EPA's criteria, the investigator gave an explanation to the building contact and the PV ended.

[11] The Indoor Air Data Collection System was software developed to collect and store information collected as part of EPA's large building studies.

If an eligible study space was identified, the investigator provided the building contact with an overview and schedule for the field study week. A handout outlining the preparation list for the field study week (Appendix E) was distributed to the building contact. This handout discussed how to prepare for the study, including security access, ladders, staging area, and shipping. The PV investigators expressed their appreciation to the manager/owner and let them know that a random selection process would be used to choose the final buildings to be studied.

2.2.5 Final Building Selection (Steps 16 and 17)

Two or three buildings were randomly selected, after all of the PVs had been completed in a chosen city, using the same method for selecting cities. Building managers/owners were notified whether their buildings had or had not been selected via telephone within a week following the PV. Formal letters were sent out to all building managers/owners visited during the PVs. In the case that a manager/owner declined to participate at this point, EH&E randomly selected a backup building.

3.0 BUILDING SELECTION PROCESS DATA SUMMARY

3.1 TRACKING BUILDING SELECTION

EH&E documented the outcome of each telephone call made by the building recruiters in a matrix for each city. Each business listing from the original randomized telephone list was assigned a number and tracked from the initial call to the farthest step in the selection process. EH&E aggregated totals from these city matrices in the *Recruitment Tracking Matrix* (Appendix F).

As the study progressed, EPA and EH&E decided to formalize the tracking methods of the building selection process. EH&E submitted a report in 1994 with initial summaries.[12] As a result of the 1994 report, EH&E added data fields to the recruiting call forms and standardized coding methods. Compilation of recruiting data was an evolutionary process over the course of the five-year study. As a result, some fields in the *Recruitment Tracking Matrix* are not available for the first seasons of the study.

3.2 BUILDING SELECTION RESULTS

3.2.1 Descriptive Statistics

The number of buildings meeting the criteria for each step in the building selection process (Figure 3.1) is based on the aggregate building recruiting data included in the *Recruitment Tracking Matrix*. Roughly one-tenth of the businesses contacted appeared to be in eligible buildings (steps 1-5, Figure 3.1). The two greatest limiting criteria were whether the call had been made to a building with office space (step 4) and whether that building had 50 or more occupants (step 5).

[12] *Building Recruiting for the Building Assessment Survey and Evaluation (BASE) Program.* EH&E report to EPA on Work Assignment III-2, Contract No. 68-D2-0066, December 28, 1994.

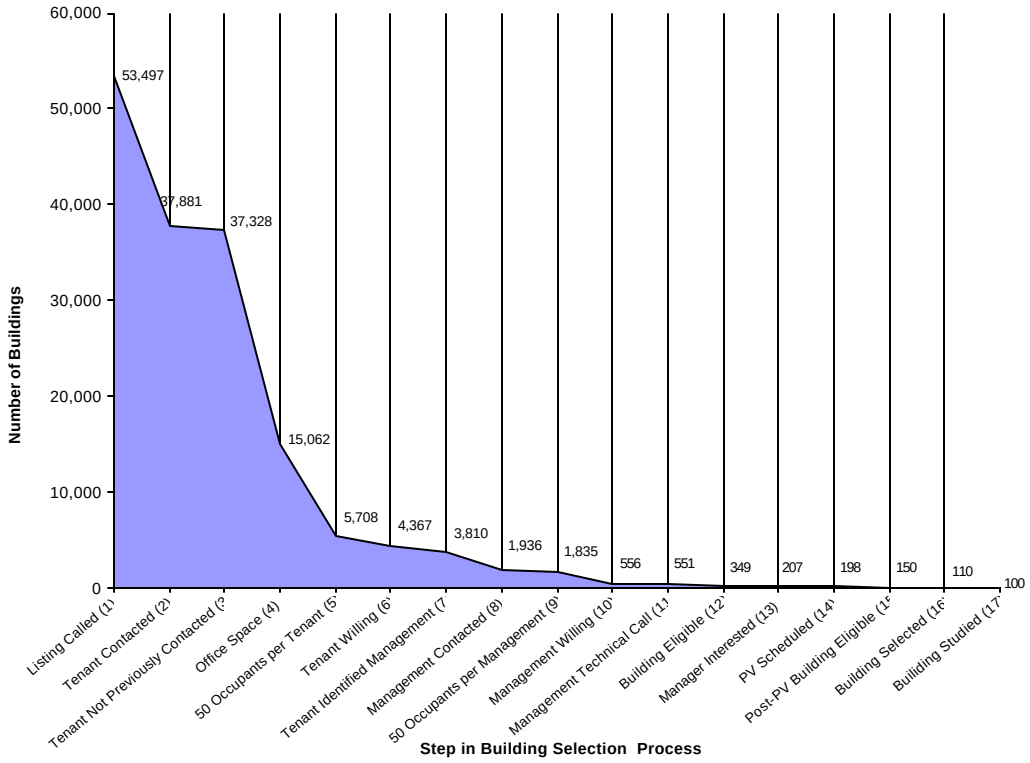


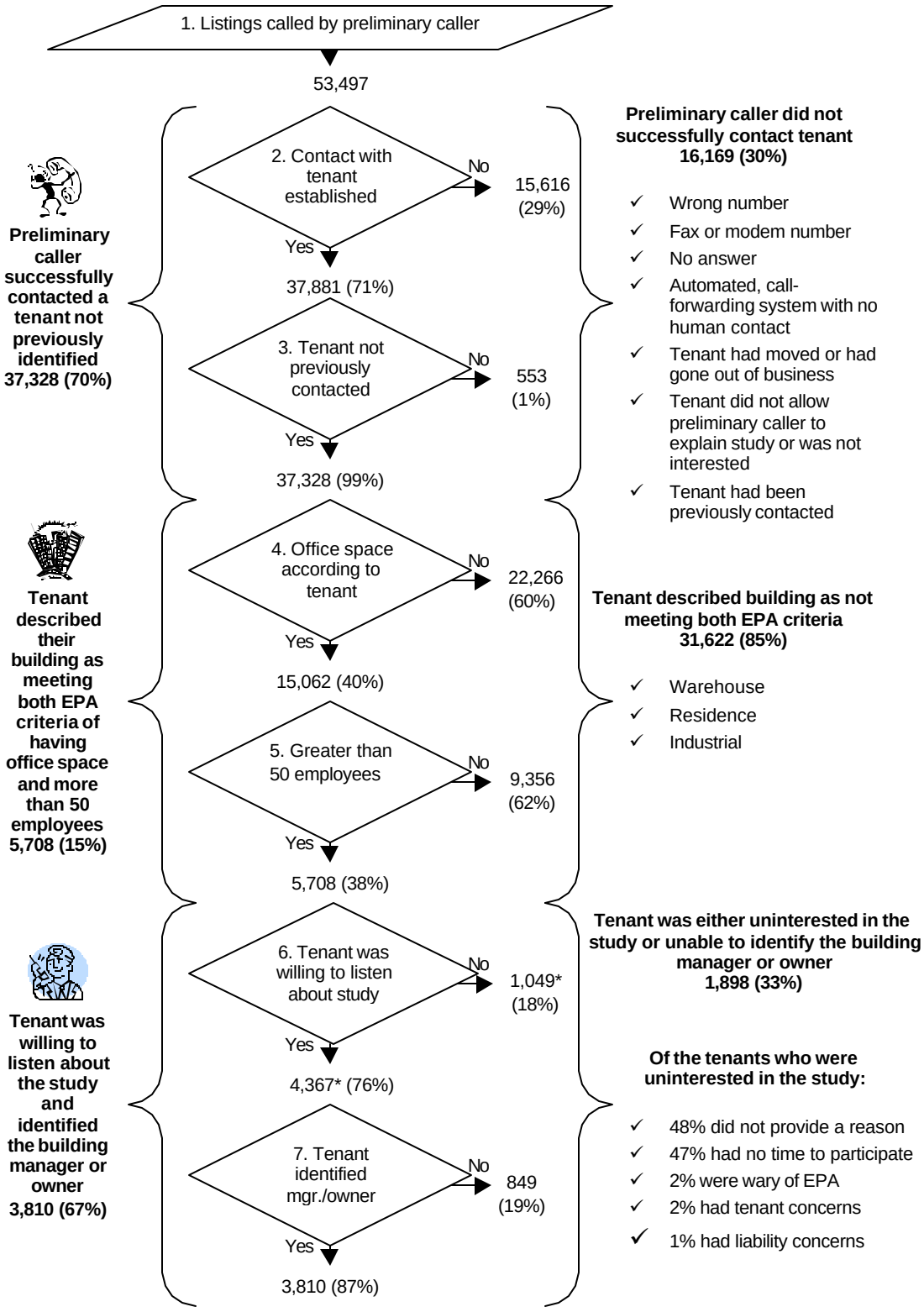
Figure 3.1 Overall Building Selection

Figure 3.2 depicts the results of each step in the building selection. All together, 53,497 telephone calls were made to recruit 150 eligible buildings in 39 different cities.[13] Of all these calls, less than a third (15,062) of the building listings were successfully contacted[14] and had any office space. A third of these office buildings had 50 or more occupants according to the tenant (5,708). Tenants identified two-thirds of the building managers/owners (3,810), and roughly half of these (1,936) could be contacted. Most of these building managers/owners (1,835) confirmed that their buildings had at least one office space with more than 50 employees. However, less than a third of these managers/owners (556) were willing for EH&E to conduct the study in their building.

13 Recruitment was actually conducted in 39 cities, but two cities (New York 1 and California 7) proved so unsuccessful that two other cities were selected.

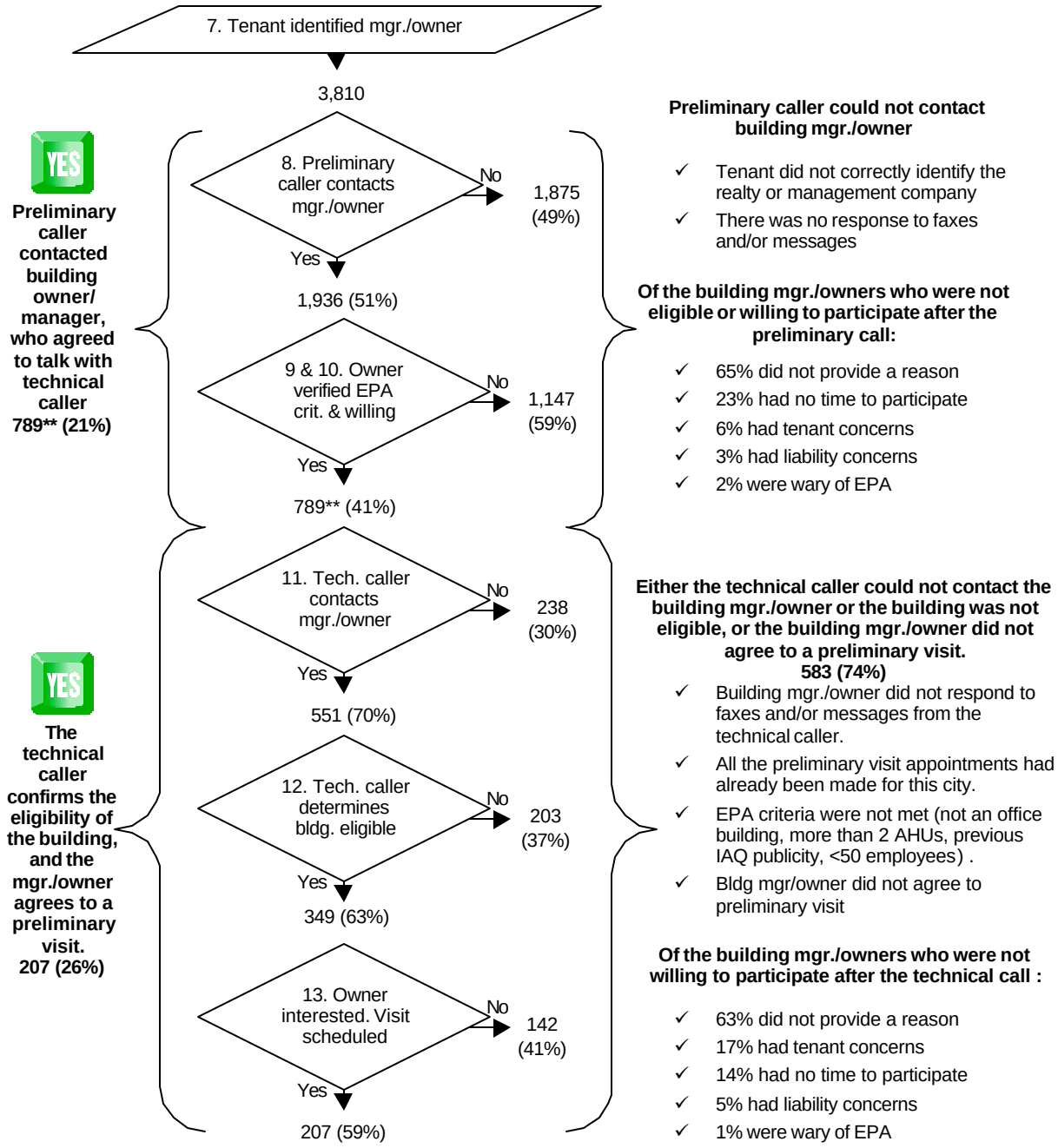
14 Five hundred and fifty-three "duplicates", defined as businesses located in the same building as a business already contacted on a previous recruiting call, were excluded.

Figure 3.2 Steps 1 – 7 of the Building Selection Process



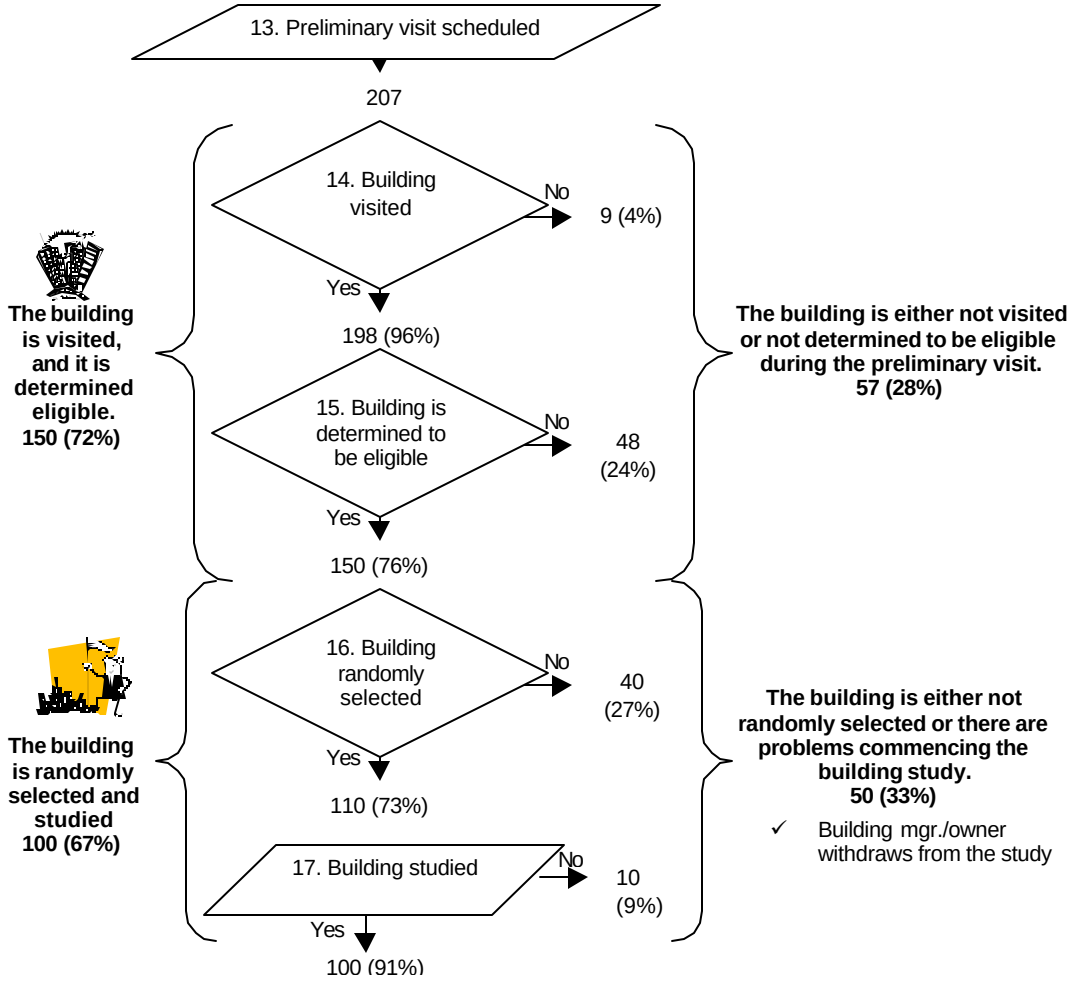
* These steps were not tracked for 1994 cities, thus the values represent tallies for 1995 through 1998

Figure 3.2 Continued Steps 7 -13 of the Building Selection Process



** These steps were not tracked for 1994 and 1995 cities, thus, 1994 and 1995 values were inferred

Figure 3.2 Continued Steps 14 -17 of the Building Selection Process



When a technical caller telephoned for a detailed conversation, he/she verified that there was at least one office space with more than 50 employees and asked whether this space was served by no more than two AHUs. After this technical call, the number of eligible buildings dropped another third to 349. After the managers/owners heard more details about the study, roughly two-thirds of those with eligible buildings were still interested, and PVs were scheduled (207).[15] PVs were conducted on nearly all these buildings (198). Of these, three-quarters (150) passed the PV screening. Roughly two-thirds of these eligible buildings were randomly selected for the study (100).

[15] Limited information on why tenants and managers/owners might not have been interested is detailed below (Section 3.3).

3.2.2 Recruiting Effectiveness

Table 3.1 summarizes several milestones of the building selection process, from the initial call (step 1), to the preliminary caller identifying an eligible building with a tenant (steps 4 and 5), to the technical caller verifying the building eligibility with a building manager/owner (step 13), and ultimately to the number of eligible buildings verified during the PV (step 15). A measure of recruiting effectiveness, defined as the "percent of eligible buildings out of the total preliminary calls made" is provided for each city.

The overall recruiting effectiveness is 0.3%. However, this measure ranges from 0.1% in Arizona 1, California 3, and Florida 3 to 3.2% in Minnesota 1 (Table 3.1). Two of the factors that may account for the higher percentage in Minnesota 1 are listed below.

- EH&E technical staff made all the preliminary calls for Minnesota 1, while hired recruiters followed a script developed by EH&E for the remaining cities. It is possible that because the EH&E staff could answer all questions relevant to the study, fewer calls were lost by the EH&E staff than by the hired recruiters.

- The Cole directory listings were more current than the ProCD listings. It is possible that fewer bad listings were experienced in the beginning of the study than at the end.

Table 3.1 Recruiting Effectiveness

	Step	1	4	5	13	15	Recruiting Effectiveness (Step 15 ¸ Step 1)
Study Season	BASE City [a]	Number of Listings Called by Preliminary Caller	Number of Buildings with Office Space According to Tenant	Number of Buildings with More than 50 Employees According to Tenant	Number of Eligible Buildings after the Technical Call	Number of Eligible Buildings after the Preliminary Visit	Percent of Eligible Buildings out of the Total Preliminary Calls Made
Winter 1994	Minnesota 1	125	18	14	4	4	3.2%
Summer 1994	Texas 1	685	133	106	3	2	0.3%
	California 1	652	103	78	5	5	0.8%
	Missouri 1	320	65	54	5	4	1.3%
	Oregon 1	357	56	40	5	5	1.4%
Winter 1995	Louisiana 1	857	117	39	7	4	0.5%
	South Carolina 1	176	60	23	3	2	1.1%
	Nevada 1	608	152	46	6	3	0.5%
	California 2	114	34	15	3	2	1.8%
Summer 1995	Arizona 1	2,282	484	60	4	3	0.1%
	Florida 1	672	146	22	4	4	0.6%
	Pennsylvania 1	1,080	298	40	5	3	0.3%
Winter 1996	Texas 2	1,497	468	279	4	3	0.2%
	Nebraska 1	1,737	727	228	6	3	0.2%
Summer 1996	California 3	4,250	1,072	390	3	3	0.1%
	Colorado 1	1,278	472	318	8	6	0.5%
	Tennessee 1	1,813	450	293	9	3	0.2%

Table 3.1 Continued

	Step	1	4	5	13	15	Recruiting Effectiveness (Step 15 ¸ Step 1)
Study Season	BASE City [a]	Number of Listings Called by Preliminary Caller	Number of Buildings with Office Space According to Tenant	Number of Buildings with More than 50 Employees According to Tenant	Number of Eligible Buildings after the Technical Call	Number of Eligible Buildings after the Preliminary Visit	Percent of Eligible Buildings out of the Total Preliminary Calls Made
Winter 1997	Michigan 1	1,053	454	126	7	4	0.4%
	Massachusetts 1	712	441	219	5	4	0.6%
	Arizona 2	892	447	127	5	4	0.4%
	California 4	1,222	631	139	7	6	0.5%
	Washington 1	342	195	64	6	5	1.5%
Summer 1997	Georgia 1	657	253	189	7	4	0.6%
	Maryland 1	1,888	448	249	6	4	0.2%
	California 5	1,359	330	179	6	4	0.3%
	Tennessee 2	1,681	533	254	9	5	0.3%
	New York 1 [b]	2,017	318	99	b	b	b
	New York 2	1,334	440	256	7	4	0.3%

Table 3.1 Continued

	Step	1	4	5	13	15	Recruiting Effectiveness (Step 15 ¸ Step 1)
Study Season	**BASE City [a]**	**Number of Listings Called by Preliminary Caller**	**Number of Buildings with Office Space According to Tenant**	**Number of Buildings with More than 50 Employees According to Tenant**	**Number of Eligible Buildings after the Technical Call**	**Number of Eligible Buildings after the Preliminary Visit**	**Percent of Eligible Buildings out of the Total Preliminary Calls Made**
Winter 1998	North Carolina 1	2,241	543	179	8	5	0.2%
	Arkansas 1	1,224	426	126	6	5	0.4%
	California 7 [b]	1,132	256	32	b	b	b
	California 6	2,224	614	168	7	5	0.2%
	South Dakota 1	2,457	619	139	5	5	0.2%
	Florida 2	2,215	557	100	5	5	0.2%
	New Mexico 1	1,390	408	110	6	4	0.3%
	Texas 3	2,156	514	284	6	5	0.2%
Summer 1998	New York 3	2,503	804	184	6	6	0.2%
	Illinois 1	2,903	665	268	5	5	0.2%
	Florida 3	1,392	311	172	4	2	0.1%
	Totals	53,497	15,062	5,708	207	150	0.3%

a Each city is represented by the name of the state followed by an ordinal to distinguish multiple cities in the same state. BASE cities are listed in the chronological order of the selection process. Complete data on building selection is found in the *Recruitment Tracking Matrix* (Appendix F).

b Buildings in this city were found to have either minimal office space or insufficient building occupancy, or building managers showed little interest in the BASE study. EH&E dropped these cities from the selection process and randomly selected a new city.

