

APPENDIX E

ADDITIONAL MATERIALS ON THE CD

This appendix provides detailed descriptions of additional study materials contained on the CD included with the final printed version of the National Petroleum Council (NPC) report, *Facing the Hard Truths about Energy: A Comprehensive View to 2030 of Global Oil and Natural Gas*. The CD contains the following files:

- Final Report
- Report Glossary
- Report Slide Presentation
- Webcast of NPC Meeting and Press Conference
- Study Topic Papers
- Study Data Warehouse Files

The contents of the CD also can be viewed and downloaded from the NPC website (www.npc.org) and additional or replacement copies of the CD can be purchased from the same site.

FINAL REPORT

The final report, as approved by the members of the National Petroleum Council and submitted to Secretary Bodman, is included on the report's CD. This copy of the printed report is in PDF format, contains hyperlinks among sections, and is searchable using Adobe software. It provides the report sections as follows:

- Transmittal Letter to Secretary Bodman (2-page summary of report)
- Table of Contents
- Preface
- Executive Summary

- Report Chapters
 - Chapter One: Energy Demand
 - Chapter Two: Energy Supply
 - Chapter Three: Technology
 - Chapter Four: Geopolitics
 - Chapter Five: Carbon Management
 - Chapter Six: Recommendations
 - Chapter Seven: Methodology
- Appendices
 - Appendix A: Request Letter and Description of the NPC
 - Appendix B: Study Group Rosters
 - Appendix C: Study Outreach Process and Sessions
 - Appendix D: Parallel Studies Process and Summaries
 - Appendix E: Additional Materials on the CD
- Acronyms and Abbreviations

REPORT GLOSSARY

The report's CD contains a detailed glossary of terms used in the report, which was drawn almost in its entirety from a glossary provided by EIA. The glossary is provided in PDF format. The NPC is appreciative of EIA allowing the use of this document and assumes responsibility for any modifications that have been made to it.

REPORT SLIDE PRESENTATION

On July 18, 2007, a detailed slide presentation on the report, *Facing the Hard Truths about Energy*, was

delivered to Secretary of Energy Samuel W. Bodman and the membership of the National Petroleum Council. This slide presentation is included on the report's CD to allow readers access to materials that were used to help explain the study process and results. Two versions are provided in PDF format:

- Slides only
- Slides with presenter's text as notes.

WEBCAST OF NPC MEETING AND PRESS CONFERENCE

The report's CD also contains a webcast of the July 18, 2007 NPC meeting as follows:

- Presentation on the report to the NPC membership
- Report approval and delivery to Secretary of Energy, Samuel W. Bodman
- Remarks by Secretary Bodman
- Press conference on July 18, 2007, following the NPC meeting.

STUDY TOPIC PAPERS

On July 18, 2007, the National Petroleum Council in approving its report, *Facing the Hard Truths about Energy*, also approved making available certain materials used in the study process, including detailed, specific subject matter papers prepared by the Task Groups and their Subgroups. These Topic Papers were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters. The final report's CD includes final versions of these papers.

These Topic Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents but approved the publication of these materials as part of the study process.

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the study results. These materials are being made available in the interest of transparency.

A list of these Topic Papers with brief abstracts for each follows.

Demand Task Group

Paper #1: Coal Impact ♦

The United States has the largest coal reserves in the world, followed by Russia and China. Coal now provides about a quarter of the energy used in the United States. The share of U.S. energy to be supplied by coal is projected to increase modestly to 2030. Coal use worldwide exhibits the same characteristics as in the United States. The largest increase in coal use through 2030 is projected to be in China, followed by the United States and India. Coal is consumed in large quantities throughout the United States, while most production is focused in a few states, requiring significant quantities of coal to be transported long distances. To that end, U.S. coal consumers and producers have access to the world's most comprehensive and efficient coal transportation system. The extent to which coal is able to help meet future U.S. energy challenges will depend heavily on the performance of coal transporters.

Paper #2: Cultural/Social/Economic Trends ♦

Population and the economy are normally directly associated with projecting energy use trends, but other factors play an important role in understanding these trends. This topic paper examined 8 of these trends, which were thought to be the most significant. These trends include the relationship between the structural change in the economy and energy use, the importance of oil and natural gas to future energy use patterns, carbon dioxide emissions and their relationship to fossil-fuel use, China and its anticipated energy use growth, the energy use conundrum related to the introduction of new energy consuming technologies into the market place, the potential for energy use savings in the light-duty vehicle fleet, energy use and its association with energy price, and the impact of fuel-switching capability in the transportation sector.

