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ENERGY USE FOR BUILDING CONSTRUCTION

Progress Report for Period

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ABSTRACT

Total (direct and indirect) energy requirements of the Construction Industry for 1967 were determined in order to examine the potential for energy savings. The Energy Input/Output Model developed at the Center for Advanced Computation, University of Illinois was expanded to include a detailed breakdown of the industry and energy intensities of 49 building construction (new and maintenance) sectors and of the overall building construction industry were determined for 1967. The latter figure was computed at about 70,000 Btu/$, i.e., the construction industry on the average required about 70,000 Btu of direct and indirect energy per dollar of output produced.

In addition, total energy requirements to final demand were developed for the construction industry for 1967. The overall industry required about 6000 trillion Btu, or about nine percent of the total U.S. energy requirement. Energy requirements were further broken down according to goods and services purchased by individual construction sectors, and energy distribution patterns were determined.

Energy cost per unit for several input materials to construction were calculated, as well as energy cost per square foot for various building sectors in 1967. Laboratories and hospitals required the most energy per square foot (2,073,755 Btu/SF and 1,722,172 Btu/SF, respectively), while warehouses required the least (558,403 Btu/SF).

Finally, a prototypical study was conducted to determine industries in which direct energy use led to a significant amount of energy embodied in New Construction for 1967. The resulting Energy Flow Chart is attached.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

Tables B1 - B17 display 1967 Energy Embodiment per Unit of Material before Delivery to Jobsite for the following materials and assemblies:

I. INTRODUCTION

This report describes results of the first six months of contract duration for "Energy Use for Building Construction," ERDA Contract No. E(11-1)-2791. Total (direct and indirect) energy requirements of the construction industry in 1967 have been determined, and applied to some specific studies of energy use by that industry.

In the first stage of the project (March 1, 1976 - May 15, 1976) detailed 1967 dollar flow data for the construction industry were obtained from the Bureau of Economic Analysis (BEA), U.S. Department of Commerce, and embedded in the Energy Input/Output Model [1] developed at the Center for Advanced Computation (CAC), University of Illinois. In addition, data on prices paid for direct energy by the construction industry in 1967 were collected by Richard G. Stein & Associates (RGSA), and these data plus BEA dollar flow data allowed CAC to form an expanded I/O Model with a high level of detail for the construction industry.

Using this expanded model, energy intensities, final demand energy requirements, and total energy requirements for 1967 were determined for the 49 construction sectors. The results of this first stage of the project are briefly discussed in Section II, and are covered fully in our Preliminary Progress Report of June, 1976 [2].

The energy figures developed by CAC then became the basis of more detailed analysis of the energy cost of construction, conducted by RGSA during the project's second stage. Section III describes the organization of energy cost data for the construction industry and the results of various studies conducted so far by RGSA. Material is organized in ways that will lead to a clearer understanding of the patterns of energy use in building, as a basis for decisions and recommendations leading to more

efficient and reduced energy use by building type, by units of construction materials, and by square foot energy requirements of the different building types. Section III contains the following sub-studies:

A. A graphic tabulation of the patterns of distribution of embodied energy by percentage as they vary from construction type to construction type, demonstrating the critical materials and the distinguishing features typical of each type. A further quantitative tabulation will sort out these points of major use within each type. From this, their impact on the construction industry as a whole can be determined.

B. Energy cost per unit of selected materials, determined according to the most refined information available to us from a variety of sources; this will be the basis for further breakdowns in different categories to units consistent with a standard cost-estimating format.

C. A tabulation of Btu/SF of various new building construction categories for 1967, using the CAC figures for total energy intensities (Btu/$) of construction in combination with figures from F. W. Dodge Co. [3] for $ cost/square foot of construction in these categories.

D. A prototypical study, diagramming energy flow in the construction industry, in order to understand in greater detail how and where energy is consumed in the production of buildings and building components. This study, at an aggregated 90-sector level of detail starts by identifying the energy applied at the construction stage of the process, and then follows the embodied energy back

into the sequence of process stages, finally identifying the energy used in the extraction of raw materials back to the point at which each contributor accounts for such a small quantity of energy that further analysis would be of little value.

A number of sources of information have been used in Section III. Two of the four key sources deal specifically with the construction industry: F. W. Dodge Company 1967 Construction Statistics (Dodge) [3], and 1967 Census of Manufactures (CM) [5] deals only with the manufacturing industries. The Fourth, the Bureau of Economic Analysis 1967 Input-Output Structure of the U.S. Economy [6], which is the basis for the CAC Energy I/O Model and for this study, deals with both. The CM was one of the major sources of data for the manufacturing sectors of the BEA tables, and the data therein can be used together with BEA data. The Dodge and CCI data, however are related to a different data base, and care must be taken in the application of their figures to either BEA or CM base. In this report, where Dodge or CCI data are used, they are always used in relation to their own bases and the resultant average or proportion is then applied to the BEA base.

Tables in this report can be found directly following the section to which they apply. The energy flow diagram and description of sub-study D is located in Appendix A.

II. THE EXPANDED ENERGY INPUT/OUTPUT MODEL

In order to develop energy figures for the entire building construction industry, a highly disaggregated BEA breakdown (484 industries in total) containing 49 building construction sectors was used in conjunction with CAC's Energy I/O Model [1], which ordinarily consists of 357 industries. The 357 order system was altered by replacing its usual 7 construction sectors with BEA's expanded 49 sectors. This results in a model with 399 sectors. These are listed in Table 1, along with the I/O codes used by BEA. (Tables referred to in this section can be found directly after the text.) The expanded construction sectors wind up in positions 23 through 71, inclusively. (For the remainder of this report, sector indices used refer to those of the 399-order model unless otherwise stated.)

In addition to the computations for deriving energy cost figures (which are fully described elsewhere [1]), it was necessary to develop direct energy transfers from the energy sectors (Coal, Crude Petroleum, Refined Petroleum, Electricity, and Natural Gas) to the 49 construction sectors. These figures (see Table 2) were computed using data collected by RGSA on energy prices paid by the construction industry in 1967. (The data collection is detailed in our Preliminary Progress Report of June, 1976 [2]). Given the price per Btu for a given energy type paid by a given construction sector and the corresponding dollar transaction from BEA, computation of the implied energy (Btu) flow is straightforward. (Where prices supplied by RGSA were in purchaser dollars, BEA margin figures were used along with inter-industry transactions.) As can be seen in Table 2, the building construction industry purchased a total of 1484.7

trillion Btu of direct energy in 1967, most of which was for refined petroleum products.

Once the direct energy figures were embedded in CAC's Energy I/O tables, energy intensities were computed. The intensity figures for building construction sectors (Btu/$) are shown in Table 3. Total primary intensity is the sum of the Coal, Crude Petroleum, and the hydro and nuclear portion of Electricity figures. The total primary intensities of construction are shown ranked in Table 4. Most intensive are New Construction of Petroleum Pipelines (147197 Btu/$) and New Construction of Gas Utilities (140038 Btu/$; this sector also involves pipeline construction).* This is probably due to the use of heavy construction equipment and large amounts of raw materials (steel, pipe, etc.).

To obtain a broad picture of the building construction industry, various average energy intensities were computed by weighting the figures for the construction sectors by the corresponding gross domestic outputs for those sectors. The gross domestic outputs of the construction sectors in 1967 are shown in Table 5. Average energy intensities are shown in Table 6. The total primary intensity of the overall building construction industry was 70059 Btu/$, while the figure for New Construction alone was 74122 Btu/$.

Using the energy intensities of construction sectors along with the total final demand dollar figures for these sectors (from BEA), the total energy of final demand required by the construction sectors was determined. These total energy figures (see Table 7) include direct and

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*This figure was recently referred to in hearings conducted by the Federal Power Commission, Bureau of Natural Gas, on "Staff Proposed Displacement Alternative to Arctic Gas Project Western Lateral to California," July 1976.

indirect energy use. Table 7 also shows the percentage of each construction sector's total energy use which was direct, and the percentage of total energy each sector required with respect to the total construction industry and the total U.S. economy. The construction industry as a whole required 6301.94 trillion Btu of direct plus indirect energy for final demand in 1967, of which just less than 20 percent was for direct energy. The industry represented 9.42 percent of the total U.S. energy requirement in 1967.

Table 8 shows the ranked total final demand energy use figures for building construction. New Highway Construction required the largest faction: 1035.87 trillion Btu, with nearly 40 percent of it for direct energy. (The zeros which appear for certain maintenance and repair construction sectors occur because these sectors have no dollar (or energy) transactions to final demand.)

To set the groundwork for further analysis of the energy used in the construction industry, the total primary energy (direct and indirect) required in 1967 by each construction sector for production of its total output was computed, along with corresponding input fractions. The resulting tables are huge (nearly 20,000 figures each) and do not appear in this report. They do, however, allow for relatively easy identification of the major embodied energy contributors to the construction industry. Table 9 is a summary table showing the total energy requirements of each sector. Note that the total energy requirements figure shown in Table 9 is larger than the total final demand energy requirements figure of Table 7. This is because certain Maintenance Construction sectors do not sell to final demand, but do interact with other sectors.

Not surprisingly, New Highway Construction had the largest inter-industry energy requirement in 1967 - 1035.86 trillion Btu. Highways represented over 14% of the total energy requirements for construction in 1967. Maintenance Construction for Local Transit had the lowest requirement - only 2.09 trillion Btu.

The next section presents various sub-studies conducted by RGSA, based on the figures described here.

TABLE 1. 399-ORDER SECTORS

399-ORDER INDEX	90-ORDER INDEX	I/O CODE	NAME
1	1	700	COAL MINING
2	2	800	CRUDE PETRO, GAS
3	3	3101	PETRO REFIN PROD
4	4	6801	ELECTRIC UTIL
5	5	6802	GAS UTILITIES
6	6	101	DAIRY
7	6	102	POULTRY, EGGS
8	6	103	MEAT,ANIMAL PROD
9	7	201	COTTON
10	7	202	FEED GRAINS
11	7	203	TOBACCO
12	7	204	FRUITS
13	7	205	VEGT,MISC CROPS
14	7	206	OIL BEARING CROP
15	7	207	FOR,GRHOUSE,NURS
16	8	300	FOREST FISH PROD
17	9	400	AG FOR,FISH SER
18	10	500	IRON ORE MINING
19	11	601	COPPER MINING
20	11	602	NONFERR MINING
21	12	900	STONE CLAY MIN
22	13	1000	CHEM MINERAL MIN
23	14	110101	NEW CONST RES--1 FAM.
24	14	110102	NEW CONST RES--2-4 FAM.
25	14	110103	NEW CONST RES--GRDN APT.
26	14	110104	NEW CONST HIGH-RISE APT.
27	14	110105	NEW CONST RES--ALT.,ADD.
28	14	110106	NEW CONST HOTELS,MOTELS
29	14	110107	NEW CONST DORMITORIES
30	14	110201	NEW CONST INDUST. BLDG.
31	14	110202	NEW CONST OFFICE BLDG.
32	14	110203	NEW CONST WAREHOUSES
33	14	110204	NEW CONST GAR.,SRV. STA.
34	14	110205	NEW CONST STORES,RSTRNTS
35	14	110206	NEW CONST RELIG. BLDG.
36	14	110207	NEW CONST EDUC. BLDG.
37	14	110208	NEW CONST HOSPITAL BLDG.
38	14	110209	NEW CONST OTH. NON-FARM
39	14	110301	NEW CONST TELEPH.,TELEG.
40	14	110302	NEW CONST RAILROADS
41	14	110303	NEW CONST ELECT. UTIL.
42	14	110304	NEW CONST GAS UTIL.
43	14	110305	NEW CONST PETROL. PIPE.
44	14	110306	NEW CONST WATER SUPPLY
45	14	110307	NEW CONST SEWER
46	14	110308	NEW CONST LOC. TRANSIT
47	14	110400	NEW CONST HIGHWAYS
48	14	110501	NEW CONST FARM RESID.
49	14	110502	NEW CONST FARM SERVICE
50	14	110503	NEW CONST OIL/GAS WELLS
51	14	110504	NEW CONST OIL/GAS EXPL.
52	14	110505	NEW CONST MILITARY
53	14	110506	NEW CONST CONS.,DEV.
54	14	110507	NEW CONST OTH. NON-BLDG.
55	15	120100	MAINT CONST RESID.
56	15	120201	MAINT CONST OTH. NON-FRM
57	15	120202	MAINT CONST FARM RESID.
58	15	120203	MAINT CONST FARM SERVICE
59	15	120204	MAINT CONST TEL.,TEL.
60	15	120205	MAINT CONST RAILROADS
61	15	120206	MAINT CONST ELECT. UTIL.
62	15	120207	MAINT CONST GAS UTIL.
63	15	120208	MAINT CONST PETR. PIPE.
64	15	120209	MAINT CONST WATER SUPPLY
65	15	120210	MAINT CONST SEWER
66	15	120211	MAINT CONST LOC. TRANSIT
67	15	120212	MAINT CONST MILITARY
68	15	120213	MAINT CONST CONSER.,DEV.
69	15	120214	MAINT CONST HIGHWAYS
70	15	120215	MAINT CONST OIL/GS WELLS
71	15	120216	MAINT CONST OTH. N-BLDG.
72	16	1301	GUIDED MISSILES
73	16	1302	AMMUNITION
74	16	1303	TANKS
75	16	1304	FIRE CONTROL EQ
76	16	1305	SMALL ARMS
77	16	1306	SMALL ARMS AMMUN
78	16	1307	OTHER ORDNANCE
79	17	1401	MEAT PRODUCTS
80	17	1402	BUTTER
81	17	1403	CHEESE
82	17	1404	CONDENSED MILK
83	17	1405	ICE CREAM
84	17	1406	FLUID MILK
85	17	1407	CANNED SEA FOODS
86	17	1408	CANNED SPECIALTY
87	17	1409	CANNED FRUIT,VEG
88	17	1410	DEHYDRATED PROD
89	17	1411	PICKLES,DRESSING
90	17	1412	FISH
91	17	1413	FROZEN FRUIT,VEG
92	17	1414	FLOUR,CEREALS
93	17	1415	PREP ANIMAL FEED
94	17	1416	RICE MILLING
95	17	1417	WET CORN MILLING
96	17	1418	BAKERY PRODUCTS
97	17	1419	SUGAR
98	17	1420	CONFECTIONERY
99	17	1421	ALCOHOLIC BEV
100	17	1422	SOFT DRINKS
101	17	1423	FLAVORINGS
102	17	1424	COTTONSEED MILLS
103	17	1425	SOYBEAN MILLS
104	17	1426	VEG OIL MILLS
105	17	1427	ANIMAL FATS
106	17	1428	COFFEE
107	17	1429	COOKING OILS
108	17	1430	MANUFACTURED ICE
109	17	1431	MACARONI
110	17	1432	FOOD PREPARATION
111	18	1501	CIGARETTES
112	18	1502	TOBACCO STEMMING
113	19	1601	BROAD FAB MILLS
114	19	1602	NAR FABRIC MILLS
115	19	1603	YARN MILLS
116	19	1604	THREAD MILLS
117	20	1701	FLOOR COVERINGS
118	20	1702	FELT GOODS
119	20	1703	LACE GOODS
120	20	1704	UPHOLSTERY FILL
121	20	1705	PROC TEX WASTE
122	20	1706	COATED FABRICS
123	20	1707	TIRE CORD
124	20	1708	SCOURING PLANTS
125	20	1709	CORDAGE, TWINE
126	20	1710	TEXTILE GOODS
127	21	1801	HOSIERY
128	21	1802	KNIT APPRL MILLS

Table 1. 399-ORDER SECTORS (continued)

399-ORDER INDEX	90-ORDER INDEX	I/O CODE	NAME
129	21	1803	KNIT FAB MILLS
130	21	1804	APPARL,PURCH MAT
131	22	1901	CURTAINS
132	22	1902	HOUSEFURNISHINGS
133	22	1903	FAB TEXTILE PROD
134	23	2001	LOGGING
135	23	2002	SAWMILLS
136	23	2003	HARDWD FLOORING
137	23	2004	SPEC PROD SAWMIL
138	23	2005	MILLWORK
139	23	2006	VENEER,PLYWOOD
140	23	2007	PREFAB WD STRUC
141	23	2008	WOOD PRESERVING
142	23	2009	WOOD PRODUCTS
143	24	2100	WOOD CONTAINERS
144	25	2201	WOOD H'HOLD FURN
145	25	2202	UPH H'HOLD FURN
146	25	2203	MET H'HOLD FURN
147	25	2204	MATTRESSES
148	26	2301	WOOD OFC FURN
149	26	2302	METAL OFC FURN
150	26	2303	PUBLIC BLDG FURN
151	26	2304	WOOD FIXTURES
152	26	2305	MET FIXTURES
153	26	2306	BLINDS, SHADES
154	26	2307	FURN, FIXTURES
155	27	2401	PULP MILLS
156	27	2402	PAPER MILLS
157	27	2403	PAPERBOARD MILLS
158	27	2404	ENVELOPES
159	27	2405	SANIT PAPER PROD
160	27	2406	BUILDING PAPER
161	27	2407	CONV PAPER PROD
162	28	2500	PAPERBOARD CONT
163	29	2601	NEWSPAPERS
164	29	2602	PERIODICALS
165	29	2603	BOOK PUBLISHING
166	29	2604	MISC PUBLISHING
167	29	2605	COMM PRINTING
168	29	2606	BUSINESS FORMS
169	29	2607	GREETING CARDS
170	29	2608	MISC PRINTING
171	30	2701	INORG-ORG CHEM
172	30	2702	FERTILIZERS
173	30	2703	AG CHEMICALS
174	30	2704	MISC CHEM PROD
175	31	2801	PLASTICS
176	31	2802	SYN RUBBER
177	31	2803	MAN-MADE FIBERS
178	31	2804	ORGANIC FIBERS
179	32	2901	DRUGS
180	32	2902	CLEANING PREP
181	32	2903	TOILET PREP
182	33	3000	PAINT PRODUCTS
183	34	3102	PAVING
184	35	3103	ASPHALT
185	36	3201	TIRES
186	36	3202	RUBBER FOOTWARE
187	36	3203	MISC RUBBER PROD
188	36	3204	MISC PLASTICS
189	37	3300	INDUST LEATHER
190	38	3401	FOOTWARE CUT STK
191	38	3402	FOOTWARE EXC RUB
192	38	3403	MISC LEATHER
193	39	3501	GLASS PRODUCTS
194	39	3502	GLASS CONTAINERS
195	40	3601	CEMENT
196	40	3602	BRICKS
197	40	3603	CERAMIC TILE
198	40	3604	CLAY REFRACT
199	40	3605	CLAY PRODUCTS
200	40	3606	PLUMBING FIXTURE
201	40	3607	FOOD UTENSILS
202	40	3608	PORCEL ELEC SUPP
203	40	3609	POTTERY PRODUCTS
204	40	3610	CONCRETE BLOCKS
205	40	3611	CONCRETE PRODUCT
206	40	3612	READY-MIX CONCR
207	40	3613	LIME
208	40	3614	GYPSUM PRODUCTS
209	40	3615	STONE PRODUCTS
210	40	3616	ABRASIVE PRODUCT
211	40	3617	ASBESTOS PRODUCT
212	40	3618	GASKETS
213	40	3619	TREATED MINERALS
214	40	3620	MINERAL WOOL
215	40	3621	NONCLAY REFRACT
216	40	3622	NONMET MIN PROD
217	41	3701	STEEL PROD
218	41	3702	IR,STL FOUNDRIES
219	41	3703	IR,STL FORGING
220	41	3704	PRIMARY MET PROD
221	42	3801	PRIMARY COPPER
222	42	3802	PRIMARY LEAD
223	42	3803	PRIMARY ZINC
224	42	3804	PRIM ALUMINUM
225	42	3805	PRIM NONFER MET
226	42	3806	SEC NONFERR MET
227	42	3807	COPPER ROLLING
228	42	3808	ALUM ROLLING
229	42	3809	NONFER ROLLING
230	42	3810	NONFER WIRE
231	42	3811	ALUM CASTINGS
232	42	3812	BRASS,OTHR CAST
233	42	3813	NONFER CASTING
234	42	3814	NONFER FORGING
235	43	3901	METAL CANS
236	43	3902	METAL BARRELS
237	44	4001	METAL SANIT WARE
238	44	4002	PLUMB FITTINGS
239	44	4003	HEATING EQUIP
240	44	4004	FAB STRUC STEEL
241	44	4005	METAL DOORS
242	44	4006	FAB PLATE WORK
243	44	4007	SHEET METAL WORK
244	44	4008	ARCH METAL WORK
245	44	4009	MISC METAL WORK
246	45	4101	SCREW MACH PROD
247	45	4102	METAL STAMPINGS
248	46	4201	CUTLERY
249	46	4202	HANDTOOLS
250	46	4203	HARDWARE
251	46	4204	COAT, ENGRAV SER
252	46	4205	FAB WIRE PRODUCT
253	46	4206	SAFES, VAULTS
254	46	4207	STEEL SPRINGS
255	46	4208	PIPE
256	46	4209	COLLAPSIBLE TUBE
257	46	4210	METAL FOIL, LEAF
258	46	4211	FAB METAL PROD
259	47	4301	STEAM ENGINES
260	47	4302	INT COMBUST ENG
261	48	4400	FARM MACHINERY
262	49	4501	CONST MACHINERY
263	49	4502	MINING MACHINERY
264	49	4503	OIL FIELD MACH