The distribution of the recruiting effectiveness measures for each city in the BASE study shows that there is a slight downward trend (Figure 3.3). Recruiting effectiveness appears to decrease as the study progressed. Also, six of the highest seven values (using 0.8% as the cutoff value, shown by a dotted line on Figure 3.3) occur in the first three recruiting seasons (Winter 1994, Summer 1994, and Winter 1995).

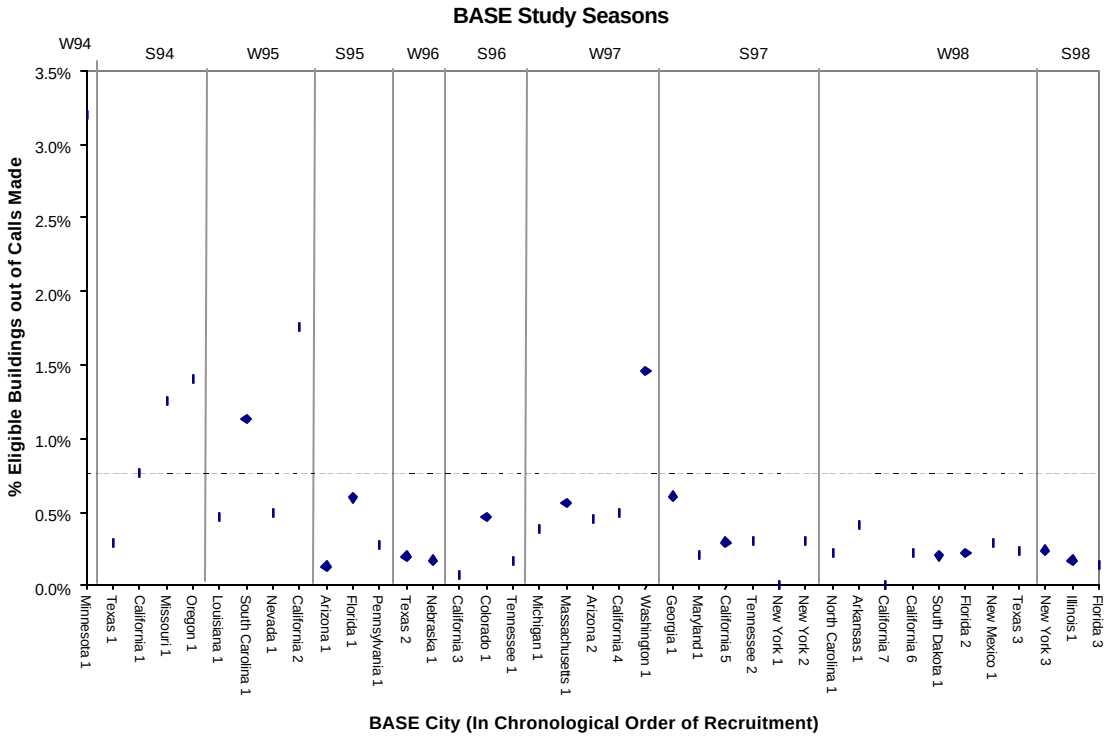


Figure 3.3 Distribution of Recruiting Effectiveness: Percent of Eligible Buildings out of the Total Preliminary Calls Made

Recruitment in the cities of California 7 and New York 1 was completely unsuccessful with roughly 1,000 and 2,000 calls made respectively and no buildings found eligible (thus, the recruiting effectiveness was at 0%). In California 7, there was little office space reported: 16% of contacted businesses were in buildings with office space, compared to the 40% average across all cities studied. In the case of New York 1, few tenants reported that their office buildings had more than 50 people: 12% compared to the 38% average. Apart from these two cases, there is no clear pattern, either geographic or demographic, to the decreasing trend in recruiting efficiencies. Examination of intermediary steps (Table 3.1), however, provides possible reasons for this trend.

By taking the initially recruited eligible buildings (the number of buildings with more than 50 employees according to the preliminary caller's contact with the tenant – Step 5), and dividing that by the number of buildings eligible after the PV (Step 15), it is possible to derive a useful ratio. This ratio captures the number of initially recruited buildings needed to recruit one eligible building (as determined after the PV) for the study (Figure 3.4).

There is a noticeable difference in these ratios as the study progresses. Prior to the winter of 1996, the recruiters provided an average of 15 buildings for every eligible PV building (ratios ranging from 4 to 73), while during the winter of 1996 until the end of the study in 1998 recruiters provided an average of 51 buildings for every eligible PV building (ratios ranging 13 to 130).

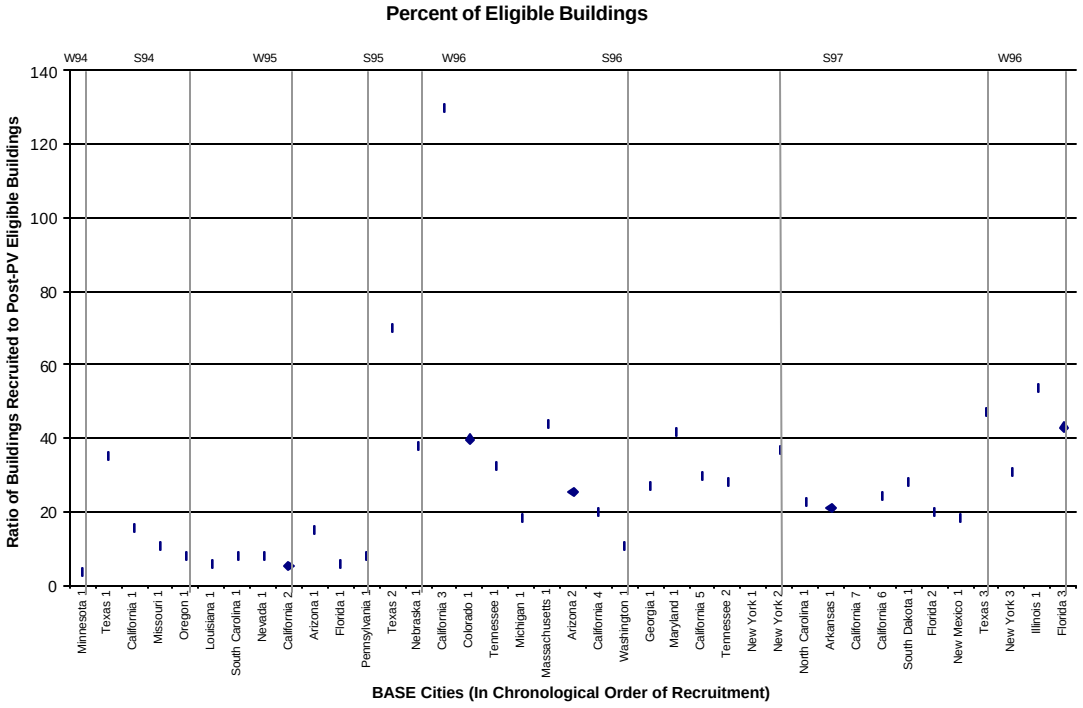


Figure 3.4 Ratios of Recruited Buildings to Post-PV Eligible Buildings

One possible explanation for this difference is that the recruiters' ability to discern eligible buildings decreased as the study progressed. A more likely explanation is that, starting in the winter of 1996, EPA requested increasing efforts from one to two field teams, thus increasing the number of cities studied per season. This created a tighter timeframe for recruiting buildings. To meet these tight timelines, more than one preliminary caller was

responsible for each city, increasing the number of buildings recruited. In addition, technical callers most likely reduced their efforts when they had identified "enough" eligible buildings ("quota sampling" as specified by the study design in *BASE Statistical Framework*[16]). On average, six buildings were scheduled for preliminary visits in each city, roughly twice the number of buildings necessary for each city. As the number of eligible buildings that the recruiters identified increased by over 200% (20 before Winter 1996 to 60 during and after Winter 1996), the number of scheduled preliminary visits increased by only 30% (4.4 to 5.8). These statistics seem to indicate that recruiting efficiencies decreased when the number of field teams increased to two.

3.2.3 Recruiting Interest

EH&E trained the recruiters to discuss the possible benefits that building managers/owners would experience by participating in the BASE study. These benefits included a free IAQ investigation of their building and an analytical report—a study estimated to be worth roughly 20 to 30 thousand dollars. Recruiters described how participants would significantly contribute to a national research project that was intended to improve IAQ conditions in U.S. office buildings. Recruiters also offered the EPA's *Building Air Quality Handbook*[17] to participants. Most recruiters found that the best incentive for participants was the free IAQ investigation and associated analyses.

EH&E developed assessments of tenant and building manager/owner interest after the preliminary and technical calls, using the *Recruitment Tracking Matrix* data (Appendix F). The Recruitment Interest Results table (Table 3.2) summarizes for each city the percentages of: interested tenants after the preliminary call, interested managers/owners after the preliminary call, and interested managers/owners after the technical call (Tables A-C, Appendix G). EH&E also analyzed recruiting data on why tenants or managers/owners declined the study (Tables A-C, Appendix G). Although recruiters made significant efforts to ascertain this information, the data are limited for at least four

16 *BASE Statistical Framework*. EH&E report to EPA on Work Assignment II-5, Task 2 “Straw Man” Sampling Plan, Contract No. 68-D2-0066, December 1, 1993.

17 EPA. 1993. *Building Air Quality: A Guide for Building Owners and Facility Managers.* Draft. Washington, D.C.: U.S. Environmental Protection Agency, Office of Air and Radiation, and U. S. Department of Health and Human Services, National Institute for Occupational Safety and Health.

reasons: (1) EPA and EH&E developed methods for tracking these data after the study began; (2) many times, tenants and managers/owners would not provide reasons; (3) when they did provide a reason, it was hard to determine whether the reason they offered was entirely honest; and (4) it is safe to assume that tenants and building managers/owners expressed their lack of interest also by not returning phone calls.

Table 3.2 Recruitment Interest Results Summary

Step	2	5	6	%	8	9	10	%	11	12	13	%
	Tenant Interest After Preliminary Call				*Building Manager/Owner Interest After Preliminary Call*				*Building Manager/Owner Interest After Technical Call*			
Base City	*Contact With Tenant Established By Prelim Caller*	*Building Eligible (According To Tenant)*	*Tenant Willing*	*Eligible Tenants Interested (After Prelim Call)*	*Contact With Bldg Mngr/Owner Established By Prelim Caller*	*Building Eligible (According To Mngr/ Owner)*	*Bldg Mngr/ Owner Willing*	*Eligible Bldg Mngrs/ Owners Interested (After Prelim Call)*	*Bldg Mngr/ Owner Contacted By Tech Caller*	*Bldg Eligible (According To Mngr/ Owner)*	*Bldg Mngr/ Owner Interested - PV Scheduled*	*Eligible Bldg Mngrs/ Owners Interested (After Tech Call)*
Minnesota 1	73	14	a	a	8	7	a	a	4	4	4	100%
Texas 1	579	106	a	a	35	32	a	a	8	7	3	43%
California 1	508	78	a	a	38	33	a	a	11	11	5	46%
Missouri 1	271	54	a	a	33	29	a	a	7	7	5	71%
Oregon 1	305	40	a	a	26	20	a	a	12	10	5	50%
Louisiana 1	574	39	21	54%	19	17	b	b	16	7	7	100%
South Carolina 1	140	23	11	48%	10	10	b	b	10	3	3	100%
Nevada 1	478	46	23	50%	22	20	b	b	20	9	6	67%
California 2	97	15	14	93%	13	13	b	b	13	3	3	100%
Arizona 1	1,375	60	34	57%	29	27	b	b	22	10	4	40%
Florida 1	381	22	10	46%	10	10	b	b	8	7	4	57%
Pennsylvania 1	669	40	25	63%	18	18	b	b	14	8	5	63%
Texas 2	827	279	232	83%	130	128	23	18%	21	12	4	33%
Nebraska 1	1,202	228	205	90%	113	113	29	26%	25	18	6	33%
California 3	3,205	390	329	84%	201	177	25	14%	25	19	3	16%
Colorado 1	952	318	307	97%	84	80	20	25%	17	12	8	67%
Tennessee 1	1,277	293	278	95%	84	70	13	19%	13	11	9	82%
Michigan 1	715	126	111	88%	57	55	28	51%	24	17	7	41%
Massachusetts 1	481	219	136	62%	85	80	35	42%	26	15	5	33%
Arizona 2	570	127	92	72%	38	37	11	30%	7	6	5	83%
California 4	859	139	117	84%	44	44	20	46%	15	11	7	64%
Washington 1	246	64	64	100%	19	19	11	58%	6	6	6	100%
Georgia 1	466	189	163	86%	46	46	11	24%	10	8	7	88%
Maryland 1	1,350	249	206	83%	68	65	17	26%	16	9	6	67%
California 5	975	179	166	93%	69	68	21	31%	13	10	6	60%
Tennessee 2	1,319	254	208	82%	75	67	17	25%	17	10	9	90%
New York 1	1,469	99	60	61%	11	11	2	18%	0	0	0	0%
New York 2	1,121	256	203	80%	73	72	33	46%	33	20	7	35%
North Carolina 1	1,561	179	119	67%	46	46	25	54%	19	9	8	89%
Arkansas 1	985	126	116	92%	40	39	10	26%	10	6	6	100%
California 7	894	32	29	91%	3	3	0	0%	0	0	0	.0%
California 6	1,721	168	143	85%	55	52	19	37%	19	9	7	78%
South Dakota 1	1,907	139	127	92%	41	38	19	50%	19	11	5	46%
Florida 2	1,707	100	97	97%	37	35	20	57%	18	10	5	50%

Table 3.2 Continued

Step	2	5	6	%	8	9	10	%	11	12	13	%
Base City	*Contact With Tenant Established By Prelim Caller*	*Building Eligible (According To Tenant)*	*Tenant Willing*	*Eligible Tenants Interested (After Prelim Call)*	*Contact With Bldg Mngr/Owner Established By Prelim Caller*	*Building Eligible (According To Mngr/ Owner)*	*Bldg Mngr/ Owner Willing*	*Eligible Bldg Mngrs/ Owners Interested (After Prelim Call)*	*Bldg Mngr/ Owner Contacted By Tech Caller*	*Bldg Eligible (According To Mngr/ Owner)*	*Bldg Mngr/ Owner Interested - PV Scheduled*	*Eligible Bldg Mngrs/ Owners Interested (After Tech Call)*
New Mexico 1	1,031	110	82	75%	15	15	7	47%	7	6	6	100%
Texas 3	1,195	284	188	66%	37	35	15	43%	9	6	6	100%
New York 3	1,842	184	127	69%	36	36	22	61%	10	7	6	86%
Illinois 1	1,630	268	208	78%	138	138	85	62%	20	10	5	50%
Florida 3	924	172	116	67%	30	30	18	60%	7	5	4	80%
Totals (Average)	37,881	5,708	4,367	(77%)	1,936	1,835	556	(30%)	551	349	207	(60%)

[a] This information was not part of the original study and not tracked during Winter 1994 and Summer 1994.
[b] Tenant interest and building manager/owner's interest were not differentiated until Winter 1996.

The percentage of interested building tenants was generally high if their building was deemed eligible (Table 3.3). Specifically, once preliminary callers had established the preliminary eligibility requirements for the building (office space and more than 50 employees), 77% of tenants in eligible buildings expressed willingness to participate in the study. Tenant interest in cities was never lower than the 45% (Florida 1) and peaked at 100% (Washington 1). The level of interest, however, was lower for building managers/owners (Figure 3.5). Of the building managers/owners (whom preliminary callers deemed had eligible buildings), only 30% on average expressed interest in participating in the study. Building manager/owner interest ranged from 0% (California 7) to 62% (Illinois 1).

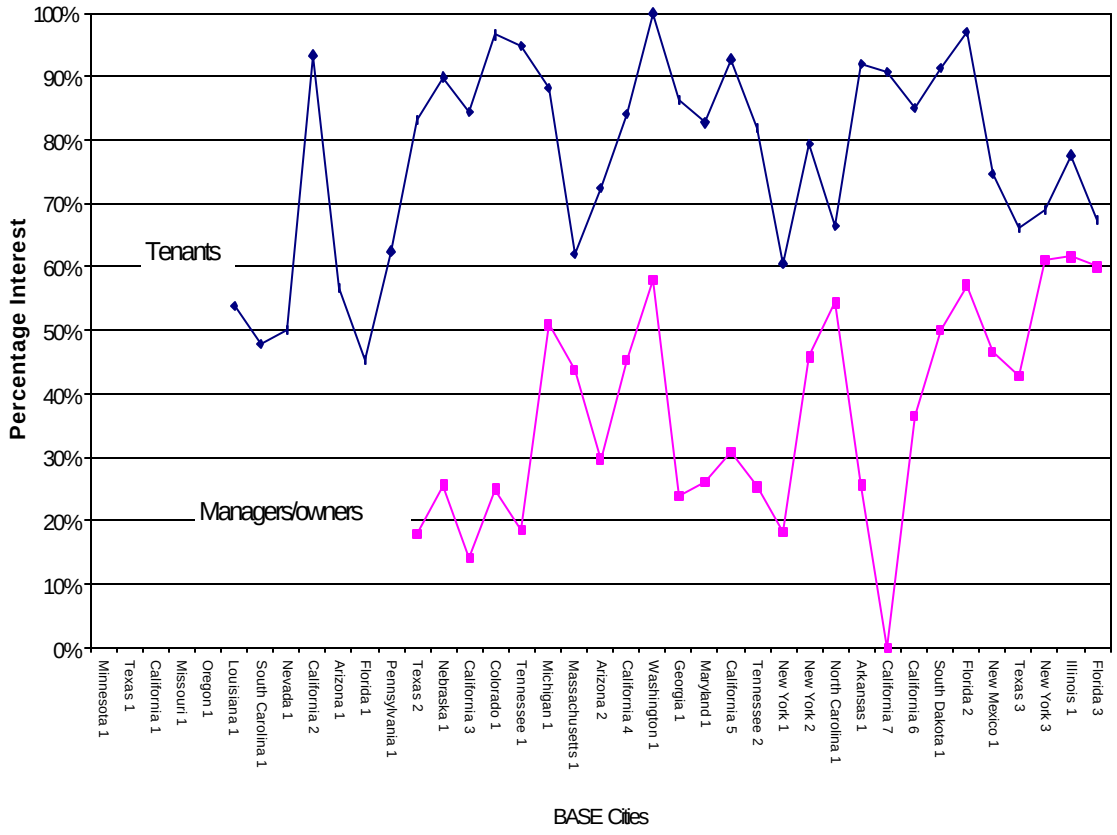


Figure 3.5 Percentages of Interested Tenants and of Managers/Owners After Preliminary Callers Determined Their Buildings to Be Eligible

When the technical callers contacted the managers/owners to verify the eligibility of their buildings and to provide more information about the study, 30% of the managers/owners from the eligible buildings remained interested (Table 3.3). Manager/owner interest after the technical call varied from 0% (New York 1)[18] to 100% (Minnesota 1, Louisiana 1, South Carolina 1, California 2, Washington 1, Arkansas 1, New Mexico 1, and Texas 3).

Most tenants uninterested in the study did not provide a reason to the preliminary callers. When tenants did provide information on their lack of interest, the most popular reason was "no time to participate" (47%). Few said they were wary of EPA (2%), had tenant concerns (2%), or liability concerns (1%). Managers/owners contacted by preliminary callers followed a similar pattern: most did not provide a reason (65%), some had no time to participate (23%), and few had tenant (3%) or liability concerns (3%) or were wary of EPA (3%). When the technical caller provided more details, most managers/owners did not provide a reason (63%), some had tenant concerns (17%), some had no time to participate, and few had liability concerns (5%) or were wary of EPA (1%).

As stated at the beginning of this section, the information regarding tenant and manager/owner lack of interest is limited; only general observations can be made. Although most tenants and managers/owners did not provide reasons, many said they were uninterested because they had no time to participate. Few said that they had tenant-, liability-, or EPA-related concerns.

[18] New York 1 is a good example of potentially hidden lack of interest. Technical callers could not contact any of the building managers/owners that the preliminary callers had identified as having eligible buildings.

4.0 ERRORS, BIASES, UNCERTAINTIES

EH&E and EPA are confident that the building selection process provided as random a selection of buildings as possible. Of course, the selection process could not be fully random due to logistics. This section describes potential errors (random and systematic), resulting biases, and uncertainties in the region and city selection, the EPA's building criteria, and the steps of the building selection process.

4.1 REGION AND CITY SELECTION

The BASE study was designed to examine a subpopulation of U.S. office buildings—large office buildings in cities with populations of over 100,000 within the continental U.S. Each study season (winter and summer), EPA selected a region from ten climate regions. From this region, EH&E randomly selected one city (Section 2.1.2). As shown in Figure 4.1, the number of cities chosen for the study reflects the proportion of cities with populations over 100,000 across the ten regions. Note the "percentage of BASE cities sampled within each region" during the study follows a similar distribution to the "percentage of eligible cities within each region" (Figure 4.1). For reference, the actual numbers of BASE cities studied and eligible cities in a given region are shown at the top of each percentage bar in Figure 4.1.

Although it looks as if the regional stratification may have caused underemphasis of regions B and D and overemphasis of region I, a chi^2 test ($X^2_{9,\ 0.98} = 2.3$) shows that that the distribution of BASE cities are not significantly different than the distribution of cities with populations over 100,000. Randomization of cities from a list not stratified by region could have provided a more representative sample within regions if the sample size were large. However, given the relatively small number of cities chosen, it is unlikely that such a random selection would have provided better regional representation than achieved by EPA.[19] As such, their stratified selection did not introduce significant bias or error.

[19] Moreover, it is important for regional analyses to have at least one city studied in each region; a random selection of 38 cities could have resulted in one or more regions having no cities represented.