Paper #3: Demand Data Evaluation ♦

This report contains the findings of the Demand Data Evaluation Subgroup of the Demand Task Group, which reviewed, analyzed, and compared projection data collected in the NPC data warehouse through surveys for both public and proprietary projections of world energy demand. Major "drivers" underpinning the demand projections are population and economy. In all cases, worldwide and U.S. energy demand is projected to increase. In a general sense, the worldwide

increase in energy is expected to be about 60 percent by 2030, matching the worldwide increase over the last 25 years. Detailed analyses were conducted using input from the U.S. Energy Information Administration (EIA) and the International Energy Agency (IEA). Other public studies were less complete than those produced by the EIA and the IEA, but confirmed the observations made from those studies as did the aggregated proprietary data collection effort.

Paper #4: Electric Generation Efficiency ◆

Expected improvements in electric generation efficiency are projected to mainly come from the replacement of old plants with new plants that are constructed using contemporary technology with better efficiencies. Existing unit efficiency is not projected to improve significantly as replacement of auxiliary equipment is the only area where contemporary technology can be introduced. There are regional differences in the rate of improvement in electric generation efficiencies as developing regions have less installed capacity and are projected to add new electric generating capability at a faster rate than in industrialized regions.

Paper #5: Industrial Efficiency ◆

This topic paper examines industrial energy use trends, the potential impact of energy efficiency technologies, and barriers to their adoption. The industrial sector is a large and price-responsive energy consumer. Energy efficiency opportunities of 5 quadrillion Btu per year, or over 15 percent of industrial energy use, exist broadly across the industrial sector. While 40 percent of these opportunities could be captured using existing technology and systems, further research-and-development is required to implement the rest. Areas of opportunity include waste-heat recovery, separations, and combined heat and power. By providing fuel-switching capability, the industrial sector serves as a quickly responding buffer against supply or demand shocks. Unfortunately, industrial fuel-switching capability has decreased in recent years.

Paper #6: Residential Commercial Efficiency ◆

About 40 percent of U.S. energy is consumed in the residential and commercial sectors. If “achievable” cost-effective energy-efficiency measures were deployed, energy use in these two sectors could be roughly 15-20 percent below that anticipated in a

business-as-usual future. Most energy consumed in these sectors is for traditional uses such as heating, cooling and lighting. However, a growing portion is being used to power new devices, many of which were rare or even nonexistent just a few years ago. Significant efficiency improvements have been made in building shells, systems, and appliances. But these improvements have been offset to some extent by additional demand for energy services resulting from trends toward bigger structures, use of increasing numbers of traditional appliances, and introduction of new energy consuming devices. Buildings typically last decades if not centuries. Many of the features of buildings that affect their energy consumption largely will go unchanged throughout the life of the building. Technologies and practices affecting energy use in these long-lived systems will be slow to penetrate and affect overall efficiency.

Supply Task Group

Paper #7: Global Access to Oil and Gas ◆

For environmental and other policy reasons, governments around the world, including the U.S., have reduced access to oil and natural gas resources. This paper is a detailed description of resource types, locations, and volumes subject to U.S. federal access restrictions or moratoria. The paper also includes data about restricted global and North American access as well as oil and gas production from marginal U.S. wells.

Paper #8: Biomass ◆

Biomass is part of the global resource endowment for supplying energy. This paper is a detailed survey of biomass, particularly cultivated crops, as a source of both energy and food. The paper considers the range of estimates for energy supplied by biomass; agricultural capacity to meet projected fuel and food demands; and the conditions needed to optimize energy crop production, including bioengineered or genetically modified crops. It also discusses infrastructure considerations and second-generation conversion technologies needed to secure biomass as a significant source of energy supply.

Paper #9: Gas to Liquids (GTL) ◆

The term gas to liquids refers to technologies that convert natural gas to liquid fuels, as an alternative to refining crude oil and other commercialization paths

for natural gas. Interest in large-scale GTL has grown over the past 10 years, based on strong demand for diesel fuel, particularly in Europe and Asia; increasingly stringent environmental specifications for diesel fuel; the commercial potential in monetizing stranded gas; and requirements to reduce flaring of natural gas and develop economic uses for the gas. This paper describes recent GTL developments and assesses potential capacity additions and commercial prospects.