TABLE 1. 399-ORDER SECTORS (continued)

399-ORDER INDEX	90-ORDER INDEX	I/O CODE	NAME
265	50	4601	ELEVATORS
266	50	4602	CONVEYORS
267	50	4603	HOISTS, CRANES
268	50	4604	INDUSTRIAL TRUCK
269	51	4701	MET CUTTING TOOL
270	51	4702	MET FORMING TOOL
271	51	4703	SPECIAL DIE TOOL
272	51	4704	MET'WORKING MACH
273	52	4801	FOOD PROD MACH
274	52	4802	TEXTILE MACH
275	52	4803	WOODWORKING MACH
276	52	4804	PAPER IND MACH
277	52	4805	PRINTING MACH
278	52	4806	SPECIAL IND MACH
279	53	4901	PUMPS,COMPRESORS
280	53	4902	BEARINGS
281	53	4903	BLOWERS
282	53	4904	INDUST PATTERNS
283	53	4905	POWER TRANS EQ
284	53	4906	INDUS FURNACES
285	53	4907	GENERAL IND MACH
286	54	5000	MACH SHOP PROD
287	55	5101	COMPUTING MACH
288	55	5102	TYPEWRITERS
289	55	5103	SCALES
290	55	5104	OFC MACHINES
291	56	5201	MERCH'DISE MACH
292	56	5202	LAUNDRY EQUIP
293	56	5203	REFRIG MACH
294	56	5204	MEASURING PUMPS
295	56	5205	SERVICE IND MACH
296	57	5301	ELEC MEAS INSTR
297	57	5302	TRANSPORMERS
298	57	5303	SWITCHGEAR
299	57	5304	MOTORS,GENERATOR
300	57	5305	IND CONTROLS
301	57	5306	WELDING APPARAT
302	57	5307	CARBON PRODUCTS
303	57	5308	ELEC IND APPARAT
304	58	5401	H'HOLD COOK EQ
305	58	5402	H'HOLD REFRIG EQ
306	58	5403	H'HOLD LAUNDRY
307	58	5404	ELECTRIC H'WARES
308	58	5405	H'HOLD VACUUMS
309	58	5406	SEWING MACHINES
310	58	5407	H'HOLD APPLIANCE
311	59	5501	ELECTRIC LAMPS
312	59	5502	LIGHT FIXTURES
313	59	5503	WIRING DEVICES
314	60	5601	RADIO,TV SETS
315	60	5602	PHONO RECORDS
316	60	5603	PHONE,TELEGR EQ
317	60	5604	R-TV COMMUN EQ
318	61	5701	ELECTRON TUBES
319	61	5702	SEMICONDUCTORS
320	61	5703	ELECTRONIC COMP
321	62	5801	STORAGE BATTERY
322	62	5802	PRIMARY BATTERY
323	62	5803	X-RAY EQUIPMENT
324	62	5804	ENGINE ELEC EQ
325	62	5805	ELECTRICAL EQUIP
326	63	5901	TRUCK,BUS BODIES
327	63	5902	TRUCK TRAILERS
328	63	5903	MOTOR VEH & PART
329	64	6001	AIRCRAFT
330	64	6002	AIRCRAFT ENGINES
331	64	6003	AIRCRAFT PROPELL
332	64	6004	AIRCRAFT EQUIP
333	65	6101	SHIPBUILDING
334	65	6102	BOATBUILDING
335	65	6103	LOCOMOTIVES
336	65	6104	RR, STREET CARS
337	65	6105	MOTOR, BICYCLES
338	65	6106	TRAILER COACHES
339	65	6107	TRANSPORT EQUIP
340	66	6201	SCIEN INSTR
341	66	6202	MECH MEAS DEVICE
342	66	6203	TEMP CONTROLS
343	66	6204	MEDICAL INSTR
344	66	6205	SURGICAL SUPPLY
345	66	6206	DENTAL EQUIPMENT
346	66	6207	WATCHES, CLOCKS
347	67	6301	OPTICAL INSTR
348	67	6302	OPHTHALMIC GOODS
349	67	6303	PHOTOGRAPHIC EQ
350	68	6401	JEWELRY
351	68	6402	MUSICAL INSTR
352	68	6403	GAMES
353	68	6404	ATHLETIC EQUIP
354	68	6405	PENS AND PENCILS
355	68	6406	ARTIFICAL FLOWER
356	68	6407	CLOTH FASTENERS
357	68	6408	BRUSHES
358	68	6409	HARD FLOOR COV
359	68	6410	MORTICIAN GOODS
360	68	6411	SIGNS, ADS
361	68	6412	MISC MFG
362	69	6501	RAILROAD
363	70	6502	LOCAL TRANSPORT
364	71	6503	MOTOR FGT TRANSP
365	72	6504	WATER TRANSPORT
366	73	6505	AIR TRANSPORT
367	74	6506	PIPE LINE TRANSP
368	75	6507	TRANSP SERVICES
369	76	6600	COMMUNICATIONS
370	77	6700	R-TV BROADCAST
371	78	6803	WATER,SANIT SER
372	79	6901	WHOLSALE TRADE
373	79	6902	RETAIL TRADE
374	80	7001	BANKING
375	80	7002	CREDIT AGENCIES
376	80	7003	SEC, COMMOD BROK
377	80	7004	INSUR CARRIERS
378	80	7005	INSURANCE AGENTS
379	81	7101	OWNER-OCC DWLNG
380	81	7102	REAL ESTATE
381	82	7201	HOTELS
382	82	7202	PERSONAL SERVICE
383	82	7203	BARB,BEAUT SHOPS
384	83	7301	MISC BUS SERVICE
385	83	7302	ADVERTISING
386	83	7303	MISC PROF SER
387	84	7500	AUTO REPAIR
388	85	7601	MOTION PICTURE
389	85	7602	AMUSMNT,REC SER
390	86	7701	DOCTORS,DENTISTS
391	86	7702	HOSPITALS
392	86	7703	MED, HEALTH SER
393	86	7704	EDUCATIONAL SER
394	86	7705	NONPROFIT ORG
395	87	7801	POST OFFICE
396	87	7804	FED GOVT ENTERP
397	88	7903	ST,LOC GOVT ENTR
398	89	8100	BUSINESS TRAVEL
399	90	8200	OFFICE SUPPLIES

TABLE 2. DIRECT ENERGY TRANSFERS TO CONSTRUCTION SECTORS -- 1967
(TRILLION BTUS)

NUMBER	399-ORDER INDEX	NAME	COAL	CRUDE PETROLEUM	REFINED PETROLEUM	ELECTRICITY	NATURAL GAS	TOTAL
1	23	NEW CONST RES--1 FAM.	0.0	0.0	74.01	1.02	2.63	77.66
2	24	NEW CONST RES--2-4 FAM.	0.0	0.0	4.45	0.05	0.18	4.68
3	25	NEW CONST RES--GRDN APT.	0.0	0.0	20.89	0.16	0.35	21.40
4	26	NEW CONST HIGH-RISE APT.	0.0	0.0	18.89	0.20	0.53	19.61
5	27	NEW CONST RES--ALT.,ADD.	0.0	0.0	7.26	0.08	0.18	7.51
6	28	NEW CONST HOTELS,MOTELS	0.0	0.0	11.67	0.13	0.35	12.15
7	29	NEW CONST DORMITORIES	0.0	0.0	10.45	0.10	0.18	10.72
8	30	NEW CONST INDUST. BLDG.	0.0	0.0	37.41	0.21	0.53	38.15
9	31	NEW CONST OFFICE BLDG.	0.0	0.0	44.55	0.44	1.05	46.04
10	32	NEW CONST WAREHOUSES	0.0	0.0	6.33	0.05	0.18	6.56
11	33	NEW CONST GAR.,SRV. STA.	0.0	0.0	4.96	0.05	0.18	5.19
12	34	NEW CONST STORES,RSTRNTS	0.0	0.0	36.09	0.34	0.88	37.31
13	35	NEW CONST RELIG. BLDG.	0.0	0.0	10.95	0.11	0.18	11.24
14	36	NEW CONST EDUC. BLDG.	0.0	0.0	65.41	0.70	1.58	67.69
15	37	NEW CONST HOSPITAL BLDG.	0.0	0.0	18.70	0.21	0.53	19.44
16	38	NEW CONST OTH. NON-FARM	0.0	0.0	39.17	0.39	0.88	40.44
17	39	NEW CONST TELEPH.,TELEG.	0.0	0.0	12.08	0.08	0.18	12.34
18	40	NEW CONST RAILROADS	0.0	0.0	2.78	0.02	0.0	2.79
19	41	NEW CONST ELECT. UTIL.	0.0	0.0	37.36	0.34	0.88	38.58
20	42	NEW CONST GAS UTIL.	0.0	0.0	61.53	0.16	0.35	62.04
21	43	NEW CONST PETROL. PIPE.	0.0	0.0	15.69	0.02	0.0	15.71
22	44	NEW CONST WATER SUPPLY	0.0	0.0	15.69	0.11	0.18	15.98
23	45	NEW CONST SEWER	0.0	0.0	15.42	0.13	0.35	15.90
24	46	NEW CONST LOC. TRANSIT	0.0	0.0	2.22	0.02	0.0	2.24
25	47	NEW CONST HIGHWAYS	0.0	0.0	407.50	0.78	1.93	410.21
26	48	NEW CONST FARM RESID.	0.0	0.0	1.32	0.02	0.0	1.34
27	49	NEW CONST FARM SERVICE	0.0	0.0	2.64	0.02	0.0	2.65
28	50	NEW CONST OIL/GAS WELLS	0.0	0.0	71.53	0.11	0.35	71.99
29	51	NEW CONST OIL/GAS EXPL.	0.0	0.0	15.83	0.03	0.0	15.87
30	52	NEW CONST MILITARY	0.0	0.0	10.14	0.07	0.18	10.38
31	53	NEW CONST CONS.,DEV.	0.0	0.0	90.56	0.20	0.53	91.28
32	54	NEW CONST OTH. NON-BLDG.	0.0	0.0	26.94	0.11	0.35	27.41
33	55	MAINT CONST RESID.	0.0	0.0	21.64	0.31	0.88	22.82
34	56	MAINT CONST OTH. NON-FRM	0.0	0.0	36.51	0.29	0.70	37.51
35	57	MAINT CONST FARM RESID.	0.0	0.0	1.85	0.03	0.0	1.88
36	58	MAINT CONST FARM SERVICE	0.0	0.0	1.85	0.0	0.0	1.85
37	59	MAINT CONST TEL.,TEL.	0.0	0.0	2.92	0.03	0.0	2.95
38	60	MAINT CONST RAILROADS	0.0	0.0	5.83	0.03	0.0	5.87
39	61	MAINT CONST ELECT. UTIL.	0.0	0.0	2.36	0.03	0.0	2.39
40	62	MAINT CONST GAS UTIL.	0.0	0.0	5.83	0.0	0.0	5.83
41	63	MAINT CONST PETR. PIPE.	0.0	0.0	2.78	0.0	0.0	2.78
42	64	MAINT CONST WATER SUPPLY	0.0	0.0	14.31	0.07	0.0	14.37
43	65	MAINT CONST SEWER	0.0	0.0	4.03	0.03	0.0	4.06
44	66	MAINT CONST LOC. TRANSIT	0.0	0.0	0.42	0.0	0.0	0.42
45	67	MAINT CONST MILITARY	0.0	0.0	14.58	0.10	0.18	14.86
46	68	MAINT CONST CONSER.,DEV.	0.0	0.0	13.19	0.0	0.0	13.19
47	69	MAINT CONST HIGHWAYS	0.0	0.0	98.75	0.08	0.18	99.01
48	70	MAINT CONST OIL/GS WELLS	0.0	0.0	11.81	0.03	0.0	11.84
49	71	MAINT CONST OTH. N-BLDG.	0.0	0.0	20.28	0.14	0.18	20.59
		TOTAL	0.0	0.0	1459.36	7.64	17.71	1484.71

TABLE 3. ENERGY INTENSITIES FOR 399-ORDER CONSTRUCTION SECTORS -- 1967
(BTUS/$)

NUMBER	399 ORDER INDEX	I/O CODE	NAME	COAL	CRUDE PETROLEUM	REFINED PETROLEUM	ELECTRICITY	NATURAL GAS	TOTAL PRIMARY
1	23	110101	NEW CONST RES--1 FAM.	14003.	39413.	19978.	3397.	18462.	55511.
2	24	110102	NEW CONST RES--2-4 FAM.	13355.	36975.	19221.	3096.	16768.	52139.
3	25	110103	NEW CONST RES--GRDN APT.	13605.	37351.	20061.	3095.	16408.	52864.
4	26	110104	NEW CONST HIGH-RISE APT.	16495.	41452.	21938.	3329.	18536.	60000.
5	27	110105	NEW CONST RES--ALT.,ADD.	15047.	34245.	14833.	3820.	18514.	51646.
6	28	110106	NEW CONST HOTELS,MOTELS	18493.	48311.	26089.	3862.	21071.	69184.
7	29	110107	NEW CONST DORMITORIES	18828.	49390.	26507.	3869.	21711.	70604.
8	30	110201	NEW CONST INDUST. BLDG.	22820.	45543.	21141.	4055.	23311.	70864.
9	31	110202	NEW CONST OFFICE BLDG.	19360.	46984.	25301.	3882.	20564.	68737.
10	32	110203	NEW CONST WAREHOUSES	24198.	50752.	26327.	4227.	23224.	77556.
11	33	110204	NEW CONST GAR.,SRV. STA.	22108.	51517.	28071.	4203.	22250.	76217.
12	34	110205	NEW CONST STORES,RSTRNTS	19519.	51308.	29090.	3821.	21039.	73183.
13	35	110206	NEW CONST RELIG. BLDG.	17318.	46060.	24464.	3598.	20481.	65597.
14	36	110207	NEW CONST EDUC. BLDG.	18677.	46869.	24693.	3857.	20996.	67924.
15	37	110208	NEW CONST HOSPITAL BLDG.	16746.	41563.	21726.	3670.	18809.	60572.
16	38	110209	NEW CONST OTH. NON-FARM	19887.	47587.	25532.	3925.	20939.	69894.
17	39	110301	NEW CONST TELEPH.,TELEG.	17424.	45895.	22999.	5381.	21808.	66636.
18	40	110302	NEW CONST RAILROADS	28458.	46451.	23903.	4339.	21433.	77585.
19	41	110303	NEW CONST ELECT. UTIL.	20993.	43175.	21598.	4008.	20546.	66639.
20	42	110304	NEW CONST GAS UTIL.	45636.	91094.	59589.	5366.	29562.	140038.
21	43	110305	NEW CONST PETROL. PIPE.	42247.	101722.	70642.	5235.	28955.	147197.
22	44	110306	NEW CONST WATER SUPPLY	23406.	47726.	25645.	4227.	20957.	73738.
23	45	110307	NEW CONST SEWER	18434.	56272.	28998.	3442.	25944.	76828.
24	46	110308	NEW CONST LOC. TRANSIT	20327.	40174.	21904.	3157.	17338.	62447.
25	47	110400	NEW CONST HIGHWAYS	20241.	101369.	75998.	3464.	23254.	123745.
26	48	110501	NEW CONST FARM RESID.	15569.	35935.	15948.	3681.	19060.	53773.
27	49	110502	NEW CONST FARM SERVICE	26409.	46623.	21702.	4744.	23754.	75956.
28	50	110503	NEW CONST OIL/GAS WELLS	37407.	76881.	49357.	4229.	25680.	116895.
29	51	110504	NEW CONST OIL/GAS EXPL.	5356.	86708.	74494.	1422.	10144.	92941.
30	52	110505	NEW CONST MILITARY	20415.	55006.	31182.	3884.	22537.	77815.
31	53	110506	NEW CONST CONS.,DEV.	12722.	70539.	54079.	2476.	14970.	84788.
32	54	110507	NEW CONST OTH. NON-BLDG.	18129.	69414.	48460.	3120.	19467.	89465.
33	55	120100	MAINT CONST RESID.	11488.	36812.	20899.	2875.	15033.	50072.
34	56	120201	MAINT CONST OTH. NON-FRM	12150.	35776.	18784.	2910.	16154.	49720.
35	57	120202	MAINT CONST FARM RESID.	20102.	48673.	26137.	4083.	21373.	71292.
36	58	120203	MAINT CONST FARM SERVICE	26852.	66421.	38132.	4890.	26744.	96288.
37	59	120204	MAINT CONST TEL.,TEL.	8819.	25240.	14395.	2385.	10267.	35530.
38	60	120205	MAINT CONST RAILROADS	15268.	26129.	13882.	2270.	11617.	42796.
39	61	120206	MAINT CONST ELECT. UTIL.	8253.	17092.	8891.	1741.	7802.	26418.
40	62	120207	MAINT CONST GAS UTIL.	22634.	58705.	40899.	2821.	16578.	83078.
41	63	120208	MAINT CONST PETR. PIPE.	32697.	82023.	57954.	3956.	22337.	117158.
42	64	120209	MAINT CONST WATER SUPPLY	11793.	48781.	34501.	2193.	13261.	61927.
43	65	120210	MAINT CONST SEWER	10341.	33544.	20229.	1880.	12580.	45044.
44	66	120211	MAINT CONST LOC. TRANSIT	11190.	35902.	23320.	2353.	11786.	48542.
45	67	120212	MAINT CONST MILITARY	11130.	49546.	34243.	2718.	14238.	62352.
46	68	120213	MAINT CONST CONSER.,DEV.	4484.	87809.	76723.	1088.	9348.	92963.
47	69	120214	MAINT CONST HIGHWAYS	7345.	67689.	55122.	1638.	11228.	76044.
48	70	120215	MAINT CONST OIL/GS WELLS	39382.	67146.	39866.	4177.	25703.	109103.
49	71	120216	MAINT CONST OTH. N-BLDG.	7104.	53819.	42237.	1819.	10464.	62045.

TABLE 4. RANKED TOTAL PRIMARY ENERGY INTENSITIES FOR 399-ORDER CONSTRUCTION SECTORS -- 1967 (BTUS/$)

RANK	399-ORDER INDEX	I/O CODE	NAME	TOTAL PRIMARY INTENSITY
1	43	110305	NEW CONST PETROL. PIPE.	147197.
2	42	110304	NEW CONST GAS UTIL.	140038.
3	47	110400	NEW CONST HIGHWAYS	123745.
4	63	120208	MAINT CONST PETR. PIPE.	117159.
5	50	110503	NEW CONST OIL/GAS WELLS	116895.
6	70	120215	MAINT CONST OIL/GS WELLS	109103.
7	58	120203	MAINT CONST FARM SERVICE	96288.
8	68	120213	MAINT CONST CONSER.,DEV.	92963.
9	51	110504	NEW CONST OIL/GAS EXPL.	92941.
10	54	110507	NEW CONST OTH. NON-BLDG.	89466.
11	53	110506	NEW CONST CONS.,DEV.	84788.
12	62	120207	MAINT CONST GAS UTIL.	83078.
13	52	110505	NEW CONST MILITARY	77815.
14	40	110302	NEW CONST RAILROADS	77585.
15	32	110203	NEW CONST WAREHOUSES	77556.
16	45	110307	NEW CONST SEWER	76828.
17	33	110204	NEW CONST GAR.,SRV. STA.	76217.
18	69	120214	MAINT CONST HIGHWAYS	76044.
19	49	110502	NEW CONST FARM SERVICE	75956.
20	44	110306	NEW CONST WATER SUPPLY	73738.
21	34	110205	NEW CONST STORES,RSTRNTS	73183.
22	57	120202	MAINT CONST FARM RESID.	71292.
23	30	110201	NEW CONST INDUST. BLDG.	70864.
24	29	110107	NEW CONST DORMITORIES	70604.
25	38	110209	NEW CONST OTH. NON-FARM	69894.
26	28	110106	NEW CONST HOTELS,MOTELS	69184.
27	31	110202	NEW CONST OFFICE BLDG.	68737.
28	36	110207	NEW CONST EDUC. BLDG.	67924.
29	41	110303	NEW CONST ELECT. UTIL.	66639.
30	39	110301	NEW CONST TELEPH.,TELEG.	66636.
31	35	110206	NEW CONST RELIG. BLDG.	65597.
32	46	110308	NEW CONST LOC. TRANSIT	62447.
33	67	120212	MAINT CONST MILITARY	62352.
34	71	120216	MAINT CONST OTH. N-BLDG.	62045.
35	64	120209	MAINT CONST WATER SUPPLY	61927.
36	37	110208	NEW CONST HOSPITAL BLDG.	60572.
37	26	110104	NEW CONST HIGH-RISE APT.	60000.
38	23	110101	NEW CONST RES--1 FAM.	55511.
39	48	110501	NEW CONST FARM RESID.	53773.
40	25	110103	NEW CONST RES--GRDN APT.	52864.
41	24	110102	NEW CONST RES--2-4 FAM.	52139.
42	27	110105	NEW CONST RES--ALT.,ADD.	51646.
43	55	120100	MAINT CONST RESID.	50072.
44	56	120201	MAINT CONST OTH. NON-FRM	49720.
45	66	120211	MAINT CONST LOC. TRANSIT	48542.
46	65	120210	MAINT CONST SEWER	45044.
47	60	120205	MAINT CONST RAILROADS	42796.
48	59	120204	MAINT CONST TEL.,TEL.	35530.
49	61	120206	MAINT CONST ELECT. UTIL.	26418.

