MTR-80W00022

Toward a National Plan for the Accelerated Commercialization of Solar Energy

Utility Applications and Synthetic Fuels and Chemicals Market Sector

WORKBOOK

The MITRE Corporation

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WORKBOOK

C. Grant Miller

Dyanne L. de Jong

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The MITRE Corporation
McLean, Virginia 22102

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ABSTRACT

This workbook summarizes the preliminary data and assumptions of the Utility Applications and Synthetic Fuels and Chemicals Market Sectors prepared in conjunction with the development of inputs for a National Plan for the Accelerated Commercialization of Solar Energy.

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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.

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[1] Toward 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.

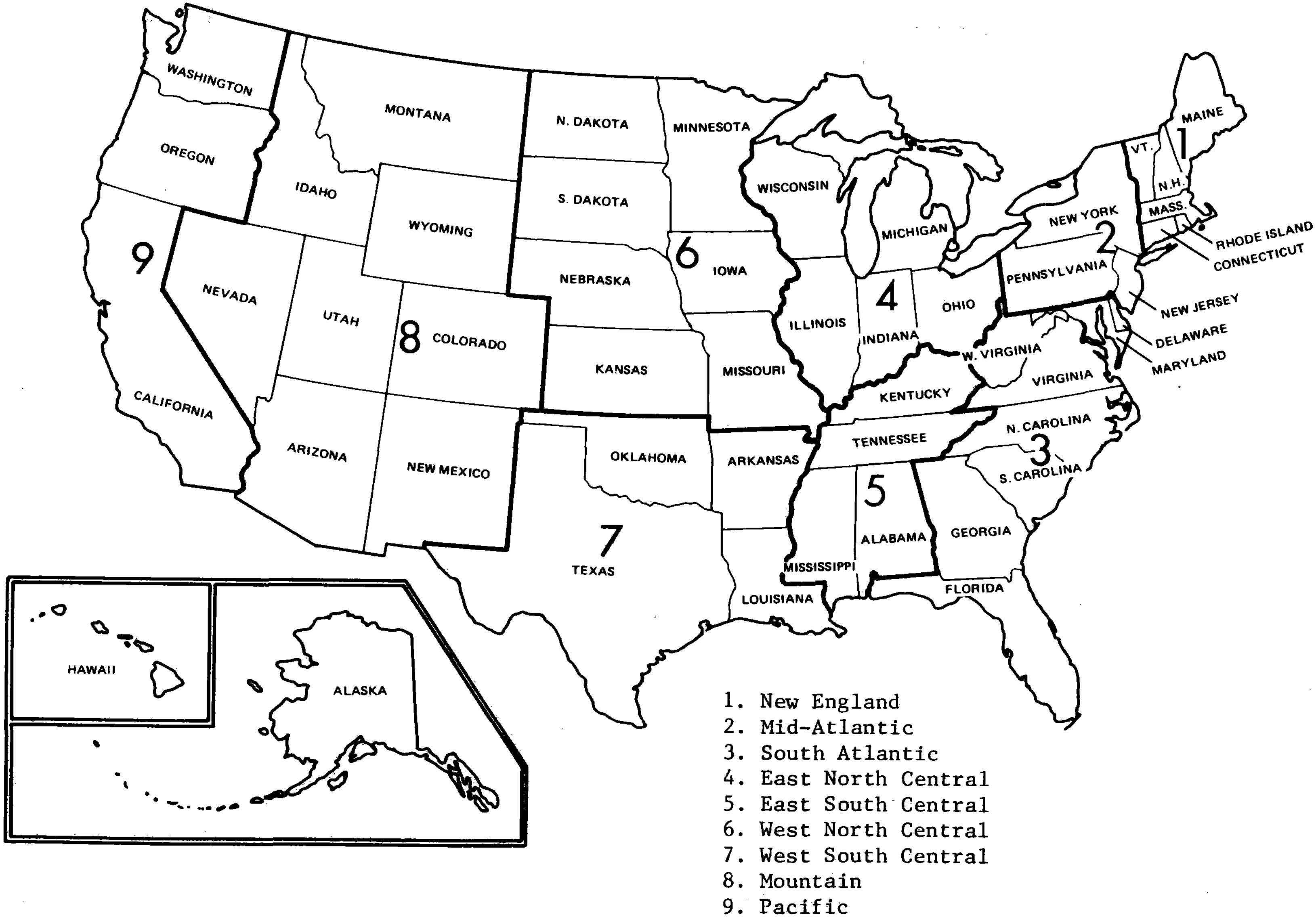

FIGURE 1
U.S. CENSUS REGIONS

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:

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

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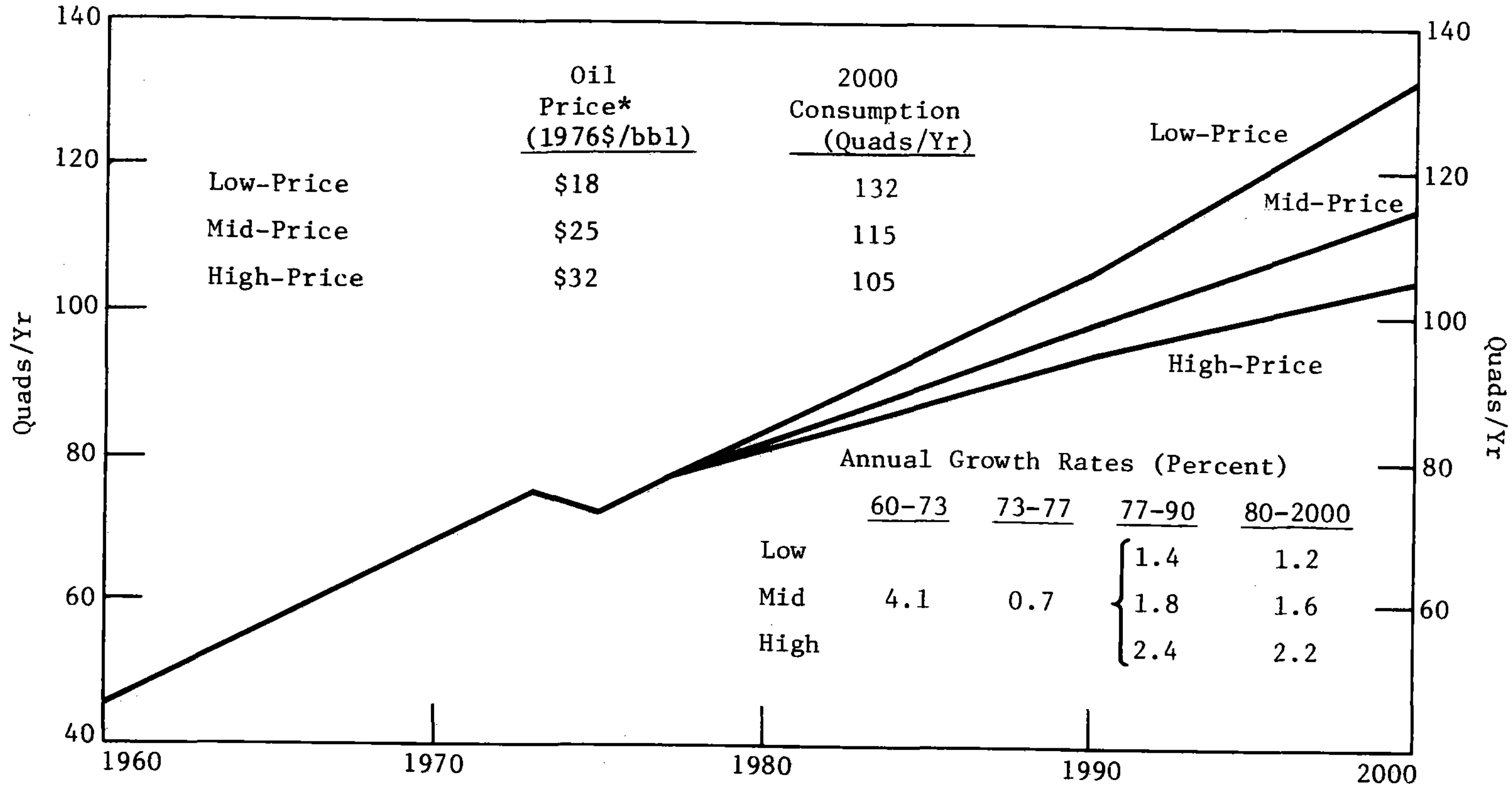
[1]Rebibo, Kathy K. Toward a National Plan for the Commercialization of Solar Energy: Price/Demand Scenarios and Projections of Solar Utilization under the National Energy Act, MTR-8057. McLean, Virginia: The MITRE Corporation, May 1979.



*Price to industrial sector

FIGURE 2
U.S. ENERGY CONSUMPTION

The market sector was analyzed[1] 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

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[1]Estimates 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.

[2]The 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&D 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 "sun rights"; and public information dissemination programs.

A summary of the market sector workbook follows.

SUMMARY
UTILITY APPLICATIONS

ELECTRIC ENERGY DEMAND

For the utility market sector, the total demand for electricity is defined for the three price/demand scenarios. The 1980 demand for all scenarios is expected to be almost 2 trillion kilowatt hours (kWh). Under the high-price scenario, this will grow by 75 percent by the year 2000 to almost 3.5 trillion kWh. The mid-price scenario shows demand growing by almost 125 percent above the 1980 level to about 4.5 trillion kWh. In the low-price scenario, demand grows by 150 percent to over 5.1 trillion kWh.

For the mid-price scenario, regional demand for electricity in the year 2000 ranges from 180 billion kWh in New England to 806 billion kWh in both the South Atlantic and East North Central regions.

Solar technologies may be used to meet several types of electric demand in the utility market sector. These include baseload, intermediate, and semipeaking demands. Solar technologies may also be operated as fuel-savers. The incremental demand for each of these applications, for each price/demand scenario, is projected from 1980 to 2000 and the solar technologies that compete in each demand category are enumerated. The market potential for the utility sector is the incremental electric demand for which solar technologies can compete. This is summarized in the workbook for the mid-price scenario.

DEVELOPMENT PLANS

Generic development plans and technology descriptions are included in the workbook. The development plans list and provide flow charts of the activities, participants, and time required to bring each of the solar technologies into operation. The technology descriptions provide the economic and technological characteristics of each generic system.

ECONOMIC INCENTIVES

Several levels of national incentives are assumed for the analysis. The Reference Case is the mid-price scenario incorporating the provisions of the NEA, which allows a 10 percent investment tax credit (ITC) for solar technologies. Option I provides a 15 percent ITC over the NEA. This level of incentive, 25 percent ITC, will be maintained through the year 2000. Option II includes a combined 40 percent ITC in 1980 that declines linearly to 30 percent by 1990 and then remains constant. Option III provides for a combined 50 percent ITC in 1980 for utility solar applications. This will decline linearly to 33 percent in 1990 and remain constant thereafter.

MARKET PENETRATION

The market penetration under the mid-price scenario for 1990 and 2000 is analyzed on a regional basis. Charts showing the busbar cost of electricity (mills/kWh) for each of four technologies and the quads of primary energy displaced by each are shown in the workbook. Under the mid-price scenario, the analysis shows that wind energy conversion systems and solar thermal technologies make the most significant contribution, and that growth of these technologies is accelerated after 1993. Other important impacts of accelerated growth in the early 1990s include a large increase in the number of units sold and, therefore, a large increase in the labor and resource requirements to produce these systems.

TOTAL MARKET

THREE SCENARIOS, HIGH-PRICE, MID-PRICE, AND LOW-PRICE WERE DEFINED IN DISCUSSIONS WITH THE DOMESTIC POLICY REVIEW COMMITTEE. TOTAL DEMAND FOR ELECTRICITY WAS DEFINED FOR EACH OF THESE SCENARIOS.

- DEMAND FOR ELECTRICITY, 10^9 kWh PER YEAR

	HIGH-PRICE*	MID-PRICE	LOW-PRICE
1980	1970	1970	1970
1990	2710	3050	3280
2000	3470	4480	5120

- GENERAL GROWTH RATE OF DEMAND FOR ELECTRICITY (%)

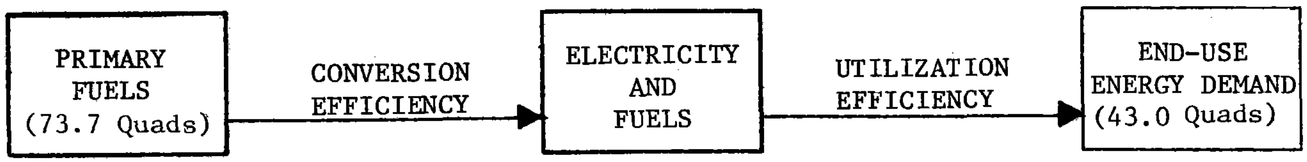
	HIGH-PRICE	MID-PRICE	LOW-PRICE
1980-1990	3.2	4.5	5.2
1990-2000	2.5	3.9	4.6

- REGIONAL GROWTH RATES

REGIONAL DEMANDS FOR ELECTRICITY WERE OBTAINED FROM THE ENERGY INFORMATION AGENCY (EIA) FOR 1988. REGIONAL DEMANDS WERE ASSUMED TO REMAIN PROPORTIONAL THROUGHOUT THE PERIOD UNDER STUDY.

*High-price refers to high prevailing prices of conventional fuels.

DEFINITIONS OF TERMS



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

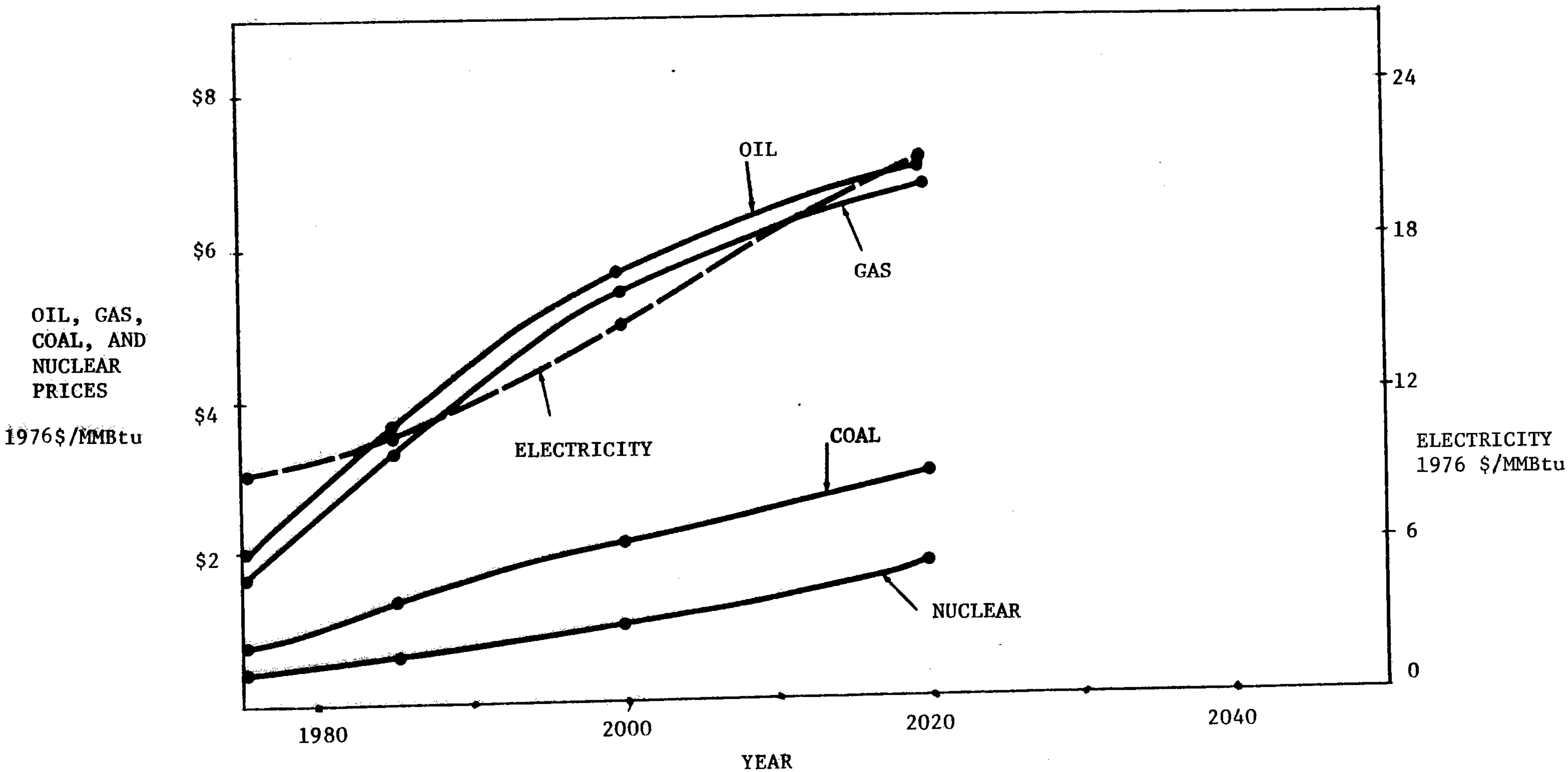
1. TRANSMISSION AND DISTRIBUTION
2. UTILIZATION EFFICIENCY

SCENARIO DESCRIPTIONS

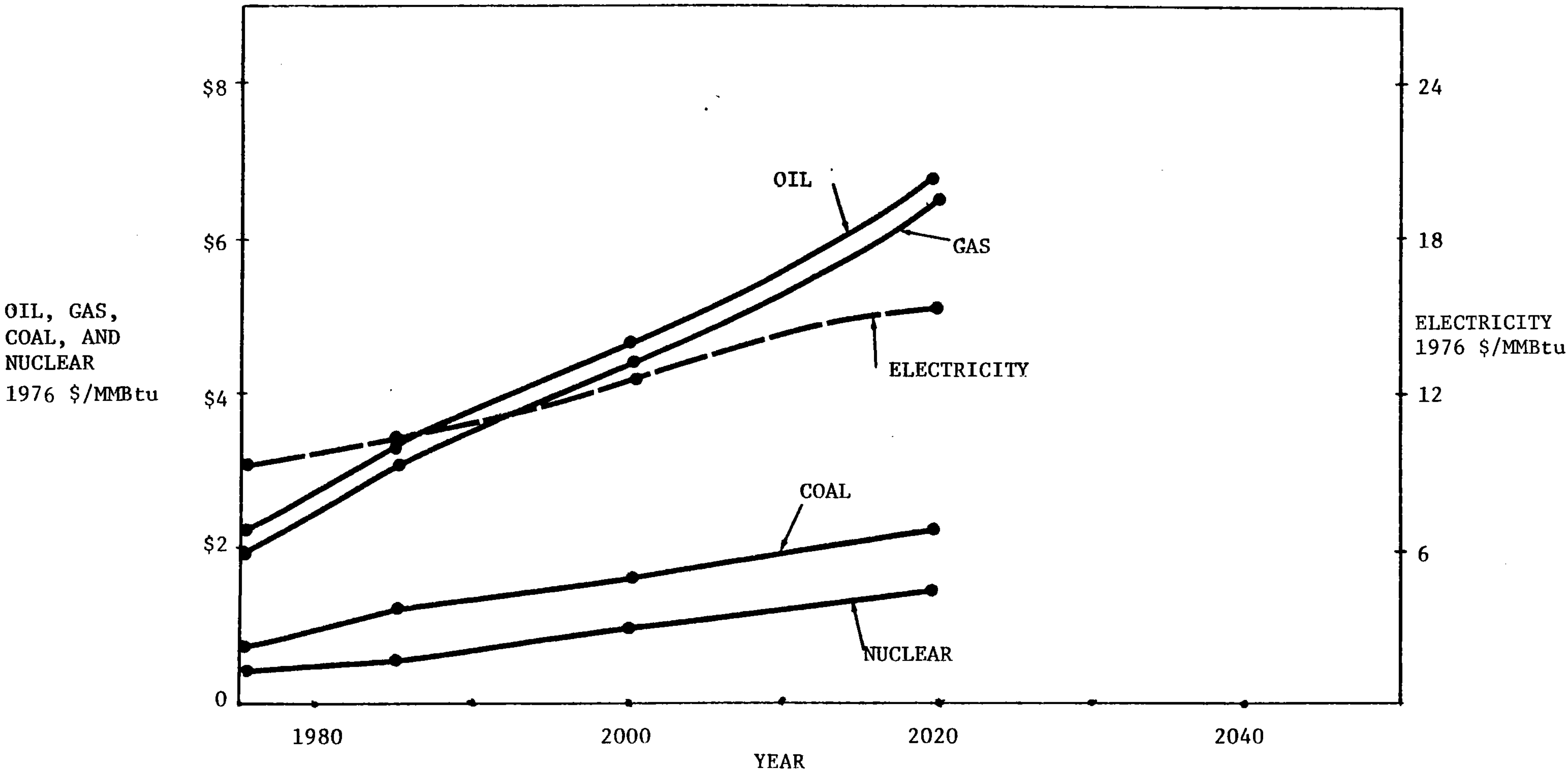
FUEL PRICES: SEE NEXT THREE PAGES FOR ACTUAL PRICES. FUEL PRICES REFLECT PREVAILING COSTS OF OIL IN CONSTANT 1976 $ OF:

	LOW-PRICE	MID-PRICE	HIGH-PRICE
YEAR 2000 PRICES:	$18/bbl	$25/bbl	$32/bbl
INFLATION RATES:	4.0%	5.0%	7.0%
DISCOUNT RATES: (COSTS OF CAPITAL)	10.02%	10.16%	13.72%
TOTAL DEMAND FOR PRIMARY ENERGY: (YR. 2000)	135 Quads	115 Quads	95 Quads

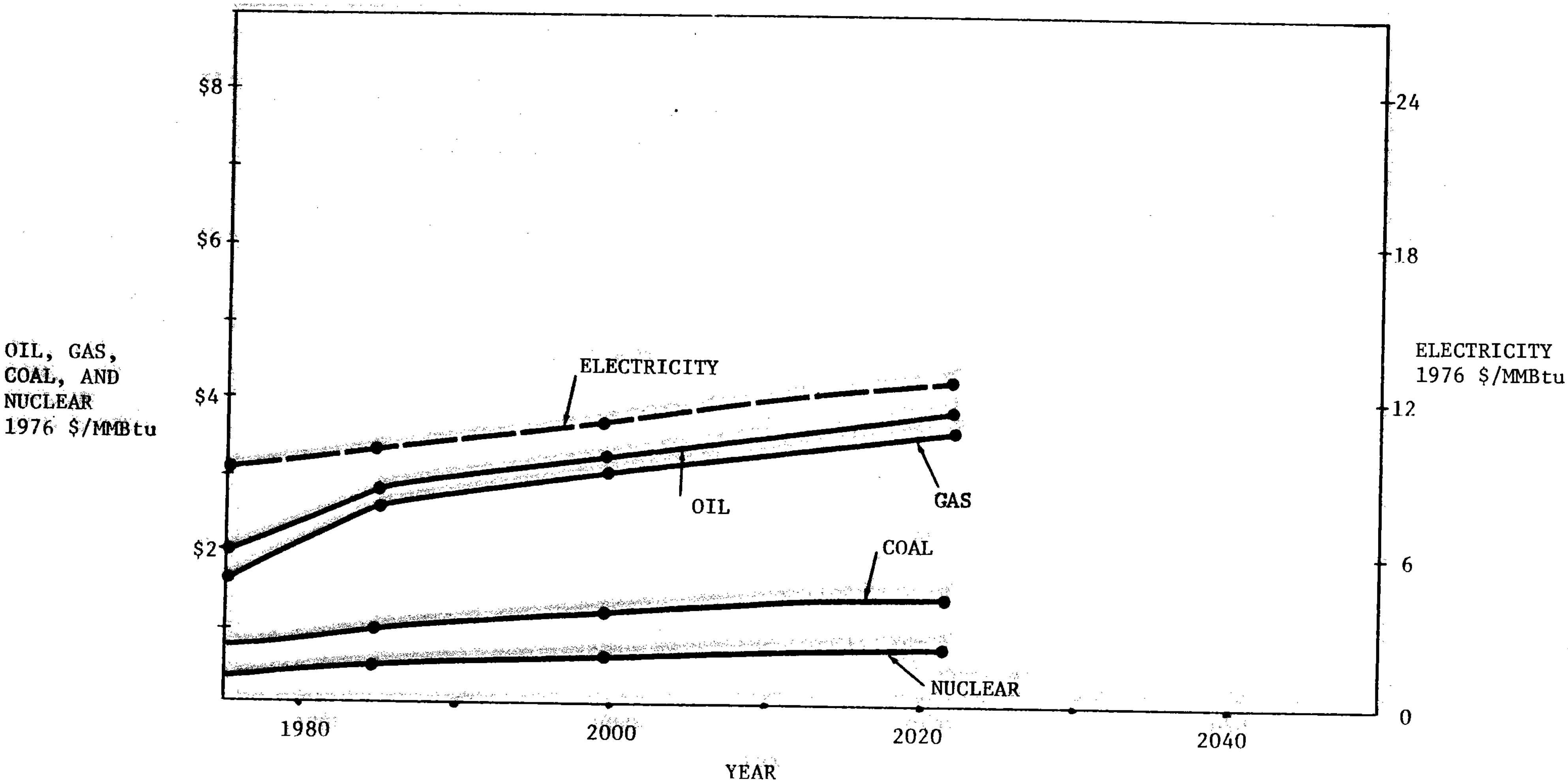
FUEL PRICE ASSUMPTIONS FOR HIGH-PRICE SCENARIO