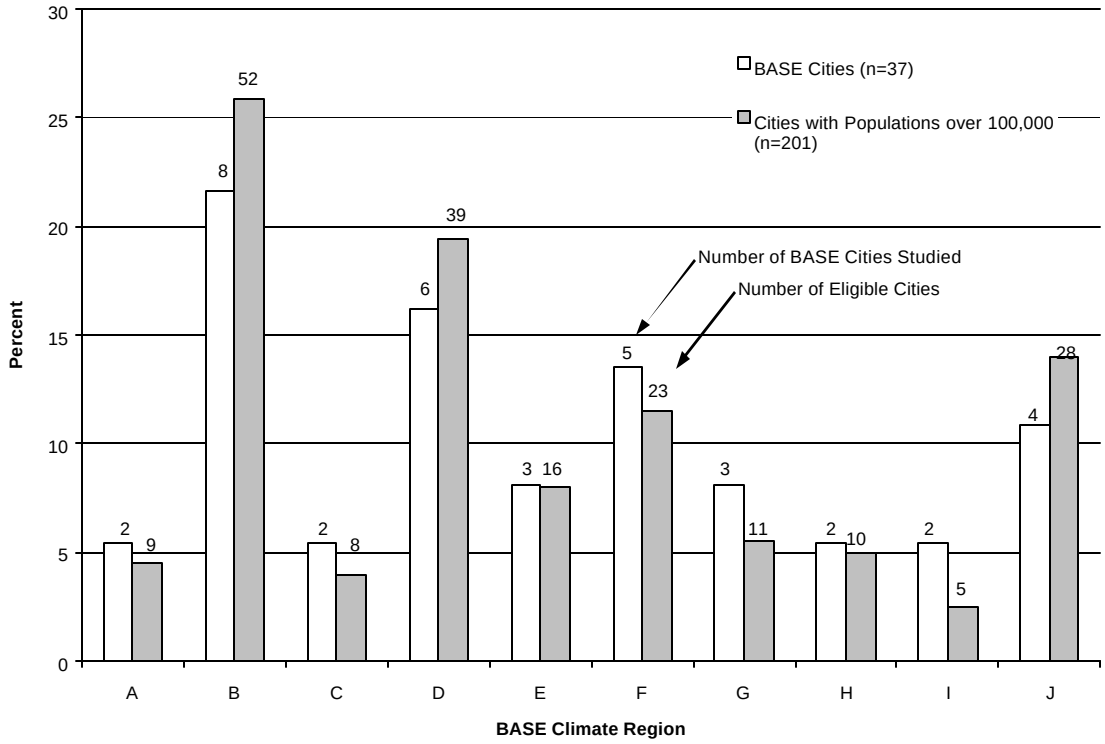


Figure 4.1 Regional Distribution of Cities

4.2 EPA BUILDING CRITERIA

To summarize earlier detailed descriptions of building criteria, there were two stages. First, preliminary callers verified that buildings had at least one office space with 50 or more occupants.[20] Later, technical callers verified that these potential sampling spaces were also serviced by no more than two AHUs and were not in buildings that had highly publicized IAQ problems and/or potential IAQ lawsuits. The requirement for 50 or more occupants biased the sample toward larger buildings than in the general population.[21]

The requirement of having no more than two AHUs service the study space excluded buildings using heat pumps and unit ventilators as primary means of ventilation. This is due to the EPA's definition of an AHU: a ventilation system that provided outdoor air to

[20] Focus groups had suggested to EPA that 50 or more occupants were an important requirement for descriptive questionnaire statistics.

[21] This bias towards larger buildings is illustrated by comparing CBECS A with CBECS C+ in Tables I-1 (square footage) and I-3 (# of floors) located in Appendix I, which will be discussed in more detail in Section 5.

the study space. As heat pumps and unit ventilators normally condition small volumes of air (e.g., 1,500 cubic feet per minute), nearly all office spaces would need more than two of these. Heat pumps and unit ventilators have more components, require more maintenance, and can be more difficult to access than larger systems. The AHU definition biases the mechanically ventilated portion of the sample toward buildings with central AHUs. The extent of this bias is unknown.

The requirement that buildings could not have had highly publicized IAQ problems or potential IAQ lawsuits biased the BASE sample toward buildings with fewer complaints and lower symptom prevalences than the general population. However, only two cases out of the 551 technical calls (<1%) were rejected because of this requirement. As such, the bias introduced is negligible.

4.3 BUILDING SELECTION

Throughout the study, EH&E put great effort into standardizing the building selection process; thus, it is unlikely that recruiters introduced significant selection biases. It is likely that tenants and building managers/owners did introduce self-selection biases throughout the process.

As the study progressed, the recruiting team improved its abilities to randomize the telephone listings (Section 2.2.1). EH&E believes that this increased effectiveness had little impact on the type of buildings in the sample.

Although preliminary callers were instructed to call every business on their randomized telephone listing, careful review of their log sheets indicate they may have skipped some of the businesses that might not meet the EPA's criteria. For example, beauty shops, pizza parlors, gas stations, and laundromats are not commonly located in office buildings; preliminary callers could have skipped them to save time. EH&E's assessment is that this did not happen often and would not have had a significant impact on the type of buildings in the sample even if it did.

One further bias resulted from preliminary callers making telephone calls during the day; this would exclude buildings only open during non-peak hours.

Preliminary callers may have introduced errors in the selection process by incorrectly transcribing information from tenants or by insufficiently documenting outcomes from the calling process on the recruiting tracking forms. The tenant contact, usually a receptionist, may have also introduced errors in the selection process by misrepresenting the type of building and/or occupancy. However, neither error would have had a significant impact on the type of buildings in the sample.

As detailed in Section 3.3, most tenants from eligible buildings were interested in the study; a lower percentage of building managers/owners were interested when they heard more details (Figure 3.4). Although recruiters made significant efforts to ascertain why tenants and building managers/owners might not be interested, the data are limited (Section 3.3). Not much can be said about why tenants and managers/owners were uninterested, though technical callers reported that some managers/owners were interested in the study because they had an IAQ problem they wanted solved. Therefore, it is reasonable to assume that the selection process included some complaint buildings.

Quota sampling was part of the study design[22]; it came into play at several stages throughout the building selection (e.g. region, cities, and number of buildings studied). Section 3.2 discusses quota sampling in detail with regard to scheduling PVs. However, this method of sampling would not have introduced any significant biases.

In summary, errors in the building selection process were few and introduced negligible biases. The EPA's stratified random selection of the BASE cities follows the regional distribution of cities with populations over 100,000. EPA's building criteria did bias the sample toward larger buildings than the normal population. Self-selection bias introduced by both the tenants and building managers/owners is potentially large; however, the majority of respondents did not provide substantive reasons. However, it is reasonable to assume that the recruiting process included some complaint buildings.

EH&E believes that the BASE sampling design was successfully followed and the study included buildings representative of large urban office buildings, proportionately

[22] *BASE Statistical Framework*. EH&E report to EPA on Work Assignment II-5, Task 2 "Straw Man" Sampling Plan, Contract No. 68-D2-0066, December 1, 1993.

distributed across the ten climate regions across the continental U.S. Although sources of systematic error have been identified (introduced primarily by sampling design), EH&E believes the resulting biases do not interfere with the EPA's goal of collecting normative data.

5.0 REPRESENTATIVENESS OF THE BUILDINGS SELECTED

This section compares the BASE sample of 100 buildings to two other sample sets of buildings with significantly larger sample sizes. The first of these sets consists of comparable buildings (urban, >50 occupants); the second is a sample of the entire office building stock across the United States. Two questions are addressed:

1. How representative are BASE buildings to large urban office buildings in the U.S.?
2. How representative are BASE buildings to all office buildings in the U.S.?

Comparison data are provided by two sources: the Commercial Building Energy Consumption Survey (CBECS)[23] and the Building Owners and Managers Association (BOMA).[24]

EH&E chose seven variables for comparison, based on the characteristics that would best characterize office buildings and the availability of the variables within the datasets:

1. Gross area of buildings (square footage)
2. Number of floors (above and below grade)
3. Hours of operation per week
4. Year building was constructed
5. Wall construction materials
6. Roof construction materials
7. Area per occupant (in occupied space)

Section 5.1 describes the data used for comparison. Section 5.2 presents the results of these comparisons for each variable. Section 5.3 discusses the representativeness of the BASE sample set to all U.S. office buildings.

[23] Energy Information Administration. 1998.

[24] Building Owners and Managers Association (BOMA) International. 1998. *1998 BOMA Experience Exchange Report: Operating a cost effective office building, Your guide to income and expense data.* Washington: BOMA.

5.1 NATIONAL BUILDING CHARACTERISTICS

5.1.1 CBECS Data

For all but one of the variables evaluated, EH&E used data gathered by the Energy Information Administration of the U.S. Department of Energy through CBECS, conducted in 1995. "CBECS is a national-level sample survey of commercial buildings and their energy suppliers conducted quadrennially… The target population of the 1995 CBECS survey consisted of all commercial buildings in the United States with more than 1,000 square feet of floor space, with the exception of buildings located on manufacturing sites."[25] For the CBECS survey, a commercial building was defined as an enclosed structure with more than 50 percent of its floor space used for activities that are neither residential, industrial, nor agricultural. The 1995 survey was conducted on a representative sample of 6,639 buildings, for which 5,766 building characteristic survey interviews were actually conducted. Of these, 1,228 were office buildings. While its building eligibility criteria are different from the BASE building eligibility criteria, the CBECS dataset was the most specific and had the best study design and the best data for comparison purposes.

To make these comparisons, EH&E downloaded CBECS microdata files made available to the public on the CBECS website at http://www.eia.doe.gov/emeu/cbecs. These files are the actual interview responses from each of the 5,766 buildings eligible for the survey with some minor modifications to preserve confidentiality. The CBECS sample was designed so that survey responses could be used to estimate characteristics of the entire commercial building stock nationwide.[26] In order to make comparisons to the BASE sample, EH&E extracted the CBECS data for *office buildings* (n=1228).

CBECS and BASE definitions for the first six comparison variables are detailed in *Comparison of Data Definitions for CBECS and BASE Studies* (Table 1, Appendix H). The CBECS survey methods and other measured variables are described in *A Look at*

[25] Energy Information Administration. 1998.

[26] To calculate national estimates from the CBECS sample, the user multiplies the values for each value surveyed by base sampling weights, also provided in the microdata files.

Commercial Buildings in 1995. The 1995 CBECS survey was used to clarify definitions of the comparison variables.[27]

The CBECS data enabled two comparisons: BASE to large urban office buildings (similar occupancy and population), and BASE to all U.S. office buildings. The Venn Diagram in Figure 5.1 depicts the relationships of the set of BASE buildings to large urban office buildings and to all U.S. office buildings. CBECS A[28] includes the entire set of 705,000 U.S office buildings, in all areas. Within CBECS A is a subset of 524,000 U.S. office buildings (CBECS B), which are located in Metropolitan Statistical Areas (MSAs)[29] with a population of over 50,000. BASE cities have a population greater than 100,000, and there is similarly a portion of the data within CBECS B that consists of buildings located in urban areas with populations over 100,000 (building set D, Figure 5.1). Unfortunately there is a slight difference between the population of the CBECS cities and the BASE cities. EPA defined BASE cities as having populations greater than 100,000 while CBECS uses the Office of Management and Budget definition of MSAs. MSAs are urbanized areas (see specific definition in footnote) with populations greater than 50,000.

Applying the criterion of number of occupants to the building set comparison results in another subset of the CBECS data: CBECS C+ consists of the set of 80,000 office buildings that contain more than 50 occupants, located in all areas of the U.S. CBECS C is the subset of CBECS C+, which contains buildings that are located in MSAs (n=70,000). It would be ideal to compare the 100 BASE study buildings (building set E) with the intersection of CBECS C and building set D: U.S. office buildings with greater than 50 occupants, located in cities with a population of over 100,000. However, the best

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27 The building questionnaire is available at http://www.eia.doe.gov/emeu/cbecs.

28 Note: CBECS original data is not designated A, B, or C. Rather, EH&E used this convention to designate the set and subsets of the CBECS data applicable to these comparisons.

29 Metropolitan Statistical Area (MSA), as defined by the U.S. Office of Management and Budget: "a county or group of contiguous counties that contain (1) at least one city of 50,000 inhabitants or more ('twin cities' with a combined population of at least 50,000 inhabitants) or (2) an urbanized area of at least 50,000 inhabitants and a total MSA population of at least 100,000 (75,000 in New England)." The contiguous counties are included in an MSA if, according to certain criteria, they are essentially metropolitan in character and are socially and economically integrated with the central city. In New England, MSAs consist of towns and cities, rather than counties.

building set available to compare BASE buildings to comparable U.S. office buildings[30] is CBECS C (Figure 5.1).

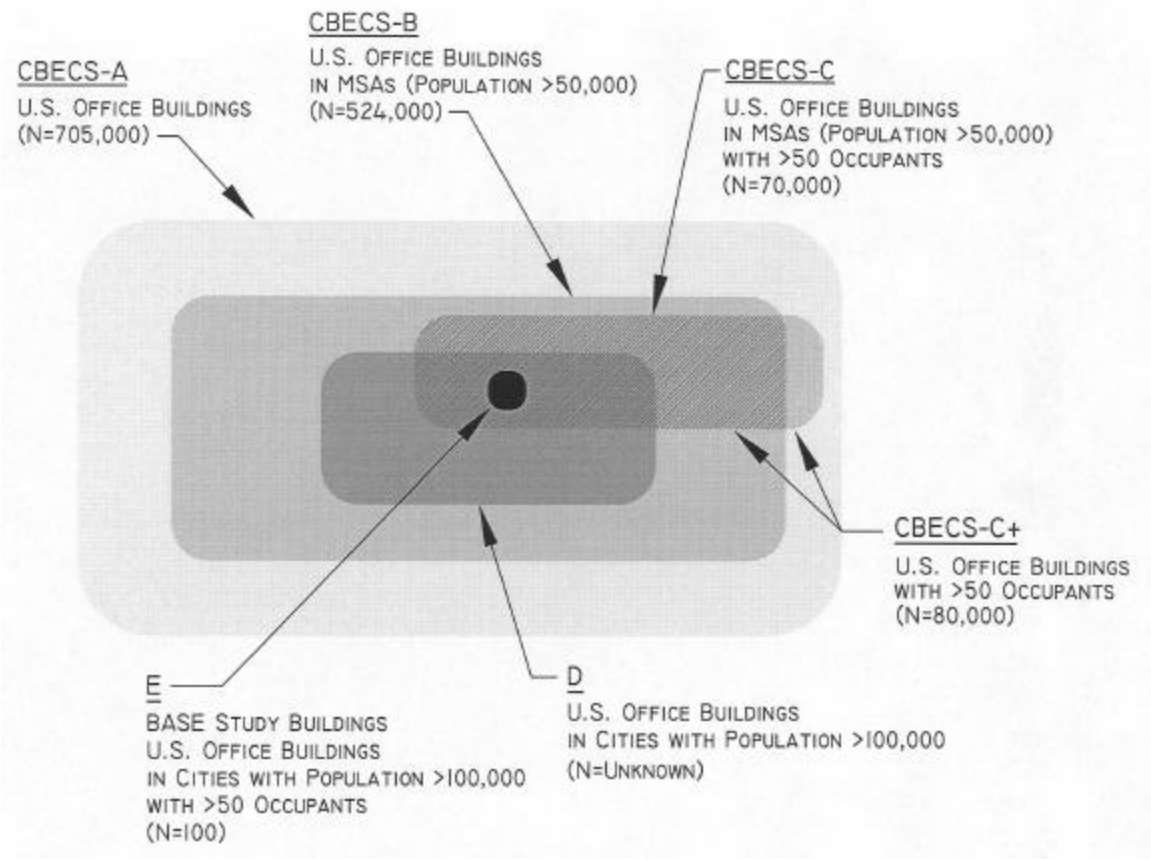

Figure 5.1 Venn Diagram Showing Sets of Buildings from BASE and CBECS

5.1.2 BOMA Data

Building Owners and Managers Association (BOMA) data, published in the *BOMA Experience Exchange Report* (1998 BOMA EER),[31] were used to assess area per occupant. The 1998 BOMA EER provides published tables of operating income and expense data for over 4,000 office buildings located throughout North America. This sample includes 3,027 U.S. private sector properties, and 632 U.S. government office

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30 That is, buildings in similar population areas with similar occupancies.

31 Energy Information Administration. 1998 Oct. *A Look at Commercial Buildings in 1995: Characteristics, Energy Consumption, and Energy Expenditures.* Washington: U.S. Department of Energy. Available from: US Government Printing Office and the National Technical Information Service and on the CBECS website as a PDF document: http://www.eia.doe.gov/emeu/cbecs.

buildings. The survey process solicited responses from property managers throughout many North American cities, with 130 cities represented by three or more properties.

There are three criteria to consider before using BOMA data for comparison to BASE data: type of building, population of cities, and occupancy. Since all BOMA buildings are office buildings, the data is comparable in that way. The BOMA data is nearly comparable to BASE in the city population requirement; of the 97 U.S. cities identified directly in the 1998 BOMA EER, 81 of them had populations over 100,000. Information on the remaining 76 cities is not readily available. The third requirement is that the buildings have more than 50 occupants. Although this data is not reported directly in the 1998 BOMA EER, it was possible to derive an average from the data that was presented. The average number of occupants was 888 in downtown U.S. office buildings and 583 in all U.S. office buildings. It seems reasonable, therefore, to assume that all occupancies were greater than 50—or certainly a sufficient number to make the comparison to BASE buildings valid.

One major difference between the BOMA survey and CBECS is that CBECS is based on a statistically representative sample whereas BOMA relies entirely on the goodwill of building owners and managers to respond to a mailed survey form. BOMA does not include the response rate to this survey.

5.2 COMPARISON OF THE VARIABLES

In the following sections, the BASE sample is compared to the CBECS C sample (large urban office buildings) and to the CBECS A sample (all U.S. office buildings) for the first six comparison variables:

1. Gross area of buildings (square footage)
2. Number of floors (above and below grade)
3. Hours of operation per week
4. Year building was constructed
5. Wall construction materials
6. Roof construction materials

Although a comparison of the seventh variable (area per occupant) was attempted, variable definitions were too disparate to draw conclusions (Section 5.2.7).

Within regions, three variables were compared (year building was constructed, wall construction materials, and roof construction materials).[32] Though regional differences for these parameters were evident within the CBECS data, differences were not observed in the BASE data, most likely due to smaller sample size in each of the CBECS regions.

[32] Based on EH&E's examination of the aggregate data for all buildings in Tables BC-6 and BC-10 in *A Look at Commercial Buildings,* the published version of CBECS 1995 data.

5.2.1 Gross Area (Square Footage)

The gross area of BASE buildings is three to four times larger than the gross area of the CBECS C buildings and 30 to 40 times larger than the CBECS A buildings (Figure 5.2).

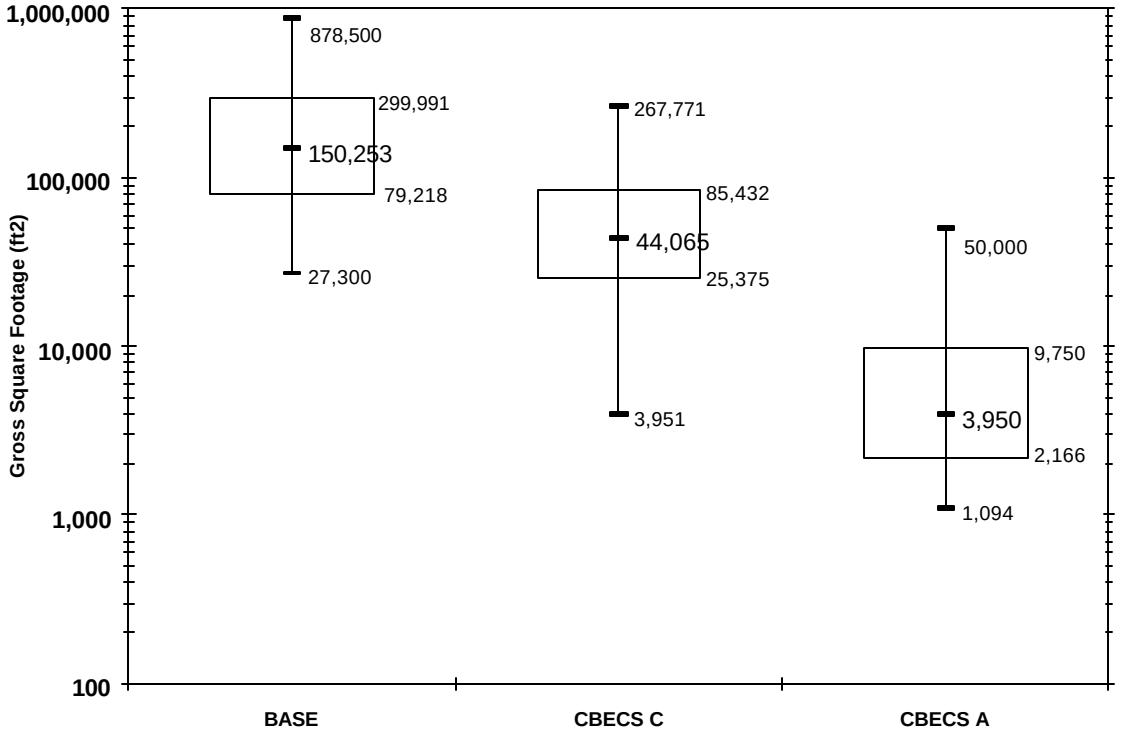


Figure 5.2 The 5th, 25th, 50th, 75th, and 95th Percentiles of Gross Area of Buildings for BASE, CBECS C, and CBECS A Buildings

5.2.2 Number of Floors

BASE buildings are taller than CBECS C and CBECS A buildings. More than 95% of BASE buildings had multiple stories, while only 80% of CBECS C and 50% of CBECS A office buildings had multiple stories (Figure 5.3).

