REPORT OF

A POLICY FORUM: WEATHER, CLIMATE, AND ENERGY

Developed by the

Atmospheric Policy Program of the American Meteorological Society

in collaboration with the

University of Oklahoma

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Dept. of Commerce (NOAA)

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PREFACE

This report of a policy forum on Weather, Climate, and Energy presents findings and recommendations that, if implemented, could position the energy sector, the providers of weather and climate science and services, and energy consumers to manage more cooperatively and effectively the production, distribution, and consumption of electrical power and fossil fuels.

Recent U.S. experience with a series of energy shortages encouraged the AMS Atmospheric Policy Program to join with the University of Oklahoma in the development of a forum to address the issues connected with responding to those shortages. We invited participation of representatives from the public, private, and academic portions of the (primarily fossil fuel-based) energy production sector, the meteorological community, political and corporate leaders, weather risk management analysts, and policy makers. Nearly 100 representatives of those communities came together on October 16-17, 2001, for intensive discussions of these important policy issues.

The Atmospheric Policy Program of the American Meteorological Society (AMS) remains poised to assist in the further development and realization of the recommendations that have emerged from the Forum.

On behalf of the AMS and the Atmospheric Policy Program I would like to acknowledge, with thanks, the contributions of numerous individuals and organizations to the success of the Forum. First and foremost, without the generous sponsorship of Williams Energy, ENRON, the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) and the Department of Energy's Office of Biological and Environmental Research (BER), the Forum could not have been held. The work of Dennis O'Brien and Pete Lamb at the University of Oklahoma and Doug Stone, Dick Hallgren, Ron McPherson, and Bob White at the AMS was critical in the planning and execution of the Forum. Of course, the Forum could not have been undertaken without the generous labors of the moderators and panelists that are listed in Appendix A. I thankfully recognize the excellent assistance of Genene Fisher and Mark Fernau, who documented the main outcomes of the discussions and contributed greatly to the writing of this report. Finally, I owe a special debt of gratitude to Bill Hooke for his substantial advice and editorial assistance.

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EXECUTIVE SUMMARY

In the late 1970's, a serious energy shortage in the U.S. led to the realization that weather and climate information plays a significant and growing role in the management of energy. Ever since, utilities have combined weather and climate information to project estimated energy demands in an effort to manage their supply and distribution operations effectively.

These efforts have accelerated since the mid-1990's, when the deregulation of the electrical power industry began. During the same period, successful forecasts of the 1997-1998 El Niño event and its evident effects on energy demand patterns were one of several factors prompting the development of specialized financial instruments for energy risk management. Hot summers in 1998 and 1999 contributed to significant spikes in spot prices for electricity, with important operational and economic consequences across the United States.

More recently, for more than a year, continuing through the summer of 2001, California has struggled with electrical shortages and price volatility. California's State Treasury and energy consumers lost billions of dollars, and a major utility filed for bankruptcy. Most analysts agree that a primary factor for this upheaval was a flawed effort to partially deregulate the California electrical utility system. However, the policies that were implemented also increased the vulnerability of energy delivery to weather and climate variations. There is general agreement that more accurate daily to seasonal weather and climate predictions could have helped energy producers and users, corporate managers, and political leaders to adjust more effectively to the changing nature of energy markets.

In the future, weather and climate information must therefore be much better integrated into the continuing development of national energy policies. That information, produced by the public and private sectors, has become a vital national asset as energy policy becomes even more critical to the state of the economy.

In response to this growing national policy need, the American Meteorological Society, in collaboration with the University of Oklahoma, organized a forum to explore how weather and climate information can be used to match energy supply and demand more effectively while reducing costs and increasing reliability. The two-day Forum brought together leading representatives from the energy producer, distributor, trader, and user communities; public and private providers of weather and climate information and services; and executive and legislative branch energy policy makers. In a series of panel discussions, the following questions and issues were addressed:

How is the energy sector changing and how can it improve its use of weather and climate information?

What advances are needed in weather and climate sciences and services?

What special requirements do emerging risk management techniques place on weather and climate services?

What public policies are needed to foster development of weather and climate services and their use by the energy sector?

Although the participants in the Forum discussed weather and climate information, forecasts, science and services, this report adopts the term "meteorological" to encompass both weather and climate. Beyond merely making the text simpler, this choice of terminology reflects the concept repeatedly stressed by the energy participants, that their needs do not recognize a boundary between weather and climate. Because of time limitations, the Forum discussions were focused on the meteorological considerations impacting the provision of fossil fuel-based energy -- principally oil, gas, and coal.

A consensus was developed on the following crosscutting findings and recommendations drawn from the panel discussions.

FINDING 1. As demand grows and supply is restricted sporadically, the Nation is in an energy-constrained economy and weather will combine with market volatility to increase risk in future.

FINDING 2. Weather, and to a lesser extent climate, has a major impact on supply, demand, and the price of energy.

FINDING 3. Forecasts of meteorological extremes are critical for energy planning.

