Toward a National Plan for the Accelerated
Commercialization of Solar Energy

Residential/Commercial
Buildings Market Sector

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WORKBOOK

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**Toward a National Plan for the Accelerated
Commercialization of Solar Energy**

MTR--80W00020

DE83 016946

**Residential/Commercial
Buildings Market Sector**

WORKBOOK

AC01-78C535147

James W. Taul, Jr.
Dyanne L. de Jong

January 1980

Prepared for
the Department of Energy
Conservation and Solar Applications
Contract No. EM-78-C-01-5147

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ABSTRACT

This workbook summarizes the preliminary data and assumptions of the Residential and Commercial/Institutional Buildings Market Sector prepared in conjunction with the development of inputs for a National Plan for the Accelerated Commercialization of Solar Energy.

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RESIDENTIAL AND COMMERCIAL/INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

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INTRODUCTION

This workbook contains preliminary data and assumptions used during the preparation of inputs to a National Plan for the Accelerated Commercialization of Solar Energy (NPAC).¹ The workbook indicates the market potential, competitive position, market penetration, and technological characteristics of solar technologies for this market sector over the next twenty years.

The workbook also presents projections of the mix of solar technologies by U.S. Census Region (see Figure 1). In some cases, data have been aggregated to the national level.

Emphasis of the workbook is on a mid-price fuel scenario, Option II, that meets about a 20 percent solar goal by the year 2000. The energy demand for the mid-price scenario is projected at 115 quads in the year 2000.

The workbook, prepared in April 1979, represents government policies and programs anticipated at that time. The data reflecting changes in government policy, energy costs, energy demands, and solar commercialization status may be periodically updated.

¹Toward a National Plan for the Accelerated Commercialization of Solar Energy:
Bennington, G., et al., The Implications of a National Commitment, MTR79W00004R-1, January 1980;
Miller, G., et al., Guidelines for Regional Planning, MTR79W00385, January 1980;
Rebibo, Kathy K., Price/Demand Scenarios and Projections of Solar Utilization under the National Energy Act, MTR-8057, May 1979. McLean, Virginia: The MITRE Corporation.

THE SCENARIOS

U.S. energy consumption in 2000 was determined by using the three macroeconomic scenarios developed for the DPR.¹ The three scenarios are:

- o low-price oil/high end-use demand
- o mid-price oil/intermediate end-use demand
- o high-price oil/low end-use demand

For NPAC, the scenarios were subjected to further review. The fuel price/energy consumption projections in Figure 2 show that end-use demand will be 132, 115, and 105 quads for low-price, mid-price, and high-price scenarios respectively.

A scenario based on low-price oil assumes a high energy end-use demand. Conversely, high-price oil would drive the energy demand down. A mid-price scenario would imply an intermediate level of demand. The low-price oil scenario assumes that in the year 2000 a barrel of oil will cost \$18 (1976 constant \$) at the wellhead. The mid-price scenario calls for a price of \$25/barrel. The high-price is assumed to be \$32/barrel.

¹Rebibo, Kathy K. Toward a National Plan for the Commercialization of Solar Energy: Price/Demand Scenarios and Projections of Solar Utilization under the National Energy Act, MTR-8057. McLean, Virginia: The MITRE Corporation, May 1979.

*Price to industrial sector

FIGURE 2
U.S. ENERGY CONSUMPTION

The market sector was analyzed¹ for the three price/demand scenarios, and each price scenario was tested at four levels of incentives. The Reference Case includes the solar commercialization incentives in the National Energy Act (NEA), 1978.² Analysis of the NEA incentives indicates that solar technologies will displace approximately 14.5 quads of primary fuel in the year 2000. The three other levels of incentives would displace approximately 18, 22, and 25 quads of primary fuel in 2000.

COMMERCIALIZATION DEVELOPMENT CONCERNS

The workbook also identifies the principal commercialization development issues facing the market sector, participants, and apparent constraints to market development. These factors, including the expected impact of current federal programs, were included in the market penetration estimates.

The marketplace has four principal participants: property owner; architectural and engineering firms responsible for designing the solar energy system; financial or lending

¹Estimates of market penetration were made using the computer simulation model, SPURR. Rebibo, K., et al. A System for Projecting the Utilization of Renewable Resources: SPURR Methodology, MTR-7570. McLean, Virginia: The MITRE Corporation, September 1977.

²The Reference Case is referred to as the NEA Option.

institutions that may be investing in "new" technologies; and the manufacturer. Economic uncertainty of the solar technologies is the prevalent concern of this market sector and participants. Economic uncertainties include the high cost of solar systems, unavailability of financing, and relative insecurity of the investment. Federal RD&D programs are underway to lower the system cost. Congress has passed investment tax credits (ITC) and low-interest loans with extended repayment terms for the same purpose. To further lower systems costs potential federal programs include larger investment tax credits, more liberal depreciation schedules for solar equipment, federal cost sharing and federal grants, government purchases, and government loan guarantees.

Commercialization of solar technologies faces institutional and technical barriers. These include lack of confidence in system reliability and performance, lack of insurability, and low public awareness of the technology. Government RD&E programs also aim at removing these social/institutional barriers by increasing performance and reliability or by demonstrating the viability of solar installations. Other programs which may help remove these barriers include: establishing warranty requirements; providing federal insurance or federally guaranteed insurance; amending or rewriting building codes; removing aesthetic zoning code barriers; creating a uniform definition of "sua rights"; and public information dissemination programs.

A summary of the market sector workbook follows.

SUMMARY
RESIDENTIAL AND COMMERCIAL/INSTITUTIONAL BUILDINGS

BUILDINGS INVENTORY

The basic inventory of the buildings market sector analysis was derived from the Ballinger survey within the General Electric Phase 0 Solar Feasibility Study.¹ Residential buildings are expected to increase from 55 million in 1970 to 74 million in 2000. Commercial/institutional buildings are expected to increase from 3.8 million in 1970 to 7.8 million in 2000. The smallest growth rates are expected to be in the New England and the Mid-Atlantic regions, while the highest growth rates are expected to be in the West South Central and the Mountain regions.

THERMAL LOAD

Although there are ten times more residential than commercial/institutional buildings, the energy demand of all residential buildings is only 15 to 20 percent greater than the energy demand of all commercial buildings. Load summaries for each submarket sector and detailed thermal loads by building type and climatic region are given in the workbook.

¹General Electric. Solar Heating and Cooling of Buildings: Phase 0 Feasibility and Planning Study Final Report. Volume 3--Book 3. Document No. -74SD4219. Valley Forge, Pennsylvania: General Electric Space Division, 1974.

ECONOMIC INCENTIVES

To hasten acceptance of alternate energy technologies and promote energy conservation, the NEA included tax incentives for "qualified energy conservation expenditures and qualified renewable energy source expenditures." In the residential sector, the income tax credits are 30 percent for the first \$2,000 and 20 percent for the next \$8,000 spent on these installations. These credits expire at the end of 1985. For commercial buildings, the NEA established a 10 percent investment tax credit for the 1978 through 1982 period only.

Three additional levels of incentives were assumed--Options I, II, and III. These levels and their time-phasing for each market sector are displayed in the workbook. In the residential sector, the highest level of incentive is a 30 percent tax credit or its equivalent, extending to the year 2000. In the commercial/institutional sector, the highest level is a 20 percent tax credit or its equivalent, extending to the year 2000. Tax credit equivalents may be in the form of accelerated depreciation schedules or reduced loan interest rates.

ENERGY COSTS

Energy costs were evaluated on a regional basis using cost criteria applicable to these technologies. The two principal measures of energy cost were cost per capacity and cost of

delivered energy. Cost per capacity is the ratio of initial cost of the solar installation and its backup system to the capacity of the entire system. The cost of delivered energy is the annualized present worth of all systems costs over the life of the system divided by the product of the system's output and a present value factor. The present value factor is used to normalize projected future energy use to a current index of usefulness. The results of these analyses, plus equations for these terms are in the workbook.

MARKET PENETRATION

The number and value of systems sold is sensitive to the three price/demand scenarios as well as the incentive levels. In general, low-price conventional fuel will depress the volume of sales, and high-price fuel will increase the annual sales volume at each level. Increase in government support from the NEA to Option I will increase the total volume of sales in 2000 by almost 30 percent. The increase in government support in Option II will increase sales over the NEA by approximately 50 percent. The highest Option level considered in this analysis, Option III, will increase sales over the NEA by about 80 percent.