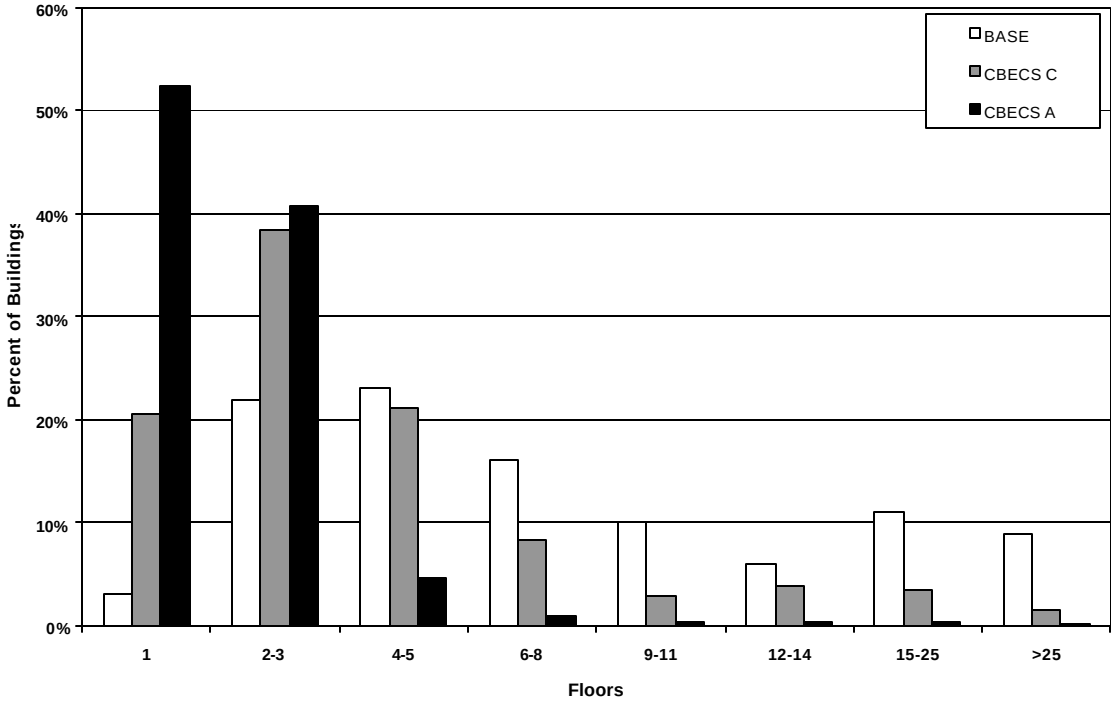


Figure 5.3 Comparison of Number of Floors for BASE, CBECS C, and CBECS A Buildings[33]

[33] Although the number of floors data could be summarized in a box plot, raw data from the CBECS study for buildings with more than 25 floors were not available for reasons of confidentiality. This prevented ranking the CBECS data from lowest to highest, necessary for deriving box plots percentiles.

5.2.3 Year of Construction

The median dates of construction for all three samples are similar: 1972 for BASE, 1977 for CBECS C, and 1975 for CBECS A. BASE building median age and interquartile range are most similar to those of CBECS A (Figure 5.4).

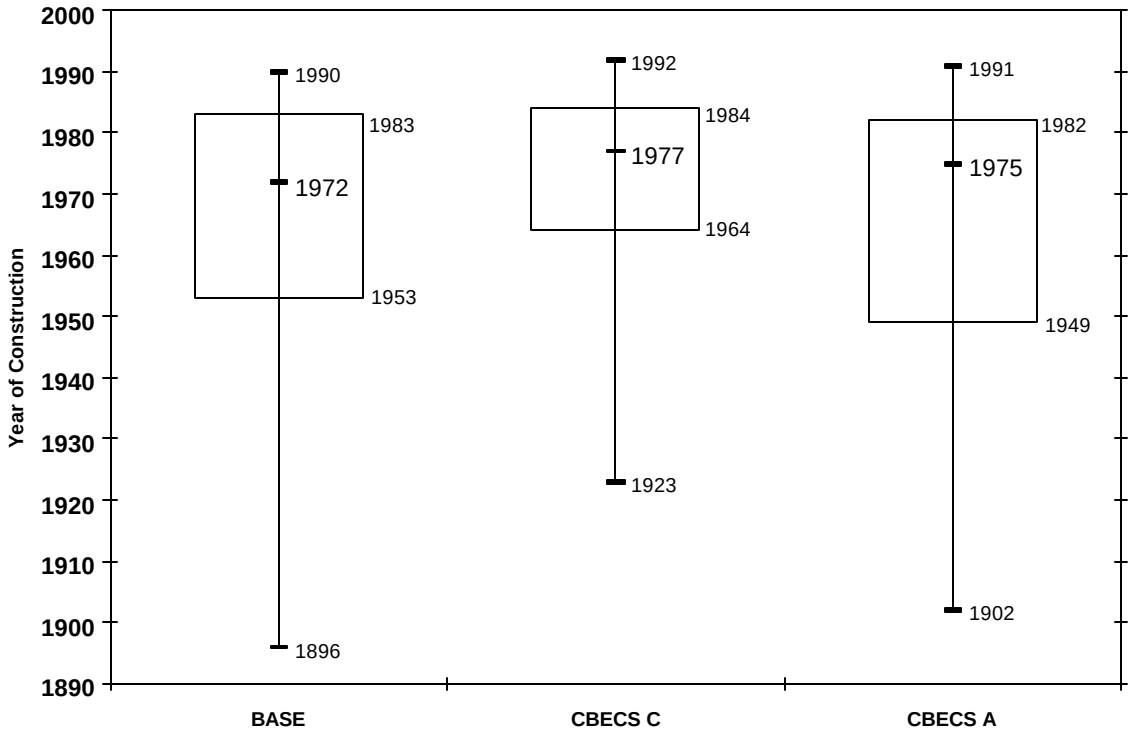


Figure 5.4 The 5th, 25th, 50th, 75th, and 95th Percentiles of Building Age for BASE CBECS C, and CBECS A Buildings

5.2.4 Hours Open per Week

BASE, CBECS C, and CBECS A buildings have similar distributions for the numbers of hours open per week, with the BASE median slightly less than that of CBECS C and slightly greater than that of CBECS A (Figure 5.5).

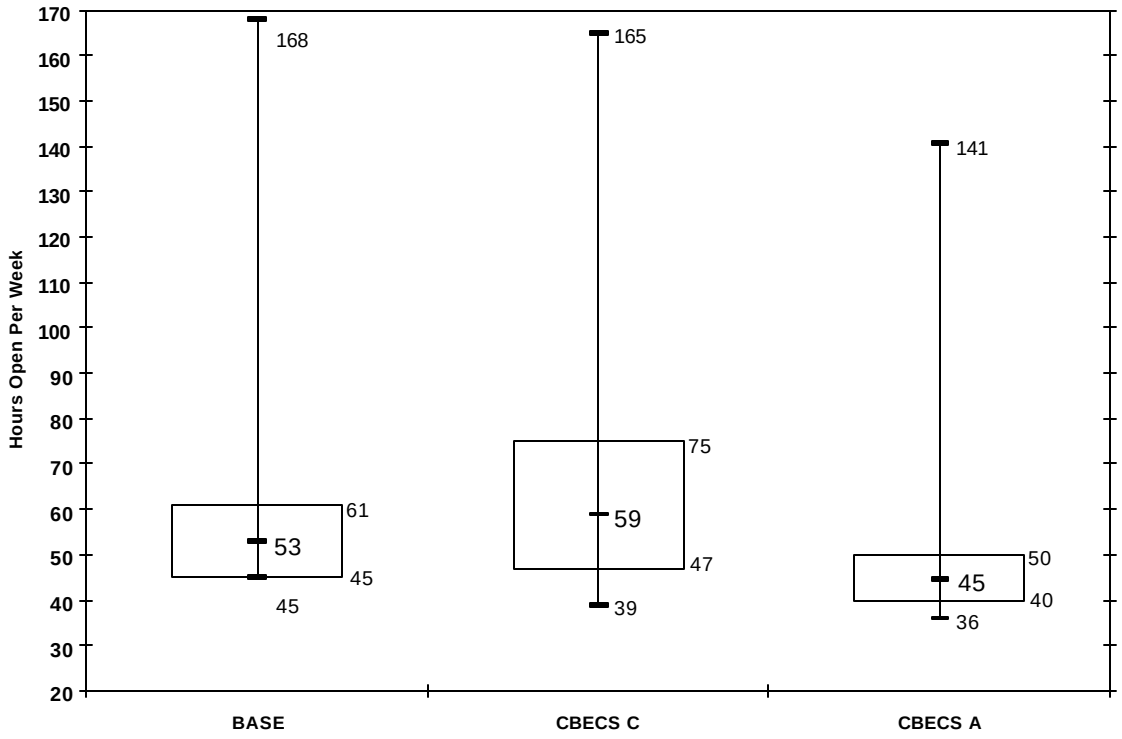


Figure 5.5 The 5th, 25th, 50th, 75th, and 95th Percentiles of Hours Open Per Week for BASE, CBECS C, and CBECS A Buildings

5.2.5 Wall Construction Material

Masonry is the predominant wall construction material for each sample: BASE (52%), CBECS C (65%), and CBECS A (74%). BASE and CBECS C buildings seem to be constructed of similar materials, while CBECS A buildings seem to be constructed of different wall materials than either BASE or CBECS C buildings. BASE buildings seem to have less masonry; more pre-cast concrete panels, glass and "other" materials; and less sheet metal panels and shingles/siding (Figure 5.6).

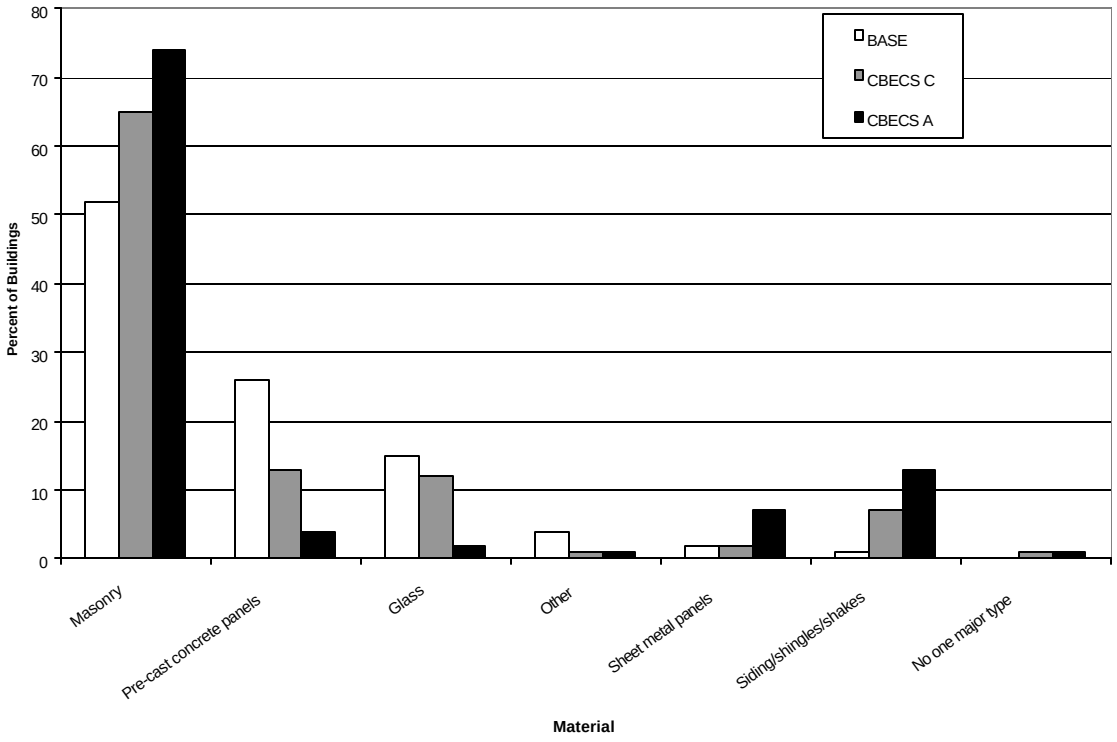


Figure 5.6 Comparison of Building Wall Construction Material for BASE, CBECS C, and CBECS A BuildingS

5.2.6 Roof Construction Material

BASE and CBECS C buildings seem to be constructed of similar roof materials, while CBECS A buildings seem to be constructed of different roof materials than either BASE or CBECS C buildings. Eighty percent or more of the roofs in BASE and CBECS C are either built-up or consist of layer(s) of plastic or rubber sheeting (ply), while CBECS A roofs are predominantly built-up or shingled (67%). BASE buildings have more built-up and ply roofs and less metal surfacing and shingled roofs than CBECS A buildings. The greatest disparity between BASE and CBECS A is in the proportion of shingled roofs: 4% vs. 40% (Figure 5.7).

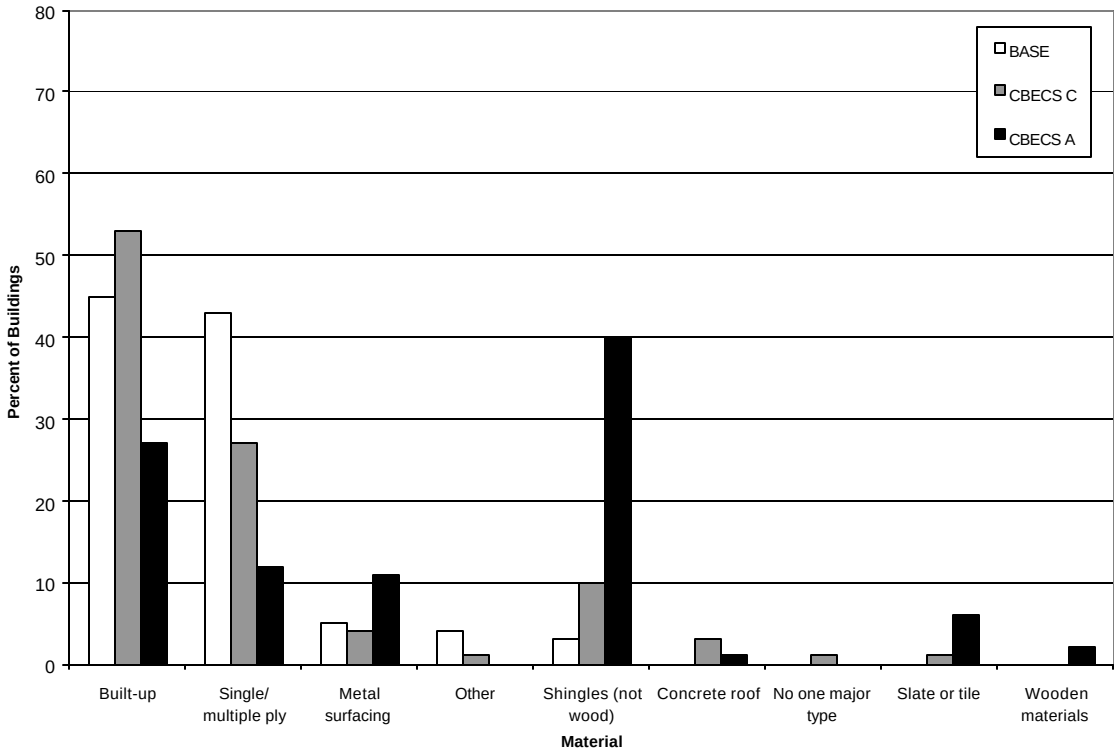


Figure 5.7 Comparison of Building Roof Construction Material for BASE, CBECS C, and CBECS A buildings

5.2.7 Area per Occupant

Area per occupant is a widely used building characteristic with standards defined by ASHRAE and state building codes. EH&E felt that this parameter merited comparison; however, difficulty was encountered due to disparities in variable definitions between the datasets. For example, the CBECS dataset does not contain a variable describing occupied building area; only gross building area is provided.

Because the CBECS comparison proved unsatisfactory, a second comparison was attempted using the BOMA data set. Similar disparities with the variable definitions were found. Since a valid comparison to BASE could not be made, these analyses are not presented.

5.3 DISCUSSION OF REPRESENTATIVENESS

Table 5.1 summarizes the two comparisons for each parameter: BASE buildings to comparable buildings (CBECS C: urban, > 50 occupants) and BASE to all U.S. office buildings (details, Appendix I). Although the number of parameters available for comparison is limited, these comparisons provide an indication of the subset of office buildings that the BASE sample might represent.

Table 5.1 Summary of Comparisons (Sections 5.2.1 – 5.2.7)\

	BASE to Comparable	BASE to All U.S.
1. Building gross area (square footage)	BASE is 3 to 4 times larger	BASE is 30 to 40 times larger
2. Number of floors (above and below grade)	BASE is taller	BASE is taller
3. Hours of operation per week	Similar – BASE is open slightly fewer hours	Similar – BASE is open more hours
4. Year building was constructed	Similar	Similar
5. Wall construction materials	Similar in top three materials	Similar only in predominant material
6. Roof construction materials	Similar	Only one of the two predominant materials matches.
7. Area per occupant (in occupied space)	Inconclusive	Inconclusive

[a] CBECS C: urban, > 50 occupants
[b] CBECS A

Taking first the question of how well BASE buildings represent comparable office buildings, the samples are similar for: hours of operation, year of construction, and wall and roof construction materials. The BASE buildings, however, are larger and taller than the comparable buildings. This is to be expected. The BASE buildings were sampled from downtown areas, whereas the comparable buildings (CBECS C) were located in MSAs.[34] BOMA data provide an independent means of comparing building size between downtown and other metropolitan areas. According to the 1998 BOMA EER, downtown office buildings are larger than other metropolitan area office buildings.[35]

[34] Metropolitan Statistical Area (MSA), as defined by the U.S. Office of Management and Budget: "a county or group of contiguous counties that contain (1) at least one city of 50,000 inhabitants or more ('twin cities' with a combined population of at least 50,000 inhabitants) or (2) an urbanized area of at least 50,000 inhabitants and a total MSA population of at least 100,000 (75,000 in New England)." The contiguous counties are included in an MSA if, according to certain criteria, they are essentially metropolitan in character and are socially and economically integrated with the central city. In New England, MSAs consist of towns and cities, rather than counties.

[35] According to BOMA, the average gross area is 299,000 square feet downtown, while the average gross area is 193,000 for the metropolitan areas. The number of above ground floors downtown average 16, while the number of above ground floors in metropolitan areas average 11.

Taking next the question of how well BASE buildings represent all U.S. office buildings, based on the parameters measured, BASE buildings do not represent the sample of all U.S. office buildings well. The most likely reason is due to size: more than 90% of all U.S. office buildings have one to three floors. Smaller buildings are often constructed with different materials than larger buildings.

The BASE buildings seem to be most similar to the comparable office buildings. At first glance, this may be disconcerting, given that the number of U.S. office buildings with more than 50 occupants represents just 11% (80,000) of the U.S. office building stock (705,000). However, the number of employees working within these buildings represents 73% (19,428,229) of all U.S. office workers (26,563,566) according to CBECS data. The BASE buildings would represent less than 73%, because they are larger than the comparable buildings; however, it is unknown by how much.

With regard to years of construction, the BASE sample is similar to both the comparable sample and the sample of all U.S. office buildings. Hours of operation were also similar. Although area per occupant would have been an important parameter to compare, disparities in definitions did not permit this. Comparison of the measured parameters between regions was also not possible due to the small number of BASE cities in each region.

Although these comparisons provide general characteristics of the buildings that BASE most likely represents (i.e., large office buildings), there are other parameters that could be analyzed, such as ventilation rate, mechanical system type, and energy consumption. However, these parameters were not examined for representativeness in this report as EH&E focused on structural and occupant-based parameters.

6.0 CONCLUSION

The purpose of this report was to describe and evaluate the implementation of the BASE building selection process. The detailed description of the process underlines the enormous effort that EPA and EH&E expended in order to randomly select US office buildings from the existing building stock. Descriptive statistics summarize the effectiveness of implementing the random selection process. Although minimal errors were identified, these do not significantly affect the validity of the results. Biases and uncertainties, mainly introduced by the design of the selection process, do not interfere with EPA's goal of characterizing typical U.S. office buildings. An evaluation of building characteristics indicates that the BASE buildings represent large office buildings, where most office employees work.

Altogether, 53,497 telephone calls were made to recruit 150 eligible buildings in 39 different cities. Approximately 70% of these calls (37,328) resulted in contacting a tenant. And approximately 15% of these tenants (5,708) reported that they worked in buildings that had office space with over 50 occupants. Most of the tenants were interested in the study; however, only 556 of the contacted managers/owners were willing for EH&E to conduct the study in their building.[36] PVs were conducted on 198 buildings, and 150 eligible buildings were used to randomly select the 100 buildings for the BASE sample.

Although significant efforts were made to track why tenants and building managers/owners were not interested in the study, the information is limited. Only general observations can be made. Most tenants and managers/owners did not provide reasons. Many said they were not interested, because they had no time to participate. And few said that they had tenant-, liability-, or EPA-related concerns. As the study progressed, recruiting conditions changed (e.g., sources of business listings and data tracking improved, and recruiting accelerated). Although data analyses indicate that recruiting effectiveness also changed over the course of the study, this did not have any significant bearing on the buildings selected.

[36] Information regarding tenant and manager/owner lack of interest is limited; only general observations can be made. Although most tenants and managers/owners did not provide reasons, many said they were not interested because they had no time to participate. Few said that they had tenant-, liability-, or EPA-related concerns.

The sampling design required quota sampling at several steps in the building selection process; however, no biases associated with this necessary approach could be identified. An analysis of the stratified component of the building selection shows that the distribution of cities chosen by EPA in climate regions do not significantly differ from the distribution of cities with populations over 100,000 in each of those regions. The requirement to include only buildings with at least one office space of 50 or more occupants biases the sample toward larger buildings, and the definition of an AHU[37] biases the mechanically ventilated portion of the sample toward buildings with central AHUs, which are easier to maintain than systems that employ heat pumps and unit ventilators. The extent of these biases is unknown. Although buildings with highly publicized IAQ problems or potential IAQ lawsuits were excluded from the sample, the resulting bias toward buildings with fewer complaints and lower symptom prevalences than the general population is most likely minimal. Only two cases out of the 551 technical calls (<1%) were rejected because of this requirement.

Comparison of the BASE sample to existing data on building and occupant characteristics indicate that the BASE buildings most likely represent large office buildings with similar construction dates and hours of operation to the general population. The BASE buildings seem to be most similar to office buildings with 50 or more employees in MSAs (CBECS C). The number of buildings in the CBECS C sample represents just 11% of the U.S. office building stock (705,000). However, the number of employees working within these buildings represents 73% of all U.S. office workers (26,563,566). A more detailed comparison of other IAQ-related parameters (e.g., pollutant concentrations, ventilation measurements, maintenance) is desirable; however, the BASE Study is the largest and most comprehensive IAQ study to date.

