MASTER

CROSS CLASSIFICATION OF CENSUS DATA FOR USE IN
ESTIMATING RESIDENTIAL HEATING DEMANDS

R.G. Tessmer, Jr.

May 1979

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DEPARTMENT OF ENERGY AND ENVIRONMENT
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973**

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By the

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ABSTRACT

This report documents the procedures and assumptions used to cross classify 1970 census data for use in estimating residential heating demands on a small areal basis. The major results for all census tracts and minor civil divisions in the U.S. comprise (1) counts of occupied dwelling units by building size, by type of space heat equipment, and by space heat fuel type; (2) counts of occupied dwelling units by building size and by water heat fuel type; and (3) the percentage distribution of occupied dwelling units in each building size category across four dwelling unit size categories. These reduced data, both at the tract/minor civil division level and aggregated county and state levels, are sufficiently accurate for systems and economic analysis of district heating and other residential energy conservation programs.

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The perseverance and fastidiousness of Gabriele Sowada in programming and debugging algorithms to handle suppressed, incomplete, and inconsistent census data is gratefully acknowledged.

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I. INTRODUCTION

Under the sponsorship of the U.S. Department of Energy, Brookhaven National Laboratory is developing a detailed model of residential space and water heat demands for the entire United States. This will be used to evaluate the economic feasibility of district heating systems supplied with heat from geothermal resources and to plan other energy conservation programs including the oil burner retrofit program. The model is unique in that it is built up from heating demand estimates for individual dwelling units whose locations are identified at a very fine level of geographic detail: the census tract (for metropolitan areas) or the minor civil division (for non-metropolitan areas). Tracts typically contain 4000 to 6000 persons, and in 1970 the U.S. contained 34,500 tracts and 26,500 minor civil divisions.

In order to make this procedure for demand estimation feasible, dwelling units in each tract and minor civil division are aggregated into a discrete number of categories for which annual unit heat demand estimates and other technical parameters can be specified. These categories are chosen so that the major factors affecting heat demand and fuel usage are captured. The existence of a wealth of detailed data from the 1970 Census of Population and Housing makes such an approach feasible for estimation of residential heat demands in 1970.

However, published census tables do not present data in the format needed for this approach. One needs to know, for example, the number of dwelling units by building size, by type of heating system, and by fuel type. But the census presents tables only of dwelling units by building size and by tenure, dwelling units by type of heating system and by tenure, and dwelling units by fuel type and by tenure. Supplementary techniques must therefore be employed to combine information for several tables on the basis of reasonable assumptions and to arrive at the necessary household cross classifications used in the heating demand model.

This report documents the techniques and the rules of logic (assumptions) used to cross classify relevant census data. The end results for each tract or minor civil division are as follows:

- o A 3-dimensional table showing counts of occupied dwelling units by building size, by type of space heat equipment, and by space heat fuel type;
- o A 2-dimensional table showing counts of occupied dwelling units by building size and by water heat fuel type;
- o A 2-dimensional table showing the percentage distribution of occupied dwelling units in each building size category across four dwelling unit size categories (specified in terms of rooms per dwelling unit);
- o A 1-dimensional table showing the percentage of occupied owned and rented units which have washing machines; and
- o A 1-dimensional table showing the average number of persons per occupied dwelling unit in each building size category.

In choosing the assumptions needed for cross classification, an attempt has been made to choose those which are most logical and which will not introduce bias when applied across the whole country. Lack of necessary information prevents the application of different rules of logic in different regions, although this could be done for specific areas where better information is available. Overall, the final procedures described below appear sufficiently

adequate in view of the inaccuracy inherent in the original census data* and the fact that many small errors are probably cancelled out by performing the procedures separately for each of the 61,000 tracts and minor civil divisions.

II. PREPARATORY MANIPULATION

A. Relevant Census Data

A printout of typical 1970 census data for a tract in Suffolk County, New York, is shown in Table 1. Data used for cross classification include the following:

- o 1970 households;
- o units per structure table (no. of occupied dwelling units by building size and tenure);
- o rooms per unit table** (no. of occupied units by no. of rooms per dwelling unit and tenure);
- o persons per unit table† (no. of occupied units by no. of persons per dwelling unit and tenure);
- o clothes washing machine table (no. of occupied units by type of washing machine and tenure);
- o heating equipment table (no. of occupied units by type of space heating equipment and tenure);
- o heating fuel table (no. of occupied units by space heat fuel type, water heat type, and tenure).

The cross classification algorithms aggregate certain categories in these tables, as shown in Table 2. Census level detail is maintained for those categories which are crucial for evaluation of district heating and building retrofit, but categories are aggregated for which such detail is not needed to make the demand estimation procedure tractable.

B. Initial Manipulation

The cross classification algorithms transform data for each tract or minor civil division record in the order in which they appear on the census computer tapes. The remainder of this report describes the logic and the assumptions employed.