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BUILDINGS MARKET SECTOR WORKBOOK

TOTAL ANNUAL BUILDING LOADS

TOTAL ANNUAL BUILDING LOADS ARE CALCULATED ON THE BASIS OF THE AGGREGATED BUILDING LOADS FOR ALL THERMAL APPLICATIONS. ALL UNITS IN QUADS, 10^{15} BTUs.

RESIDENTIAL BUILDINGS

YEAR	LOW-PRICE SCENARIO	MID-PRICE SCENARIO	HIGH-PRICE SCENARIO
1985	8.28	8.10	8.08
1990	8.97	8.78	8.76
2000	10.56	10.37	10.35

COMMERCIAL AND INSTITUTIONAL BUILDINGS

YEAR	LOW-PRICE SCENARIO	MID-PRICE SCENARIO	HIGH-PRICE SCENARIO
1985	7.20	7.04	7.02
1990	7.34	7.18	7.17
2000	7.97	7.82	7.81

APRIL 1979

RESIDENTIAL AND COMMERCIAL/INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

RESIDENTIAL AND COMMERCIAL BUILDINGS LOADS
(All units in millions of Btu's)

ANNUAL HOT WATER LOADS

REGION	1&2 FAM	LOW RISE	AUDITORIUM	ST,CLNIC	EDUCAT	HOSPITAL	MALLS	MOTELS	WAREHOUSE
Region 1	20.736	151.659	12.963	12.963	178.623	432.590	72.592	227.358	0.0
Region 2	20.736	151.559	12.963	12.963	178.623	432.590	72.592	227.358	0.0
Region 3	20.736	151.559	12.963	12.963	178.623	432.590	72.592	227.358	0.0
Region 4	20.736	151.559	12.963	12.963	178.623	432.590	72.592	227.358	0.0
Region 5	20.736	151.659	12.963	12.963	178.623	432.590	72.592	227.358	0.0
Region 6	20.736	151.659	12.963	12.963	178.623	432.590	72.592	227.358	0.0
Region 7	20.736	151.659	12.963	12.963	178.623	432.590	72.592	227.358	0.0
Region 8	20.736	151.659	12.963	12.963	178.623	432.590	72.592	227.358	0.0
Region 9	20.736	151.659	12.963	12.963	178.623	432.590	72.592	227.358	0.0

ANNUAL HEATING LOADS

REGION	1&2 FAM	LOW RISE	AUDITORIUM	ST,CLNIC	EDUCAT	HOSPITAL	MALLS	MOTELS	WAREHOUSE
Region 1	86.368	314.245	1141.173	322.259	2036.095	1003.676	14478.324	512.131	0.0
Region 2	89.114	277.658	990.704	801.736	1755.390	760.526	94408.927	442.806	0.0
Region 3	93.018	276.318	646.335	174.506	1131.162	159.519	63523.281	370.411	0.0
Region 4	88.117	596.608	2011.380	572.536	3684.709	2266.934	28455.023	990.086	0.0
Region 5	61.624	226.222	1262.784	198.004	1259.223	445.065	55667.977	337.466	0.0
Region 6	76.467	410.125	1533.166	440.526	2808.073	1745.061	22068.395	739.233	0.0
Region 7	50.372	261.197	735.274	186.896	1211.802	288.017	39861.074	535.160	0.0
Region 8	51.649	313.036	977.870	262.254	1686.231	627.153	10059.992	457.873	0.0
Region 9	34.046	290.533	1010.027	282.064	1793.513	832.566	12454.703	458.348	0.0

ANNUAL COOLING LOADS

REGION	1&2 FAM	LOW RISE	AUDITORIUM	ST,CLNIC	EDUCAT	HOSPITAL	MALLS	MOTELS	WAREHOUSE
Region 1	34.549	93.892	422.094	138.088	872.840	1131.848	11375.887	189.423	5055.465
Region 2	57.030	124.772	557.182	512.600	1122.279	1328.993	13816.844	248.965	5586.359
Region 3	189.801	536.243	2046.742	618.772	4010.331	3791.655	39634.145	1001.662	9954.973
Region 4	10.614	51.907	223.492	85.585	550.623	971.547	8499.594	113.012	5615.680
Region 5	96.196	255.240	566.051	323.066	2054.573	2027.250	22224.203	485.405	13673.551
Region 6	16.787	83.933	276.578	90.216	575.146	784.071	7753.742	135.103	7012.918
Region 7	132.480	464.411	1715.738	531.961	3449.047	3312.307	34847.422	1383.802	17459.250
Region 8	91.544	313.122	1195.218	377.474	2426.551	2508.980	25868.734	595.390	5576.531
Region 9	50.075	170.713	701.846	221.659	1409.279	1546.216	15851.543	331.956	2792.124

ANNUAL LOADS, ALL THERMAL APPLICATIONS

REGION	1&2 FAM	LOW RISE	AUDITORIUM	ST,CLNIC	EDUCAT	HOSPITAL	MALLS	MOTELS	WAREHOUSE
Region 1	141.653	559.796	1576.229	473.309	3087.559	2568.114	25926.801	928.911	5055.465
Region 2	166.879	554.099	1560.848	1327.298	3056.292	2542.105	108298.312	919.130	5586.359
Region 3	303.555	964.220	2706.040	806.240	5320.113	4423.762	103230.000	1599.430	9954.973
Region 4	119.467	800.174	2247.834	671.083	4413.953	3671.101	37027.207	1327.456	5615.680
Region 5	178.556	633.122	1781.798	534.033	3492.417	2904.904	77964.750	1050.225	13673.551
Region 6	113.990	645.716	1816.207	543.704	3561.840	2961.723	29894.727	1071.694	7012.918
Region 7	203.583	877.268	2463.974	731.820	4839.469	4032.933	74781.062	2211.322	17459.250
Region 8	163.928	777.817	2186.050	652.691	4291.402	3568.723	36001.316	1290.621	5576.531
Region 9	104.857	612.906	1724.835	516.686	3381.415	2811.371	28378.836	1017.664	2792.124

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DEFINITION OF TERMS*

1. RESOURCE EXTRACTION
2. REFINING AND CONVERSION
3. TRANSPORT AND STORAGE
4. CENTRAL STATION CONVERSION
5. TRANSMISSION AND DISTRIBUTION

1. UTILIZING DEVICE
(BURNER LOSSES, ELECTRIC RESISTANCE HEATING EFFICIENCY, ELECTRIC HEAT PUMP COP, AIR CONDITIONING COP)

*1976 Energy Use Data

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DEFINITION OF TERMS

ANNUAL SALES: TOTAL AMOUNT OF MONEY, IN CONSTANT 1976 DOLLARS, SPENT IN ANY SPECIFIED YEAR FOR THE EQUIPMENT COSTS, SYSTEM DESIGN COSTS, AND INSTALLATION COSTS OF SOLAR SYSTEMS INSTALLED IN THAT YEAR. DOES NOT INCLUDE COST OF REQUIRED BACKUP EQUIPMENT.

BUILDING DEMAND: THE AMOUNT OF THERMAL ENERGY REQUIRED TO MEET LOADS. BUILDING DEMAND IS CALCULATED ONLY BY THERMAL-LOSS COEFFICIENTS, INFILTRATION, RELATIVE HUMIDITY, AND OTHER CONVENTIONAL ASHRAE DETERMINATES. IT DOES NOT INCLUDE UTILIZATION EFFICIENCIES, WHICH ARE USED IN CALCULATING END-USE ENERGY REQUIREMENTS. (SEE GRAPHIC DEFINITION OF TERMS)

COMMERCIAL BUILDINGS: INCLUDES SIX ARCHITECTURAL BUILDING TYPES, ALL OF WHICH USE SIMILAR ECONOMIC DECISION CRITERIA IN MAKING THE DECISION TO PURCHASE SOLAR SYSTEMS. FIVE OF THE SIX TYPES--AUDITORIUMS, STORES AND CLINICS, HOSPITALS, SHOPPING MALLS, AND MOTELS--ARE STRICTLY COMMERCIAL BUILDINGS. ONE OF THE SIX, LOW-RISE RESIDENTIAL, IS USED FOR RESIDENTIAL PURPOSES BUT HAS COMMERCIAL BUILDING ECONOMIC CRITERIA, AND IS GROUPED WITH THEM FOR MARKET AND ANALYSIS PURPOSES.