In summary, EH&E believes that the building selection process introduced limited error and biases, both in design and in execution. The resulting sample provides a useful dataset for future IAQ comparisons for large office buildings.

[37] This is due to the EPA's definition of an AHU: a ventilation system that provided outdoor air to the study space.

APPENDIX A

Breakdown of Climatic Regions and Cities within those Regions

EPA Building Assessment Survey and Evaluation Study

APPENDIX A Breakdown of Climatic Regions and Cities within those Regions

A	B		C	D	
Anchorage, AK	Bridgeport, CT	Lansing, MI	Kansas City, KS	Huntsville, AL	Philadelphia, PA
Aurora, CO	Hartford, CT	Livonia, MI	Overland Park, KS	Mobile, AL	Columbia, SC
Colorado Springs, CO	New Haven, CT	Sterling Heights, MI	Topeka, KS	Washington, DC	Chattanooga, TN
Denver, CO	Stamford, CT	Warren, MI	Wichita, KS	Jacksonville, FL	Knoxville, TN
Lakewood, CO	Waterbury, CT	Minneapolis, MN	Independence, MO	Tallahassee, FL	Beaumont, TX
Boise, ID	Cedar Rapids, IA	St. Paul, MN	Kansas City, MO	Atlanta, GA	Alexandria, VA
Reno, NV	Des Moines, IA	Springfield, MO	St. Louis, MO	Columbus, GA	Chesapeake, VA
Salt Lake City, UT	Chicago, IL	Omaha, NE	Lincoln, NE	Macon, GA	Hampton, VA
Spokane, WA	Peoria, IL	Paterson, NJ		Savannah, GA	Newport News, VA
	Rockford, IL	Albany, NY		Baton Rouge, LA	Norfolk, VA
	Springfield, IL	Buffalo, NY		Baltimore, MD	Portsmouth, VA
	Evansville, IN	Rochester, NY		Charlotte, NC	Richmond, VA
	Fort Wayne, IN	Syracuse, NY		Durham, NC	Virginia Beach, VA
	Gary, IN	Akron, OH		Greensboro, NC	
	Indianapolis, IN	Cincinnati, OH		Raleigh, NC	
	South Bend, IN	Cleveland, OH		Winston-Salem, NC	
	Lexington-Fayette, KY	Columbus, OH		Elizabeth, NJ	
	Louisville, KY	Dayton, OH		Jersey City, NJ	
	Boston, MA	Toledo, OH		Newark, NJ	
	Lowell, MA	Allentown, PA		Bronx, NY	
	Springfield, MA	Erie, PA		Brooklyn, NY	
	Worcester, MA	Pittsburgh, PA		Manhattan, NY	
	Ann Arbor, MI	Providence, RI		New York, NY	
	Detroit, MI	Sioux Falls, SD		Queens, NY	
	Flint, MI	Madison, WI		Staten Island, NY	
	Grand Rapids, MI	Milwaukee, WI		Yonkers, NY	

APPENDIX A Continued

E	F	G	H	I	J
Tucson, AZ	Birmingham, AL	Fort Lauderdale, FL	Glendale, AZ	Eugene, OR	Anaheim, CA
Bakersfield, CA	Montgomery, AL	Hialeah, FL	Mesa, AZ	Portland, OR	Berkeley, CA
Concord, CA	Little Rock, AR	Hollywood, FL	Phoenix, AZ	Salem, OR	Chula Vista, CA
Fresno, CA	Shreveport, LA	Miami, FL	Scottsdale, AZ	Seattle, WA	Escondido, CA
Modesto, CA	Jackson, MS	Orlando, FL	Tempe, AZ	Tacoma, WA	Fremont, CA
Moreno Valley, CA	Oklahoma City, OK	St. Petersburg, FL	El Monte, CA		Fullerton, CA
Pomona, CA	Tulsa, OK	Tampa, FL	Ontario, CA		Garden Grove, CA
Riverside, CA	Memphis, TN	Honolulu, HI	Pasadena, CA		Glendale, CA
Sacramento, CA	Nashville-Davidson, TN	New Orleans, LA	Rancho Cucamon, CA		Hayward, CA
Santa Rosa, CA	Abilene, TX	Corpus Christi, TX	San Bernardino, CA		Huntington Beach, CA
Stockton, CA	Arlington, TX	Laredo, TX			Inglewood, CA
Vallejo, CA	Austin, TX				Irvine, CA
Albuquerque, NM					Long Beach, CA
Las Vegas, NV	Dallas, TX				Los Angeles, CA
Amarillo, TX	Fort Worth, TX				Oakland, CA
El Paso, TX	Garland, TX				Oceanside, CA
	Houston, TX				Orange, CA
	Irving, TX				Oxnard, CA
	Lubbock, TX				Salinas, CA
	Mesquite, TX				San Diego, CA
	Pasadena, TX				San Francisco, CA
	Plano, TX				San Jose, CA
	San Antonio, TX				Santa Ana, CA
	Waco, TX				Santa Clarita, CA
					Simi Valley, CA
					Sunnyvale, CA
					Thousand Oaks, CA
					Torrance, CA

APPENDIX B

RECRUITING PRELIMINARY CALLER FORM AND TECHNICAL FOLLOW-UP CALLING FORM

EPA Building Assessment Survey and Evaluation Study

-+

Figure B1: Preliminary Caller Form

Recruiter_____ Date___/___/___ **Call ID#** _____

Tenant_____ Phone (___)_____

Address_____

A. Contact with Tenant

1. Phone call placed? YES NO

( ) Building mgr/owner previously contacted by recruiter: _____ (see # ___).

( ) Phone call was not made because _____.

2. Contact established? YES NO

( ) hung up
( ) no answer
( ) fax/modem number
( ) wrong number
( ) number no longer in service

3. First call to this tenant? YES NO

4. Office space? YES NO

5. Number of employees?

more than 50 less than 50

6. Tenant interested? YES NO

( ) wary of EPA
( ) tenant concerns
( ) liability concerns
( ) no time to participate
( ) other (define) _____

7. Bldg. mgr./owner identified? YES NO

7a.

Manager/Owner_____ Company_____

Phone # (____)_____ Fax #(____)_____ Date Faxed___/___/___

B. Contact with Building Management

1. Contact established? YES NO

( ) Phone call was not made because building mgr/owner has been contacted by recruiter: _____ (see # _____).

( ) Phone call was not made because _____.

2. Number of employees?

more than 50 less than 50

3. Bldg. mgmt. interested?

YES NO

( ) wary of EPA
( ) tenant concerns
( ) liability concerns
( ) no time to participate
( ) other (please specify)

_____

NOTES:

Figure B2: Technical Follow-up Call Form

Technical Follow-up Call

Call contact when?_____

Recruiter_____ Tech. Caller_____ Recruitment #_____

Tenant and
Address_____

Owner/Manager_____

Address_____

Phone_____ Fax_____

Selling Points

- EPA-contracted study on IAQ in *(state)* during *(month)*. Building was **randomly** selected for this study.
- **Goal** of BASE is to survey 150-300 buildings. Data gathered will be used to **develop a database** *re*. current IAQ conditions.
- Everything is **confidential**.
- The study will be completed in 1 work week. It includes: study of the building; **brief (15 min)** employee questionnaire, given only to occupants of study area; talking to maintenance workers; measuring **ventilation rates** and **concentrations of indoor air pollutants**.
- BASE team is only 4 people and very **unobtrusive**.
- Personal participation includes: a visit with BASE study coordinator during **half-day PV**, to explain and demonstrate the building's work areas and mechanical systems.

Notes

Any questions about BASE?
_____
_____
_____
_____
Interest: No___ Yes___
If no, why?
_____
_____
_____

Building Description:

% office space____ *% res. space____

% laboratory_____ %med. space_____

full-time emp.____

Age of bldg._____ # stories_____

Square footage_____

*Describe office space activities:

Figure B2: Continued

Technical Follow-up Calling Form

Building Description (cont'd)

HVAC Description

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Is there a definitive office area with at least 50 employees, served by no more than two AHUs? Yes_____

Will there be access to the study area between 7:00am and 7:00pm? Yes____

Has the owner also given approval for the Study? yes no

Potential Tenant Concerns?

_____
_____
_____
_____
_____

General notes

Preliminary Visit Schedule

* (check PV/Tech Caller book for PV schedule, set visits for 8 am and 1 pm daily)

Is the Tenant at the same address as the Owner/Manager? yes no

If not, confirm address for PV packet and PV meeting

Will the mechanical person for the building be available during the PV and present with mechanical plans?
yes no

PV Date/Time _____

Confirmed? _____

PV Package

Cover letter ___
Tenant memo ___
NY Times article ___
EPA letter ___
PV checklist ___

Sent on:_____

APPENDIX C

FAX INFORMATION PACKET

EPA Building Assessment Survey and Evaluation Study

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
AIR AND RADIATION

Dear Potential BASE Study Building Owner/Manager:

The Building Assessment Survey and Evaluation (BASE) program is a non-regulatory, information-gathering program to develop baseline data on the quality of indoor air in office buildings across the country. The purpose of the study is three-fold:

- Research and explore indoor air quality (IAQ) in public and private office space in order to define the status of IAQ and occupants' perceptions;

- Establish a database of IAQ information to be used by researchers; and

- Develop guidance for property owners and managers on building operations and maintenance activities and the impact of such activities on IAQ.

The buildings in the study are randomly selected. However, they must meet specific criteria regarding occupancy, and the heating, ventilation, and air conditioning configuration. The confidentiality of the building and the occupants will be maintained throughout the study. No names are associated with the occupant questionnaires. Building level data collected by the field team are coded to protect the identity of the building. Information is transferred to the EPA database using only the numerical codes which are not associated with the building's name. The information is linked to a state location, not the city. The purpose for the linkage to a state is to allow for analysis of data based on climatic variations across the country.

Building specific information is discussed only with the building manager. After the BASE sampling season, data from the buildings will undergo thorough quality assurance processing. Once this is completed, a summary of a building's data will be available only to the building owner/manager. As stated before this is a non-regulatory program. Information beyond the scope of the study will not be reported to other agencies and will only be discussed with the building management.

Environmental Health & Engineering (EH&E) of Newton, MA is a contractor of the U.S. Environmental Protection Agency. They have been contracted to conduct the BASE program to collect information on IAQ in randomly selected buildings across the United States. Please feel free to discuss any aspect of the program or building information with EH&E or myself. My number is 202-233-9057.

Sincerely,

Susan E Womble

Susan E. Womble
BASE Program Manager
Indoor Air Division
US Environmental Protection Agency

BUILDING ASSESSMENT SURVEY & EVALUATION (BASE) STUDY

QUESTIONS & ANSWERS

What is the BASE program?

BASE, the Building Assessment Survey & Evaluation program, is a study being undertaken by the Environmental Protection Agency (EPA) to define the status of existing office buildings with respect to determinants of indoor air quality (IAQ) and occupant perception.

The EPA BASE program is a research project, not a regulatory program. Its goal is to sample IAQ in commercial buildings selected from all parts of the country so that the EPA can determine typical conditions in these buildings. These studies will be done at no cost to the owner, manager, or tenants.

Once the program is completed, the EPA will be better able to educate state and local governments, engineers, building owners and managers, building occupants, and the public about this important issue.

Environmental Health & Engineering, Inc. (EH&E), a private firm specializing in indoor air quality, has been contracted by the EPA to conduct the building evaluations. [redacted] and your building were selected by a completely random process.

Why is EPA studying indoor air quality?

Although the quality of outdoor air has been the focus of much discussion and research, until relatively recently, little attention has been directed toward IAQ. Research indicates that we spend about 90% of our time indoors and that air within homes, offices, and other buildings may be more polluted than outdoor air in large, industrialized cities. EPA designed the BASE program to broaden our understanding of IAQ.

How many buildings will EPA study?

EPA plans to study three commercial buildings in the [redacted] metropolitan area in the month of September. The entire BASE study will include evaluation of approximately 100 office buildings nationwide.

What will the study involve?

The study will include an examination of the overall building design, brief interviews with building facility workers, measurement of various indoor air components, and completion of a short, confidential questionnaire by selected building occupants. EPA has designed the procedures to be quick and unobtrusive. Measurement devices will be in place for only three days and the entire evaluation for each building in the BASE study will be completed during one work week in September.

What types of questions are in the occupant's questionnaire?

Many items in the questionnaire ask the occupants about their workplace environment. For example, there are questions about lighting, carpeting, furniture, and temperature in their offices. Other items ask about the occupants' health and any discomfort they may experience, such as headaches and sore throats. Because many of these symptoms may or may not be associated with IAQ problems in the building, the questionnaire also includes items about work activities and responsibilities outside of work.

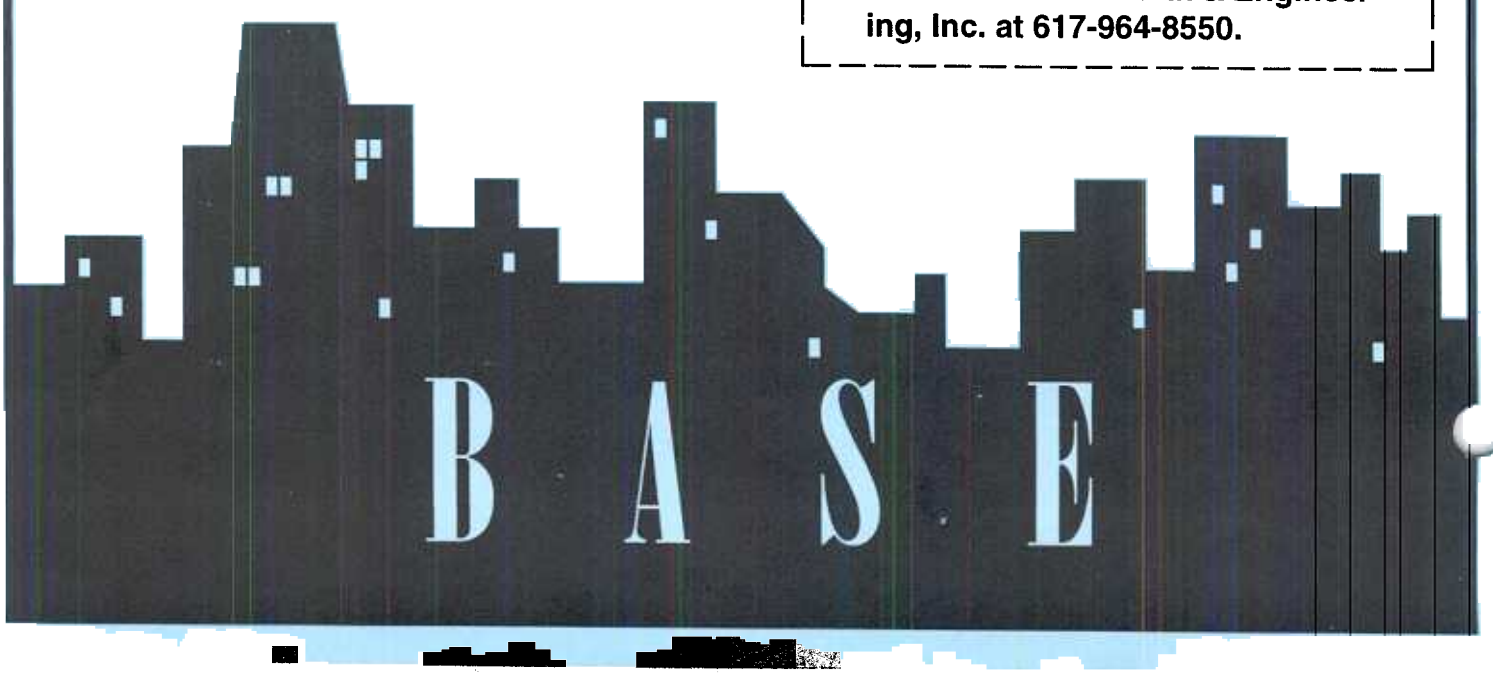
Do all the tenants or occupants in our building have to participate?

No, but a high level of participation will increase the level of success for the BASE study. EH&E will obtain explicit approval from the occupant of each private office before any testing begins; completion of the occupant survey is voluntary.

How will the study results be used?

The results will be used by the EPA to improve methods for sampling IAQ, to educate the public about IAQ issues, and to determine questions for future indoor air research. All of the data from the BASE study will serve as a source of information about current quality of indoor air in office buildings all across the country.

Interested in learning more about the BASE study? Please contact Mark Carpenter or Lynda Davis of Environmental Health & Engineering, Inc. at 617-964-8550.



From *The New York Times*, Tuesday, March 15, 1994

Government to Study Quality of Indoor Air

By TIM HILCHEY

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Researchers will try to determine what substances are present in office air, will interview building occupants and examine how building design and heating, ventilation and air-conditioning systems affect air quality.

The results will be used to create a computer data base that can serve as a baseline for further research. Independent researchers are also being encouraged to adopt the agency's protocols and to contribute to the data base, Ms. Womble said.

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What scientists agree on is that many indoor air pollutants — volatile organic compounds, man-made mineral fibers, auto emissions and residue from modern building materials, among others — contribute to a problem that largely results from the trend toward more energy-efficient buildings, whose recirculated air retains pollutants.

The World Health Organization estimates that excessive health complaints related to indoor air quality are present in up to 30 percent of new and remodeled buildings worldwide.

Symptoms associated with sick-building syndrome include sneezing or coughing; watery eyes; headaches; eye, nose or throat irritation; dry or itchy skin; nausea and dizziness; fatigue; difficulty in concentrating, and sensitivity to odors.

In some cases, symptoms are temporary, possibly related to outdoor conditions like airborne pollen. But in buildings where health complaints persist, the problems are most likely internal ones, researchers say. They hope the data base will help them to diagnose problems, improve building design and prevent problems.

Marian C. Marbury, an environmental epidemiologist with the Minnesota Department of Health who has written extensively on sick-building syndrome, said she was pleased that the E.P.A. was developing an air-quality data base, but she believes more needs to be done.

"People are being forced to act to address health problems without having any reasonable scientific basis for their actions," she said. "It seems to be ridiculous for this to be such a large problem, and yet nobody in the United States is funding an epidemiologic study that really looks at a large number of buildings."

APPENDIX D

Preliminary Visit Information Packet

EPA Building Assessment Survey and Evaluation Study

YY (DATE)

YY (ADDRESS)

Dear **YY:**

We want to thank you for your willingness to participate in the EPA BASE study, a nationwide study designed to evaluate indoor air quality in office buildings. Based on your discussion with **YY** today, we have scheduled a meeting with you for **YY (DAY), YY (DATE)** at **YY** am.

The purpose of the preliminary visit is to determine whether your building meets all of the design criteria necessary to qualify for the EPA study. We have enclosed some information materials for your review. The first is a memo addressed to the tenants of the **YY** that advises them about the Preliminary Visit. We have prepared this memo so that you can print it on your own letterhead, if you so choose. We have also included 50 copies of a flier describing the EPA BASE Study that can be distributed to the occupants. A copy of an article published in *The New York Times* that discusses the BASE study is included for your reference. Also, a letter from the EPA BASE Program Manager has been provided to address issues regarding data confidentiality and availability. Finally, the check list for the preliminary visit represents some of the items we would be reviewing and discussing during the preliminary visit.

Again, we appreciate your willingness to participate in this EPA study. If you have any questions, please do not hesitate to contact me.

Sincerely,

Brian Baker
BASE Project Manager

Enclosures: Memo for building occupants
50 fliers describing BASE Study
Reprint of NY Times article on BASE study
EPA letter regarding data confidentiality and availability
Check list for preliminary visit

To: Tenants of **YY**
From: **YY**, Building Administrator
Re: EPA Indoor Air Quality Research Study
Date: **YY**

The Environmental Protection Agency (EPA) will be conducting a study, the Building Assessment and Survey Evaluation (BASE), to evaluate indoor air quality in several office buildings in the **YY** metropolitan area during **YY** of 1996. Our building has been randomly selected as a possible participant for this study.

During the week of **YY**, two individuals from the company contracted by EPA to do this study will be conducting a preliminary evaluation of the building. The purpose of this evaluation is to determine whether or not our building meets the design criteria necessary to participate in the EPA BASE study. Your offices may be visited as part of this preliminary visit, but this visit should not interfere with your workday or that of your co-workers.

Attached is a flier that answers many of the questions that you may have about the EPA BASE study. If our building is selected for this study, the collected information will be part of a database about indoor air quality in office buildings from all across the country. I would appreciate your cooperation during this preliminary evaluation.

BUILDING ASSESSMENT SURVEY & EVALUATION (BASE) STUDY

QUESTIONS & ANSWERS

What is the BASE program?

BASE, the Building Assessment Survey & Evaluation program, is a study being undertaken by the Environmental Protection Agency (EPA) to define the status of existing office buildings with respect to determinants of indoor air quality (IAQ) and occupant perception.

The EPA BASE program is a research project, not a regulatory program. Its goal is to sample IAQ in commercial buildings selected from all parts of the country so that the EPA can determine typical conditions in these buildings. These studies will be done at no cost to the owner, manager, or tenants.

Once the program is completed, the EPA will be better able to educate state and local governments, engineers, building owners and managers, building occupants, and the public about this important issue.

Environmental Health & Engineering, Inc. (EH&E), a private firm specializing in indoor air quality, has been contracted by the EPA to conduct the building evaluations. [redacted] and your building were selected by a completely random process.

Why is EPA studying indoor air quality?

Although the quality of outdoor air has been the focus of much discussion and research, until relatively recently, little attention has been directed toward IAQ. Research indicates that we spend about 90% of our time indoors and that air within homes, offices, and other buildings may be more polluted than outdoor air in large, industrialized cities. EPA designed the BASE program to broaden our understanding of IAQ.

How many buildings will EPA study?

EPA plans to study three commercial buildings in the [redacted] metropolitan area in the month of September. The entire BASE study will include evaluation of approximately 100 office buildings nationwide.

What will the study involve?

The study will include an examination of the overall building design, brief interviews with building facility workers, measurement of various indoor air components, and completion of a short, confidential questionnaire by selected building occupants. EPA has designed the procedures to be quick and unobtrusive. Measurement devices will be in place for only three days and the entire evaluation for each building in the BASE study will be completed during one work week in September.

What types of questions are in the occupant's questionnaire?