FUEL PRICE ASSUMPTIONS FOR MID-PRICE SCENARIO

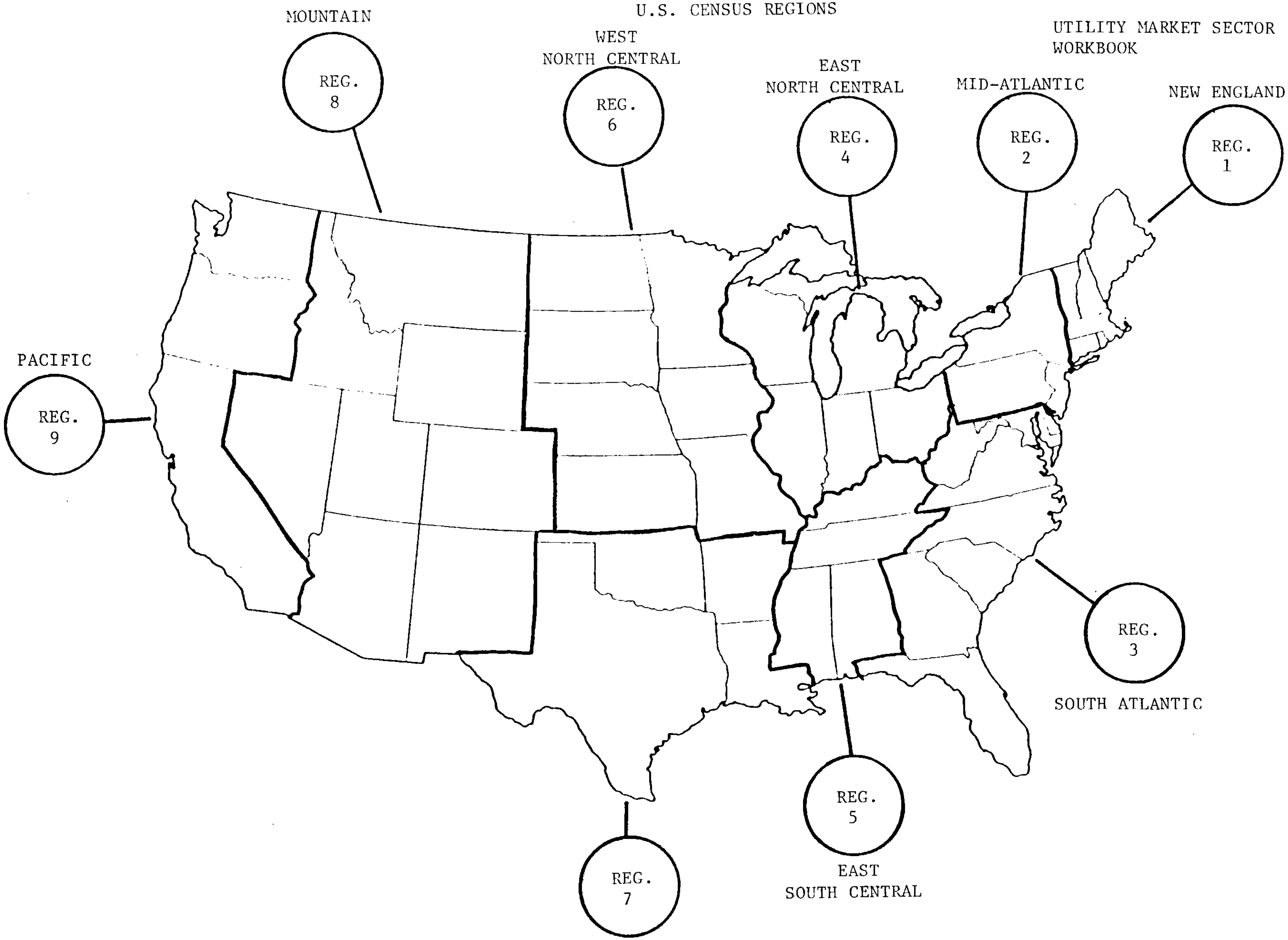


FUEL PRICE ASSUMPTIONS FOR LOW-PRICE SCENARIO

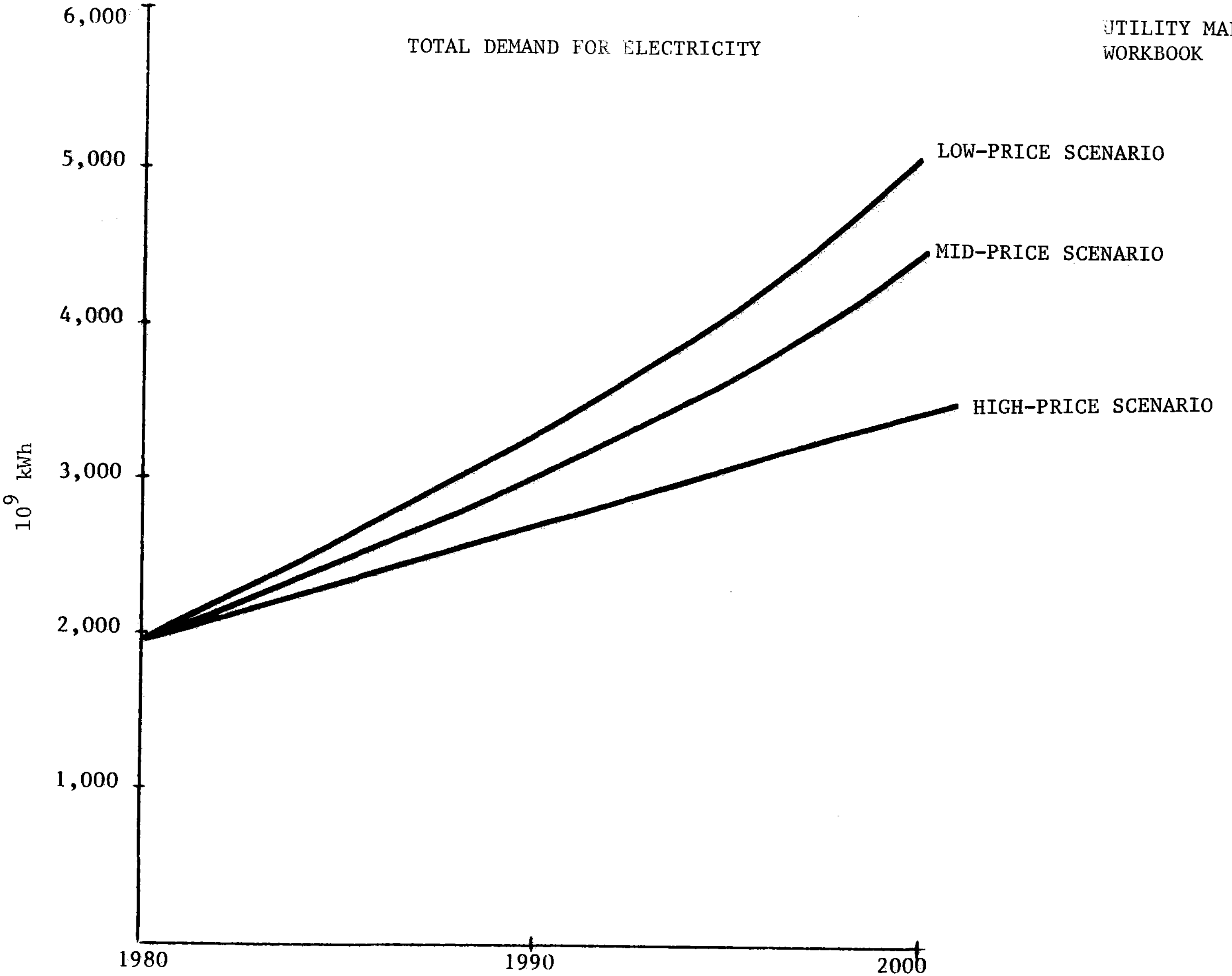


U.S. CENSUS REGIONS

UTILITY MARKET SECTOR
WORKBOOK

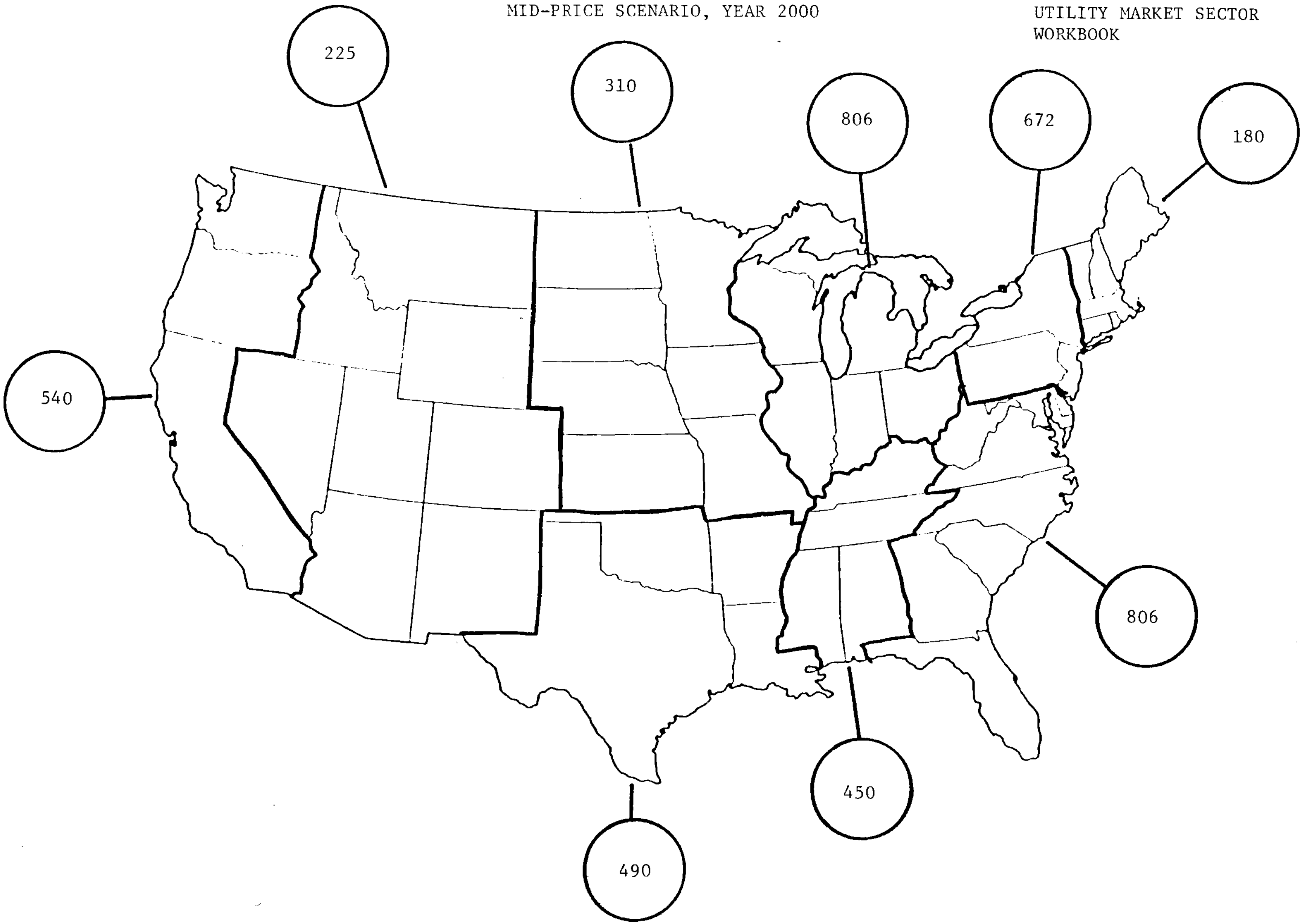


TOTAL DEMAND FOR ELECTRICITY



MARKET POTENTIAL, REGIONAL DEMAND FOR ELECTRICITY, 10^9 kWh
MID-PRICE SCENARIO, YEAR 2000

UTILITY MARKET SECTOR
WORKBOOK



BASELOAD DEMAND, INCREMENTAL DEMAND FROM 1980, 10^9 kWh

- DEMAND FOR BASELOAD ELECTRICITY, INCREMENTAL FROM 1980

	HIGH-PRICE	MID-PRICE	LOW-PRICE
1980	0	0	0
1990	480	680	850
2000	980	1630	2050

- SOLAR COMPETITORS
  - OTEC TECHNOLOGY LIMITED TO THE SOUTH ATLANTIC, EAST SOUTH CENTRAL AND WEST SOUTH CENTRAL REGIONS OF THE U.S.
  - DIRECT COMBUSTION OF BIOMASS TECHNOLOGIES
  - WIND ENERGY CONVERSION SYSTEMS COUPLED WITH COMBINED CYCLE UNITS

INTERMEDIATE ELECTRICITY

- DEMAND FOR INTERMEDIATE ELECTRICITY, INCREMENTAL FROM 1980, 10^9 kWh

	HIGH-PRICE	MID-PRICE	LOW-PRICE
1980	0	0	0
1990	160	230	290
2000	330	550	690

- SOLAR COMPETITORS
  - WIND ENERGY CONVERSION SYSTEMS WITH GAS TURBINE BACKUP
  - WIND ENERGY CONVERSION SYSTEMS WITH HYDROELECTRIC IN A "WATER SAVER" CONFIGURATION FOR USE ONLY IN THE NEW ENGLAND, EAST SOUTH CENTRAL, MOUNTAIN AND PACIFIC REGIONS OF THE U.S.
  - PHOTOVOLTAICS BASED ON SILICON CELL TECHNOLOGY
  - PHOTOVOLTAICS BASED ON THIN FILM TECHNOLOGY
  - PHOTOVOLTAICS BASED ON CONCENTRATOR TECHNOLOGY
  - SOLAR THERMAL CENTRAL RECEIVERS WITH COMBINED CYCLE BACKUP
  - SOLAR THERMAL CENTRAL RECEIVERS WITH STORAGE BACKUP
  - SOLAR THERMAL REPOWERING OF EXISTING OIL AND GAS FIRED UNITS
  - DIRECT COMBUSTION OF BIOMASS

DEMAND FOR SEMIPEAKING ELECTRICITY, INCREMENTAL FROM 1980, 10^9 kWh

	HIGH-PRICE	MID-PRICE	LOW-PRICE
1980	0	0	0
1990	80	120	140
2000	170	280	350

SOLAR COMPETITORS

- SOLAR THERMAL CENTRAL RECEIVERS WITH THERMAL STORAGE
- PHOTOVOLTAICS THIN FILM TECHNOLOGY
- PHOTOVOLTAICS SILICON TECHNOLOGY

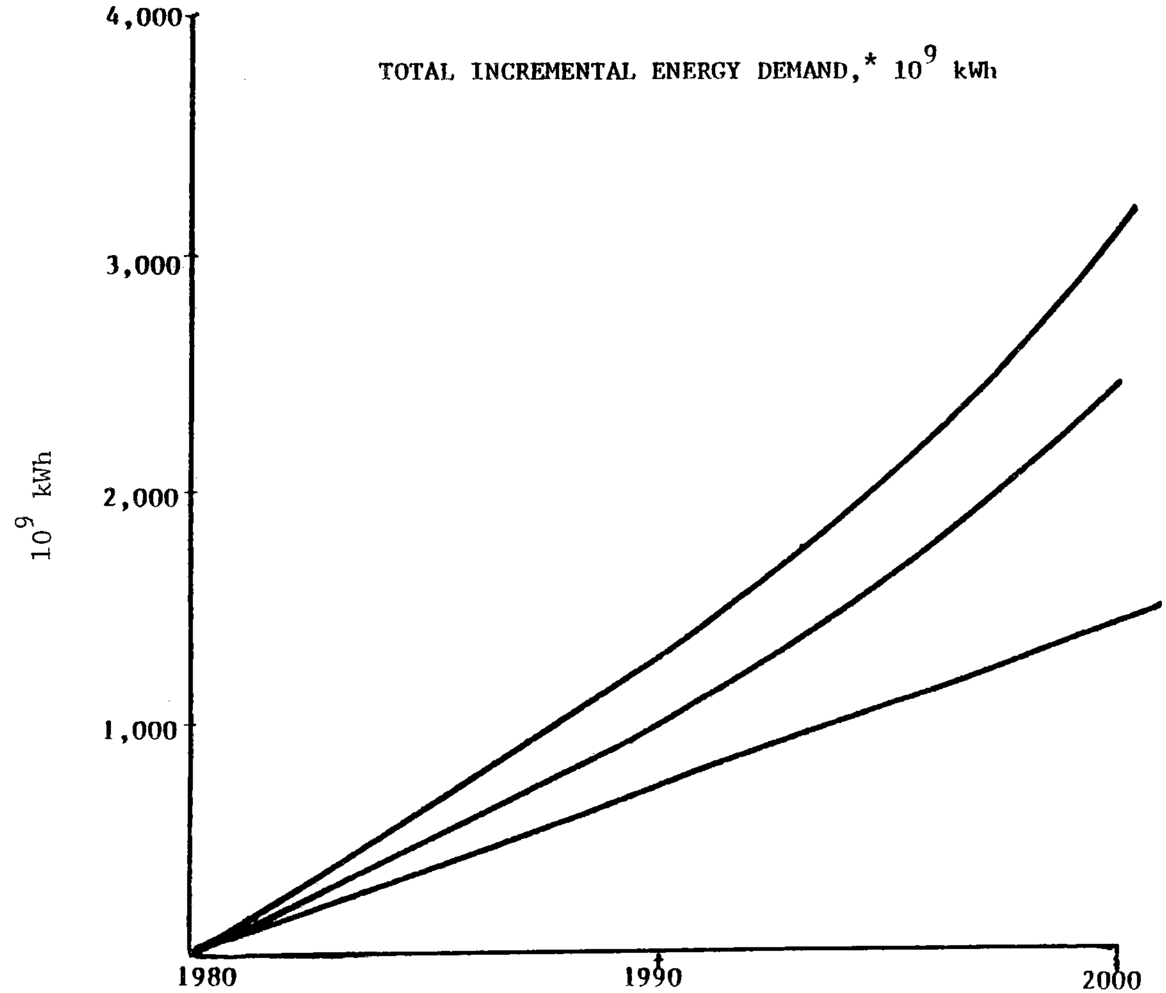
DEMAND FOR FUEL SAVER ELECTRICITY, INCREMENTAL FROM 1980, 10^9 kWh

	HIGH-PRICE	MID-PRICE	LOW-PRICE
1980	0	0	0
1990	70	110	130
2000	150	250	320

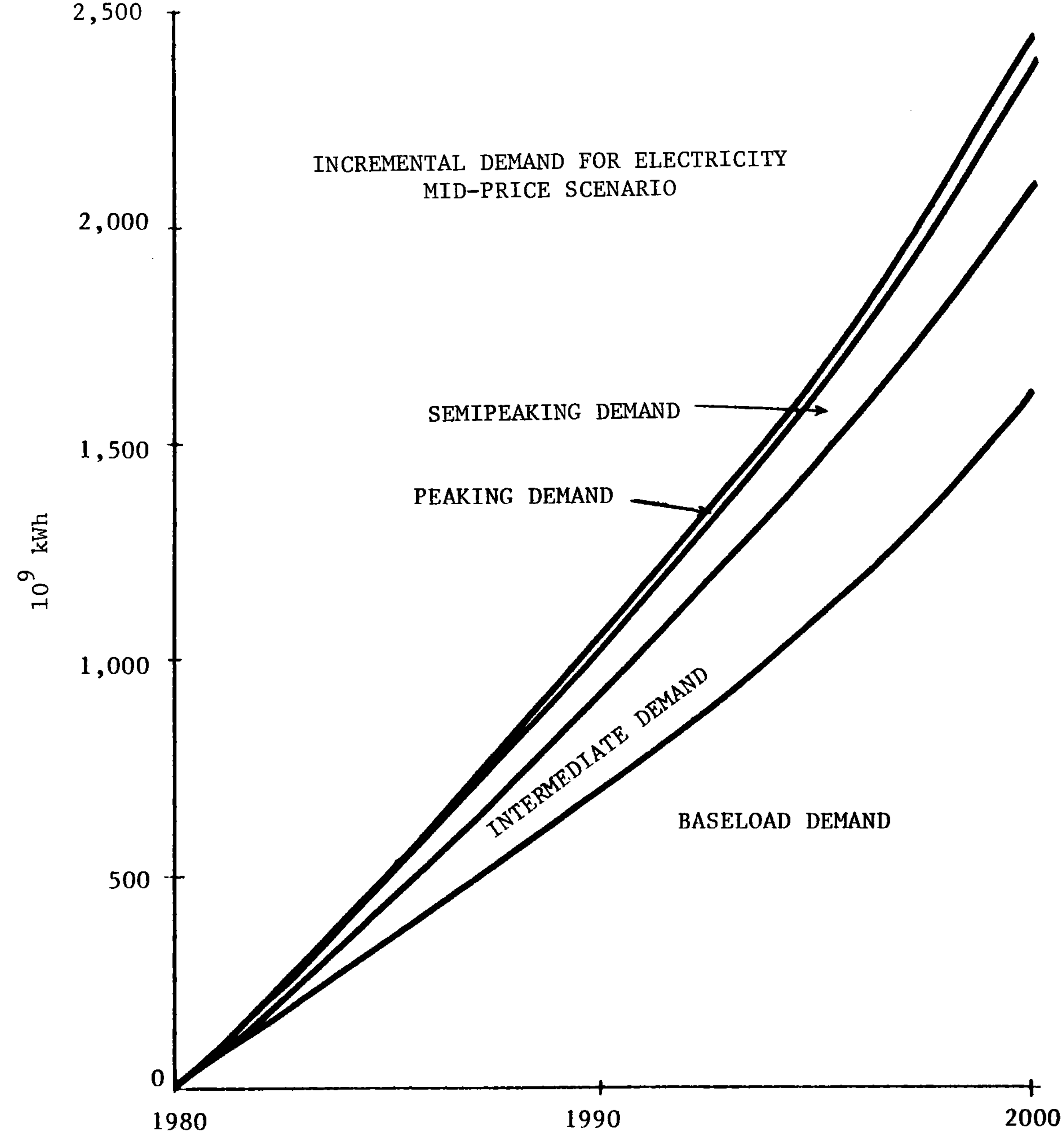
SOLAR COMPETITORS

- WIND ENERGY CONVERSION SYSTEMS FOR SITES OF 14 MPH AVERAGE WINDSPEED OR ABOVE
- PHOTOVOLTAICS THIN FILM TECHNOLOGY
- SOLAR THERMAL CENTRAL RECEIVERS

UTILITY MARKET SECTOR
WORKBOOK



TOTAL INCREMENTAL ENERGY DEMAND IS THE SUM TOTAL OF INCREMENTAL DEMAND FOR BASELOAD, INTERMEDIATE, SEMI-PEAKING AND PEAKING ELECTRICITY. FUEL SAVER DEMAND REPRESENTS A DISPLACEMENT OF CONVENTIONAL ELECTRICITY PRODUCTION. FOR EVERY KWH OF SOLAR FUEL SAVER ELECTRICITY PRODUCED, ONE KWH OF CONVENTIONAL ELECTRICITY IS DISPLACED.