FINDING 4. Current policies are driving a need for more timely, more precise, more quantitative, longer-term forecasts, along with a better understanding and quantitative measures of the uncertainties involved in the predictions.

FINDING 5. Weather derivatives have emerged as important risk management tools, but users must be alert to their limitations.

FINDING 6. A sound national energy policy must recognize the full range of actions that will involve improvement in the delivery infrastructure and longer lead-time meteorological forecasts.

Two **general recommendations** emerged from the discussions:

RECOMMENDATION 1. The Administration and Congress should provide additional investments for better observations, models, computers, and information systems to improve meteorological forecasts to meet national energy requirements.

RECOMMENDATION 2. The public, private, and university meteorological service and research groups should work closely with the user/energy community through partnership arrangements.

Several of the recommendations that emerged from the Forum were focused on specific issues for Congress, the Executive Branch, meteorological partnerships, academia, the energy industry, and energy/meteorological partnerships.

Focused Recommendations

Congress should:

- Ensure that weather and climate variability is considered in formulation of the National Energy Policy;
- Invest in needed improvement and integration of the national meteorological observational network and forecast models; and
- Work with meteorology sector in all other ways necessary to implement the National Energy Policy and, *inter alia*, make better forecasts available to Congress.

Executive Agencies should:

- Increase the number of people who have meteorology backgrounds in federal agencies that deal with the interface of energy, weather, and climate and can influence National Energy Policy;
- Develop more effective cooperation between DOE and NOAA to produce meteorological products to assist the energy sector;
- Work with Congress to modify regulations that currently create huge problems in meeting the national energy needs; and
- Involve states in developing energy policies including the initiation of demonstration projects that include state agencies, universities, and energy companies.

NOAA, in particular, should:

- Working in partnership with private-sector meteorological service providers, expand efforts to educate the energy sector on NWS and NESDIS products that can improve its use of the data in decision making and risk management by holding workshops, preparing informational web pages, brochures, etc.;

- Focus the next generation satellite systems not just on the sensors, but on better application of data and algorithms that make the information more applicable to energy sector needs;

- Improve observational networks and data availability –global system should be improved and data should be transparent.

The meteorological partnership, which includes the public and private sectors, should:

- Use all available means of communication – meetings, workshops, newsletters, reports, etc. – to ensure data and products are understandable to the end users and the delivery of information is efficient; and

- Work with the energy sector to develop improved products and services to serve their needs.

Universities should:

- Develop research programs that encompass a multidisciplinary approach — involving experts in: energy, meteorology, finance, economics, human behavior, and public policy — to create data sets, as well as models and protocols for more effective collaboration, needed for energy analysis; and

- Foster an environment where graduate students develop multidisciplinary skills and can learn, test, and evaluate methods and means for performing integrated meteorological - energy research.

The energy industry should:

- Take more steps (e.g. hold workshops, convene conferences, seek consultation) to learn about the full scope of meteorological products and services available for application to energy sector needs, and emerging trends in capabilities of these products and services;

- Explore ways to work with the meteorological community to improve application of meteorological information for energy decision making and risk management;

- Promote research consortia in context of major energy/meteorological research areas; and

- Promote start-up businesses (through the Small Business Administration) that would focus on the interface of energy and meteorology.

The energy sector and the meteorological communities, collectively, should:

- Develop tools to better manage risk in the energy sector and jointly analyze meteorological impacts on energy operations;

- Develop user scenarios that could be used with meteorological data for application to the energy sector;

- Advise the government on where federal investments should be made to improve tools for public and private sector energy decision makers; and

- Include energy policymakers in future discussions and work with them to deal with risk management.

These recommendations, although directed, for the most part, at specific portions of the various interested communities can be best implemented through cooperative efforts among those communities. These cooperative efforts, therefore, require effective partnerships to be developed. There was broad agreement that policies that develop from these recommendations should be sufficiently flexible to allow for the roles of the partners to evolve with time. Finally, participants also felt that the energy sector and the meteorological communities should collectively draw on AMS capabilities to:

- Promote continued dialogue between the energy industry and meteorological community through a series of round tables; and

- Build connections with domestic and international energy associations to develop short courses at meetings to inform participants about meteorological information and services that can be used for decision making and risk management.

A POLICY FORUM: WEATHER, CLIMATE, AND ENERGY

I. INTRODUCTION

In the late 1970's, the United States experienced a serious energy shortage. Since then, energy producers and consumers have steadily extended their use of weather and climate information to project estimated energy demands and operate more effectively.

These efforts have accelerated since the mid-1990's, when the deregulation of the electrical power industry began. While deregulation arguably lowers costs by reducing excess generating capacity and making more effective use of regional power grids, it also increases the vulnerability of energy delivery to unexpected weather and climate variability and associated sudden changes in demand. During the same period, successful forecasts of the 1997-1998 El Niño event and its evident effects on energy demand patterns was one of several factors prompting the development of specialized financial instruments for energy risk management. Hot summers in 1998 and 1999 contributed to significant spikes in spot prices for electricity, with important operational and economic consequences across the United States. These events triggered increased public concern.

