WEATHER, CLIMATE, AND ENERGY

A policy forum developed by the

ATMOSPHERIC POLICY PROGRAM
AMERICAN METEOROLOGICAL SOCIETY

in collaboration with

THE UNIVERSITY OF OKLAHOMA

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Panel 1

Changing Nature of the Energy Industry – Weather and Climate Information Needs

POSITION PAPERS

A Policy Forum: Weather Climate & Energy
Washington, October 16-17 2001

Potential Ways to Increase Value of Weather and Climate Information for the Energy Sector

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Utility of the Current NWS Products

The present suite of products available from the National Weather Service/Climate Prediction Center do cover the full span of time scales that are important for the energy sector and provide good all-purpose products. Between the National Weather Service forecasts updated 2-4 times a day for the next 3-7 days and the official Climate Prediction Center outlooks for the 6-10 day and 8-14 day periods updated once a day, many of the most important weather forecasting time periods are covered. Further, the Climate Prediction Center 30-day and long-lead seasonal outlooks, updated once monthly, provide a necessary look into longer time periods that aids many energy sector businesses in planning appropriately for potential climate patterns that may unfold. What makes these products valuable are (1) their regular issuance on an operational schedule, and (2) the fact that they provide insight into the observed temperature, which is used as an input into algorithms analyzing energy demand.

In addition to providing information important for assessing energy demand, the National Weather Service, through its specialized centers like the National Hurricane Center and the Storm Prediction Center, provides key information on important extreme weather events. Hurricane forecasts are important not only for the protection of life and property, but also for determining whether these storms will reach key drilling platforms in the Gulf of Mexico. Drilling companies rely on these forecasts in order to protect their employees and evacuate them when necessary. Also, the impact of these storms on the supply of natural gas and oil are important factors for consideration in the energy markets. In addition to hurricanes, forecasts of severe weather are important for energy companies who must manage assets such as electric generation/transmission, and gas pipelines. These companies must be prepared to handle the adverse impact of severe weather on their operations in order to fulfill the commitments they have to their customers as well as to protect their employees as well.

However, there are ways that the present suite of products, available from the National Weather Service through its operational offices and specialized centers can be improved so as to be more valuable for the energy (and other) sectors. These are: (1) provide more longer-range forecasts that provide actual weather values instead of probabilities, and (2) incorporate into forecasts more attention toward the chance of extreme events.

Companion to Statistical Probabilities

The Climate Prediction Center's 6-10 day, 8-14 day, and long-lead forecasts utilize a probability scale whereby the outlooks give the percentage chance of above, below, and normal temperatures/precipitation. For these outlooks, above and below normal are determined by the statistical properties of the weather

variable at each station (e.g., above normal temperature for December in Chicago may be 5°F above the average whereas at Miami above normal may be 2°F above the average). This forecast definitely has its merits because it does standardize across all stations and prevents the overlooking of low-anomaly forecasts. Even though an anomaly of 2°F in Florida is a small number, it still may be significant for energy companies in that region. However, there is also a need for a companion product that would provide the best estimate of the actual temperatures both averaged over these time periods and (where appropriate) as they evolve in these periods.

The primary reason for having a companion product that gives actual values is that actual weather values are used by many companies in the energy sector as prime estimators of energy demand. The provision of best estimate forecast values for any location would be a valuable addition to the current suite of products at the National Weather Service. Many of the forecast products in the short term give a range, and then in the 6-10 day range, this switches to a probability category. There are no single value forecasts through the 10 day period. The current coded city forecasts do provide best estimate values for the next 72 hours or so, but there are no estimates beyond that time period. Granted, there are the Medium Range Forecast (MRF) model MOS statistics out to 8 days, and these are used in the energy sector, but it is known that these forecast values contain model biases that have not been corrected for. The ultimate solution would be to have (perhaps produced by each National Weather Service forecast office) a product that gives a forecast value for the next 7-8 days and also a product that gives forecast values for all the cities for the 6-10 day period.