Paper #10: Geologic Endowment ♦

The geologic endowment of oil, natural gas, coal, or other hydrocarbons is a fundamental consideration for energy policy. This paper defines the major types of hydrocarbons and essential concepts such as reserves and resources that are used in energy discussions. The paper discusses a wide range of global resource estimates, their underlying methodologies, and the challenges in making resource assessments. The discussion concludes with a call to update estimates of global hydrocarbon resources using best-practice assessment techniques.

Paper #11: Hydrogen ♦

Hydrogen is of great interest in the longer-term as the potential basis for a non-hydrocarbon energy economy. This paper describes the potential role of hydrogen at large scale in reducing U.S. petroleum imports and carbon emissions. The paper summarizes a range of estimates for hydrogen's share of energy supply through 2030 and beyond and discusses the R&D, distribution, and infrastructure requirements needed to make hydrogen a viable supply option.

Paper #12: Infrastructure ♦

Transportation infrastructure is a vast, complex network of pipelines, railways, waterways, and roads that deliver energy from sources of supply to points of demand. Much of the U.S. transportation system was in place by the 1970s. This paper concludes that the network is approaching a tipping point as aging infrastructure contends with growing and increasingly diversified demand. Fragmented or outdated data about infrastructure add to the uncertainty in assessing the current state or planning for future requirements. The paper concludes that energy transportation infrastructure should become a national priority in the interests of economic security and national security.

Paper #13: Liquefied Natural Gas (LNG) ♦

Liquefied natural gas is gas that has been cooled as a liquid for transport when pipelines are not economically or otherwise feasible. This paper describes the principal elements of the global LNG trade, defines the LNG "value chain," and assesses the prospects of emerging LNG exporters and consumers.

Paper #14: Non-Bio Renewables ♦

This paper surveys the economic, technical, and policy prospects for non-bio renewable energy sources, including wind, solar, tidal, and geothermal power. Although these energy sources do not produce liquid fuels that compete with petroleum products, they all generate electricity or heat that can displace hydrocarbon power sources such as natural gas or coal. While each renewable source has unique features, they all share such characteristics as high construction or installation costs but low operating costs. The paper discusses these characteristics and their implications for potential timing, scale, and rate of adoption of renewable energy sources.

Paper #15: Summary Discussions on Peak Oil ♦

This paper defines "peak oil" as one class of oil production forecasts and summarizes the arguments made for this point of view. The paper is based on two teleconferences with peak-oil forecasters, and a third teleconference with forecasters who do not share their view. The paper describes key concepts and indicators for the peak-oil position, including new field discoveries, production maxima in some oil-producing countries, and the inability of some producing countries to meet both domestic and export demand. The report concludes that concerns about supply shortfalls due to post-peak production have merit and warrant further consideration. It also warns that inconsistent definitions and reporting of production and reserve data raise uncertainty in supply forecasts.

Paper #16: Refining and Manufacturing ♦

This paper addresses questions about the refining capacity that will be needed over the next 25 years; the location of that capacity; the technology required to process unconventional feedstock; and policy or regulatory issues that inhibit new refining capacity. The paper concludes that all projections for 2015 show

that primary oil demand will exceed projected refining capacity, even assuming that all announced refinery expansion projects are implemented. Growing oil demand in the United States is projected to outpace the increase in domestic refining capacity, leading to increased imports of finished products. Increasing technical complexity, regulatory requirements, and lengthy permitting procedures will have a combined effect on capacity expansion.

Technology Task Group

Paper #17: Carbon Capture and Sequestration (CCS) ♦

It is likely that the world is moving into an era of carbon management involving several measures to reduce CO₂ emissions, including improvements in the efficiency of energy use and the use of alternatives to fossil fuels such as biofuels, solar, wind, and nuclear power. However, to meet the energy demands of the nation, the United States will continue using fossil fuels, including coal, extensively over the next 50 years or more. To do so it will be necessary to capture and sequester a large fraction of the CO₂ produced by burning these fossil fuels, as discussed in this report.

Paper #18: Coal to Liquids and Gas ♦

This Topic Report focuses on the potential of coal to liquids and coal to gas technologies, and potential advances in these conversion processes. It examines the inputs and assumptions from various publications and the range of production estimates from these technologies.