Many items in the questionnaire ask the occupants about their workplace environment. For example, there are questions about lighting, carpeting, furniture, and temperature in their offices. Other items ask about the occupants' health and any discomfort they may experience, such as headaches and sore throats. Because many of these symptoms may or may not be associated with IAQ problems in the building, the questionnaire also includes items about work activities and responsibilities outside of work.

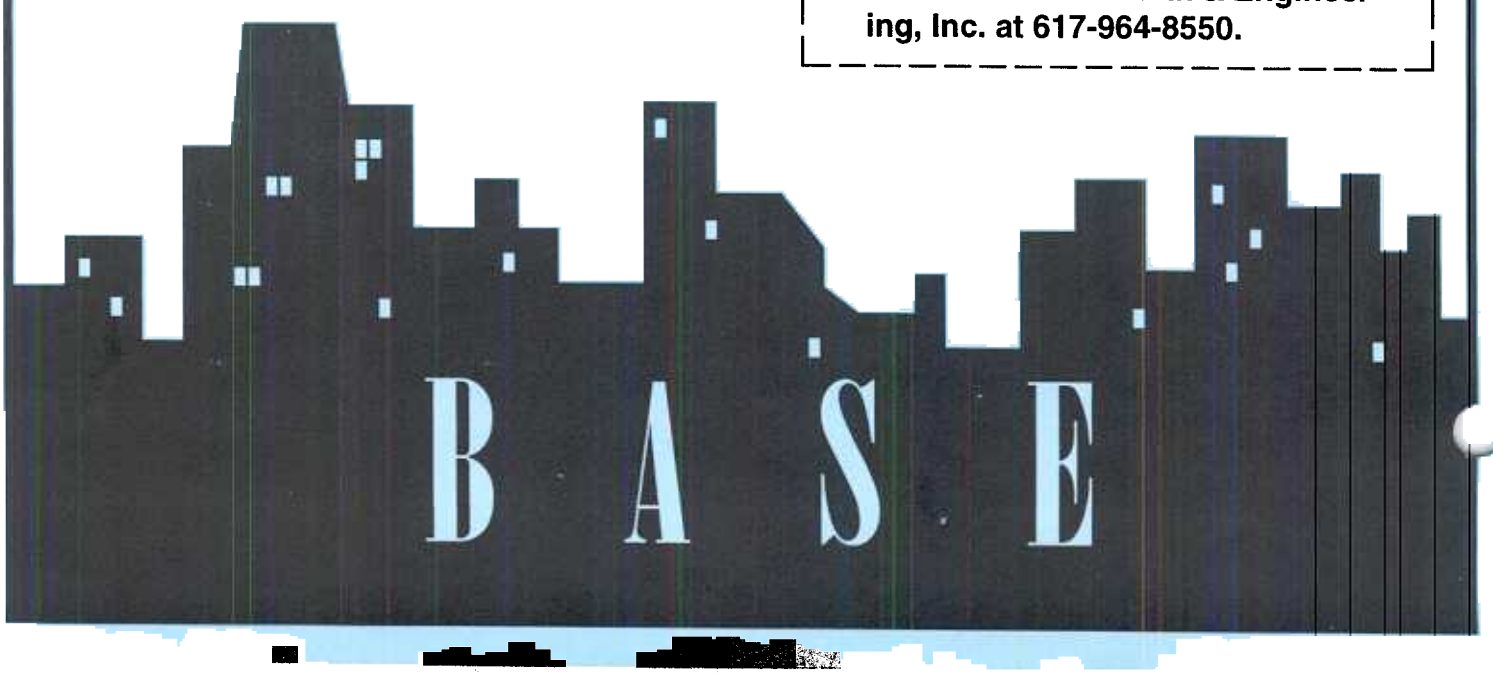
Do all the tenants or occupants in our building have to participate?

No, but a high level of participation will increase the level of success for the BASE study. EH&E will obtain explicit approval from the occupant of each private office before any testing begins; completion of the occupant survey is voluntary.

How will the study results be used?

The results will be used by the EPA to improve methods for sampling IAQ, to educate the public about IAQ issues, and to determine questions for future indoor air research. All of the data from the BASE study will serve as a source of information about current quality of indoor air in office buildings all across the country.

Interested in learning more about the BASE study? Please contact Mark Carpenter or Lynda Davis of Environmental Health & Engineering, Inc. at 617-964-8550.



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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
AIR AND RADIATION

Dear Potential BASE Study Building Owner/Manager:

The Building Assessment Survey and Evaluation (BASE) program is a non-regulatory, information-gathering program to develop baseline data on the quality of indoor air in office buildings across the country. The purpose of the study is three-fold:

- Research and explore indoor air quality (IAQ) in public and private office space in order to define the status of IAQ and occupants' perceptions;

- Establish a database of IAQ information to be used by researchers; and

- Develop guidance for property owners and managers on building operations and maintenance activities and the impact of such activities on IAQ.

The buildings in the study are randomly selected. However, they must meet specific criteria regarding occupancy, and the heating, ventilation, and air conditioning configuration. The confidentiality of the building and the occupants will be maintained throughout the study. No names are associated with the occupant questionnaires. Building level data collected by the field team are coded to protect the identity of the building. Information is transferred to the EPA database using only the numerical codes which are not associated with the building's name. The information is linked to a state location, not the city. The purpose for the linkage to a state is to allow for analysis of data based on climatic variations across the country.

Building specific information is discussed only with the building manager. After the BASE sampling season, data from the buildings will undergo thorough quality assurance processing. Once this is completed, a summary of a building's data will be available only to the building owner/manager. As stated before this is a non-regulatory program. Information beyond the scope of the study will not be reported to other agencies and will only be discussed with the building management.

Environmental Health & Engineering (EH&E) of Newton, MA is a contractor of the U.S. Environmental Protection Agency. They have been contracted to conduct the BASE program to collect information on IAQ in randomly selected buildings across the United States. Please feel free to discuss any aspect of the program or building information with EH&E or myself. My number is 202-233-9057.

Sincerely,

Susan E Womble

Susan E. Womble
BASE Program Manager
Indoor Air Division
US Environmental Protection Agency

Environmental
Health &
Engineering, Inc.

CHECK LIST OF BUILDING INFORMATION FOR PRELIMINARY VISIT

The purpose of the Preliminary Visit is to characterize the building and select the Study Area for the U.S. EPA BASE Study. We thank you for all the time that you have already spent preparing for this visit. Listed below are some of the topics we would like to discuss during the visit. Assembling the following information and materials would greatly facilitate our meeting:

- Building floor plans and layouts such as fire escape plans, HVAC mechanical plans, and plans depicting the building foot print.

  Information describing the operation of the HVAC system as well as any corresponding maintenance schedule.

  Information regarding occupancy levels through all areas of the building.

- Locations of office vs. non-office space.

  Information on types of construction for the interior and exterior architecture.

- Locations and times of renovations occurring within the last 3 years. (carpeting, roofing, partitions, painting, etc.)

As part of our meeting, we would like to do a walk-through inspection of the building and the HVAC systems. We will also like discuss issues relating to interior and exterior pesticide use and the use of domestic cleaning materials.

Thank you in advance for your efforts.

Environmental Health & Engineering, Inc
60 Wells Avenu
Newton, MA 02159-321
TEL (617) 964-8550 FAX (617) 964-855
EMAIL EHE1@AOL.CO

APPENDIX E

Field Week Schedule and Preparation List Handout

EPA Building Assessment Survey and Evaluation Study

Figure E1 Field Week Schedule

BASE Sampling Schedule

The study area will consist of 5 sampling site locations. Four of these sites will be designated as the location for fixed sites where monitoring equipment will be placed on TV carts. The outdoor monitoring station is typically located on the roof to monitor outdoor air entering the building. HVAC monitoring is also conducted at the return air and supply air ducts serving the study area.

The primary field objectives for the BASE Study are to collect uninterrupted data during the occupants' workday under normal working conditions.

MONDAY

Introduction: An optional informational meeting can be held for the study area occupants Monday or Tuesday.

Radon Sampling: A 4-day continuous sample using diffusion barrier charcoal canisters. Several samplers are placed in the study area on Monday and retrieved Thursday afternoon.

Continuous monitoring of certain parameters is started on Monday at indoor, outdoor, and HVAC locations. Monitoring will be conducted continuously through Thursday afternoon using electrical sensor systems at the following locations and for the following parameters:

Indoor Continuous Monitoring is started at 4 fixed sites in the study area to measure the following parameters:

- Carbon dioxide (CO_2)
- Carbon monoxide (CO)
- Temperature levels at multiple heights: (0.1, 0.6, 1.1, and 1.7 meters from floor)
- Relative humidity (RH)
- Sound levels
- Light levels

Outdoor Continuous Monitoring is started at the outdoor air (OA) intake for an air handling unit (AHU) serving the study area to measure the following parameters:

- Carbon dioxide (CO_2)
- Carbon monoxide (CO)
- Temperature
- Relative humidity (RH)

HVAC Continuous Monitoring is started in the return air stream and the supply air stream for AHU(s) serving the study area. Carbon dioxide concentrations will be measured in these air streams.

Figure E1 Continued

TUESDAY

Study Area Supply Air Diffusers: Measurement of supply air diffuser flow rates is conducted throughout the study area.

AHU Supply Air Delivery: Total supply air delivery rate is measured at the AHU(s) serving the study area.

Exhaust Flow Rates: Total exhaust flow rates are measured within the study space and the totals are measured for the fans serving the study area.

WEDNESDAY

Integrated Environmental Sampling: Eight hour integrated samples are collected at the indoor fixed and outdoor site locations for the following parameters:

- Volatile Organic Compounds (VOCs): collected using SUMMA canisters and sorbent tubes
- Aldehydes: collected using DNPH coated media in cartridge
- Particulate Matter: collected using impactor nozzles for size ranges of <2.5 and <10 micron

Bioaerosols: Two minute and five minute samples are collected onto agar plates using an Andersen N6 impaction sampler. Samples are collected in the morning and afternoon and are analyzed for thermophylic bacteria, mesophylic bacteria, and fungi.

Four-minute samples are collected onto slides using a Burkard sampler. Samples are collected in the morning and afternoon and are analyzed for viable and non-viable fungal spores.

HVAC Measurements: Measurements are conducted in the morning and afternoon for each AHU serving the study area. Measurements are conducted to determine the following parameters:

- Total AHU supply air delivery
- Total AHU outdoor air delivery rate
- AHU Percentage of outdoor air as determined through volume flow rate measurement and CO_2 mass balance
- AHU supply air discharge temperature and relative humidity
- AHU return air temperature and relative humidity
- Outdoor air temperature and relative humidity

Study Area Mobile Monitoring: All 5 sampling site locations in the study area will be designated as mobile monitoring locations. Spot check measurements are taken at these locations in the morning and afternoon at a designated supply air diffuser at each location. Air discharging from these diffusers will be measured for the following parameters

- Volume flow rate CFM
- Temperature
- Relative humidity (RH)
- Carbon dioxide (CO_2)

Figure E1 Continued

THURSDAY

Occupant Questionnaire: Occupant questionnaires are distributed individually to each occupant in the study area. Questionnaires are distributed in the morning and requested to be returned to drop boxes by 5 PM. All questionnaires are voluntary and confidential.

Carpet Dust Sampling: Carpet dust samples are taken from 3 of the fixed site locations. Samples are collected with a small vacuum cleaner equipped with a special filter insert.

HVAC Measurements: Repeat of Wednesday's measurements

Study Area Mobile Monitoring: Repeat of Wednesday's measurements

Equipment breakdown and packing will begin in the late afternoon hours

FRIDAY

Final packing and shipping of equipment and supplies will be ongoing throughout the morning. Shipping out of equipment generally occurs during the early afternoon.

ADDITIONAL EXPLANATIONS:

Calibration of equipment and downloading of data to portable computers will be conducted before or after each workday.

Figure E2 Preparation List

U.S. EPA BASE Study
Arrangements for the Sampling Week

During the sampling week, it would be greatly appreciated if you could help with arrangements for the following items or personnel. This will assist us in working effectively at your building with as little bother to others once we begin:

- **Ladders**
  Two step ladders are needed for ceiling access in the Study Area. One step stool would also be useful, if available.

- **Outdoor electricity**
  The closest outlet to the outdoor air intake needs to be identified for our outdoor monitoring station. Indoor monitoring stations use standard AC power.

- **"Staging" Area**
  The field team will require the use of a vacant space (about 14' x 16') for sample preparation, equipment storage, and paperwork. This area can be an unused office, meeting room, a low-traffic open area, or a mechanical room located close to the Study Area. If available, a few chairs and a table would be useful.

- **HVAC technician**
  On Monday and Tuesday of the Sampling Week, the field team will be tracking ductwork, identifying measurement locations, and drilling for velocity traverses, etc. We would appreciate access to one of your staff who knows and understands the mechanical systems in the building. We can arrange a schedule for his/her time when we arrive Monday.

- **Contact Person within the Study Area**
  A contact person within the Study Area who can assist us in coordinating an informational meeting, and answering occupant questions.

- **Security**
  Depending upon your building's security requirements, special arrangements may be needed for before- and after-hours access to the Study Area, "staging" area, rooftop access, mechanical rooms, and the building. This is especially important when there is more than one tenant within the Study Area.

- **Photographs**
  Documentation photography of the sampling equipment and Study Area is typically part of the monitoring process. Please advise the field team of any concerns or restrictions, which will be respected.

Again, thank you for your interest in participating in the U.S. EPA BASE Study.

APPENDIX F

BUILDING RECRUITMENT TRACKING MATRIX

EPA Building Assessment Survey and Evaluation Study

Appendix F: Recruitment Tracking Matrix

Step Number	1	2		3		4		5		6							7		8		9	
Description	Initiation of Call	Tenant Contact Established		Previous Contact		Office Space		> 50 Employees		Tenant Interest							bldg mngr / owner		mngr./owner contacted by		> 50 Employees	
Location	Listings called by preliminary caller	Contact w/ tenant not fully established	Contact w/ tenant established	Tenant previously contacted	Tenant not previously contacted	No office space according to tenant	Office space according to tenant	<50 emp. according to tenant	>50 emp. according to tenant or no information	Tenant not interested	Not interested: wary of EPA	Not interested: tenant concerns	Not interested: liability concerns	Not interested: no time to participate	Not interested: other	Tenant willing	Tenant unable/unwilling to identify bldg. mngr./owner	Tenant identified bldg. mngr./owner	Bldg. mngr./owner not contacted by preliminary caller	Bldg. mngr./owner contacted by preliminary caller	<50 emp. according to bldg. mngr./owner	>50 emp. according to bldg. mngr./owner or no info
Minnesota 1	125	52	73	14	59	41	18	4	14	a	a	a	a	a	a	a	2	12	4	8	1	7
Texas 1	685	106	579	31	548	415	133	27	106	a	a	a	a	a	a	a	50	56	21	35	3	32
California 1	652	144	508	13	495	392	103	26	78	a	a	a	a	a	a	a	24	54	16	38	5	33
Missouri 1	320	49	271	12	259	194	65	12	54	a	a	a	a	a	a	a	8	46	13	33	4	29
Oregon 1	357	52	305	17	288	232	56	16	40	a	a	a	a	a	a	a	9	31	6	26	5	20
Louisiana 1	857	283	574	61	513	396	117	78	39	18	1	0	0	1	16	21	1	20	1	19	2	17
South Carolina 1	176	36	140	3	137	77	60	37	23	12	0	0	0	2	10	11	0	11	1	10	0	10
Nevada 1	608	130	478	57	421	269	152	106	46	23	3	0	0	5	17	23	1	22	0	22	2	20
California 2	114	17	97	31	66	32	34	19	15	1	0	0	0	0	0	14	1	13	0	13	0	13
Arizona 1	2,282	907	1,375	73	1,302	818	484	424	60	26	1	1	0	4	20	34	1	33	4	29	2	27
Florida 1	672	291	381	12	369	223	146	124	22	12	2	1	0	0	9	10	0	10	0	10	0	10
Pennsylvania 1	1,080	411	669	46	623	325	298	258	40	15	0	2	1	4	8	25	0	25	7	18	0	18
Texas 2	1,497	670	827	7	820	352	468	189	279	47	3	1	1	13	29	232	29	203	73	130	2	128
Nebraska 1	1,737	535	1,202	17	1,185	458	727	499	228	23	0	3	1	0	19	205	16	189	76	113	0	113
California 3	4,250	1,045	3,205	65	3,140	2,068	1,072	682	390	61	0	2	0	18	41	329	67	262	61	201	24	177
Colorado 1	1,278	326	952	29	923	451	472	154	318	11	0	0	0	2	9	307	56	251	167	84	4	80
Tennessee 1	1,813	536	1,277	39	1,238	788	450	157	293	15	0	0	0	8	7	278	42	236	152	84	14	70
Michigan 1	1,053	338	715	0	715	261	454	328	126	15	0	0	0	7	8	111	23	88	31	57	2	55
Massachusetts 1	712	231	481	0	481	40	441	222	219	83	0	1	1	32	49	136	20	116	31	85	5	80
Arizona 2	892	322	570	0	570	123	447	320	127	35	0	1	1	4	29	92	14	78	40	38	1	37
California 4	1,222	363	859	6	853	222	631	492	139	22	0	0	0	13	9	117	27	90	46	44	0	44
Washington 1	342	96	246	2	244	49	195	131	64	0	0	0	0	0	0	64	11	53	34	19	0	19
Georgia 1	657	191	466	1	465	212	253	64	189	26	0	1	1	11	13	163	35	128	82	46	0	46
Maryland 1	1,888	538	1,350	3	1,347	899	448	199	249	43	0	4	0	17	22	206	44	162	94	68	3	65
California 5	1,359	384	975	0	975	645	330	151	179	13	0	1	0	12	0	166	40	126	57	69	1	68
Tennessee 2	1,681	362	1,319	1	1,318	785	533	279	254	46	4	1	0	26	15	208	40	168	93	75	8	67
New York 1	2,017	548	1,469	0	1,469	1,151	318	219	99	39	2	2	0	12	23	60	28	32	21	11	0	11
New York 2	1,334	213	1,121	0	1,121	681	440	184	256	53	1	0	0	30	22	203	23	180	107	73	1	72
North Carolina 1	2,241	680	1,561	0	1,561	1,018	543	364	179	60	4	1	0	14	41	119	22	97	51	46	0	46
Arkansas 1	1,224	239	985	0	985	559	426	300	126	10	1	0	0	2	7	116	6	110	70	40	1	39
California 7	1,132	238	894	1	893	637	256	224	32	3	0	0	0	2	1	29	3	26	23	3	0	3
California 6	2,224	503	1,721	6	1,715	1,101	614	446	168	25	0	0	0	16	9	143	18	125	70	55	3	52
South Dakota 1	2,457	550	1,907	1	1,906	1,287	619	480	139	12	2	2	0	5	3	127	10	117	76	41	3	38
Florida 2	2,215	508	1,707	0	1,707	1,150	557	457	100	3	0	0	0	1	2	97	6	91	54	37	2	35
New Mexico 1	1,390	359	1,031	0	1,031	623	408	298	110	28	0	0	0	19	9	82	29	53	38	15	0	15
Texas 3	2,156	961	1,195	0	1,195	681	514	230	284	96	2	0	1	84	9	188	47	141	104	37	2	35
New York 3	2,503	661	1,842	4	1,838	1,034	804	620	184	57	0	2	0	31	24	127	32	95	59	36	0	36
Illinois 1	2,903	1,273	1,630	1	1,629	964	665	397	268	60	0	1	0	42	17	208	44	164	26	138	0	138
Florida 3	1,392	468	924	0	924	613	311	139	172	56	1	0	1	52	2	116	20	96	66	30	0	30
Totals	53,497	15,616	37,881	553	37,328	22,266	15,062	9,356	5,708	1,049	27	27	8	489	499	4,367	849	3,810	1,875	1,936	100	1,835

a This information was not part of the original study information collected, and was not tracked during Winter 1994 and Summer 1994.

