After the Natural Gas Bubble:
An Economic Evaluation of the Recent
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Abstract

This perspective paper reviews and critiques the policy analysis and modeling of future natural gas markets in the National Petroleum Council's 2003 natural gas study (NPC Study). The NPC Study provided an important and timely review of long-term natural gas supply, demand and potential policies to increase supply or suppress demand. However, its long-term scenarios used assumptions and simplifications that led to understating likely longer-term market reactions to higher natural gas prices, which results in exaggeration of the potential benefits of the policies recommended by the NPC. In addition, the narrow scope of the NPC Study did not address many important considerations in natural gas policy, such as the costs of recommended policies, or their impacts on taxpayers, resource owners, or the environment. Overall, the study does not provide the evidence needed to justify major natural gas policies, especially in view of the current uncertain market environment.

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I. INTRODUCTION

From the mid-1980s through the 1990s, natural gas prices in North America were generally low and relatively stable, as the industry maintained a healthy margin of productive capacity over increasing demand while continuing to add to proven reserves each year. More recently, however, the "gas bubble" has apparently ended – the rate of decline of production at existing wells in mature North American supply basins has been increasing, and while the industry continues to add new wells, it has done so at increasing cost. Largely as a result of these developments, natural gas prices have risen and become much more volatile since 2000, despite flat or declining consumption (Figure 1).

While consumption has been flat, the recent boom in construction of gas-fired electric generation should lead to growing natural gas demand in the coming years. Industry analysts now generally agree that to satisfy future North American natural gas demand, it will be necessary to look to significant new sources of supply, such as expanded imports of liquefied natural gas (LNG), additional Lower-48 resources currently on restricted federal lands, and/or construction of an Alaska natural gas pipeline. More efficient use of natural gas, in addition to greater reliance on alternate fuels, reduces natural gas demand and also helps to balance demand and supply.

Experts and market participants now anticipate natural gas prices above $4/MMBtu unless world crude oil prices fall substantially. At such prices, new sources of supply (for example, LNG, or unconventional gas, such as coal bed methane or tight sands) become economic, and many additional demand-side investments also become worthwhile. However, these longer-term responses entail multi-year lead times and require expectations that prices will remain at higher levels for an extended period of time. The strong longer-term price signals are relatively recent;[1] thus, while we can be assured that the market will respond to the price signals, it is too soon to see much of that reaction, or to judge the extent to which the market will continue to respond over the coming years.

Recent high natural gas prices and uncertainty about future market directions have understandably led to a wide range of opinions regarding the need for major government initiatives to encourage expanded gas supply and temper gas demand. Many industry stakeholders, including both producers and consumers, have been advocating immediate, aggressive government action. Other industry observers would support many of the proposed policy measures, but question whether those with potentially significant costs and broad-ranging impacts are warranted in the current, highly uncertain environment; they would allow additional time for the energy markets to respond and longer-term trends to emerge.

In this context, the National Petroleum Council[2] (NPC) undertook a major study (NPC Study) of natural gas supply and demand, resulting in its September, 2003 report, *Balancing Natural Gas Policy – Fueling the Demands of a Growing Economy* (NPC Report).[3] The NPC Study was requested by U.S. Secretary of Energy Spencer Abraham, who, in addition to an examination of natural gas supply and demand through 2025, expressed interest in the NPC's

[1] After the first sharp increase in natural gas prices in 2000, prices returned to the levels of the 1990s during 2001 and 2002 (Figure 1). Since 2002, however, prices have again increased, and expectations of longer-term natural gas prices have now also risen significantly. The U.S. Energy Information Administration (EIA) annual forecasts of 2015 natural gas prices were consistently around $3/MMBtu (in 2002 dollars) until 2003, and are now over $4/MMBtu. Natural gas futures prices for deliveries several years out are well over $4/MMBtu (in nominal dollars) as of May, 2004, but were under $4/MMBtu in late 2002, and close to $4/MMBtu in mid 2003.
[2] The National Petroleum Council is a federally chartered and privately funded advisory committee (Pratt, Becker and McClenahan, 2002). According to its web site (www.npc.org), "the purpose of the NPC is solely to represent the views of the oil and natural gas industries in advising, informing, and making recommendations to the Secretary of Energy with respect to any matter relating to oil and natural gas, or to the oil and gas industries submitted to it or approved by the Secretary."
[3] The NPC Report consists of Volume I- Summary of Findings and Recommendations (Final, September 2003), Volume II- Integrated Report (Final, made available to the public March 2004), and three volumes of Task Group reports (still in draft form as of November 2004, and first made available to the public in June, 2004). These reports

advice on "actions that can be taken by industry and Government to increase the productivity and efficiency of North American natural gas markets and to ensure adequate and reliable supplies of energy for consumers."[4] NPC, which has produced over 200 reports since its formation in 1946, previously performed natural gas studies at the request of the Secretary of Energy in 1999 and 1992.

In light of the recent changes in the natural gas market, the NPC Report was timely, and it has received wide attention. Study participants presented it in numerous forums, and it has frequently been cited as an authoritative source on North American natural gas market conditions and prospects. While the NPC Report's forecasts of natural gas supply and demand are of great interest to industry observers, the primary importance of such a study is its implications for the major policy issues of the day. Accordingly, this paper reviews and critiques the NPC Study with particular attention paid to its policy analysis and recommendations, and the modeling of future natural gas markets under various policy assumptions to support the policy recommendations. Our review, which also compares NPC Study results to those of other modeling efforts, benefited from additional NPC Study details and data provided by NPC at the authors' request.

II. OVERVIEW OF THE NPC STUDY

To pursue the study, the NPC formed a Committee on Natural Gas, a Coordinating Subcommittee, three task groups, and several subgroups; reportedly over 300 individuals were

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are available at www.npc.org. Citations to the NPC Report throughout this paper will note the volume number (for example, p. II-43 refers to page 43 in Volume II, Integrated Report).

[4] Letter from Spencer Abraham, Secretary of Energy, to William A. Wise, then-Chairman, National Petroleum Council, dated March 13, 2000, and included as Appendix A to the NPC Report.

involved. The majority of the participants were from the oil and gas industry, with some representation of other industries, governmental organizations, large consumers, and other interests. The study was pursued over a twelve-month period beginning August 2002.

The study focused on North American natural gas demand and supply – a more comprehensive analysis of energy markets was not attempted. The various subgroups researched the determinants of specific components of natural gas supply and demand, including public policies. North American natural gas demand, supply, and prices to 2025 were simulated using computer models provided by outside contractors.

The study's most significant finding was that traditional North American producing areas will provide much less supply than expected just a few years ago, and will meet only 75 percent of long-term U.S. gas needs.[5] As a result, the NPC Report concluded that new sources of supply will be needed, and energy efficiency and use of alternate fuels are now also essential, both in the near-term and long-term, to balance supply and demand and moderate price levels.[6]

The NPC Study made several noteworthy contributions to our understanding of current and likely future natural gas supply and demand. First, it involved an extensive review of the North American natural gas resource base at a disaggregated level, and updated current thinking about factors influencing the costs of different categories of resources, such as the rate of finding additional supplies with increased drilling. This effort led to the NPC Study's most significant finding regarding the North American resource base. Second, it summarized critical information about the growing international LNG trade and the role such imports can play in meeting North

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[5] Finding 5, p. I-30. At present North American supplies are meeting 97% of U.S. natural gas demand, with the remainder met by LNG.