Additionally, the probability forecasts can be more difficult to understand than actual forecast values. While the current Climate Prediction Center products giving probabilities of statistical categories do help determine the broad category of above, near, or below normal, there is no indication on the magnitude of the anomaly. For example, they do not indicate how far above normal a particular region is expected to be in the particular period. The provision of actual forecast values to accompany the probabilistic forecasts would provide a product suite much easier to interpret than the statistical category probability product alone.

Although forecasting actual weather values for the time frames of the Climate Prediction Center products is challenging, providing actual forecast values as companions to the current suite of products would be of interest to many members of the energy industry.

Value of Extreme Events

Many of the current forecast products from the National Weather Service and Climate Prediction Center have been designed with the goal of minimizing forecast error over a time period. This essentially creates a product giving on average a good forecast. Taking this type of approach to forecast development is very useful for getting basic fundamental information. But developing forecasts in order to minimize error can decrease the attention given to extreme weather events, since they do not occur frequently and are therefore not as important when trying to minimize forecast error over a time period.

However, there is substantial value for the energy sector in the extreme weather events that lie outside of the “middle of the distribution”, due to their significant impact on energy fundamentals. The extreme events impact both the potential energy demand and supply more dramatically than less extreme events. On the demand side, higher temperatures in the summer and colder temperatures in the winter each lead to increased energy demand (electricity and natural gas/heating oil, respectively). So as the temperature approaches the real extremes of the distribution in these seasons, the impact on demand increases substantially. It can even be exponential in some cases, particularly in the summer, when the increase in

energy demand between a temperature of 90°F and 95°F is not nearly as great as that between 100°F and 105°F, even though the increase in degree days is linear.
Similar impacts from extreme weather events occur on the energy supply side of the equation. The amount of electricity available can be influenced by precipitation fluctuations due to hydroelectric generation. While typical hydro seasons (e.g., in the Pacific Northwest) are influenced by the amount of precipitation accumulated over several months, how this precipitation is accumulated is important. If a significant number of heavy precipitation events occur, then hydroelectric facilities may not be able to fully utilize all of the water for generation, instead being forced to spill some water through spillways instead of through generators. Also, severe storms can damage electricity transmission lines and impact the flow of electricity through the grid. Another impact on electricity supply comes from unusually hot and humid conditions during the summer. Not only do hot conditions influence demand, but the excessive humidity can influence the efficiency of generation facilities (and therefore the amount of electricity available). This was one factor that played a role in the price spikes that affected the Ohio valley area in July 1999. Finally, the excessively cold conditions in February 1996 significantly reduced natural gas supply in the central and southeastern U.S. because persistent cold temperatures caused the shutting down of drilling equipment.

There are a number of products that the Climate Prediction Center has recently begun issuing that are great steps in the direction of focusing on extreme weather events important to the energy sector. The Degree Day Assessment, a product that has been around for some time now, helps address extreme events since it uses accumulated degree days, which can be better measures of energy demand and are weighted more toward extreme events. However, this product is issued only weekly and is based on the MRF model, therefore including some biases that could be removed by a human forecaster. Other new products are the Drought Assessment (monthly) and the Threats Assessment (weekly), both of which give attention toward forecasting extreme weather events. But again, it would be helpful if these products, as they mature, are issued on a daily basis.

Summary

The current suite of products from the National Weather Service and its specialized centers provide quality, effective, all-purpose products. However, with some additional modifications, they would be of even more value to the energy sector. The key changes that would yield benefits would be (1) adding companion products to the current suite that give best estimate forecast values for the 6-10 day period and the 8-14 day period, and (2) continuing to provide forecasts of extreme events, updated daily, that are expected over all forecast periods. These enhancements would provide easily interpreted and even more useful products that a majority of the energy sector would find of use.