One problem with the census is that tabled data are frequently missing or suppressed, especially in low population tracts. If this is the case with the first record being read, arbitrary data are inserted in all blank tables. For succeeding records with missing data, it is assumed that the percentage distribution of dwelling units for each missing table is the same as that in the previous record. Since neighboring records on the census tape are generally from

*For example, data on space heat equipment type were collected from only 20% of the households, and data on fuel type were collected from only 5% of the households.

**Aggregate row (AGG) is total number of rooms in all occupied units.

†Aggregate row (AGG) is total number of persons in all households (not including persons in group quarters).

TYPICAL DATA FOR A CENSUS TRACT

T NAME=TRACT 1588.02

TRACT-CODE=158802

SHSA-CODE=5600

AREA (ACRES)	POPULATION	PCP.DENS. (PERS/SCH)	POP.CENT. (1970)	HOUSEHOLDS	PER CAPITA INCOME	AVG.HOUSEH. INCOME	POPULATION (13-34 YEARS) BY SCHOOL TYPE
60	2994		LA= 407509	70	69	3390	KIND: PUB= 183, PAR= 6, PRV= 0
70	4284		LD= 730339	1240	69	11594	ELEM: PUB= 690, PAR= 22, PRV= 0
							HIGH: PUB= 294, PAR= 11, PRV= 0
							COLL: PUB= 66, PRV= 121

YEAR STRUCTURE BUILT	UNITS	PER STRUCTURE	ROOMS PER UNIT	PERSONS PER UNIT	SEWAGE DISPOSAL (BY UNIT)
OWN.OCC REN.OCC	OWN.OCC REN.OCC VAC.REN VAC.SAL	OWN.OCC REN.OCC	OWN.OCC REN.OCC	OWN.OCC REN.OCC	OWN.OCC REN.OCC
69-70 20 0 1 DET 1072 139 SUPP. SUPP.	1 2 7 1 122 29	PUBLIC SEWER 36 10			
65-68 81 0 1 ATT 0 0	2 1 3 2 295 51	SEPTIC TANK 1044 148			
60-64 102 5 2 5 15	3 12 13 3 207 36	OTHER MEANS 7 0			
50-59 387 53 3-4 0 0	4 132 52 4 100 22				
40-49 74 27 5-9 11 0	5 226 37 5 116 11				
...-39 424 69 10-19 0 0	6 303 32 6 84 8	CLOTH. WASHING MACHINE (BY UNIT)			
	7 244 15 7 34 5	OWN.OCC REN.OCC			
	8 91 1 8 21 2	AUTOM./SEMI-AUTO 880 65			
	9.. 73 4 9.. 17 8	WASHER/SEP. SPIN 38 22			
	AGG 6682 790 AGG 3750 481	NONE 183 10			

HEATING EQUIPMENT (BY UNIT)	AIR CONDITIONING (BY UNIT)	SOURCE OF WATER (BY UNIT)
OWN.OCC REN.OCC VAC.REN VAC.SAL	OWN.OCC REN.OCC	OWN.OCC REN.OCC
STEAM/HOT WATER 690 66 SUPP. SUPP.	1 IND.ROOM UNIT 153 21	PUBLIC SYS./PRV.CO. 917 142
CENTRAL WARM AIR FURNACE 277 54	2..IND.RM.UNITS 42 6	INDIVIDUAL WELL 170 16
BUILT IN ELECTRIC UNITS 20 5	CENTR.AIRC.SYS. 19 6	OTHER 0 0
FLOOR,WALL,PIPELESS FURNACE 69 24	NO AIR COND. 873 125	
ROOM HEATERS WITH FLUE 32 5		
ROOM HEATERS WITHOUT FLUE 0 0		
FIREPL.,STOVE,PORTABLE R.h. 0 0		
NOT HEATED 0 0		

HEATING FUEL	HOUSE ...	WATER ...
OWN.OCC REN.OCC	OWN.OCC REN.OCC	OWN.OCC REN.OCC
UTILITY GAS 183 27	130 17	
BOTTLED,TANK,LP GAS 20 0	26 0	
ELECTRICITY 37 0	260 43	
FUEL OIL,KEROSENE,... 933 78	667 45	
COAL,COKE 0 0	0 0	
WOOD 0 0	0 0	
OTHER FUEL 0 0	0 0	
NO FUEL USED 0 0	10 0	

Table 2
Aggregation of Census Data

Census parameter	Original categories	Final categories	
Units per structure (bldg. size)	1(detached)	1(detached)	
	1(attached)		
	2	1(attached)-4	
	3-4		
	5-9	5-19	
	10-19		
	20-49	20+	
	50+		
	mobile home/trailer	mobile home/trailer	
		<u>1-4 units per struc.</u>	<u>5+ units per struc., mob. home, trailer</u>
Rooms per unit (dwelling unit size)	1		1-2
	2		
	3	1-4	
	4		3-4
	5	5-6	5-6
	6		
	7	7-8	
	8		7+
	9	9+	
Space heat equipment	steam/hot water	steam/hot water	
	central warm air	central warm air	
	built-in electric	built-in electric	
	floor/wall/pipeless furnace		
	room heater w/flue		
	room heater w/o flue	other	
	fireplace, stove, port. R.H.		
	unheated	unheated	
House heating fuel & water heating fuel	utility gas	utility gas	
	buid, tank, LP gas	buid, tank, LP gas	
	electricity	electricity	
	fuel oil, kerosene	fuel oil, kerosene	
	coal, coke		
	wood	other	
	other		
	no fuel	no fuel	