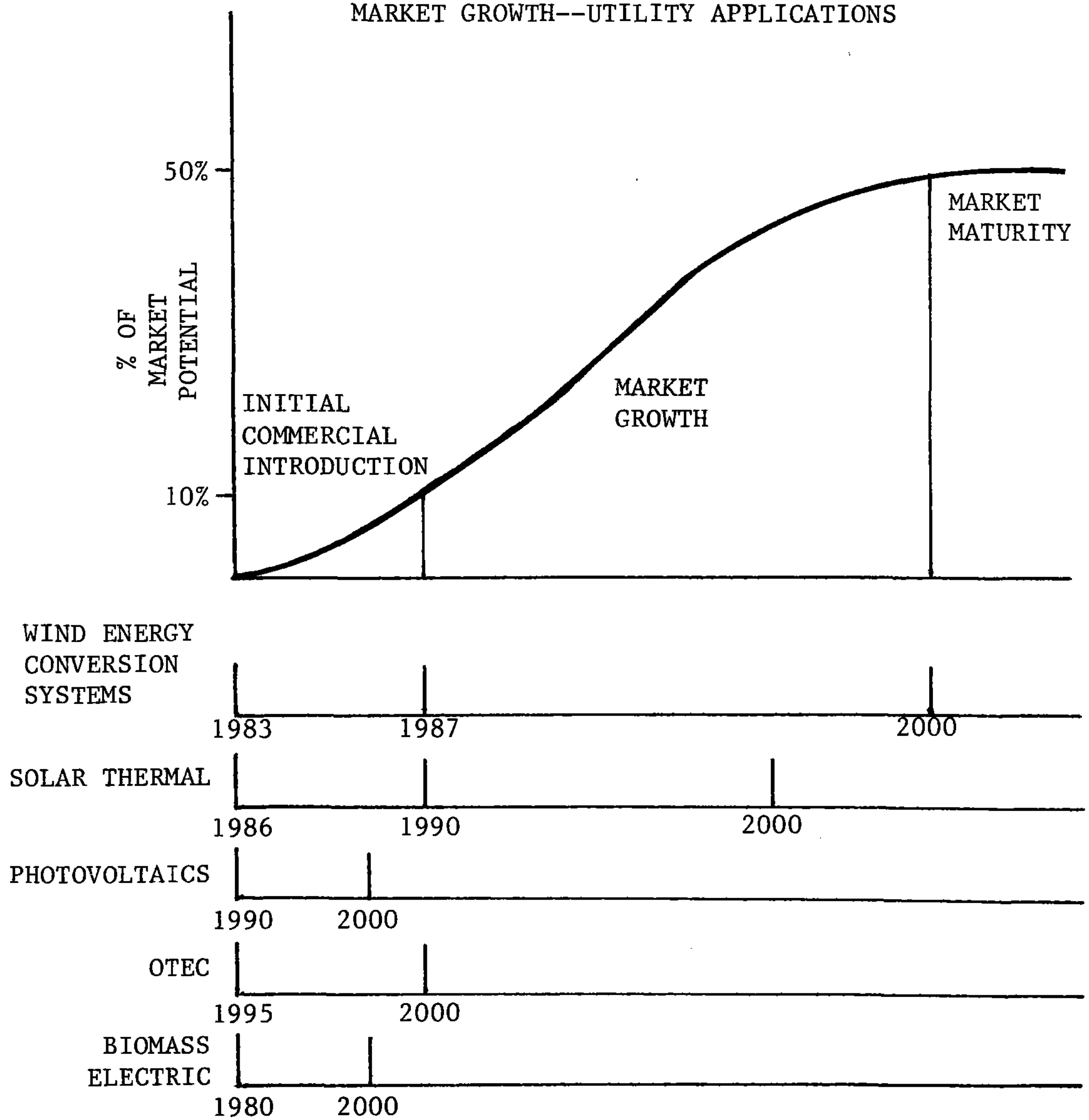

INCREMENTAL DEMAND FOR ELECTRICITY
MID-PRICE SCENARIO
2,500
2,000
1,500
1,000
500
0
10^9 kWh
SEMIPEAKING DEMAND
PEAKING DEMAND
INTERMEDIATE DEMAND
BASELOAD DEMAND
1980
1990
2000

MARKET POTENTIAL FOR SOLAR ELECTRIC APPLICATIONS*

	BASELOAD	INTERMEDIATE	SEMIPEAKING	PEAKING	FUEL SAVER	TOTAL
OTEC (3 Regions Only)	640	-	-	-	-	640
WECS	1630	550	-	-	320	2500
SOLAR THERMAL	-	550	120	-	320	980
PHOTOVOLTAICS	-	550	120	-	320	990
BIOMASS COMBUSTION	1630	550	-	-	-	2180

*This is the incremental electric demand for which the technology can compete. The values given are for the year 2000 in 10^9 kWh, mid-price scenario.

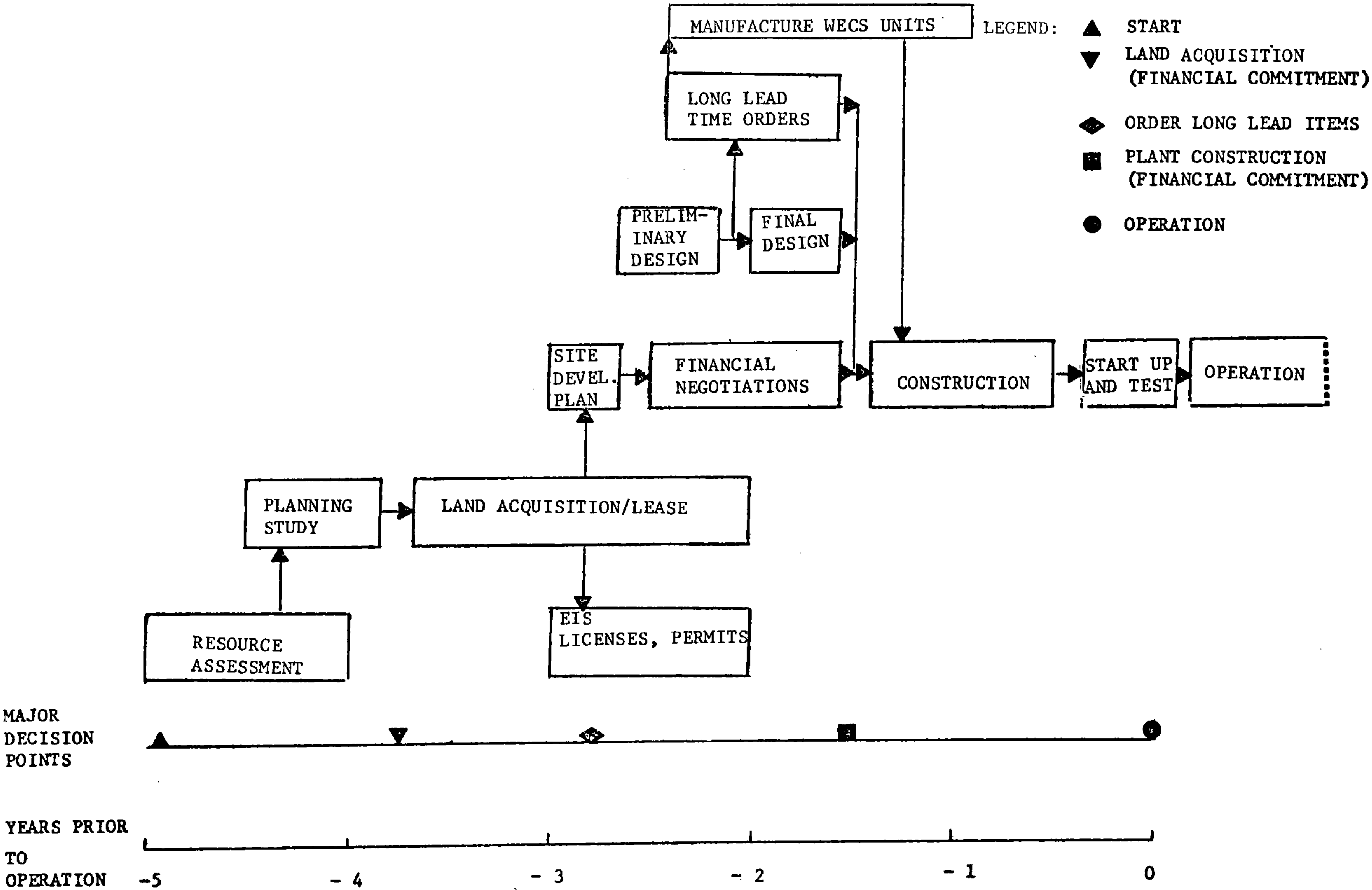
MARKET GROWTH--UTILITY APPLICATIONS



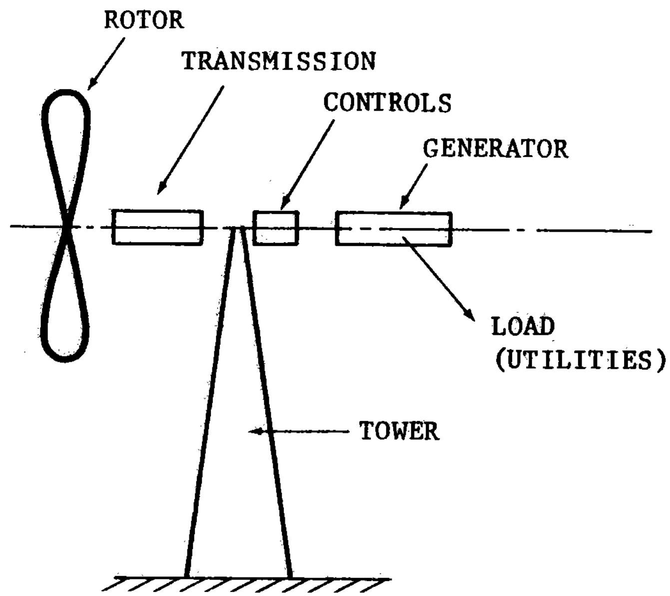
WIND ENERGY CONVERSION SYSTEMS GENERIC DEVELOPMENT PLAN

OVERALL DEVELOPMENT OF A 100 MW WECS UNIT ARRAY IS EXPECTED TO TAKE ABOUT 5.0 YEARS INCLUDING UP TO 15 MONTHS FOR ASSESSMENT, 24 MONTHS FOR LAND ACQUISITION/LEASES, 18 MONTHS FOR LONG LEAD TIME ITEMS AND 9 TO 12 MONTHS FOR ERECTING WECS AT THE SITE.

ACTIVITY	PARTICIPANTS	TIME REQUIRED RANGE (MOS)	TIME REQUIRED GDP (MOS)
RESOURCE ASSESSMENT	UTILITY/A&E FIRM	12-15	12
PLANNING STUDY	UTILITY	5-9	6
LAND ACQUISITION/LEASE	UTILITY	18-24	24
LICENSES, PERMITS, ENVIRONMENTAL IMPACT STATEMENT (EIS)	UTILITY/GOVERNMENT BODIES	12-18	12
FINANCIAL NEGOTIATIONS	UTILITY/BANKS, STOCKHOLDERS	12-18	12
FINAL DESIGN	UTILITY/A&E FIRMS	3-6	3
ORDER LONG LEAD TIME ITEMS	UTILITY/SUPPLIER	12-24	12
MANUFACTURE WECS UNIT	WECS SUPPLIER	18	18
CONSTRUCTION	UTILITY/A&E FIRM, GENERAL CONTRACTOR	12-15	12
START UP AND TEST	UTILITY/A&E FIRM	3	3



WIND ENERGY CONVERSION SYSTEMS GENERIC DEVELOPMENT PLAN, 100 MW ARRAY



MAJOR COMPONENTS OF WIND ENERGY CONVERSION SYSTEMS

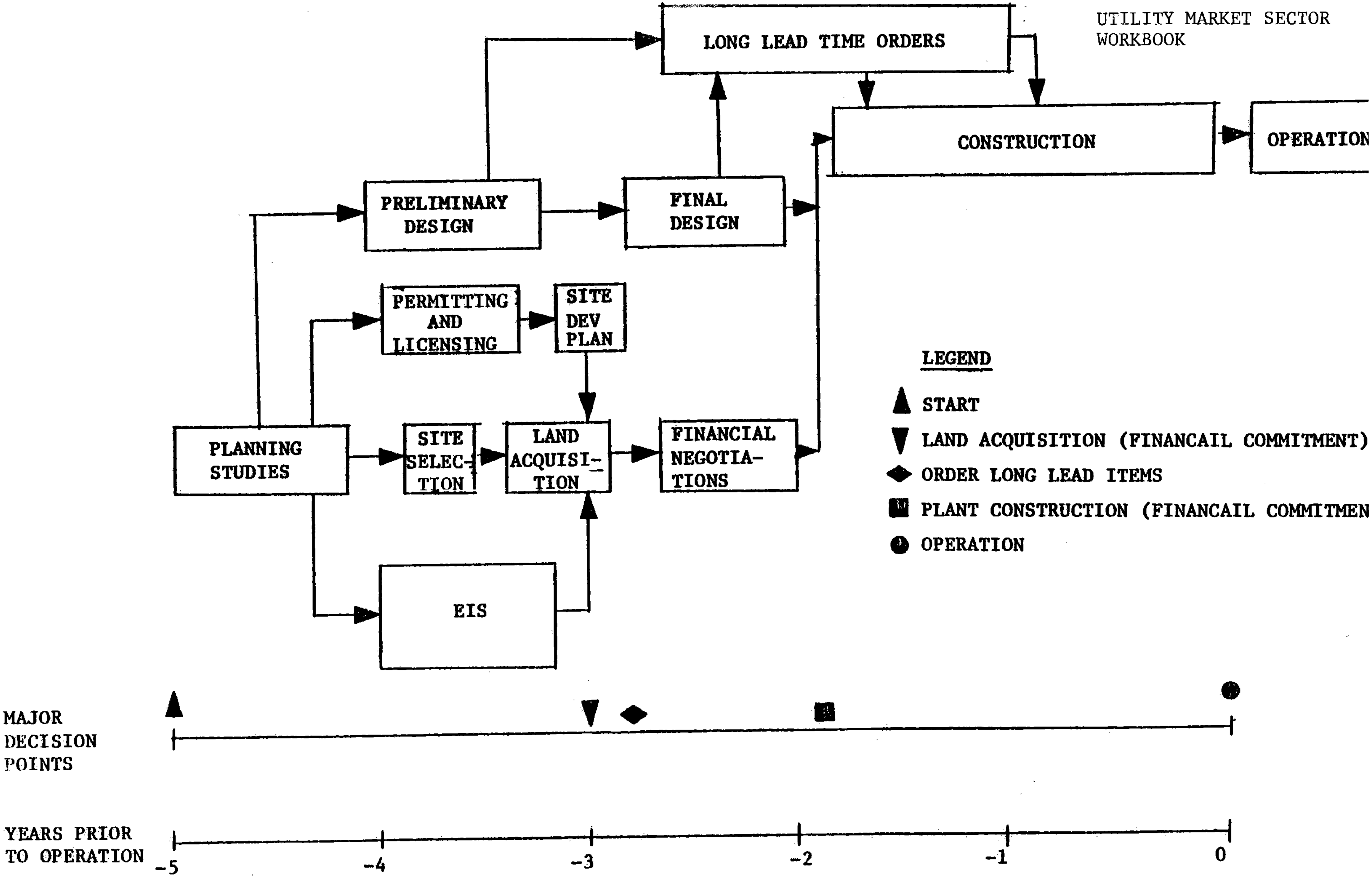
SOLAR THERMAL GENERIC DEVELOPMENT PLAN

THE PLANNING AND CONSTRUCTION OF A COMMERCIAL 10-100 MW SOLAR THERMAL PLANT REQUIRES A FIVE YEAR PERIOD.

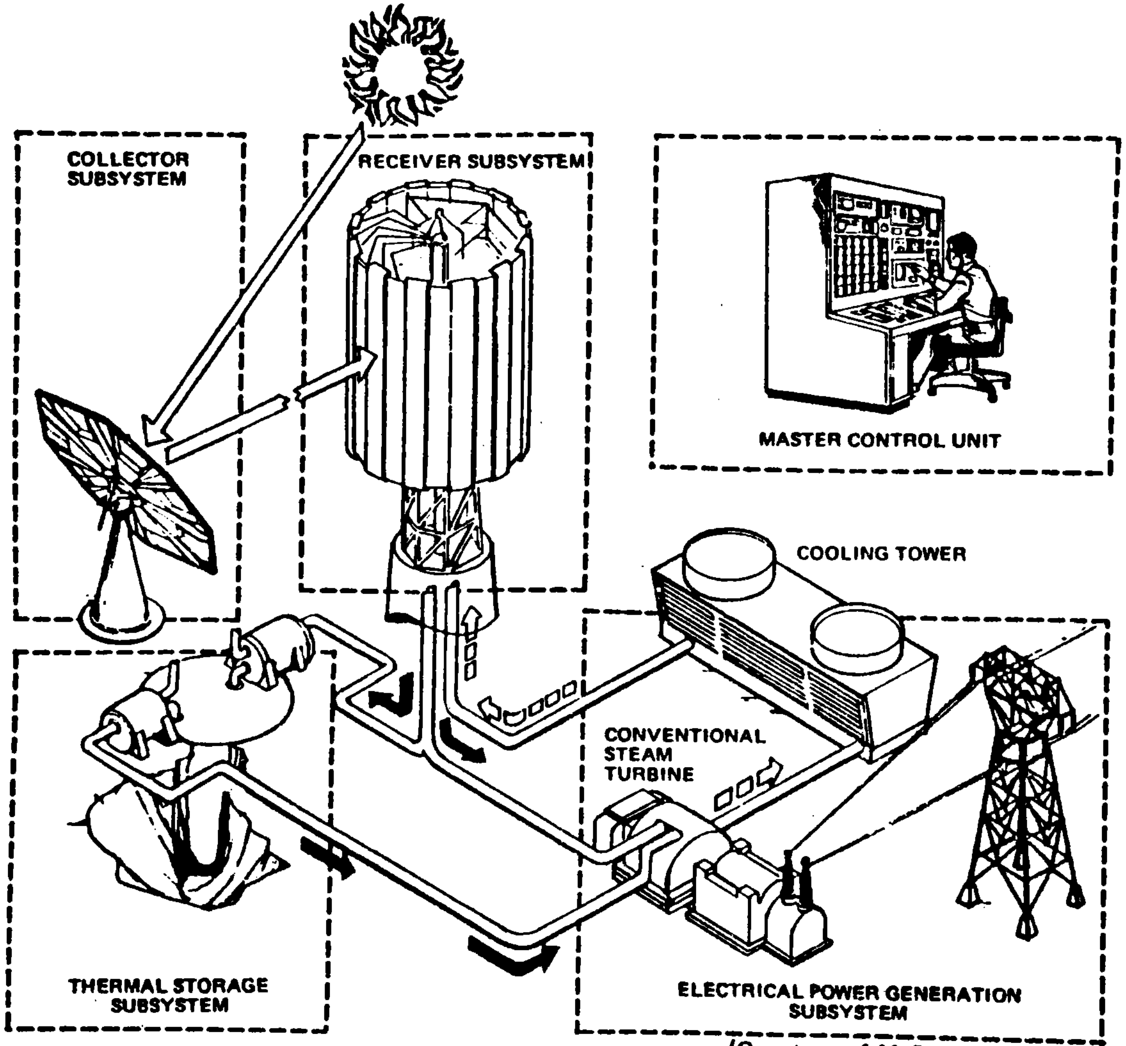
ACTIVITY	PARTICIPANTS	TIME REQUIRED RANGE (MOS)	TIME REQUIRED GDP (MOS)
PLANNING STUDIES	UTILITIES	12	12
SITE SELECTION	UTILITIES	6	6
LAND ACQUISITION	UTILITIES/LAND DEALERS	12	12
SITE DEVELOPMENT PLAN (SDP)	UTILITIES/A&E FIRM	6	6
PRELIMINARY DESIGN (INCLUDES EIS AND 1500 PERMITS & LICENSES)	UTILITIES/A&E FIRM LOCAL GOVERNMENT	12	12
CAPITAL FORMATION	UTILITIES/BANKS/ STOCKHOLDERS	6-24	12
FINAL PLANT DESIGN	UTILITIES/A&E FIRM	12-18	12
ACQUIRE LONG LEAD TIME ITEMS	UTILITIES/A&E FIRM/ MANUFACTURER	24-36	24
CONSTRUCTION	UTILITIES/A&E FIRM	24-36	24
START UP AND TEST	UTILITIES/ENGINEERING FIRM	2	2

THE PLANNING AND CONSTRUCTION OF COMMERCIAL 1 MW SOLAR THERMAL (TOTAL ENERGY) SYSTEMS IS TWO YEARS SHORTER:

- ONE YEAR LESS DUE TO REDUCED LAND, DESIGN COMPLEXITY, AND LICENSING REQUIREMENTS PRIOR TO CONSTRUCTION
- ONE YEAR LESS DUE TO SHORTER CONSTRUCTION TIME



SOLAR THERMAL CRITICAL TIME PATH



(Courtesy of McDonnell-Douglas)

SOLAR THERMAL McDONNEL-DOUGLAS CENTRAL RECEIVER SYSTEM

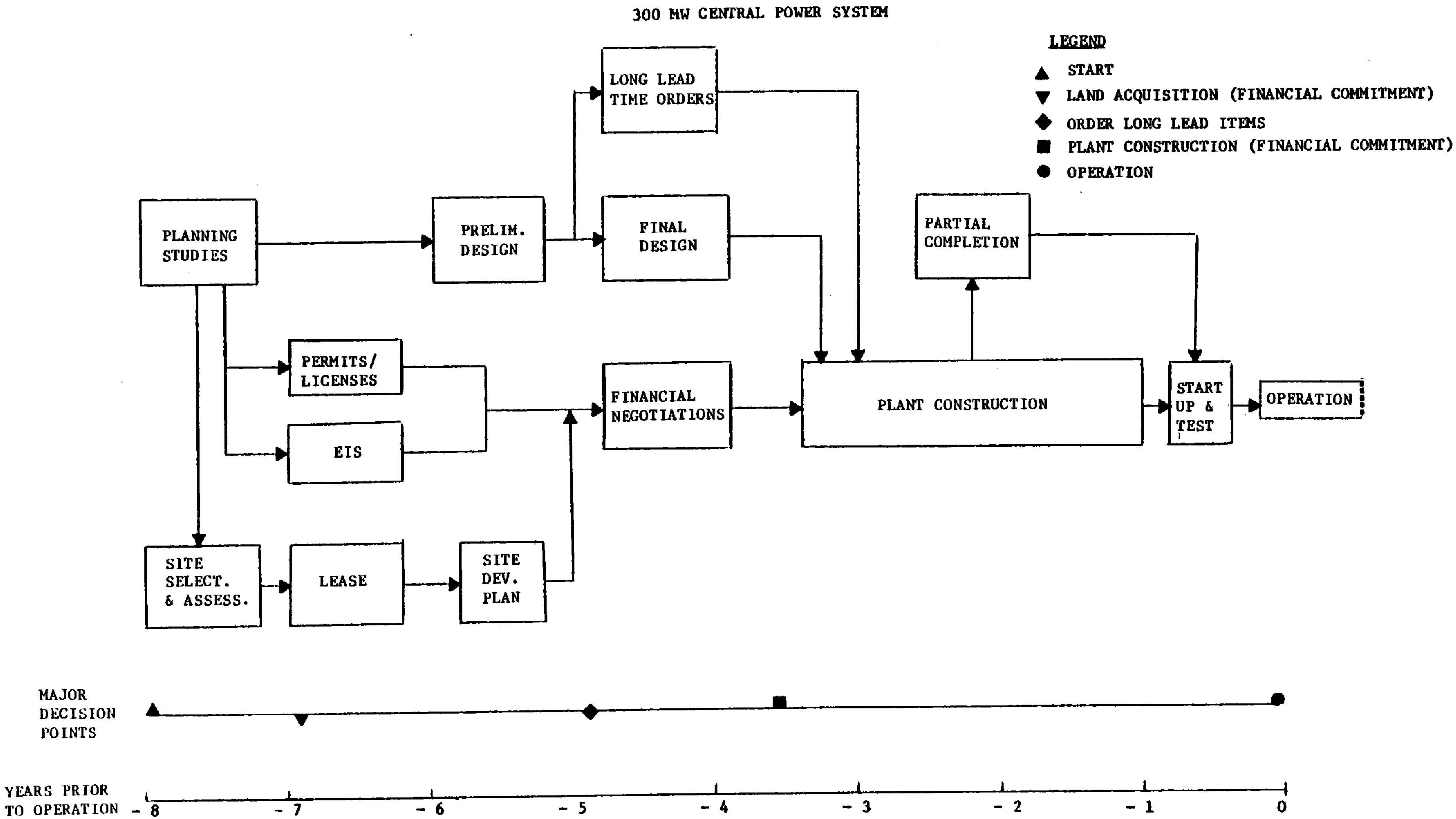
PHOTOVOLTAICS GENERIC DEVELOPMENT PLAN

FULL PHOTOVOLTAIC POWER PLANT DEPLOYMENT TIMES ARE ABOUT SIX YEARS FOR LOAD CENTERS AND EIGHT YEARS FOR CENTRAL SYSTEMS.*