COST OF DELIVERED ENERGY:

$$\frac{(\text{TOTAL LIFE-CYCLE COST OF SOLAR AND BACKUP SYSTEM INCLUDING CONVENTIONAL NATIONAL FUEL PURCHASED})}{(\text{NET PRESENT VALUE FACTOR}) (\text{TOTAL ENERGY OUTPUT OF SOLAR AND BACKUP SYSTEM OVER LIFE OF SYSTEM})}$$

UNITS: 1976 \$/MMBTU

COST PER CAPACITY:
$$\frac{(\text{TOTAL INITIAL COST OF SOLAR AND BACKUP SYSTEM})}{(\text{TOTAL ANNUAL LOAD ON SOLAR AND BACKUP SYSTEM})}$$

UNITS: 1976 \$/MMBTU/YR.

DEMAND: THE AMOUNT OF ENERGY USED PER UNIT OF TIME.

END-USE ENERGY: THE AMOUNT OF ENERGY BOUGHT FROM UTILITIES BY BUILDING USERS. GENERALLY IT IS LARGER IN AMOUNT THAN THE BUILDING DEMAND THAT IT IS USED TO MEET. (SEE GRAPHIC DEFINITION OF TERMS)

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DEFINITION OF TERMS (CONTINUED)

FRONT-END INCENTIVES: INCENTIVES GIVEN TO SOLAR TECHNOLOGIES IN THE FIRST FEW YEARS OF MARKET ACCELERATION THAT MAKE TYPICAL SOLAR APPLICATIONS IN THAT MARKET SECTOR COST COMPETITIVE WITH TYPICAL CONVENTIONAL FUELS USED IN THAT MARKET SECTOR.

INSTITUTIONAL BUILDINGS: INCLUDES ONLY ONE ARCHITECTURAL BUILDING TYPE--EDUCATIONAL BUILDINGS. THIS BUILDING TYPE IS OFTEN GROUPED WITH COMMERCIAL BUILDINGS BECAUSE THE DECISION-MAKERS IN THIS MARKET SECTOR USE SIMILAR DECISION CRITERIA. THE ONLY DIFFERENCE IN THE ECONOMIC CALCULATIONS IS THE LESS COSTLY TAX COMPONENT OF LIFE-CYCLE COST CALCULATIONS FOR INSTITUTIONAL BUILDINGS.

LOAD: THE TOTAL AMOUNT OF THERMAL ENERGY REQUIRED FOR A PARTICULAR APPLICATION IN A BUILDING OVER AN ENTIRE YEAR, NOT AN INSTANTANEOUS LOAD.

LONG-RUN PARITY: LONG-TERM INCENTIVES GIVEN TO SOLAR THAT GIVE IT PARITY IN LEVEL OF SUBSIDY (\$/MMBTU) WITH THAT PROVIDED TO CONVENTIONAL FUEL TYPES.

MARKET PENETRATION: THE NUMBER AND TYPE OF SOLAR ENERGY SYSTEMS PROJECTED TO BE INSTALLED IN FUTURE YEARS.

MARKET POTENTIAL: THE PORTION OF THE MARKET THAT CONSIDERS THE INSTALLATION OF SOLAR IN ANY GIVEN YEAR; ONLY A FRACTION OF THE POTENTIAL MARKET IS PENETRATED BY SOLAR.

NEA: NATIONAL ENERGY ACT

NET NATIONAL VALUE: LONG-TERM INCENTIVES GIVEN TO SOLAR BECAUSE OF THE VALUE IT REPRESENTS TO THE NATION IN TERMS OF EMBARGO PROTECTION AND ENVIRONMENTAL BENEFITS.

NEW/RETROFIT: REFERS TO THE CONDITIONS UNDER WHICH A SOLAR SYSTEM IS INSTALLED. NEW SYSTEMS ARE INSTALLED WHILE THE BUILDING IS UNDER INITIAL CONSTRUCTION. RETROFIT SYSTEMS ARE INSTALLED AFTER THE BUILDING IS CONSTRUCTED.

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DEFINITION OF TERMS (CONCLUDED)

NEW STARTS: BUILDINGS WHICH START CONSTRUCTION DURING A PARTICULAR TIME PERIOD.

PRIMARY ENERGY: THE AMOUNT OF FOSSIL FUEL EQUIVALENT USED TO PRODUCE AN AMOUNT OF END-USE ENERGY. FOR EXAMPLE, THREE QUADS OF PRIMARY ENERGY ARE USED IN THE PRODUCTION OF ONE QUAD OF ELECTRICITY. (SEE GRAPHIC DEFINITION OF TERMS)

RESIDENTIAL BUILDINGS: INCLUDES ONLY ONE ARCHITECTURAL BUILDING TYPE TO REPRESENT ALL ONE- AND TWO-FAMILY DETACHED HOMES. THIS BUILDING TYPE USES THE RESIDENTIAL DECISION CRITERIA, WHICH RELIES HEAVILY ON INITIAL SYSTEM COST AS WELL AS ANNUAL SAVINGS.

RETROFIT: SEE "NEW/RETROFIT"

MOUNTAIN

U.S. CENSUS REGIONS

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WEST
NORTH CENTRAL

EAST
NORTH CENTRAL

MID-ATLANTIC

NEW ENGLAND

REG.
8

REG.
6

REG.
4

REG.
2

REG.
1

PACIFIC

REG.
9

REG.
3

SOUTH ATLANTIC

REG.
5

EAST
SOUTH CENTRAL

REG.
7

WEST
SOUTH CENTRAL

B-17

RESIDENTIAL AND COMMERCIAL/INSTITUTIONAL
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BUILDING CONSERVATION SCENARIOS

BUILDING CHARACTERISTICS WERE DERIVED FROM THE BALLINGER SURVEY DONE AS PART OF THE GE PHASE O STUDY. AVERAGE VALUES OF BUILDING SIZE, HEAT LOSS COEFFICIENTS, AND INFILTRATION WERE DETERMINED FROM THE SURVEY AND WERE ASSUMED TO DESCRIBE THE AVERAGE BUILDING IN THE YEAR 1976. CONSERVATION SCENARIOS WERE THEN SELECTED FOR EACH FUEL PRICE SCENARIO TO DEVELOP BUILDING HEATING, COOLING, AND HOT WATER LOADS IN SUBSEQUENT YEARS.

- o IN EACH YEAR A CERTAIN PERCENTAGE OF ALL BUILDINGS, BOTH NEW AND RETROFIT, WILL BE SUBJECT TO ENERGY CONSERVATION PACKAGES:

DEMAND	1978	1985	1990	2000
LOW-PRICE	0%	0%	0%	0%
MID-PRICE	10%	12.5%	15%	20%
HIGH-PRICE	10%	12.5%	15%	20%

- o THE CONSERVATION PACKAGES WILL RESULT IN A PERCENTAGE DECREASE IN TOTAL BUILDING DEMAND:

DEMAND	NEW BUILDINGS	RETROFIT BUILDINGS
LOW-PRICE	0%	0%
MID-PRICE	40%	30%
HIGH-PRICE	50%	50%

BUILDING INVENTORIES

RESIDENTIAL BUILDINGS
MARKET SECTOR WORKBOOK

RESIDENTIAL BUILDING INVENTORY
ONE- AND TWO-FAMILY BUILDINGS, MILLIONS OF BUILDINGS

	1970		1980		1990		2000		
REGION	NEW STARTS	TOTAL INVENT.	NEW STARTS	TOTAL INVENT.	NEW STARTS	TOTAL INVENT.	NEW STARTS	TOTAL INVENT.	AVERAGE ANNUAL GROWTH RATE IN TOTAL INVENT.
1	0.00	1.83	0.96	2.09	0.92	2.25	0.96	2.41	0.92%
2	0.00	11.10	4.81	12.69	4.62	13.70	4.97	14.68	0.94%
3	0.00	7.00	2.10	8.03	2.03	8.84	2.21	9.31	0.96%
4	0.00	9.05	4.12	10.27	3.98	11.05	4.19	11.88	0.91%
5	0.00	3.96	1.46	4.55	1.41	5.00	1.57	5.50	1.10%
6	0.00	4.69	1.58	5.13	1.61	5.59	1.76	6.09	0.87%
7	0.00	7.17	2.69	8.21	2.71	9.10	2.96	10.14	1.16%
8	0.00	2.55	1.00	2.92	1.02	3.28	1.06	3.56	1.12%
9	0.00	7.32	2.71	8.20	3.08	9.09	3.22	10.06	1.07%
U.S.	0.00	54.67	21.43	62.10	21.40	67.89	22.89	73.64	1.00%

New starts represents the new building starts in the decade previous to the year noted. Building retirements for any period may be found by subtracting the difference in total inventory between the beginning and end of the period from the sum of new starts in that period.