the same geographic area, this procedure will not introduce much error if neighborhood housing patterns are rather homogeneous. An exception is made in case of electric space heating. The assumption that the percentage distribution of dwelling units in missing space heat fuel tables is the same as that in the previous record results in an upward bias for electric space heating at the state level for almost all states. To reduce this bias, the number of electrically heating dwelling units and the number of dwellings with built-in electric heating, when carried forward to a tract with missing tables, are reduced to one fifth in all states except Florida.

The predominant heating fuels in the tract or minor civil division are now identified for later use. Considering only utility gas, bottled gas, electric, and fuel oil, the space and water heat fuels used by the greatest and second greatest number of households are identified as the #1 fuel types and #2 fuel types. Considering all of the six fuel types not yet identified, the space and water heat fuels used by the greatest number of households are then identified as the #3 fuel types.

Adjustments are made to the units per structure table when only a small number of households are listed in larger buildings. If the numbers of occupied dwelling units in the 50+ units per structure categories are less than 25, they are assigned to the 20-49 units per structure category, maintaining their same tenure classification. Then, if the numbers of occupied dwelling units in the 20-49 units per structure categories are less than 10, they are reassigned to the 10-19 units per structure category, maintaining their same tenure classification.

The numbers of rented and owned mobile homes/trailers listed in the units per structure table are used as control totals for future manipulations. Total 1970 households minus these units becomes the control total for occupied dwelling units in all other structure size categories, and this is split into rented and owned units by using the percentage breakdown for occupied units (except mobile homes/trailers) in the units per structure table. Percentages are used to establish these control totals because the total numbers of occupied dwelling units in the various tables do not, in general, agree with each other or with total tabulated households as a result of sampling errors or statistical adjustment techniques.

III. SPACE HEAT CROSS CLASSIFICATION PROCEDURE

The general strategy here is to identify and cross classify special dwelling unit categories first, and then to proceed to major fuel and equipment types. Throughout this process housing units, as they are classified, are subtracted from control tallies of units remaining to be classified. The algorithm proceeds for each census record until all units have been classified. All operations are done separately for owned and rented units so that information is not lost. Finally, owned and rented units in the same classifications are added together to form the final cross classification table, which is not tenure-specific.

A. Mobile Homes/Trailers

If no #1 and #2 fuel types are identified for the tract, all mobile homes are assigned the #3 fuel type and the corresponding equipment type (no equipment

for no fuel used, and room heaters with flue for coal, wood, or other fuel types). A corresponding number of dwelling units are subtracted from the heating equipment tables.

If a #1 fuel type is identified for the tract, mobile homes are assigned this fuel (constrained by the number of units listed in the fuel table) and successively assigned to warm air systems (constrained by the units listed in the heating equipment table) and to room heaters with flues. These units are subtracted from the mobile home control tallies, heating fuel, and heating equipment tables.

If mobile home units still remain to be classified, they are assigned to the #2 fuel type (constrained by the number of units listed in the fuel table) and successively assigned to warm air systems and to room heaters with flue. These dwelling units are subtracted from the mobile home control tallies, heating fuel, and heating equipment tables.

If unclassified mobile homes still remain, or if no #2 fuel type was identified for the tract, all of the remaining units are assigned to the #3 fuel type and the corresponding heating equipment type. These units are subtracted from the heating fuel and heating equipment tables.

Rented and owned mobile homes are then combined for corresponding fuel and equipment classifications, and they are assigned to the final space heat cross classification table, which will eventually contain all occupied dwelling units by size of structure, heating fuel, and heating equipment. It should be noted that the only equipment types permitted for mobile homes are warm air, other, and unheated. All fuel types, however, are permitted.

B. Succeeding Methodology

Because of inconsistency among the total households listed in the basic census tract tables, dwelling units other than mobile homes are cross classified on a percentage basis, starting with 100% of the rented and 100% of the owned units to be assigned to a space heat percentage cross classification table. This table cross classifies on the basis of heating fuel and heating equipment only, and not number of units per structure. The steps listed below (C-F) are performed successively until the remaining percentages of rented and owned units to be classified drop to zero.

C. Built-in Electric

The number of rented and owned units in the equipment table with built-in electric systems are assigned to the percentage cross classification table. These units are subtracted from the equipment table, from the electric heated units in the fuel table, and from the rented and owned percentage tallies of units still to be classified.

D. Unheated

The number of rented and owned units with no heating equipment in the heating equipment table are assigned to the percentage cross classification table. Corresponding entries in the fuel and equipment tables are set to zero and the number of assigned units subtracted from the rented and owned percentage tallies of units still to be classified.