More recently, for more than a year, continuing through the summer of 2001, California struggled with electrical power shortages while its major utility filed for bankruptcy. The media conjectured that the United States was rocketing towards its worst energy crisis in more than two decades. Most analysts today agree that a primary factor for those shortages was a flawed effort to partially deregulate the California electrical utility system. However, the policies that were implemented had an additional, unintended consequence: they increased the vulnerability of energy delivery to weather and climate variations. During that summer a severe drought gripped the Columbia River basin causing the second worst water shortage in that watershed since records have been kept, dating back to 1929. The resulting reduction in hydroelectric sources contributed significantly to California's energy shortage. Simultaneously, heat waves in California drove demands up sharply leading to enormous increases in "spot market" electricity prices. More accurate daily to seasonal weather and climate predictions could have helped energy producers and users, corporate managers, and political leaders minimize the market volatility and local and regional power disruptions.

Thus new energy policies have combined with previously existing weather and climate uncertainties to confront suppliers and users of energy in the corporate world with new and substantial economic risks. This in turn has fostered new approaches to managing the risks involved in dealing with energy supplies. One such approach is the use of "weather derivatives," a financial instrument for hedging against weather fluctuations, which has matured in the past several years. According to the Weather Risk Management Association, by March 2001, the weather derivative market has reached $7.5 billion in total cumulative principal amount of transactions. This notional value is substantially larger than the actual amount of money that has changed hands as a result of the contracts.

However, while weather derivatives provide some measure of protection for energy providers and users, they themselves place new demands on the accuracy, timeliness, and reliability of weather and climate data and predictions. Moreover, while helping to reduce pricing risk, weather derivatives do very little to improve energy efficiency.

As a result, weather and climate information must become an integral consideration in the continuing development of national energy policies. That information, produced by the public and private sectors, has become a vital national asset, as energy policy becomes even more critical to the state of the economy.

In response to this growing national policy need, the American Meteorological Society, in collaboration with the University of Oklahoma, organized a forum to explore how weather and climate information can be used to effectively match energy supply and demand while reducing costs and increasing reliability. The Forum was co-sponsored by Williams Energy, ENRON, the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), and the Department of Energy's Office of Biological and Environmental Research (BER). The two-day Forum brought together leading representatives from the energy producer, distributor, trader, and user communities; public and private providers of weather and climate information and services; and executive and legislative branch energy policy makers. In a series of panel discussions, the following questions and issues were addressed:

How is the energy sector changing and how can it improve its use of weather and climate information?

What advances are needed in weather and climate sciences and services?

What special requirements do emerging risk management techniques place on weather and climate services?

What public policies are needed to foster development of weather and climate services and their use by the energy sector?

The Forum discussions were focused by the presentations of four panels covering, respectively, the changing nature of the energy industry, advances in weather/climate science and services, risk management, and implications for policy. These panels were composed of public- and private-sector experts in the respective subjects who prepared position papers to guide discussion. The names and affiliations of the experts are available in Appendix A and the position papers of panel members and other experts are available on the Internet at the site — http://www.ametsoc.org/ams/atmospolicy.

Each panel was moderated by a distinguished member of the relevant community, who provided an initial overview and directed the ensuing discussions that took place among the panels and between the panels and the participants. The Forum program is Appendix B and the list of participants is Appendix C.

Although the participants in the forum discussed weather and climate information, forecasts, science and services, this report adopts the term "meteorological" to encompass both weather and climate. Beyond merely making the text simpler, this choice of terminology reflects the concept repeatedly stressed by the energy participants, that their needs do not recognize a boundary between weather and climate. They need the information about the phenomena treated as a continuum and the more general term is used to capture that concept.

Because of time limitations, the Forum discussions were focused on the meteorological considerations impacting the provision of fossil fuel-based energy, principally oil, gas, and coal. The discussions addressed the broader risk management context only in a limited way. For example, the discussions only touched upon the threat posed by space weather to the operation of large-scale electrical power distribution grids. Other sources of energy, e.g., hydroelectric, nuclear, photovoltaic, and wind power were only briefly mentioned.

This report enumerates the Forum's principal findings and recommendations that were formulated in the course of the discussions.

Meaningful actions in response to these recommendations will require cooperative and collaborative efforts by the organizations and individuals involved in the nation's energy sector and the meteorological communities at the federal, regional, state, and local levels and within the public, academic, and private sectors. Especially because some of the required actions are necessarily long-term, they should be undertaken with a sense of urgency to ensure that the nation's energy is produced and distributed as efficiently as possible, while minimizing the potential for disruptions in future years.