Source: GE Phase O Building Study

COMMERCIAL AND INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

COMMERCIAL AND INSTITUTIONAL BUILDING INVENTORY
NATIONAL SUMMARY, THOUSANDS OF BUILDINGS

	1970		1980		1990		2000		AVERAGE ANNUAL GROWTH RATE IN TOTAL INVENT.
	NEW STARTS	TOTAL INVENT.	NEW STARTS	TOTAL INVENT.	NEW STARTS	TOTAL INVENT.	NEW STARTS	TOTAL INVENT.	
LOW-RISE RESIDENTIAL	0.0	1791.3	1538.5	2770.8	1744.6	3687.2	2070.1	4938.8	3.44%
AUDITORIUMS	0.0	505.4	188.3	561.6	208.7	628.9	208.3	679.0	0.99%
STORES AND CLINICS	0.0	1203.1	454.4	1355.0	503.8	1524.2	509.7	1669.1	1.10%
EDUCATIONAL	0.0	155.5	46.5	163.5	49.7	173.1	87.5	173.9	0.35%
HOSPITAL	0.0	49.3	19.4	55.9	21.7	63.2	20.9	67.5	1.05%
MALLS	0.0	21.5	7.6	23.1	7.9	25.9	7.9	27.9	0.87%
MOTELS	0.0	84.2	69.4	118.9	100.0	178.8	70.5	201.7	2.96%

New starts represents the new building starts in the decade previous to the year noted.
Building retirements for any period may be found by subtracting the difference in total
inventory between the beginning and end of the period from the sum of new starts in that period.

Source: GE Phase 0 Building Study

COMMERCIAL AND INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

COMMERCIAL AND INSTITUTIONAL BUILDING INVENTORY
YEAR 2000, THOUSANDS OF BUILDINGS

REGION	LOW-RISE RESIDENTIAL	AUDITORIUMS	STORES AND CLINICS	EDUCATIONAL	HOSPITALS	SHOPPING MALLS	HOTELS/ MOTELS
1	226.1	22.9	55.1	5.6	2.7	1.0	6.8
2	1306.7	134.3	360.4	34.5	14.5	5.5	42.8
3	774.3	83.3	245.6	21.8	7.6	2.9	26.3
4	762.9	112.5	273.1	27.6	14.0	5.0	33.7
5	259.0	44.2	97.7	11.3	4.2	1.8	9.8
6	307.5	50.3	120.5	13.2	5.9	1.9	13.7
7	390.0	75.9	182.4	20.6	6.3	3.2	19.7
8	184.4	28.3	75.0	7.9	3.5	0.8	14.0
9	727.9	127.4	259.3	31.3	8.8	5.6	34.9
U.S.	4938.8	679.0	1669.1	173.9	67.5	27.9	201.7

Source: GE Phase O Building Study

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TECHNOLOGY DESCRIPTION: DIRECT THERMAL HOT WATER

THE SYSTEM CONFIGURED BELOW IS THE GENERIC DESIGN FOR DIRECT THERMAL HOT WATER. THE COLLECTOR IS A SINGLE-GLAZED, SELECTIVELY SURFACED COPPER TUBE-IN-PLATE. THE LIQUID HEAT TRANSFER MEDIUM (WATER AND ETHYLENE GLYCOL) IS CIRCULATED VIA A PUMP THROUGH A COUNTERFLOW HEAT EXCHANGER TO WARM WATER IN THE STORAGE TANK. THE SERVICE HOT WATER TANK DRAWS HEAT AND WATER FROM THE STORAGE TANK FOR DEMAND USE.

IT IS ASSUMED THAT IN 1985, THE FLAT PLATE IS REPLACED BY AN EVACUATED TUBE COLLECTOR.

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BUILDINGS MARKET SECTOR WORKBOOK

TECHNOLOGY DESCRIPTION: SOLAR HEATING AND HOT WATER WITH A LIQUID HEAT TRANSFER MEDIUM

THE SYSTEM CONFIGURED BELOW IS THE GENERIC DESIGN FOR SOLAR HEATING AND HOT WATER WITH A LIQUID HEAT TRANSFER MEDIUM. THE COLLECTOR IS A DOUBLE-GLAZED, SELECTIVELY SURFACED COPPER TUBE-IN-PLATE COLLECTOR IN A CLOSED LOOP. HEAT IS DRAWN OFF STORAGE FOR POTABLE HOT WATER AS WELL AS TO CIRCULATE THROUGH A WATER-TO-AIR HEAT EXCHANGER COIL THAT SUPPLIES HEAT TO THE BUILDING.

IT IS ASSUMED THAT IN 1985, THE FLAT PLATE IS REPLACED BY AN EVACUATED TUBE COLLECTOR.

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BUILDINGS MARKET SECTOR WORKBOOK

TECHNCLOGY DESCRIPTION: SOLAR HEATING AND HOT WATER WITH AN
AIR HEAT TRANSFER MEDIUM

THE SYSTEM CONFIGURED BELOW IS THE GENERIC DESIGN FOR SOLAR HEATING AND HOT WATER WITH AIR AS A HEAT TRANSFER MEDIUM. THE COLLECTOR IS A DOUBLE-GLAZED, BLACK-SURFACED STEEL COLLECTOR. HEAT IS TRANSFERRED EITHER DIRECTLY INTO THE BUILDING OR TO A PEBBLE BED STORAGE, WHICH IS DRAWN FROM DURING SUNLESS PERIODS. A COUNTERFLOW AIR-TO-WATER EXCHANGER IN THE DUCTING SYSTEM PROVIDES HEAT FOR POTABLE HOT WATER.

RESIDENTIAL AND COMMERCIAL/INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

TECHNOLOGY DESCRIPTION: SOLAR HEATING AND HOT WATER WITH ABSORPTION COOLING

THE SYSTEM CONFIGURED BELOW IS THE GENERIC DESIGN FOR SOLAR HEATING AND HOT WATER WITH ABSORPTION COOLING. THE SYSTEM IS PROVIDED WITH HOT WATER FROM AN EVACUATED TUBE COLLECTOR AND IS CIRCULATED THROUGH A WATER-TO-AIR HEAT EXCHANGER COIL TO PROVIDE HEAT. WHEN COOLING IS DESIRED, IT IS CIRCULATED TO AN ABSORPTION CHILLER. THE AUXILIARY UNIT PROVIDES BACKUP HOT WATER FOR BOTH THE HEATING AND COOLING LOADS.

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TECHNOLOGY DESCRIPTION: SOLAR HEATING AND HOT WATER WITH HEAT PUMP
AUXILIARY AND HEAT PUMP COOLING

THE SYSTEM CONFIGURED ON THE FOLLOWING PAGE IS THE GENERIC DESIGN FOR SOLAR HEATING AND HOT WATER WITH HEAT PUMP AUXILIARY AND HEAT PUMP COOLING. THE COLLECTOR IS A DOUBLE-GLAZED, SELECTIVELY SURFACED COPPER TUBE-IN-PLATE COLLECTOR.

THE SOLAR-ASSISTED HEAT PUMP IS, IN ESSENCE, A HYBRID SYSTEM. IN THIS SYSTEM, THE LOAD IS SUPPLIED WITH HEAT DIRECTLY FROM THE SOLAR SYSTEM WHEN THE TEMPERATURE OF THE AVAILABLE HEAT IS SUFFICIENTLY HIGH. WHEN THIS OCCURS AND THERE IS NO DEMAND, HEAT IS STORED. WHEN THE TEMPERATURE OF THE HEAT IS NOT SUFFICIENTLY HIGH TO WARM THE LOAD, THE HEAT IS SUPPLIED TO THE HEAT PUMP. THIS HEAT WILL ACT TO INCREASE THE COEFFICIENT OF PERFORMANCE (COP) OF THE HEAT PUMP, THUS SUPPLYING MORE EFFICIENTLY AN AUXILIARY FORM OF HEATING. IN THE EVENT THAT THE HEAT AVAILABLE FROM THE SOLAR SYSTEM OR FROM STORAGE IS AT A LOWER TEMPERATURE THAN THE AMBIENT, THE HEAT PUMP USES THE AMBIENT AS A HEAT SOURCE. IF THE AMBIENT TEMPERATURE IS TOO LOW TO SUPPLY THE HEAT PUMP WITH USABLE HEAT, AN AUXILIARY HEATER WITHIN THE HEAT PUMP CUTS ON TO SUPPLY HEAT. THE HEAT PUMP MAY ALSO BE USED IN REVERSE DURING THE SUMMER TO PRODUCE COOLING.