E. Wood Fuel

Dwelling units burning wood are first assigned to the fireplace, stove, or portable room heater equipment type. If there is not enough of this equipment type, the remaining wood fueled units are assigned to the room heater w/o flue equipment type. Corresponding entries in the fuel and equipment tables are reduced by the number of dwelling units so classified, and the rented and owned percentage tallies are reduced accordingly.

F. All Remaining Fuel and Heating Equipment

The percentages of rented and owned units remaining to be classified will now be usually less than one. The heating equipment and fuel tables (with units cross classified up to this point having been removed) are now restated on a comparable percentage basis. That is, the new numbers in both tables will add up to the tallied percentages of rented and owned units remaining to be classified. This, again, is necessary since total units among the several basic census tables are not usually the same to begin with. The steps described below are performed separately for owned and rented units so that no information from the original census tables is lost. The fact that this is done for individual census tracts rather than for very large areas tends to limit the error introduced.

Fuels are first allocated to dwelling units with steam or hot water heating systems. From inspection of selected census records it appears that either utility gas, fuel oil, or coal can be the predominant fuel for tracts in which central heating systems predominate. If steam/hot water systems remaining to be classified are greater than the availability of these three fuel types, all units with these three fuel types are allocated to this heating system, and additional fuels are successively assigned in the order of LPG,* other, and electricity. Otherwise, utility gas, fuel oil, and coal are assigned to the number of steam/hot water systems remaining to be classified in proportion to their availability in the fuel table.

Fuels are next allocated to dwelling units with central warm air systems. As with steam/hot water systems, utility gas, fuel oil, and coal are assumed to be the most likely fuel and allocated according to their availability in the fuel table (if warm air systems are greater than their total in the fuel table), or in proportion to their availability (if warm air systems are less than their total). When these fuels are not sufficient, fuels are successively assigned in the order of LPG, electricity, and other.

Finally, any units in the fuel table remaining to be classified are assigned to the "other" heating system category.

G. Cross Classification by Building Size

Dwelling units other than mobile homes/trailers, having been cross classified by fuel and heating equipment type, are now further characterized by building size (the number of units in the building). For lack of more specific information, it is assumed that the distribution of units by building size is independent of heating fuel and equipment types.

*Bottled, tank or liquified petroleum gas.

The percentage of units in each of four building size categories is separately determined for owned and rented units. (Units that are mobile homes or trailers have previously been determined.) The percentages of owned units in each fuel and equipment category (aggregated to 6 fuel types and 5 system types) are then multiplied by total number of owned units and distributed according to building size by the percentage breakdown just determined. Rented units are distributed in the same manner and added to owned units in the same fuel, heating equipment, and building size category. Totals are rounded to the nearest integer, and this three-dimensional array comprises the space heat cross classification table.

H. Reallocation for Large Apartment Buildings

The procedure described above will sometimes result in a very small number of dwelling units in large apartment buildings being identified with particular fuel and heating system combinations. It would be highly unlikely that such a situation, say only 3 units in a 20+ unit building having oil hot water heat, would actually exist. Such units are therefore reclassified, and appropriate adjustments are made to the space heat table.

The fuel and system types to which the greatest number of units in the 20+ units per structure category have been assigned are identified. Units in the 20+ category for all other fuel and equipment combinations are then checked. For any entry with less than 13 units, the entry is reduced to zero, and these units are reassigned to the major fuel and equipment category for units in 20+ buildings. To maintain consistency in all aggregate classifications, a corresponding number of units in smaller buildings having the same major fuel and system types are subtracted in the space heat table and reallocated to the fuel and system type from which the original small number of units in the 20+ category were initially subtracted. This latter step is performed successively, as necessary, for units in the 5 to 19, 1 (attached) to 4, and single detached units per structure categories. This procedure ensures that total numbers of dwelling units for each fuel category, for each heating system category, and for each building size category are not changed.

IV. WATER HEAT CROSS CLASSIFICATION PROCEDURE

A. Mobile Homes/Trailers

The space heat fuels used by the greatest numbers of owned and rented mobile homes are designated as the primary water heat fuels. Owned and rented mobile homes/trailers are separately allocated these fuels for water heat, subject to their availability in the water heat fuel table. If units remain to be classified, they are successively allocated the next two most predominant water heat fuels. Classified owned and rented units are then added together for each fuel type and aggregated into the final six fuel types. These units are subtracted from the water heat fuel table.

B. All Other Housing Units

Housing units remaining in the water heat fuel table are now restated on a percentage basis for owned and rented units. For lack of additional information, it is assumed that the distribution of units by building size is

independent of water heat fuel. Units in each building size category are assigned water heat fuels in proportion to the water heat fuel percentage breakdowns. That is, the percentage of dwelling units in each building size category is multiplied by the percentage of units with each water heat fuel type and by either total owner occupied or rented occupied units (other than mobile homes/trailers). Finally, owned and rented units are added together for each building size and water heat fuel category.

C. Reallocation of Large Apartment Buildings

As with space heat, this procedure will sometimes result in a very small number of dwelling units in large apartment buildings being identified with a particular water heat fuel. It would be highly unlikely that such a situation would actually exist. Such units are therefore reclassified and appropriate adjustments are made to the water heat fuel table.