II. GENERAL FINDINGS AND RECOMMENDATIONS

At the conclusion of the Forum, a representative group drawn from the moderators, panelists, and participants met to consider crosscutting findings and recommendations that had emerged from the panel discussions. The group consisted of Mary Altalo (SAIC), Mitchell Baer (DOE), Jeff Kimpel and David Rogers (NOAA), Peter Lamb and Dennis O'Brien (University of Oklahoma), Robert White (UCAR), Richard Greenfield, William Hooke, Gary Rasmussen, Genene Fisher, and Mark Fernau (AMS). That discussion initiated the process to develop the general Forum findings and recommendations. A draft report was then circulated to the panelists and moderators for comment.

Following are the general findings and recommendations that emerged from that process:

A. GENERAL FINDINGS

FINDING 1. As demand grows and supply is restricted sporadically, the Nation is in an energy-constrained economy and market volatility, especially in response to weather conditions, will increase risk in future.

In recent years, the nature and extent of energy constraints has been changing rapidly in response to deregulation. Electrical power providers are driving down costs in part by reducing excess generating capacity and increasing reliance on regional power grids. Heating oil producers and natural gas providers are also attempting to reduce costs and inventories. Such change will continue, as the energy industry responds to deregulation, changes in patterns of global supply and demand, and constraints imposed by consumer preferences and environmental considerations. Changes also include a general increase in price volatility and sensitivity to external factors such as weather and climate. The industry is responding in many ways, including the development of new tools to manage risk.

FINDING 2. Weather, and to a lesser extent climate, has a major impact on supply, demand, and the price of energy.

Weather and climate impacts on energy supply, demand, and price are multi-faceted. Weather extremes generally are much more frequent than seasonal extremes. For example, in a given winter, it is not uncommon to have several three-day periods of extremely cold days although the average temperature for that winter could be quite near the long-term seasonal average (climate). As a result, the principal impacts on energy demand arise from short-term weather extremes that force energy suppliers to look to the "spot market" thereby dramatically raising the price. Of course, if there are enough short-term extremes in a season, the seasonal average will reflect that and there will be a "climatic" impact on demand, supply, and price.

FINDING 3. Forecasts of meteorological extremes are critical for energy planning.

Weather is an important determinant of energy supply and demand. Based on extrapolation of the estimates of the Tennessee Valley Authority, the annual national cost of electricity could decrease by as much as $1 billion if the accuracy of daily forecasts of maximum and minimum temperatures could be improved by one degree Fahrenheit. Climate forecasts are important for energy planning on all time scales, i.e., seasonal, interannual, and decadal.

The social and economic impacts of weather and climate, however, are highly nonlinear. Variability below a threshold (whose value depends on the resiliency of the portion of the energy delivery system in question) can be readily handled by existing system operating protocols. Greater variations, however, demand extreme operating measures and trigger price volatility. Forecasting of these extreme events is therefore more important than detailed forecasting of routine variability. Note that the definition of an extreme meteorological event is dependent on the operational or societal impact of the event. In the case of energy, meteorological extreme events of interest to the energy sector not only create increased energy demand and price volatility but can also disrupt energy delivery capability and service to the consumer. In some cases, nature imposes an obviously disruptive event; for example, an ice storm can down power lines. However, in the current deregulated, low energy-margin environment, a simple error of a few degrees in the daily temperature forecast can translate into unanticipated energy demands that trigger alerts in the power grid, spot price volatility, or actual rolling brownouts or blackouts. For that reason, the term "disruptive events" rather than "extreme meteorological events" is more appropriate as the primary focus of forecasts for the energy sector.

FINDING 4. Current policies are driving a need for more timely, more precise, more quantitative, longer-term forecasts, along with a better understanding and quantitative measures of the uncertainties involved in the predictions.

Ironically, from the perspective of the energy industry, meteorological information, particularly on the short-to-medium range, is often much more precise than other information being fed into its decision making. However, current meteorological products are not always understood and applied correctly. Moreover, deregulation, increased competition, and the desire to reduce energy costs have become important drivers in efforts to improve meteorological forecasts with respect to timeliness, accuracy, depiction of uncertainty, and impacts. For example, current weather derivative instruments are confined primarily to address accumulated heating and cooling degree-days over periods of weeks or months. As such, they do not provide hedges with respect to short-term weather events and associated volatility, lasting only for periods of hours to several days. As the full weather and climate sensitivities of the revenues and profits of energy providers and consumers become better understood and are more clearly delineated, demand for new products and associated weather services will grow.

It is therefore vital that users of meteorological information be involved as the forecast products are being developed. Through better cooperation between meteorologists and

energy decision makers, forecast improvements will result in more informed decision-making.

FINDING 5. Weather derivatives have emerged as important risk management tools, but users must be alert to their limitations.