[6] The NPC Report also made various recommendations regarding transmission and distribution, capital investment, market rules, and other topics. This paper focuses on subjects directly pertaining to natural gas supply, demand, prices and policies addressing broader market conditions.

American demand. Third, it provided a detailed look at current natural gas use in industry and the power sector, including recent experiences with fuel-switching between natural gas and oil within plants with dual-fuel capability, and the prospects for efficiency improvements and greater reliance on other fuels in these sectors. Fourth, it identified numerous actions policy-makers at various levels could take to help the markets increase supply or reduce demand.

The NPC Report's forecasting and policy analysis focus on two primary scenarios that differ only in their public policy assumptions. The first scenario, dubbed the "Reactive Path", is portrayed as neither a worst-case, nor a business-as-usual scenario. It generally assumes the continuance over the next twenty years of many current policies that have contributed to recent high gas prices, such as restrictions on access to potential supplies in the Rockies and offshore Lower-48 states, environmental regulations, and limitations on use of alternate fuels. At the same time, it assumes discovery and development of significant new quantities of gas in the Lower-48 states and Canada, increasing LNG imports, and construction of an Alaskan natural gas pipeline. The second NPC scenario, the "Balanced Future", contrasts sharply with Reactive Path, assuming numerous policy changes to increase supply and reduce demand. Supply-enhancing measures include reducing access restrictions, accelerating the permitting process for LNG terminals, and relaxing and providing greater certainty about environmental regulations. Demand-reducing measures include removing regulatory barriers to fuel flexibility in industrial and power generation applications, enhancing the efficiency of natural gas and electricity end uses, and encouraging more power generation using coal, oil, and renewables.

The NPC's modeling leads to substantial price differences between the Balanced Future and Reactive Path scenarios over the long term (Figure 2). Based on the forecast price differential between the scenarios, the NPC Report concludes that the broad package of policies assumed under the Balanced Future scenario could save $1 trillion in U.S. natural gas costs over the next 20 years.[7]

The potential significance of the NPC Study can be seen through comparison of its scenarios to other long-term natural gas outlooks. Figure 3 compares U.S. natural gas prices and total consumption in 2020 under the two primary NPC Study scenarios, the U.S. Energy Information Administration (EIA) Annual Energy Outlook 2004[8] (AEO 2004), five forecasts noted in the AEO 2004 report, and seven projections reported in a recent Stanford Energy Modeling Forum study.[9] All projections in this figure were prepared by government or consulting organizations to provide their most current assessment of natural gas conditions. Despite using different assumptions and modeling methods, all of these outlooks in Figure 3 show similar consumption levels with 2020 natural gas prices in the $3 to $5 range (in 2002 dollars per MMBtu), with the exception of the NPC Reactive Path scenario, which is over $6. Since the estimated benefits of the proposed NPC policy package rest on the price difference between the Balanced Future and Reactive Path scenarios, it is important to examine the causes of these prices and price differences, which is the main topic of the remainder of this paper.

Several reviewers of this paper suggested that as a study sponsored and conducted by an oil and gas industry-based group, the NPC Study might have a bias for finding large benefits to policies favored by the industry. While the NPC working groups were composed primarily of staff from oil and gas companies, they also included representatives from energy-using sectors

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[7] NPC Report Finding 11, page I-50. The $1 trillion figure is apparently roughly based on the price difference between the Reactive Path and Balanced Future scenarios (which averages $1.52/MMBtu over the 20-year horizon; see Figure 2), applied to total U.S. gas consumption (an average of 26 Tcf/year over the 20-year horizon). NPC did not provide a specific calculation.
[8] U.S. Energy Information Administration (2004a).
[9] Energy Modeling Forum (2003). The EMF low-supply scenarios are shown in Figure 3 as they are the most comparable to the NPC scenarios.

such as electricity and industry, as well as government. However, for a study evaluating future market conditions, it would have been invaluable to allow a greater role for a wider group of interests and for more independent experts knowledgeable about economics and market processes and experienced in modeling such processes.

III. CRITIQUE OF THE REACTIVE PATH SCENARIO

While the NPC Study resulted in valuable updates to supply and demand data, our review finds that its long-term forecasting involves assumptions and parameters that prevent or understate the likely long-term responses of natural gas producers and consumers to higher natural gas prices. With such assumptions, the NPC model shows natural gas prices rising to and remaining at very high levels, without sufficient supply or demand response to moderate them, for decades into the future (under the Reactive Path scenario) – unless the recommended government policies are implemented (the Balanced Future scenario). Significantly understating market response exaggerates the potential impact of the recommended policies on gas prices, leading to inflated estimates of the benefits of the policies. For some components of supply or demand, values were set exogenously, and were therefore totally insensitive to prices; in other instances, "behavioral parameters" were used, but apparently reflected only short-term responses, or very muted long-term responses, to prices; and in other instances, it was assumed that policies restricted responses to prices, and that such policies would not be relaxed even in the face of very high prices over a period of decades. The overall result of these assumptions was to allow prices to remain very high for an extended period of time under the Reactive Path scenario.

A. "Reactive Path" Assumptions That Mute Long-term Responses to Prices

To accurately forecast future natural gas supply, demand and price under changing conditions, a model must characterize how supply and demand would respond to significant changes in the prices of natural gas and competing fuels. Consumers, and especially the industrial and power generation sectors have some ability to shift away from higher-priced fuels, especially if price expectations suggest that such adaptations may provide long-term savings. If firms do not substitute lower priced fuels for natural gas, they must try to pass along higher energy costs to their customers who are buying electricity, steel, chemicals or other final products or services. If these customers are unwilling to absorb the higher energy costs, in some cases they may purchase the product overseas or begin reducing their demand for the final product, which will also reduce the demand for natural gas. In the short term, firms will try to replace natural gas in any equipment that can also use another fuel, or substitute between plants that use a different fuel, such as dispatching a power plant that uses coal for more hours than a power plant that uses natural gas. Over time, firms can replace their old equipment, which provides them with an opportunity to not only choose a different fuel but also to reduce the energy intensity of the purchased equipment. On the supply side as well, a much broader array of alternatives becomes available with time and sufficient price incentive. The technology for international shipments of natural gas (LNG) has existed for a long time, but proposals for importing substantial quantities of LNG to the United States were put forth only when long-term price expectations rose to profitable levels.