The fuel type to which the greatest number of units in the 20+ units per structure category have been assigned is identified. Units in the 20+ category for all fuel categories are then checked. For any entry with less than 13 units, the entry is reduced to zero and these units are reassigned to the major fuel for units in 20+ buildings. To maintain consistency in all aggregate classifications, a corresponding number of units in small buildings having the same major fuel type are subtracted in the water heat table and reallocated to the fuel type from which the original small number of units in the 20+ category were initially subtracted. This latter step is performed successively, as necessary, for units in the 5 to 19, 1 (attached) to 4, and single detached units per structure categories. This procedure ensures that total numbers of dwelling units for each fuel category and for each building size category are not changed.

V. ALLOCATION OF DWELLING UNITS BY UNIT SIZE

Another table is now formed which shows a percentage allocation of units across four dwelling unit size categories for each of the five building sizes. For single family detached and attached units and for 2-4 units per structure, the categories are 1-4 rooms per unit, 5-6 rooms per unit, 7-8 rooms per unit, and 9+ rooms per unit. For all others the categories are 1-2 rooms per unit, 3-4 rooms per unit, 5-6 rooms per unit, and 7+ rooms per unit. However, mobile homes/trailers are allocated only in the 3-4 and 5-6 rooms per unit categories.

Owned and rented mobile homes/trailers are first assigned to the 5-6 rooms per unit category. If there are insufficient units of this size in the rooms per unit table, the remainders are assigned to the 3-4 rooms per unit category. The numbers of units remaining in the rooms per unit table are next restated as percentages of the owned and rented units remaining in the table. It is then assumed that these distributions by dwelling unit size are independent of building size. Percentages of owned units are multiplied by the percentage of owned units in each unit size category and added to the corresponding percentage of rented units for each structure size category.

VI. DETERMINATION OF AVERAGE HOUSEHOLD SIZE FOR EACH BUILDING SIZE

Household size is incorporated by estimating average persons per unit for each building size category. From the persons per unit table, two average

numbers of persons per unit are calculated (for owned and rented units). Average numbers of persons per unit by building size are just weighted averages of these numbers with the percentage breakdown of owned and rented units in each building size category used as weights.

VII. WASHING MACHINES

The data on clothes washing machines do not appear to be very accurate. Percentages of dwelling units with washing machines are therefore calculated from this table only on the basis of tenure (owned or rental units) and are not cross classified with respect to building size.

VIII. RESULTS FOR CROSS CLASSIFICATION ALGORITHM

Typical results for the cross classification algorithm are shown in Table 3. These data are for the same census tract as for Table 1.

IX. AGGREGATED DATA FOR COUNTIES AND STATES

The data, aggregated to large geographic areas, can be of use to other energy conservation programs as well as to those on district heating. If a conservation program is specific to certain building types (such as single family homes), heating system types, or fuel types, these aggregated data can assist in identifying localities in which the conservation program might have the greatest impact and in assessing potential energy savings.

Tables 4 and 5 present cross classified data for Suffolk County, New York, and for all of New York State, respectively. Table 6 defines the categories in which data are presented. Similar tables can be printed out for all counties and states in the nation.

From these tables it is apparent that heating patterns can vary appreciably within a state. In Suffolk County, for example, the estimated ratio of gas boilers to gas furnaces in single family houses is about 3 to 1, whereas the state as a whole has more gas furnaces than boilers. Furthermore, in Suffolk County electric heat is more common in single family buildings, but statewide it is more common in multi-family buildings.

It must be remembered that these data are only estimates. Classification by fuel type, for example, is based on a sample of only 5% of 1970 households.

Comparison with published data at the state level and certain other information indicates that numbers of households, aggregated by fuel type or by heating system type, are very close to estimates published by the Bureau of the Census at the state level. For every state the total households using each fuel type (summed across all building size and heating equipment types) have been compared with the house heating fuel tabulations published by the Bureau of the Census for states.* For the 12 tabulations of more than 1,000,000 households, all but 2 of the cross classified estimates are within 2% of the census numbers. For the 23 tabulations lying between 500,000 and 1,000,000 households,

*Bureau of the Census, "Housing Characteristics for States, Cities, and Counties; United States Summary", Vol. 1, pt. 1, pp. 255-9, Dec. 1972.