A Policy Forum: Weather Climate & Energy

Washington, October 16-17 2001

Oil & Weather

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My purpose is to provide a brief overview of the inter-play between weather and oil markets as well as make some comments about recent trends in this relationship and likely future developments as I see them. As we all know, the primary interaction between weather and oil markets lies in the seasonality of oil demand that is driven mainly by winter heating requirements. There are also other facets of the relationship but these are secondary to this fundamental seasonal driver. I will look at this seasonal relationship from a broad global perspective as well as from the perspective of individual types of oil, where the market impact is felt.

In contrast to natural gas or electricity, where the impact of weather on demand is felt relatively rapidly, the relationship between weather and oil markets is more complex and attenuated due to the longer supply chains, a much greater degree of processing, and the added complications created by the several layers of inventory within this system. Thus while weather is extremely important in shaping oil markets, supply decisions are generally made only on the basis of "normal" seasonal weather, leaving the downstream system to adjust to actual requirements.

Overview

The overall seasonal pattern of global oil demand is clearly visible by looking at the monthly pattern of worldwide refined product consumption. This shows that there is a swing between winter and summer of about 6 million barrels per day, or roughly 8.5% of average annual demand. This seasonal demand is driven primarily by winter fuel requirements across the developed countries of the Northern Hemisphere. Other seasonal patterns such as the peak in summer gasoline demand in the US and Europe or the winter fuel requirements of the Southern Hemisphere provide only a slight offset. The main fuels that drive this seasonal pattern are heating oil or gas oil in North America and Europe and kerosene in Asia.

Interestingly, despite the clear seasonality of oil consumption, crude oil supply and refinery demand for it as feedstock show much less seasonal fluctuation. Despite the talk in Opec at times about the need to adjust output to seasonal needs, the reality is that refinery demand for crude oil is fairly constant throughout the year. Refiners in general seek to operate their plants as efficiently as possible and do not want to leave capacity idle, especially at sophisticated plants. As a result, they use a combination of the flexibility of their processing systems and oil inventories to anticipate and manage seasonal shifts in demand. In the US, the general pattern is to start building inventories of heating oil in about September by maximizing yields of that product while cutting back on gasoline. Refinery yields are usually tilted back in favor of gasoline in about February.

However, this relative lack of weather impact on demand for crude oil does not mean that crude oil markets are completely insulated from the weather. Actually, weather has a bigger impact on crude oil supply than does demand. For certain fields, such as those in Alaska and the North Sea, production peaks in the winter. In Alaska this is because of the greater efficiency of gas injection and in the North Sea it is because field maintenance is concentrated in a few summer months. In terms of demand, the impact of weather is felt mainly for particular crude oils that enjoy especially wide cuts of the middle distillates that

are needed for making heating fuels. Examples are Nigerian Forcados crude in the Atlantic Basin or Malaysian Tapis Blend in Asia. When demand for winter fuels is strong, refiners seek out these grades and pay premiums for them that reflect their richer yields.

The heating oil markets of the US and Northwest Europe follow similar seasonal patterns and cope with the vagaries of the weather in fairly similar ways. The markets are also intertwined through arbitrage and cargoes will move east or west across the Atlantic according to relative price signals. In a peak week, arbitrage volumes can exceed 1 million barrels per day or more.

In addition to the processing flexibility that refiners in both North America and Europe have to maximize heating oil output, the system also has inventories that are held at refineries and terminals and also by consumers. In Germany, which is the core of European heating oil demand, these consumer tanks can have a big market impact. German homeowners have large tanks, holding three or four times as much as in North America, which means that consumers typically buy once a season. They are extremely price responsive in these purchases, and their collective decisions can have a big impact. For example, this summer there was a lot of early buying by German consumers and we know that demand will thus be relatively slack this autumn and winter.

The European market is also impacted by the availability of Russian exports, which tend to dry up abruptly in late autumn, as supplies are kept at home for winter needs. Other weather impacts in Europe include water levels on the Rhine and other key river transportation systems.