TABLE 5. GROSS DOMESTIC OUTPUT FOR CONSTRUCTION SECTORS -- 1967
(MILLIONS OF DOLLARS)

399-ORDER INDEX	NAME	GDO
23	NEW CONST RES--1 FAM.	14069.0
24	NEW CONST RES--2-4 FAM.	668.0
25	NEW CONST RES--GRDN APT.	2795.0
26	NEW CONST HIGH-RISE APT.	1966.0
27	NEW CONST RES--ALT.,ADD.	5070.0
28	NEW CONST HOTELS,MOTELS	998.0
29	NEW CONST DORMITORIES	819.0
30	NEW CONST INDUST. BLDG.	6539.0
31	NEW CONST OFFICE BLDG.	3763.0
32	NEW CONST WAREHOUSES	745.0
33	NEW CONST GAR.,SRV. STA.	423.0
34	NEW CONST STORES,RSTRNTS	2692.0
35	NEW CONST RELIG. BLDG.	1046.0
36	NEW CONST EDUC. BLDG.	6439.0
37	NEW CONST HOSPITAL BLDG.	1935.0
38	NEW CONST OTH. NON-FARM	3306.0
39	NEW CONST TELEPH.,TELEG.	1638.0
40	NEW CONST RAILROADS	327.0
41	NEW CONST ELECT. UTIL.	4561.0
42	NEW CONST GAS UTIL.	1549.0
43	NEW CONST PETROL. PIPE.	312.0
44	NEW CONST WATER SUPPLY	1270.0
45	NEW CONST SEWER	1058.0
46	NEW CONST LOC. TRANSIT	204.0
47	NEW CONST HIGHWAYS	8371.0
48	NEW CONST FARM RESID.	562.0
49	NEW CONST FARM SERVICE	762.0
50	NEW CONST OIL/GAS WELLS	2015.0
51	NEW CONST OIL/GAS EXPL.	243.0
52	NEW CONST MILITARY	695.0
53	NEW CONST CONS.,DEV.	2124.0
54	NEW CONST OTH. NON-BLDG.	925.0
55	MAINT CONST RESID.	6265.0
56	MAINT CONST OTH. NON-FRM	7166.9
57	MAINT CONST FARM RESID.	354.2
58	MAINT CONST FARM SERVICE	396.8
59	MAINT CONST TEL.,TEL.	517.0
60	MAINT CONST RAILROADS	1094.0
61	MAINT CONST ELECT. UTIL.	717.0
62	MAINT CONST GAS UTIL.	259.0
63	MAINT CONST PETR. PIPE.	65.0
64	MAINT CONST WATER SUPPLY	993.0
65	MAINT CONST SEWER	401.0
66	MAINT CONST LOC. TRANSIT	43.0
67	MAINT CONST MILITARY	849.0
68	MAINT CONST CONSER.,DEV.	194.0
69	MAINT CONST HIGHWAYS	2988.0
70	MAINT CONST OIL/GS WELLS	426.0
71	MAINT CONST OTH. N-BLDG.	662.0
	TOTAL	103278.3

TABLE 6. AVERAGE ENERGY INTENSITIES FOR CONSTRUCTION -- 1967
(BTUS/$)

	NEW CONSTRUCTION	MAINTENANCE AND REPAIR CONSTRUCTION	ALL CONSTRUCTION
COAL	19138.	12059.	17535.
CRUDE PETROLEUM	52678.	42498.	50372.
REFINED PETROLEUM	30755.	26946.	29893.
ELECTRICITY	3742.	2635.	3492.
NATURAL GAS	20695.	14601.	19315.
TOTAL PRIMARY	74122.	56182.	70059.

TABLE 7. TOTAL ENERGY OF FINAL DEMAND FOR CONSTRUCTION SECTORS -- 1967 (TRILLIONS OF BTUS)

NUMBER	399-ORDER INDEX	I/O CODE	NAME	TOTAL ENERGY (DIRECT AND INDIRECT)	PERCENT DIRECT	PERCENT OF TOTAL CONSTRUCTION (DIRECT AND INDIRECT)	PERCENT OF TOTAL UNITED STATES (DIRECT AND INDIRECT)
1	23	110101	NEW CONST RES--1 FAM.	780.98	9.94	12.39	1.17
2	24	110102	NEW CONST RES--2-4 FAM.	34.83	13.43	0.55	0.05
3	25	110103	NEW CONST RES--GRDN APT.	147.76	14.49	2.34	0.22
4	26	110104	NEW CONST HIGH-RISE APT.	117.96	16.63	1.87	0.18
5	27	110105	NEW CONST RES--ALT.,ADD.	261.85	2.87	4.16	0.39
6	28	110106	NEW CONST HOTELS,MOTELS	69.05	17.60	1.10	0.10
7	29	110107	NEW CONST DORMITORIES	57.82	18.54	0.92	0.09
8	30	110201	NEW CONST INDUST. BLDG.	463.38	8.23	7.35	0.69
9	31	110202	NEW CONST OFFICE BLDG.	258.66	17.80	4.10	0.39
10	32	110203	NEW CONST WAREHOUSES	57.78	11.35	0.92	0.09
11	33	110204	NEW CONST GAR.,SRV. STA.	32.24	16.09	0.51	0.05
12	34	110205	NEW CONST STORES,RSTRNTS	197.01	18.94	3.13	0.29
13	35	110206	NEW CONST RELIG. BLDG.	68.61	16.39	1.09	0.10
14	36	110207	NEW CONST EDUC. BLDG.	437.36	15.48	6.94	0.65
15	37	110208	NEW CONST HOSPITAL BLDG.	117.21	16.58	1.86	0.18
16	38	110209	NEW CONST OTH. NON-FARM	231.07	17.50	3.67	0.35
17	39	110301	NEW CONST TELEPH.,TELEG.	109.15	11.31	1.73	0.16
18	40	110302	NEW CONST RAILROADS	25.37	11.01	0.40	0.04
19	41	110303	NEW CONST ELECT. UTIL.	303.94	12.69	4.82	0.45
20	42	110304	NEW CONST GAS UTIL.	216.92	28.60	3.44	0.32
21	43	110305	NEW CONST PETROL. PIPE.	45.93	34.21	0.73	0.07
22	44	110306	NEW CONST WATER SUPPLY	93.65	17.07	1.49	0.14
23	45	110307	NEW CONST SEWER	81.28	19.56	1.29	0.12
24	46	110308	NEW CONST LOC. TRANSIT	12.74	17.57	0.20	0.02
25	47	110400	NEW CONST HIGHWAYS	1035.87	39.60	16.44	1.55
26	48	110501	NEW CONST FARM RESID.	30.22	4.42	0.48	0.05
27	49	110502	NEW CONST FARM SERVICE	57.88	4.59	0.92	0.09
28	50	110503	NEW CONST OIL/GAS WELLS	235.54	30.56	3.74	0.35
29	51	110504	NEW CONST OIL/GAS EXPL.	22.58	70.25	0.36	0.03
30	52	110505	NEW CONST MILITARY	54.08	19.19	0.86	0.08
31	53	110506	NEW CONST CONS.,DEV.	180.09	50.68	2.86	0.27
32	54	110507	NEW CONST OTH. NON-BLDG.	82.76	33.12	1.31	0.12
33	55	120100	MAINT CONST RESID.	8.81	7.28	0.14	0.01
34	56	120201	MAINT CONST OTH. NON-FRM	70.79	10.53	1.12	0.11
35	57	120202	MAINT CONST FARM RESID.	0.0	0.0	0.0	0.0
36	58	120203	MAINT CONST FARM SERVICE	0.0	0.0	0.0	0.0
37	59	120204	MAINT CONST TEL.,TEL.	0.0	0.0	0.0	0.0
38	60	120205	MAINT CONST RAILROADS	0.0	0.0	0.0	0.0
39	61	120206	MAINT CONST ELECT. UTIL.	0.0	0.0	0.0	0.0
40	62	120207	MAINT CONST GAS UTIL.	0.0	0.0	0.0	0.0
41	63	120208	MAINT CONST PETR. PIPE.	0.0	0.0	0.0	0.0
42	64	120209	MAINT CONST WATER SUPPLY	0.0	0.0	0.0	0.0
43	65	120210	MAINT CONST SEWER	0.0	0.0	0.0	0.0
44	66	120211	MAINT CONST LOC. TRANSIT	0.0	0.0	0.0	0.0
45	67	120212	MAINT CONST MILITARY	52.94	28.07	0.84	0.08
46	68	120213	MAINT CONST CONSER.,DEV.	18.03	73.16	0.29	0.03
47	69	120214	MAINT CONST HIGHWAYS	220.00	43.57	3.49	0.33
48	70	120215	MAINT CONST OIL/GS WELLS	0.0	0.0	0.0	0.0
49	71	120216	MAINT CONST OTH. N-BLDG.	9.85	50.13	0.16	0.01
			TOTAL	6301.94	19.52	100.00	9.42

TABLE 8. RANKED TOTAL ENERGY OF FINAL DEMAND FOR CONSTRUCTION SECTORS -- 1967 (TRILLION BTUS)

RANK	399-ORDER INDEX	NAME	TOTAL ENERGY (DIRECT AND INDIRECT)	PERCENT DIRECT
1	47	NEW CONST HIGHWAYS	1035.87	39.60
2	23	NEW CONST RES--1 FAM.	780.98	9.94
3	30	NEW CONST INDUST. BLDG.	463.38	8.23
4	36	NEW CONST EDUC. BLDG.	437.36	15.48
5	41	NEW CONST ELECT. UTIL.	303.94	12.69
6	27	NEW CONST RES--ALT.,ADD.	261.85	2.87
7	31	NEW CONST OFFICE BLDG.	258.66	17.80
8	50	NEW CONST OIL/GAS WELLS	235.54	30.56
9	38	NEW CONST OTH. NON-FARM	231.07	17.50
10	69	MAINT CONST HIGHWAYS	220.00	43.57
11	42	NEW CONST GAS UTIL.	216.92	28.60
12	34	NEW CONST STORES,RSTRNTS	197.01	18.94
13	53	NEW CONST CONS.,DEV.	180.09	50.68
14	25	NEW CONST RES--GRDN APT.	147.76	14.49
15	26	NEW CONST HIGH-RISE APT.	117.96	16.63
16	37	NEW CONST HOSPITAL BLDG.	117.21	16.58
17	39	NEW CONST TELEPH.,TELEG.	109.15	11.31
18	44	NEW CONST WATER SUPPLY	93.65	17.07
19	54	NEW CONST OTH. NON-BLDG.	82.76	33.12
20	45	NEW CONST SEWER	81.28	19.56
21	56	MAINT CONST OTH. NON-FRM	70.79	10.53
22	28	NEW CONST HOTELS,MOTELS	69.05	17.60
23	35	NEW CONST RELIG. BLDG.	68.61	16.39
24	49	NEW CONST FARM SERVICE	57.88	4.59
25	29	NEW CONST DORMITORIES	57.82	18.54
26	32	NEW CONST WAREHOUSES	57.78	11.35
27	52	NEW CONST MILITARY	54.08	19.19
28	67	MAINT CONST MILITARY	52.94	23.07
29	43	NEW CONST PETROL. PIPE.	45.93	34.21
30	24	NEW CONST RES--2-4 FAM.	34.83	13.43
31	33	NEW CONST GAR.,SRV. STA.	32.24	16.09
32	48	NEW CONST FARM RESID.	30.22	4.42
33	40	NEW CONST RAILROADS	25.37	11.01
34	51	NEW CONST OIL/GAS EXPL.	22.58	70.25
35	68	MAINT CONST CONSER.,DEV.	18.03	73.16
36	46	NEW CONST LOC. TRANSIT	12.74	17.57
37	71	MAINT CONST OTH. N-BLDG.	9.85	50.13
38	55	MAINT CONST RESID.	8.81	7.23
39	57	MAINT CONST FARM RESID.	0.0	0.0
40	58	MAINT CONST FARM SERVICE	0.0	0.0
41	59	MAINT CONST TEL.,TEL.	0.0	0.0
42	60	MAINT CONST RAILROADS	0.0	0.0
43	61	MAINT CONST ELECT. UTIL.	0.0	0.0
44	62	MAINT CONST GAS UTIL.	0.0	0.0
45	63	MAINT CONST PETR. PIPE.	0.0	0.0
46	64	MAINT CONST WATER SUPPLY	0.0	0.0
47	65	MAINT CONST SEWER	0.0	0.0
48	66	MAINT CONST LOC. TRANSIT	0.0	0.0
49	70	MAINT CONST OIL/GS WELLS	0.0	0.0

TABLE 9. TOTAL ENERGY REQUIREMENT BY CONSTRUCTION SECTOR -- 1967
(TRILLION BTU)

NUMBER	399-ORDER INDEX	NAME	TOTAL REQUIREMENT	PERCENT OF GRAND TOTAL
1	23	NEW CONST RES--1 FAM.	780.96	10.79
2	24	NEW CONST RES--2-4 FAM.	34.83	0.48
3	25	NEW CONST RES--GRDN APT.	147.75	2.04
4	26	NEW CONST HIGH-RISE APT.	117.96	1.63
5	27	NEW CONST RES--ALT.,ADD.	261.85	3.62
6	28	NEW CONST HOTELS,MOTELS	69.05	0.95
7	29	NEW CONST DORMITORIES	57.82	0.80
8	30	NEW CONST INDUST. BLDG.	463.37	6.40
9	31	NEW CONST OFFICE BLDG.	258.66	3.57
10	32	NEW CONST WAREHOUSES	57.78	0.80
11	33	NEW CONST GAR.,SRV. STA.	32.24	0.45
12	34	NEW CONST STORES,RSTRNTS	197.01	2.72
13	35	NEW CONST RELIG. BLDG.	68.61	0.95
14	36	NEW CONST EDUC. BLDG.	437.35	6.04
15	37	NEW CONST HOSPITAL BLDG.	117.21	1.62
16	38	NEW CONST OTH. NON-FARM	231.07	3.19
17	39	NEW CONST TELEPH.,TELEG.	109.15	1.51
18	40	NEW CONST RAILROADS	25.37	0.35
19	41	NEW CONST ELECT. UTIL.	303.94	4.20
20	42	NEW CONST GAS UTIL.	216.92	3.00
21	43	NEW CONST PETROL. PIPE.	45.92	0.63
22	44	NEW CONST WATER SUPPLY	93.65	1.29
23	45	NEW CONST SEWER	81.28	1.12
24	46	NEW CONST LOC. TRANSIT	12.74	0.18
25	47	NEW CONST HIGHWAYS	1035.86	14.32
26	48	NEW CONST FARM RESID.	30.22	0.42
27	49	NEW CONST FARM SERVICE	57.88	0.80
28	50	NEW CONST OIL/GAS WELLS	235.54	3.26
29	51	NEW CONST OIL/GAS EXPL.	22.58	0.31
30	52	NEW CONST MILITARY	54.08	0.75
31	53	NEW CONST CONS.,DEV.	180.09	2.49
32	54	NEW CONST OTH. NON-BLDG.	82.76	1.14
33	55	MAINT CONST RESID.	313.70	4.34
34	56	MAINT CONST OTH. NON-FRM	356.33	4.92
35	57	MAINT CONST FARM RESID.	25.25	0.35
36	58	MAINT CONST FARM SERVICE	38.21	0.53
37	59	MAINT CONST TEL.,TEL.	18.37	0.25
38	60	MAINT CONST RAILROADS	46.82	0.65
39	61	MAINT CONST ELECT. UTIL.	18.94	0.26
40	62	MAINT CONST GAS UTIL.	21.52	0.30
41	63	MAINT CONST PETR. PIPE.	7.62	0.11
42	64	MAINT CONST WATER SUPPLY	61.49	0.85
43	65	MAINT CONST SEWER	18.06	0.25
44	66	MAINT CONST LOC. TRANSIT	2.09	0.03
45	67	MAINT CONST MILITARY	52.94	0.73
46	68	MAINT CONST CONSER.,DEV.	18.03	0.25
47	69	MAINT CONST HIGHWAYS	227.22	3.14
48	70	MAINT CONST OIL/GS WELLS	46.48	0.64
49	71	MAINT CONST OTH. N-BLDG.	41.07	0.57
		GRAND TOTAL	7235.55	100.00

III. ENERGY USE SUB-STUDIES

This section describes the following four sub-studies of energy use in the construction industry for 1967:

A - Energy Distribution Patterns.

B - Energy Embodiment Per Unit of Material.

C - Energy Use Per Square Foot Per Building Type.

D - Energy-Flow Diagram.

These sub-studies were conducted by RGSA, using energy figures developed by CAC as described in Section II. Sector indices referred to in the sub-studies are those of the 399-order model (see Table 1, Section II) unless otherwise stated. Tables referred to in this section are numbered according to the sub-study to which they apply, and are located directly following the text.

A. Energy Distribution Patterns.

Tables A1-3 show the division of direct and embodied energy requirements of each of the 49 construction sectors in relation to the entire 1967 Construction Industry. It is important to note that in these tables, as well as in the rest of this section, direct energy use refers to the total energy embodied in direct fuels purchased. In other words, the direct energy requirements shown include the energy content of the fuels purchased plus the energy cost of producing those fuels.

Tables A1-3 indicate the following:

1. In all, construction required 7,235.6 trillion Btu in 1967, representing 10.82 percent of overall U.S. energy use in that year.

2. Of this, New Building construction (Sectors 23-38, 48 & 49) used 3,421.6 trillion Btu (47.3 percent of the Construction use). Nearly 1/3 of this (1,107.9 trillion) went to the various small residential sectors. (23, 24, 27, 28.)

3. New Non-building Construction Sectors, 38-47 and 50-54 used 2,499.9 trillion Btu (34.6 percent of the construction use). Over 40 percent of this (1,035.9 trillion) went to New Highway Construction alone.

4. Building Maintenance and Repair Construction (Sectors 55-58) used 733.5 trillion Btu (10.1 percent of the Construction use.)

5. Non-building Maintenance and Repair Construction (Sectors 59-71) used 580.6 trillion Btu (8.0 percent of the Construction use, about half of which (227.2 trillion) went to Highway Maintenance and Repair).

Referring to point 1 above, it should be noted that the figures represent the total energy required by the Construction Industry to produce its total output in 1967. Some of the output in the Maintenance and Repair Construction Sectors, however, is not normally assigned to the Construction Industry, but rather to the industries which receive such output. For example, the energy cost of repairing a steel mill roof would normally be assigned to the Steel Industry. Because this type of activity is in fact construction activity, we have added the energy requirements it generates to the total of the Construction Industry. If total energy requirements were calculated in this manner for several industries and then summed and/or compared to the U.S. energy use total, the potential overlap of activities would produce duplication. In a study such as this one, however, in which

a single industry is considered, this overlapping segment must be included. Thus, the total output of the Construction Industry represents 10.82 percent of the total U.S. energy requirement for 1967, while that portion of construction sold for final consumption represents only 9.42 percent of total energy use. The remaining portion is sold to other industries.

Tables A4 - 12 show the percentage division within each construction sector of the entire direct and majority of the embodied energy represented by each of the 399 sectors contributing to the subject sector. In the charts the 399 sectors have been aggregated to the 90-level, and only the most significant contributors have been identified at the 399 level. (See Table 1, Section II for correspondence between 90 and 399 level sectors.) A study of the percentage divisions within each construction sector allows one to see the variations in the patterns of energy embodiment inherent in each construction sector or group of sectors.

It is immediately apparent that the patterns typical of building construction differ significantly from those of non-building construction.

Most new building construction sectors follow similar patterns in their use of energy and materials. (It is important to note that these are the <u>average</u> uses of materials by the different building type categories and may differ sharply from any individual example within the category. There are sharper variations within a category than between categories.) The exceptions to this are the small residential sectors 23, 24, 27 and 48, which use a much larger percentage of wood and wood products and a smaller percentage of direct fuel than the other categories, and New Farm Service Facilities (sector 49,) in which energy embodied in direct fuel use accounts for only about 5-1/2 percent of all energy use

and which shows a pattern of energy use consistent with a specialized use of materials. In Sector 49, over 20 percent of the total energy use comes through 399-level Sector 245, Miscellaneous Metal Work, which includes reinforcing steel, plastering accessories, and metal curtain walls. The extensive use of the products of this sector for farm service buildings is accounted for largely by the use of corrugated metal roofs, and metal siding commonly used in construction of barns, silos, storage buildings, etc. Including this one major exception, in general, in new building construction, the same 25 input sectors out of 399 account for approximately 70 to 80 percent of the total direct and embodied energy allocated to each new building construction sector.

In the new Building Category, the sectors, starting with the greatest energy user - One-Family Residential - and following in diminishing order of energy embodiment are:

SECTOR	TRILLION BTU (BTU x 10^{12})	PERCENT OF NEW BUILDING ENERGY	PERCENT OF TOTAL U.S. ENERGY
23 1-family Residential	780.96	22.8	1.174
30 Industrial Building	463.37	13.5	.697
36 Education Buildings	437.35	12.8	.658
27 Residential Alt. & Add.	261.85	7.7	.394
31 Office Buildings	258.66	7.6	.389
38 Other Non-farm Buildings	231.07	6.8	.347
34 Stores & Restaurants	197.01	5.8	.296
25 Residential-Garden Apts.	147.75	4.3	.222
26 Residential High Rise	117.96	3.4	.177
37 Hospitals	117.21	3.4	.176
28 Hotels/Motels	69.05	2.0	.104
35 Religious Buildings	68.61	2.0	.103
49 Farm Service Buildings	57.88	1.7	.087
29 Dormitories	57.82	1.7	.087
32 Warehouses	57.78	1.7	.087
24 2-4 Family Residences	34.83	1.0	.052
33 Garage & Service Stations	34.24	0.9	.051
48 Farm Residential	30.22	0.9	.045
1967 TOTAL ENERGY ATTRIBUTED TO NEW BUILDING CONSTRUCTION	3,421.62	100.0	5.146

The impact of any construction sector on the total energy attributable to all construction varies with both the energy intensity inherent in the construction type and also the quantity of that type of construction completed in the year studied. Thus, in 1967, One-Family Residential Construction, which incorporates 702,214 Btu/SF of Construction accounted for nearly three times the total energy attributable to Office Buildings which are over twice as energy-intensive (1, 641, 440 Btu/SF). (See Table C-1).