TABLE 3

TRACT 150802 (TRACT 1508.02) COUNTY = SUFFOLK (1131) STATE = NEW YORK (NY,361) SHSA = 5601

AREA (ACRES)	POPULATION	POP.DENS. (PERS./SQMI)	POP.CENT. (1971)	HOUSEHOLDS	PER CAPITA INCOME	AVG. HOUSEH. INCOME
TOTL= 1206						
WATP= 153	66	293.	01	1691	LA= 47569	7C 1240
LAND= 1133	70	4244	7C	2421	LO= 731339	77E 1309
NRES= 2	77E	4117	77E	2321	82P	1152
INST= 0	82P	3998	82P	2250		

SPACE HEATING HOUSEHOLD CROSS-CLASSIFICATION

FUEL IS UTIL. GAS	STEAM,HW	WARM AIR	B-I ELEC	OTHER	NONE	FUEL IS L.P. GAS	STEAM,HW	WARM AIR	B-I ELEC	OTHER	NONE
1 DET.	03	46	1	12	1	0	0	0	0	27	0
1A-4	2	1	0	1	0	0	0	0	0	6	0
5-19	1	1	0	6	0	0	0	0	0	6	0
20+	0	0	0	0	0	0	0	0	0	0	0
HH,TR	0	1	0	0	0	0	0	0	0	0	0

FUEL IS ELECTRIC.	STEAM,HW	WARM AIR	B-I ELEC	OTHER	NONE	FUEL IS OIL, KEROS.	STEAM,HW	WARM AIR	B-I ELEC	OTHER	NONE
1 DET.	0	0	24	17	0	660	263	0	0	71	0
1A-4	0	1	1	0	0	0	5	1	0	2	0
5-19	0	1	1	0	0	6	3	0	0	1	0
20+	0	1	0	0	0	0	0	0	0	0	0
HH,TR	0	1	0	0	0	0	0	0	0	0	0

FUEL IS COAL, WOOD	STEAM,HW	WARM AIR	B-I ELEC	OTHER	NONE	FUEL IS NONE	STEAM,HW	WARM AIR	B-I ELEC	OTHER	NONE
1 DET.	0	0	0	0	0	0	0	0	0	0	0
1A-4	0	0	0	0	0	0	0	0	0	0	0
5-19	0	0	0	0	0	0	0	0	0	0	0
20+	0	0	0	0	0	0	0	0	0	0	0
HH,TR	0	0	0	0	0	0	0	0	0	0	0

WATER HEATING HOUSEHOLD CROSS-CLASSIFICATION	UTIL. GAS	L.P. GAS	ELECTRIC.	OIL, KEROS.	COAL, WOOD	NONE
1 DET.	150	25	312	712	0	10
1A-4	1	0	7	10	0	0
5-19	1	0	3	7	0	0
20+	0	0	0	0	0	0
HH,TR	0	0	0	0	0	0

POPULATION (13-34 YEARS)

BY SCHOOL TYPE	103, PRV=	1, PAR=
KINDIPUB=	103, PRV=	1, PAR=
ELEMIPUB=	690, PRV=	1, PAR=
HIGHIPUB=	294, PRV=	0, PAR=
COLLIPUB=	66, PRV=	121

PERCENTAGE BREAKDOWN OF ROOMS/UNIT

YEAR STRUCTURE BUILT	OWN. OCC.	REN. OCC.
1 DET.	17.26	40.03
1A-4	4.64	13.86
5-19	1.2	3.4
20+	0.28	13.24
HH,TR	0.00	0.00

AVERAGE PERSONS/UNIT

1 DET.	1A-4	5-19	20+	HH,TR
3.39	3.19	3.43	0.10	0.66

TOTAL UNITS VACANT

OWN. OCC.	REN. OCC.	PERC. H. WASH. HACH.
0	0	83.38

AIR CONDITIONING (BY UNIT)

OWN. OCC.	REN. OCC.
1 IND. ROOM UNIT	153
2... IND. RM. UN.	42
CENTR. AIRC. SYS.	19
NO AIR COND.	873

SOURCE OF WATER (BY UNIT)

OWN. OCC.	REN. OCC.
PUB. SYS./PRV. CO.	917
INDIVIDUAL WELL	170
OTHER	0

SEWAGE DISPOSAL (BY UNIT)

OWN. OCC.	REN. OCC.
PUBLIC SEWER	36
SEPTIC TANK	1044
OTHER MEANS	7

Table 4

CROSS CLASSIFIED DATA FOR SUFFOLK COUNTY, NEW YORK

AGGREGATED CROSS-CLASSIFIED CENSUS DATA FOR NEW YORK STATE COUNTY 103

(289 TRACTS/HOCS USED)

AREA (ACRES)	POPULATION	HOUSEHOLDS
68	467485	70 296151
70	1127330	

SPACE HEATING HOUSEHOLD CROSS-CLASSIFICATION

FUEL IS UTIL. GAS

	STEAM, HW	WARM AIR	B-I ELEC	OTHER	NONE
1 DET.	34134	15745	0	1565	0
1A-4	2116	566	0	171	0
5-19	1851	595	0	128	0
20+	356	53	0	0	0
HH, TR	0	0	0	5	0

FUEL IS L.P. GAS

	STEAM, HW	WARM AIR	B-I ELEC	OTHER	NONE
1 DET.	50	880	0	3052	0
1A-4	10	94	0	241	0
5-19	0	67	0	206	0
20+	0	0	0	13	0
HH, TR	0	0	0	0	0

FUEL IS ELECTRIC.