Our examination of the NPC results suggests that such responses were allowed to operate only to a very limited extent in the Reactive Path case. As one example of muted price responses in the NPC Study, resources in major supply basins, including mature, declining ones as well as expanding ones, were assumed to be developed at rates that varied very little depending upon prices. This is evident from a comparison of the Reactive Path to a sensitivity case in which all supply assumptions were the same, but prices differed because of alternate assumptions about the strength of demand (a Low Economic Growth scenario). Prices differ by an average of over $.50/MMBtu during 2011-2020 between these scenarios, so we should expect available resources to be produced somewhat sooner under the higher price case. However, the production of resources under the higher price case by 2020 was accelerated by only 14 days in the West South Central[10] region, and by only 23 days in the Mountain[11] region (these two regions provide over 40% of Lower-48 production).[12] By contrast, in several natural gas forecasting models participating in a study by the Stanford Energy Modeling Forum,[13] such price changes led to acceleration of production in these regions ranging from 50 to a few hundred days.

LNG quantities, and the size and timing of the Alaska and Mackenzie Delta pipelines, were set exogenously (outside of the model). LNG represents a source of supply that can be delivered to North America in potentially large quantities at $2 to $4/MMBtu (NPC Report, p. II-192), and prices substantially and persistently above this level, as in the Reactive Path scenario, should stimulate accelerated development of additional LNG receipt capacity. A recent summary (U.S. Federal Energy Regulatory Commission, 2004) identified a total of about 45 Bcf/day of existing, proposed and planned LNG receipt terminal capacity for North America; while not all of these plans will go forward (for a variety of reasons, including government and "NIMBY"

[10] Includes Arkansas, Louisiana, Oklahoma and Texas.
[11] Includes Arizona, New Mexico, Nevada, Utah, Colorado, Wyoming, Montana, and Idaho.
[12] The acceleration expressed in days for a supply region is calculated as follows. The total cumulative production from the present to 2020 is calculated for each scenario. The difference in cumulative production up to 2020 between the scenarios is the acceleration, and it is expressed in days by dividing it by the average daily production in 2020.
[13] The Stanford Energy Modeling Forum, its recent natural gas study, and the participating models are described in detail in a later section of this paper.

constraints on siting new facilities), the assumption that only 12.5 Bcf/day will be in place after 20 years of prices at the Reactive Path levels seems highly questionable. By setting LNG quantities exogenously, the NPC's model did not have the capability to add economic LNG capacity, even with a substantial delay. As a result, the adopted LNG assumptions seem implausible under the price outcomes of the scenario (considering the high prices, larger quantities available sooner should have been assumed). In a recent summary of forecasts of LNG imports, the NPC Reactive Path was at the low end of the range, despite its much higher anticipated prices (Martin, 2004: slide 12).

For prices to remain high under the Reactive Path, the demand side must also exhibit little response. The modeling of the electric power sector also reflects various assumptions that result in truncating the potential response to high gas prices. Electric demand was assumed to grow in relation to GDP growth, and independent of higher natural gas prices and their subsequent impact on electric costs. The assumptions also result in significant ongoing additions of gas-fired generating capacity despite the high gas prices. Under the Reactive Path scenario, gas prices rise to $6 and beyond while coal prices decline and oil prices remain flat, resulting in the other fuels having a substantial cost advantage over natural gas. Yet Reactive Path assumptions restricting use of other types of capacity result in gas-fired capacity additions at a fairly steady rate over 2011-2025, averaging over 9,000 MW/year, with lower quantities of coal capacity added. No new coal capacity is added until 2011, an assumption that appears likely to prove incorrect, as a recent summary (U.S. Department of Energy, 2004) identifies approximately 40,000 MW of potential coal additions for 2004-2010, and another 20,000 MW for which an in-service date has not been determined. The total quantity and mix of generating capacity additions were nonresponsive to natural gas prices – the same quantity mix was added in each year across NPC cases with very different natural gas prices.[14] Using a fixed generating-capacity mix greatly limits the potential long-term response of the power sector to different levels of long-term gas prices under different scenarios.

In addition to electric demand and the generating capacity mix being unresponsive to prices, the Reactive Path further assumed that fuel-switching at dual-fuel plants was restricted, and remained restricted through 2025 despite the high gas prices.

The inflexibility of gas use for power generation in the NPC's modeling is exhibited by NPC sensitivity scenarios where supply-side changes lead to gas price differences, but these have very little impact on gas use. For example, comparing scenarios where average gas prices differ by 9% over 2011-2025, gas use for power generation differs by only 1%. Recent market behavior suggests the market is more price-responsive than this. In 2002, the prices of natural gas and oil for use in the power sector were close – gas cost 107% of oil, on average (U.S. Energy Information Administration, 2004b: Tables 4.10B and 4.11B). In 2003, both prices rose, but natural gas rose much more, and the ratio of gas to oil cost increased to 123% (coal prices were lower, and nearly unchanged). From 2002 to 2003, power sector natural gas use declined 0.74 Tcf, with oil and coal use increasing 0.24 and 0.54 Tcf, respectively (U.S. Energy Information Administration, 2004c: Table 2.6).

[14] The NPC Report states that nuclear, coal, and other types of capacity competed with natural gas for capacity additions. However, the identical mix and total quantity of capacity each year is included in the Reactive Path scenario, and also in the two most extreme scenarios in terms of natural gas prices – the Low Resource and High Resources cases, under which natural gas prices averaged $8.55 and $4.44, respectively, over the twenty year period. Apparently the various constraints imposed on coal and other types of capacity were binding under all price scenarios.

Total industrial natural gas demand also is relatively insensitive to changes in price in the NPC modeling, due to various assumptions that limit fuel and equipment choices and prevent industrial production levels from responding to the high gas prices.

Because natural gas in the years before 2000 was generally economical and plentiful, policies have favored its use, and there is limited ability for industry to switch to oil at the present time, as the NPC Report correctly describes. Natural gas prices have never exceeded oil prices on a $/MMBtu basis for more than brief periods. As shown in Figure 4, natural gas and oil have maintained a fairly consistent price relationship during 1999 to 2002, except during winter natural gas price spikes. However, the Reactive Path scenario has natural gas prices rising above and averaging 175% of crude oil prices, and 139% of #2 fuel oil prices, over the period 2006 - 2025. Various Reactive Path assumptions ensure that industry continues to use natural gas and does not switch to oil or other fuels to any appreciable degree over the coming decades, despite the enormous economic incentive to do so under that scenario's prices. These assumptions include restrictions on fuel, equipment, and location choices by industrial consumers, and also an assumed persistent refusal by public policy-makers to relax restrictions on use of alternate fuels, despite high gas prices.

Industrial production (output) was exogenous and therefore independent of natural gas prices in the NPC modeling. As with other exogenous assumptions, those affecting industrial production apparently were not prepared based on the rising Reactive Path natural gas prices, and are therefore inconsistent with those prices. However, the chemical industry and other gas-intensive industries have strenuously argued that they will be forced to reduce production if high natural gas prices persist.