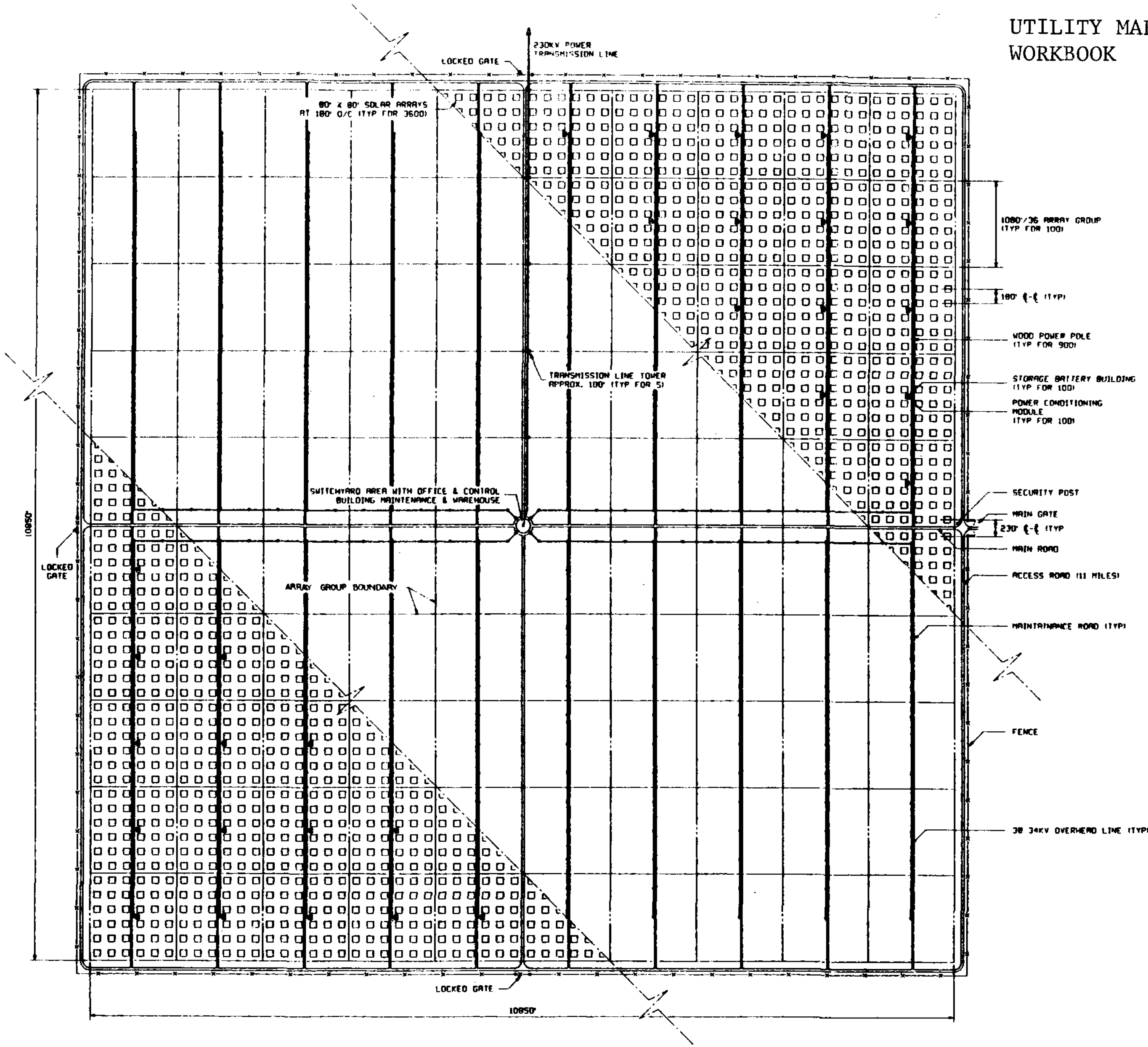
ACTIVITY	PARTICIPANTS	TIME REQUIRED RANGE (MOS)	TIME REQUIRED GDP (MOS)
SITE SELECTION AND ASSESSMENT	UTILITIES/A&E FIRM	6-18	12
PLANNING STUDIES/CONCEPTUAL DESIGN	UTILITIES/A&E	6-18	12
EIS	UTILITIES	6-36	12
LAND LEASE/PURCHASE	UTILITIES	3-12	6
SITE/ACCESS DEVELOPMENT PLAN	UTILITIES/A&E/GOVERNMENT	3-12	6
PERMITS & LICENSES	UTILITIES	12-36	12
FINANCIAL NEGOTIATIONS	UTILITIES	6-24	12
PLANT DESIGN	A&E FIRM	12-24	12
CONSTRUCTION	A&E FIRM/CONTRACTORS	24-48	24/48*
START UP & TEST	UTILITIES/A&E FIRM	2-6	2

AVAILABILITY OF PURCHASED MATERIALS/SUBSYSTEMS ASSUMED TO SUPPORT GENERIC DEVELOPMENT PLAN.

*2 years for load centers
4 years for central systems



PHOTOVOLTAICS CRITICAL TIME PATH

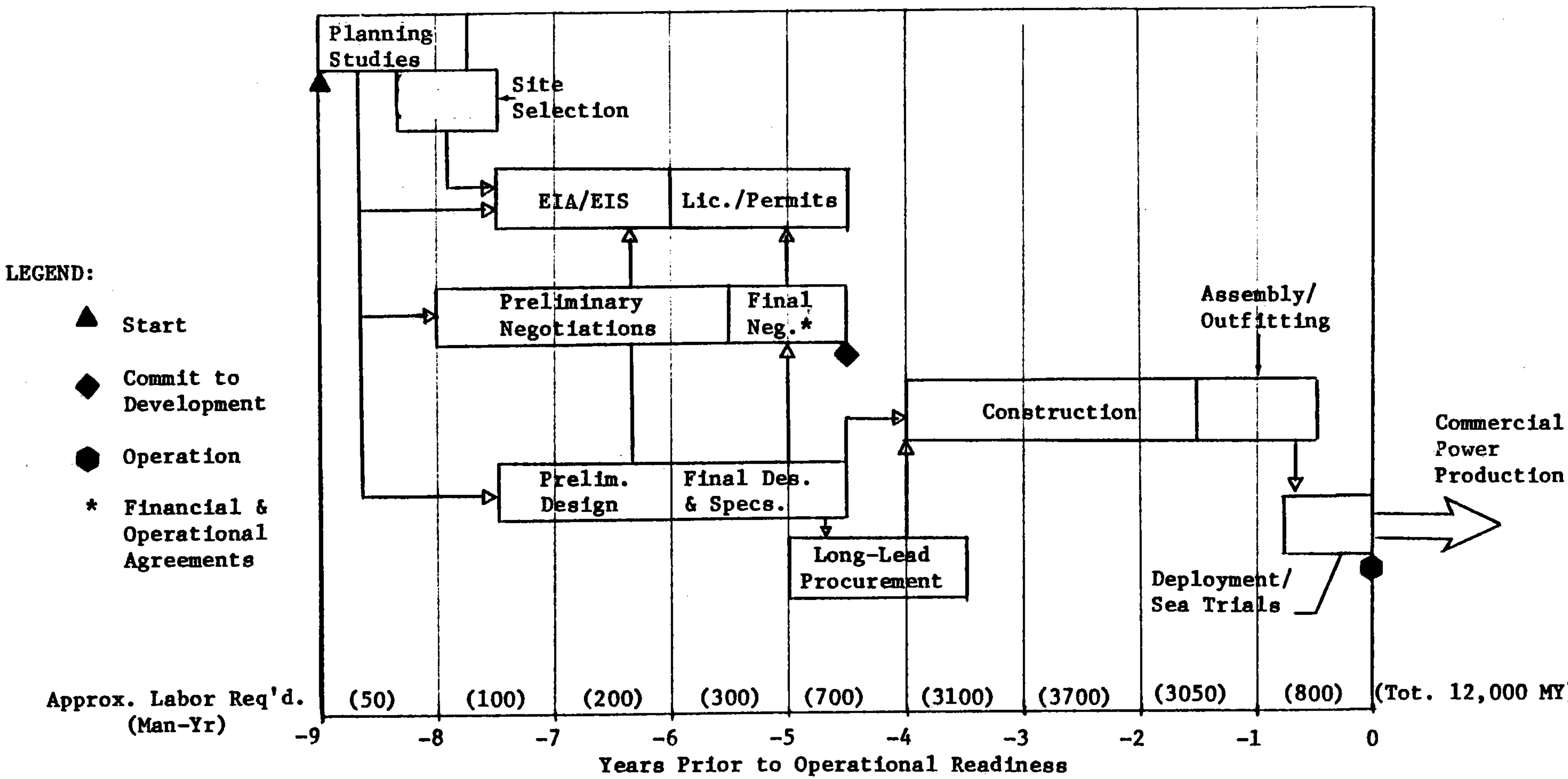


PHOTOVOLTAICS SPECTROLAB/BECHTEL PLANT LAYOUT

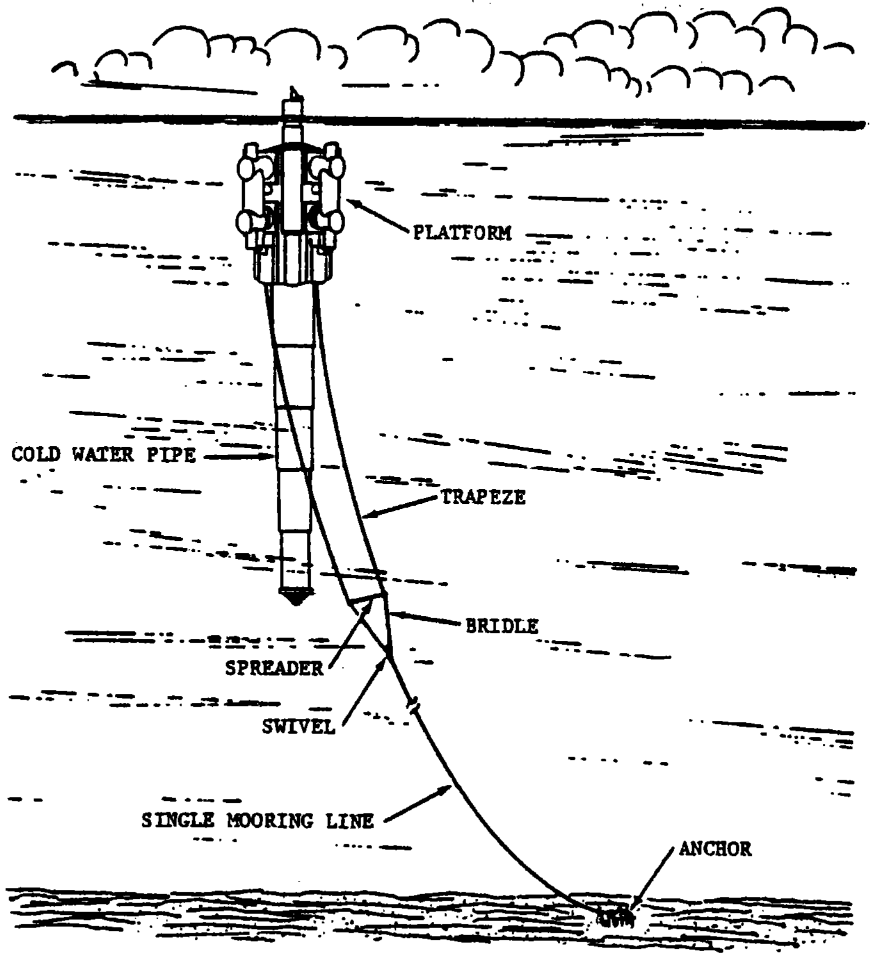
OCEAN THERMAL ENERGY CONVERSION (OTEC) DEPLOYMENT ACTIVITIES AND SCHEDULE

RAPID INITIATION OF COMMERCIALIZATION IS REQUIRED TO MEET THE PREDICTED DEPARTMENT OF ENERGY MINIMUM CAPACITY GOAL BY THE YEAR 2000. IT WILL BE NECESSARY TO USE EIGHT CONSTRUCTION FACILITIES BEGINNING IN 1989. THE FIRST FOUR SHIP-YARDS ARE FOLLOWED BY THREE MORE WITHIN A YEAR.

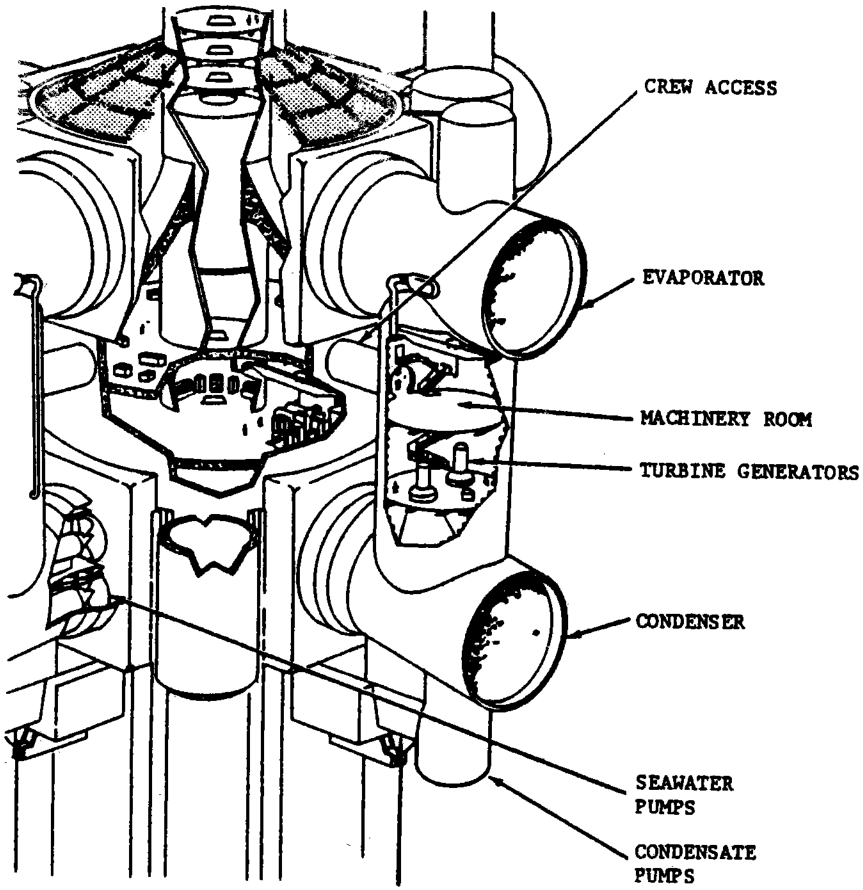
- A MINIMUM OF EIGHT SHIPYARD FACILITIES ARE REQUIRED. THE AVAILABILITY OF THESE SHIPYARDS MUST BE ASSESSED. COMMITMENT TO SHIPYARD OR CONSTRUCTION FACILITIES MUST BE MADE FIVE YEARS PRIOR TO OPERATING EXPERIENCE IN THE INITIAL FOUR SITES.
- THE ALTERNATE OR SHORTER GENERIC DEVELOPMENT PLAN IS USED. IF THE CONSTRUCTION TIME CANNOT BE LIMITED TO THE ALTERNATE GENERIC DEVELOPMENT PLAN, MORE SHIPYARDS WILL BE REQUIRED TO MEET THE ERDA GOALS.
- FINANCIAL COMMITMENT FOR THE FIRST 250 MW PLAN IS MADE AFTER FIVE YEARS OPERATING EXPERIENCE WITH THE DEMONSTRATION PLANT.
- FINANCIAL COMMITMENT FOR THE FIRST 400 MW PLANT IS MADE AFTER ACCRUING SIX YEARS EXPERIENCE WITH THE DEMONSTRATION PLANT.



OTEC GENERIC COMMERCIAL DEVELOPMENT
(FIRST PLANT ON LINE IN A COMPLEX; 400 MW_e (NET) DESIGN CAPACITY)



DEPLOYED OTEC PLANT (LOCKHEED)



CUTAWAY VIEW LOCKHEED OTEC PLANT

TECHNOLOGY DESCRIPTION: WIND ENERGY CONVERSION SYSTEMS

THE WIND ENERGY CONVERSION SYSTEMS CONSIDERED IN THIS STUDY ARE LARGE 1.5 MW UNITS CONFIGURED TO OPERATE AT SITES OF AVERAGE WINDSPEED OF 14 MPH OR ABOVE. THE ECONOMIC AND TECHNOLOGIC CHARACTERISTICS OF THESE UNITS ARE IS GIVEN BELOW.

	UNIT TYPE			
WECS CHARACTERISTIC	WECS FUEL SAVER	WECS WITH COMBINED CYCLE BACKUP (BASELOAD)	WECS WITH GAS TURBINE BACKUP (INTERMEDIATE)	WECS WATER SAVER (INTERMEDIATE)
INITIAL CAPITAL COST ($/kW)	1380	1614	1495	1670
ULTIMATE CAPITAL COST ($/kW)	800	1035	920	1090
O&M COST ($/kW)	27.8	28.5	21.3	17.0
FUEL TYPE	0	oil	oil	0
FUEL CONSUMPTION (Btu/kWh)	0	1565	2700	0
CAPACITY FACTOR	0.4	0.6	0.4	0.4
CONSTRUCTION TIME (yrs)	2	3	3	3
LIFETIME	30	30	30	30
TAX LIFE	23	23	23	23
DATE OF AVAILABILITY	1989	1989	1989	1986

TECHNOLOGY DESCRIPTION: SOLAR THERMAL

THE SOLAR THERMAL SYSTEMS CONSIDERED IN THIS STUDY INCLUDE PRIMARILY CENTRAL RECEIVER SYSTEMS USED AS FUEL SAVERS, WITH STORAGE OR OIL-FUELED BACKUP SYSTEMS:

SOLAR THERMAL SYSTEM (100 MW RATED CAPACITY)

	CENTRAL RECEIVER STORAGE (INT.)	REPOWERING (INT.)	CENTRAL RECEIVER STORAGE (SP)	FUEL SAVER
INITIAL CAPITAL COST	4130	2160	2690	2330
ULTIMATE CAPITAL COST	1430	700	980	870
O&M COST	20	8	14	12
FUEL TYPE	-	-	-	-
FUEL CONSUMPTION	-	-	-	-
CAPACITY FACTOR*	.50-.20	.37	.35-.15	.36-.15
CONSTRUCTION TIME	2	2	2	2
LIFETIME	30	30	30	30
TAX LIFE	23	23	23	23
DATE OF AVAILABILITY	1989	1986	1991	1991

*Dependent on region of the U.S.

TECHNOLOGY DESCRIPTION: PHOTOVOLTAICS

THE PHOTOVOLTAICS SYSTEMS CONSIDERED IN THIS STUDY INDICATE SILICON, THIN FILM AND CONCENTRATOR SYSTEMS IN A VARIETY OF CONFIGURATIONS (100 MW peak rated capacity).

	SILICON (INTERMEDIATE)	THIN FILM (INTERMEDIATE)	SILICON (SEMIPEAK)	THIN FILM (SEMIPEAK)	THIN FILM (FUEL SAVER)
INITIAL CAPITAL COST ($/kW)	40800	64000	25550	30690	21315
ULTIMATE CAPITAL COST ($/kW)	1920	1550	1170	920	585
O&M COST ($/kW/yr)	64.1	82	29	39	19.4
CAPACITY FACTOR*	.45-.26	.45-.26	.30-.17	.30-.17	.26-.15
CONSTRUCTION TIME	2	2	2	2	2
LIFETIME	30	30	30	30	30
TAX LIFE	23	23	23	23	23
DATE OF AVAILABILITY	1991	1991	1991	1991	1991
CAPACITY CREDIT	-	-	-	-	.38-.22

*Dependent on region of the U.S.

TECHNOLOGY DESCRIPTION: OTEC

THE OTEC SYSTEMS CONSIDERED IN THIS STUDY ARE LARGE 400 MW UNITS. THE CHARACTERISTICS OF THESE UNITS INCLUDE:

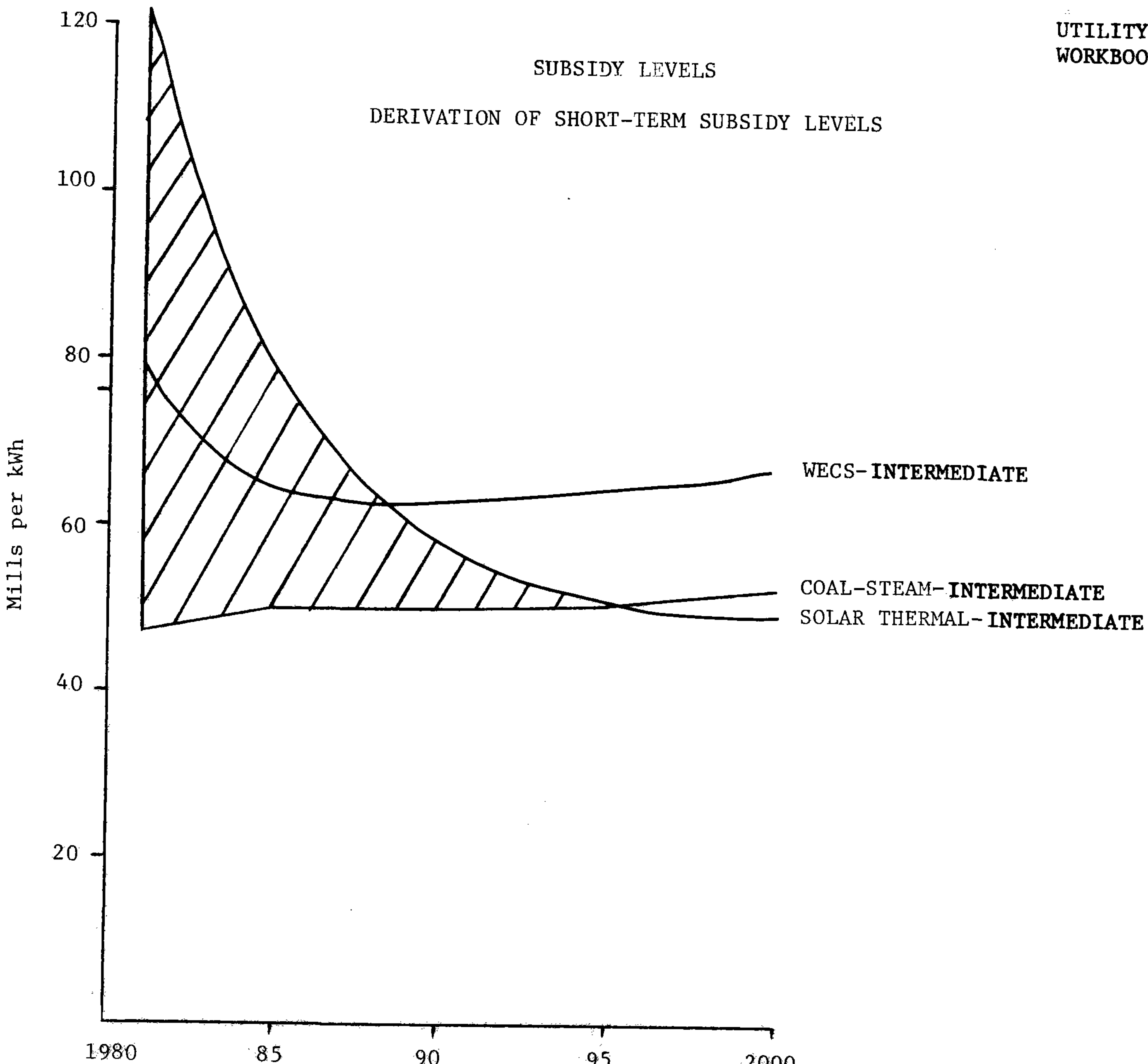
INITIAL CAPITAL COST ($/kW)	2570
ULTIMATE CAPITAL COST ($/kW)	1745
O&M COSTS ($/kW/yr)	35
CAPACITY FACTOR	.83
CONSTRUCTION TIME (yrs)	5
LIFETIME (yrs)	30
TAX LIFE (yrs)	23
DATE OF AVAILABILITY	1995

TECHNOLOGY DESCRIPTION: BIOMASS COMBUSTION FOR ELECTRICITY

	BIOMASS COMBUSTION SYSTEM (46 MW rated capacity)	
	BASELOAD	INTERMEDIATE
CAPITAL COST ($/kW)	1190	1190
O&M COST ($/kW/yr)	78	48.7
FUEL TYPE	MILL RESIDUE/ SILVICULTURAL PRODUCT	MILL RESIDUE/ SILVICULTURAL PRODUCT/LOG RESIDUES
DATE OF AVAILABILITY	1980/1995	1991/1995/1991
FUEL CONSUMPTION BTU/KWH	13000	13000
CAPACITY FACTOR	0.80	0.50
TIME FOR CONSTRUCTION	2	2
LIFETIME	30	30
TAX LIFE	20	20

SUBSIDY LEVELS

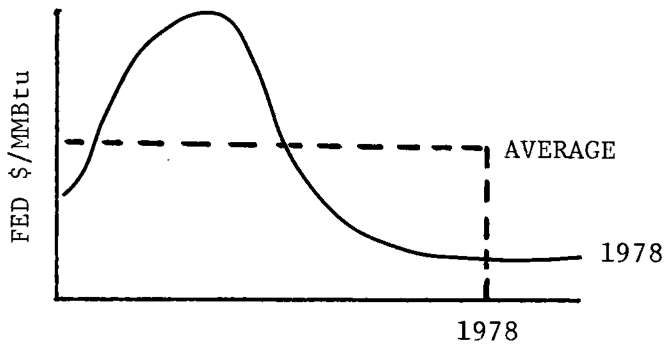
DERIVATION OF SHORT-TERM SUBSIDY LEVELS



	1980	85	90	
SOLAR THERMAL	62%	37%	12%	LEVEL OF TAX CREDIT (IN ADDITION TO 10% ITC OF THE NEA)
WECS	41%	22%	22%	

DEFINITION OF LONG-TERM SUBSIDY LEVELS

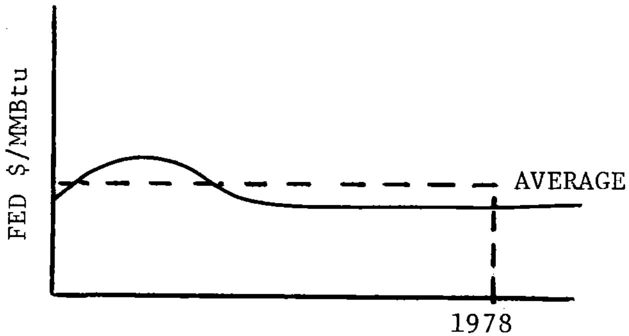
A. HISTORIC COMPOSITE OF ALL SUBSIDIZED ENERGY SOURCES



AVERAGE = $.10-.30/MMBtu

1978 = $.05/MMBtu

B. OIL STRIPPER WELLS



AVERAGE ≈ 1978 ≈ $1.10/MMBtu

THESE FIGURES REPRESENT THE RANGE; THE FOLLOWING SUBSIDIES WERE ASSUMED:

LEVEL I = .20/MMBtu

LEVEL II = .80/MMBtu

LEVEL III = 1.00/MMBtu

FIGURES BASED ON BATTELLE NORTHWEST LABORATORIES REPORT:
pp. 263, 210, 150

ADDITIONAL SOLAR BENEFITS

IT HAS BEEN ESTIMATED THAT, DUE TO SHORT-RUN REDUCTIONS AND LONG-RANGE REDUCTIONS IN THE GNP GROWTH RATE, THE COST OF AN EMBARGO IS ROUGHLY $40 BILLION/QUAD.