In the past, utility managers blamed meteorological events for economic losses. Given improvements in forecasting and the availability of hedging options, stockholders, industry analysts, customers, and the general public are increasingly reluctant to accept such excuses. With the development of new financial instruments for hedging weather risk as well as advances in forecasting, both energy producers and consumers are increasingly expected to minimize economic losses and disruption due to weather and climate. This is even more important for gas and electric utilities, which have load profiles correlated to historical weather patterns. However, deregulation and corresponding reductions in supply margins have exposed energy companies to greater market risk. In addition, there are serious limitations in the application of weather derivatives as a risk management tool. Some of these are inherent to derivatives themselves:

a) problems with market-liquidity, indexing, etc.,
b) Heating and Cooling Degree Days (HDD/CDD) are only a partial surrogate for day-to-day risks associated with energy supply and demand,
c) price and attach points are difficult to define,
d) uncertainties caused by the underlying climate statistical distributions because of data limitations and climate change,
e) low oil and gas inventories still critically affect regional energy supply.

In the future, the range of weather derivative products will almost certainly grow. Moreover, it is likely that other financial instruments for dealing with weather and climate energy risk – insurance, catastrophe bonds, etc. – will emerge.

FINDING 6. A sound national energy policy must recognize the full range of actions that will involve improvement in the delivery infrastructure and longer lead-time meteorological forecasts.

The growth in the use of derivatives and greater efficiency in addressing financial weather risk has led to some unintended consequences. Petroleum companies became preoccupied with reducing costs in the 1990s and part of this effort was directed at cutting inventories to the minimum in a process known as "just-in-time inventory management." Through better use of computers and pushing their operations further than they thought possible, companies have been able to significantly reduce their working capital costs. The result is a lower level of energy stockpiles than has been the norm in the past. This trend has not eliminated seasonal inventories but simply allowed companies to operate with lower levels of stocks all year. As a result, the discretionary inventory cushion available for dealing with unexpected problems is smaller and the risks of an extreme price swing in the face of extreme weather are greater. Derivatives ultimately only handle financial risk not the physical supply risks.

As a consequence, the nation has an oil market that is more efficient and an energy industry that operates with lower costs. However, the current approach to efficient inventory and risk management also means that extreme weather can quickly lead to a serious supply problem because the system tries to operate with as little reserve as possible. A similar situation exists with respect to the other energy forms. Thus, the nation must have an energy policy that deals with this problem by addressing the energy delivery infrastructure's resilience to extremes, at the same time, ensuring the provision of longer lead-time and more accurate meteorological forecasts in order to improve energy efficiency and reduce price volatility.

B. GENERAL RECOMMENDATIONS

There were two general recommendations that emerged from the consensus discussions. These are:

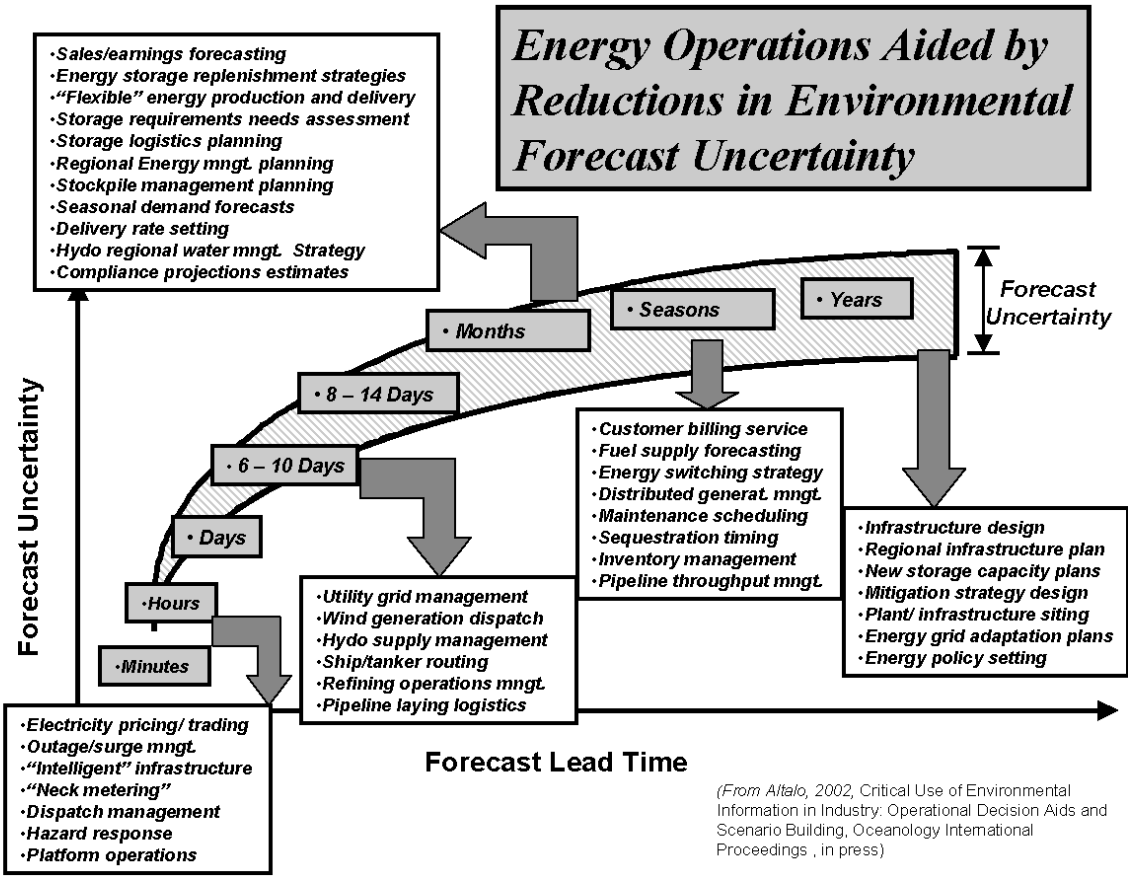
RECOMMENDATION 1. The Administration and Congress should provide additional investments for better observations, models, computers, and information systems to improve meteorological forecasts to meet national energy requirements.