Similarly, the differences in energy intensity between sectors is also attributable to variations between quantity and energy intensity of the materials inherent to the sector as well as variations in direct fuel consumption.

In Sector 23, One-Family Residential, which uses relatively little heavy equipment and virtually no temporary heat in the construction process, energy embodied in direct fuel use accounts for only 12-1/4 percent of its total energy, while wood products (in itself a low-energy-intensity industry) accounts for about 16-1/2 percent.

In Sector 31, Office Buildings, which uses a good deal of heavy equipment and temporary heat, energy embodied in direct fuel use accounts for 21-1/2 percent of the total energy to the sector, and Fabricated Metals Products and Stone and Clay Products (which incorporate the highest energy intensity industries in Building Construction) together account for an additional 55-1/2 percent. Wood Products account for only 1-1/2 percent.

In Non-building Construction, not only are the patterns of materials and energy use different from those of Building Construction (in general a much greater percentage of energy use is direct) but also, for the most

part, there is a far greater degree of specialization in the non-building categories and hence, a greater amount of variation from one non-building category to another.

The 25 input sectors which account for approximately 70 to 80 percent of energy in the new building construction sectors account for only 40 to 50 percent of the energy in most new non-building sectors. The main exceptions to this statement, 47: Highway, 51: Oil Exploration and 53: Conservation Development show an unusually high input of energy embodied in direct fuels.

Almost half the energy embodied in Highways (46.7 percent) is applied directly to the construction process, reflecting not only the extensive amount of diesel powered equipment and the use of asphalt plants and spreaders in the construction process, but also the inclusion of asphalt paving in the direct fuel Refined Petroleum Sector. (See reference [2] for details.) Oil Exploration (84.54 percent energy embodied in direct fuels) purchases and uses large quantities of fuel for the operation of deep drilling rigs. Conservation Development (60.97 percent energy embodied in direct fuels) includes dams and other large earthmoving projects which also use a great deal of mechanized equipment but incorporate comparatively little other material in the finished product.

The following chart demonstrates in a general way the amount and type of variation between major groups of New Construction Sectors.

	ENERGY EMBODIED IN DIRECT FUEL (almost entirely refined petroleum)	25 SELECTED* INPUT SECTORS (out of 399)	TOTAL PERCENT ACCOUNTED FOR
NEW BUILDING			
1-family residences & farm buildings & residential alterations & additions	3 - 6-1/2%	65-80%	70-82%
Other New Building	10-20%	55-70%	70-80%
NEW NON-BUILDINGS			
Highways	47%	43%	90%
Oil & Gas Exploration	85%	4%	89%
Conservation development	60%	25%	85%
Other Non-buildings	13-35%	30-50%	45-80%

The Maintenance and Repair Sectors show patterns of energy use which are again different from the New Construction Sectors, and within the Maintenance and Repair group, Building Sectors differ from Non-building Sectors. As might be expected, the building sectors show primarily a very large use of paint, asphalt and asphalt coatings, and next, heating, air-conditioning and plumbing equipment. The Non-building Sectors each show a heavy dependency on the materials specific to the sector. (E.g. non-ferrous wire accounts for nearly 13% of the energy attributable to Electric Utility

*These selected input sectors are: Refined Petroleum, Sawmills, Millwork, Veneer Plywood, Prefabricated Wood Structures, Paint Products, Paving, Asphalt (products & coatings), Cement, Bricks, Concrete Blocks, Concrete Products, Ready-mix Concrete, Gypsum Products, Mineral Wool, Fabricated Structural Steel, Metal Doors, Sheet Metal Work, Miscellaneous Metal Work, Transportation Sectors, and Wholesale and Retail Trade.

Maintenance and Repair Construction.) Those Sectors which are dependent on a great deal of heavy equipment use with relatively little addition of material show a disproportionately high percentage of energy embodied in direct fuel use (e.g. over 87 percent for Conservation Development Maintenance and Repair.)

An examination of the 399-order Sectors contributing to the Maintenance and Repair Sectors indicates that each Maintenance and Repair Construction Sector adds an increment of energy embodiment, but no further square footage or bulk to the New Construction Category to which it pertains.

In the Building categories, with which we are dealing, Maintenance Sectors have been so greatly aggregated (there are only 4 Building Maintenance Sectors: Farm Residential; Farm Service; Other Residential; and Other) that it is not possible to apportion their energy embodiment to the appropriate New Construction Sectors. Therefore, although the materials which contribute to Maintenance & Repair Construction will be investigated together with all construction materials, and thus, it would be possible to assign an energy cost to, say, repainting an office interior, the Maintenance Sectors as such will not be considered in greater detail in this study.

Because of their very specific nature, the New Non-building Construction Sectors cannot be combined with the New Building Sectors nor with each other, but should be studied individually.* In this study,

*Highway Construction, which has already been the subject of a number of energy studies, is a particular case in point. Not only is it an energy intensive category, but, in 1967 at least, it accounted for a large percentage of the dollar volume of construction (9-1/2% of total dollar volume and nearly 20% of total construction energy for new construction and maintenance combined.)

(Footnote continued on next page)

however, our main concern is specific to the energy embodied in buildings; thus, in the further stages of the study, we shall be dealing with non-building construction only tangentially, where it is particularly relevant.

B. Energy Embodiment Per Unit of Material

In this sub-study we have subdivided certain of the 399-level sectors (which correspond with Standard Industrial Classification (SIC) 4-digit classifications) into the SIC 6-digit classifications, corresponding to the 1967 Census of Manufacturers (CM). [5]

The 6-digit breakdown, shown by the CM for the output of all manufacturing sectors, begins to approach the type of unit breakdown necessary for an energy estimate of building materials and components. That is, industrial products are subdivided not only with respect to dollar of product, but also by quantities of production: e.g., number of board feet of lumber, divided into rough or milled lumber, hardwood versus softwood, etc. In most cases, corresponding dollar value is also given. To the unit price obtained from these figures, we have applied the CAC figure for total energy intensity (Btu/$) of product, arriving at a figure for embodied Btu/unit.

Even at this preliminary stage, certain difficulties become apparent, and further investigation is necessary. The 399-level figures are average figures, each of which covers a large aggregation of building products. Since most of the 399 sectors (although not all) deal with similar industries,

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Between 1967 and now, there has continued to be a great deal of activity in Highway Construction and the 1972 benchmark data can be expected to show a similar or even greater weighting of this sector. At this time, however, with most of the Interstate System complete and with an apparent shift occurring in national construction priorities, we expect New Highway Construction to show a slackening off in importance.

and the entire aggregation can be represented by dollars of product, the 399 breakdown and the average figures for each sector are valid in a study of economics. In a study of building components, however, the sectors must be broken down further, as the units within each sector are not similar and are not comparable. For example, Section 138: Millwork includes wood moldings per board foot; wood window and door frames, per unit; wood doors, per unit, etc. These subdivisions are further broken down by the CM; e.g., wood doors are divided into panel type, flush type hollow core and flush type solid core, and each door type is divided up according to the type of wood in its composition.

The price variation between even similar units is not dependent on the amount of energy in the manufacturing process, but on a variety of other factors: rarity of material, amount of material, labor intensity, etc. The average Btu/$ of manufacture figure applied at the 4-digit breakdown level at this scale of breakdown (SIC 7-digit) is the most refined figure now available; however, for an accurate representation of energy input into building components suitable for use as a companion to a cost estimating manual, more investigation is necessary.

There are two methods of approach to this investigation:

1. The Census Bureau has detailed information regarding direct energy input to all of the CM industries. The CM report, which documents industry output at 7-digit detail, reports input to industry only at 4-digit detail. According to BEA all further information is broken down into separate establishments reports, and is stored on confidential tapes within the Census Bureau. Access to this information, which we believe to be highly accurate, may be available only to

Census Bureau personnel, and the Census Bureau may be the only organization capable of carrying out the necessary investigation.

2. Isolate direct energy data for specific units from published sources. A number of such studies exist. They do not cover all relevant industries, nor do different studies of the same industry correspond with each other. The lack of correspondence is based on differences in approach, difference in parameters of study, and difference in data base. There are also industry studies of direct energy use, which we would expect to be highly accurate. However, many (or most) of these are confidential and not accessible.

The most accurate of the approaches outlined above would be the use of the Census Bureau data since it is not only comprehensive, but it also corresponds to a very high degree with the BEA data on which the CAC Energy I/O Model is based.

In the further stages of this study we intend to investigate all outside sources of information available to us to refine the figure for direct energy into units of building material. A combination of a precise direct energy figure with the CAC average figure for embodied energy to each unit should provide an acceptably accurate total.

At this stage of the report all figures shown are based on the BEA producers' dollar data. In the case of units of material used in construction, the producer is the manufacturer - or producer - of that material. The data do not include the transportation and trade costs (margins) between the producer and the purchaser - in this case the Contractor. Since these activities are a part of the process that produces buildings and since all use some energy (light, space heating,

transportation, etc.), that energy use must be included. In the further stages these figures will be adjusted so that the margins are included and the data will correlate with the dollar data found in standard cost estimating sources.

Tables B1 - 15 show preliminary Btu/unit figures for 399-level sectors 135: Sawmill Products; 136: Hardwood Flooring; 137: Special Sawmill Products; 138: Millwork; 139: Veneer Plywood; 140: Prefabricated Wood Structures; 182: Paints; 184: Asphalt Felts & Coatings; 193: Plate Glass; 195: Hydraulic Cement; 196: Brick; 197: Ceramic Tile; 204: Concrete Blocks; 206: Ready-Mix Concrete; 207: Lime; 208: Gypsum Products; and 214: Mineral Wool Insulation.

Tables B16 - 17 show a sample application of some of these preliminary figures to typical wall assemblies. (In these tables, U is the overall coefficient of heat transmission -- the Btu per hour flowing from air to air through 1 square foot of wall or other building component in place in the structure under actual conditions for a temperature difference of 1°F between inside and outside air; R is thermal resistance -- the reciprocal of the coefficient of heat transmission, expressed in hours per Btu for the standard square foot of surface and 1°F temperature difference.)

C. Energy Use Per Square Foot Per Building Type

The base document for this sub-study is the Dodge Construction Statistics, United States Summary Bulletin for December, 1967, [3] which tabulates both square footage and dollar cost of construction in that year according to various building types. The building types categories used by Dodge are closely comparable to those used by BEA, which also uses the

Dodge data as one of its sources, and the 23 building sectors isolated by Dodge are easily aggregated for comparison with 15 of the 18 New Building sectors isolated by BEA. Three of the BEA New Building sectors are not included: 27: Residential Alterations & Additions; 48: Farm Residential; and 49: Farm Service Facilities.

Sector 27 is not quantifiable on a square foot basis, in that alterations add dollar cost and energy use to the total for the construction industry but do not add square footage to the building, while additions add all three. It can be assumed that the $ or Btu/SF figure applied to Sector 23: 1-Family Residential would apply to residential additions as well.

Sectors 48 and 49: Farm Buildings have not been covered because of a lack of information at this time. Sector 48: Farm Residential should be similar to Sector 23: 1-Family Residential. Sector 49: Farm Service poses several problems, however. First of all, the buildings covered, ranging from corn cribs to milking parlors, are highly disparate, and the same Btu/SF figure would not apply to each. Secondly, a great deal of the construction activity included in this sector is not building construction but site work, and cannot be described in terms of square feet at all. The Department of Agriculture will be used as a source of information for these two sectors in the further stages of the study.

Table C1 shows Btu/SF used in 1967 by various new Building Construction Sectors. As has been mentioned earlier in this report, the data compiled by F. W. Dodge Company, noting dollars and square feet of construction for the various types of building construction must be used with a certain degree of care. The Dodge figures are based on information received from contractors for construction projects bid in 1967. This

data base is comparable to that used by the Department of Commerce for its Census of Construction Industries (CCI) [4]. However, since Dodge does not cover the smaller establishments or smaller construction contracts, they report only about 75% of the dollar volume of construction reported in CCI.

Neither Dodge nor CCI reports that segment of construction performed by establishments or individuals not classified as "contractors" i.e., suppliers, materials manufacturers, and "do-it-yourself." According to BEA, which does include this activity in its data, this segment is substantial, and accounts for nearly 1/3 of the dollar volume of all construction.

However, although the dollar figures shown by Dodge, CCI, and BEA cannot be used interchangeably, the average cost per square foot ($/SF) of the various building types derived from the Dodge data alone is a valid average figure which can be applied to BEA/CAC figures. This application results in the derivation of not only a Btu/SF figure for each building type, but also a revised estimate of the total square footage of building in the year under study. It should be noted that the Dodge figures correspond to end use, i.e., they include value added (rents, profits, wages, etc.). Energy intensities produced by CAC are compatible with the Dodge figures, however, since the former account for value added. (See reference [1].)

D. Energy-Flow Diagram

This diagram (see Appendix A) charts the energy flow at the CAC 90-level into that level's Sector 14: New Construction. New Construction is an aggregation of the 399-level Sectors 23-54 and includes both building

and nonbuilding construction. Each sector contributing to the construction industry can be viewed as a chain of industrial process, with a direct energy input at each stage of the chain. In order to ascertain the most effective methods of conserving energy through the construction process, it is vital to know at which stages of the chain the significant amounts of direct energy are introduced.

If the major direct energy input for a given product occurs in the course of industrial process, the use of smaller quantities of that material, while conserving some energy, may not be as direct or as effective as the application of conservation measures to the process itself. If a significant amount of embodied energy is introduced into the product through the transportation sectors, the most effective conservation measure might be arrived at through investigation of local industry and a substitution of local materials for those which would have to be transported long distances.

One immediate observation to be made from an inspection of the diagram is the very large part played by the primary metals industries - even larger than one would assume simply from knowledge of the construction field. Thus, conservation measures applied to the iron smelting process will have a far greater impact on total energy consumption through construction than would be assumed by a simple investigation of, say a structural steel beam.

This chart, which has been derived from the CAC 90-Order Energy Input/Output Model [1] is intended to be a prototype only. The aggregation at that level is such (e.g., this chart combines all new construction, both building & non-building) that very little quantitative information

can be drawn from it. Methods used to produce the chart at this level will be refined for handling the problem for some of the 399-order construction sectors.

The chart plus a full description can be found in Appendix A.

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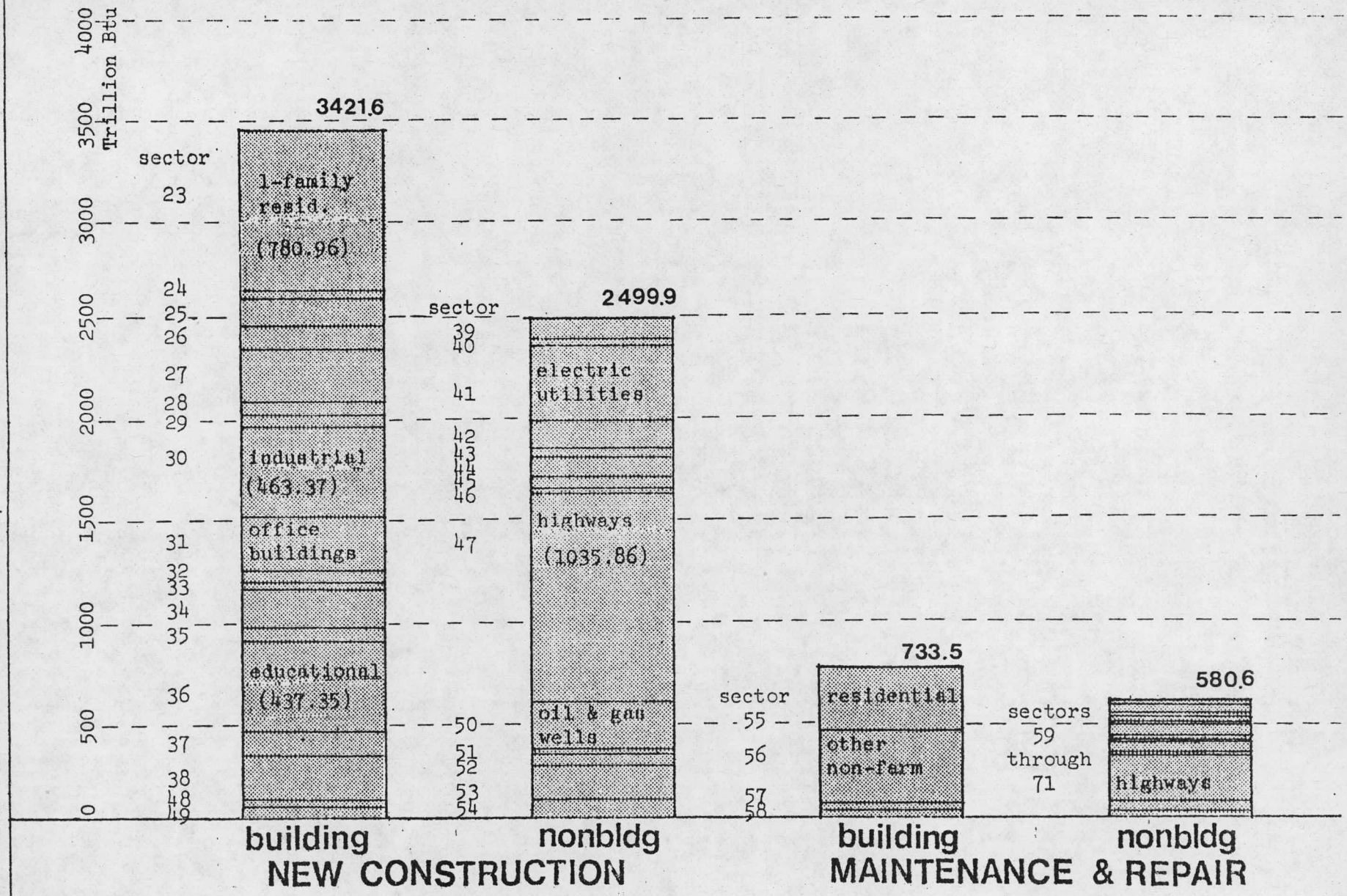
ENERGY IN BUILDING CONSTRUCTION
ERDA Contract No. E(11-1)-2791
Subject Analysis of Energy to Construction Industry

by CAC RGS & A
file A1
date



In 1967 the Construction Industry required a total of 7,235.6 trillion Btu to produce its total output.

49 CONSTRUCTION SECTORS – breakdown by major sector groupings – 1967 trillion Btu

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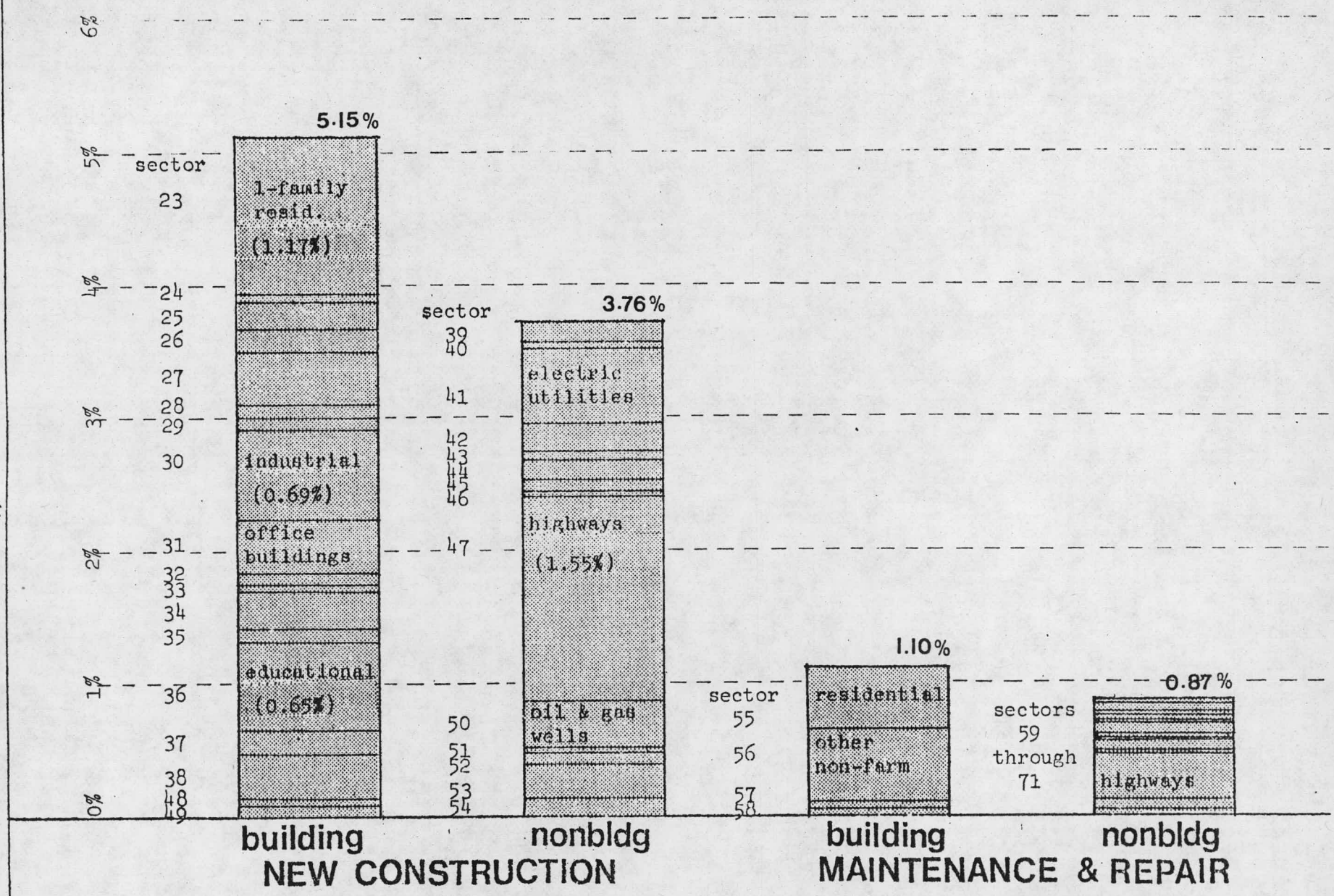

Altogether, the 49 Construction Sectors accounted for 10.82% of total U.S. energy consumption. (See page 20 of the text for some cautions on interpreting these figures.)