As one specific example, ammonia production, which is highly natural gas-intensive, declines in the Reactive Path scenario to 203 Bcf/year, but then remains constant from 2017 through 2025. The "floor" on ammonia production apparently reflects the exogenous assumption that ammonia production capacity outside of the West South Central and South Atlantic regions will continue producing regardless of natural gas prices; a "maximum import share" is also mentioned (NPC Report Volume III: p. 3-18). These constraints seem questionable: under the Reactive Path scenario, U.S. ammonia producers' costs would be $200-$250/tonne, while ammonia can be imported from various countries for an estimated $100 to $150/tonne (Potash Corporation, 2004: p. 50, 57).

For most industrial sectors, the potential impact of higher prices on gas demand was modeled using "intensity elasticities" (reflecting how well industry can adjust its production to reduce energy use per unit of output in response to gas prices). Figure 3-24 on page II-51 of the NPC Report shows how the intensity elasticities were used, and result in virtually the same relationship between gas use and gas prices in 2025 as in 2003. The reaction modeled is essentially a short-term response to short-term prices, and does not depend upon whether a price change persists for one year or a decade or more. This approach gives inadequate consideration to the longer-term decisions (capital investments, fuel switching equipment, plant location) that would be expected in response to longer-term price movements and expectations.

B. Supply/Demand Response to Prices – Comparison to Other Modeling Efforts

Comparisons of NPC results to those of other natural gas modeling efforts corroborate the above observation that the NPC Study's modeling assumptions result in understating long-term supply and demand responses to prices.

The extent to which supply or demand responds to prices in a model can be explored through sensitivity analysis. Sensitivity cases that involve only changes to demand-side assumptions reveal how supply changes in response to the price impact of stronger (or weaker) demand. Similarly, sensitivity cases that involve only changes to supply-side assumptions reveal how demand responds to prices. Sensitivity analyses were available for the NPC Reactive Path scenario, for EIA's AEO 2004, and for participating models of the Stanford Energy Modeling Forum (EMF)[15], allowing comparison of the long-term responses to price changes. Data was not available to evaluate the demand and supply responses of the other models shown in Figure 3 above. The fact that they showed substantially lower prices than the NPC Reactive Path for similar consumption levels, however, suggests that markets respond more strongly to prices in the long run in these models than in the NPC modeling. In this respect, their responses are probably more similar to those of the EIA and EMF models than the NPC's model.

Figure 5 compares the demand response under the NPC modeling to the demand response of AEO 2004 and the models participating in the EMF study. Low supply cases were compared to reference cases, to determine the impact of the resulting higher prices on consumption in 2020. The demand responses are shown per penny of gas price impact, to account for the fact that prices changed by different amounts in the different models. Because these sensitivity cases result in price changes over an extended period of time, the 2020 quantities reflect consumers' long-run adaptations to prices – that is, the responses that occur when energy-using firms have

[15] The goals and approach of Stanford's Energy Modeling Forum and a fuller explanation of the various models are discussed in their report (Energy Modeling Forum, 2003). The seven participating organizations (with models in parentheses) are: U.S. Energy Information Administration (National Energy Modeling System or NEMS); U.S. Department of Energy and Onlocation, Inc. (Policy Office Electricity Modeling System or POEMS), U.S. Environmental Protection Agency and ICF Consulting (NANGAS and IPM); California Energy Commission (North American Regional Gas or NARG); Charles River Associates (Model for US and International Natural Gas Simulations or MUSINGS); U.S. Department of Energy and Brookhaven National Laboratory (U.S. MARKAL); and Canadian Energy Research Institute (Energy 2020). The NPC Study used a model that has been widely applied for natural gas forecasting; its proprietors, however, chose not to participate in EMF 20.

time to change their plants and equipment in response to the prices, in order to use natural gas more efficiently or switch to alternate fuels. Figure 5 shows that the other models generally expect larger reactions in the residential and commercial sectors than does the NPC Reactive Path; these responses, however, are small compared to those in the industrial and electric power sectors. The largest difference between the models is in gas use for electric generation, where the other models show three to ten times more response than the NPC Reactive Path. Consistent with higher price-responsiveness of demand, the other models also have gas and oil prices remaining fairly close on a dollar per MMBtu basis, while the Reactive Path has gas prices more than double oil prices.

Similarly, Figure 6 compares the responsiveness of various categories of supply to price in the various models, determined by comparing a high demand case to a reference case. There are substantial differences between the various models in the quantities of additional supply attracted by a long-term price increase attributable to strong demand.[16] However, the total supply response, and the response of Lower-48 onshore production, are much larger in all of these models than under the Reactive Path scenario, when compared on the basis of the additional quantity per unit of price change.

Figure 6 shows that two of the other models show no significant response of the LNG quantity to the price impact of high demand; this is because prices remain well under $4/MMBtu (in 2002 dollars) in these models, and LNG was exogenous and/or uneconomical. Since prices under the Reactive Path scenario are much higher than in any of the other models (Figure 2),

[16] For the model labeled EMF#2 in Figure 6, the results reflect the impact of an Alaskan gas pipeline becoming available in the sensitivity case, resulting in only a very small price difference to the reference case. In the model labeled EMF#5, on- and off-shore supplies were not distinguished.

some additional categories of supply that are not economical in the other models should be economical under the Reactive Path.

Which view – stronger or weaker long-term responsiveness to prices – is more likely to prove accurate? Figures 5 and 6 summarize the impacts of numerous assumptions about how various components of supply and demand respond to price changes in each model, and experts will disagree about how such assumptions should be set. However, the NPC modeling approach reflected various characteristics that cause it to understate market reactions, such as values that are exogenous or severely constrained, as described above. Consequently, it is apparent that it is not so much a different view regarding certain parameters, but simplifications and shortcomings in the modeling approach, that led to the muted price response in the Reactive Path scenario.

IV. Critique of the "Balanced Future" Scenario

In contrast to the Reactive Path assumptions, the "Balanced Future" scenario assumes that market participants will expand supply, reduce demand, and switch to alternate fuels, and policy-makers will implement and maintain various policies supportive of these adaptations. Market participants and policy-makers are assumed to persist in these actions and policies over an extended period of time, despite a relative lack of incentive to do so in light of the relatively low natural gas prices (compared to the Reactive Path) that result from the scenario.

Recall that the Reactive Path and Balanced Future scenarios differ only in the assumed government policies and their direct impacts -- all other assumptions are the same. The numerous Balanced Future policies increase the quantities of various sources of supply and decrease the quantities of various segments of demand. However, supply and demand are also influenced by natural gas prices, which differ sharply between the two scenarios. Consequently, in principle, the differences in supply and demand quantities in the Balanced Future scenario compared to the Reactive Path scenario should reflect both the direct impacts of the Balanced Future policies and the impact of the resulting lower natural gas prices -- two forces that push in opposite directions. However, details were generally not available to allow distinguishing these two impacts.

A number of Balanced Future assumptions seem questionable compared to the corresponding Reactive Path assumptions. In some instances the assumed impacts of the recommended policies on supply or demand appear to have been quite optimistic, and/or would likely require very costly policies to achieve, especially in light of the significant price differences between the two scenarios.