Both the US and European heating oil markets are mature and increasingly secondary in terms of overall middle distillate demand. In terms of fuel quality, heating oil and diesel fuel are nearly identical except that heating oil is allowed to have a higher sulfur content. Most of the attention of refiners has been on meeting the tighter sulfur regulations for diesel and the continuing growth in demand for transport fuels as opposed to the more stagnant markets for heating fuels. As a frame of reference, US heating oil demand averaged just under 1.2 million b/d last year, or 31% of total distillate fuel demand. Diesel, which has been growing steadily over the years with the automotive fleet and miles traveled averaged almost 2.6 million b/d or 69%. Ten years ago the split was about 50-50. The same general pattern holds true in Europe.

Both diesel fuel and jet kerosene can be blended with heating oil to expand supplies and this is also a way that refiners and terminal operators cope with increased demand in periods of severe cold. But this also means that a strong pull on demand for heating oil in the winter also tightens supplies of jet kerosene and diesel fuel, driving up their prices. This occurs in both Europe and the US on a fairly regular basis.

The impact of weather is not all on the demand side. In periods of extreme cold, refinery operations are sometimes disrupted and the market looses extremely important sources of supply. This obviously exacerbates any tightness that the market is feeling from increased, weather-driven demand. These kind of incidents are rare but both the US Gulf Coast and the Mediterranean, which are both important export centers for heating oil and other products, have lost considerable refinery capacity for periods of days and weeks as a result of unexpected hard freezes that have disrupted operations.

In Northeast Asia, the main winter heating fuel is kerosene, which is used in individual heaters rather than furnaces. Seasonality is most pronounced in Japan and Korea, and as with the heating oil markets of the US and Europe, refiners manage these requirements through a combination of inventories and processing flexibility. Consumer stocks are quite small relative to seasonal requirements, but the distribution systems have multiple layers of inventories.

Since jet fuel is virtually the same fuel as the kerosene that is used for home heating in Asia, seasonal demand there has a more direct impact on jet fuel markets than in Europe or the US. Imported kerosene supplies also play a big role, with cargoes coming into Northeast Asia from the refining centers of Singapore and the Persian Gulf.

Weather and seasonality also impact oil markets in a wide variety of other ways beyond heating needs, where the impact is most clearly visible. One example of an important secondary area such as this is in the US gasoline market -- the largest refined products market in the world. While demand does peak in the summer months, this trend is complicated by the seasonal change in fuel qualities. Due to environmental regulations, different qualities of gasoline are sold in the summer and the winter in most urban areas in the US, and refiners must shift their inventories and supply systems in response to these requirements. However, these weather impacts are predictable and only have a significant market impact if other factors beyond the weather also intervene.

Trends and Implications

Going beyond this overview, I would like to make some observations about recent trends in the relationship between oil and weather and also offer a few conclusions.

By the mid-1990s, most participants in oil markets had come to realize that the impact that seasonal shifts in demand had had on prices were declining. Although weather patterns hadn't changed, price trends had. The usual winter price peaks were not as high and summer lows were less pronounced. This change can be explained in part by operational factors such as greater refinery flexibility and more effective inventory management, but I think the main culprit is the rise of derivatives. The growth and importance of futures markets and the advent of swaps provided a very clear picture of the forward price curve and strong signals about the need to hold stocks. It also allowed those that wanted to reduce their risks to pass them on to other market participants that were eager to hold that risk. The end result was a more efficient market that could better absorb the seasonal shifts and better manage the impact of weather on oil.

On the flip side of this growth in the use of derivatives and greater efficiency is a countervailing trend. Oil companies became very 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 stocks 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. But, 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 help handle the risk, but ultimately they only handle the financial risk not the physical supply risks.