49 CONSTRUCTION SECTORS – breakdown by major sector groupings – 1967

% of total United States consumption

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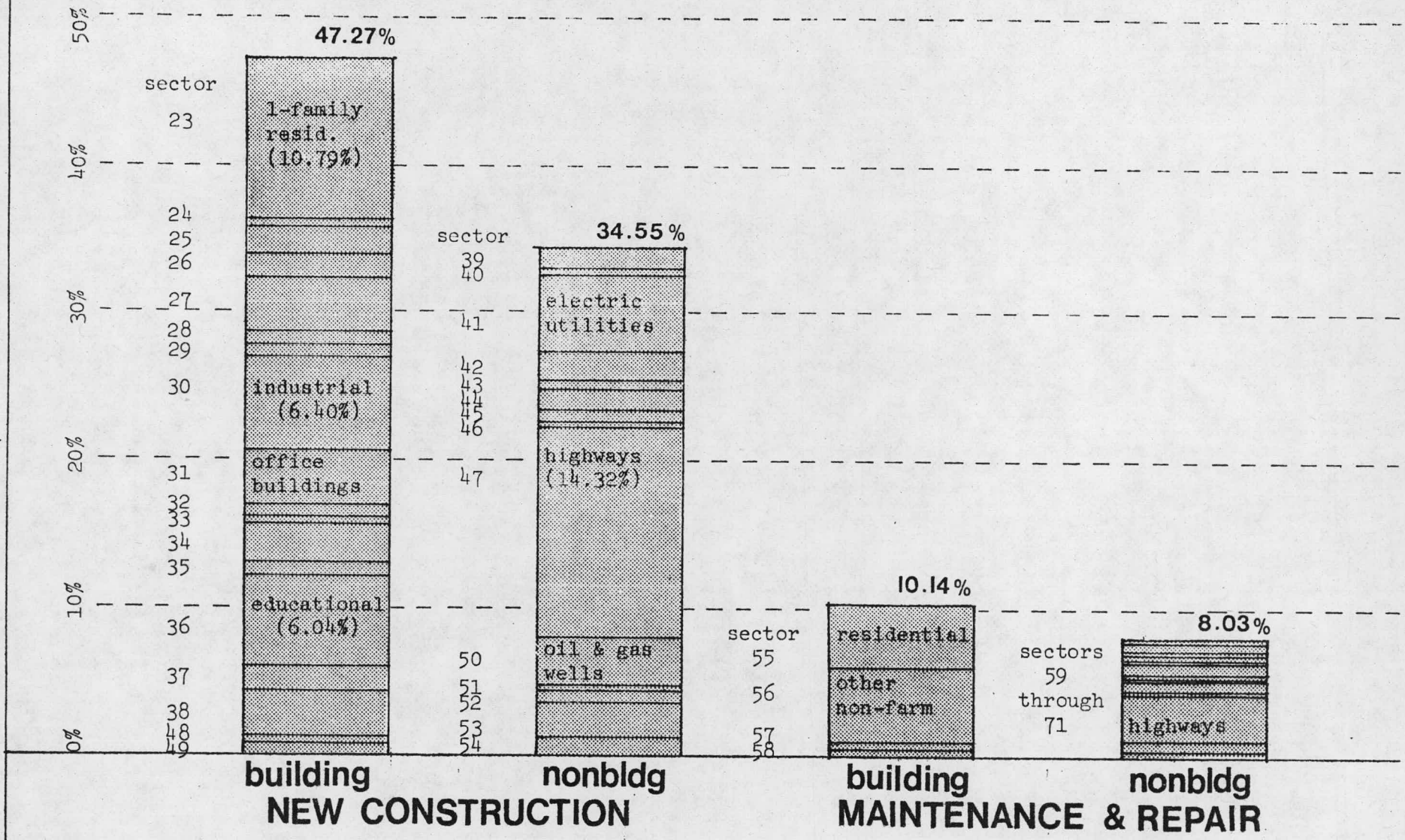
date:

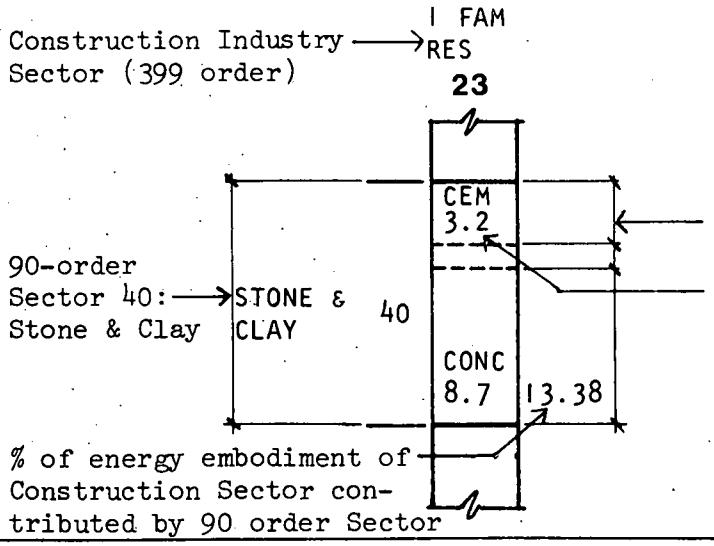


49 CONSTRUCTION SECTORS – breakdown by major sector groupings – 1967
% of total Construction Industry consumption

Abbreviations

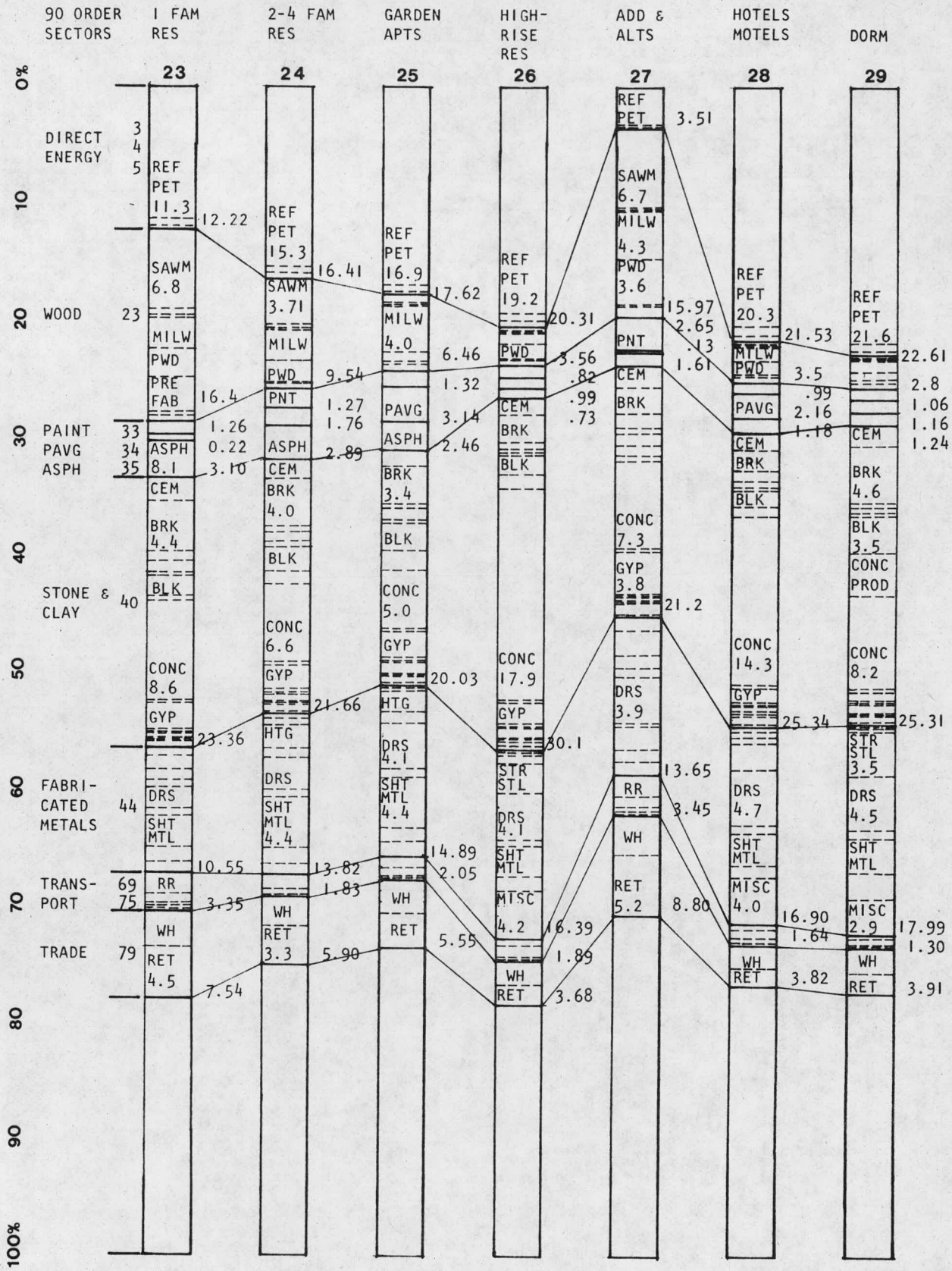
ARCH MTL	Architectural Metal Work
ADD & ALTS	Residential Additions & Alterations
ASB	Asbestos Products
ASPH	Asphalt & Asphalt Coatings
BLDGS	Buildings
BLK	Concrete Blocks
BRK	Bricks
CEM	Cement
CLAY PROD	Clay Products
CONC	Ready-Mix Concrete
CONC PROD	Concrete Products
CONS DEV	Conservation Development
DRS	Metal Doors
EDUC	Educational
ELEC	Electrical
FAB	Fabricated
GYP	Gypsum Products
HTG/HTG EQPT	Heating Equipment
INDUST	Industrial
INS	Mineral Wool Insulation
M + R	Maintenance & Repair
MILW	Millwork
MISC	Miscellaneous Metal Work
N-C REFR	Non-Clay Refractories
PAVG	Paving
PL/FAB PL	Fabricated Plate Work
PETR	Petroleum
PLB	Plumbing Fittings
PNT	Paint Products
PREFAB	Prefabricated Wood Structures
PWD	Veneer, Plywood
REF PET	Refined Petroleum
REFR	Refractories
RELIG	Religious
RES	Residential
REST	Restaurants
RET	Retail Trade
RR	Railroad
SAWM	Sawmills
SERV	Service
SHT MTL	Sheet Metal Work
STR STL	Fabricated Structural Steel
SVC STA	Service Stations
TRANSP	Transport
TRK	Truck Transport
UTIL	Utilities
WD PRES	Wood Preserving
WH	Wholesale Trade

Key



Notes

1. "Direct Energy" in this instance includes both the energy content of the fuels and the energy cost of producing those fuels.



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Subject: Energy Input Fractions By Construction Sector

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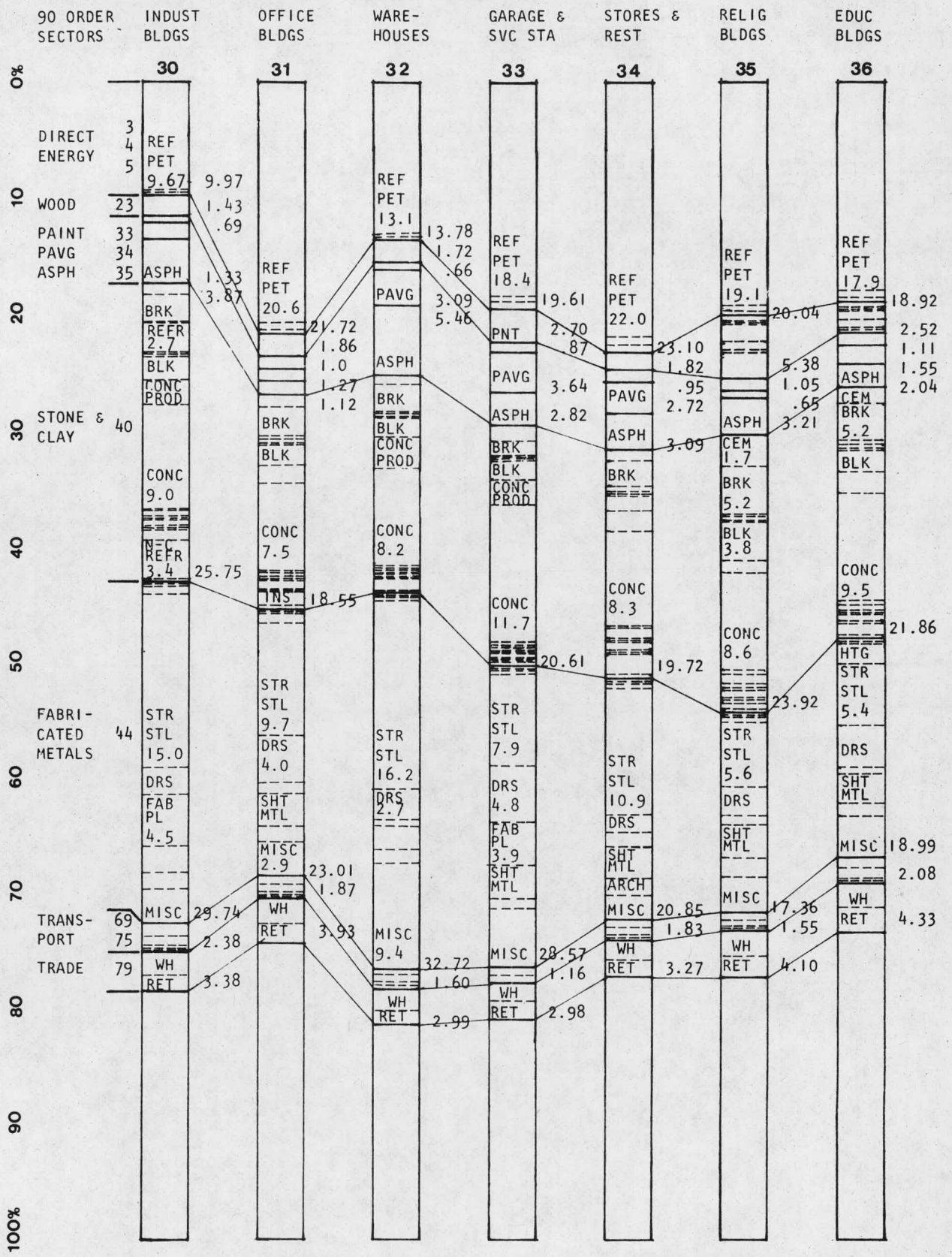

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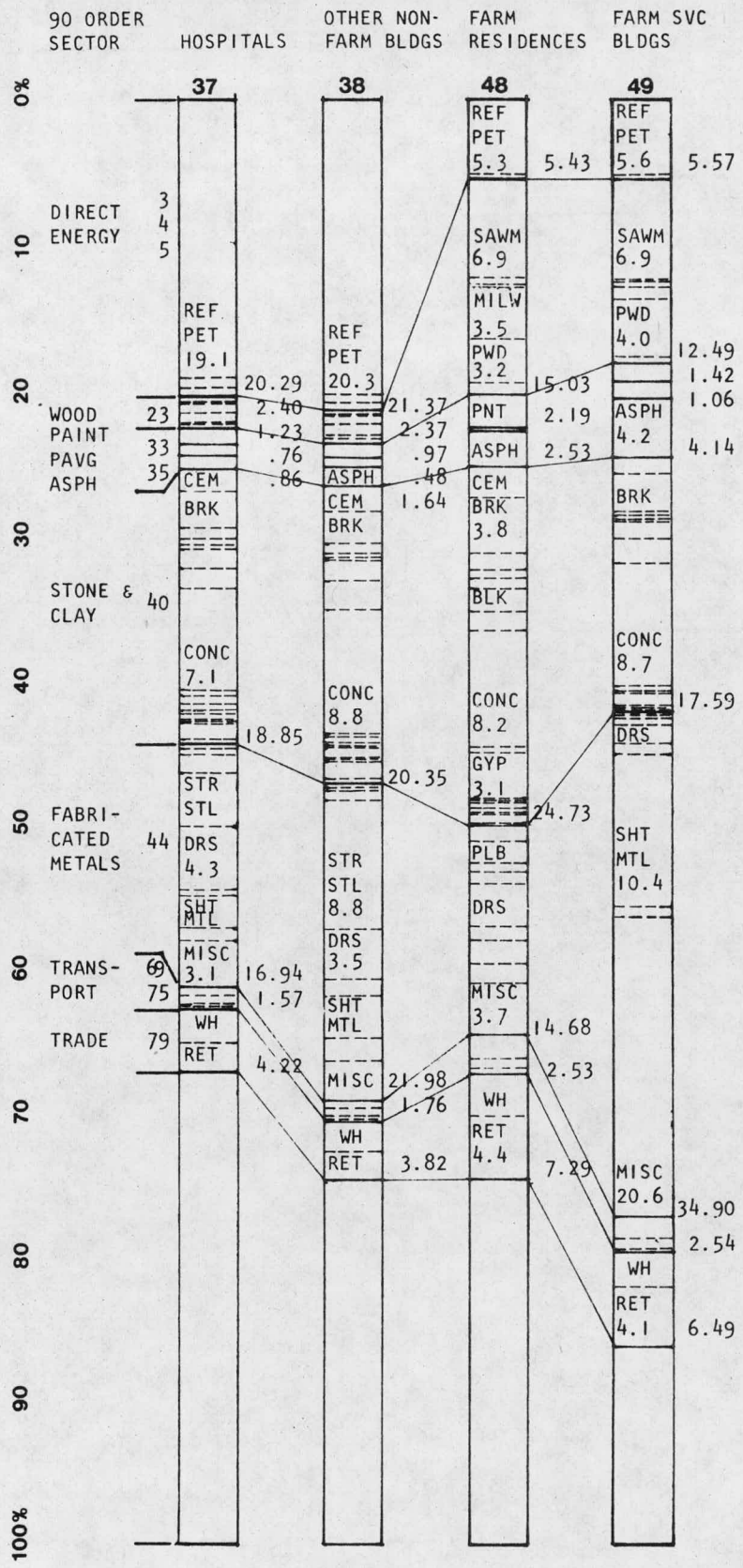