ASSUMING A 10% PROBABILITY OF AN EMBARGO:

$40 BILLION X .1 = $4 BILLION/QUAD = VALUE OF EMBARGO PROTECTION

AT PRESENT, .30 to .50/MMBtu IS BEING SPENT TO CLEAN COAL. ASSUMING THIS IS THE VALUE SOCIETY PUTS ON CLEAN ENERGY AND ADDING THE VALUE OF EMBARGO PROTECTION ($4 BILLION/QUAD = .40/MMBtu):

THE RANGE OF EXTERNALITY VALUE IS:
$.70 TO $.90/MMBtu

THESE VALUES:

$.70/MMBtu
$.80/MMBtu
$.90/MMBtu

WILL BE ADDED TO THE LONG-RUN SUBSIDIES.

CONVERTING CONTINUOUS SUBSIDIES TO CAPITAL SUBSIDIES

TOTAL SUBSIDIES ARE DEFINED AS:

OPTION I $ .20/MMBtu + .70/MMBtu (TOTAL NATIONAL VOLUME) = $ .90/MMBtu

OPTION II $ .80/MMBtu + .80/MMBtu (TOTAL NATIONAL VOLUME) = $1.60/MMBtu

OPTION III $1.00/MMBtu + .90/MMBtu (TOTAL NATIONAL VOLUME) = $1.90/MMBtu

LONG-TERM SUBSIDIES:

THE PRIMARY SOLAR TECHNOLOGIES EXPECTED TO BE BUILT BEFORE 2000 ARE WECS AND SOLAR THERMAL. THESE PRODUCE POWER AT A COST OF APPROXIMATELY $6.00/MMBtu ON A PERCENTAGE BASIS. THIS REPRESENTS SUBSIDIES OF APPROXIMATELY:

	ADDITIONAL SUBSIDY	NEA SUBSIDY	TOTAL SUBSIDY
Option I	15%	10%	25%
Option II	20%	10%	30%
Option III	23%	10%	33%

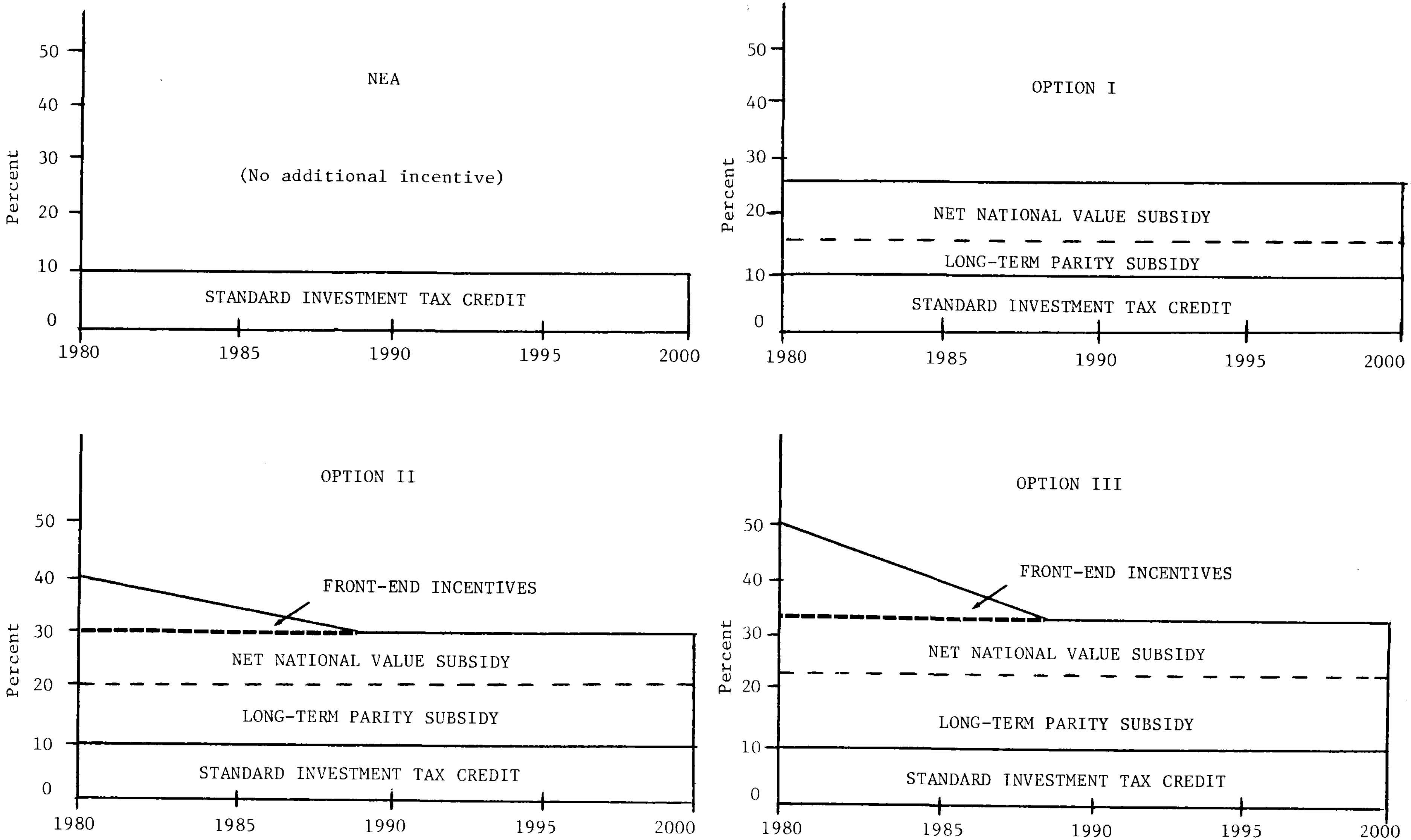
SHORT-TERM SUBSIDIES:

SHORT-TERM SUBSIDIES ARE DESIGNED TO PROVIDE SHORT-TERM COMPETITIVENESS OF SOLAR TECHNOLOGIES. WITHIN THE TIME FRAME OF SHORT-TERM SUBSIDIES, ONLY WECS UNITS ARE LIKELY TO BE COMMERCIAL. TOTAL COMPETITIVENESS OF WECS IS ASSURED IN 1980 BY A 50% SUBSIDY DEFINING ONE LEVEL OF SUBSIDY UNDER OPTION III. SHORT-TERM SUBSIDY UNDER OPTION I IS DEFINED AS THAT PROVIDED BY THE $.20/MMBtu SUBSIDY. SINCE THIS IS LESS THAN THE LONG-TERM SUBSIDY ALREADY PROVIDED, THE SHORT-TERM SUBSIDY IS ASSUMED TO BE AT LEAST EQUIVALENT TO THE LONG-TERM SUBSIDY.

DEFINITION OF SUBSIDY LEVELS

NEA:	10% INVESTMENT TAX CREDIT. RD&D PROGRAMS AS CURRENTLY PROGRAMMED.
OPTION I:	PROGRAMS CURRENTLY INCLUDED UNDER THE NEA. ADDITIONAL 15% INVESTMENT TAX CREDIT OVER THE NEA. TOTAL ITC = 25%.
OPTION II:	ACCELERATED RD&D PROGRAMS. $1 BILLION ADDITIONAL COST. AGGRESSIVE UTILITY PARTICIPATION PROGRAM IN DEMONSTRATIONS. 40% ITC BEGINNING IN 1980, DECLINING LINEARLY TO 30% ITC BY 1990 AND THEREAFTER CONSTANT AT 30% ITC.
OPTION III:	ACCELERATED RD&D PROGRAMS. $1.3 BILLION COST OVER THE NEA. AGGRESSIVE UTILITY PARTICIPATION PROGRAM. REQUIRE USE OF SOLAR WHERE PRACTICAL. 50% ITC BEGINNING IN 1980, DECLINING LINEARLY TO 33% IN 1990 AND THEREAFTER CONSTANT AT 33% ITC.

LEVELS OF INCENTIVES
(% equivalent ITC)

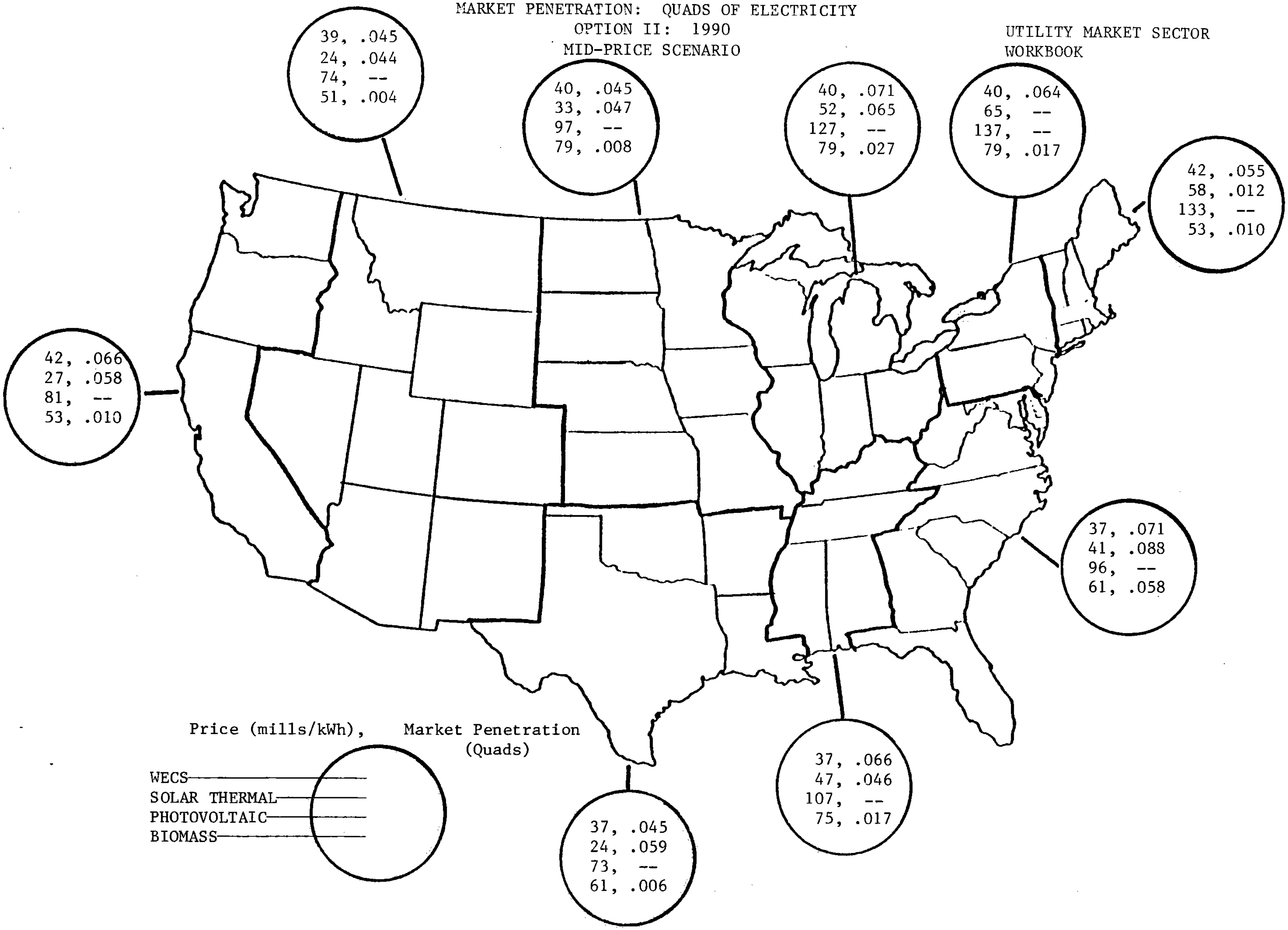


COMMERCIALIZATION INCENTIVES

PARTICIPANTS	PRIMARY CONCERNS	CURRENT PROGRAMS	POTENTIAL PROGRAMS	IMPACTS
UTILITY MANUFACTURERS A&E FIRMS	HIGH SYSTEM COSTS	FEDERAL RD&D		LOWER SYSTEM COSTS
		INVESTMENT TAX CREDIT (20%)		
		MULTIPLE DEMONSTRATION PROGRAMS TO PROMOTE COMPETITION	INCREASED INVESTMENT TAX CREDIT ACCELERATED DEPRECIATION FEDERAL COST SHARING FEDERAL GRANTS	LOWER EFFECTIVE SYSTEMS COSTS
MANUFACTURERS	RELUCTANCE TO EARLY COMMITMENT TO MAJOR MANUFACTURING FACILITIES		GOVERNMENT PURCHASE PROGRAMS GUARANTEED MARKET GOVERNMENT PRICE GUARANTEES GOVERNMENT GRANTS OR LOANS FOR CONSTRUCTION OF MANUFACTURING FACILITIES	EARLY REDUCTION OF UNIT COSTS DUE TO LARGE SCALE PRODUCTION AND LEARNING CURVE EFFECTS

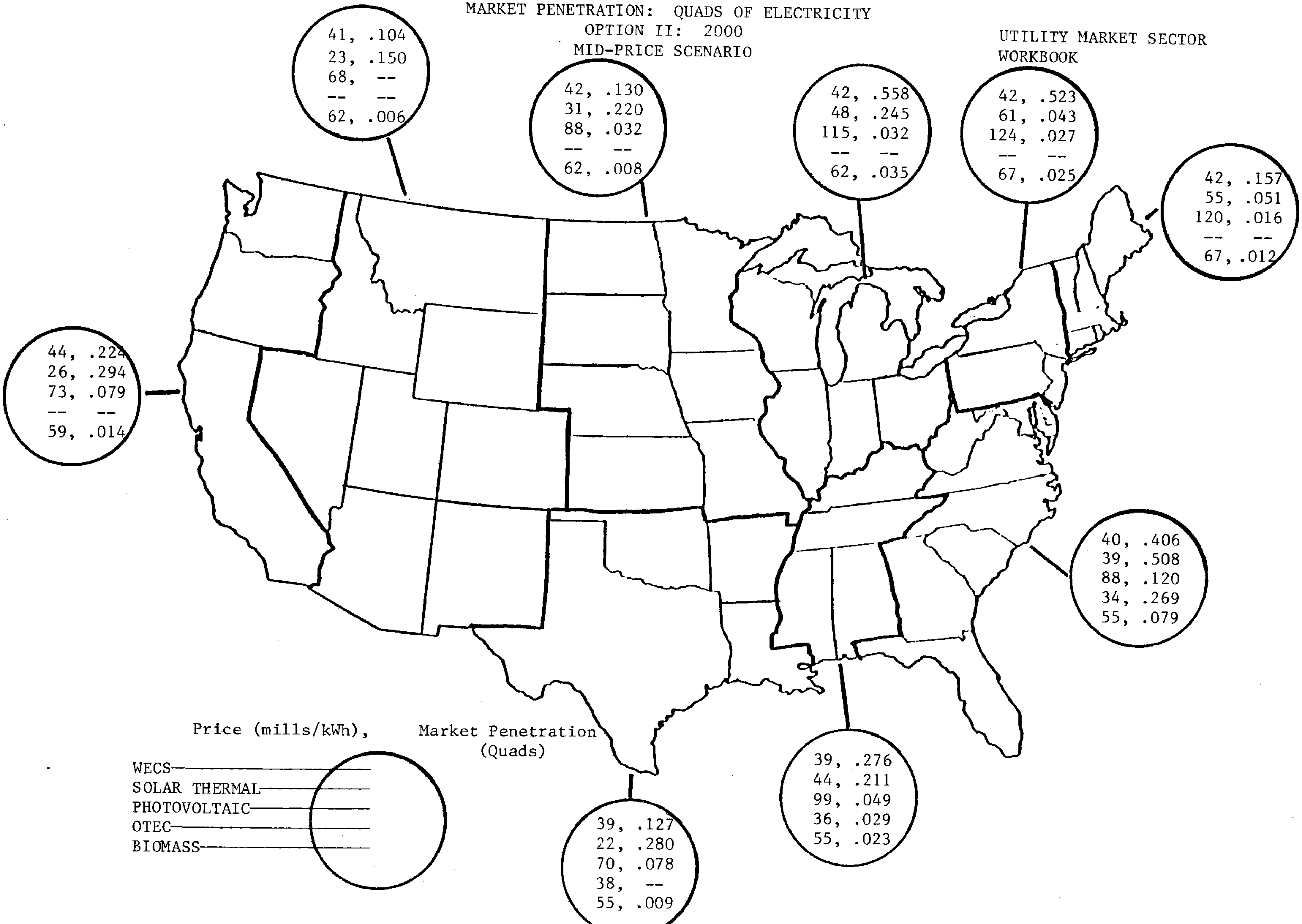
PARTICIPANTS	PRIMARY CONCERNS	CURRENT PROGRAMS	POTENTIAL PROGRAMS	IMPACTS
UTILITY, A&E FIRMS	SYSTEM RELIABILITY	FEDERAL R&D PROGRAMS	FEDERAL PERFORMANCE STANDARDS TESTING NEW EQUIPMENT	REDUCE O&M COSTS. DECREASE POWER COSTS
UTILITY, A&E FIRMS	CONSTRUCTION DELAYS		GENERIC EIS, EXPEDITING LICENSING AND PERMITTING PROCEDURES	REDUCTION OF CONSTRUCTION TIME REDUCED COSTS
UTILITY	AVAILABILITY OF CAPITAL		ESTABLISH A GOVERNMENT FUNDING OR LEASING CORPORATION ESTABLISH A FEDERAL UTILITY CORPORATION (SOLAR TVA)	ALLEVIATION OF CAPITAL FUNDING BARRIERS
BANKING AND LENDING INSTITUTIONS	SECURITY OF INVESTMENT IN "NEW" TECHNOLOGIES		GOVERNMENT LOAN GUARANTEES GOVERNMENT PERFORMANCE GUARANTEES GOVERNMENT WARRANTY	ALLEVIATION OF RISK
UTILITY, A&E FIRMS	MARKET RESISTANCE DUE TO INSUFFICIENT MARKET DATA		MARKET RESEARCH AND TESTING	

MARKET PENETRATION: QUADS OF ELECTRICITY
OPTION II: 1990
MID-PRICE SCENARIO



MARKET PENETRATION: QUADS OF ELECTRICITY
OPTION II: 2000
MID-PRICE SCENARIO

UTILITY MARKET SECTOR WORKBOOK



MARKET PENETRATION

PRICE OF ELECTRICITY, MILLS/kWh, 1976, WEST SOUTH CENTRAL REGION

1990

	HIGH-PRICE				MID-PRICE				LOW-PRICE			
	NEA	I	II	III	NEA	I	II	III	NEA	I	II	III
WIND ENERGY CONVERSION SYSTEM	56	48	45	44	44	39	37	36	42	34	32	31
SOLAR THERMAL REPOWERING	49	37	32	29	36	27	24	21	48	28	24	21
SOLAR THERMAL	79	59	51	46	58	43	38	34	72	46	38	34
PHOTOVOLTAICS	103	85	78	73	79	65	60	56	78	63	58	55
OTEC	NA	NA	NA	56	NA	NA	NA	41	NA	NA	NA	41
BIOMASS ELECTRIC	68	62	71	70	57	52	61	60	53	48	47	46

MARKET PENETRATION

PRICE OF ELECTRICITY MILLS/kWh, 1976, WEST SOUTH CENTRAL REGION

2000 (Concluded)

	HIGH-PRICE				MID-PRICE				LOW-PRICE			
	NEA	I	II	III	NEA	I	II	III	NEA	I	II	III
WIND ENERGY CONVERSION SYSTEM	57	50	47	46	47	41	39	38	41	35	33	32
SOLAR THERMAL REPOWERING	42	33	30	28	31	25	22	21	33	24	22	21
SOLAR THERMAL	66	52	48	45	50	39	36	34	55	39	35	33
PHOTOVOLTAICS	102	79	70	65	75	61	54	52	77	69	63	51
OTEC	76	61	51	49	55	43	38	35	60	47	43	41
BIOMASS ELECTRIC	74	67	65	64	62	57	55	54	59	49	48	47

MARKET PENETRATION

QUADS OF FUEL DISPLACED BY SOLAR TECHNOLOGIES

1990

	HIGH-PRICE				MID-PRICE				LOW-PRICE			
	NEA	I	II	III	NEA	I	II	III	NEA	I	II	III
WIND ENERGY CONVERSION SYSTEM	.11	.21	.45	.57	.15	.25	.53	.67	--	.12	.39	.59
SOLAR THERMAL REPOWERING	.02	.04	.05	.07	.02	.05	.07	.09	--	.03	.06	.10
SOLAR THERMAL	.03	.07	.19	.41	.03	.10	.35	.58	--	.03	.24	.44
PHOTOVOLTAICS	--	--	--	.04	--	--	--	.09	--	--	--	.04
OTEC	--	--	--	--	--	--	--	--	--	--	--	--
BIOMASS ELECTRIC	.01	.05	.11	.18	.01	.07	.17	.20	--	.01	.06	.12
TOTAL	.17	.37	.80	1.27	.21	.47	1.12	1.63	--	.19	.75	1.29

MARKET PENETRATION

QUADS OF FUEL DISPLACED BY SOLAR TECHNOLOGIES

2000 (Concluded)

	HIGH-PRICE				MID-PRICE				LOW-PRICE			
	NEA	I	II	III	NEA	I	II	III	NEA	I	II	III
WIND ENERGY CONVERSION SYSTEMS	0.77	1.61	2.09	2.26	1.32	2.00	2.50	2.79	.03	.49	1.20	1.63
SOLAR THERMAL REPOWERING	.10	.25	.39	.38	.18	0.39	.36	.35	--	.28	.40	.37
SOLAR THERMAL	.43	.85	1.05	1.15	.79	1.19	1.64	1.89	--	.79	1.37	1.60
PHOTOVOLTAICS	--	.14	.27	.35	--	.39	.46	.62	--	--	--	.26
OTEC	.04	.04	.27	.22	.10	.15	.30	.41	--	--	--	--
BIOMASS ELECTRIC	.02	.09	.13	.21	.03	.14	.21	.26	--	.01	.06	.13
TOTAL	1.36	2.98	4.21	4.57	2.42	4.26	5.47	6.32	.03	1.57	3.03	3.99

NUMBERS OF UNITS SOLD

BASED UPON THE ASSUMPTIONS OF THE MID-PRICE, OPTION II SCENARIO, THE FOLLOWING CUMULATIVE NUMBERS OF SOLAR SYSTEMS WERE BUILT IN THE UTILITY SECTOR.