Paper #19: Conventional Oil and Gas (including Arctic and Enhanced Oil Recovery) ♦

Large volumes of technically recoverable, domestic oil resources—estimated at 400 billion barrels—remain undeveloped and are yet to be discovered, from undeveloped remaining oil in place of over a trillion barrels. This resource includes undiscovered oil, stranded light oil amenable to CO₂-EOR technologies, unconventional oil (deep heavy oil and oil sands), and new petroleum concepts, such as residual oil in reservoir transition zones. The status of these resources is the topic of this report.

Paper #20: Deepwater ♦

Deepwater oil and natural gas resources are conventional reserves in an unconventional setting. The Topic Report describes the top priority deepwater-specific technological challenges. These are reservoir characterization, extended system architecture, high-pressure and high-temperature (HPHT) completion systems, and metocean (meteorological and subsurface) forecasting and systems analysis.

Paper #21: Exploration Technology ♦

The exploration topic study group identified five core exploration technology areas in which future developments have the potential to significantly impact exploration results over the next 25 years. These areas are seismic technologies, controlled source electromagnetism, interpretation technology, earth-systems modeling, and subsurface measurements. The Topic Report describes these and other aspects of exploration technology.

Paper #22: Heavy Oil ♦

Heavy oil, extra-heavy oil, and bitumen are unconventional oil resources that are characterized by high viscosity (resistance to flow) and high density compared to conventional oil. Production methods currently in use and those needed in the future are described in the Topic Report.

Paper #23: Human Resources ♦

The majority of oil and natural gas industry professionals are less than ten years from retirement eligibility. There are fewer academic departments in petrotechnical areas now than 20 years ago, and significantly fewer petrotechnical students are being trained to replace upcoming retirees. The upcoming demographic shift in employees is described in the Topic Report.

Paper #24: Hydrates ♦

Gas hydrates are found within and under permafrost in arctic regions, and also within a few hundred meters of the seafloor on continental slopes and in deep seas and lakes. The reservoir architecture, technology needs, and eventual economic importance of hydrates in arctic and marine environments may be very different. Arctic hydrates lack validated methods for economical production, but for marine hydrate resources the added challenge is even more

fundamental: a validated means of reliably finding them in significant deposits.

Paper #25: Nuclear Power ♦

Nuclear power is expected to have a greater impact on use of coal rather than oil or natural gas, because it provides base-load power. This Topic Report discusses the predictions of future nuclear power usage.

Paper #26: Oil and Gas Technology Development ♦

Since the beginning of the modern age of oil and natural gas, technology has played a fundamental role in supporting the efficient production of hydrocarbons. Payoff from a new technology can be huge, both for the individual company and for national energy security. However, commercializing technology in the oil and gas market is costly and time intensive; with an average of 16 years from concept to widespread commercial adoption. The Topic Report describes the technology development process.

Paper #27: Oil Shales ♦

Globally, it is estimated that there are roughly 3 trillion barrels of shale oil in place, which is comparable to the original world endowment of conventional oil. About half of this immense total is found near the common borders of Wyoming, Utah, and Colorado. The Topic Report describes very recent advances in recovering this resource and the additional challenges ahead.

Paper #28: Transportation Efficiency ♦

Improved efficiency in transportation can have a significant influence on future energy usage. This report examines several studies on transportation technologies and discusses the efficiency gains to be obtained in segments of light-duty vehicles, heavy-duty vehicles, air transport, marine shipping, and rail transport.

Paper #29: Unconventional Gas ♦

Unconventional natural gas resources constitute some of the largest components of remaining natural gas resources in the United States. The Topic Report describes in detail tight sand, coalbed methane, and gas shale resources, and discusses advances needed in these areas.

Geopolitics & Policy Task Group

Paper #30: Historical Perspective on Energy Crises and U.S. Policy Responses ♦

Section I excerpted from 1987 NPC Report, *Factors Affecting U.S. Oil & Gas Outlook*.

Macroeconomic Subgroup Reference Reports

Paper #31: Energy Markets Grow Up: How the Changing Balance of Participation Influences Oil Price, Katherine Spector, 6/15/05 ♦

This report explores who trades financial energy today, and how they participate in the market. The increase in the number of would-be buyers of energy over the past few years—including energy consumers, fundamentally inspired speculators, and passive investors—coincided, as prices rose, with a marked decline in hedging by producers, the market's natural sellers. The result is a sharp increase in the competition for forward price that has changed the way the market responds to bullish energy fundamentals.