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date 1 Aug 1976

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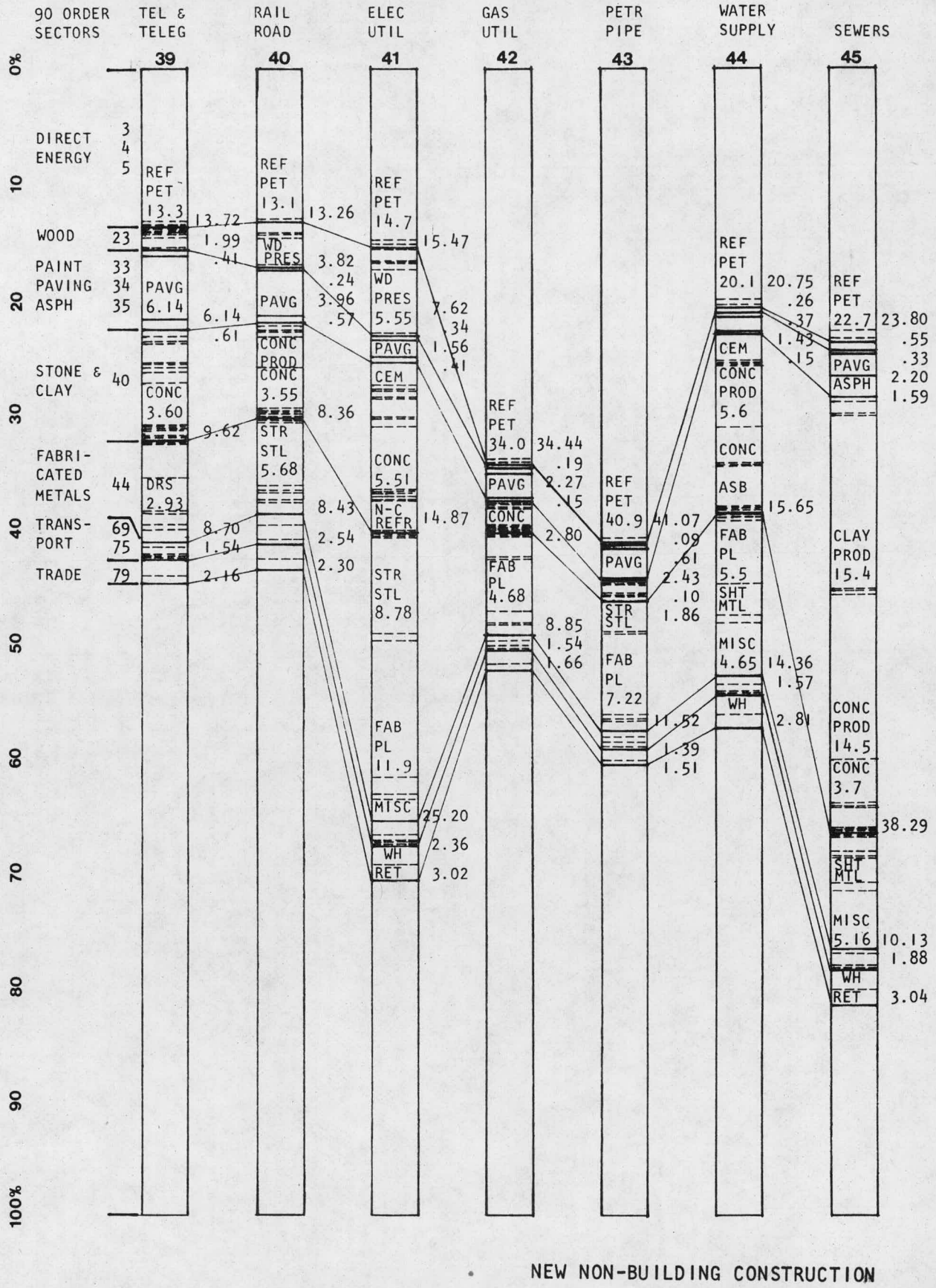
A7



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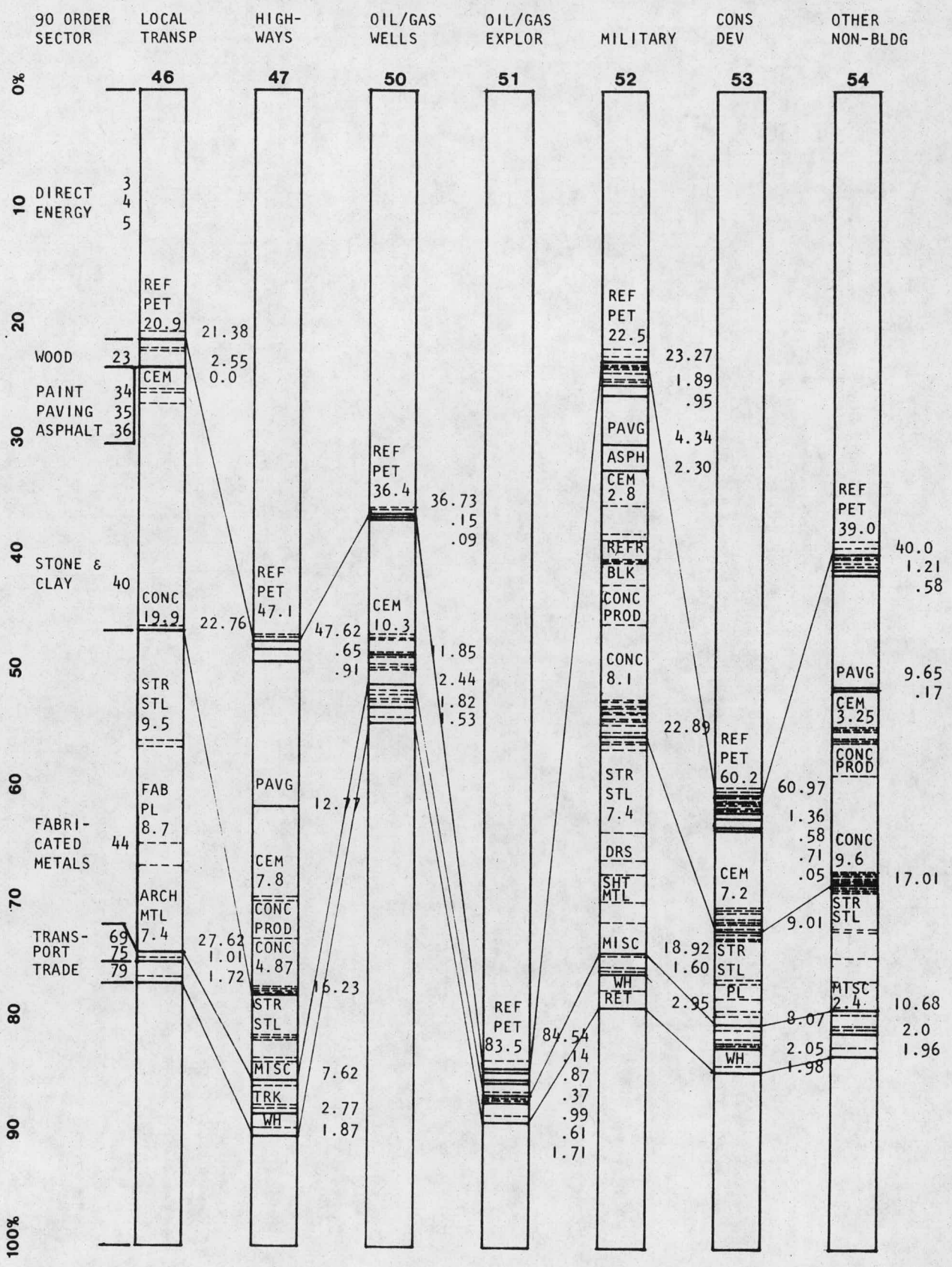
ERDA Contract No. E (11-1)-2791

date: 1 Aug 1976

Subject: Energy Input Fractions By Construction Sector

by: CAC, RGS & A

file: A8



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date: 1 Aug 1976

Subject: Energy Input Fractions By Construction Sector

by: CAC, RGS & A

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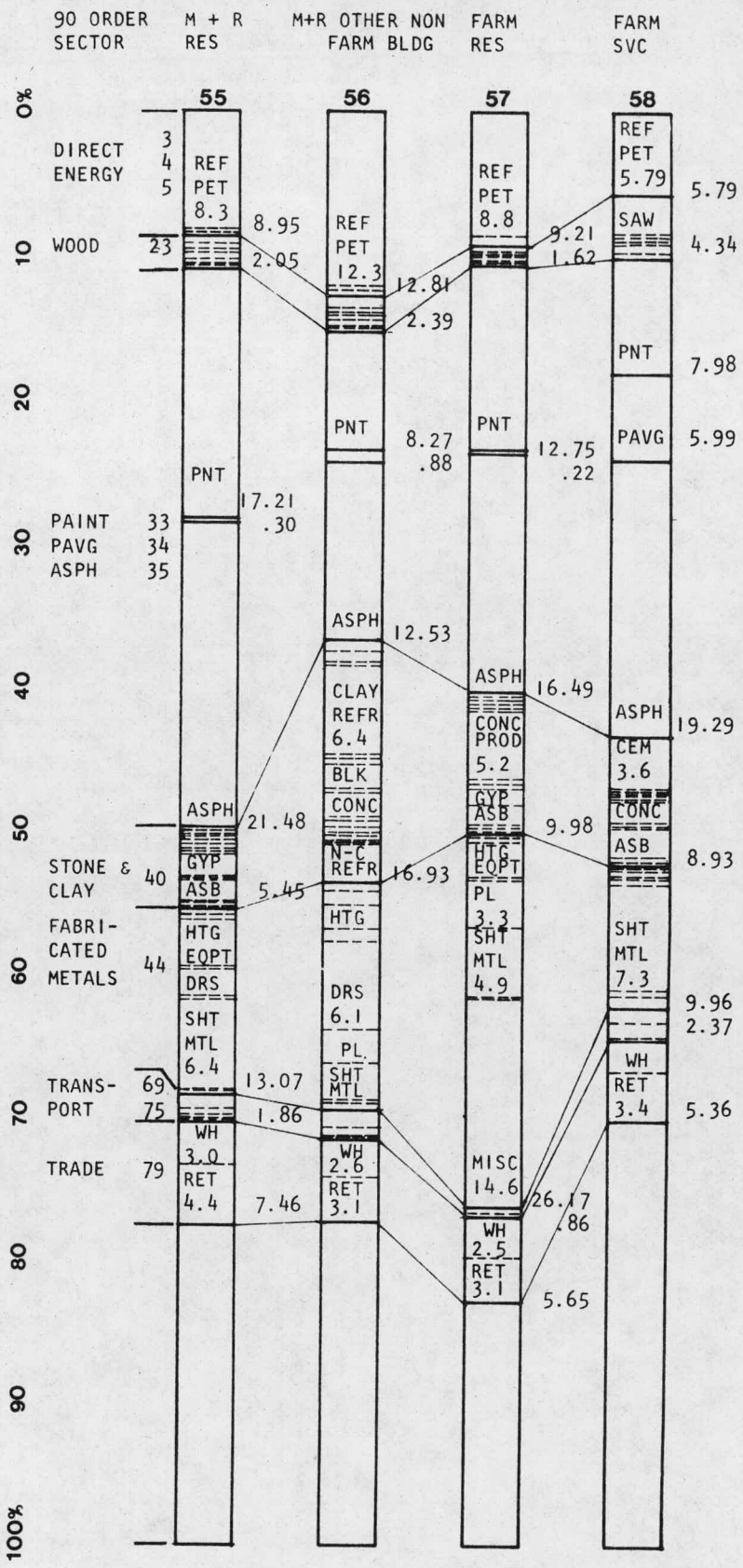

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Subject: Energy Input Fractions By Construction Sector

by: CAC, RGS & A

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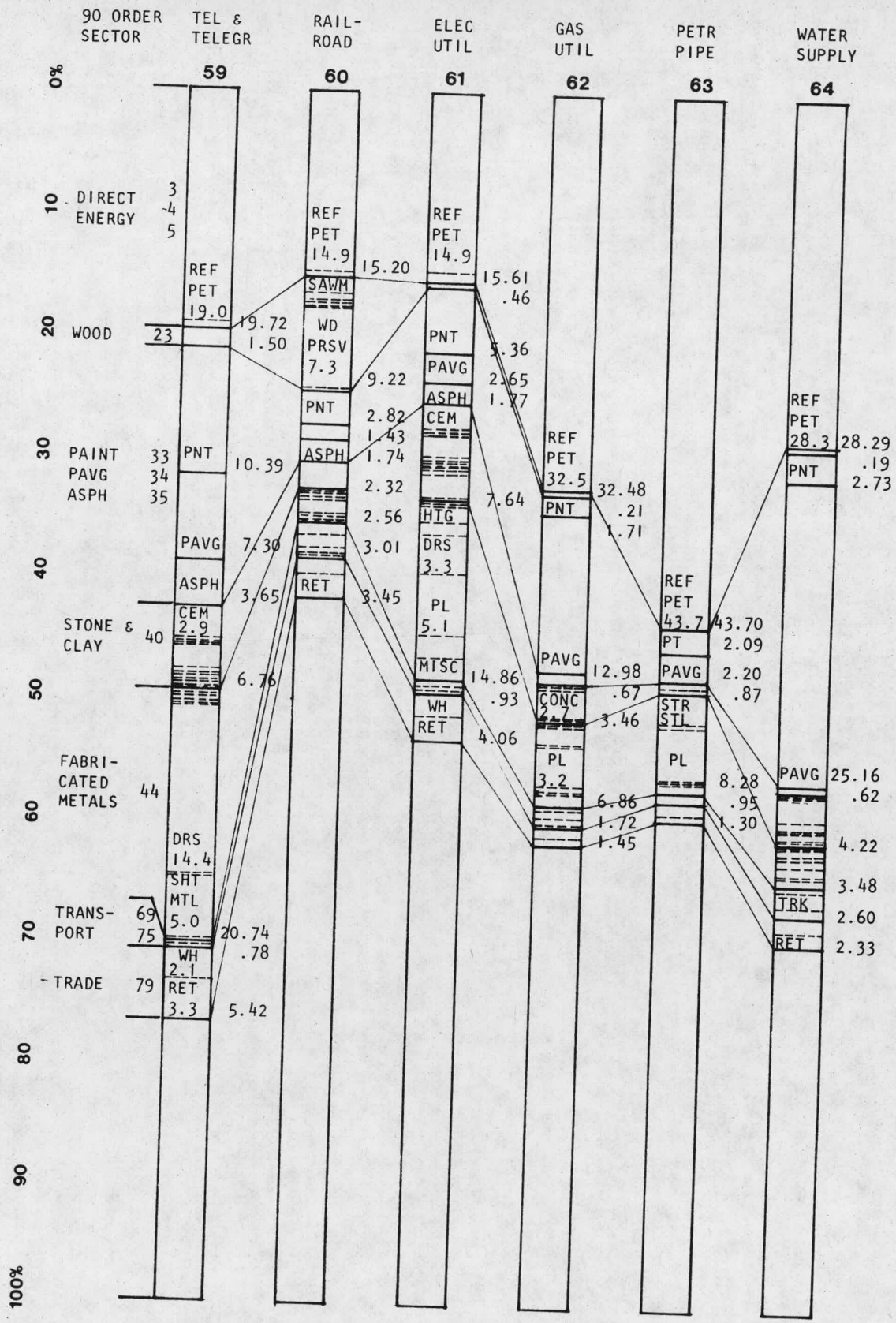

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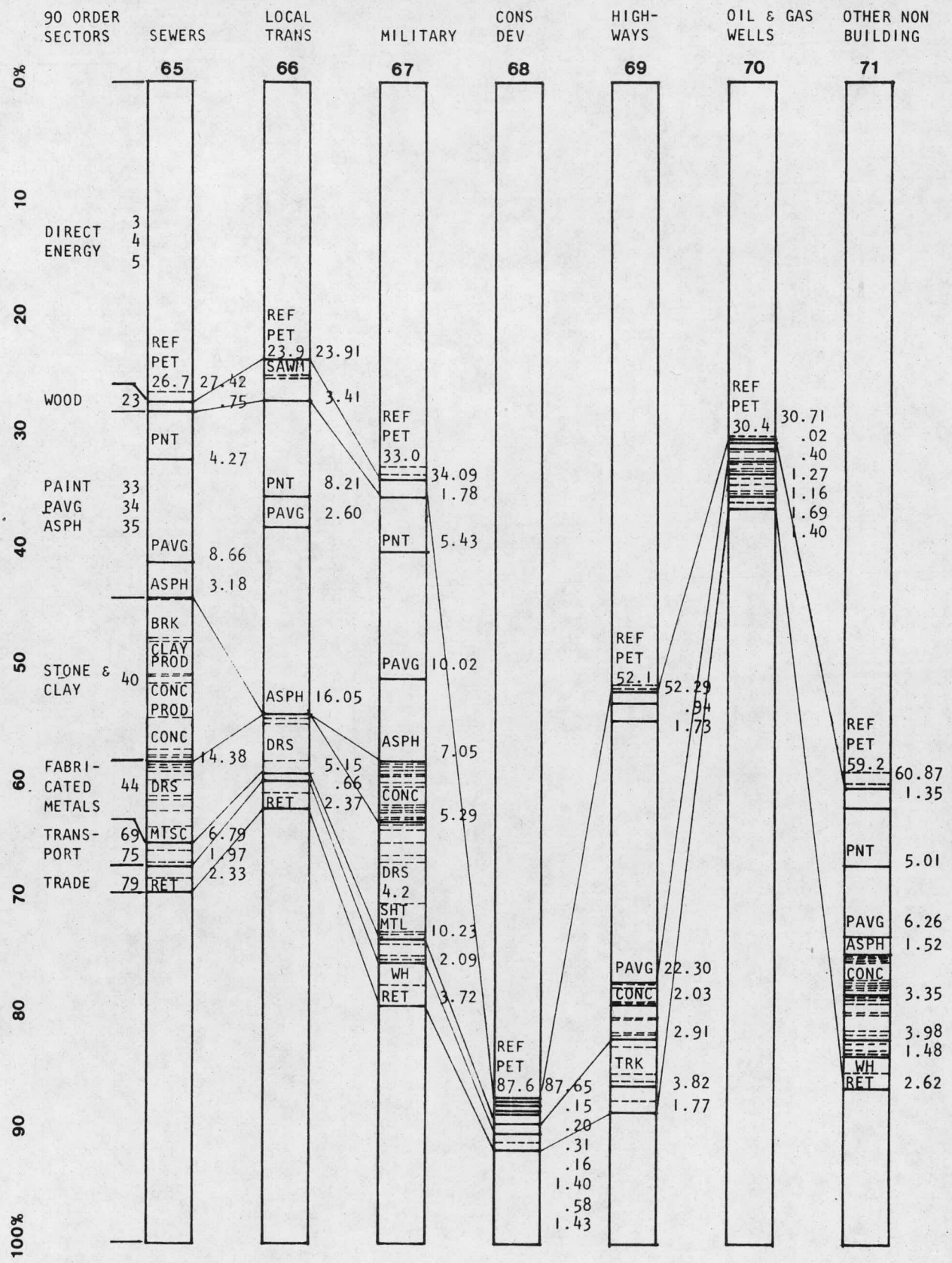
ERDA Contract No. E (11-1)-2791

date: 1 Aug 1976

Subject: Energy Input Fractions By Construction Sector

by: CAC, RGS & A

file: A11



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ERDA Contract No. E (11-1)-2791

date: 1 Aug 1976

Subject: Energy Input Fractions By Construction Sector

by: CAC, RGS & A

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ENERGY IN BUILDING CONSTRUCTION
ERDA Contract No. E(11-1)-2791
Subject: Embodied Energy Per Unit of Building Material
by: CAC
file:
date: 1 Aug 1975
B1

1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO	SIC TITLE	CENSUS OF MANUFACTURES UNIT	NO OF UNITS	TOTAL $	AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNIT)
135	2421	SAWMILL & PLANING MILL PRODUCTS					65285	
	24211 61 24211 63 24211 65	ROUGH LUMBER - SOFTWOOD	BD FT	4,545,100,000	364,100,000	.08	65285	5222.8
	24212 21 24212 23 24212 25	DRESSED LUMBER - SOFTWOOD	BD FT	19,819,600,000	1,640,000,000	.08	65285	5222.8
	24212 27	DRESSED LUMBER - HARDWOOD	BD FT	732,400,000	74,400,000	.10	65285	6528.51
	24218 11	SOFTWOOD FLOORING	BD FT	120,500,000	13,000,000	.11	65285	7181.35

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1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO	SIC TITLE	CENSUS OF MANUFACTURES UNIT	NO OF UNITS	TOTAL $	AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNIT)
136	24261	HARDWOOD DIMENSION & FLOORING					55,516	
	24261 11 24261 19	OAK FLOORING	BD FT	676,400,000	111,800,000	.17		
	24261 31 24261 98	MAPLE & OTHER FLOORING	BD FT	67,400,000	15,100,000	.22		
		TOTAL		743,800,000	126,900,000	.171	55,516	9,471.60

NOTE: THE PRODUCTION OF HARDWOOD FLOORING FOLLOWS THE SAME PROCESS REGARDLESS OF THE TYPE OF WOOD USED. THE PRICE DIFFERENTIAL IS BASED ON SCARCITY OF MATERIAL AND MARKET CONDITIONS, NOT ENERGY EXPENDED. THEREFORE, THE TWO CATEGORIES HAVE BEEN COMBINED TO ARRIVE AT AN AVERAGE BTU/BD FT FIGURE.

PRELIMINARY

ENERGY IN BUILDING CONSTRUCTION
ERDA Contract No. E (11-1)-2791

Subject: Embodied Energy Per Unit of Building Material

by: CAC, RGS & A

date: 1 Aug 1976

file: B2

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ENERGY IN BUILDING CONSTRUCTION
ERDA Contract No. E (11-1)-2791

Subject: Embodied Energy Per Unit of Building Material
by: CAC
date: 1 Aug 1976
file: B3

1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO	SIC TITLE	CENSUS OF MANUFACTURES			AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNIT)
			UNIT	NO OF UNITS	TOTAL $			
137	2429	SPECIAL PRODUCT SAWMILL GOODS					39319	
	24290 03 24290 05 24290 07	RED CEDAR SHINGLES & SHAKES	I SQ FT	325,860,000	38,800,000	.12	39319	4718

PRELIMINARY

1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO	SIC TITLE	CENSUS OF MANUFACTURES UNIT	NO OF UNITS	TOTAL $	AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNIT)
138	2431	MILLWORK					47350.	
	24311 33 24311 36 24311 39	WINDOW UNITS - WOOD[2]	1 EA	7,387,000	142,300,000	19.26	47350.	NOTE 1
	24312 11 24312 13 24312 15 24312 65	WINDOW SASH - WOOD	1 EA	10,007,000	36,600,000	3.66	47350.	NOTE 1
	24314 11 24314 13 24314 19	DOORS, PANEL TYPE - WOOD	1 EA	5,089,000	10,400,000	13.84	47350.	NOTE 1
	24314 31 24314 33	DOORS, FLUSH TYPE - HOLLOW CORE	1 EA	22,936,000	126,000,000	5.50	47350.	NOTE 1
	24314 43 24314 44	DOORS, FLUSH TYPE - SOLID CORE	1 EA	3,571,000	67,400,000	18.88	47350.	NOTE 1
	24315 51	COMB. STORM & SCREEN DOORS	1 EA	804,000	10,200,000	12.69	47350.	NOTE 1
	24315 61	GARAGE DOORS - WOOD	1 EA	1,087,000	57,200,000	52.61	47350.	NOTE 1
	24315 71	SCREEN DOORS - WOOD	1 EA	1,562,000	8,900,000	5.70	47350.	NOTE 1
	24315 81	LOUVRE DOORS	1 EA	2,044,000	15,400,000	7.53	47350.	NOTE 1
	24316 11 24316 51	FINISHED WOOD MOULDINGS	BD FT	668,000,000	189,100,000	.28	47350.	13258

NOTE: 1. DUE TO THE GREAT VARIETY AMONG UNITS, ANY AVERAGE FIGURE DERIVED FROM DIVIDING TOTAL TRANSACTIONS BY QUANTITY OF UNITS CANNOT BE ASSUMED TO BE ACCURATE. FURTHER STUDY IS NECESSARY.