So, in conclusion, I would say that we have an oil market that is more efficient and an industry that operates with lower costs, but in a way we are just as exposed to weather as ever. And the kind of weather we are most exposed to are the extremes. The oil industry and supply system can handle normal weather, and that is the kind of weather that these market innovations of the last ten years have helped us cope with effectively. But the current approach to inventory management and markets also means that extreme weather can quickly lead to a serious supply problem because the system tries to operate with as little cushion as possible. Better weather forecasting is one thing that should help, but it will have to be done accurately and on a longer-term basis to have much of an impact given the long lead times of weeks inherent in producing and delivering oil products.

A Policy Forum: Weather Climate & Energy

Washington, October 16-17 2001

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1. What are the weather and climate science and services that would be most useful for the energy sector?

There is already a wealth of weather services, both government and private, available that cover many of the needs of the industry. For example, every trader usually starts the day by looking at weather forecasts. The most useful areas for additional resources are in longer-range forecasts. Many are available, but it is difficult to evaluate their accuracy. It is these longer-range forecasts that are vital to storage, production and investment decisions. For example, it can take several weeks for crude oil produced overseas to reach U.S. refineries. Shipping refined products from refineries to consumers can take an additional two to three weeks depending on location. Natural gas also takes weeks to flow from wellhead to burner tip and storage decisions for natural gas must be made months in advance. Our recent experience with El Nino has revealed the regional variation in fuel mix needs and the difficulty of planning from one season to the next.

In the climate area, the U.S. needs a major investment in modeling especially regional modeling. According to the Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (p. 352) "*It still is not possible to assess regional responses to shifts in climate trends, and it is unknown if a general warming will increase or decrease the frequency and intensity of decadal-scale changes in regions*…" Additionally, the impact of solar variability on climate is one area that more and more is being learned, but the models fail to account adequately for it. If we are to make long-term decisions on energy production, we will need far better data on potential regional impacts of climate change. However, there may be a time-frame disconnect. While the oil and gas industry has to plan for 10, 20 and 30 years in the future to make investments, the climate time-frame is 50 years, 100 years or longer.

2. How can the energy sector improve its use of weather and climate information?

Markets work. Only a fool fails to pay attention to the potential impacts of weather on their energy business. Companies are getting better and better in this area, but they obviously have a ways to go. For example, the companies that forecasted a cold November and December and adjusted their storage of natural gas and oil accordingly did very well. Others that did not anticipate the record cold fared poorly. Further, the understanding of the interdependence of all energy sectors and the impact of weather on the overall energy market can be improved.

Impact of Climate Change Forecasts on Business Planning

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Chevron (Texaco) is a global company providing energy and chemical products and services vital to the growth of the world's economies. Our core values include a commitment to protecting the safety and health of people and the environment. This commitment is a critical component of the value we deliver to our stockholders, customers, government partners and employees.

In addition to contributing to economic growth, the use of fossil fuels to meet the world's energy needs has contributed to an increase in "greenhouse" gases – mainly carbon dioxide and methane – in the earth's atmosphere. Concern is growing that this increase is leading to climate change with adverse effects on the environment. We at Chevron (Texaco) recognize the increasing public and government concerns about global climate change and integrate these concerns into our business decisions. Chevron (Texaco) works proactively with governments and others to create environmentally, technically and economically sound solutions for responsible growth.

We invest in research to: improve understanding of global climate change; to identify mitigation strategies; and to improve the cost effectiveness of mitigation technology. However, given the large amount of research on climate change, at this time we do not anticipate that new climate change forecasts will significantly alter global concern about climate change. Thus, we are focusing on developing and applying cost-effective technologies that reduce the carbon emissions of producing, delivering and consuming our products.

Our goal is to reduce emissions per unit output from operations. We inventory our emissions and use innovative technologies to continually improve the energy efficiency of our existing operations, new projects and products. We are incorporating greenhouse gas emission assessments into our capital project evaluations.

Our research and business units are actively evaluating and investing in advanced energy technologies that have the potential of being commercially viable and beneficial to the environment.