Appendix F: Recruitment Tracking Matrix

Step Number	10							11		12		13							14		15		16		17	
Description	Bldg. mngr./owner interest							Tech Caller contact w/ bldg mngr / owner		Bldg Eligible		Bldg. mngr./owner not interested after technical call							Preliminary Visit		Bldg Eligibility		Bldg. selection		Bldg. studied	
Location	Bldg. mngr./owner not interested	Not interested: wary of EPA	Not interested: tenant concerns	Not interested: liability concerns	Not interested: no time to participate	Not interested: other	Bldg. mngr./owner willing	Bldg. mngr./owner not contacted by tech. caller	Bldg. mngr./owner contacted by tech. caller	Technical caller determines bldg. to be ineligible (HVAC, publicity, or occupancy reasons)	Technical caller determines bldg. to be eligible	Bldg. mngr./owner not interested	Not interested: wary of EPA	Not interested: tenant concerns	Not interested: liability concerns	Not interested: no time to participate	Not interested: other	Bldg. mngr./owner interested - PV scheduled	Scheduled PV but bldg. not visited	Scheduled PV and bldg. visited	PV-determined ineligibility	PV-determined eligibility	Bldg. not randomly selected for study	Bldg. randomly selected for study	Bldg. not studied	Bldg. studied
Minnesota 1	a	a	a	a	a	a	a	5	4	0	4	0	a	a	a	a	a	4	0	4	0	4	1	3	0	3
Texas 1	a	a	a	a	a	a	a	23	8	2	7	4	a	a	a	a	a	3	0	3	1	2	0	2	0	2
California 1	a	a	a	a	a	a	a	19	11	0	11	6	a	a	a	a	a	5	0	5	0	5	2	3	0	3
Missouri 1	a	a	a	a	a	a	a	22	7	0	7	2	a	a	a	a	a	5	0	5	1	4	1	3	1	2
Oregon 1	a	a	a	a	a	a	a	7	12	2	10	5	a	a	a	a	a	5	0	5	0	5	2	3	0	3
Louisiana 1	b	b	b	b	b	b	b	1	16	9	7	0	b	b	b	b	b	7	1	6	2	4	1	3	0	3
South Carolina 1	b	b	b	b	b	b	b	0	10	7	3	0	b	b	b	b	b	3	0	3	1	2	0	2	0	2
Nevada 1	b	b	b	b	b	b	b	0	20	11	9	3	b	b	b	b	b	6	0	6	3	3	0	3	0	3
California 2	b	b	b	b	b	b	b	0	13	10	3	0	b	b	b	b	b	3	0	3	1	2	0	2	0	2
Arizona 1	b	b	b	b	b	b	b	5	22	12	10	6	1	1	1	1	2	4	0	4	1	3	1	2	0	2
Florida 1	b	b	b	b	b	b	b	2	8	1	7	3	0	1	0	0	2	4	0	4	0	4	2	2	0	2
Pennsylvania 1	b	b	b	b	b	b	b	4	14	6	8	3	0	2	0	1	0	5	0	5	2	3	1	2	0	2
Texas 2	105	1	0	5	5	94	23	2	21	9	12	8	0	0	0	1	7	4	0	4	1	3	0	3	1	2
Nebraska 1	84	0	2	2	6	74	29	4	25	7	18	12	0	1	1	0	10	6	0	6	3	3	0	3	0	3
California 3	152	5	8	5	21	113	25	0	25	6	19	16	0	6	0	2	8	3	0	3	0	3	0	3	2	1
Colorado 1	60	0	2	0	16	42	20	3	17	5	12	4	0	3	0	0	1	8	2	6	0	6	2	4	1	3
Tennessee 1	57	6	4	0	17	30	13	0	13	2	11	2	0	0	0	0	2	9	1	8	5	3	0	3	0	3
Michigan 1	27	0	1	1	9	16	28	4	24	7	17	10	1	0	0	1	8	7	0	7	3	4	1	3	0	3
Massachusetts 1	45	1	0	4	10	30	35	9	26	11	15	10	0	0	1	2	7	5	1	4	0	4	1	3	0	3
Arizona 2	26	1	0	2	7	16	11	4	7	1	6	1	0	0	0	0	1	5	0	5	1	4	1	3	0	3
California 4	24	0	7	4	3	10	20	5	15	4	11	4	0	0	2	0	2	7	1	6	0	6	3	3	0	3
Washington 1	8	0	1	0	2	5	11	5	6	0	6	0	0	0	0	0	0	6	0	6	1	5	2	3	0	3
Georgia 1	35	0	0	0	11	24	11	1	10	2	8	1	0	0	0	0	1	7	0	7	3	4	1	3	0	3
Maryland 1	48	1	6	2	11	28	17	1	16	7	9	3	0	1	0	0	2	6	0	6	2	4	1	3	0	3
California 5	47	3	1	0	21	22	21	8	13	3	10	4	0	1	0	1	2	6	0	6	2	4	0	4	1	3
Tennessee 2	50	3	5	3	15	24	17	0	17	7	10	1	0	0	0	0	1	9	0	9	4	5	2	3	0	3
New York 1	9	0	1	0	1	7	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New York 2	39	0	0	0	13	26	33	0	33	13	20	13	0	0	0	4	9	7	1	6	2	4	0	4	1	3
North Carolina 1	21	0	3	0	7	11	25	6	19	10	9	1	0	0	0	1	0	8	0	8	3	5	1	4	1	3
Arkansas 1	29	1	7	1	11	9	10	0	10	4	6	0	0	0	0	0	0	6	0	6	1	5	2	3	0	3
California 7	3	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
California 6	33	1	5	0	11	16	19	0	19	10	9	2	0	0	0	2	0	7	1	6	1	5	2	3	0	3
South Dakota 1	19	1	1	0	7	10	19	0	19	8	11	6	0	2	0	1	3	5	0	5	0	5	2	3	0	3
Florida 2	15	0	1	0	4	10	20	2	18	8	10	5	0	0	1	0	4	5	0	5	0	5	2	3	0	3
New Mexico 1	8	1	1	1	1	4	7	0	7	1	6	0	0	0	0	0	0	6	0	6	2	4	0	4	1	3
Texas 3	20	0	0	0	8	12	15	6	9	3	6	0	0	0	0	0	0	6	0	6	1	5	2	3	0	3
New York 3	14	0	0	0	3	11	22	12	10	3	7	1	0	1	0	0	0	6	0	6	0	6	3	3	0	3
Illinois 1	53	0	1	0	21	31	85	65	20	10	10	5	0	1	0	0	4	5	0	5	0	5	1	4	1	3
Florida 3	12	0	0	0	5	7	18	11	7	2	5	1	0	0	0	0	1	4	1	3	1	2	0	2	0	2
Totals	1,043	25	58	30	246	684	556	238	551	203	349	142	2	20	6	17	77	207	9	198	48	150	40	110	10	100

a This information was not part of the original study information collected, and was not tracked during Winter 1994 and Summer 1994.

b Information on building manager/owner's interest was not tracked during this period. As recruiting data collection methods progressed, more detail on both tenant and building manager/owner's interest was collected

APPENDIX G

BUILDING RECRUITMENT INTEREST TABLES

EPA Building Assessment Survey and Evaluation Study

Appendix G

Table A: Tenant Interest in Study after Preliminary Call

Step	1	2	5	6							
				Tenant Interest after Preliminary Call							
BASE City	Listings Called By Preliminary Caller	Contact With Tenant Established by Prelim Caller	Building Eligible (According to Tenant)	Tenant not interested	Not interested: wary of EPA	Not interested: tenant concerns	Not interested: liability concerns	Not interested: no time to participate	Not interested: other	Tenant willing	% of Eligible Tenants Interested [a]
Minnesota 1	125	73	14	b	b	b	b	b	b	b	b
Texas 1	685	579	106	b	b	b	b	b	b	b	b
California 1	652	508	28	b	b	b	b	b	b	b	b
Missouri 1	320	271	54	b	b	b	b	b	b	b	b
Oregon 1	357	305	40	b	b	b	b	b	b	b	b
Louisiana 1	857	574	39	18	1	0	0	1	16	21	54%
South Carolina 1	176	140	23	12	0	0	0	2	10	11	48%
Nevada 1	608	478	46	23	3	0	0	5	17	23	50%
California 2	114	97	15	1	0	0	0	0	0	14	93%
Arizona 1	2,282	1,375	60	26	1	1	0	4	20	34	57%
Florida 1	672	381	22	12	2	1	0	0	9	10	45%
Pennsylvania 1	1,080	669	40	15	0	2	1	4	8	25	63%
Texas 2	1,497	827	279	47	3	1	1	13	29	232	83%
Nebraska 1	1,737	1,202	228	23	0	3	1	0	19	205	90%
California 3	4,250	3,205	390	61	0	2	0	18	41	329	84%
Colorado 1	1,278	952	318	11	0	0	0	2	9	307	97%
Tennessee 1	1,813	1,277	293	15	0	0	0	8	7	278	95%
Michigan 1	1,053	715	126	15	0	0	0	7	8	111	88%
Massachusetts 1	712	481	219	83	0	1	1	32	49	136	62%
Arizona 2	892	570	127	35	0	1	1	4	29	92	72%
California 4	1,222	859	139	22	0	0	0	13	9	117	84%
Washington 1	342	246	64	0	0	0	0	0	0	64	100%
Georgia 1	657	466	189	26	0	1	1	11	13	163	86%
Maryland 1	1,888	1,350	249	43	0	4	0	17	22	206	83%
California 5	1,359	975	179	13	0	1	0	12	0	166	93%
Tennessee 2	1,681	1,319	254	46	4	1	0	26	15	208	82%
New York 1	2,017	1,469	99	39	2	2	0	12	23	60	61%
New York 2	1,334	1,121	256	53	1	0	0	30	22	203	79%
North Carolina 1	2,241	1,561	179	60	4	1	0	14	41	119	66%
Arkansas 1	1,224	985	126	10	1	0	0	2	7	116	92%
California 7	1,132	894	32	3	0	0	0	2	1	29	91%
California 6	2,224	1,721	168	25	0	0	0	16	9	143	85%
South Dakota 1	2,457	1,907	139	12	2	2	0	5	3	127	91%
Florida 2	2,215	1,707	100	3	0	0	0	1	2	97	97%
New Mexico 1	1,390	1,031	110	28	0	0	0	19	9	82	75%
Texas 3	2,156	1,195	284	96	2	0	1	84	9	188	66%
New York 3	2,503	1,842	184	57	0	2	0	31	24	127	69%
Illinois 1	2,903	1,630	268	60	0	1	0	42	17	208	78%
Florida 3	1,392	924	172	56	1	0	1	52	2	116	67%
Totals	53,497	37,881	5,658	1,049	27	27	8	489	499	4367	77%

a Percentage of Contacted Tenants Interested is the number of tenants willing to participate in the study divided by the number of tenants with whom the preliminar established contact.

b This information was not part of the original study information collected, and was not tracked during Winter 1994 and Summer 1994. the preliminary caller contact, but this information was not differentiated in Winter 1995 or Summer 1995.

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Table B: Building Manager/Owner Interest in Study After Initial Contact

Step	1	8	9	10							
				Building Manager/Owner Interest After Preliminary Caller Contact							
BASE City	Listings Called By Preliminary Caller	Contact with Bldg Mngr/Owner Established by Prelim Caller	Building Eligible (According to Mngr/Owner)	Bldg Mngr/Owner not interested	Not interested: wary of EPA	Not interested: tenant concerns	Not interested: liability concerns	Not interested: no time to participate	Not interested: other	Bldg Mngr/Owner willing	% Eligible Bldg Mngr/Owners Interested (after prelim call) [a]
Minnesota 1	125	8	7	b	b	b	b	b	b	b	b
Texas 1	685	35	32	b	b	b	b	b	b	b	b
California 1	652	38	33	b	b	b	b	b	b	b	b
Missouri 1	320	33	29	b	b	b	b	b	b	b	b
Oregon 1	357	26	20	b	b	b	b	b	b	b	b
Louisiana 1	857	19	17	c	c	c	c	c	c	c	c
South Carolina 1	176	10	10	c	c	c	c	c	c	c	c
Nevada 1	608	22	20	c	c	c	c	c	c	c	c
California 2	114	13	13	c	c	c	c	c	c	c	c
Arizona 1	2,282	29	27	c	c	c	c	c	c	c	c
Florida 1	672	10	10	c	c	c	c	c	c	c	c
Pennsylvania 1	1,080	18	18	c	c	c	c	c	c	c	c
Texas 2	1,497	130	128	105	1	0	5	5	94	23	18%
Nebraska 1	1,737	113	113	84	0	2	2	6	74	29	26%
California 3	4,250	201	177	152	5	8	5	21	113	25	14%
Colorado 1	1,278	84	80	60	0	2	0	16	42	20	25%
Tennessee 1	1,813	84	70	57	6	4	0	17	30	13	19%
Michigan 1	1,053	57	55	27	0	1	1	9	16	28	51%
Massachusetts 1	712	85	80	45	1	0	4	10	30	35	44%
Arizona 2	892	38	37	26	1	0	2	7	16	11	30%
California 4	1,222	44	44	24	0	7	4	3	10	20	45%
Washington 1	342	19	19	8	0	1	0	2	5	11	58%
Georgia 1	657	46	46	35	0	0	0	11	24	11	24%
Maryland 1	1,888	68	65	48	1	6	2	11	28	17	26%
California 5	1,359	69	68	47	3	1	0	21	22	21	31%
Tennessee 2	1,681	75	67	50	3	5	3	15	24	17	25%
New York 1	2,017	11	11	9	0	1	0	1	7	2	18%
New York 2	1,334	73	72	39	0	0	0	13	26	33	46%
North Carolina 1	2,241	46	46	21	0	3	0	7	11	25	54%
Arkansas 1	1,224	40	39	29	1	7	1	11	9	10	26%
California 7	1,132	3	3	3	0	1	0	0	2	0	0%
California 6	2,224	55	52	33	1	5	0	11	16	19	37%
South Dakota 1	2,457	41	38	19	1	1	0	7	10	19	50%
Florida 2	2,215	37	35	15	0	1	0	4	10	20	57%
New Mexico 1	1,390	15	15	8	1	1	1	1	4	7	47%
Texas 3	2,156	37	35	20	0	0	0	8	12	15	43%
New York 3	2,503	36	36	14	0	0	0	3	11	22	61%
Illinois 1	2,903	138	138	53	0	1	0	21	31	85	62%
Florida 3	1,392	30	30	12	0	0	0	5	7	18	60%
Totals	53,497	1,936	1,835	1,043	25	58	30	246	684	556	30%

a Percentage of Contacted Tenants Interested is the number of tenants willing to participate in the study divided by the number of tenants with whom the preliminary caller established contact.

b This information was not part of the original study information collected, and was not tracked during Winter 1994 and Summer 1994.

c As the BASE study recruitment data collection methods progressed, both the tenant's interest as well as the building manager/owner's interest in the study was tracked during the preliminary caller contact, but this information was not differentiated in Winter 1995 or Summer 1995, and is recorded as tenent interest for these seasons.

Appendix G

Table C: Building Manager Interest in Study After Technical Call

Step	1	11	12	13							
				Building Manager/Owner Interest After Technical Caller Contact							
BASE City	Listings Called By Preliminary Caller	Bldg Mngr/Owner Contacted by Tech Caller	Bldg Eligible (According to Mngr/Owner)	Bldg Mngr/Owner not interested	Not interested: wary of EPA	Not interested: tenant concerns	Not interested: liability concerns	Not interested: no time to participate	Not interested: other	Bldg Mngr/Owner interested - PV scheduled	% Eligible Bldg Mngrs Interested (after tech call) [a]
Minnesota 1	125	4	4	0	b	b	b	b	b	4	100%
Texas 1	685	8	7	4	b	b	b	b	b	3	43%
California 1	652	11	11	6	b	b	b	b	b	5	45%
Missouri 1	320	7	7	2	b	b	b	b	b	5	71%
Oregon 1	357	12	10	5	b	b	b	b	b	5	50%
Louisiana 1	857	16	7	0	b	b	b	b	b	7	100%
South Carolina 1	176	10	3	0	b	b	b	b	b	3	100%
Nevada 1	608	20	9	3	b	b	b	b	b	6	67%
California 2	114	13	3	0	b	b	b	b	b	3	100%
Arizona 1	2,282	22	10	6	1	1	1	1	2	4	40%
Florida 1	672	8	7	3	0	1	0	0	2	4	57%
Pennsylvania 1	1,080	14	8	3	0	2	0	1	0	5	63%
Texas 2	1,497	21	12	8	0	0	0	1	7	4	33%
Nebraska 1	1,737	25	18	12	0	1	1	0	10	6	33%
California 3	4,250	25	19	16	0	6	0	2	8	3	16%
Colorado 1	1,278	17	12	4	0	3	0	0	1	8	67%
Tennessee 1	1,813	13	11	2	0	0	0	0	2	9	82%
Michigan 1	1,053	24	17	10	1	0	0	1	8	7	41%
Massachusetts 1	712	26	15	10	0	0	1	2	7	5	33%
Arizona 2	892	7	6	1	0	0	0	0	1	5	83%
California 4	1,222	15	11	4	0	0	2	0	2	7	64%
Washington 1	342	6	6	0	0	0	0	0	0	6	100%
Georgia 1	657	10	8	1	0	0	0	0	1	7	88%
Maryland 1	1,888	16	9	3	0	1	0	0	2	6	67%
California 5	1,359	13	10	4	0	1	0	1	2	6	60%
Tennessee 2	1,681	17	10	1	0	0	0	0	1	9	90%
New York 1	2,017	0	0	0	0	0	0	0	0	0	none
New York 2	1,334	33	20	13	0	0	0	4	9	7	35%
North Carolina 1	2,241	19	9	1	0	0	0	1	0	8	89%
Arkansas 1	1,224	10	6	0	0	0	0	0	0	6	100%
California 7	1,132	0	0	0	0	0	0	0	0	0	none
California 6	2,224	19	9	2	0	0	0	2	0	7	78%
South Dakota 1	2,457	19	11	6	0	2	0	1	3	5	45%
Florida 2	2,215	18	10	5	0	0	1	0	4	5	50%
New Mexico 1	1,390	7	6	0	0	0	0	0	0	6	100%
Texas 3	2,156	9	6	0	0	0	0	0	0	6	100%
New York 3	2,503	10	7	1	0	1	0	0	0	6	86%
Illinois 1	2,903	20	10	5	0	1	0	0	4	5	50%
Florida 3	1,392	7	5	1	0	0	0	0	1	4	80%
Totals	53,497	551	349	142	2	20	6	17	77	207	59%

a Percentage of Contacted Tenants Interested is the number of tenants willing to participate in the study divided by the number of tenants with whom the preliminary caller established contact.

b This information was not part of the original study information collected, and was not tracked during Winter 1994, Summer 1994 or Winter 1995.

APPENDIX H

COMPARISON OF DATA DEFINITIONS FOR CBECS, BASE AND BOMA STUDIES

EPA Building Assessment Survey and Evaluation Study

Table H1 Comparison of Data Definitions for CBECS and BASE Studies

Building Characteristics Definitions

Parameter	CBECS definition	BASE definition with database variable names in parentheses	Comparable? (Yes/No)	Comments
Building square footage	Floor space, in units of square feet. All of the area enclosed by the exterior walls of a building, including indoor parking facilities, basements, hallways, lobbies, stairways, and elevator shafts.	(A1AREA2) Gross floor area of building Comprised of the total floor area within the building footprint, including all parking areas integral to the building structure, basements, mechanical space, and shafts. Database units reported in square meters and converted to square feet for comparison.	Yes	
Number of Floors	The number of levels in the tallest section of a building that are actually considered a part of the building, including parking areas, basements, or other floors below ground level.	(A1ABOVE) Represents the number of floors above grade. (A1BELOW) Represents the number of floors below grade. For floors that were partially above and below grade, the grade designation was selected based on what the case was for the majority of the floor.	Yes	For comparing the CBECS data with the BASE data, the BASE variables A1ABOVE and A1BELOW were summed to yield the number of floors that comprised the building.

Table H1 (Continued) Comparison of Data Definitions for CBECS and BASE Studies

Building Characteristics Definitions

Parameter	CBECS definition	BASE definition with database variable names in parentheses	Comparable? (Yes/No)	Comments
Hours of operation per week	The number of hours per week that a building is used, excluding hours when the building is occupied only by maintenance, security, or other support personnel. For buildings with a schedule that varied during the year, "Weekly Operating Hours" refer to the total weekly hours for the schedule most often followed. If operating hours varied throughout a building, the usual operating hours of the largest business in the building (based on floorspace) determined the operating hours for the building.	(A1HOURS1) Represents the hours per *weekday* that the building is occupied. (A1HOURS2) Represents the hours per *weekend* day that the building is occupied. For both variables listed above, the hours of operation for the building was based on what was typical for the bulk of the office occupants rather than simply the hours that the building was "open". Buildings that had sporadic usage by few occupants (as sometimes occurs over weekends) was not included.	Yes	For comparing the CBECS data with the BASE data, the BASE variables A1HOURS1 and A1HOURS2 were summed to yield the total weekly hours of operation for the building.
Year constructed	The year in which the major part or the largest portion of a building was constructed.	(A1YEAR) Represents the year that the building construction was "first completed".	Yes	For the BASE data, this variable represented the year that building construction was completed while the CBECS definition refers to the year in which the building was constructed. For buildings that underwent multi-year construction schedules, these variables by definition may be slightly different. However, EH&E would feel that these differences would be minor.

Table H1 (Continued) Comparison of Data Definitions for CBECS and BASE Studies				
Wall Material Definitions				
Wall construction materials	**Predominant exterior wall material as defined by CBECS**	**Primary exterior wall construction material as defined by BASE (database variable names in parentheses)**	**Comparable? (Yes/No)**	**Comments**
Masonry	A general term covering wall construction and the use of masonry materials, such as brick, concrete block, stone, and tile that are set in mortar; also included is stucco. This category does not include concrete panels since concrete panels represent a different method of constructing buildings.	(A1WALLB, Masonry) Wall construction material defined as brick, stone or stone block. Under the BASE definition, this category did not include concrete panels or stucco. Rather, concrete panels were defined as a separate construction method while stucco was included in the BASE database category defined as "OTHER"	Yes	The definitions suggest that these variables are comparable with the exception of buildings using stucco as a primary exterior wall construction material. In the BASE data set there was only two buildings with stucco as its primary wall construction material. In making the comparison between BASE and CSECS, these buildings were combined with the BASE masonry category.
Siding/ shingles/ shakes	An exterior wall covering material made of aluminum, asbestos, plastic or wood. The structural walls may be masonry or wood. Siding is generally produced in the shape of boards and applied to the outside of a building in overlapping rows. Shingles are considered as flat pieces of weatherproof material laid with others in a series of overlapping rows. Materials include fiberglass, plastic, baked clay, tile, asbestos, asphalt, aluminum, and wood. Shakes (similar to wood shingles) have textured grooves and a rough appearance.	(A1WALLF, Siding on frame construction). Wall construction material defined as shingles shakes, or siding. Shingles or shakes and siding. These included shingles, shakes or siding constructed of wood, fiberglass, plastic, baked clay, tile, asbestos, asphalt, aluminum, or vinyl.	Yes	

Table H1 (Continued) Comparison of Data Definitions for CBECS and BASE Studies

Wall Material Definitions

Wall construction materials	Predominant exterior wall material as defined by CBECS	Primary exterior wall construction material as defined by BASE (database variable names in parentheses)	Comparable? (Yes/No)	Comments
Sheet metal panels	An exterior wall construction material made of aluminum or galvanized steel panels fabricated in factories and fastened to the frame of the building to form outside walls. Pre-engineered metal buildings are also included in this category.	(A1WALLG Metal building system) Wall construction material defined as metal panels fastened to the frame of the building to form the outside walls.	Yes	
Pre-cast Concrete panels	A wall construction panel made of concrete that is either prefabricated in a factory or poured at the site and then hoisted on to the structure.	(A1WALLC, Pre-cast concrete panels) Wall construction material defined as pre-fabricated concrete panels hoisted on to the structure to form the outside walls.	Yes	
Window or vision glass and Decorative or construction glass	An exterior wall construction material made of glass that can be seen through from the inside of the building, like the glass found in windows. For example, walls that are glass-covered or constructed of non-transparent material.	(A1WALLA Glass and metal curtain) Wall construction material made up of glass and metal framing.	Yes	

Table H1 (Continued) Comparison of Data Definitions for CBECS and BASE Studies				
Wall Material Definitions				
Wall construction materials	**Predominant exterior wall material as defined by CBECS**	**Primary exterior wall construction material as defined by BASE (database variable names in parentheses)**	**Comparable? (Yes/No)**	**Comments**
Other and No one Major Type	"Other" is a category included in the CBECS database to specify wall construction materials not included as a main category "No one major type" is a category included in the CBECS database to specify buildings with no single predominant wall construction material	(A1WALLH). "Other" is a category included in the BASE database to specify wall construction materials not included as a main category "No one major type" This is not a category in the BASE database.	No	One difference between the CBECS and BASE database for wall construction materials is the CBECS category "No one major type". This variable is not a category in the BASE database. For BASE, a single wall construction material was selected as being predominant.
Roof Material Definitions				
Roof construction materials	**Predominant roof material as defined by CBECS**	**Primary roof construction material as defined by BASE (database variable names in parentheses)**	**Comparable? (Yes/No)**	**Comments**
Built-up	A roof covering consisting of several successive layers (each of which is called a "ply"), usually of roofing felt, with mopping of hot asphalt between layers and topped by a mineral – surfaced layer or by gravel embedded in a heavy coat of asphalt.	(A1ROOFA Built up roof) defined as plys of asphalt impregnated sheets adhered together with hot asphalt.	Yes	

Table H1 (Continued) Comparison of Data Definitions for CBECS and BASE Studies

Roof Material Definitions

Roof construction materials	Predominant roof material as defined by CBECS	Primary roof construction material as defined by BASE (database variable names in parentheses)	Comparable? (Yes/No)	Comments
Shingles	Non-wood shingle materials include asphalt, fiberglass, plastic, baked clay, tile, asbestos, and aluminum.	(A1ROOFD Shingles) For BASE, roof shingle materials included wood, asphalt, fiberglass, plastic, baked clay, tile, asbestos, and aluminum. Note: BASE would have put wood-shingled roofs in this category, however there were none.	Yes	Based on a comparison of the definitions, these variables are comparable with the exception of buildings using wood shingles. Although there is a difference in the definitions for this variable, there were no BASE buildings with a wood shingle roof construction and therefore, these variables are comparable
Metal surfacing	Light-gauge metal sheets used for roofing.	(A1ROOFE Metal). Metal sheets used for roofing.	Yes	
Single/ Multiple ply	Plastic, rubber or synthetic sheeting.	(A1ROOFB Single ply membrane) defined as plastic, rubber or synthetic sheeting	Yes	

Table H1 (Continued) Comparison of Data Definitions for CBECS and BASE Studies

Roof Material Definitions

Roof construction materials	Predominant roof material as defined by CBECS	Primary roof construction material as defined by BASE (database variable names in parentheses)	Comparable? (Yes/No)	Comments
Slate or Tile	Tile refers to any thin, square, or rectangular piece of baked clay, stone, or concrete used as a roofing material. Slate refers to a particular stone used for roofing.	Note that "Slate or Tile" was not a category in the BASE database. : BASE would have put this category in the "Other" category.	No	This variable is not a category in the BASE database. For BASE, this material would have been categorized as "Other".
Wooden Materials	Wood shingles, wood shakes, or other wooden materials used as roofing materials	Note that "Wooden Materials" was not a category in the BASE database. : BASE would have put this category in the "Shingles" category.	No	This variable is not a category in the BASE database. For BASE, this material would have been categorized as "Shingles".
Other and No one Major Type	"Other" is a category included in the CBECS database to specify roof construction materials not included as a main category "No one major type" is a category included in the CBECS database to specify buildings with no single predominant roof construction material	(A1ROOFF). "Other" is a category included in the BASE database to specify roof construction materials not included as a main category "No one major type" This is not a category in the BASE database.	No	One difference between the CBECS and BASE database for wall construction materials is the CBECS category "No one major type". This variable is not a category in the BASE database. For BASE, a single wall construction material was selected as being predominant.