	1990	2000
WIND ENERGY CONVERSION SYSTEMS (100 MW)	170	797
SOLAR THERMAL (100 MW)	151	710
PHOTOVOLTAICS (100 MW)	4	188
BIOMASS (46 MW)	70	90
OTEC (400 MW)	0	10

ENERGY IMPACTS OF SOLAR MARKET PENETRATION

BASED ON THE MID-PRICE, OPTION II SCENARIO, THE ENERGY IMPACTS OF SOLAR MARKET PENETRATION ARE:

	QUADS OF PRIMARY FUEL SAVINGS	
	1990	2000
WIND ENERGY CONVERSION SYSTEMS	.53	2.50
SOLAR THERMAL	.43	2.00
PHOTOVOLTAIC	.01	.46
OTEC	--	.30
BIOMASS	.17	.21

ANNUAL SALES OF SOLAR SYSTEMS

BASED ON THE MID-PRICE, OPTION II SCENARIO, THE ANNUAL SALES OF SOLAR SYSTEMS IN THE UTILITY SECTOR ARE PROJECTED TO BE:

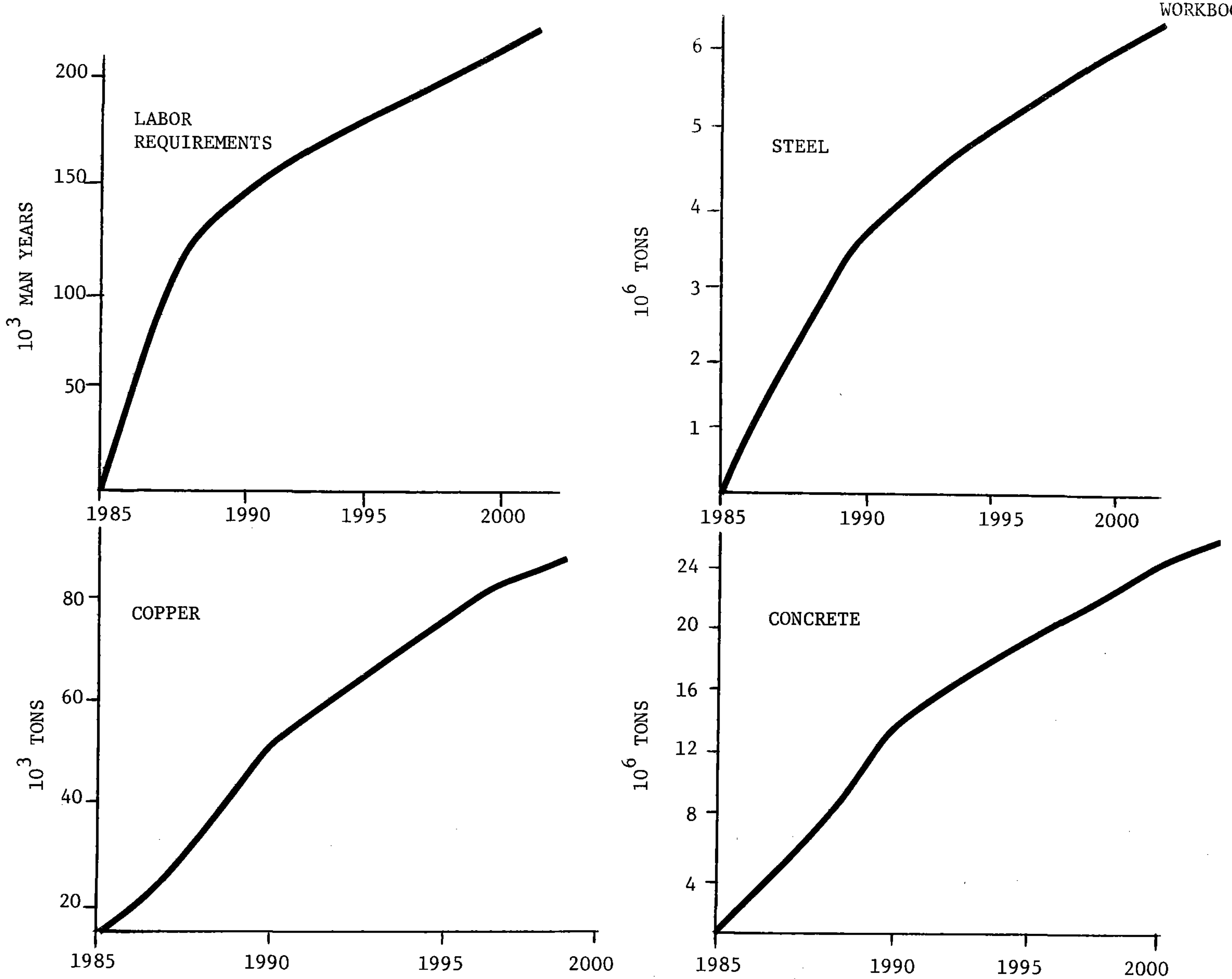
	1990	2000
WIND ENERGY CONVERSION SYSTEMS	29	70
SOLAR THERMAL	33	45
PHOTOVOLTAIC	0	23
OTEC	0	1
BIOMASS	3	5

RESOURCE REQUIREMENTS

THE FOLLOWING REQUIREMENTS FACTORS WERE USED IN DETERMINING PROJECTIONS OF RESOURCE REQUIREMENTS: MATERIALS ARE IN TONS PER MW OF PEAK CAPACITY. LABOR IS IN MAN YEARS PER MW.

	LABOR	STEEL	COPPER	CONCRETE	GLASS	SILVER	TITANIUM	INSULATION	ALUMINUM
WIND ENERGY CONVERSION SYSTEMS	5.3	80	3.0	650	-	-	-	-	1
SOLAR THERMAL	15	500	5	1500	50	30	-	30	35
PHOTOVOLTAICS	11.7	283	4.2	1090	260	-	-	-	6
OTEC	4.5	175	7	1800	-	-	45	-	27

RESOURCE REQUIREMENTS, MID-PRICE SCENARIO, OPTION II



SYNTHETIC FUELS AND CHEMICALS

MARKET SECTOR WORKBOOK

TABLE OF CONTENTS

SUMMARY
SYNTHETIC FUELS AND CHEMICALS

SYNTHETIC FUEL DEMAND

The synthetic fuels in this analysis include methanol, synthetic crude oil, ammonia, and synthetic natural gas. Incremental demand for these fuels is estimated from trends in past usage. In 1990, the incremental demand (in quads of primary fuel) for both the high- and mid-price scenarios is 0.6 quads. The projections under the low-price scenario call for 0.5 quads of incremental demand. By the year 2000, incremental demand is projected to grow by a factor of five under each scenario.

MARKET POTENTIAL

The market potential is considered to be constrained by biomass fuel availability. Biomass availability is estimated for three feedstocks by region. Logging and mill residues provide near-term and midterm contributions to the biomass supply. The South Atlantic, East South Central, West South Central, and Pacific regions provide the majority of these two resources. The long-term use of logging and mill residues for fuel is expected to decline as those products are diverted to chip board and other higher priority uses. Silvicultural plantation products are not expected to be available until the year 1990. The South Atlantic and Central regions of the U.S. are expected to provide the major share of this feedstock.

DEVELOPMENT PLANS

Generic development plans and technology descriptions for biomass conversion technologies are in the workbook. It is assumed that the four synthetic fuel types could be derived from any of the three biomass feedstocks. Residue facilities would require at least three years to become operational. Timelines for the installation of several different end-product processes are provided in the workbook. Silvicultural farms may require three to nine years to become established and provide silvicultural feedstocks.

ECONOMIC INCENTIVES

The levels of investment tax credits provided for biomass conversion technologies are equivalent to those provided for the process heat market sector. The reference scenario and three levels of increased financial support are used to calculate product costs from biomass. The product costs in $/MMBtu are shown for the South Atlantic region, expected to be one of the regions most suitable to the production of biomass feedstocks.

MARKET PENETRATION

Market penetration estimates are determined based on projected product costs and levels of incentives using the SPURR market penetration methodology. The level of incentives provided under Option II, including an investment tax credit of 35 percent, is the minimum level required to result in market penetration of biomass-based synthetic fuels production by 1990. By the year 2000 the market penetration of biomass-based synthetic fuels technologies is projected to result in the displacement of from 0.5 quads of energy, with the incentives provided under the NEA scenario, to 0.8 quads under Option III incentives. Under the high-price fuel scenario the range of energy savings varies from 0.5 quads with NEA incentives to 0.9 quads with Option III incentives. Under the low-price fuel scenario the range of energy savings is projected to be from .021 quads (NEA) to .024 quads (Option III).

As with all other market sectors, the growth trends for number of facilities built, labor, and resource requirements reflect projected market penetrations. The final section of this workbook provides detailed estimates of these parameters.

TOTAL DEMAND FOR SYNTHETIC FUELS
(Quads of primary fuel)

- TOTAL DEMAND ASSUMED:

	TOTAL DEMAND	METHANOL	SYNCRUDE	AMMONIA	SNG
1990					
HIGH-PRICE	0.6	.1	.21	.15	.15
MID-PRICE	0.6	.1	.24	.15	0.1
LOW-PRICE	0.5	.1	.21	.15	0.0
2000					
HIGH-PRICE	2.8	.3	1.6	.4	0.5
MID-PRICE	2.9	.3	1.8	.4	0.3
LOW-PRICE	2.3	.3	1.6	.4	0.0

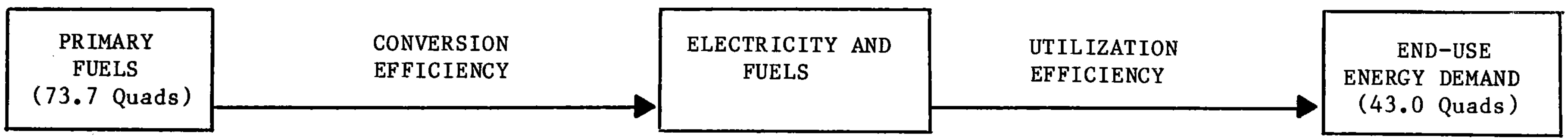
- TOTAL NEW MARKET--SAME AS TOTAL DEMAND

- REGIONAL GROWTH

MILL RESIDUES AND LOGGING RESIDUES ARE LIMITED IN AVAILABILITY TO THE ESTIMATED SUPPLIES OF THESE FUELS BY U.S. CENSUS REGION (SEE PAGE 5.)

TOTAL SILVICULTURAL FUELS ARE LIMITED BY THE SUPPLY OF AVAILABLE LAND

DEFINITION OF TERMS



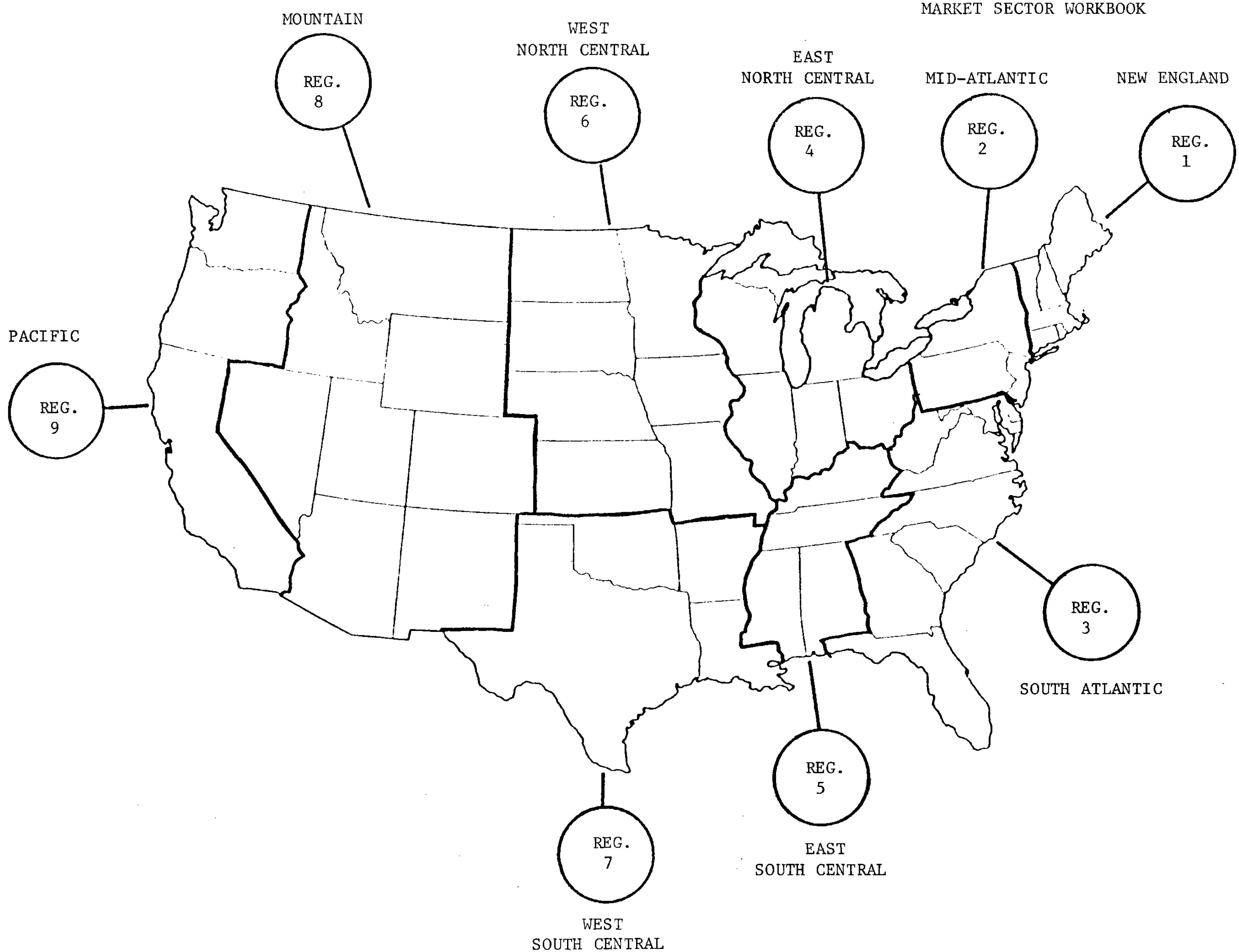
Conversion efficiency:

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

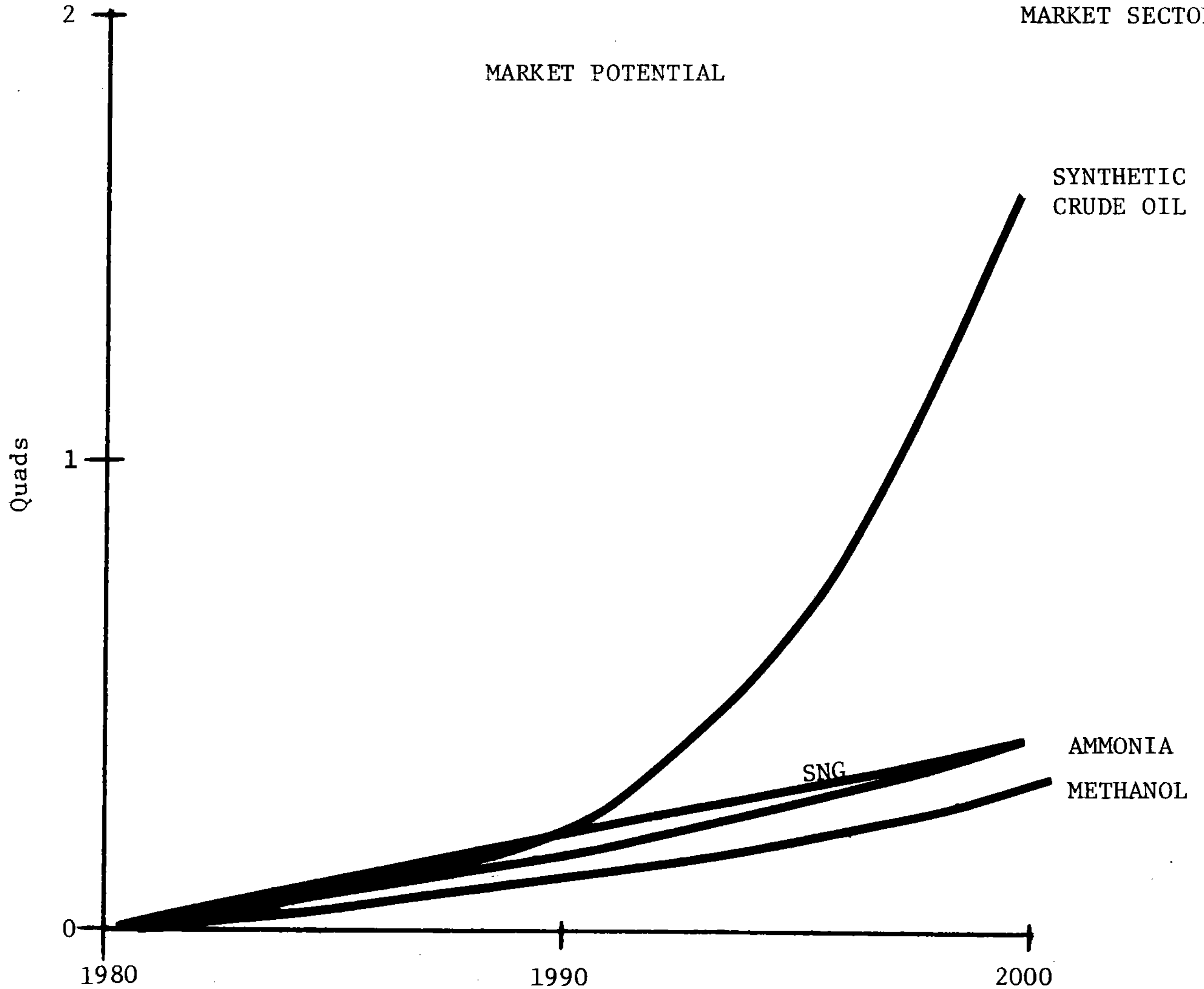
Utilization efficiency:

1. TRANSMISSION AND DISTRIBUTION
2. UTILIZING DEVICE

U.S. CENSUS REGIONS



MARKET POTENTIAL



MARKET POTENTIAL FOR SYNTHETIC FUELS AND CHEMICALS

BIOMASS FUEL AVAILABILITY*
(Quads of fuel)

U.S. CENSUS REGION	SILVICULTURAL PLANTATION PRODUCT		LOGGING RESIDUES*			MILL RESIDUES*		
	2000	2020	1980-1993	2000	2020	1980-93	2000	2020
NEW ENGLAND	.14	.25	.05	.03	.01	.03	.02	.01
MID-ATLANTIC	.23	.42	.05	.03	.01	.03	.02	.01
SOUTH ATLANTIC	1.17	2.16	.34	.18	.04	.10	.06	.02
EAST NORTH CENTRAL	.54	1.00	.19	.06	.01	.03	.02	.01
EAST SOUTH CENTRAL	.63	1.16	.37	.20	.04	.05	.03	.01
WEST NORTH CENTRAL	.45	.83	.05	.03	.01	.01	.01	.0
WEST SOUTH CENTRAL	1.22	2.24	.29	.15	.03	.04	.02	.01
MOUNTAIN	.0	.0	.07	.06	.01	.06	.03	.01
PACIFIC	.14	.25	.36	.19	.04	.17	.10	.03
TOTAL	4.5	8.3	1.7	.9	.2	.50	.30	.10

*Logging residues and mill residues decline in availability as feedstocks due to increasing use in chipboard and other high-priority uses.

Other biomass feedstocks include excess food crops, crop residues, animal residues and municipal wastes.

SCENARIO DESCRIPTIONS

FUEL PRICES REFLECT PREVAILING COSTS OF OIL IN CONSTANT 1976 $ OF:

	HIGH-PRICE	MID-PRICE	LOW-PRICE
YEAR 2000 PRICES:	$32/bbl	$25/bbl	$18/bbl
INFLATION RATES:	7.0%	5.0%	4.0%
COSTS OF CAPITAL:	18.0%	13.7%	12.98%
TOTAL DEMAND FOR PRIMARY ENERGY: (yr. 2000)	95 Quads	115 Quads	135 Quads

SOLAR TECHNOLOGIES CONSIDERED

METHANOL--FROM LOG RESIDUES, MILL RESIDUES OR SILVICULTURAL PRODUCT

SYNTHETIC CRUDE OIL--FROM LOG RESIDUES, MILL RESIDUES OR SILVICULTURAL PRODUCT

AMMONIA--FROM LOG RESIDUES, MILL RESIDUES OR SILVICULTURAL PRODUCT

SNG--FROM LOG RESIDUES, MILL RESIDUES OR SILVICULTURAL PRODUCT

THESE TECHNOLOGIES HAVE THE POTENTIAL TO SUPPLY THE MARKET REQUIREMENTS FOR THE SYNTHETIC PRODUCT INDICATED.

GENERIC DEVELOPMENT PLAN FOR AN ENERGY FARM

THE PLANNING AND CONSTRUCTION OF COMMERCIAL FUELS FROM BIOMASS FARM REQUIRES THE PERFORMANCE OF THE FOLLOWING TASKS OVER 3 TO 9 YEARS.*

ACTIVITY	PARTICIPANT	TIME REQ'D RANGE (MOS)	TIME REQ'D GDP (MOS)
o SITE SELECTION	DEVELOPER/AGRONOMIST	6 - 18	12
o ENVIRONMENTAL ASSESSMENT	DEVELOPER/AGRONOMIST	3 - 6	4
o PREPARE NEGATIVE DECLARATION OR ENVIRONMENTAL IMPACT STATEMENT (EIS)	DEVELOPER/AGRONOMIST/A&E	12 - 36	18
o OBTAIN PERMITS AND LEASES	DEVELOPER/A&E/AGRONOMIST/ GOVERNMENT/PATENT HOLDERS	8 - 36	15
o MAKE FINANCIAL ARRANGEMENTS	DEVELOPER/BANKS/STOCKHOLDERS	12 - 24	16
o ACQUIRE LAND	DEVELOPER/LAND MANAGEMENT CO./ LAND HOLDERS OR LESSORS	24 - 74	48
o DESIGN CONVERSION PLANT	DEVELOPER/A&E/SUBCONTRACTORS	8 - 18	24
o DESIGN PLANTING & HARVESTING EQUIPMENT; ORDER	DEVELOPER/AGRICULTURAL ENGINEER/ MECHANICAL ENGINEER/MANUFACTURER	12 - 36	24
o CONSTRUCT PLANT	DEVELOPER/A&E/SUBCONTRACTORS	12 - 40	26

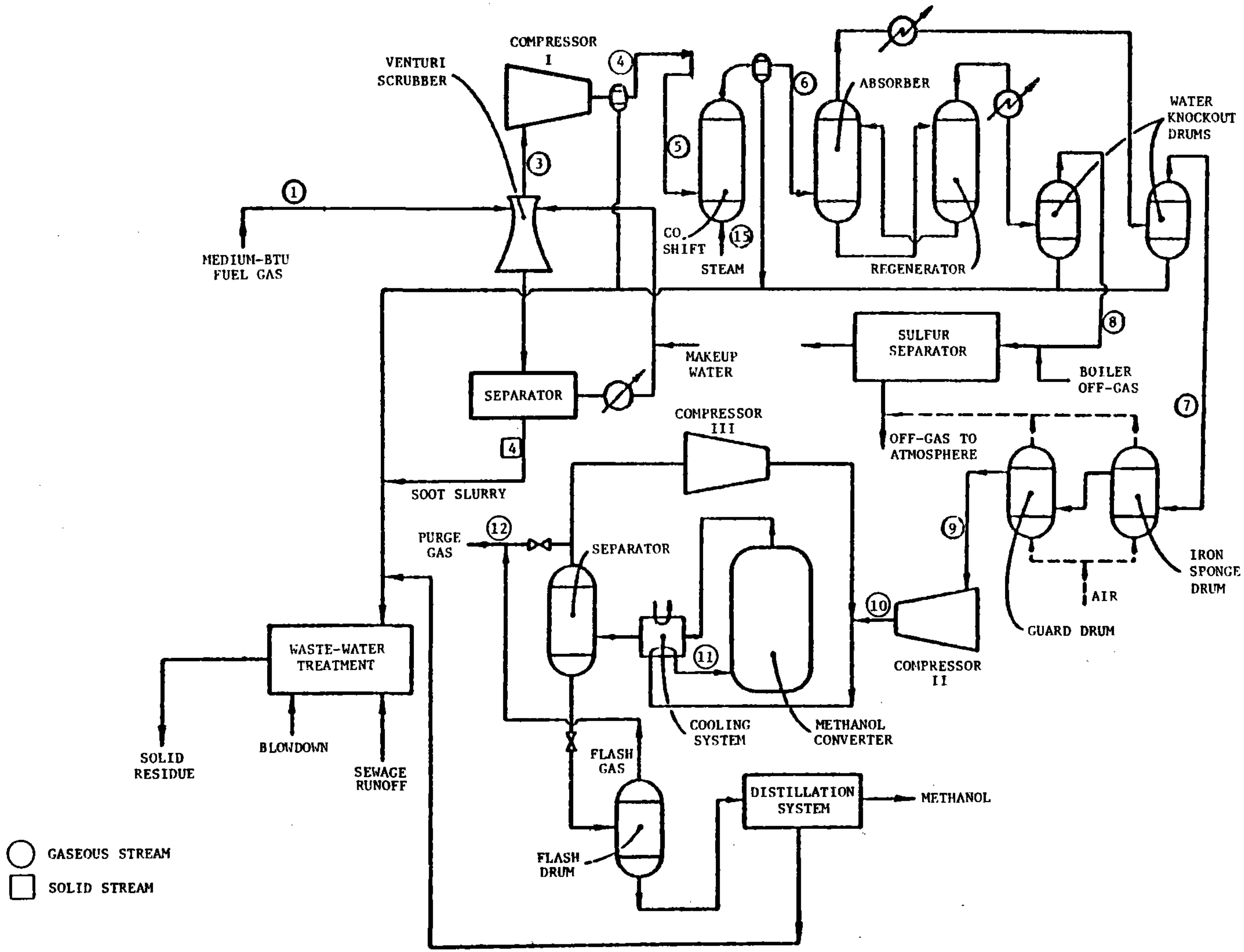
*Earliest date of commercial availability is 1995.