Improvements in basic meteorological infrastructure (including observations, modeling, and communications) will make it possible for both public and private providers of weather and climate information to provide greater economic benefit to their users. These will not be limited to energy providers but will extend downstream throughout the energy based economic sector including the broad base of consumers. In addition, such investments in improved meteorological services will benefit the nation in many more areas than the energy sector, e.g., agriculture, construction, public health, recreation and tourism, retailing, transportation, and water resource management.

RECOMMENDATION 2. The public, private, and university meteorological service and research groups should work closely with the user/energy community through partnership arrangements.

No single element of either the energy community or the meteorological services and sciences community can achieve the desired policy goals acting alone. A common theme throughout the Forum discussions was the need to generate effective partnerships between the energy sector and the meteorological community. These partnerships should be based on a recognition of the importance of meteorological information and products that can be used for a more energy-efficient economy at national, regional, state, and local levels. The partnerships should take advantage of the unique cross-disciplinary approach to problem solving that universities and other research institutions can provide. New and improved

meteorological information and services must be formulated to respond to energy sector needs. When improving services, it is vital that the improvements are designed to serve the energy sector. For the most effective application by energy users, meteorological information must be provided as a continuum over the forecast time periods as opposed to disparate weather and climate products and the uncertainties need to be quantified (see schematic). It was clearly recognized that better science would result in better risk management decisions. In addition, better meteorological information could help congressional appropriators as they develop fiscal responses to seasonal impacts.



(From Altalo, 2002, Critical Use of Environmental Information in Industry: Operational Decision Aids and Scenario Building, Oceanology International Proceedings , in press)

C. FOCUSED RECOMMENDATIONS

Several of the recommendations that emerged from the Forum to address these findings were focused on specific issues for the Executive Branch, Congress, meteorological partnerships, academia, the energy industry, and finally, energy/meteorological partnerships.

Congress

The Senate Committee on Energy and Natural Resources is currently developing a National Energy Policy. They are looking for new, proactive policies and technology-driven approaches to address the U.S. energy problems.

Recommendations

Congress should:

- Ensure that weather and climate variability is considered in formulation of the National Energy Policy;
- Invest in needed improvement and integration of the national meteorological observational network and forecast models; and
- Work with the meteorology sector in all other ways necessary to implement the National Energy Policy and, *inter alia*, make better forecasts available to Congress.

Executive Branch

The Federal Government presently has some limited policy responses regarding the impact of weather on the energy markets. For example, to help individuals deal with high energy bills caused by extreme weather, the Federal Government provides money to low-income families to help pay their heating bills through the Low Income Home Energy Assistance Program (LIHEAP). The government also secures a strategic reserve of heating oil stocks located in the Northeast that holds about 2 million barrels of oil.

President George W. Bush has made energy a high priority. As a result, NOAA and DOE are working with the energy sector to develop products useful to the industry. The Forum, however, recognized that there are barriers that make it difficult for federal agencies to collaborate on related energy and meteorological issues. Another challenge is dealing with

the numerous state-to-state incompatibilities in regulations that inhibit moving gasoline from region to region, with resulting impacts on the refinement of heating oil.

Recommendations

Executive Agencies should:

- Increase the number of people who have meteorology backgrounds in federal agencies that deal with the interface of energy, weather, and climate and can influence National Energy Policy;

- Develop more effective cooperation between DOE and NOAA to produce meteorological products to assist the energy sector;

- Work with Congress to modify regulations that currently create huge problems in meeting the national energy needs;

- Involve states in developing energy policies including the initiation of demonstration projects that include state agencies, universities, and energy companies.

NOAA, in particular, should:

- Working in partnership with private-sector meteorological service providers, expand efforts to educate the energy sector on NWS and NESDIS products that can improve its use of the data in decision making and risk management by holding workshops, preparing informational web pages, brochures, etc.;

- Focus the next generation satellite systems not just on the sensors but on better application of data and algorithms that make the information more applicable to energy sector needs;

- Improve observational networks and data availability –global system should be improved and data should be transparent.