Paper #32: Energy Markets Grow Up Part II: Who Trades Energy Now and How Much Does It Matter? Katherine Spector, 1/8/07 ♦

This is the follow-up report to “Energy Markets Grow Up: How the Changing Balance of Energy Market Participation Influences Price,” a report which looked at who trades energy and why, and explained how the development of the financial energy market has changed the path of not only energy prices, but the shape of the futures curve and volatility. This report updates that discussion, examines what has changed in the past year, and—in a market with so little hard data on money flows—attempts to quantify the role that some of these market participants play. Specifically, this report estimates the per-commodity inflows and outflows associated with index investment on a quarterly basis since 2002. This report attempts to isolate the flow of money from rebalancing pure index positions to maintain fixed allocations to commodities. The report also explores some of the strategies that investors are using to improve returns—and that banks are using to manage the risk associated with selling index style products to real money customers.

Paper #33: Oil Shocks and the Global Business Cycle, David Hensley, 5/12/06 ♦

This report examines the increase in oil prices in the 1970s and the increase in oil prices in the 2000s and identifies the factors that contributed to the different outcomes in the two periods, including the difference in energy intensity, the rapidity of the price rise, and geopolitical tensions.

Paper #34: The Good, the Bad and the Ugly about the Oil Shock Impact on Emerging Markets, Luis Oganés & Katherine Spector, 10/21/05 ♦

This report examines the impact of the increase in oil prices seen in 2003–2005 on net oil exporters in Emerging Market.

Paper #35: Three Propositions on the Economics of Greenhouse-Gas Regulation, Marc Levinson, 2/14/07 ♦

This presentation was presented by Marc Levinson at the NPC Carbon Management meeting on February 14, 2007 in Princeton. Three propositions about climate change include: (1) If greenhouse-gas emissions cause social harm, emitters should bear a cost intended to discourage emissions; (2) Although it is impossible to calculate an “optimal” cost of emissions, the cost must be high enough to discourage consumption of greenhouse-gas-intensive goods and services; (3) The real cost of emissions should rise on a predictable path over an extended period of time, as extremely sharp or erratic price changes have the potential to cause significant economic harm.

Paper #36: Capturing the Gains from Carbon Capture, Marc Levinson, 4/11/07 ♦

Carbon sequestration—the burying of carbon dioxide captured from power generation and manufacturing—is likely to develop into an extremely large industry in the face of mounting concern about climate change. Investor interest in climate change has so far centered on utilities and fossil-fuel producers. This report seeks to widen this focus and look at opportunities for the industrial companies that are staking out roles in the infant capture-and-sequestration industry.

Paper #37: Carbon Dioxide: A Commodity Market Perspective, Scott Speaker, 3/27/07 ♦

This report intends to assess the emerging risks and opportunities of impending regulation of carbon dioxide emissions from U.S. power generators and heavy industries from a commodity market perspective and quantify potential impacts where possible.

Paper #38: All You Ever Wanted to Know About Carbon Trading, January 2007 ♦

This report provides an introduction to carbon trading and examines the emerging risks and opportunities of impending regulation of carbon dioxide emissions.

STUDY DATA WAREHOUSE FILES

To make the study’s broad-ranging and original sources easily available to all participants, a data warehouse was developed. This provided for centralized management of the multidimensional data collected. By the time it concluded, the study had compiled and used nearly 100 energy forecasts or outlooks. These forecasts and several hundreds of papers/documents on various aspects of the energy sector were used in the interpretations that formed the basis of the study findings and recommendations.

The data warehouse was designed to be the main analytical tool for the Task Groups, accepting all data collected from the survey questionnaire and other data sources. Once in the data warehouse, selected values or ranges of values for any or all dimensions could be applied as a filter to enable analysis.

As with the Topic Papers, the National Petroleum Council has not endorsed or approved the contents of the study’s Data Warehouse but approved making available this information as part of the study process.

The NPC believes that the information in the Data Warehouse will be of interest to the readers of the report and will help them better understand the study results. The structured data used in the NPC study, along with software to display data and graphics, are being made available in the interest of transparency.