GENERIC DEVELOPMENT PLAN FOR A RESIDUE FACILITY

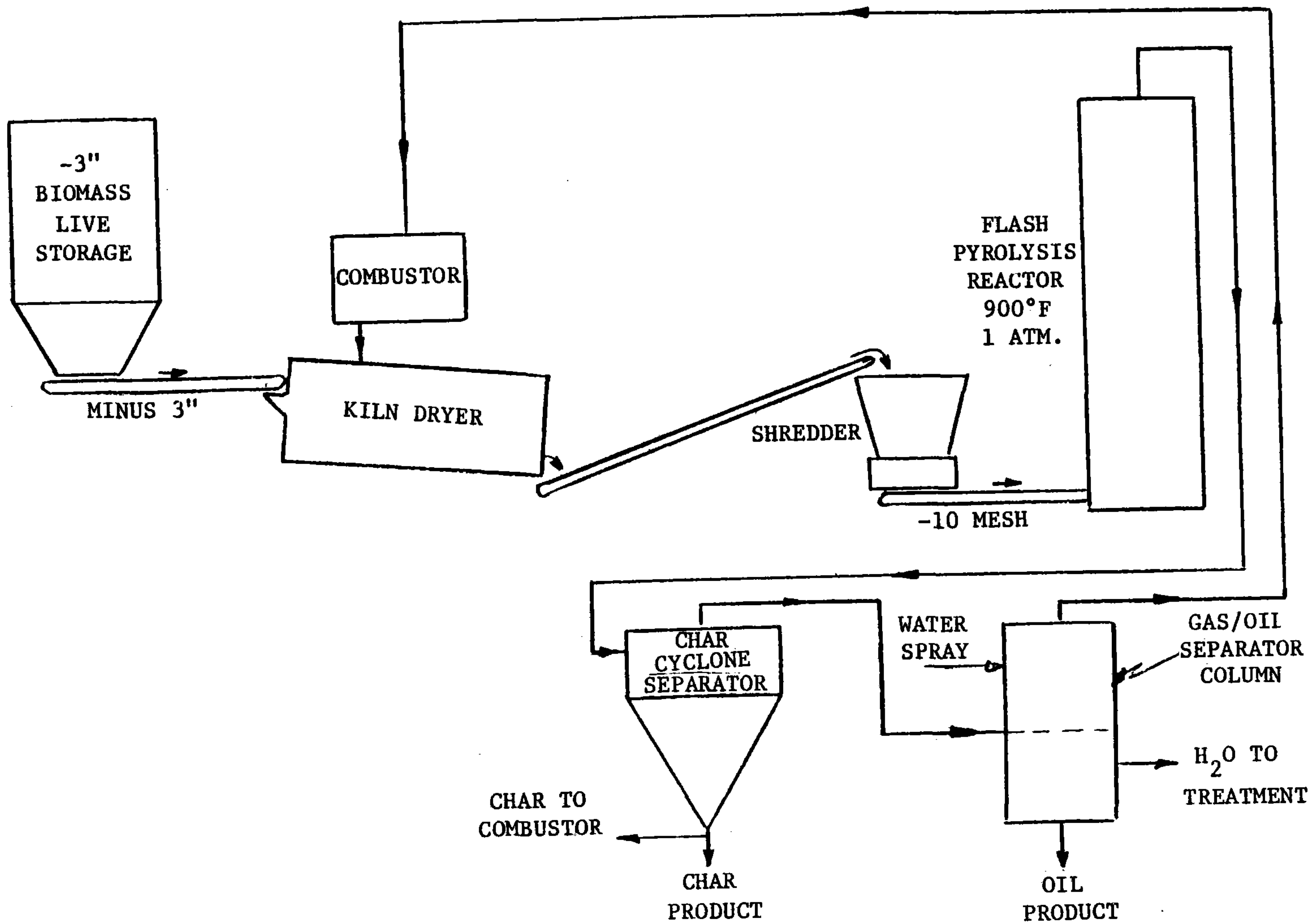
THE PLANNING AND CONSTRUCTION OF A COMMERCIAL FUEL FROM BIOMASS RESIDUE CONVERSION PLANT REQUIRES THE PERFORMANCE OF THE FOLLOWING TASKS OVER APPROXIMATELY 3 YEARS (30 - 79 MONTHS).*

ACTIVITY	PARTICIPANT	TIME REQ'D RANGE (MOS)	TIME REQ'D GDP (MOS)
o SITE SELECTION	DEVELOPER	3 - 9	6
o ENVIRONMENTAL ASSESSMENT	DEVELOPER/A&E	3 - 6	4
o PREPARE NEGATIVE DECLARATION OR EIS	DEVELOPER/A&E	8 - 24	12
o OBTAIN PERMITS AND LEASES	DEVELOPER/RESIDUE SUPPLIER/ GOVERNMENT/PATENT HOLDERS	4 - 24	12
o MAKE FINANCIAL ARRANGEMENTS	DEVELOPER/BANKS/STOCKHOLDERS	6 - 12	8
o PRELIMINARY DESIGNS	DEVELOPER/A&E/SUBCONTRACTORS	4 - 12	6
o FINAL DESIGN	DEVELOPER/A&E/SUBCONTRACTORS	4 - 12	6
o ORDER LONG LEAD ITEMS	DEVELOPER/A&E/SUBCONTRACTORS/ MANUFACTURERS	18 - 36	24
o CONSTRUCTION	DEVELOPER/A&E/SUBCONTRACTORS	16 - 34	20
o START UP & TEST	DEVELOPER/A&E/SUBCONTRACTORS	3 - 6	2

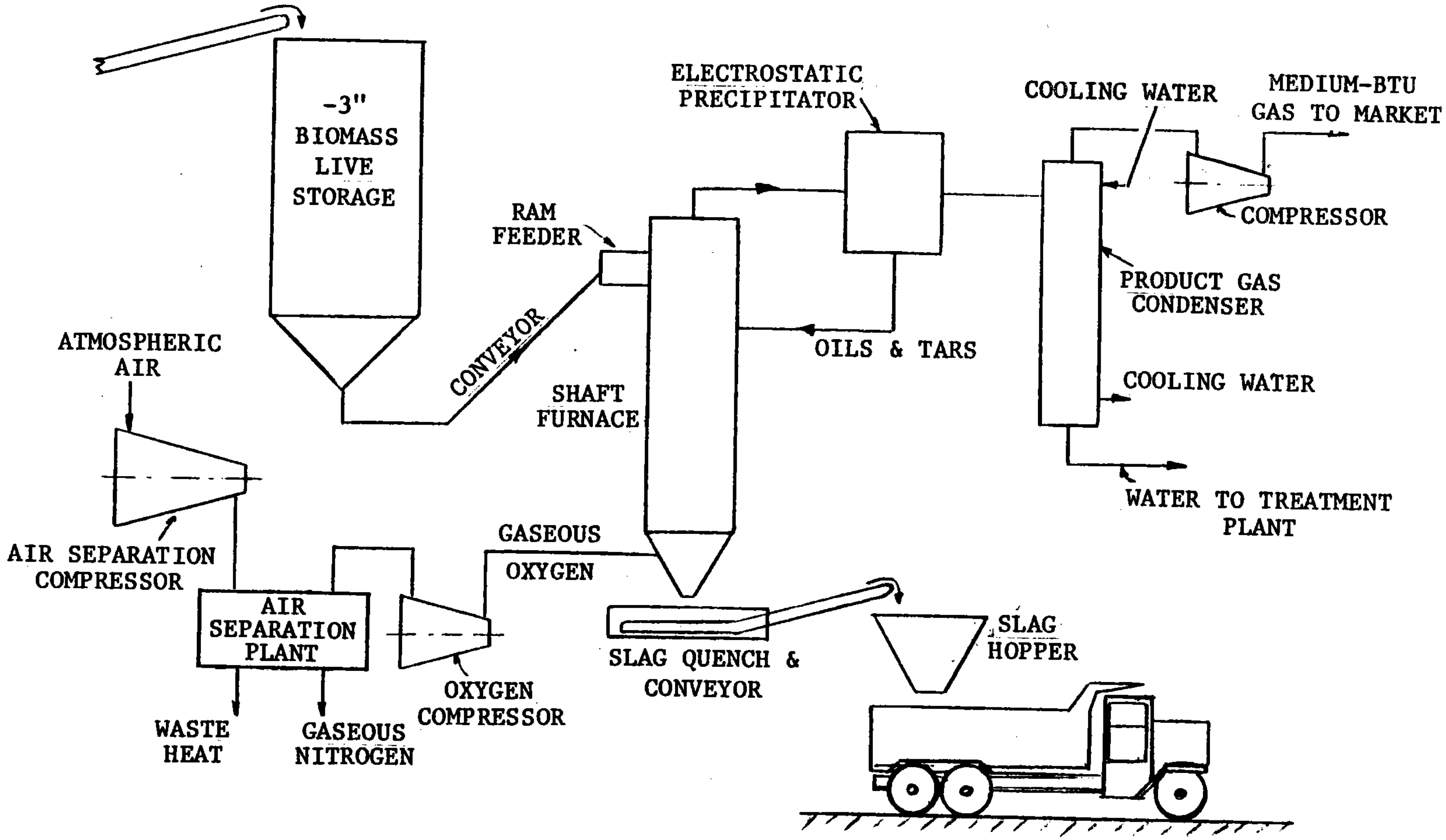
*Earliest date of commercial availability is assumed to be 1990 utilizing logging residues and mill residues.



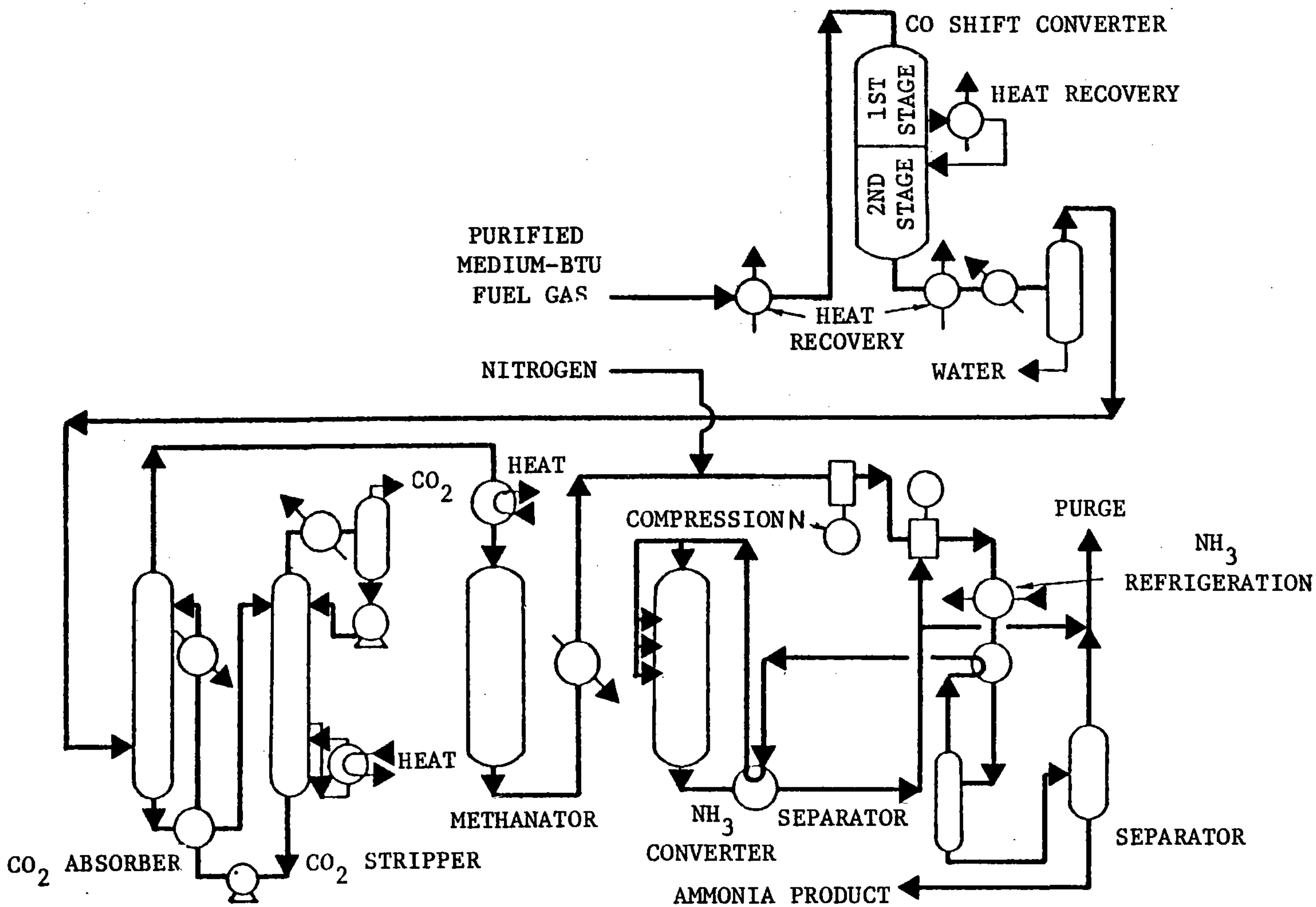
SCHEMATIC FLOW DIAGRAM, METHANOL FROM MEDIUM-BTU FUEL GAS



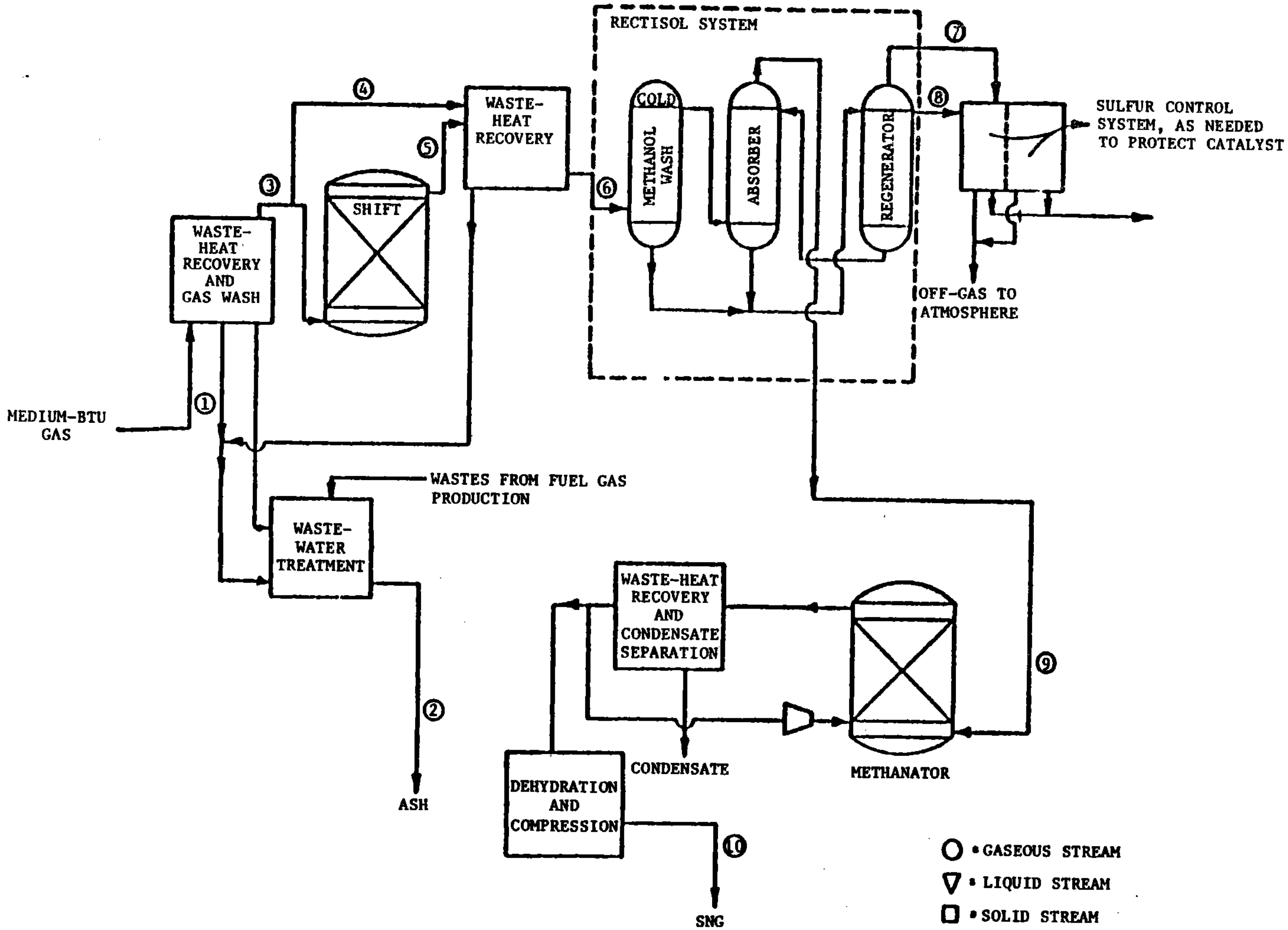
SCHEMATIC FLOW DIAGRAM, MODIFIED OCCIDENTIAL PYROLYSIS--OIL PROCESS



SCHEMATIC FLOW DIAGRAM, PUROX ATMOSPHERIC PRESSURE GASIFICATION PLANT



SCHEMATIC FLOW DIAGRAM, AMMONIA FROM MEDIUM-BTU FUEL GAS



SCHEMATIC FLOW DIAGRAM, SUBSTITUTE NATURAL GAS FROM MEDIUM-BTU GAS

TECHNOLOGY DESCRIPTION: METHANOL FROM BIOMASS

PLANT CAPACITY 10^6 MMBtu/yr	4.8		
CAPITAL COST $/MMBtu/yr	13.4		
O&M COST $/MMBtu	2.03		
FUEL TYPES	MILL RESIDUES,	LOGGING RESIDUES,	SILVICULTURAL PRODUCT
AVAILABILITY DATE	1991	1991	1995
FUEL CONSUMPTION	2,206,000 Btu/MMBtu of product		
CAPACITY FACTOR	0.8		
TIME FOR CONSTRUCTION (yrs)	2		
LIFETIME (yrs)	30		
TAX LIFE (yrs)	23		

TECHNOLOGY DESCRIPTION: SYNTHETIC CRUDE OIL FROM BIOMASS

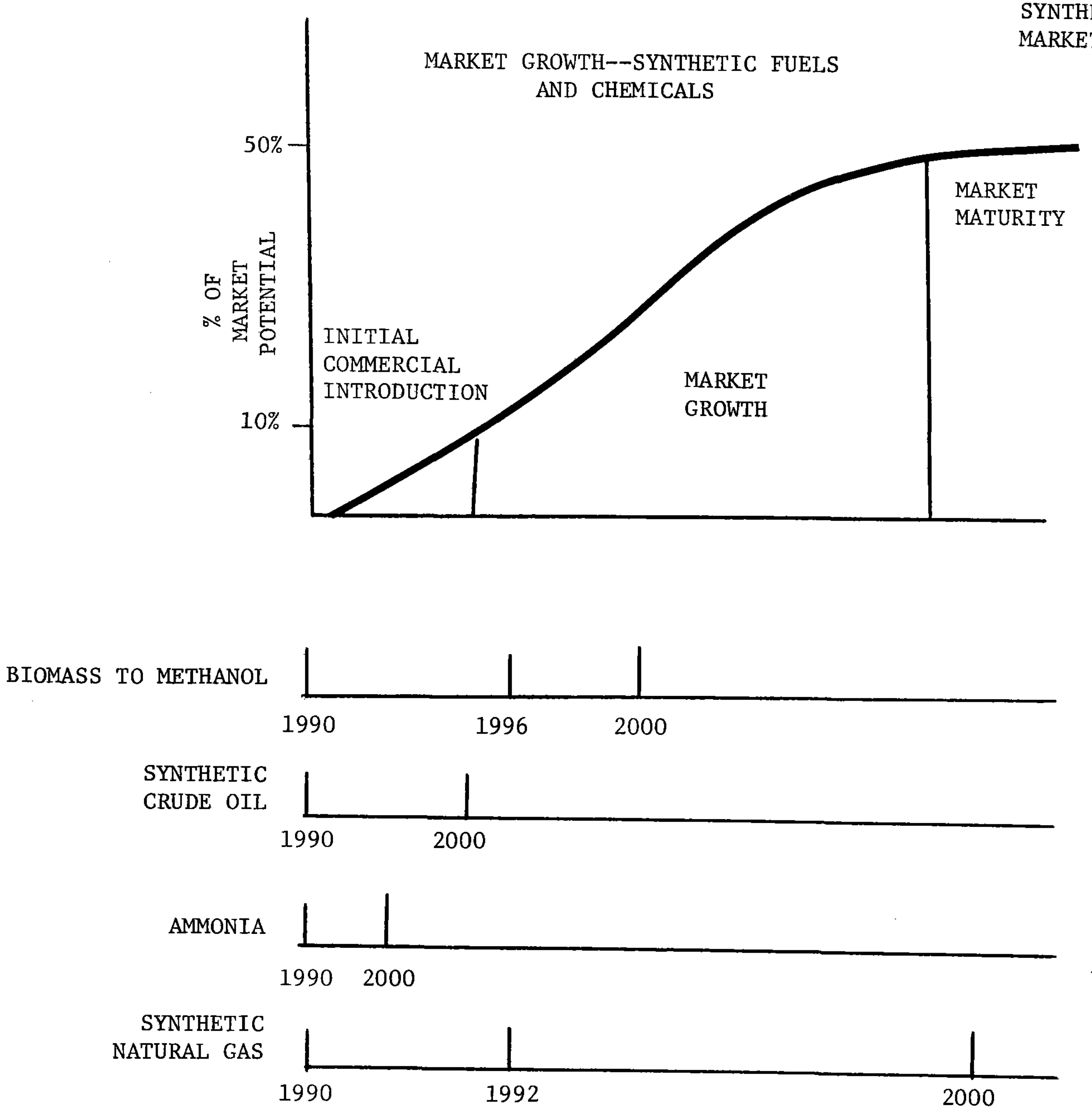
PLANT CAPACITY 10^6 MMBtu	6.5		
CAPITAL COST $/MMBtu	3.7		
O&M COST $/MMBtu	.73		
FUEL TYPE	MILL RESIDUES,	LOGGING RESIDUES,	SILVICULTURAL PRODUCT
AVAILABILITY DATE	1991	1991	2000
FUEL CONSUMPTION	1,631,700 Btu/MMBtu		
CAPACITY FACTOR	0.8		
TIME FOR CONSTRUCTION (yrs)	4		
LIFETIME (yrs)	25		
TAX LIFE (yrs)	19		

TECHNOLOGY DESCRIPTION: AMMONIA

PLANT CAPACITY 10^6 ton/yr	0.359		
CAPITAL COST $/ton/yr	173		
O&M COST $/ton/yr	28		
FUEL TYPE	MILL RESIDUES,	LOGGING RESIDUES,	SILVICULTURAL PRODUCT
AVAILABILITY DATE	1991	1991	2000
FUEL CONSUMPTION	29,340,000 Btu/ton		
CAPACITY FACTOR	0.80		
TIME FOR CONSTRUCTION (yrs)	2		
LIFETIME (yrs)	30		
TAX LIFE (yrs)	23		

TECHNOLOGY DESCRIPTION: SYNTHETIC NATURAL GAS

PLANT CAPACITY 10^6 MMBtu	7.0		
CAPITAL COST $/MMBtu	5.4		
O&M COST $/MMBtu	1.18		
FUEL TYPE	MILL RESIDUES,	LOGGING RESIDUES,	SILVICULTURAL PRODUCT
AVAILABILITY DATE	1990	1990	2000
FUEL CONSUMPTION	1,515,000 Btu/MMBtu		
CAPACITY FACTOR	0.80		
TIME FOR CONSTRUCTION (yrs)	2		
LIFETIME (yrs)	30		
TAX LIFE (yrs)	23		


MARKET GROWTH--SYNTHETIC FUELS AND CHEMICALS
50%
10%
% OF MARKET POTENTIAL
INITIAL COMMERCIAL INTRODUCTION
MARKET GROWTH
MARKET MATURITY
BIOMASS TO METHANOL
1990
1996
2000
SYNTHETIC CRUDE OIL
1990
2000
AMMONIA
1990
2000
SYNTHETIC NATURAL GAS
1990
1992
2000

INCENTIVES FOR OPTIONS ANALYSIS

NEA OPTION

- 10% STANDARD INVESTMENT TAX CREDIT, 1978 - 2000
- 10% SOLAR INVESTMENT TAX CREDIT, 1978 - 1982
- CONTINUATION OF DOE SYNTHETIC FUELS AND CHEMICALS PROGRAM

TECHNOLOGY DEVELOPMENT RD&D CURRENT PROGRAMS		TIME CONSTANT ALLOWING A POTENTIAL MARKET CAPTURE OF 50% IN 40 YEARS
MARKET DEVELOPMENT PROGRAMS - ITC, 10% STANDARD, 10% SOLAR, 1978-1982	ACCELERATE COMMERCIAL ATTRACTIVENESS OF BIOMASS SYSTEMS	
REGULATORY, INSTITUTIONAL, INFORMATION PROGRAMS	INSIGNIFICANT IMPACT	

OPTION I

OPTION I IS DEFINED AS:

- $.20/MMBtu SUBSIDY, BASED ON PARITY, EQUIVALENT TO 1.3% INVESTMENT TAX CREDIT (ITC), 1978-2000
- $.70/MMBtu SUBSIDY, BASED ON NET NATIONAL VALUE, EQUIVALENT TO 4.6% ITC, 1978-2000
- $.90/MMBtu TOTAL SUBSIDY, 1978-2000, EQUIVALENT TO 5.9% ITC, 1978-2000
- CONTINUATION OF CURRENT DOE SYNTHETIC FUELS AND CHEMICALS PROGRAM, AS SPECIFIED IN THE NEA OPTION.