Public and Private Meteorological Partnerships

During the Forum, the energy representatives noted that meteorological products and services must be accurate, timely, and characterize uncertainty in order to be useful to the energy industry. Some participants from the energy sector also acknowledged that they are unaware of much of the meteorological information available and how to use it in their analyses.

Recommendations

The meteorological partnership, which includes the public and private sectors, should:

- Use all available means of communication – meetings, workshops, newsletters, reports, etc. – to ensure data and products are understandable to the end users and the delivery of information is efficient; and

- Work with the energy sector to develop improved products and services to serve their needs.

Universities

The Forum discussed the importance of the research universities building an energy and meteorological partnership. Universities are in a unique position because they have access to data, tools, and graduate students. Moreover, universities are centers for multi-disciplinary research that can be funded by different federal agencies.

Recommendations

Universities should:

- Develop research programs that encompass a multidisciplinary approach — involving experts in: energy, meteorology, finance, economics, human behavior, and public policy — to create data sets, as well as models and protocols for more effective collaboration, needed for energy analysis; and

- Foster an environment where graduate students develop multidisciplinary skills and can learn, test, and evaluate methods and means for performing integrated meteorological - energy research.

Energy Industry

The Forum discussed the meteorological community's role in meeting the energy industry's needs and which meteorological products and services would be most useful for them. The energy representatives strongly endorsed the need for a partnership and continued dialogue with the meteorological community.

Recommendations

The energy industry should:

- Take more steps (e.g. hold workshops, convene conferences, seek consultation) to learn about the full scope of meteorological products and services available for application to energy sector needs, and emerging trends in capabilities of these products and services;

- Explore ways to work with the meteorological community to improve application of meteorological information for energy decision making and risk management;

- Promote research consortia in context of major energy/meteorological research areas; and

- Promote start-up businesses (through the Small Business Administration) that would focus on the interface of energy and meteorology.

Energy/Meteorological Partnerships

A common theme throughout the Forum was the need to generate an effective partnership between the energy sector and the meteorological community. This partnership should recognize the importance of weather and climate in the economy and how meteorological products can be used for a more energy-efficient economy. There was general agreement that the application of the results of meteorological science will result in better energy decisions and risk management. The following recommendations were made for joint activities to achieve that goal, within a partnership approach:

Recommendations

The energy sector and the meteorological communities, collectively, should:

- Develop tools to better manage risk in the energy sector and jointly analyze meteorological impacts on energy operations;

- Develop user scenarios that could be used with meteorological data for application to the energy sector;

- Advise the government on where federal investments should be made to improve tools for public and private sector energy decision makers; and

- Include energy policymakers in future discussions and work with them to deal with risk management.

III. CONCLUSION

The recommendations developed in this forum, although directed, for the most part, at specific portions of the various interested communities, can be best implemented through cooperative efforts among those communities. These cooperative efforts, therefore, require effective partnerships to be developed. There was broad agreement that policies that develop from these recommendations should be sufficiently flexible to allow for the roles of the partners to evolve with time. Finally, participants also felt that the energy sector and the meteorological communities should collectively draw on AMS capabilities to:

- Promote continued dialogues between the energy industry and the meteorological community through a series of round tables and;

- Build connections with domestic and international energy associations to develop short courses at meetings to inform participants about meteorological information and services that can be used for decision making and risk management.

Many aspects of the challenges summarized in this report must be met by the private sector—the energy producers and consumers as well as the value-added meteorological services industry. However, some aspects require government investments and university research. Therefore, only through effective public-private sector energy-meteorological-policy-maker partnerships, will the nation be assured of an efficient, supply of energy. The implementation of the recommendations developed by the Forum, as presented in this report, would result in those partnerships that would benefit the nation greatly.

APPENDIX A — LIST OF PANELISTS AND SPEAKERS

1. Changing Nature of the Energy Industry

Dr. Dennis J. O'Brien (Moderator)
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2. Advances in Weather/Climate Science and Services

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3. Risk Management

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4. Implications for Public Policy

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Overarching Policies

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SPEAKERS

Energy Keynote

Mr. Michael C. Lynch
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Weather/Climate Keynote

Dr. John E. Dutton
Dean, College of Earth & Mineral Sciences
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Media Featured Speaker

Mr. Peter J. Cook
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Forum Luncheon Speaker

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Forum Dinner Speaker

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APPENDIX B — PROGRAM

AMS-OU POLICY FORUM: WEATHER, CLIMATE, AND ENERGY

Washington Court Hotel
525 New Jersey Avenue, N.W.
Washington, D.C. 20001

Tuesday - October 16, 2001

0800 **Continental Breakfast/Registration**

0845 **Opening Remarks/Welcome/Forum Overview**
Robert Serafin, President, AMS; Dennis O'Brien, Director, Institute for Energy Economics, U. of Oklahoma.; Richard Greenfield, Senior Policy Fellow, Atmospheric Policy Program, AMS