	STEAM, HW	WARM AIR	B-I ELEC	OTHER	NONE
1 DET.	0	242	4110	1284	0
1A-4	0	74	579	190	0
5-19	0	77	787	177	0
20+	0	15	97	0	0
HH, TR	0	3	0	2	0

FUEL IS OIL, KEROS.

	STEAM, HW	WARM AIR	B-I ELEC	OTHER	NONE
1 DET.	146783	44594	0	7058	0
1A-4	10255	2284	0	800	0
5-19	4453	1438	0	414	0
20+	2677	112	0	0	0
HH, TR	0	2458	0	0	0

FUEL IS COAL, WOOD

	STEAM, HW	WARM AIR	B-I ELEC	OTHER	NONE
1 DET.	194	130	0	459	0
1A-4	13	16	0	29	0
5-19	12	21	0	42	0
20+	0	0	0	0	0
HH, TR	0	0	0	0	0

FUEL IS NONE

	STEAM, HW	WARM AIR	B-I ELEC	OTHER	NONE
1 DET.	0	0	0	0	83
1A-4	0	0	0	0	11
5-19	0	0	0	0	5
20+	0	0	0	0	0
HH, TR	0	0	0	0	0

WATER HEATING HOUSEHOLD CROSS-CLASSIFICATION

	UTIL. GAS	L.P. GAS	ELECTRIC	OIL, KEROS.	COAL, WOOD	NONE
1 DET.	60130	10033	22456	167432	578	1866
1A-4	3834	772	1649	10974	39	140
5-19	3129	534	941	5685	27	73
20+	730	43	173	2482	0	0
HH, TR	5	0	0	2460	0	0

POPULATION (3-34 YEARS)

BY SCHOOL TYPE

KIND: PUB=	25026, PRV=	505, PAR=	201
ELEM: PUB=	201157, PRV=	1362, PAR=	20960
HIGH: PUB=	77263, PRV=	2086, PAR=	4200
COLL: PUB=	16994, PRV=	13994	

YEAR STRUCTURE BUILT

	OWN, OCC.	REN, OCC.	TOTAL UNITS VACANT
49-70	8965	2135	
65-69	39290	7374	
80-84	51004	7620	
90-99	87513	11365	
00-09	19210	5879	
..-39	39324	15142	1344 984

AIR CONDITIONING (BY UNIT)

	OWN, OCC.	REN, OCC.
1 IND. ROOM UNIT	43742	10547
2... IND. RM. UN.	22131	2901
CENTR. AIRC. SYS.	8246	665
NO. AIR COND.	12107	13100

SOURCE OF WATER (BY UNIT)

	OWN, OCC.	REN, OCC.
PUB. SYS./PRV. CO.	663221	1317052
INDIVIDUAL WELL	194982	38352
OTHER	10880	3430

SEWAGE DISPOSAL (BY UNIT)

	OWN, OCC.	REN, OCC.
PUBLIC SEWER	9380	15810
SEPTIC TANK	235065	33553
OTHER MEANS	1589	429

CROSS CLASSIFIED DATA FOR NEW YORK STATE

AGGREGATED CROSS-CLASSIFIED CENSUS DATA FOR NEW YORK (36)

(4554 TRACTS/HOUS USED)

AREA (ACRES)	POPULATION	HOUSEHOLDS
60	16778624	70 5915063
70	16241111	

SPACE HEATING HOUSEHOLD CROSS-CLASSIFICATION

FUEL IS UTIL. GAS	STEAM,HW	WARM AIR	B-I ELEC	OTHER	NONE
1 DET.	366471	523515	0	68468	0
1A-4	409329	210242	0	84435	0
5-19	166047	44747	0	17404	0
20+	284510	29305	0	3337	0
MULTI	0	14391	0	57	0

FUEL IS L.P. GAS

STEAM,HW	WARM AIR	B-I ELEC	OTHER	NONE
151	4250	0	23476	0
925	3071	0	11465	0
870	3124	0	6279	0
499	3696	0	2688	0
0	66	0	98	0

FUEL IS ELECTRIC.

TYPE OF EQUIPMENT	STEAM, HW	WARM AIR	B-I ELEC	OTHER	NONE
1 DET.	18	2193	33396	12443	
1A-4	167	2064	18446	7893	
5-19	84	2308	13562	3894	
20+	327	5744	12862	1235	
MULTI	0	15	0	2	

FUEL IS OIL, KERO.

STEAM,HW	WARM AIR	B-I ELEC	OTHER	NONE
716618	394822	0	69325	0
560620	143844	0	41332	0
336283	36575	0	16572	0
976491	69364	0	10116	0
0	56261	0	36	0

FUEL IS COAL, WOOD

FUEL IS	COKE,HW	WARM AIR	B-I ELEC	OTHER	NONE
	STEAM,HW				
1 DET.	7065	11878	0	9511	
1A-4	7529	4516	0	9336	
5-19	11334	4654	0	8990	
20+	27284	9651	0	13143	
MULTI	0	0	0	0	