IT IS ASSUMED THAT IN 1985, THE FLAT PLATE IS REPLACED BY AN EVACUATED TUBE COLLECTOR.

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TECHNOLOGY DESCRIPTION: SOLAR HEATING AND HOT WATER WITH HEAT PUMP
AUXILIARY AND HEAT PUMP COOLING (Concluded)

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BUILDINGS MARKET SECTOR WORKBOOK

TECHNOLOGY DESCRIPTION: DIRECT GAIN PASSIVE SPACE HEATING SYSTEM

THE SYSTEM PICTURED BELOW IS THE GENERIC DESIGN FOR A DIRECT GAIN SOUTH WALL FOR PASSIVE SPACE HEATING IN CONJUNCTION WITH A BACKUP SPACE HEATING SYSTEM THAT CAN MEET THE FULL HEATING LOAD. THE DIRECT GAIN SYSTEM CONSISTS OF A DOUBLE-GLAZED SOUTH FACING WINDOW THAT ALLOWS SOLAR RADIANT GAIN TO HEAT THERMAL MASS. THE THERMAL MASS IS A THICK, INSULATED, CONCRETE FLOOR, WHICH SLOWLY RELEASES ITS HEAT TO THE OCCUPIED SPACE BY RADIATION, CONDUCTION, AND CONVECTION.

RESIDENTIAL AND COMMERCIAL/INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

TECHNOLOGY DESCRIPTION: TROMBE WALL PASSIVE SPACE HEATING SYSTEM

THE SYSTEM PICTURED BELOW IS THE GENERIC DESIGN FOR A TROMBE WALL FOR PASSIVE SPACE HEATING IN CONJUNCTION WITH A BACKUP SPACE HEATING SYSTEM THAT CAN MEET THE FULL HEATING LOAD. THE TROMBE WALL IS A DOUBLE GLAZED, BLACK PAINTED, 12" THICK CONCRETE WALL THAT RADIATES AND CONVECTS HEAT TO THE OCCUPIED SPACE. IT HAS NO INSULATION AND HAS AN UPPER AND LOWER VENT WITH BACKDRAFT DAMPERS TO PREVENT NIGHT RADIATION.

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TECHNOLOGY DESCRIPTION: THERMOSIPHON PASSIVE SPACE HEATING SYSTEM

THE SYSTEM PICTURED BELOW IS THE GENERIC DESIGN FOR A THERMOSIPHON IN CONJUNCTION WITH A BACKUP SPACE HEATING SYSTEM THAT CAN MEET THE FULL HEATING LOAD. THE THERMOSIPHON SYSTEM CONSISTS OF DOUBLE-GLAZING OVER BLACK-PAINTED WIRE MESH AND INSULATED SHEET METAL WITH UPPER AND LOWER VENTS FITTED WITH BACKDRAFT DAMPERS. HEATED AIR IN THE THERMOSIPHON NATURALLY CONVECTS TO THE OCCUPIED SPACE, THE THERMAL STORAGE FOR THE SYSTEM.

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COMMERCIALIZATION DEVELOPMENT CONCERNS: ALL TECHNOLOGIES

THE FOLLOWING PAGES LIST THE COMMERCIALIZATION DEVELOPMENT CONCERNS OF PARTICIPANTS IN THE RESIDENTIAL AND COMMERCIAL/INSTITUTIONAL BUILDINGS MARKET SECTORS.

THE PROGRAMS CONSIDERED ARE ALL AIMED AT PRODUCING A COMMERCIALIZABLE PRODUCT. ALL THE PROBLEMS ADDRESSED ARE VIEWED AS IMPEDIMENTS TO MARKET DEVELOPMENT. THE PROGRAMS EXAMINED WILL REDUCE RISKS AND BARRIERS, THUS BROADENING THE MARKET.

PROGRAMS THAT INCREASE SALES OF SYSTEMS AND IMPROVE DESIGN EXPERIENCE MOVE THE TECHNOLOGY FURTHER ALONG THE MARKET PENETRATION CURVE, REDUCING THE TIME TO TECHNOLOGY MATURITY. PROGRAMS THAT REDUCE SYSTEMS COSTS TO THE BUYER SHIFT THE TECHNOLOGY TO A MORE ADVANTAGEOUS MARKET PENETRATION CURVE, RESULTING IN AN INCREASE IN SALES.

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COMMERCIALIZATION DEVELOPMENT CONCERNS

MARKET SECTOR PARTICIPANT	CONCERNS	PROGRAMS IN PLACE	POTENTIAL PROGRAMS	IMPACTS
Building Owner	High cost of solar systems	State and local tax incentives	Federal tax incentives	Decreased first costs
Architect		Reduced loan rates		Decreased life- cycle costs
Engineer				
Financier		Federal R&D programs	Federal incentives to promote R&D programs	Decreased system costs through development
Equipment Manufacturer		Federal demonstra- tion programs		Decreased system costs through experience
			Tax rebate for do-it-yourselfers	Decreased first costs
Building Owner	Will solar reduce utility bills?	Studies of utility rate structures	Regulations of utility rate structures for solar hook-ups	Equitable utility rate structures
Solar Equipment Manufacturer				
Financier				

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MARKET SECTOR PARTICIPANT	CONCERNS	PROGRAMS IN PLACE	POTENTIAL PROGRAMS	IMPACTS
All	Availability of financing	1) Reduced loan rates 2) Extended loan terms 3) Financing through utilities	1) Federal guaran- tees for solar loans 2) Federal loan fund for solar 3) Financing through installer	Greater availability of financing
Building Owner Financier	Impact of solar installations on property taxes		Tax rebate	Decreased initial costs Makes larger collec- tor size more optimal
Building Owner Engineer Equipment Manufacturer Financier	Reliability and performance of solar systems Warranties	HUD Demonstration Program requires 5-year warranty	Establish require- ment of warranties	1) Increased reli- ability of collectors 2) Decreased number of manufacturers

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MARKET SECTOR PARTICIPANT	CONCERNS	PROGRAMS IN PLACE	POTENTIAL PROGRAMS	IMPACTS
Building Owner Engineer Equipment Manufacturer	Obsolescence of system	R&D efforts		New technologies available at an earlier time Increasingly de- veloped systems for sale
Building Owner Financier	Resale value of solar-powered building		Tax incentives for resale	Reduction of buyer risk
Building Owner Equipment Manufacturer Financier	Availability of insurance for systems and solar-powered buildings		Federal insurance or federally guar- anteed insurance until commercial insurance is available	1) Decreased risk to consumer 2) Increased general acceptability of system
Building Owner Architect	Appearance of system, rejec- tion of system on aesthetic codes		Removal of aes- thetic zoning code barriers	Solar systems permitted in architecturally controlled areas

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MARKET SECTOR PARTICIPANT	CONCERNS	PROGRAMS IN PLACE	POTENTIAL PROGRAMS	IMPACTS
Building Owner Engineers Architects	Availability of qualified architects/ solar system designers	ASHRAE, AIA, etc., offer systems courses and con- ferences	Require education of architects/ engineers as solar system designers	1) Increased confi- dence in system designs 2) Insured quality of designers 3) Decreased number of designers
Building Owner Architect Equipment Manufacturer Financier	Reliability of maintainers		Certification or licensing of maintainers	Removal from mar- ket of unreliable maintainers
Building Owner Equipment Manufacturer	Maintenance costs		Require system warranties	Guard against unnecessarily high maintenance costs

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MARKET SECTOR PARTICIPANT	CONCERNS	PROGRAMS IN PLACE	POTENTIAL PROGRAMS	IMPACTS
Building Owner Architect Engineer	Solar Access	State building codes which prohibit inter- ference with sun rights		Decreased risk to inhibited performance
Equipment Manufacturer Architect Engineer	Overly high expectations from solar	Information dissemination		Inform consumers about limitations and reliability of solar
Equipment Manufacturer and Dealer Financier	Availability of funds for industrial expansion	SBA loans	Federal loan funds for solar industry	Small increase in availability of capital Large increase in availability of capital