0900 **Energy Keynote** – Michael Lynch, V.P., Wharton Econometric Forecasting Associates
Perspective: Overview/macroeconomic and macro energy implications and effects of weather and climate on the economy and energy

0930 **Panel 1: Changing Nature of the Energy Industry–Weather and Climate Information Needs**
Moderator: Dennis O'Brien, Director, Institute for Energy Economics, U. of Oklahoma

Denise Russell, Director, Market Research and D. Montroy, Manager, Weather and Market Research, Williams Energy
Perspective: How weather and climate drive energy fundamentals and prices

Tom Wallin, President, Energy Intelligence Group
Perspective: Impact of weather and climate on the global crude and products market and the refining industry

John Felmy, Director, Policy Analysis & Strategic Planning, Amer. Petroleum Institute
Perspective: Impact of weather and climate on natural gas

Eve Sprunt, Coordinator, Technology Development, Chevron
Perspective: Impact of climate change outlooks/forecasts on business planning in a major energy company

1030 **Break**

1100 **Discussion** - lead speaker – Peter Fusaro, President, Change, Inc.
Focus on recommendations based on the questions:

1. What are the weather and climate science and services that would be most useful for the energy sector?
2. How can the energy sector improve its use of weather and climate information?

1200 **Luncheon** **Executive Room**

Speaker – Michael Roberts, Vice President for Research, ENRON
"Weather Science from an Energy Business Perspective"

1330 **Weather/Climate Keynote** – John Dutton, Dean, College of Earth & Mineral Sciences, PSU
Perspective: New directions in weather and climate services

1400 **Panel 2**: Advances in Weather/Climate Science and Services:
Moderator: Ronald McPherson, Exec. Director, American Meteorological Society

David Rogers, Director of Weather and Air Quality Research, OAR/NOAA
Perspective: Government development of national weather prediction products and services

Thomas Karl, Director, NCDC, NOAA
Perspective: Government development of national climate products and services

Robert Brammer, Chief Technical Officer, TASC, Inc.
Perspective: Present and future capabilities of private providers of weather and climate products and services

Peter Lamb, Director, CIMMS, U. of Oklahoma
Perspective: Role of university research

1500 **Break**

1530 **Discussion** - lead speaker – Ronald McPherson, Executive Director, AMS
Focus on recommendations based on the questions:

1. What are the near-term advances anticipated in weather and climate science and services?
2. How can those advances be applied to the energy sector needs?

1630 **First-day wrap-up**

1730 **Reception** **Atrium Ballroom**
1830 **Dinner**

Speaker –Robert Corell, Senior Fellow, American Meteorological Society and Harvard University - "Impact of Climate Variability and Change on the Energy Sector"

Wednesday - October 17, 2001

0800 **Continental Breakfast/Registration**
0845 **Preliminary Remarks**

Richard Greenfield, Ronald McPherson, Executive Director, AMS

0900 **Featured Speaker**: Peter Cook, Bureau Chief, Energynewslive
"Media Coverage of Weather, Climate, and Energy Issues"

0930 **Panel 3**: Risk Management

Bradford Leach, Director- Electricity and Natural Gas Research, NYMEX
Francis Diebold, WP Carey Prof. of Econ., Finance, & Statistics, U. of Pennsylvania

1030 **Break**

1100 **Discussion**

Focus on recommendations based on the following questions:

1. What special requirements do emerging risk management techniques place on present weather and climate science and services?
2. What new weather and climate science and services would be most useful for managing energy risks?

1200 **Luncheon** **Springwood Room**

1330 **Panel 4**: Implications for Public Policy
Moderator: Jeff Kimpel, Director, NSSL, NOAA

Cal Kilgore, Director, Energy Markets and End Use, EIA/DOE
Perspective: How does the EIA factor weather and climate into their analysis and what improvements are needed?
Klaus Rehaag**,** Director, Monthly Oil Report, International Energy Agency
Perspective: How does the IEA factor weather and climate into their analysis and what improvements are needed?
Scott Gudes, Acting Under Secretary for Oceans & Atmosphere, Dept. of Commerce
Perspective: Policy changes that could facilitate the provision of weather and climate services for the energy sector.
Robert Simon, Majority Staff Director, Senate Comm. On Energy and Natural Resources
Perspective: Policy changes that Congress might make to have weather and climate information more effectively used in energy production and distribution decisions.

1445 **Break**

1515 **Discussion** – Overarching Policies - lead speaker – Robert White, President Emeritus, National Academy of Engineering and Senior Fellow, University Corporation for Atmospheric Research

Focus on recommendations based on the following questions:

1. What public policies are needed to foster development of energy-related weather and climate services?
2. What public policies are needed to facilitate their use by the energy industry?

1615 **Forum Wrap-up** – Robert White - final review of all recommendations

1645 **Work assignments** – Richard Greenfield

APPENDIX C — LIST OF PARTICIPANTS

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