FUEL IS NONE

STEAM,HW	WARM AIR	B-I ELEC	OTHER	NONE
0	0	0	0	694
0	0	0	0	1027
0	0	0	0	1332
0	0	0	0	27
0	0	0	0	0

WATER HEATING HOUSEHOLD CROSS-CLASSIFICATION

UTIL. GAS	L.P. GAS	ELECTRIC.	OIL, KERO.	COAL, WOOD	NONE
1 DET.	1055620	104036	351740	699126	7374
1A-4	779109	31242	77749	557379	12312
5-19	250456	14185	31264	357339	15409
20+	372181	10572	3351	984576	49411
MULTI	19223	817	12191	42036	0

POPULATION (15-34 YEARS)

BY SCHOOL TYPE			
KIND: PUB=	265958, PRV=	9710, PAR=	21577
ELEM: PUB=	2218740, PRV=	51810, PAR=	495964
HIGH: PUB=	1028580, PRV=	58064, PAR=	146105
COLL: PUB=	324387, PRV=	335800	

YEAR STRUCTURE BUILT

OWN. OCC.	REN. OCC.
65-70	50986
65-69	216631
60-64	294141
50-59	659066
40-49	276169
00-39	1309609

TOTAL UNITS VACANT

OWN. OCC.	REN. OCC.
69, 03	6732

AIR CONDITIONING (BY UNIT)

OWN. OCC.	REN. OCC.
1 IND. ROOM UNIT	484197
2... IND. ROOM.	354074
CENTR. AIRC. SYS.	117102
NO AIR COND.	1650932

SOURCE OF WATER (BY UNIT)

OWN. OCC.	REN. OCC.
PUB. SYS./PRV. CO.	2355304
INDIVIDUAL WELL	417676
OTHER	33419

SEWAGE DISPOSAL (BY UNIT)

OWN. OCC.	REN. OCC.
PUBLIC SEWER	1743264
SEPTIC TANK	1042823
OTHER MEANS	20319

Table 6

EXPLANATORY DESCRIPTION OF AGGREGATED CROSS CLASSIFIED CENSUS TABLES

	State Name	County FIPS Code	No. of tracts and/or minor civil divisions aggregated
1960 & 1970 Total Population (Those in plus those not in households)	1970 No. of Households (also no. of year- round occupied housing units)	Note: Data in tables identified by an asterisk (*) will be incomplete when individual tract or minor civil division data is suppressed.	
Space Heating Cross Classification No. of year-round occupied housing units by major house heating fuel: utility gas electricity coal, coke, wood, other bottled, tank, LP gas fuel oil, kerosene, etc. none by type of heating system: steam, hot water central warm air built-in electric floor, wall, pipeless furnace; room heaters; fireplaces, stoves not heated and by building size: 1 unit, detached 1 unit, attached; 2-4 units per bldg. 5-19 units per bldg. 20 + units per bldg. mobile home, trailer			
Water Heating Cross Classification No. of year-round occupied housing units by major water heating fuel: utility gas electricity coal, coke, wood, other bottled, tank, LP gas fuel oil, kerosene, etc. none and by building size: 1 unit, detached 1 unit, attached; 2-4 units per bldg. 5-19 units per bldg. 20 + units per bldg. mobile home, trailer			Population By School Type No. of persons (of ages 3-14) in school by grade: kindergarten elementary (1st-8th grade) high school (9th-12th grade) college and by type: public parochial other private
Year Structure Built* No. of year-round occupied housing unit by year of construction: 1969-70 1950-59 1965-68 1940-49 1960-64 prior to 1940 and by tenure: owner occupied renter occupied		Total Units Vacant* No. of vacant year-round housing units by status: vacant for sale vacant for rent	
Air Conditioning* No. of year-round occupied housing units by type of air conditioning: 1 room unit 2 or more room units central air conditioning none and by tenure: owner occupied renter occupied		Source of Water* No. of year-round occupied housing units by source of water: public system; private co. individual well other and by tenure: owner occupied renter occupied	
Sewage Disposal* No. of year-round occupied housing units by type of sewage disposal: public sewer septic tank, cesspool other and by tenure: owner occupied renter occupied			

all but 4 are within 6% of the census numbers. For the 66 tabulations lying between 100,00 and 500,000 households, all but 10 are within 11% of the census numbers. Deviations, on a percentage basis, become greater for state fuel use totals of less than 100,000 households, but the actual magnitudes are, of course, small. When cross classified totals by heating equipment type are compared with state totals from the Bureau of the Census, deviations are even smaller than for the fuel type comparison. This is primarily because fewer equipment type tables are suppressed in the tract/minor civil division level census data.

The ratio of oil heated buildings with boilers to warm air furnaces in New York State has been checked also against data furnished by ReTech, the research division of Industry Publications, Inc. The cross classified data show a boiler to furnace ratio of roughly 2.08, and the ReTech estimate for January 1, 1970, is 1.99.

Data for other states from ReTech and data from other sources will be used for comparison as they become available. The comparisons made to date, however, indicate that the cross classification algorithms described above appear to generate a very good breakdown of dwelling units by building size, heating equipment, and fuel, and that they are sufficiently accurate for systems and economic analysis of district heating and other residential energy conservation programs.