As one example, LNG was assumed to provide 12.5 Bcf/d of supply in 2025 under the Reactive Path case, and a greater quantity -- 15 Bcf/d -- under the lower-priced, Balanced Future scenario (p. I-36). However, the only difference in policy assumptions between the two scenarios with regard to LNG is a one-year difference in the time required to obtain permits (p. I-37), reducing the total estimated time to obtain permits and construct a terminal from five to four years. It seems implausible to assume that a one-year reduction in the lead time to bring an LNG terminal online will more than overcome the significantly lower price incentive under the Balanced Future assumptions, especially considering the large number of receipt terminals already in the planning stage. The sponsors of LNG projects (and other stakeholders, including government agencies) would be expected to have a stronger incentive to persevere and overcome the various obstacles to LNG under the higher Reactive Path prices, even with an additional year of lead time. Apparently, the forecasts of LNG for the two scenarios were prepared considering only the policy difference (reduction in permitting time), and without consideration of the price differential and market incentive. This same shortcoming likely exists in the assumptions about policy impacts on various other demand and supply segments, although in most cases the specific policies assumed in the Balanced Path scenario and their specific impacts were not identified as explicitly as they were for LNG.

The power sector provides additional examples of Balanced Future assumptions that appear to not reflect the substantial price differences between the scenarios. Electric demand is assumed to grow at a slower rate under the Balanced Future scenario because of assumed impacts of energy efficiency programs in the power sector, leading to 53 TWh lower demand in 2025 than under the Reactive Path scenario. The assumption that electric demand depends only on GDP growth and is not affected by natural gas prices may seem unimportant; however, a rough estimate of the impact the gas price difference between the scenarios would be expected to have on electric demand is three times the assumed difference between the two scenarios due to energy efficiency.[17]

Under the Reactive Path assumptions, 73 GW of new renewable capacity is constructed over the horizon of the study, while more than twice as much (155 GW) becomes available under the Balanced Future scenario (p. I-26). A larger quantity of renewables would be expected under a scenario with higher gas prices, as the high prices raise electric prices, increasing the profitability of renewables, and, perhaps most important, they also make gas-fired capacity less competitive. The Balanced Future policies, to accomplish the assumed higher level of

[17] The impact of the higher natural gas prices on electric demand would be roughly 150 TWh. This estimate is based on the impact of the average gas price difference between the two cases over 2011-2025 on the average retail cost of electricity, and the impact of this on electricity demand, using a long-run own-price elasticity of electric demand = -1. The elasticity value is from Dahl (1993).

renewables, must not only attract the additional quantity of renewable energy, but also overcome the impact of the significantly lower gas prices under the Balanced Future scenario. The specific Balanced Future policies with regard to renewables are not identified and their costs are not estimated. However, the required subsidy to achieve such a large shift in the supply of renewables would likely have to be significant at the relatively moderate Balanced Future gas prices.

Additional examples of policies that trump markets concern industrial natural gas demand, which in most sectors is roughly the same under the two scenarios, despite the large gas price difference. The NPC Report suggests that various policies will encourage increased energy efficiency and greater use of alternate fuels. Four times as much oil is used in industrial boilers under the Balanced Future scenario as under the Reactive Path scenario. Oil is much cheaper than natural gas under the Reactive Path scenario, as described earlier, but oil and gas prices are much more competitive under the Balanced Future scenario. The price elasticities of energy intensity in industry are assumed double under the Balanced Future scenario compared to the Reactive Path scenario, but the specific energy efficiency measures assumed to accomplish this are not identified.

As described above, U.S. ammonia production declines under the Reactive Path scenario, but only to a "floor" of 203 Bcf/year, due to exogenous constraints. The same floor was imposed on the Balanced Future scenario. As a result, ammonia production is exactly the same under the two scenarios at the end of the horizon, despite the large and persistent price difference for natural gas, which represents over 80% of the cost of ammonia production. To the NPC task group participants that imposed them, the constraints on ammonia production may have seemed unimportant (because ammonia production is only a small percentage of total gas demand) and reasonable (because large differences in gas prices between the scenarios were not anticipated when the constraints were agreed). However, while the 203 Bcf/year floor might be a reasonable assumption under one of the scenarios, the implication that there would be no difference in ammonia production between the scenarios despite the huge natural gas price difference clearly understates price response between the scenarios, contributing to the exaggerated price difference between the scenarios.

Other assumptions and results also reflect this pattern – the policy differences across the two scenarios are assumed to create large shifts in demand and supply conditions, while the substantial price difference between the scenarios apparently was not considered, or was assumed to have little or no impact on supply and demand. The result is that market responses are understated, and the potential impacts of policy overstated.

V. CRITIQUE OF THE SCOPE AND STRUCTURE OF THE NPC STUDY'S POLICY ANALYSIS

The NPC Study modeled the impact of government policies on natural gas demand, supply and prices, and estimated the potential consumer savings that would result from natural gas price reductions resulting from a recommended package of policies. The NPC Study's policy analysis was limited by the focus on a single policy package and scenario. Since the various candidate policy actions all have roughly the same general impact (increasing supply or decreasing demand), they are all largely substitutes, and there will be diminishing marginal returns as a larger set of policies is considered. For example, if a large amount of LNG receipt capacity is constructed, the need for and value of other major new sources of supply would likely be substantially reduced. It is quite possible that the majority of the price-moderating impact anticipated from the entire policy package can be obtained through a small subset of the recommended policies. Consequently, policy-makers will need candidate policies evaluated individually and in various groupings.

The NPC Report did provide some sensitivity analyses that were interpreted as policy evaluations; for instance, Finding 6 on page I-33 states, "Increased access to U.S. resources (excluding designated wilderness areas and national parks) could save $300 billion in natural gas costs over the next 20 years." This finding was based on a sensitivity analysis to the Reactive Path scenario, that essentially assumed none of the other recommended Balanced Future policies would be implemented. The forecast savings due to increased access would be lower if it were recognized that other policies are likely to be implemented.

In addition, policy-makers must consider that, given the substantial uncertainty at the present time about the future natural gas market, policy options that entail significant costs must be considered especially risky. The potential benefits of acting now must be balanced against the considerable value of delaying such decisions, to discern how supply and demand will react to the recent shifts in the markets without major government initiatives, and whether expectations of longer-term natural gas prices will decline from the present levels. The NPC Study's policy analysis approach does not address this dimension of policy choice.

In addition to natural gas price impacts, policy-makers will also need to consider the impacts of policies on producer revenues and profits, the environment, and other sectors of the economy. Sound policy will also have to consider the direct costs of the policies to consumers or taxpayers, such as subsidies to reduce the risks of major supply projects, or to stimulate renewable energy or energy efficiency that would otherwise not occur. The vulnerability of supplies to major disruptions is another significant consideration; for example, decisions regarding the rate of development of North American resources, reliance on supplies from distant sources delivered through pipelines, and development of LNG have significant impacts on supply security in the near term and over the longer term. Because of the NPC Study's limited scope in this regard, it does not provide a full analysis of the costs and benefits of recommended policies. Consequently, it should not be understood as providing a well-grounded basis for determining whether any particular policies are in the public interest and, therefore, should be implemented.