2. ACCORDING TO BEA, ABOUT 90% OF PREFABRICATED WINDOW UNITS WERE GLAZED IN 1967 AND THE TRANSACTIONS FIGURE INCLUDES GLAZING. NO AVERAGE FIGURES CAN BE ASSIGNED IN THIS CATEGORY WITHOUT FURTHER STUDY.

PRELIMINARY

1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO	SIC TITLE	CENSUS OF MANUFACTURES UNIT	NO OF UNITS	TOTAL $	AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNIT)
139	2432	VENEER & PLYWOOD					67686	
	24321 00	HARDWOOD PLYWOOD	SQ FT SM	1,741,300,000	333,000,000	.19	67686	12860
	24322 00	SOFTWOOD PLYWOOD (INTERIOR TYPE)	SQ FT 3/8"	6,919,100,000	387,400,000	.06	67686	4060
	24323 00	SOFTWOOD PLYWOOD (EXTERIOR TYPE)	SQ FT 3/8"	6,183,800,000	401,100,000	.07	67686	4738
	24324 00	PREFINISHED HARDWOOD PLYWOOD	SQ FT SM	922,800,000	105,100,000	.11	67686	7448
	24324 21 24324 23	HARDWD & SOFTWD BASES	SQ FT SM	576,600,000	57,200,000	.10	67686	6760
	24325 11	HARDWD VENEER-SPECIAL & TYPE FACE	SQ FT SM	2,387,500,000	91,700,000	.04	67686	2707
	24325 21	HARDWD VENEER-COMMERCIAL & UTILITY TYPES	SQ FT SM	985,600,000	24,700,000	.03	67686	2031
	24325 51 24325 71	HARDWD VENEER-CONTAINER & FLAT TYPE	SQ FT SM	377,400,000	6,500,000	.02	67686	1354
	24326 11	SOFTWD VENEER-PLYWOOD	SQ FT 1"	1,419,100,000	131,700,000	.09	67686	6092
	24326 31	SOFTWD VENEER-CONTAINER	SQ FT 1"	33,500,000	3,600,000	.11	67686	7445

NOTE: THE PRICE DIFFERENTIAL EVIDENT AMONG THE VARIOUS PLYWOOD CATEGORIES IS NOT NECESSARILY A RESULT OF ENERGY EXPENDITURE, BUT RATHER LABOR INTENSIVITY &/OR RELATIVE RARITY OF MATERIAL. FURTHER STUDY IS NECESSARY IN THIS SECTOR

PRELIMINARY

1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO	SIC TITLE	CENSUS OF MANUFACTURES UNIT	NO OF UNITS	TOTAL $	AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNIT)
140	2433	PREFABRICATED WOOD STRUCTURES					55182.	
	24331 31	GLUED LAMINATED LUMBER	BD FT	147,800,000	39,300,000	.27	55182.	14,899
	24331 33	SAWN LUMBER	BD FT	57,900,000	5,900,000	.10	55182.	5,518
	24331 35	COMB. GLUED LUMBER & SAWN LUMBER	BD FT	68,100,000	17,800,000	.26	55182.	14,347
	24332 31	READY CUT & PREFABRICATED WOOD BLDGS - DWELLINGS	1 EA	57,700	264,400,000	4582.32	55182.	NOTE 1
	24332 41	READY CUT & PREFABRICATED WOOD BLDGS GARAGES, FARM BLDGS, ETC.	1 EA	13,300	26,800,000	2015.04	55182.	NOTE 1
	24332 51	ROOF TRUSSES MADE OF SAWN LUMBER - LIGHT CONSTRUCTION	1 EA	2,956,800	41,600,000	14.07	55182.	NOTE 1

NOTE: DUE TO THE GREAT VARIETY AMONG UNITS, ANY AVERAGE FIGURE DERIVED FROM DIVIDING TOTAL TRANSACTIONS BY QUANTITY OF UNITS CANNOT BE ASSUMED TO BE ACCURATE. FURTHER STUDY IS NECESSARY

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ENERGY IN BUILDING CONSTRUCTION
ERDA Contract No. E (11-1)-2791

Subject: Embodied Energy Per Unit of Building Material

by: CAC

date: 1 Aug 1976

file: B6

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1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO	SIC TITLE	CENSUS OF MANUFACTURES UNIT	NO OF UNITS	TOTAL $	AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNIT)
182	2851	PAINTS & ALLIED PRODUCTS					122,390	
	28511 11 28511 21 28511 22 28511 24 28511 25 28511 27 28511 28 28511 31 28511 32 28511 33 28511 34 28511 35 28511 37 28511 39	EXTERIOR OIL-TYPE TRADE SALES PAINT PRODUCTS	GAL	88,800,000	297,200,000	3.35	122,390	409.620
	28512 11 28512 16 28512 19	EXTERIOR WATER-TYPE TRADE SALES PRINT PRODUCTS	GAL	36,700,000	124,000,000	3.38	122,390	413,530
	28513 52 28513 53 28513 54 28513 56 28513 59	INTERIOR OIL-TYPE TRADE SALES PAINT PRODUCTS- OILS, ENAMELS, VARNISHES IN READY-MIX FORM	GAL	54,600,000	191,800,000	3.51	122,390	429,590
	28513 65 28513 67 28513 71	INTERIOR OIL-TYPE TRADE SALES PAINT PRODUCTS- VARNISHES & STAINS	GAL	9,800,000	34,100,000	3.48	122,390	425,870
	28514 11 28514 21 28514 31 28514 98	INTERIOR WATER-TYPE TRADE SALES PAINT PRODUCTS INCLUDING TINTING BASES	GAL	93,900,000	283,200,000	3.02	122,390	369,130

NOTE: ON AN AVERAGE, 1 GALLON OF PAINT WILL SUPPLY 1 COAT OF PAINT FOR 300-350 SF OF EXTERIOR WOOD OR MASONRY WALL; 475 SF OF INTERIOR WALL OR TRIM; AND 525 SF OF EXTERIOR TRIM.

PRELIMINARY

ENERGY IN BUILDING CONSTRUCTION
ERDA Contract No. E(11-1)-2791

Subject: Embodied Energy Per Unit of Building Material

by: **CAC** **RGS & A**

date: 1 Aug 1976

file: **B7**

1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO	SIC TITLE	CENSUS OF MANUFACTURES UNIT	NO OF UNITS	TOTAL $	AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNIT)
184	2952	ASPHALT FELTS & COATINGS					478,610	
	29522 12	ROOFING ASPHALT	SH T*	1,535,500	43,100,000	28.07	478,610	13,434,580
	29523 11	ASPHALT ROOFING: SMOOTH SURFACED ROLLED ROOFING & CAP SHEET, INCLUDING SANDED, TALC, MICA, & OTHER FINE MATERIAL SURFACING	SQ FT	1,690,000,000	26,500,000	.02	478,610	9,570
	29523 13	MINERAL SURFACED ROLL ROOFING & CAP SHEET	SQ FT	1,370,000,000	30,500,000	.02	478,610	9,570
	29523 14	STRIP SHINGLES-SELF SEALING	SQ FT	1,910,000,000	114,900,000	.06	478,610	28,720
	29523 16	STANDARD OR REGULAR STRIP SHINGLES	SQ FT	2,330,000,000	119,500,000	.05	478,610	23,930
	29523 17	INDIV. SHINGLES-ALL STYLES	SQ FT	400,000,000				
	29523 31	ASPHALT BLDG SIDINGS: ROLL FORM & SHINGLE FORM ALL PATTERNS	SQ FT	40,000,000	1,100,000	.03	478,610	14,360
	29523 35	MINERAL-SURFACED INSULATING BOARD BASE SIDING (ALL TYPES & FINISHES)	SQ FT	30,000,000	4,100,000	.14	478,610	67,000
	29523 51	SATURATED FELTS: ASPHALT SATURATED FELTS FOR ROOFING AND SIDINGS	SH T	864,600	47,700,000	55.17	478,610	26,404,910
	29523 55	SATURATED FELTS: TAR SATURATED FELTS FOR ROOFING & SIDING	SH T	46,600	3,200,000	68.67	478,610	32,866,150

*SHORT TON (2,000 LBS.)

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ERDA Contract No. E(11-1)-2791

Subject: Embodied Energy Per Unit of Building Material

by: CAC

date: 1 Aug 1976

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ERDA Contract No. E(11-1)-2791

Subject
Embodied Energy Per Unit of Building Material

by
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RGS & A

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1 Aug 1976

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1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO	SIC TITLE	CENSUS OF MANUFACTURES UNIT	NO OF UNITS	TOTAL $	AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNIT
193	3211	FLAT GLASS					102,810	
	32111 22	UNCOLORED SINGLE STRENGTH	SQ FT	490,000,000	56,700,000	.12	102,810	11,900
	32111 23	UNCOLORED DOUBLE STRENGTH	SQ FT	205,000,000	26,800,000	.13	102,810	13,440
	32111 24	HEAVY SHEET (UNCOLORED)	SQ FT	300,000,000	37,000,000	.12	102,810	12,680
	32111 26	THIN, INCLUDING PICTURE GLASS & TINTED OR COLORED (ALL THICKNESSES)	SQ FT	65,000,000	11,000,000	.17	102,810	17,400
	32114 21 32114 23 32114 29	TEMPERED GLASS FOR ARCHITECTURAL & CONSTRUCTION PURPOSES INCLUDING GLASS FOR SHOWER DOORS & ENTRANCE DOORS & OTHER USES, AUTOMOTIVE	SQ FT	166,900,000	102,600,000	.61	102,810	62,710
	32114 98	OTHER FLAT GLASS (SUCH AS PLATE GLASS BLANKS, BENT OR ENAMELED SHEET, PLATE, FLOAT, & ROLLED GLASS, GLASS DOORS & TUB ENCLOSURES (OTHER THAN TEMPERED) MULTIPLE-GLAZED SEALED INSULATING UNITS	SQ FT	19,100,000	5,600,000	.29	102,810	30,140
	32112 13	PLATE & FLOAT GLASS NOT OVER 1/8" IN THICKNESS	SQ FT	282,500,000	89,800,000	.32	102,810	32,680
	32112 15	PLATE & FLOAT GLASS OVER 1/8" IN THICKNESS	SQ FT	210,400,000	85,600,000	.41	102,810	41,830

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1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO	SIC TITLE	CENSUS OF MANUFACTURES UNIT	NO OF UNITS	TOTAL $	AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNIT
193	3211	FLAT GLASS					102,810	
	32112 17 32112 11	PLATE GLASS & FLOAT GLASS OVER 1/4" IN THICKNESS, & ROLLED & WIRE GLASS	SQ FT	54,200,000	25,100,000	.46	102,810	47,610
	32113 11 32313 11	LAMINATED PLATE GLASS	SQ FT	190,000,000	342,000,000	1.80	102,810	185,060
	32113 31 32313 31							
	32113 51 32313 51 32113 71 32313 98	LAMINATED SHEET GLASS & OTHER LAMINATED GLASS	SQ FT	20,500,000	19,700,000	.96	102,810	98,800

ENERGY IN BUILDING CONSTRUCTION
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Subject: Embodied Energy Per Unit of Building Material

by: CAC, RGS & A

date: 1 Aug 1976

file: B9-2

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1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO	SIC TITLE	CENSUS OF MANUFACTURES UNIT	NO OF UNITS	TOTAL $	AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNIT)
195	3241	CEMENT, HYDRAULIC					479,590	
	32410 11	PORTLAND CEMENT	1 bbl @ 376 lbs	361,900,000	1,151,900,000	3.18	479,590	1,526,500[1]
	32410 31	PREPARED OR MIXED HYDRAULIC & MASONRY CEMENTS OTHER THAN SPECIAL PORTLANDS	1 bbl @ 280 lbs	20,800,000	66,400,000	3.19	479,590	1,530,950[1]

NOTE: AN AMERICAN GAS ASSOCIATION STUDY USING 1964 FIGURES FOR DIRECT PROCESS ENERGY ALONE SHOWED 1,372 MILLION BBL OF CEMENT PRODUCED USING 423 MILLION BTU OR ABOUT 1,140,000 BTU/BBL. A STUDY OF ENERGY CONSERVATION POTENTIAL IN THE CEMENT INDUSTRY BY THE PORTLAND CEMENT ASSOCIATION FOR FEA (1975) INDICATED AN AVERAGE OF 1,080,000 BTU/BBL OF CEMENT IN DIRECT PROCESS ENERGY AT THE KILN IN 1967 (AND SLIGHTLY LESS FOR 1964).

ENERGY IN BUILDING CONSTRUCTION
ERDA Contract No. E (11-1)-2791

Subject: Embodied Energy Per Unit of Building Material

by: CAC, RGS & A

date: 1 Aug 1976

file: B10

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1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO	SIC TITLE	CENSUS OF MANUFACTURES UNIT	NO OF UNITS	TOTAL $	AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNIT
196	3251	BRICK & STRUCTURAL TILE					340,290	
	32511 11	BLDG OR COMMON BRICK & FACE (2 1/4" x 3 5/8" x 7 5/8")	1 BRK	7,394,900,000	294,900,000	.04	340,290	13,570
	32511 19	OTHER BRICK (PAVING, FLOOR & SEWER) (2 1/4" x 3 5/8" x 7 5/8")	1 BRK	21,000,000	1,500,000	.07	340,290	24,300
	32512 11	STRUCTURAL CLAY TILE EXCEPT FACING INCLUDING LOAD BEARING & NON-LOAD BEARING TILE	1 TILE[1]	80,200,000	6,200,000	.08	340,290	26,300
	32512 31	FACING TILE (STRUCTURAL) & CERAMIC GLAZED BRICK (2 1/4" x 3 5/8" x 7 5/8")	1 BRK	231,500,000	21,600,000	.09	340,290	31,750
	32412 51	UNGLAZED & SALT GLAZED FACING TILE (8" x 5" x 12")	1 TILE	4,200,000	800,000	.19	340,290	64,870

NOTE: 1. CENSUS OF MANUFACTURES LISTED QUANTITIES BY WEIGHT ONLY FOR THIS CATEGORY. THE UNIT QUANTITY WAS DETERMINED BY ASSUMING AN AVERAGE STRUCTURAL CLAY TILE WEIGHS APPROXIMATELY 6 POUNDS.

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ENERGY IN BUILDING CONSTRUCTION
ERDA Contract No. E(11-1)-2791

Subject
Embodied Energy Per Unit of Building Material

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1 Aug 1976

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B11

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1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO	SIC TITLE	CENSUS OF MANUFACTURES UNIT	NO OF UNITS	TOTAL $	AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNIT
197	3253	CERAMIC WALL & FLOOR TILE					110,610	
	32530 71	QUARRY TILE & PROMENADE TILE	SQ FT	34,900,000	14,700,000	.42	110,610	46,590
	32530 13	CERAMIC MOSAIC TILE & ACCESSORIES - GLAZED	SQ FT	6,000,000	3,400,000	.57	110,610	62,680
	32530 53	CERAMIC MOSAIC TILE & ACCESSORIES - UNGLAZED	SQ FT	29,900,000	15,700,000	.53	110,610	58,080

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ENERGY IN BUILDING CONSTRUCTION
ERDA Contract No. E (11-1)-2791

Subject
Embodied Energy Per Unit of Building Material

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1 Aug 1976

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1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO	SIC TITLE	CENSUS OF MANUFACTURES UNIT	NO OF UNITS	TOTAL $	AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNI
204	3271	CONCRETE BLOCKS						
	32710 16	STRUCTURAL BLOCK - HEAVY WEIGHT AGGREGATE 8" x 8" x 16"	1 BLK	567,000,000	114,600,000	.20	141,630	28,330
	32710 18	STRUCTURAL BLOCK - DECORATIVE	1 BLK	63,600,000	14,600,000	.23	141,630	32,510
	32710 51	BRICK (2 1/4 x 3 5/8 x 7 5/8")	1 BRK	479,700,000	15,400,000	.03	141,630	4,550

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ENERGY IN BUILDING CONSTRUCTION
ERDA Contract No. E (11-1)-2791

Subject: Embodied Energy Per Unit of Building Material

by: CAC, RGS & A

date: 1 Aug 1976

file: **B13**

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1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO	SIC TITLE	CENSUS OF MANUFACTURES UNIT	NO OF UNITS	TOTAL $	AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNI
206	3273	READY MIX CONCRETE	CU YD	162,400,00	2,330,500,000	14.35	180,130	2,588,49
207	3274	LIME					507,010	
	32740 11	QUICKLIME	1 T	7,548,000	95,200,000	12.61	507,010	6,394,12
	32740 51	HYDRATED LIME	1 T	2,123,000	36,900,000	17.38	507,010	8,812,37
	32740 71	DEAD BURNED DOLOMITE	1 T	1,307,000	23,400,000	17.90	507,010	9,077,30
208	3275	GYPSUM PRODUCTS					158,540	
	32751 11	CALCINED GYPSUM BLDG MATERIALS, BLDG PLASTERS & PREFAB BLDG MATERIALS	1 T	8,686,000	339,100,000	39.04	158,540	6,189,40
	32752 11	OTHER CALCINED GYPSUM PRODUCTS, INDUSTRIAL PLASTERS	1 T	785,000	19,400,000	24.71	158,540	3,918,06

NOTE: 1. AN AMERICAN GAS ASSOCIATION STUDY, USING 1964 FIGURES FOR DIRECT PROCESS ENERGY ALONE ESTIMATED AN AVERAGE ENERGY COST OF 6,000,000 BTU/T OF LIME.