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MARKET SECTOR PARTICIPANT	CONCERNS	PROGRAMS IN PLACE	POTENTIAL PROGRAMS	IMPACTS
Equipment Manufacturer and Dealer	Expense of warranty test- ing and claims	R&D programs		Establishment of realistic warranties
			Government funding of warranty testing	More collector systems in market- place
			Government funding of claims against warranties	Decreased collector costs
Equipment Manufacturer and Dealer	Availability of distribution channels		Certification or licensing of ven- dors or installers	Decreased risk to consumer and manufacturer
			Tax break to solar wholesaler	Decreased risk to wholesaler and increase their num- ber and flexibility in a developing market

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MARKET SECTOR PARTICIPANT	CONCERNS	PROGRAMS IN PLACE	POTENTIAL PROGRAMS	IMPACTS
Equipment Manufacturer and Dealer	Uncertainties about market potential	National Solar Heating and Cooling Informa- tion Center		Increased geo- graphic meteoro- logical information
System Maintainers			Market potential studies	Increased market information
			Quickly decide on government programs	Relieve market apprehension about effects of govern- ment programs
Building Owner	Interface of alternative and conventional systems	R&D programs		Increased confi- dence in system interface
Architect		Demonstration programs		
Engineer				
Equipment Manufacturer and Dealer	Lack of engineering standards	Development of ASHRAE, ASTM etc., standards	Building code prototypes, BOCA	Increased confi- dence in design standards
	Maintaining structural integrity of buildings in retrofit	Demonstration programs	Building code prototypes, BOCA	Decreased per- ceived risk

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MARKET SECTOR PARTICIPANT	CONCERNS	PROGRAMS IN PLACE	POTENTIAL PROGRAMS	IMPACTS
Equipment Manufacturer and Dealer	Availability of trained main- tainers	University train- ing programs	CETA	Provision of pro- grams to keep up supply of trained installers and maintainers
System Maintainers		Manufacturer's educational programs		
Building Owner				
Equipment Manufacturer and Dealer	Availability of spare parts		Establish typical rates of parts retirement	Increased confi- dence of consumer in maintenance cost estimates
System Maintainers	Frequency of repair and			
Building Owner	repair costs			

LEVELS OF INCENTIVES
(% equivalent ITC)

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LEVELS OF INCENTIVES
(% equivalent ITC)

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MARKET PENETRATION

ACTIVE SYSTEM COST/CAPACITY IN 1978
ALL PRICE SCENARIOS

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ACTIVE SYSTEM COST/CAPACITY IN 1985
MID-PRICE SCENARIO

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MARKET SECTOR WORKBOOK

PHOTOVOLTAIC SYSTEM COST/CAPACITY IN 1985
MID-PRICE SCENARIO

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WIND SYSTEM COST/CAPACITY IN 1985
MID-PRICE SCENARIO

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ACTIVE AND PASSIVE SYSTEM COST/CAPACITY IN 2000
MID-PRICE SCENARIO

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PHOTOVOLTAIC SYSTEM COST/CAPACITY IN 2000
MID-PRICE SCENARIO

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ACTIVE SYSTEM COST/CAPACITY IN 1978
ALL SCENARIOS

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ACTIVE SYSTEM COST/CAPACITY IN 1985
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PHOTOVOLTAIC SYSTEM COST/CAPACITY IN 1985
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ACTIVE AND PASSIVE SYSTEMS COST/CAPACITY IN 2000
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WIND SYSTEM COST/CAPACITY IN 2000
MID-PRICE SCENARIO

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1976 \$/MMBtu/Yr

ACTIVE SYSTEM COST OF DELIVERED ENERGY IN 1978
ALL PRICE SCENARIOS

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ACTIVE SYSTEM COST OF DELIVERED ENERGY IN 1985
MID-PRICE SCENARIO

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PHOTOVOLTAIC SYSTEM COST OF DELIVERED ENERGY IN 1985
MID-PRICE SCENARIO

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WIND SYSTEM COST OF DELIVERED ENERGY IN 1985
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ACTIVE AND PASSIVE SYSTEM
COST OF DELIVERED ENERGY IN 2000
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PRIMARY ENERGY DISPLACED BY INSTALLED SYSTEMS (QUADS)
MID-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	.056	.154	.554	.073	.227	.712	.084	.268	.767	.114	.334	.807
H&HW	.063	.136	.414	.080	.198	.575	.106	.242	.648	.149	.328	.864
C, H, & HW	.012	.022	.091	.013	.050	.221	.064	.115	.334	.109	.207	.584
PASSIVE												
H&HW	.004	.030	.174	.005	.044	.242	.007	.053	.272	.009	.072	.363
PHOTO- VOLTAICS	.001	.019	.177	.001	.032	.255	.002	.046	.333	.002	.051	.373
WECS	.008	.051	.312	.013	.080	.420	.019	.109	.527	.021	.122	.590

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PRIMARY ENERGY DISPLACED BY INSTALLED SYSTEMS (QUADS)
HIGH-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	.059	.179	.667	.077	.261	.815	.092	.300	.885	.123	.373	.882
H&HW	.053	.116	.378	.066	.172	.527	.094	.220	.608	.127	.293	.786
C,H,&HW	.008	.019	.087	.010	.040	.204	.050	.099	.309	.091	.181	.536
PASSIVE												
H&HW	.004	.030	.176	.005	.044	.245	.007	.057	.283	.010	.076	.366
PHOTO- VOLTAICS	-	-	-	-	-	-	-	-	-	-	-	-
WECS	-	-	-	-	-	-	-	-	-	-	-	-

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PRIMARY ENERGY DISPLACED BY INSTALLED SYSTEMS (QUADS)
LOW-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	.054	.146	.503	.070	.214	.656	.082	.253	.707	.109	.318	.766
H&HW	.084	.179	.534	.107	.257	.723	.146	.316	.795	.195	.413	1.013
C,H,&HW	.023	.053	.232	.028	.106	.477	.106	.212	.679	.170	.355	1.080
PASSIVE												
H&HW	.005	.031	.176	.006	.045	.238	.009	.055	.262	.012	.072	.334
PHOTO- VOLTAICS	-	-	-	-	-	-	-	-	-	-	-	-
WECS	-	-	-	-	-	-	-	-	-	-	-	-

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PRIMARY ENERGY DISPLACED BY INSTALLED SYSTEMS, REGIONAL BREAKOUT
AS PERCENTAGE OF U.S. TOTAL, MID-PRICE SCENARIO, OPTION II

	REG 1	REG 2	REG 3	REG 5	REG 7	REG 4	REG 6	REG 8	REG 9	U.S.
<u>1985</u>										
ACTIVE										
HW	4	23	6	6	12	20	11	8	10	100
H&HW	6	27	4	3	10	23	8	6	12	100
C,H,&HW	1	6	3	4	56	7	9	13	1	100
PASSIVE										
H&HW	2	26	2	2	14	25	14	2	13	100
<u>2000</u>										
ACTIVE										
HW	3	17	4	8	15	24	8	8	13	100
H&HW	7	30	3	3	8	26	8	5	10	100
C,H,&HW	1	3	1	3	56	13	10	13	0	100
PASSIVE										
H&HW	8	31	3	2	8	25	8	4	11	100
	NESEC		SSEC			MASEC		WSUN		

PRIMARY ENERGY DISPLACED BY INSTALLED SYSTEMS, QUADS
MID-PRICE SCENARIO, OPTION II

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PRIMARY ENERGY DISPLACED BY INSTALLED SYSTEMS (QUADS)
MID-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	.009	.025	.066	.012	.031	.074	.017	.036	.077	.024	.042	.082
H&HW	.057	.135	.331	.074	.158	.352	.096	.182	.380	.127	.212	.410
C,H,&HW	.056	.111	.267	.078	.157	.371	.110	.206	.448	.158	.269	.535
PASSIVE												
H&HW	.003	.012	.050	.004	.014	.053	.005	.016	.057	.007	.019	.062
PHOTO- VOLTAICS	.000	.002	.025	.000	.005	.034	.000	.007	.043	.000	.008	.048
WECS	.000	.004	.123	.000	.006	.031	.001	.008	.038	.001	.009	.042