It cannot be assumed that if anticipated consumer savings are large, they would likely dwarf the cost and other impacts of the recommended measures. For instance, a recent EIA analysis found that, while accelerating the start of the Alaska pipeline would save consumers $9.9 billion in present value over 2002-2025, over the same period lower-48 producers would lose $23.4 billion in revenue (U.S. Energy Information Administration, 2003: Table 12, page 47). This reflects the fact that when government policies push and pull on demand and supply to lower prices, the resulting natural gas consumer savings may be obtained largely through wealth transfers from energy producers, taxpayers, and/or consumers in other sectors of the economy, without necessarily providing net benefits to society as a whole.

We make these observations about the limited scope of the NPC Study's policy evaluations to emphasize that additional analysis would be required before it could be concluded that significant resources should be devoted to implementing the NPC recommendations. We are not suggesting that NPC should have performed more extensive policy analysis – indeed, even the limited policy analysis NPC did perform was beyond the scope of the Secretary of Energy's request, which asked for recommendations, but not evaluations or quantification of benefits.

Furthermore, we feel that for policy evaluations, the Secretary of Energy should rely on institutions that are more independent of the industry, such as EIA.

VI. CONCLUSIONS

The NPC Report was important and timely. Its wide dissemination brought attention to the view that recent circumstances in the natural gas markets may reflect changing longer-term fundamentals in the natural gas market, and not merely short-term market imbalances. It identified many of the changing market conditions in some detail, as well as potential modifications to government policies, including both major actions and minor adaptations, that could help moderate natural gas prices by increasing supply or reducing demand.

However, our review leads to the conclusion that the NPC scenarios greatly understate the likely longer-term response of markets to higher prices, with or without new government initiatives. This problem is especially acute under the Reactive Path scenario, which has natural gas prices persisting over an extended period of time at levels that until recently were seen only during brief price spikes. High prices should open up a new realm of supply-side and demand-side options that were not previously economic; but the NPC results inadequately reflect this. The muted market reactions to prices lead to an exaggeration of the potential impact of government policies to influence supply, demand and prices, and drive the NPC Study's overall conclusion that policy-makers can generate enormous consumer savings if they act immediately to implement a long list of recommended policies.

The NPC Report's estimates of consumer savings (the $1 trillion and $300 billion numbers mentioned in earlier sections) are greatly overstated; in addition, they are also not estimates of the full costs and benefits to society from the proposed policy interventions. Specifically, they do not reflect the full range of impacts on producers, the environment, and on inter-related sectors of the economy. The calculations also do not reflect the fact that the various policies are largely substitutable, and a small subset of them would likely provide the vast majority of the potential benefit – for instance, if an Alaskan gas pipeline is built, the value of expanded access to federal restricted lands, LNG imports, or the need for greater energy efficiency would be much less. The calculations simplistically assume that the many recommended policies are a single package and a single, one-time decision. To the contrary, many policy-makers at the federal, state, and local levels can and will decide to implement various elements of the package, at some time over the coming years, according to their independent estimates of the value of the various policies to their specific constituencies. Consequently, NPC's large dollar figures, in addition to being based on questionable analysis, are conditioned on unrealistic, oversimplified policy questions, and provide only one element of the impacts that policy-makers must consider.

We are also concerned that the audiences reached by the NPC Report (and the many presentations of it) may have received an overly confident impression of the likely robustness of the NPC's forecasts and policy recommendations. The 2003 NPC Report acknowledges there is uncertainty surrounding its results, and some sensitivity runs on the two principal policy cases were conducted. However, the report does not discuss how this uncertainty may influence its recommendations or the major policy decisions of the day. Views of the future – and corresponding policy recommendations -- can and do change quickly, as the energy sectors have repeatedly demonstrated over the past few decades. Forecasts that seem reasonable at one point in time can quickly prove otherwise, and the policies that were warranted under those forecasts may no longer be appropriate.

For instance, the NPC Report's Finding #1 states, "There has been a fundamental shift in the natural gas supply/demand balance that has resulted in higher prices and volatility in recent years…" (p. I-17) To be clear, however, the fundamental shift in the NPC outlook has been in supply, not in demand. In the NPC's 1999 natural gas report (National Petroleum Council, 1999), Supply Finding #1 stated, "Sufficient resources exist to meet growing demand well into the twenty-first century." (p. 36) In the 2003 NPC Report, the resource base assessment for Lower-48 and Canada has been reduced 20% (p. II-111), and the conclusion is now that these resources will meet only 75% of a lower level of future demand. The NPC forecast of U.S. gas consumption for the 2005 to 2015 period has been reduced over 15% compared to the 1999 report (from 29 Tcf/year to 24 Tcf/year; p. II-101), while prices are expected to be 40% to 70% higher than anticipated in the 1999 report.[18]

Consistent with its forecast at the time, NPC's 1999 report promoted policies to encourage use of natural gas. It stated that long-term gas demand growth "translates into opportunities for the industry and the government," and noted that increased gas demand provides benefits for government in the form of greater revenues from royalties, rentals, and bonuses from leasing and development of federal resources. (p. 29) The 1999 report also recommended a process for "reviewing any proposed regulations to ensure that the benefits of increasing natural gas use are considered in the regulatory process." (p. 30) The 1999 report noted that fuel-switching was becoming more difficult (p. 50), but did not identify this as a

[18] The 1999 report forecast prices in the $2.80 to $3.80 range in 2002 dollars (p. 22 Figure 13), while the 2003 NPC Report now forecasts prices averaging either $4.45 (Balanced Future) or $5.53 (Reactive Path) over the 2005-2015 period.

serious problem to be addressed. The 2003 NPC Report, in light of its much more pessimistic supply assessment, now recommends policies that reduce demand much more than they increase supply.[19]

The point to be made here is not to criticize the accuracy of NPC's past efforts at forecasting and identifying needed policies – many other efforts likely performed no better and some even worse – but to emphasize how quickly and substantially forecasts and recommendations can change. In light of the considerable uncertainty at the present time about future gas market directions, it would be understandable if policy-makers question whether the case has been made for policies recommended in the NPC Report that have potentially significant cost or other impacts.

[19] Page II-309, Figure 9-4. The horizontal shift in the demand curve between the Reactive Path and Balanced Future scenarios suggested in this figure is almost 50% greater than the horizontal shift in the supply curve.