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ENERGY IN BUILDING CONSTRUCTION
ERDA Contract No. E(11-1)-2791

Subject: Embodied Energy Per Unit of Building Material

by: CAC, RGS & A

file: B14

date: 1 Aug 1976

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ENERGY IN BUILDING CONSTRUCTION
ERDA Contract No. E(11-1)-2791

Subject: Embodied Energy Per Unit of Building Material

by: CAC, RG&A

date: 1 Aug 1976

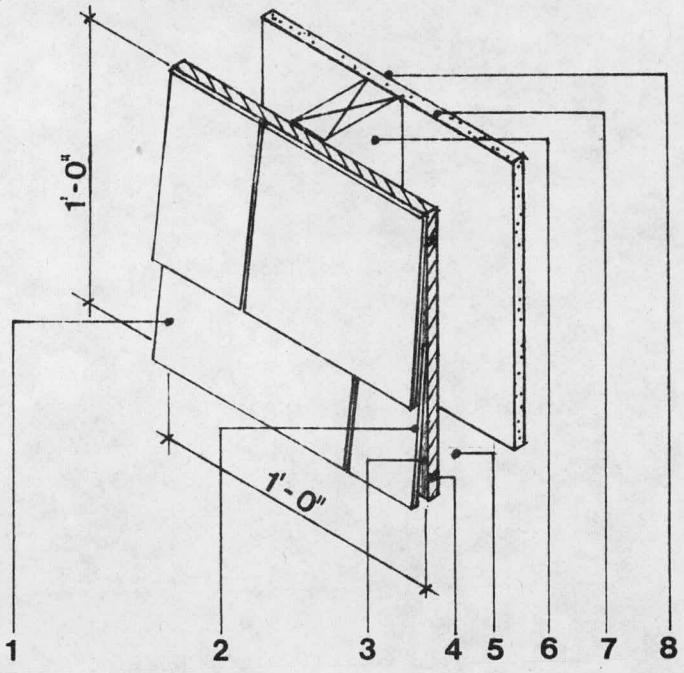
file: B15

1967 ENERGY EMBODIMENT PER UNIT OF MATERIAL BEFORE DELIVERY TO JOBSITE

CAC NO	SIC NO		CENSUS OF MANUFACTURES UNIT	NO OF UNITS	TOTAL $	AVERAGE COST/UNIT	CAC BTU/$	EMBODIED ENERGY (BTU/UNI
214	3296	MINERAL WOOL (FOR STRUCTURAL INSULATION)					155,870	
	32961 11	LOOSE FIBER (BLOWING & POURING) & GRANULATED FIBER	1 SH T	261,900,000	19,200,000	73.31	155,870	11,426,8
	32961 23	4.5 INCHES OR MORE THICK (BLDG BATTS, BLANKETS & ROLLS)	SQ FT	274,900,000	13,100,000	.05	155,870	7,7
	32961 27	3.0 TO 4.4 INCHES THICK	SQ FT	1,014,600,000	39,600,000	.04	155,870	6,2
	32961 33	2.0 TO 2.9 INCHES THICK	SQ FT	561,500,000	22,200,000	.04	155,870	6,2
	32961 37	LESS THAN 2.0 INCHES THICK	SQ FT	417,200,000	11,400,000	.03	155,870	4,2

PRELIMIN

WOOD FRAME WALLS



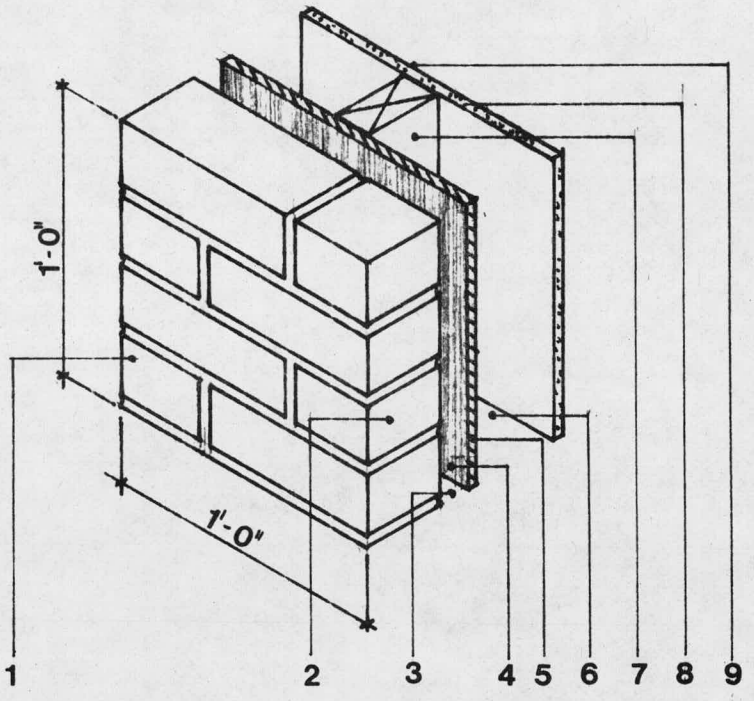
	CONSTRUCTION	R VALUE	EMBODIED ENERGY (BTU/SQ FT) IN BLDG SECTION
1.	OUTSIDE SURFACE (15 MPH WIND)	.17	-
2.	WOOD SHINGLES (1/2" x 8" LAPPED)	.87	4,718
3.	BLDG PAPER (ASPHALT)	.15	-
4.	PLYWOOD (1/2")	.62	4,738
5.	4" AIRSPACE	.97	-
6.	2" x 4" @ 16" o.c.	-	2,585
7.	GYPSUM WALLBOARD (1/2")	.45	9,510
8.	INSIDE SURFACE (STILL AIR)	.68	-
		3.91	21,551

U = 1/R = .26

ADDITION OF INSULATION	R VALUE	EMBODIED ENERGY (BTU/SQ FT) IN BLDG SECTION
ADD 3 1/2" BATT INSULATION	11.00	ADD 6,230
DEDUCT R VALUE OF AIR SPACE	.97	
	10.03	
ADD TO ABOVE R VALUE	3.91	
	13.79	27,781

U = 1/R = .07

BRICK ON WOOD FRAME WALLS



	CONSTRUCTION	R VALUE	EMBODIED ENERGY (BTU/SQ FT) IN BLDG SECTION
1.	OUTSIDE SURFACE (15 MPH WIND)	.17	-
2.	BRICK & MASONRY (4")	.44	143,060
3.	1" AIRSPACE	.97	-
4.	BUILDING PAPER (ASPHALT)	.15	-
5.	PLYWOOD (3/8")	.47	4,738
6.	4" AIRSPACE	.97	-
7.	2" x 4" @ 16 o.c.	-	2,585
8.	GYPSUM WALLBOARD (3/8")	.32	7,920
9.	INSIDE SURFACE	.68	-
		3.98	159,893

U = 1/R = .25

ADDITION OF INSULATION	R VALUE	EMBODIED ENERGY, ((BTU/SQ FT) IN BLDG SECTION
ADD 3 1/2" BATT INSULATION	11.00	ADD 6,230
DEDUCT R VALUE OF AIRSPACE	.97	
	10.03	
ADD TO ABOVE R VALUE	3.98	
	14.01	166,123

U = 1/R = .07

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1967 ENERGY EMBODIMENT PER SQ FT OF BUILDING TYPE

CAC NO	1967 I/O 399 LEVEL NEW CONSTRUCTION	TOTAL SQ FT	TOTAL $ [1]	TOTAL $/SQ FT	BTU/$ [2]	BTU/SQ FT
23	RESIDENTIAL - 1 FAMILY	1,050,517,000	13,285,874,000	12.65	55,511	702,21
24	RESIDENTIAL - 2-4 FAMILY	40,609,000	486,827,000	11.99	52,139	625,14
25	RESIDENTIAL - GARDEN APT	352,452,000	4,323,280,000	12.27	52,864	736,20
26	RESIDENTIAL - HIGH RISE				60,000	
27	RESIDENTIAL - ALTER & ADDN	-	-	-	51,646	
28	HOTEL/MOTEL	35,633,000	581,310,000	16.31	69,184	1,128,39
29	DORMITORIES	42,372,000	858,629,000	20.26	70,604	1,430,43
30	INDUSTRIAL BUILDINGS	269,650,000	3,700,726,000	13.72	70,864	972,25
31	OFFICE BUILDINGS	158,318,000	3,781,344,000	23.88	68,737	1,641,44
32	WAREHOUSES	95,390,000	686,843,000	7.20	77,556	558,40
33	GARAGES/SERVICE STATIONS	37,720,000	381,812,000	10.12	76,217	771,31
34	STORES/RESTAURANTS	170,146,000	2,188,587,000	12.86	73,183	941,13
35	RELIGIOUS BUILDINGS	41,379,000	793,407,000	19.17	65,597	1,257,49
36	EDUCATIONAL	204,258,000	4,168,058,000	20.41	67,924	1,386,32
37	HOSPITAL BUILDINGS	65,820,000	1,873,269,000	28.46	60,512	1,722,17
	OTHER NON-FARM BUILDINGS					
38	a. AMUSEMENT, SOCIAL & RECREATION	42,249,000	834,047,000	19.74	69,894	1,379,70
	b. MISC NON-RESIDENTIAL BUILDINGS	43,299,000	682,678,000	15.77	69,894	1,102,22
	c. LABORATORIES	20,387,000	604,970,000	29.67	69,894	2,073,75
	d. LIBRARIES, MUSEUMS, ETC.	17,763,000	443,119,000	24.96	69,894	1,744,55
48	FARM RESIDENCES	-	-	-	53,773	
49	FARM SERVICE	-	-	-	76,956	
	TOTAL BUILDING (EXCLUDING ALT & ADD, FARM	2,687,951,000	39,674,780,000			

NOTES:

1. SOURCE: F. W. DODGE CO., DODGE CONSTRUCTION STATISTICS 1967 (BASED ON CONTRACTORS' BID PRICES)
2. FROM CAC

ENERGY IN BUILDING CONSTRUCTION
ERDA Contract No. E(11-1)-2791

Subject: Embodied Energy (Btu/SF) for Building Types

by: CAC, RGS & A

date: 1 Aug 1976

file: C1

IV. FUTURE WORK

For the remaining six months of the project, our approach to determining possible energy savings in building construction will be two-fold. First, we will consider the effects of substitution of materials on the energy cost of building construction, as described in "Energy Use for Building Construction: Project Plan," February 24, 1976. This effort will include extension and refinement of our determination of energy cost per unit of material, analysis of energy cost of selected building components which can be used interchangeably with the same performance, and determination of the energy savings due to interchangeability of basic materials which comprise such components. (We will also consider the energy cost of trade and transportation necessary to deliver basic materials to the construction site.) Future study will also deal with the broader energy trade-off of minimizing the total (construction plus operation) energy cost of buildings by substitution of different assemblies.

The second line of approach involves determining which industries are major contributors to the total energy requirements of building construction due to their own use of direct energy to produce goods and services for the construction industry. The Flow Chart in Appendix A is a first attempt at identifying such industries for New Construction (an aggregate sector). Conservation in these contributing industries would result in energy savings in building construction. In the next phase of the project, we will refine the method for conducting such an analysis and direct it towards pinpointing energy-contributing industries for some of the highly disaggregated 399-level construction sectors.

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[3] Dodge Construction Statistics, United States Summary Bulletin for December, 1967, F. W. Dodge Company, New York City.

[4] 1967 Census of Construction Industries, U.S. Department of Commerce, Bureau of the Census, U. S. Government Printing Office, Washington, D.C., January 1971, Vols. I and II.

[5] 1967 Census of Manufactures, U. S. Department of Commerce, Bureau of the Census, U.S. Government Printing Office, Washington, D. C., 1971, Vols. I and II.

[6] "The Input-Output Structure of the U.S. Economy," Survey of Current Business, Vol. 54, No. 2., Bureau of Economic Analysis, U.S. Department of Commerce, February 1974.

ADDITIONAL SOURCES

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W. J. Barney Corporation, Hawthorn, New York, George Marcus.

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APPENDIX A

The purpose of this sub-study is to develop the means for identifying the points of entry into the economy of primary energy which eventually is transferred into New Construction as embodied energy. The study uses data from the 90-level Input/Output Model [1] of energy flow through the United States economy developed by the Center for Advanced Computation at the University of Illinois. The basic data have been reformulated to generate a flow diagram into a single 90-level sector, in this case, New Construction.

This new formulation differs from the Input-Output Model in that it deals only with the portions of industries which feed directly or indirectly into Sector 14 - New Construction.* The flow diagram has several significant characteristics.

Scale - The vertical dimensions of the elements composing the flow diagram represent the quantities of energy which these sectors transfer directly or indirectly into New Construction. The sectors which made major contributions are immediately apparent.

Indirect Primary Energy Input - The flow chart locates all of the major inputs of primary energy to New Construction directly, to industries which sell their products to new construction, and to industries which sell their products to other industries which in turn sell to New Construction. The magnitudes of the primary energy inputs indicated on the flow diagram represent only the primary energy inputs which are eventually transferred to New Construction as embodied energy.

---

*In this section, sector indices are those of the 90-level model. Refer to Table 1, Section II for the relationship between 90 and 399 order sectors.

Major Indirect Contributors - The flow chart permits the identification of those sectors which make substantial indirect contributions to New Construction through their contributions to sectors which sell directly to New Construction.

Distribution Patterns - The flow chart indicates graphically the transfers of embodied energy from the indirect contributors to New Construction through the direct contributors to New Construction and finally to New Construction itself.

Development of Flow Data from Input/Output Data

The Input/Output Model for 1967 contains two sets of data which are directly applicable to the flow diagram. The first is the total direct and embodied energy in the new construction sector. This total is 5566.7 trillion Btu, and is indicated by Column A of the flow diagram.

The second set of data which is directly transferable from the Input/Output Model to the flow diagram is the list of direct energy inputs to New Construction. These total 1286.2 trillion Btu and are represented on the flow diagram by the red bar in Column B. This indicates the total quantity of primary energy which is consumed as a result of purchases by the New Construction sector directly from the energy sectors. The remaining 4280.5 trillion Btu of the total direct and indirect energy used by New Construction is introduced as embodied energy in the products which New Construction purchases from other sectors.

A third set of data, almost directly transferable from the Input/Output Model to the energy flow diagram is the quantity of embodied energy transferred from the non-energy sectors to New Construction. At this point, the basic data from the Input/Output Model are modified as follows:

The sectors contributing to New Construction are divided into two

categories - those which contribute greater than one percent of the total embodied energy in New Construction and those which contribute less than one percent. The sectors which contribute less than one percent are combined into groupings which, according to indexing used by CAC, fall numerically between the larger contributing sectors. For example, between Large Sector 35, Asphalt Coverings, and Large Sector 40, Stone and Clay Products, there is a grouping of Sectors 36 through 39. Reformulation of the data is represented by the remainder of Column B. The groupings of small contributing sectors are shown in blue and the 14 large contributing sectors are shown unshaded. It can be seen that the largest indirect energy contributor to New Construction at this level is Sector 40, Stone and Clay Products (1015.4 trillion Btu).

Columns C and D examine the smaller contributors in greater detail. In Column C the small contributing sectors are broken down into those which contribute more than 10 trillion Btu and groupings which contain the rest. Thus, in the grouping of Sectors 13 through 22, which contains a total of 24.7 trillion Btu, it can be seen from Column C that 18.9 trillion Btu comes from Sector 20, Miscellaneous Textile Goods, and the remaining 5.8 trillion Btu comes from the other sectors contained in that grouping.

In order to extend the analysis to transactions further removed from New Construction, the basic assumption has been made that the pattern of energy input distribution, indicated by the Input/Output Model, will be representative of the portion of each sector which is purchased by New Construction. While this may not be accurate in all cases, it serves as a starting point for a general anleysis.

Column D on the energy flow diagram indicates the direct energy input into those sectors and groups of sectors which are less than one percent of New Construction. As usual, the red bars represent total energy embodied in direct fuels. In order to derive this quantity, it is necessary to perform two operations on the Input/Output data. First, the sum of the input coefficients of the direct energy inputs is computed for each sector. For a particular sector this sum indicates the percent of the total energy embodied by that sector which results from direct energy consumption. Second, by multiplying the total embodied energy transfer from the particular sector to New Construction by this percentage, the primary energy consumed by each sector which is in turn transferred as embodied energy to New Construction is quantified.

These results are displayed in Columns D and E of the energy flow diagram. Comumn D relates to those sectors which contribute less than one percent of the total energy embodied in New Construction, while Column E relates to the 14 sectors which contribute greater than one percent of the total. The energy embodied in direct energy input is identified by the red bars, and the energy embodied in the products purchased from other sectors is represented by the blue bars in Columns D and E.

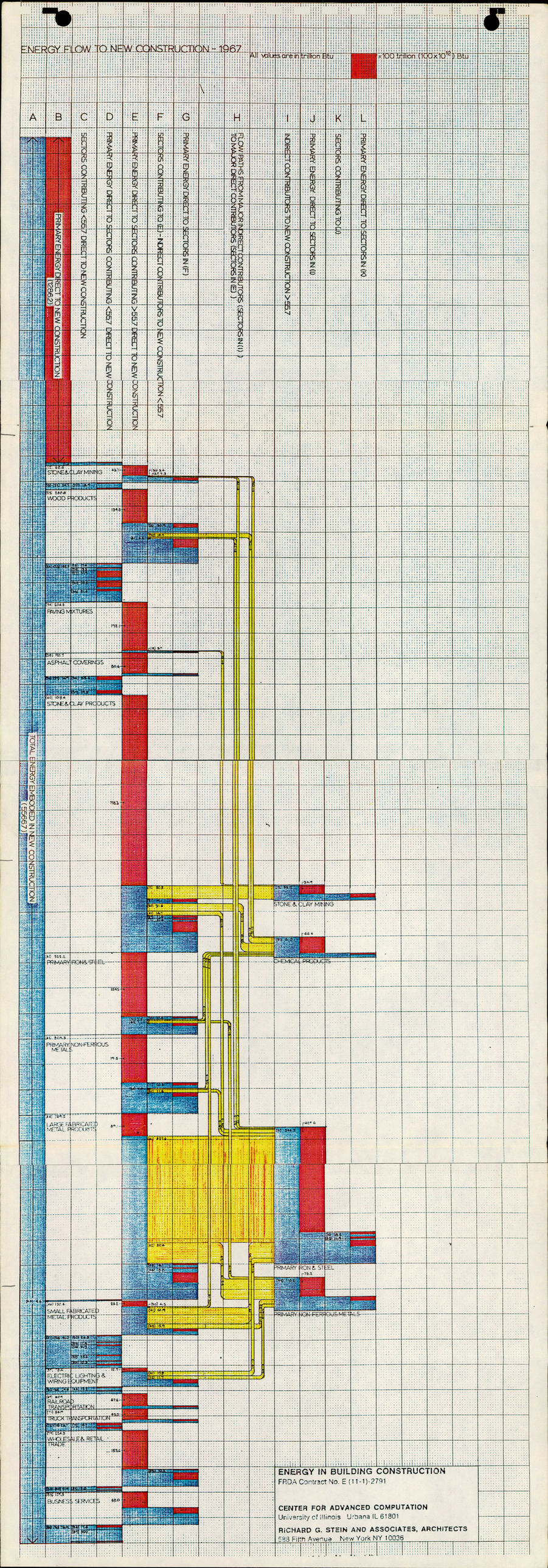
For the 14 sectors which contribute greater than one percent of the embodied energy to New Construction, the sources of the energy which they embody due to their purchases from other sectors are examined in greater detail. It is at this point that the analysis differs between the major contributing sectors and the minor ones. For the minor sectors, the flow diagram simply indicates that there is energy embodied in purchases which they make from other sectors. For the major sectors, the flow diagram identifies the sources of the major contributors (Column F) and the primary

energy which these sectors have embodied directly (Column G). These results are developed using a series of detailed operations on the Input/Output Model. The total indirect contribution to New Construction of each sector through the 14 major sectors is then determined. Where this total contribution is greater than one percent of New Construction (55.7 trillion Btu), it is represented in Column I. All other contributions are treated individually. Where the individual contribution is greater than 10 trillion Btu, it is shown graphically separated. The remaining contributions which are each less than 10 trillion Btu are grouped. In the case of contributions from sectors greater than 55.7 trillion Btu, all contributions greater than 3 trillion Btu are shown by the yellow paths connecting Column E to Column I. The contributions which the sectors in Column I make to the sectors in Column E which are less than 3 trillion Btu are not shown; however, they are included in the total values for the sectors in Column I.

The four sectors which contribute indirectly more than one percent of the total energy embodied in New Construction are shown in Columns I, J, K, and L. The method for the breakdown of these sectors is the same as that for the 14 major sectors contributing directly to New Construction Column I shows the total embodied energy in each sector. Column J shows the breakdown between the primary energy introduced directly into each sector and the energy which is embodied in products which that sector purchases from other sectors. Column K further breaks down the embodied energy introduced into each sector into the major contributing sectors,

that is, those sectors which contribute more than 10 trillion Btu and groupings of all other sectors. Column L shows the primary energy input into the sectors which contribute the energy which is then embodied by the four sectors shown. In this case no sector which contributes to any or all of the four sectors has a total input greater than 55.7 trillion Btu (one percent of New Construction), and therefore, the analysis is discontinued at this point. The energy embodied in total direct energy input (which has been identified by the red bars on the flow chart) accounts for about 81 percent of all of the energy embodied in New Construction at this stage of the analysis. The remaining 19 percent is introduced in the form of embodied energy in products which come from very small contributors and therefore are not specifically identified.

For the purposes of this study the flow diagram has several distinct limitations. First, it is a diagram of the entire New Construction sector of which a substantial portion is in Non-building Construction. Because of this, it may not be possible to draw accurate conclusions regarding the patterns of primary energy input into New Building Construction. Second, the descriptions of the contributing categories is at 90-level specificity. The diagram does, however, serve in two significant ways. It is a prototypical model of an approach to determining the input patterns into specific building types from specific supplying sectors at a more disaggregated level. The methods used here can be refined and implemented on a digital computer to display construction industry input patterns for selected sectors at the 399-level, for example. In addition, the diagram provides an overall qualitative view of the primary energy input points and the flows of embodied energy which eventually create the total energy embodied by all New Construction.


ENERGY FLOW TO NEW CONSTRUCTION - 1967
All values are in trillion Btu
=100 trillion (100 x 10^12) Btu
A
B
C
D
E
F
G
H
I
J
K
L
PRIMARY ENERGY DIRECT TO NEW CONSTRUCTION (12662)
SECTORS CONTRIBUTING <557 DIRECT TO NEW CONSTRUCTION
PRIMARY ENERGY DIRECT TO SECTORS CONTRIBUTING <557 DIRECT TO NEW CONSTRUCTION
PRIMARY ENERGY DIRECT TO SECTORS CONTRIBUTING >557 DIRECT TO NEW CONSTRUCTION
SECTORS CONTRIBUTING TO (E) - INDIRECT CONTRIBUTORS TO NEW CONSTRUCTION <557
PRIMARY ENERGY DIRECT TO SECTORS IN (F)
FLOW PATHS FROM MAJOR INDIRECT CONTRIBUTORS (SECTORS IN (I)) TO MAJOR DIRECT CONTRIBUTORS (SECTORS IN (E))
INDIRECT CONTRIBUTORS TO NEW CONSTRUCTION >557
PRIMARY ENERGY DIRECT TO SECTORS IN (I)
SECTORS CONTRIBUTING TO (J)
PRIMARY ENERGY DIRECT TO SECTORS IN (K)
TOTAL ENERGY EMBODIED IN NEW CONSTRUCTION (5567)
STONE & CLAY MINING
WOOD PRODUCTS
PAVING MIXTURES
ASPHALT COVERINGS
STONE & CLAY PRODUCTS
PRIMARY IRON & STEEL
PRIMARY NON-FERROUS METALS
LARGE FABRICATED METAL PRODUCTS
SMALL FABRICATED METAL PRODUCTS
ELECTRIC LIGHTING & WIRING EQUIPMENT
RAILROAD TRANSPORTATION
TRUCK TRANSPORTATION
WHOLESALE & RETAIL TRADE
BUSINESS SERVICES
CHEMICAL PRODUCTS
ENERGY IN BUILDING CONSTRUCTION
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