A Facsimile Report

DISCLAIMER

DISCLAIMER

EAB

Toward a National Plan for the Accelerated Commercialization of Solar Energy

WORKBOOK

Summaries

Robert E. Gerstein
Narasimhan P. Kannan
C. Grant Miller
Michael J. Shulman
James W. Taul, Jr.
Dyanne L. de Jong, ed.

January 1980

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

The MITRE Corporation
McLean, Virginia 22102

MTR-80W00019

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

ABSTRACT

This report summarizes the preliminary data and assumptions of the three Market Sector Workbooks prepared in conjunction with the development of inputs for a National Plan for the Accelerated Commercialization of Solar Energy.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

TABLE OF CONTENTS

TABLE OF CONTENTS (Concluded)

LIST OF FIGURES

INTRODUCTION

These workbooks contain preliminary data and assumptions used during the preparation of inputs to a National Plan for the Accelerated Commercialization of Solar Energy (NPAC).[1] The workbooks indicate the market potential, competitive position, market penetration, and technological characteristics of solar technologies over the next twenty years for five market sectors: residential buildings; commercial and institutional buildings; agricultural and industrial process heat; utility applications; and synthetic fuels and chemicals.

The workbooks also present 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 workbooks 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 workbooks, prepared in April 1979, represent 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.

---

[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.

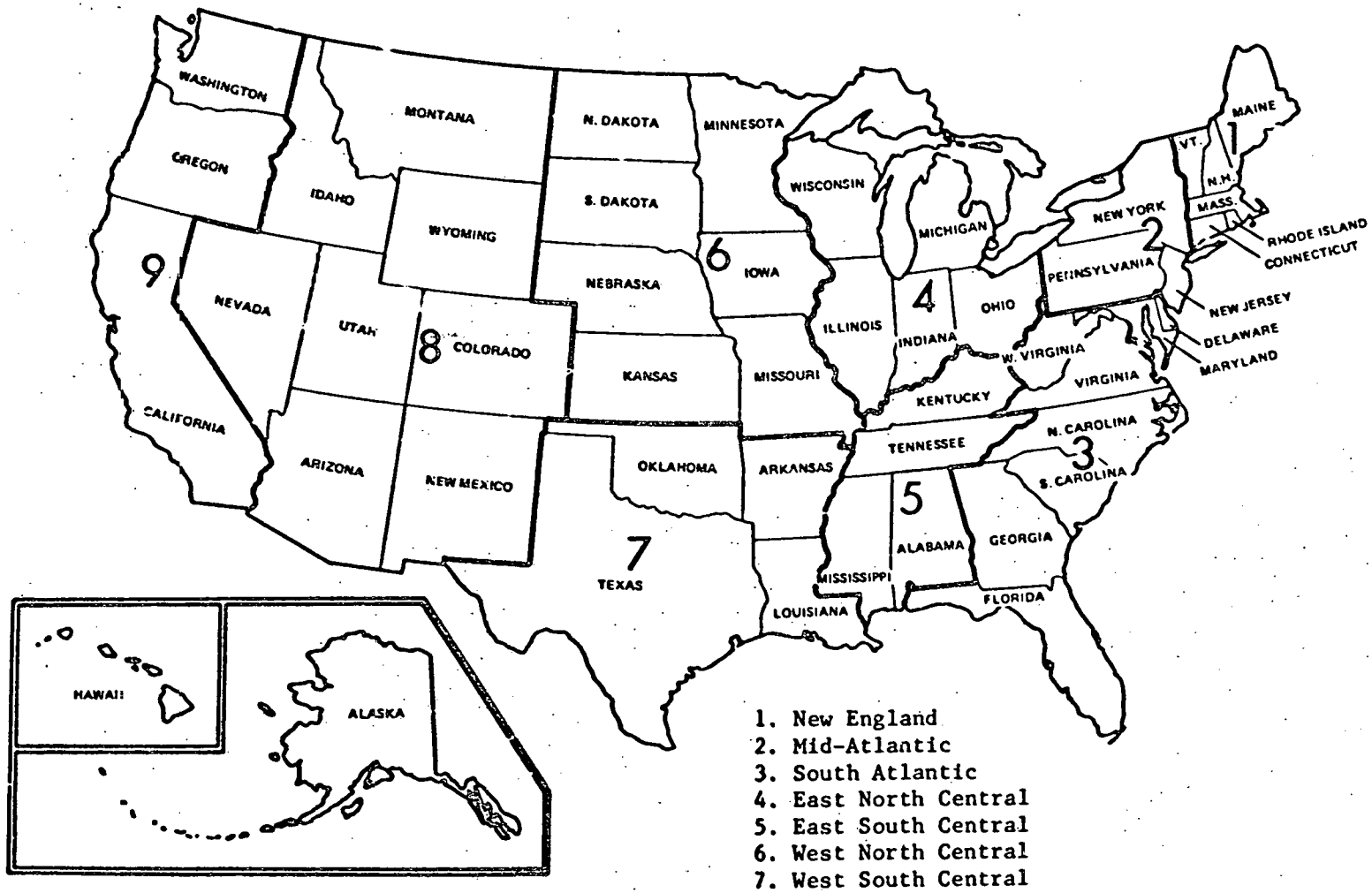


FIGURE 1
U.S. CENSUS REGIONS

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:

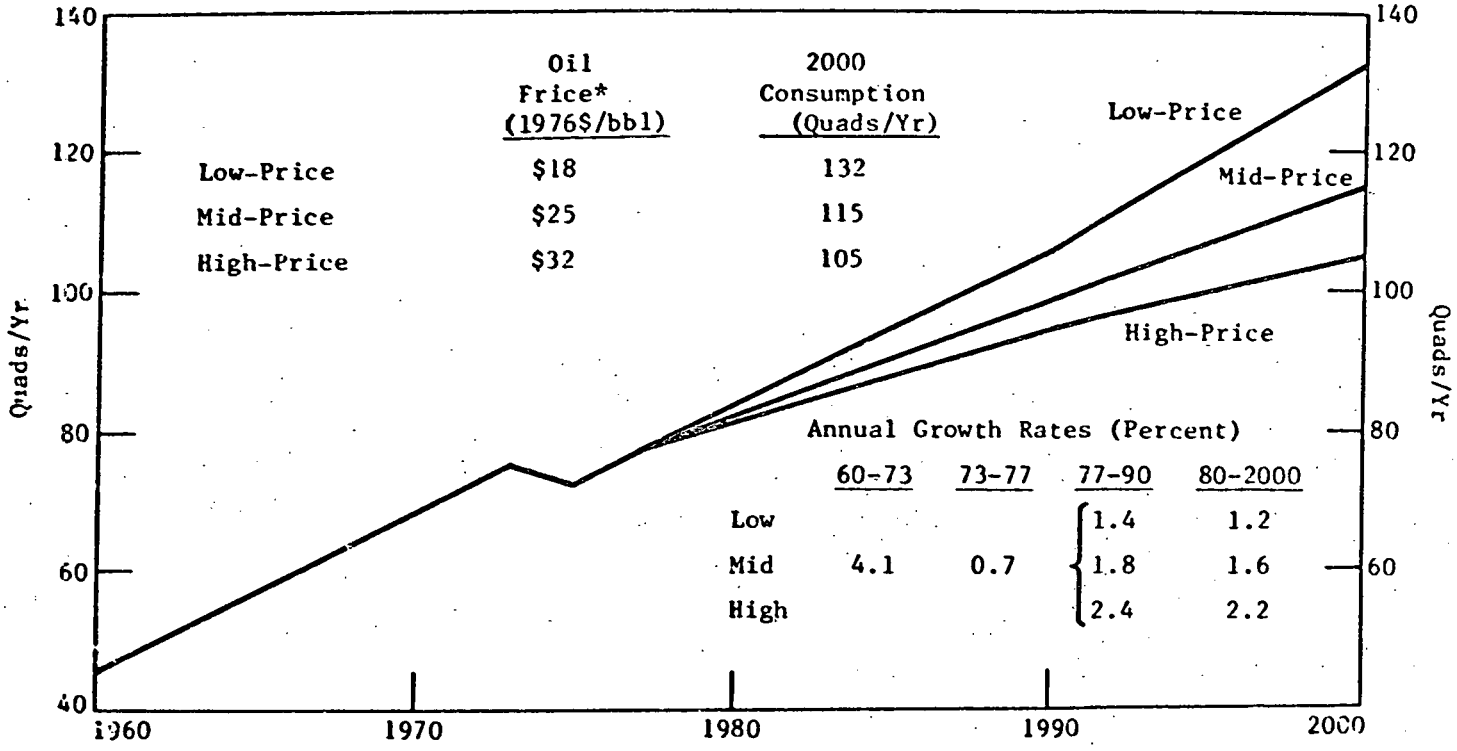
- o low-price oil/high end-use demand
- o mid-price oil/intermediate end-use demand
- o high-price oil/low end-use demand

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.

---

[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

Each of the five market sectors 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 workbooks also identify the principal commercialization development issues facing each market sector, participants in each market sector, 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

---

[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 across all market sectors 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 program.

A summary of the market sector workbooks 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.

---

[1]General 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.

SUMMARY
AGRICULTURAL AND INDUSTRIAL PROCESS HEAT (AIPH)

ENERGY DEMAND

The process heat market sector differs from the residential and commercial/institutional buildings market sectors because it relies on the energy demand, rather than the number of installations, to define the market. Service demand is the end-use energy demand for delivering a specific service. Primary fuel demand is the fossil fuel required to meet a service demand.