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Figure 1: U.S. Natural Gas Demand and Prices

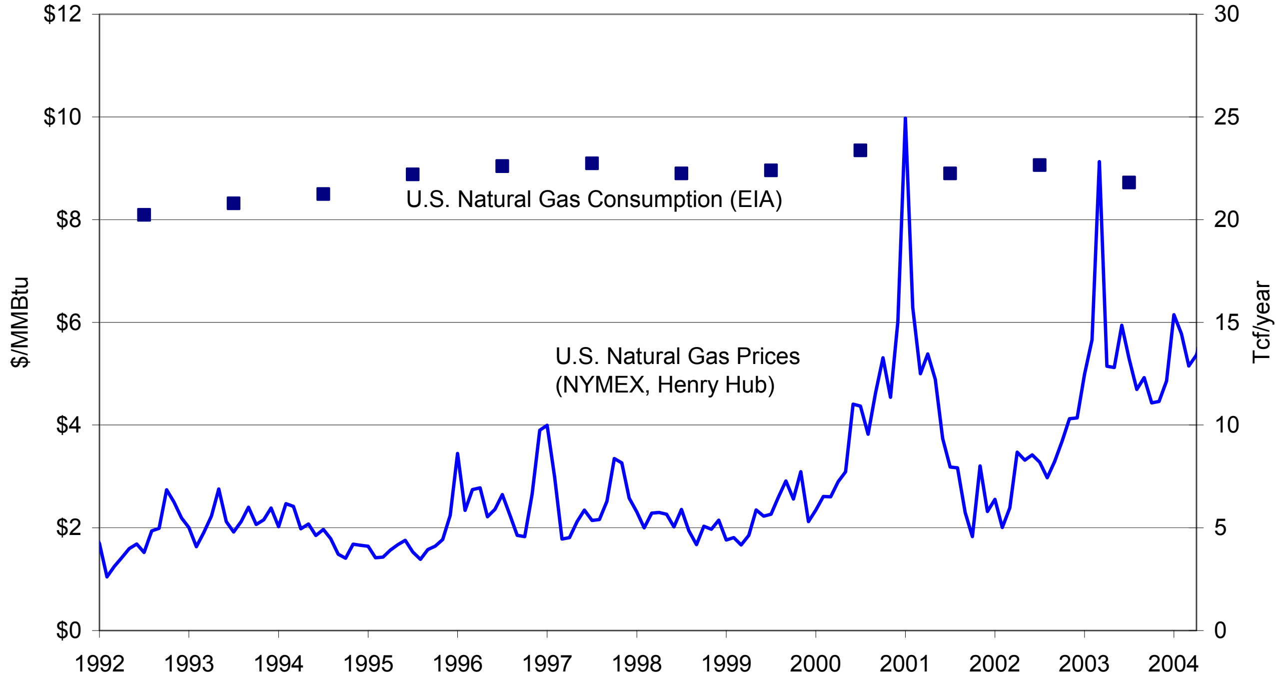

Figure 2: "Reactive Path" and "Balanced Future" Scenarios

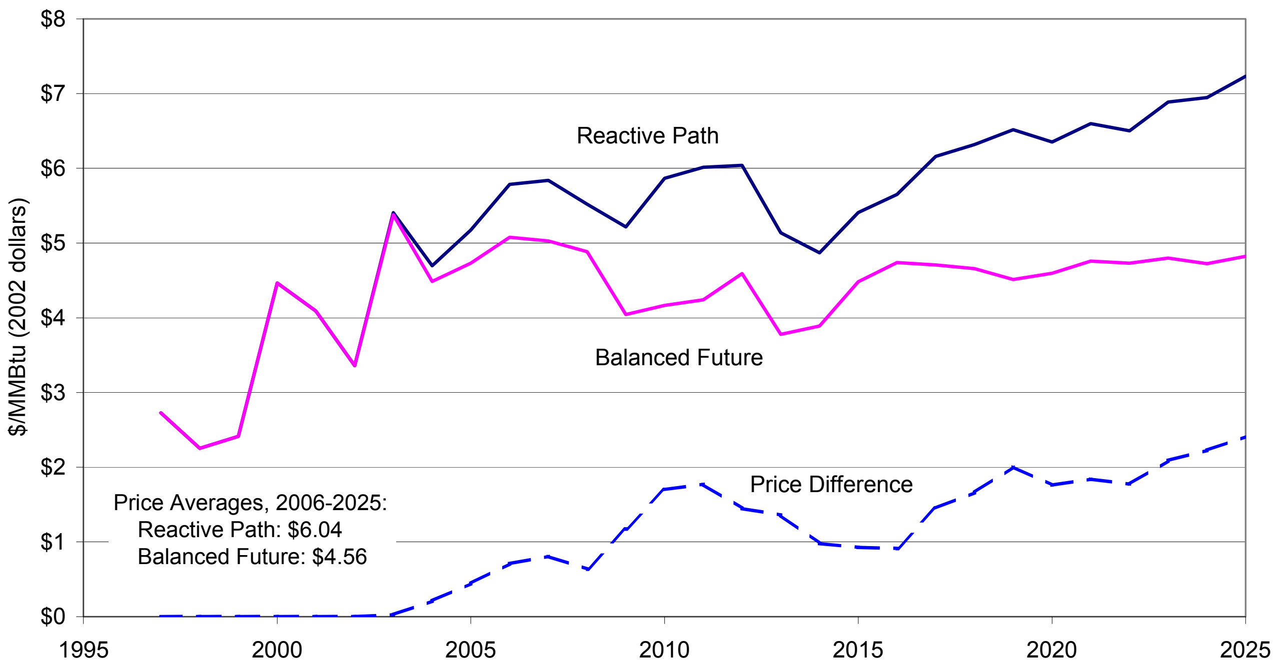

Figure 3: Comparison of Natural Gas Outlooks, 2020