TECHNOLOGY DEVELOPMENT, RD&D

MARKET DEVELOPMENT PROGRAMS - ITC 10% STANDARD, 10% SOLAR, 1978-1982	ACCELERATE COMMERCIAL ATTRACTIVENESS OF SYNTHETIC FUELS AND CHEMICALS SYSTEMS	CHANGE IN TIME CONSTANT ALLOWING A POTENTIAL MARKET CAPTURE OF 50% FROM 40 TO 34 YEARS
REGULATORY, INSTITUTIONAL, INFORMATION PROGRAMS	INSIGNIFICANT IMPACT	
PARITY IN TREATMENT/NET NATIONAL VALUE SUBSIDY	INCREASE COMMERCIAL COMPETITIVENESS OF SOLAR BIOMASS SYSTEMS	

OPTION II

OPTION II IS DEFINED AS:

- $.80/MMBtu SUBSIDY, BASED ON PARITY, EQUIVALENT TO A 5.2% ITC
- $.80/MMBtu SUBSIDY, BASED ON NET NATIONAL VALUE, EQUIVALENT TO A 5.2% ITC
- $1.60/MMBtu TOTAL SUBSIDY, EQUIVALENT TO A 10.4% ITC.

OPTION II INCENTIVES ARE:

- THE NEA, 1978-1982
- AN ADDITIONAL 10% ITC, 1978-1982, FOR SYNTHETIC FUELS AND CHEMICALS SYSTEMS, FOR A TOTAL ITC OF 30%
- A DECLINING ITC, 1982-1988, FROM 30%-21%, THE PARITY LEVEL OF SUBSIDIES
- CONTINUATION OF CURRENT DOE SYNTHETIC FUELS AND CHEMICALS PROGRAM, AS SPECIFIED IN THE NEA OPTION.

<u>TECHNOLOGY DEVELOPMENT, RD&D</u>	ACCELERATE MARKET ENTRY DATE OF TECHNOLOGIES	MARKET ENTRY DATES OF TECHNOLOGIES ARE ACCELERATED BY 3 YEARS
<u>MARKET DEVELOPMENT PROGRAMS</u> FINANCIAL INCENTIVES - ITC EQUIVALENT 35-2%, 1978-1988	ACCELERATE COMMERCIAL ATTRACTIVENESS OF BIOMASS SYSTEMS	CHANGE IN TIME CONSTANT ALLOWING A POTENTIAL MARKET CAPTURE OF 50% FROM 40 TO 30 YEARS
<u>REGULATORY, INSTITUTIONAL, INFORMATION PROGRAMS</u>	AGGRESSIVE DEMONSTRATION PROGRAMS WITH INDUSTRY INVOLVEMENT ACCELERATE MARKET ACCEPTANCE	
<u>PARITY IN TREATMENT/NET NATIONAL VALUE SUBSIDY</u>	INCREASE COMMERCIAL COMPETITIVENESS OF SYNTHETIC FUELS AND CHEMICALS PRODUCED FROM BIOMASS	

OPTION III

OPTION III IS DEFINED AS:

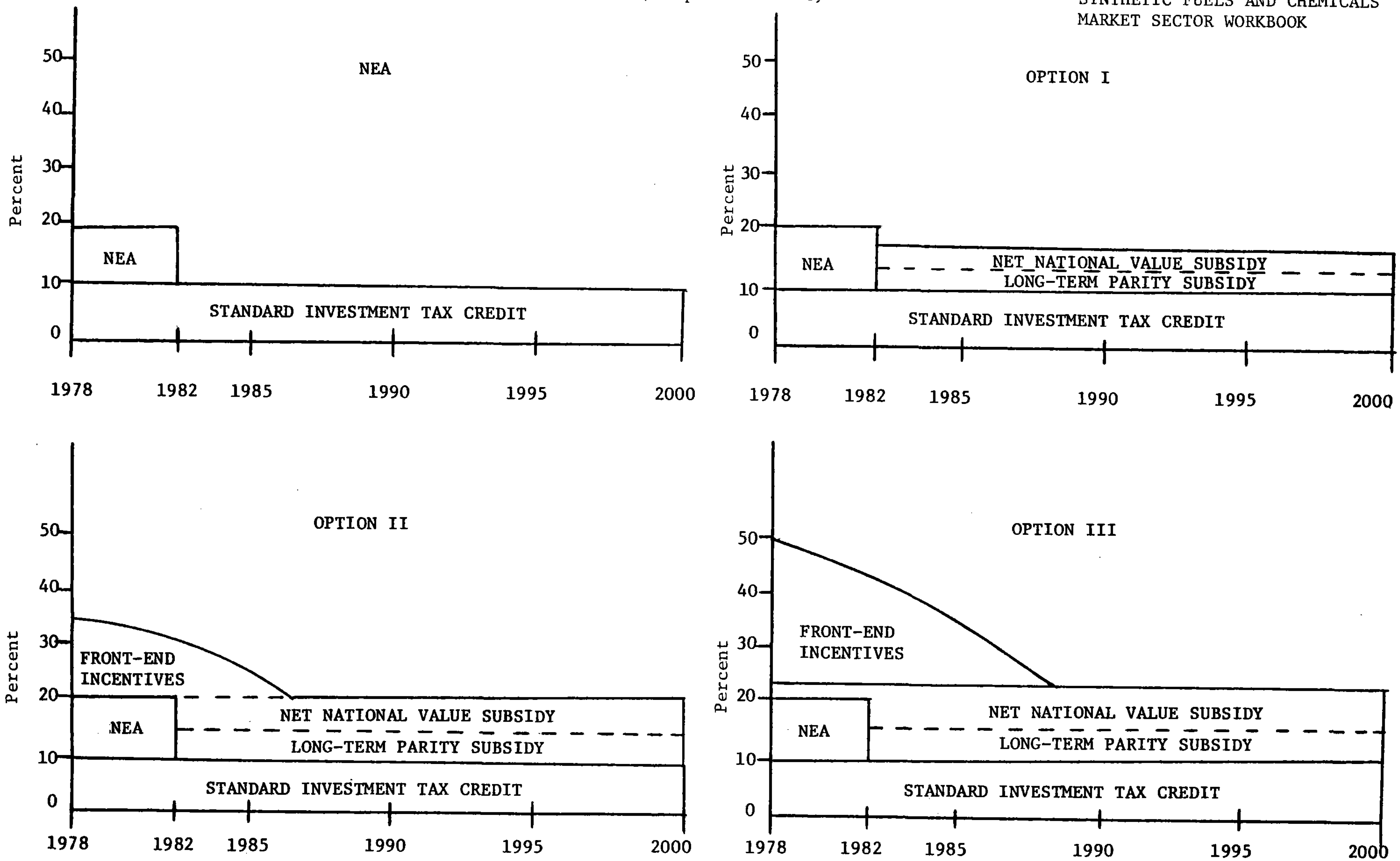
- $1.00/MMBtu SUBSIDY, BASED ON PARITY, EQUIVALENT TO A 6.5% ITC
- $.90/MMBtu SUBSIDY, BASED ON NET NATIONAL VALUE, EQUIVALENT TO A 5.9% ITC
- $1.90/MMBtu SUBSIDY, EQUIVALENT TO 12.4% ITC.

OPTION III INCENTIVES ARE:

- THE NEA, 1978-1982
- AN ADDITIONAL 15% ITC, 1978-1982, FOR A TOTAL SOLAR BIOMASS ITC OF 35%
- A DECLINING ITC, 1982-1988, 35%-23%, THE PARITY LEVEL OF SUBSIDIES
- ADDITIONAL DEMONSTRATION PROGRAMS FOR BIOMASS TECHNOLOGIES; $1 BILLION BY 1995.

TECHNOLOGY DEVELOPMENT, RD&D	ACCELERATE MARKET ENTRY DATE	MARKET ENTRY DATES ARE ACCELERATED BY APPROXIMATELY 5 YEARS
MARKET DEVELOPMENT PROGRAMS FINANCIAL INCENTIVES, ITC EQUIVALENT 50-23%, 1978-1988	ACCELERATE COMMERCIAL ATTRACTIVENESS OF BIOMASS SYSTEMS	
REGULATORY, INSTITUTIONAL, INFORMATION PROGRAMS	OVERCOME MARKET INERTIA	
PARITY IN TREATMENT/NET NATIONAL VALUE SUBSIDY	INCREASE COMMERCIAL COMPETITIVENESS OF SOLAR BIOMASS SYSTEMS	CHANGE IN TIME CONSTANT ALLOWING A POTENTIAL MARKET CAPTURE OF 50% FROM 40 TO 27 YEARS

LEVELS OF INCENTIVES
(% equivalent ITC)



COMMERCIALIZATION INCENTIVES

PARTICIPANT	PRIMARY CONCERNS	CURRENT PROGRAMS	POTENTIAL PROGRAMS	IMPACTS
DEVELOPER A&E FIRMS	HIGH CONVERSION SYSTEM COSTS	FEDERAL RD&D PROGRAMS		LOWERS SYSTEMS COSTS
		INVESTMENT TAX CREDIT (20%)		"
			ADDITIONAL INVESTMENT TAX CREDIT	
			ACCELERATED DEPRECIATION	LOWER EFFECTIVE SYSTEM COSTS
			FEDERAL COST SHARING	
			MULTIPLE DEMONSTRATION PROGRAMS TO PROMOTE COMPETITION	
DEVELOPER	AVAILABILITY OF BIOMASS RESOURCES		ESTABLISH A FEDERAL SITE BANK PROGRAM	ASSURE AVAILABILITY OF CONTIGUOUS LAND AREAS
			ALLOW USE OF FEDERAL LANDS OR FEDERAL RESERVES	
		DEMONSTRATIONS OF SILVICULTURAL PLANTATIONS		ASSURE PRODUCTIVITY AND COST-EFFECTIVENESS OF BIOMASS FUELS
		RD&D ON CANDIDATE BIOMASS SPECIES		

PARTICIPANT	PRIMARY CONCERNS	CURRENT PROGRAMS	POTENTIAL PROGRAMS	IMPACTS
DEVELOPER A&E FIRM	CONSTRUCTION DELAYS		GENERIC EIS, EXPEDITING LICENSING AND PERMITTING PROCEDURES	REDUCED TIME FOR CONSTRUCTION REDUCED COSTS
DEVELOPER	AVAILABILITY OF CAPITAL		ESTABLISH A GOVERNMENT FUNDING OR LEASING CORPORATION ESTABLISH A FEDERAL CORPORATION (BIOMASS TVA)	ALLEVIATION OF FUNDING BARRIERS
BANKING AND LENDING INSTITUTIONS	SECURITY OF INVESTMENT IN "NEW" TECHNOLOGIES		GOVERNMENT LOAN GUARANTEES GOVERNMENT PERFORMANCE GUARANTEES	ALLEVIATION OF RISK IN VENTURE CAPITAL
DEVELOPER	SYSTEM RELIABILITY	FEDERAL RD&D PROGRAMS	FEDERAL PERFORMANCE STANDARDS	REDUCED O&M COSTS REDUCED RISKS

PRODUCT COSTS+, \$/MMBTU, OPTION II
1990

	HIGH-PRICE	OPTIONS			MID-PRICE	OPTIONS			LOW-PRICE	OPTIONS		
	NEA	I	II	III	NEA	I	II	III	NEA	I	II	III
METHANOL	0	0	13	13	0	0	11	12	0	0	9	10
SYNTHETIC CRUDE OIL	0	0	7	7	0	0	6	6	0	0	6	6
AMMONIA	0	0	10	10	0	0	8	8	0	0	8	-
SYNTHETIC NATURAL GAS	0	0	7	7	0	0	6	7	0	0	5	6

PRODUCT COSTS+, $/MMBTU, OPTION II
2000
(Concluded)

		HIGH-PRICE OPTIONS				MID-PRICE OPTIONS				LOW-PRICE OPTIONS		
	NEA	I	II	III	NEA	I	II	III	NEA	I	II	III
METHANOL	13	12	12	12	11	10	10	10	-	-	9	9
SYNTHETIC CRUDE OIL	6	5	5	5	-	-	5	-	-	-	4	-
AMMONIA	9	9	8	8	8	7	7	7	7	7	7	7
SYNTHETIC NATURAL GAS	7	7	7	7	6	6	6	6	6	6	5	5

+product costs are presented for South Atlantic Region
[a]primary feed stock is log residues
[b]primary feed stock is mill residues
[c]primary feed stock is silvicultural farm
[d]where no entry is made, the SPURR model does not calculate product costs

MARKET PENETRATION, 10^{12} BTUs OF FUEL DISPLACED, OPTION II
1990

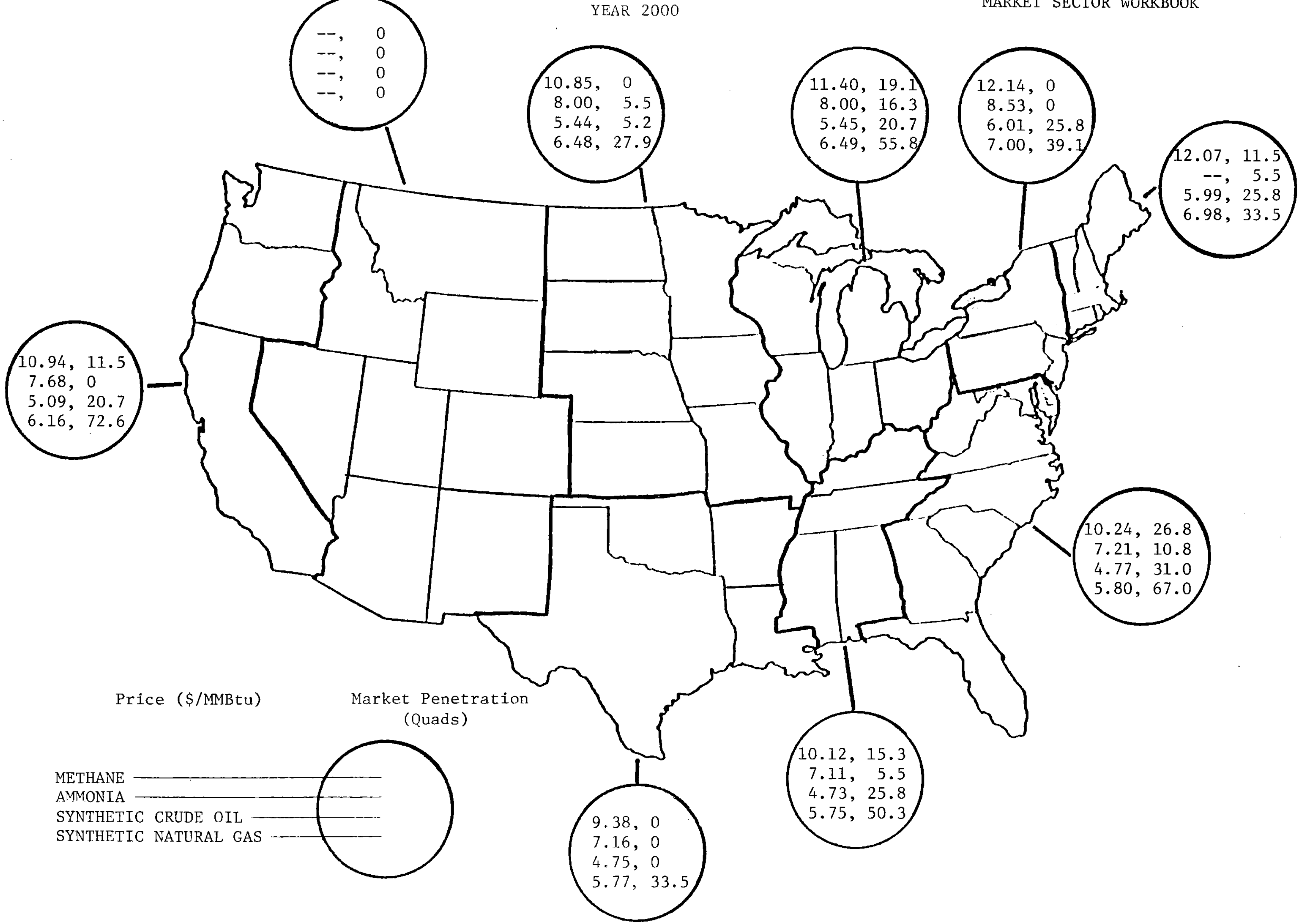
		OPTIONS HIGH-PRICE				OPTIONS MID-PRICE				OPTIONS LOW-PRICE		
	NEA	I	II	III	NEA	I	II	III	NEA	I	II	III
METHANOL	0	0	27	34	0	0	11	27	0	0	0	15
SYNTHETIC CRUDE OIL	0	0	52	72	0	0	31	41	0	0	0	0
AMMONIA	0	0	-	16	0	0	-	5	0	0	0	0
SYNTHETIC NATURAL GAS	0	0	67	95	0	0	95	151	0	0	0	0

MARKET PENETRATION 10^{12} BTUs OF FUEL DISPLACED, OPTION II
2000
(Concluded)

	OPTIONS HIGH-PRICE				OPTIONS MID-PRICE				OPTIONS LOW-PRICE			
	NEA	I	II	III	NEA	I	II	III	NEA	I	II	III
METHANOL	103	119	149	157	57	69	84	99	0	0	4	19
SYNTHETIC CRUDE OIL	165	171	279	357	83	98	171	207	16	10	10	5
AMMONIA	11	27	66	120	11	11	44	71	0	0	0	0
SYNTHETIC NATURAL GAS	184	162	279	262	296	262	380	407	6	11	11	0

MARKET PENETRATION: \$/MMBTU, 10^{12} BTU OF FUEL DISPLACED
MID-PRICE OPTION II
YEAR 2000

SYNTHETIC FUELS AND CHEMICALS
MARKET SECTOR WORKBOOK



ENERGY IMPACTS OF SOLAR MARKET PENETRATION, OPTION II, QUADS

	1990			2000		
	HIGH-PRICE	MID-PRICE	LOW-PRICE	HIGH-PRICE	MID-PRICE	LOW-PRICE
METHANOL	.027	.011	-	.149	.084	.004
SYNTHETIC CRUDE OIL	-	-	-	.066	.044	.000
AMMONIA	.052	.031	-	.279	.171	.010
SYNTHETIC NATURAL GAS	.067	.095	-	.279	.380	.011
TOTAL	.146	.137	0	.773	.679	.025

NUMBER OF UNITS SOLD, CUMULATIVE, OPTION II

SCENARIO	1990			2000		
	HIGH-PRICE	MID-PRICE	LOW-PRICE	HIGH-PRICE	MID-PRICE	LOW-PRICE
METHANOL						
LOG RESIDUES	-	-	-	0	-	-
MILL RESIDUES	7	3	-	13	5	1
SILVICULTURE	-	-	-	26	17	-
AMMONIA						
LOG RESIDUES	-	-	-	3	-	-
MILL RESIDUES	-	-	-	-	-	-
SILVICULTURE	-	-	-	9	8	-
SYNTHETIC CRUDE OIL						
LOG RESIDUES	5	2	-	20	7	-
MILL RESIDUES	5	4	-	5	5	2
SILVICULTURE	-	-	-	29	21	-
SYNTHETIC NATURAL GAS						
LOG RESIDUES	1	2	-	5	16	-
MILL RESIDUES	11	15	-	19	21	2
SILVICULTURE	-	-	-	26	31	-

ANNUAL INSTALLATION OF SOLAR SYSTEMS, OPTION II

NUMBER OF BIOMASS PLANTS PROJECTED IN THE SYNTHETIC FUELS AND CHEMICALS SECTOR, 1990 and 2000:

	1990			2000		
	HIGH-PRICE	MID-PRICE	LOW-PRICE	HIGH-PRIDE	MID-PRICE	LOW-PRICE
METHANOL FROM BIOMASS	2	-	-	6	3	-
AMMONIA	-	-	-	3	2	-
SYNCRUDE	2	-	-	9	8	-
SNG	1	5	-	8	9	1

PLANT CAPACITIES:

METHANOL	4.8×10^6 MMBtu/yr
AMMONIA	6.8×10^6 MMBtu/yr
SYNCRUDE	6.5×10^6 MMBtu/yr
SNG	7.0×10^6 MMBtu/yr

RESOURCE REQUIREMENTS* FOR CONVERSION FACILITIES

SYSTEM	LABOR	CONCRETE	COPPER	STEEL	NITROGEN	POTASSIUM	PHOSPHOROUS
METHANOL	25.6	1.93	.04	1.23	1.40	0.70	.53
AMMONIA	36.2	2.73	.05	1.74	1.98	0.50	.38
SYNCRUDE	34.6	2.61	.05	1.66	1.90	0.95	.71
SNG	37.2	2.81	.05	1.79	2.04	1.02	.77

*Resource requirements factors for one conversion facility:

MATERIALS = 10^3 tons per facility
LABOR = man years per facility

TOTAL U.S. RESOURCE REQUIREMENTS*, MID-PRICE, OPTION II SCENARIO

SYSTEMS	LABOR	CONCRETE	COPPER	STEEL	NITROGEN	POTASSIUM	PHOSPHOROUS
METHANOL	77	5.9	.12	3.7	4.2	2.1	1.6
AMMONIA	72	5.5	.10	3.5	4.0	1.0	.8
SYNCRUDE	277	20.9	.40	13.3	15.2	7.6	5.7
SNG	235	25.3	.45	16.1	18.4	9.2	6.9

*Total resource requirements required per year in the year 2000:

MATERIALS = 10^3 tons/yr
LABOR = man years