The total process heat service demand for all scenarios was estimated on a regional basis. The East North Central and West South Central regions each account for 23 percent of the total service demand. The New England and Mountain regions have the lowest requirement for process heat service demand, accounting for 2.8 percent each. The demand in the other five regions--Mid-Atlantic, South Atlantic, East South Central, Pacific, and West North Central--ranges between 6 and 14 percent. It was assumed that the percentage used in each region will remain constant, although total demand will increase over time. Specific details of total process heat service demand for the various scenarios in selected census regions and annual market potential, i.e., the annual growth of the process heat market, are in the workbook.

ECONOMIC INCENTIVES

The AIPH market sector shares the same economic concerns as the other sectors. The sector will also benefit from the tax credits included in the NEA.

Estimates of additional tax credits parallel the analysis conducted for the other market sectors. The standard 10 percent industrial investment tax credit (ITC) was left in place through the year 2000 for the incentive levels. In the Reference Case, an additional 10 percent industrial process heat tax credit is available for the 1978 through 1982 period only. Option I assumes that a long-term solar industrial process heat subsidy will be in effect for the period after 1982. This subsidy is set at 5 percent above the standard ITC (a total of 15 percent) and is comprised of a long-term parity subsidy and a net national value subsidy.

The Option II commitment level is a 35 percent ITC, made up of a 15 percent front-end incentive for solar, a 10 percent NEA solar tax credit, and the standard 10 percent ITC. The solar incentives decline gradually through 1988 until the entire tax credit totals 20 percent, and this level remains in effect through the turn of the century.

The highest level of commitment, Option III, contains equivalent tax credits totaling 50 percent of systems costs in 1978. These decline to the 20 percent level by 1988 and remain in place through the turn of the century.

MARKET PENETRATION

These commitment levels produce different levels of market penetration. Factors in the market penetration analysis include the cost of installed system capacity; for AIPH, it was calculated in 1976 $/sq. ft. of solar collector used. The 1985 cost per capacity for all price/demand scenarios and for all commitment levels ranges between $25 and $30 per sq. ft. This is expected to decline to about $12 per sq. ft. by the year 2000.

The second factor considered in analyzing the market penetration in the process heat sector is the cost of delivered energy, in $/MMBtu. For all price/demand scenarios and for each commitment level, the most dramatic decline in this cost occurs in the 1985 through 1990 period; this decline in solar cost occurs in all price/demand scenarios and across all four levels of incentives. Between 1990 and 2000, the cost/MMBtu declines more gradually. Solar technologies begin to satisfy significant amounts of process heat service demand in the early 1990s, with the trend to even greater contributions by the year 2000.

The cost per capacity, the cost of delivered energy, and the service demand supplied by solar by region and application is estimated over time for the three price/demand scenarios and for the various commitment levels. The installed capacity and the dollar value of sales (1976 $) are estimated in a similar manner. Detailed estimates are in the workbook.

Energy savings are tabulated over time, by scenario and commitment level, for the new and the fuel savers market and measured in quads of fossil fuel displaced.

ADDITIONAL PROCESS HEAT TECHNOLOGIES

Two other sections of this workbook consider on-site industrial electric power generation and industrial combustion of biomass. The mid-price/demand scenario is the only scenario tested. The on-site electric power generation analysis includes wind, photovoltaic, and solar thermal electric technologies. The biomass analysis includes the four U.S. industries that are the principal users of biomass: food, lumber, furniture, and paper. This analysis shows that biomass utilization in these four industries will grow from a current level of 27.1 percent of primary fuel consumed in 1978 to 40 percent by the year 2000.

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.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

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. Detailed estimates of these parameters are provided in the final section of the workbook.

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

APPENDIX

MARKET SECTOR WORKBOOK CONTENTS:

RESIDENTIAL AND COMMERCIAL/INSTITUTIONAL BUILDINGS

AGRICULTURAL AND INDUSTRIAL PROCESS HEAT

UTILITY APPLICATIONS

SYNTHETIC FUELS AND CHEMICALS

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

RESIDENTIAL AND COMMERCIAL/INSTITUTIONAL
BUILDINGS MARKET SECTOR WORKBOOK

CONTENTS

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

AGRICULTURAL AND INDUSTRIAL PROCESS HEAT
MARKET SECTOR WORKBOOK

CONTENTS

AGRICULTURAL AND INDUSTRIAL PROCESS HEAT
MARKET SECTOR WORKBOOK

CONTENTS (Continued)

AGRICULTURAL AND INDUSTRIAL PROCESS HEAT
MARKET SECTOR WORKBOOK

CONTENTS (Concluded)

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

UTILITY APPLICATIONS
MARKET SECTOR WORKBOOK

CONTENTS

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

SYNTHETIC FUELS AND CHEMICALS
MARKET SECTOR WORKBOOK

CONTENTS