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PRIMARY ENERGY DISPLACED BY INSTALLED SYSTEMS (QUADS)
HIGH-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	.010	.026	.070	.012	.032	.076	.017	.037	.079	.024	.042	.084
H&HW	.047	.112	.284	.062	.132	.304	.080	.150	.320	.105	.175	.351
C,H,&HW	.047	.093	.224	.064	.120	.306	.091	.172	.369	.129	.221	.436
PASSIVE												
H&HW	.003	.010	.047	.004	.012	.050	.005	.013	.053	.007	.016	.058
PHOTO- VOLTAICS	-	-	-	-	-	-	-	-	-	-	-	-
WECS	-	-	-	-	-	-	-	-	-	-	-	-

COMMERCIAL AND INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

PRIMARY ENERGY DISPLACED BY INSTALLED SYSTEMS (QUADS)
LOW-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	.009	.024	.065	.012	.030	.073	.017	.035	.077	.024	.043	.082
H&HW	.074	.175	.434	.098	.208	.470	.127	.237	.497	.175	.283	.554
C,H,&HW	.080	.172	.458	.114	.245	.636	.164	.325	.775	.242	.430	.931
PASSIVE												
H&HW	.003	.012	.051	.004	.014	.055	.005	.016	.058	.007	.020	.065
PHOTO- VOLTAICS	-	-	-	-	-	-	-	-	-	-	-	-
WECS	-	-	-	-	-	-	-	-	-	-	-	-

COMMERCIAL AND INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

PRIMARY ENERGY DISPLACED BY INSTALLED SYSTEMS, REGIONAL BREAKOUT
AS PERCENTAGE OF U.S. TOTAL, MID-PRICE SCENARIO, OPTION II

	REG 1	REG 2	REG 3	REG 5	REG 7	REG 4	REG 6	REG 8	REG 9	U.S.
<u>1985</u>										
ACTIVE										
HW	6	18	12	5	12	17	6	6	18	100
H&HW	4	25	8	3	5	27	9	3	16	100
C,H,&HW	0	16	12	8	19	16	8	5	16	100
PASSIVE										
H&HW	6	15	15	6	6	15	16	6	15	100
<u>2000</u>										
ACTIVE										
HW	3	18	9	7	12	21	7	7	16	100
H&HW	4	24	6	4	4	31	8	3	16	100
C,H,&HW	1	11	10	9	20	15	9	7	18	100
PASSIVE										
H&HW	4	25	5	3	4	32	8	4	15	100
	NESEC		SSEC			MASEC		WSUN		

PRIMARY ENERGY DISPLACED BY INSTALLED SYSTEMS, QUADS
MID-PRICE SCENARIO, OPTION II

RESIDENTIAL BUILDINGS
MARKET SECTOR WORKBOOK

NUMBER OF INSTALLED SYSTEMS (MILLIONS)
MID-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	4.17	9.35	25.55	5.43	13.06	31.64	6.25	15.03	33.59	8.36	18.59	35.71
H&HW	1.32	2.60	5.69	1.69	3.80	9.33	2.22	4.62	10.44	3.12	6.28	13.60
C,H,&HW	0.17	0.30	0.95	0.19	0.56	1.98	0.63	1.10	2.88	1.04	1.90	4.88
PASSIVE												
H&HW	0.15	0.97	4.87	0.19	1.42	6.79	0.25	1.72	7.60	0.35	2.34	9.90
PHOTO- VOLTAICS	0.02	0.65	5.90	0.03	0.94	8.50	0.04	1.22	11.10	0.04	1.37	12.43
WECS	0.00	0.03	0.41	0.20	1.40	8.55	0.26	1.77	10.80	0.28	1.97	12.01

RESIDENTIAL BUILDINGS
MARKET SECTOR WORKBOOK

NUMBER OF INSTALLED SYSTEMS (MILLIONS)
HIGH-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	4.35	10.19	28.60	5.66	14.10	34.06	6.57	16.08	35.64	8.70	19.55	37.05
H&HW	1.33	2.65	7.18	1.70	3.94	9.97	2.36	4.91	11.34	3.21	6.58	14.56
C,H,&HW	0.14	0.27	1.01	0.16	0.53	2.09	0.58	1.06	3.03	1.00	1.88	5.09
PASSIVE												
H&HW	0.15	0.99	4.93	0.19	1.47	5.85	0.27	1.33	7.79	0.36	2.45	10.00
PHOTO- VOLTAICS	-	-	-	-	-	-	-	-	-	-	-	-
WECS	-	-	-	-	-	-	-	-	-	-	-	-

RESIDENTIAL BUILDINGS
MARKET SECTOR WORKBOOK

NUMBER OF INSTALLED SYSTEMS (MILLIONS)
LOW-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	4.10	9.07	24.20	5.33	12.67	30.31	6.18	14.62	32.28	8.21	18.18	35.04
H&HW	1.35	2.70	6.96	1.73	3.88	9.38	2.34	4.73	10.31	3.08	6.13	12.77
C,H,&HW	0.24	0.46	1.47	0.28	0.78	2.70	0.76	1.40	3.75	1.18	2.25	5.87
PASSIVE												
H&HW	0.17	0.99	4.91	0.22	1.42	6.62	0.29	1.73	7.27	0.39	2.25	9.01
PHOTO- VOLTAICS	-	-	-	-	-	-	-	-	-	-	-	-
WECS	-	-	-	-	-	-	-	-	-	-	-	-

RESIDENTIAL BUILDINGS
MARKET SECTOR WORKBOOK

NUMBER OF INSTALLED SYSTEMS (MILLIONS), REGIONAL BREAKOUT
MID-PRICE SCENARIO, OPTION II

	REG 1	REG 2	REG 3	REG 5	REG 7	REG 4	REG 6	REG 8	REG 9	U.S.
<u>1985</u>										
ACTIVE										
HW	.22	1.35	.33	.32	1.03	1.19	.58	.43	.80	6.25
H&HW	.11	.53	.08	.07	.25	.46	.17	.14	.42	2.22
C,H,&HW	.01	.06	.01	.03	.27	.01	.01	.01	.01	0.63
PASSIVE										
H&HW	.01	.06	.01	.01	.03	.05	.02	.02	.05	.25
<u>2000</u>										
ACTIVE										
HW	1.19	7.18	1.67	2.20	5.46	6.26	2.94	1.95	4.74	33.59
H&HW	.66	2.93	.22	.27	.99	2.39	.81	.56	1.62	10.44
C,H,&HW	.03	.18	.02	.08	1.23	.59	.45	.29	.02	2.88
PASSIVE										
H&HW	.48	2.13	.16	.20	.72	1.74	.59	.41	1.18	7.60
	NESEC		SSEC			MASEC		WSUN		

NUMBER OF INSTALLED SYSTEMS, MILLIONS
MID-PRICE SCENARIO, OPTION II

RESIDENTIAL BUILDINGS
MARKET SECTOR WORKBOOK

COMMERCIAL AND INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

NUMBER OF INSTALLED SYSTEMS (MILLIONS)
MID-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	0.15	0.36	0.31	0.20	0.43	0.87	0.26	0.49	0.88	0.33	0.55	0.88
H&HW	0.13	0.29	0.50	0.17	0.34	0.64	0.22	0.39	0.68	0.27	0.43	0.70
C,H,&HW	0.09	0.17	0.38	0.11	0.22	0.47	0.14	0.26	0.55	0.18	0.32	0.63
PASSIVE												
H&HW	0.01	0.04	0.13	0.01	0.05	0.14	0.02	0.05	0.15	0.02	0.06	0.15
PHOTO- VOLTAICS	0.00	0.00	0.00	0.00	0.01	0.04	0.00	0.01	0.05	0.00	0.02	0.06
WECS	0.00	0.00	0.04	0.00	0.01	0.04	0.00	0.02	0.05	0.00	0.02	0.05

COMMERCIAL AND INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

NUMBER OF INSTALLED SYSTEMS (MILLIONS)
HIGH-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	0.15	0.37	0.81	0.20	0.44	0.86	0.26	0.49	0.86	0.33	0.54	0.84
H&HW	0.13	0.29	0.60	0.17	0.35	0.64	0.23	0.39	0.67	0.28	0.43	0.70
C,H,&HW	0.09	0.17	0.37	0.11	0.22	0.46	0.14	0.26	0.53	0.18	0.31	0.61
PASSIVE												
H&HW	0.01	0.03	0.12	0.01	0.04	0.13	0.02	0.04	0.13	0.02	0.04	0.14
PHOTO- VOLTAICS	-	-	-	-	-	-	-	-	-	-	-	-
WECS	-	-	-	-	-	-	-	-	-	-	-	-