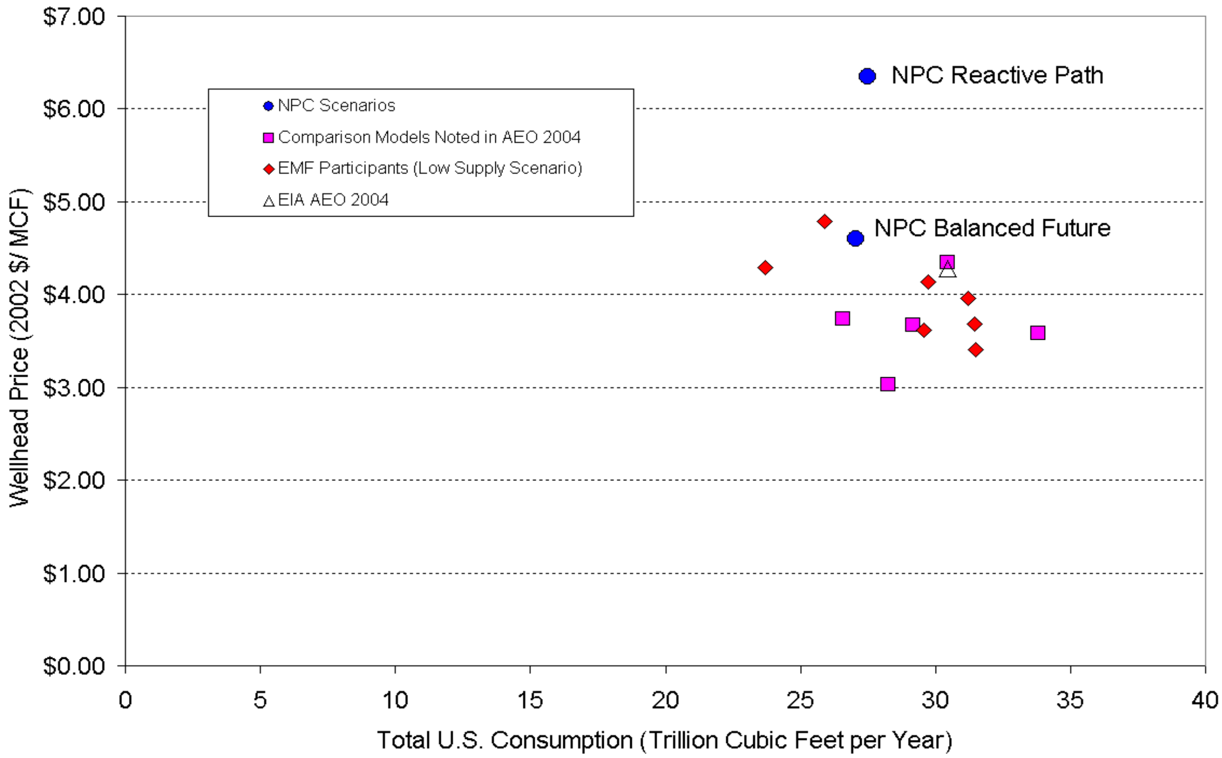

Figure 4: Natural Gas and Crude Oil Prices

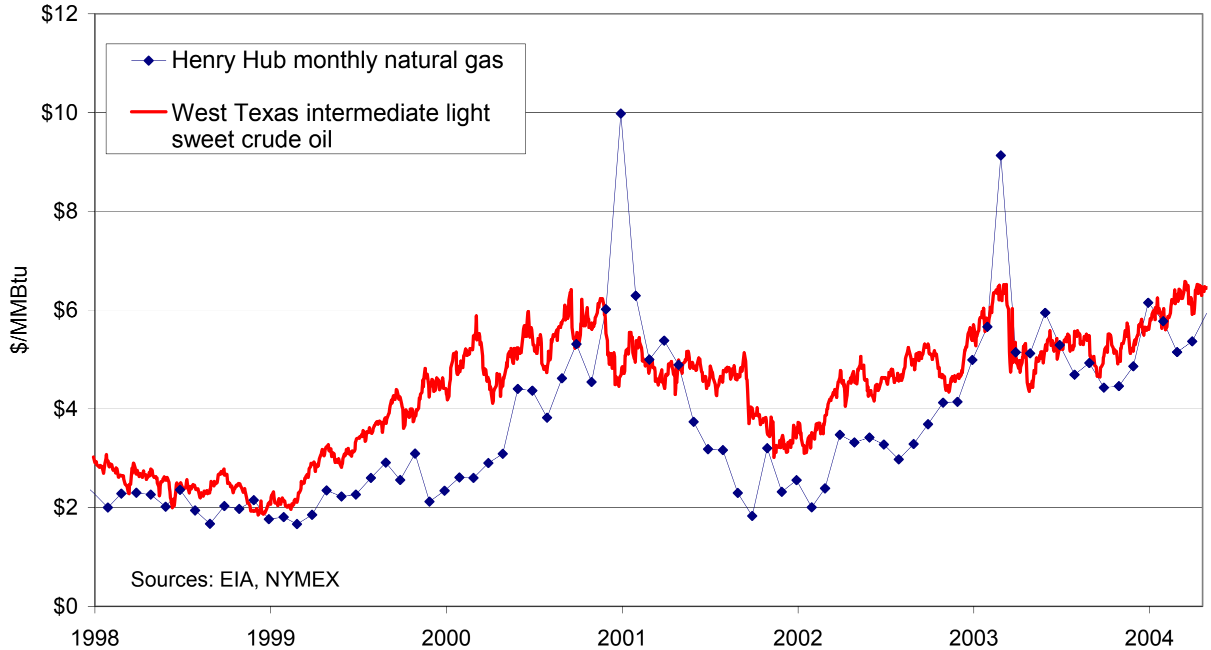

Figure 5: Demand Response to Higher Prices, 2020

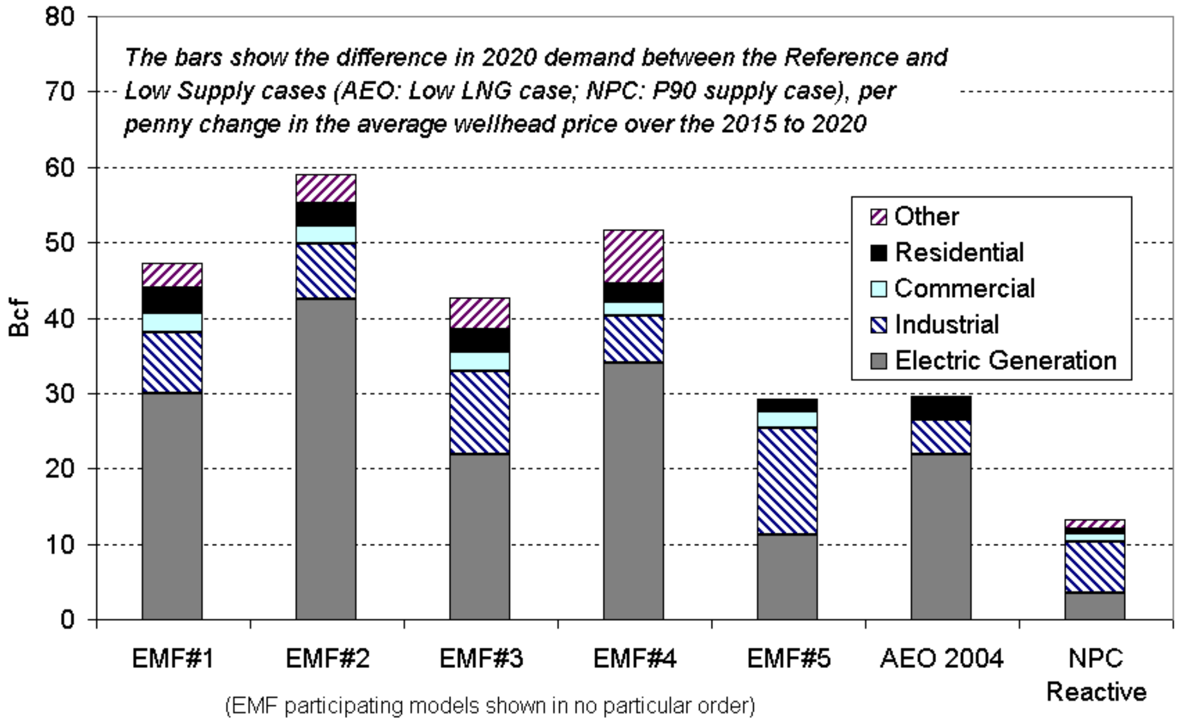

Figure 6: Supply Response to Higher Prices, 2020