Table H2 Comparison of Variable Definitions Used to Determine Area per Occupant in U.S. Office Buildings

Parameter used to Determine Area Per Occupant	BASE Variable with definition	BOMA Variable with definition	Comparable? (Yes/No)	Comments
Area of office space	*Occupied Building Area (database variable A1AREA).* This variable represents the occupied building area as reported by the building manager or calculated from plans. This value excludes corridors, restrooms, stairwells, etc.	Occupied area determined through a calculation of the following variables; *a) Square footage of office space* as reported by the building manager. *b) Office occupancy rate* (%) as reported by the building manager Occupied area determined by multiplying the square footage of office space in each building by its office occupancy rate	No	The BOMA variable for *square footage of office space* is specific to office space while the BASE variable *occupied building area* does not distinguish between office and non office space.
Occupancy	Typical building occupancy including visitors (A1OCCUP)	Occupancy: Number of employees excluding building staff	No	The BASE variable for building occupancy differs from that of BOMA in that BASE occupancy also includes visitors

APPENDIX I

BUILDING CHARACTERISTIC COMPARISON TABLES
(BASE, CBECS)

EPA Building Assessment Survey and Evaluation Study

Table I1 Building Square Footage Comparison

Variable	CBECS-A Office Buildings		CBECS-B Office Buildings in MSAs		CBECS-C+ Office Buildings with more than 50 occupants		CBECS-C Office Buildings in MSAs (population >50,000) with more than 50 occupants		BASE Office Buildings in cities with population > 100,000	
Square Footage	Estimated Count	%	Estimated Count	%	Estimated Count	%	Estimated Count	%	Actual Count	%
1,001-5,000	405,491	58%	265,952	51%	9,786	12%	3,742	5%	0	<1%
5,001-10,000	131,482	19%	108,711	21%	371	<1%	371	1%	0	<1%
10,001-25,000	94,443	13%	80,628	15%	12,172	15%	10,350	15%	3	3%
25,001-50,000	35,430	5%	33,205	6%	23,387	29%	22,071	32%	12	12%
50,001-100,000	22,074	3%	19,670	4%	18,697	23%	17,640	25%	20	20%
100,001-200,000	9,774	1%	9,774	2%	9,311	12%	9,311	13%	22	22%
200,001-500,000	4,964	1%	4,964	1%	4,933	6%	4,933	7%	28	28%
500,001-million	936	<1%	936	<1%	928	1%	928	1%	11	11%
>Million	335	<1%	335	<1%	327	<1%	327	<1%	4	4%
Total	704,931	100%	524,176	100%	79,912	100%	69,673	100%	100	100%

Table I2 Number of Floors Per Building Comparison

Variable	CBECS-A Office Buildings		CBECS-B Office Buildings in MSAs		CBECS-C+ Office Buildings with more than 50 occupants		CBECS-C Office Buildings in MSAs (population >50,000) with more than 50 occupants		BASE Office Buildings in cities with population > 100,000	
Number of Floors	Estimated Count	%	Estimated Count	%	Estimated Count	%	Estimated Count	%	Actual Count	%
1	369,680	52%	243,003	46%	20,670	26%	14,292	21%	3	3%
2	219,600	31%	173,380	33%	15,440	19%	14,428	21%	5	5%
3	67,310	10%	62,785	12%	14,068	18%	12,283	18%	17	17%
4	24,348	3%	22,021	4%	9,695	12%	8,839	13%	8	8%
5	8,152	1%	7,355	1%	5,953	7%	5,953	9%	15	15%
6	3,103	<1%	3,006	1%	2,474	3%	2,377	3%	8	8%
7	2,486	<1%	2,375	<1%	2,283	3%	2,172	3%	7	7%
8	1,319	<1%	1,319	<1%	1,211	2%	1,211	2%	1	1%
9	874	<1%	874	<1%	874	1%	874	1%	6	6%
10	821	<1%	821	<1%	222	<1%	222	<1%	2	2%
11	968	<1%	968	<1%	968	1%	968	1%	2	2%
12	841	<1%	841	<1%	841	1%	841	1%	3	3%
13	1,103	<1%	1,103	<1%	1,103	1%	1,103	2%	1	1%
14	896	<1%	896	<1%	720	1%	720	1%	2	2%
15-25	2,402	<1%	2,402	<1%	2,370	3%	2,370	3%	11	11%
Over 25	1,027	<1%	1,027	<1%	1,019	1%	1,019	1%	9	9%
Total	704,931	100%	524,176	100%	79,912	100%	69,673	100%	100	100%

Table I4 Total Number of Hours Building is Open Per Week Comparison

Variable	CBECS-A Office Buildings		CBECS-B Office Buildings in MSAs		CBECS-C+ Office Buildings with more than 50 occupants		CBECS-C Office Buildings in MSAs (population >50,000) with more than 50 occupants		BASE Office Buildings in cities with population > 100,000	
Number of Hours / Week	Estimated Count	%	Estimated Count	%	Estimated Count	%	Estimated Count	%	Actual Count	%
1-39	55,339	8%	32,313	6%	582	1%	582	1%	0	0%
40-48	403,884	57%	291,420	56%	20,613	26%	18,382	26%	29	29%
49-60	164,962	23%	128,561	25%	25,318	32%	24,360	35%	46	46%
61-84	31,583	4%	30,683	6%	11,599	15%	11,599	17%	13	13%
86-167	6,525	1%	5,613	1%	3,783	5%	3,783	5%	12	12%
Inapplicable	9,049	1%	3,004	1%	9,049	11%	3,004	4%	0	0%
Open continuously	33,589	5%	32,582	6%	8,969	11%	7,963	11%	0	0%
Total	704,931	100%	524,176	100%	79,912	100%	69,673	100%	100	100%

Table I3 Building Year Constructed Comparison

Variable	CBECS-A Office Buildings		CBECS-B Office Buildings in MSAs		CBECS-C+ Office Buildings with more than 50 occupants		CBECS-C Office Buildings in MSAs (population >50,000) with more than 50 occupants		BASE Office Buildings in cities with population > 100,000	
Year	Estimated Count	%	Estimated Count	%	Estimated Count	%	Estimated Count	%	Actual Count	%
1899 or before	20,700	3%	12,452	2%	524	1%	161	<1%	6	6%
1900-1919	36,083	5%	28,696	5%	3,142	4%	2,649	4%	7	7%
1920-1945	73,789	10%	52,179	10%	12,058	15%	4,811	7%	10	10%
1946-1959	127,968	18%	91,728	17%	5,309	7%	5,196	7%	8	8%
1960-1969	75,462	11%	65,244	12%	10,290	13%	9,660	14%	17	17%
1970-1979	158,123	22%	112,255	21%	14,695	18%	14,576	21%	15	15%
1980-1989	151,232	21%	122,984	23%	25,931	32%	25,048	36%	30	30%
1990-1992	38,438	5%	24,175	5%	3,773	5%	3,773	5%	4	4%
1993-1995	23,137	3%	14,463	3%	4,191	5%	3,799	5%	2	2%
1996–present	NA	NA	NA	NA	NA	NA	NA	NA	1	1%
Total	704,931	100%	524,176	100%	79,912	100%	69,673	100%	100	100%

NA = Not Applicable. CBECS data was collected prior to 1996.

Table I5 Building Wall Construction Material Comparison

Variable	CBECS-A Office Buildings		CBECS-B Office Buildings in MSAs		CBECS-C+ Office Buildings with more than 50 occupants		CBECS-C Office Buildings in MSAs (population >50,000) with more than 50 occupants		BASE Office Buildings in cities with population > 100,000	
Wall Construction Material	Estimated Count	%	Estimated Count	%	Estimated Count	%	Estimated Count	%	Actual Count	%
Glass[a]	10,877	2%	10,718	2%	54,744	69%	8,521	12%	15	15%
Masonry	523,815	74%	397,432	76%	727	1%	44,943	65%	52	52%
No one major type	1,703	<1%	1,703	<1%	303	<1%	727	1%	*	*
Other	1,041	<1%	670	<1%	9,055	11%	303	<1%	4	4%
Pre-cast concrete panels	28,016	4%	27,748	5%	1,203	2%	8,787	13%	26	26%
Sheet metal panels	46,030	7%	19,276	4%	5,359	7%	1,203	2%	2	2%
Siding/shingles/ shakes	93,448	13%	66,628	13%	8,521	11%	5,188	7%	1	1%
Total	704,931	100%	524,176	100%	79,912	100%	69,673	100%	100	100%

[a]Includes Decorative/construction glass, Window/vision glass, and Glass and metal curtain wall

*Indicated wall construction material is not a selection option in the BASE data collection software. Therefore, if this particular wall construction material existed, it was classified in BASE as “other”.

Table I6 Building Roof Construction Material Comparison

Variable	CBECS-A Office Buildings		CBECS-B Office Buildings in MSAs		CBECS-C+ Office Buildings with more than 50 occupants		CBECS-C Office Buildings in MSAs (population >50,000) with more than 50 occupants		BASE Office Buildings in cities with population > 100,000	
Roof Construction Material	Estimated Count	%	Estimated Count	%	Estimated Count	%	Estimated Count	%	Actual Count	%
Built-up	190,675	27%	160,574	31%	37,794	47%	37,010	53%	45	45%
Concrete roof	9,577	1%	9,480	2%	1,907	2%	1,810	3%	*	*
Metal surfacing	74,963	11%	34,105	7%	3,542	4%	3,023	4%	5	5%
No one major type	619	0%	619	0%	619	1%	619	1%	*	*
Other	443	0%	443	0%	443	1%	443	1%	4	4%
Shingles (not wood)	281,201	40%	209,446	40%	14,264	18%	7,264	10%	3	3%
Single/multiple ply	87,700	12%	63,216	12%	20,737	26%	18,898	27%	43	43%
Slate or tile	44,376	6%	30,919	6%	492	1%	492	1%	*	*
Wooden materials	15,375	2%	15,375	3%	114	0%	114	0%	*	*
Total	704,931	100%	524,176	100%	79,911	100%	69,673	100%	100	100%

*Indicated roof construction material is not a selection option in the BASE data collection software. Therefore, if this particular roof construction material existed, it was classified as “other”.

APPENDIX I

BUILDING CHARACTERISTIC COMPARISON TABLES
(BASE, CBECS)

EPA Building Assessment Survey and Evaluation Study

Table I1 Building Square Footage Comparison

Variable	CBECS-A Office Buildings		CBECS-B Office Buildings in MSAs		CBECS-C+ Office Buildings with more than 50 occupants		CBECS-C Office Buildings in MSAs (population >50,000) with more than 50 occupants		BASE Office Buildings in cities with population > 100,000	
Square Footage	Estimated Count	%	Estimated Count	%	Estimated Count	%	Estimated Count	%	Actual Count	%
1,001-5,000	405,491	58%	265,952	51%	9,786	12%	3,742	5%	0	<1%
5,001-10,000	131,482	19%	108,711	21%	371	<1%	371	1%	0	<1%
10,001-25,000	94,443	13%	80,628	15%	12,172	15%	10,350	15%	3	3%
25,001-50,000	35,430	5%	33,205	6%	23,387	29%	22,071	32%	12	12%
50,001-100,000	22,074	3%	19,670	4%	18,697	23%	17,640	25%	20	20%
100,001-200,000	9,774	1%	9,774	2%	9,311	12%	9,311	13%	22	22%
200,001-500,000	4,964	1%	4,964	1%	4,933	6%	4,933	7%	28	28%
500,001-million	936	<1%	936	<1%	928	1%	928	1%	11	11%
>Million	335	<1%	335	<1%	327	<1%	327	<1%	4	4%
Total	704,931	100%	524,176	100%	79,912	100%	69,673	100%	100	100%

Table I2 Number of Floors Per Building Comparison

Variable	CBECS-A Office Buildings		CBECS-B Office Buildings in MSAs		CBECS-C+ Office Buildings with more than 50 occupants		CBECS-C Office Buildings in MSAs (population >50,000) with more than 50 occupants		BASE Office Buildings in cities with population > 100,000	
Number of Floors	Estimated Count	%	Estimated Count	%	Estimated Count	%	Estimated Count	%	Actual Count	%
1	369,680	52%	243,003	46%	20,670	26%	14,292	21%	3	3%
2	219,600	31%	173,380	33%	15,440	19%	14,428	21%	5	5%
3	67,310	10%	62,785	12%	14,068	18%	12,283	18%	17	17%
4	24,348	3%	22,021	4%	9,695	12%	8,839	13%	8	8%
5	8,152	1%	7,355	1%	5,953	7%	5,953	9%	15	15%
6	3,103	<1%	3,006	1%	2,474	3%	2,377	3%	8	8%
7	2,486	<1%	2,375	<1%	2,283	3%	2,172	3%	7	7%
8	1,319	<1%	1,319	<1%	1,211	2%	1,211	2%	1	1%
9	874	<1%	874	<1%	874	1%	874	1%	6	6%
10	821	<1%	821	<1%	222	<1%	222	<1%	2	2%
11	968	<1%	968	<1%	968	1%	968	1%	2	2%
12	841	<1%	841	<1%	841	1%	841	1%	3	3%
13	1,103	<1%	1,103	<1%	1,103	1%	1,103	2%	1	1%
14	896	<1%	896	<1%	720	1%	720	1%	2	2%
15-25	2,402	<1%	2,402	<1%	2,370	3%	2,370	3%	11	11%
Over 25	1,027	<1%	1,027	<1%	1,019	1%	1,019	1%	9	9%
Total	704,931	100%	524,176	100%	79,912	100%	69,673	100%	100	100%

Table I4 Total Number of Hours Building is Open Per Week Comparison

Variable	CBECS-A Office Buildings		CBECS-B Office Buildings in MSAs		CBECS-C+ Office Buildings with more than 50 occupants		CBECS-C Office Buildings in MSAs (population >50,000) with more than 50 occupants		BASE Office Buildings in cities with population > 100,000	
Number of Hours / Week	Estimated Count	%	Estimated Count	%	Estimated Count	%	Estimated Count	%	Actual Count	%
1-39	55,339	8%	32,313	6%	582	1%	582	1%	0	0%
40-48	403,884	57%	291,420	56%	20,613	26%	18,382	26%	29	29%
49-60	164,962	23%	128,561	25%	25,318	32%	24,360	35%	46	46%
61-84	31,583	4%	30,683	6%	11,599	15%	11,599	17%	13	13%
86-167	6,525	1%	5,613	1%	3,783	5%	3,783	5%	12	12%
Inapplicable	9,049	1%	3,004	1%	9,049	11%	3,004	4%	0	0%
Open continuously	33,589	5%	32,582	6%	8,969	11%	7,963	11%	0	0%
Total	704,931	100%	524,176	100%	79,912	100%	69,673	100%	100	100%

Table I3 Building Year Constructed Comparison

Variable	CBECS-A Office Buildings		CBECS-B Office Buildings in MSAs		CBECS-C+ Office Buildings with more than 50 occupants		CBECS-C Office Buildings in MSAs (population >50,000) with more than 50 occupants		BASE Office Buildings in cities with population > 100,000	
Year	Estimated Count	%	Estimated Count	%	Estimated Count	%	Estimated Count	%	Actual Count	%
1899 or before	20,700	3%	12,452	2%	524	1%	161	<1%	6	6%
1900-1919	36,083	5%	28,696	5%	3,142	4%	2,649	4%	7	7%
1920-1945	73,789	10%	52,179	10%	12,058	15%	4,811	7%	10	10%
1946-1959	127,968	18%	91,728	17%	5,309	7%	5,196	7%	8	8%
1960-1969	75,462	11%	65,244	12%	10,290	13%	9,660	14%	17	17%
1970-1979	158,123	22%	112,255	21%	14,695	18%	14,576	21%	15	15%
1980-1989	151,232	21%	122,984	23%	25,931	32%	25,048	36%	30	30%
1990-1992	38,438	5%	24,175	5%	3,773	5%	3,773	5%	4	4%
1993-1995	23,137	3%	14,463	3%	4,191	5%	3,799	5%	2	2%
1996–present	NA	NA	NA	NA	NA	NA	NA	NA	1	1%
Total	704,931	100%	524,176	100%	79,912	100%	69,673	100%	100	100%

NA = Not Applicable. CBECS data was collected prior to 1996.

Table I5 Building Wall Construction Material Comparison

Variable	CBECS-A Office Buildings		CBECS-B Office Buildings in MSAs		CBECS-C+ Office Buildings with more than 50 occupants		CBECS-C Office Buildings in MSAs (population >50,000) with more than 50 occupants		BASE Office Buildings in cities with population > 100,000	
Wall Construction Material	Estimated Count	%	Estimated Count	%	Estimated Count	%	Estimated Count	%	Actual Count	%
Glass[a]	10,877	2%	10,718	2%	54,744	69%	8,521	12%	15	15%
Masonry	523,815	74%	397,432	76%	727	1%	44,943	65%	52	52%
No one major type	1,703	<1%	1,703	<1%	303	<1%	727	1%	*	*
Other	1,041	<1%	670	<1%	9,055	11%	303	<1%	4	4%
Pre-cast concrete panels	28,016	4%	27,748	5%	1,203	2%	8,787	13%	26	26%
Sheet metal panels	46,030	7%	19,276	4%	5,359	7%	1,203	2%	2	2%
Siding/shingles/ shakes	93,448	13%	66,628	13%	8,521	11%	5,188	7%	1	1%
Total	704,931	100%	524,176	100%	79,912	100%	69,673	100%	100	100%

[a]Includes Decorative/construction glass, Window/vision glass, and Glass and metal curtain wall

*Indicated wall construction material is not a selection option in the BASE data collection software. Therefore, if this particular wall construction material existed, it was classified in BASE as “other”.

Table I6 Building Roof Construction Material Comparison

Variable	CBECS-A Office Buildings		CBECS-B Office Buildings in MSAs		CBECS-C+ Office Buildings with more than 50 occupants		CBECS-C Office Buildings in MSAs (population >50,000) with more than 50 occupants		BASE Office Buildings in cities with population > 100,000	
Roof Construction Material	Estimated Count	%	Estimated Count	%	Estimated Count	%	Estimated Count	%	Actual Count	%
Built-up	190,675	27%	160,574	31%	37,794	47%	37,010	53%	45	45%
Concrete roof	9,577	1%	9,480	2%	1,907	2%	1,810	3%	*	*
Metal surfacing	74,963	11%	34,105	7%	3,542	4%	3,023	4%	5	5%
No one major type	619	0%	619	0%	619	1%	619	1%	*	*
Other	443	0%	443	0%	443	1%	443	1%	4	4%
Shingles (not wood)	281,201	40%	209,446	40%	14,264	18%	7,264	10%	3	3%
Single/multiple ply	87,700	12%	63,216	12%	20,737	26%	18,898	27%	43	43%
Slate or tile	44,376	6%	30,919	6%	492	1%	492	1%	*	*
Wooden materials	15,375	2%	15,375	3%	114	0%	114	0%	*	*
Total	704,931	100%	524,176	100%	79,911	100%	69,673	100%	100	100%

*Indicated roof construction material is not a selection option in the BASE data collection software. Therefore, if this particular roof construction material existed, it was classified as “other”.