COMMERCIAL AND INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

NUMBER OF INSTALLED SYSTEMS (MILLIONS)
LOW-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	0.15	0.36	0.33	0.20	0.44	0.90	0.26	0.50	0.92	0.34	0.60	0.91
H&HW	0.12	0.26	0.55	0.16	0.32	0.61	0.21	0.36	0.64	0.26	0.41	0.67
C,H,&HW	0.08	0.17	0.38	0.11	0.21	0.47	0.14	0.26	0.54	0.18	0.31	0.62
PASSIVE												
H&HW	0.01	0.04	0.13	0.01	0.05	0.14	0.02	0.06	0.15	0.02	0.06	0.16
PHOTO- VOLTAICS	-	-	-	-	-	-	-	-	-	-	-	-
WECS	-	-	-	-	-	-	-	-	-	-	-	-

COMMERCIAL AND INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

NUMBER OF INSTALLED SYSTEMS (MILLIONS), REGIONAL BREAKOUT
MID-PRICE SCENARIO, OPTION II

	REG 1	REG 2	REG 3	REG 5	REG 7	REG 4	REG 6	REG 8	REG 9	U.S.
<u>1985</u>										
ACTIVE										
HW	.01	.05	.03	.02	.03	.05	.02	.01	.04	.26
H&HW	.01	.05	.03	.01	.02	.04	.01	.01	.04	.22
C,H,&HW	*	.02	.02	.01	.02	.03	.02	.01	.02	.14
PASSIVE										
H&HW	*	.01	*	*	*	*	*	*	*	.02
<u>2000</u>										
ACTIVE										
HW	.03	.16	.09	.06	.10	.18	.07	.05	.14	.88
H&HW	.04	.16	.07	.03	.04	.13	.04	.02	.13	.68
C,H,&HW	.01	.07	.08	.04	.07	.10	.08	.03	.08	.55
PASSIVE										
H&HW	.01	.04	.02	.01	.01	.03	.01	.01	.03	.15
	NESEC		SSEC			MASEC		WSUN		

*Less than .01 million

NUMBER OF INSTALLED SYSTEMS, MILLIONS
MID-PRICE SCENARIO, OPTION II

COMMERCIAL AND INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

RESIDENTIAL BUILDINGS
MARKET SECTOR WORKBOOK

ANNUAL SALES OF SYSTEMS, BILLIONS OF 1976 DOLLARS
MID-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	0.72	1.37	2.12	0.91	1.88	1.86	0.95	2.10	1.62	1.17	2.25	1.12
H&HW	1.16	1.62	2.58	1.43	2.42	3.07	1.76	2.60	3.59	2.15	3.17	4.57
C, H, & HW	0.43	0.54	1.93	0.45	1.40	3.99	1.54	1.88	4.93	1.85	3.50	7.99
PASSIVE												
H&HW	0.19	0.71	2.23	0.23	1.06	2.65	0.29	1.14	3.10	0.35	1.39	3.95
PHOTO- VOLTAICS	0.09	0.62	2.41	0.14	0.89	3.47	0.17	1.17	4.53	0.19	1.31	5.08
WECS	0.16	0.59	1.58	0.22	0.79	2.13	0.27	1.00	2.69	0.30	1.12	2.99

RESIDENTIAL BUILDINGS
MARKET SECTOR WOOKBOOK

ANNUAL SALES OF SYSTEMS, BILLIONS OF 1976 DOLLARS
HIGH-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	0.73	1.63	2.25	0.93	2.15	1.83	0.97	2.31	1.56	1.19	2.35	1.06
H&HW	1.03	1.63	2.75	1.27	2.47	3.18	1.57	2.65	3.70	1.95	3.23	4.44
C,H,&HW	0.31	0.59	2.12	0.35	1.45	4.27	1.34	1.95	5.35	1.66	3.56	8.39
PASSIVE												
H&HW	0.20	0.79	2.41	0.25	1.20	2.79	0.30	1.28	3.24	0.38	1.57	3.89
PHOTO- VOLTAICS	-	-	-	-	-	-	-	-	-	-	-	-
WECS	-	-	-	-	-	-	-	-	-	-	-	-

RESIDENTIAL BUILDINGS
MARKET SECTOR WORKBOOK

ANNUAL SALES OF SYSTEMS, BILLIONS OF 1976 DOLLARS
LOW-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
EW	0.72	1.30	1.98	0.91	1.79	1.77	0.94	1.97	1.61	1.16	2.19	1.17
H&HW	1.38	1.95	3.09	1.70	2.82	3.44	2.07	2.96	3.62	2.53	3.52	4.65
C,H,&HW	0.70	1.01	3.34	0.77	2.23	5.78	2.14	2.90	6.97	2.59	4.86	10.44
PASSIVE												
H&HW	0.19	0.74	2.30	0.23	1.07	2.56	0.29	1.12	2.69	0.35	1.34	3.46
PHOTO- VOLTAICS	-	-	-	-	-	-	-	-	-	-	-	-
WECS	-	-	-	-	-	-	-	-	-	-	-	-

ANNUAL SALES OF SYSTEMS, BILLIONS OF 1976 DOLLARS
MID-PRICE SCENARIO, OPTION II

RESIDENTIAL BUILDINGS
MARKET SECTOR WORKBOOK

COMMERCIAL AND INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

ANNUAL SALES OF SYSTEMS, BILLIONS OF 1976 DOLLARS
MID-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	0.15	0.26	0.23	0.20	0.27	0.21	0.24	0.25	0.19	0.28	0.22	0.18
H&HW	0.86	1.37	1.21	1.12	1.35	1.22	1.34	1.23	1.26	1.48	1.15	1.28
C,H,&HW	1.03	1.51	2.06	1.42	2.02	2.55	1.78	2.27	2.81	2.19	2.47	3.05
PASSIVE												
H&HW	0.18	0.47	0.89	0.23	0.46	0.90	0.28	0.42	0.93	0.31	0.39	0.94
PHOTO- VOLTAICS	0.00	0.04	0.20	0.00	0.05	0.27	0.00	0.07	0.33	0.00	0.08	0.40
WECS	0.01	0.04	0.07	0.01	0.05	0.09	0.01	0.07	0.11	0.01	0.08	0.12

COMMERCIAL AND INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

ANNUAL SALES OF SYSTEMS, BILLIONS OF 1976 DOLLARS
HIGH-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	0.15	0.26	0.21	0.19	0.27	0.19	0.23	0.25	0.17	0.27	0.21	0.15
H&HW	0.77	1.25	1.22	1.00	1.23	1.22	1.20	1.13	1.21	1.29	1.04	1.24
C,H,&HW	0.96	1.44	1.90	1.29	1.88	2.24	1.60	2.09	2.43	1.94	2.26	2.63
PASSIVE												
H&HW	0.19	0.45	0.50	0.25	0.44	0.90	0.30	0.41	0.89	0.32	0.37	0.91
PHOTO- VOLTAICS	-	-	-	-	-	-	-	-	-	-	-	-
WECS	-	-	-	-	-	-	-	-	-	-	-	-

COMMERCIAL AND INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

ANNUAL SALES OF SYSTEMS, BILLIONS OF 1976 DOLLARS
LOW-PRICE SCENARIO

	NEA OPTION			OPTION I			OPTION II			OPTION III		
	1985	1990	2000	1985	1990	2000	1985	1990	2000	1985	1990	2000
ACTIVE												
HW	0.15	0.26	0.24	0.20	0.28	0.23	0.25	0.26	0.22	0.30	0.22	0.18
H&HW	1.02	1.62	1.55	1.32	1.62	1.58	1.59	1.51	1.61	1.87	1.41	1.65
C,H,&HW	1.19	1.79	2.48	1.67	2.38	3.13	2.16	2.70	3.49	2.71	2.93	3.77
PASSIVE												
H&HW	0.19	0.50	0.99	0.25	0.50	1.01	0.30	0.47	1.03	0.35	0.44	1.05
PHOTO- VOLTAICS	-	-	-	-	-	-	-	-	-	-	-	-
WECS	-	-	-	-	-	-	-	-	-	-	-	-

COMMERCIAL AND INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

ANNUAL SALES OF SYSTEMS, BILLIONS OF 1976 DOLLARS
MID-PRICE SCENARIO, OPTION II