Is A Natural Gas Strategic Reserve for the US Necessary? A System Dynamics Approach

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Abstract

The large volume of shut-in natural gas production in the US Gulf of Mexico following the 2005 hurricane season led some US policymakers to consider whether creating a Natural Gas Strategic Reserve (NGSR) might be beneficial. This paper uses a system dynamics-based approach to analyze whether a NGSR is needed, and what having one would mean for the US natural gas infrastructure. Analysis shows that the infrastructure is likely resilient in the face of a more stringent test than the 2005 hurricane season provided. Moreover, as the infrastructure is essentially a closed system, any replenishment of the NGSR would compete for gas with other users, and depending on the rate of replenishment could cause a disruption as large as that it was created to prevent.

Keywords: natural gas, strategic reserve

Problem Statement

The goal of this paper is to examine whether establishing a Natural Gas Strategic Reserve (NGSR) for the US would be justified. We divide this problem into two issues: 1) how resilient is the current system, and 2) how would having an NGSR impact the system as a whole.

We define resiliency as the ability to supply gas to customers willing to pay the clearing price, even in the face of supply constraints. If gas were unavailable to an area at any price, we would say that the system is not resilient.

Moreover, we do not attempt to measure the ability of a NGSR to reduce natural gas spot price increases after a production shut-in, and calculate an economic benefit to gas consumers due to the existence of the reserve. We believe the primary concern of the US government, which would presumably finance the creation of an NGSR, should be that gas be available to paying customers in the aftermath of a disaster – not whether customers pay more after a disaster than they would like.

We will first present an introduction to the US natural gas system, proceed to examine the model created to assist in evaluating system resiliency and the effect of an NGSR on the system, and finally discuss the pros and cons of an NGSR.

Introduction

Natural gas has become a key energy source for the US. About 24% of all energy consumed in the US is from natural gas. 17% of electrical power in the US is generated by natural gas, and natural gas supplies 30% of US industrial energy consumption (EIA 2005).

Natural gas also happens to be the cleanest of all fossil fuels, producing the least amount of greenhouse gases and combustion byproducts of all fossil fuels. Environmental considerations and stricter air pollution laws are not the only reason for the attractiveness of natural gas. It is projected that most new power plants to be built in the coming decade will be gas turbine plants, as these have the lowest capital cost and highest energy efficiency of all fossil fuel plants.

Natural gas is unique among fossil fuels in another way: as a gas, it cannot be easily transported in the way that solids or liquids can. It must be transported either by pipelines, or cooled down to -162C (where it becomes a liquid, called Liquid Natural Gas – or LNG) and transported in special thermally insulated vessels.

Below we will discuss the key elements of the US natural gas system: production, consumption, storage, transmission, and imports. We will also discuss the overall impacts of the 2005 hurricane season on the system.

Production

Production throughout the year in North America is fairly constant. The rate at which new wells come online and old wells become depleted is roughly the same. Wells are not adjusted for output throughout the year based on demand – they are designed to operate at maximum efficiency at all times.

In 2003, 24 Tcf was withdrawn from US wells (with 17.8 Tcf from gas wells, and 6.2 Tcf from oil wells). Of this, 19 Tcf of dry gas remained to be sent to customers (EIA 2005). 44% of this amount was produced in the Southwest and 15% in the Central region, with the Southeast, West, Northeast, and Midwest producing 3%, 2%, 2%, and 1%, respectively. Alaska produced 15% of the total, while Federal Offshore areas (mainly in the Gulf of Mexico) produced 19%.

Consumption

In stark contrast with the constant rate of gas production, gas demand is highly seasonal. Residential and commercial demand peak in winter, and are at a low point during the summer. Power generation from natural gas has a peak in the summer. And industrial consumption is fairly constant throughout the year.

The net effect is that gas demand is much higher than production during the winter, and much lower than production during the summer (with a slight summer uptick due to power generation demand). With production constant and demand seasonal, the role of storage capacity is to bridge that gap.

Storage

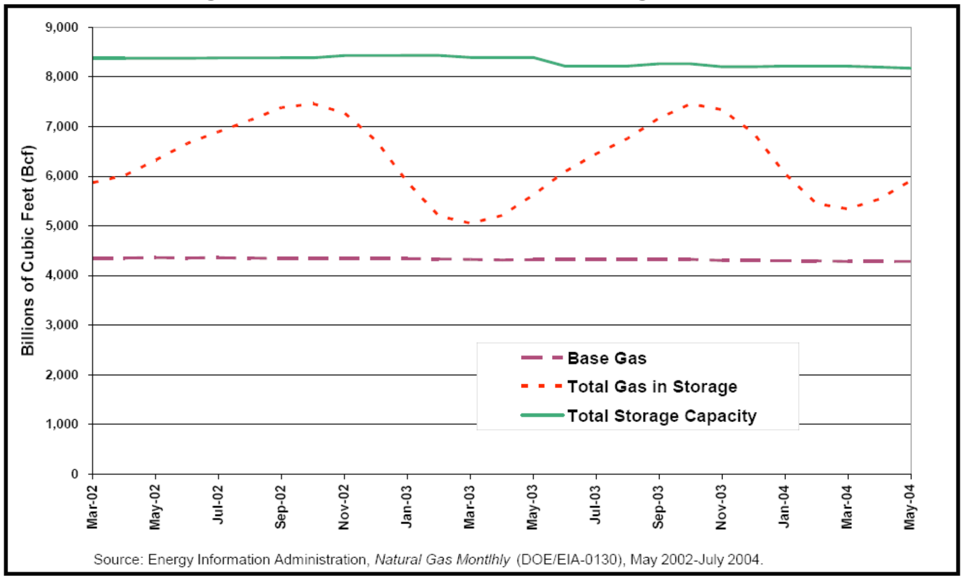
As of May 2004, there was roughly 8 Tcf of gas storage capacity in the US, with about 4 Tcf needed to always remain in storage as base gas. Base gas is needed in order to provide enough pressure for gas to be withdrawn on demand. Therefore, total working storage capacity is about 4 Tcf. This is equal to approximately 17% of annual consumption.

Most gas storage is in depleted gas or oil fields, with the second largest storage capacity being in aquifers, and the smallest in salt caverns. Depleted gas or oil fields are the cheapest to commission, as they take advantage of existing wells, internal distribution systems, and pipeline connections. They are also widely available. Aquifers are suitable for gas storage if the water-bearing sedimentary rock is overlaid with impermeable cap rock. The use of aquifers requires more base gas than does depleted gas or oil fields. Last, salt caverns provide high withdrawal and injection rates, and have low base gas requirements. The commissioning of cavern storage is more expensive than depleted field conversions, but this type of storage allows several withdrawal-injection cycles per year (EIA 2004).

Gas storage is heavily clustered in the consuming Northeast / Midwest, with most of the depleted field storage in Pennsylvania, West Virginia, Ohio, and Wisconsin, and most of the aquifer storage in Illinois and Indiana. Storage is also clustered in the producing Southwest, where there is mainly depleted field storage, but also a growing amount of salt cavern storage (primarily in coastal areas).

Typically, gas storage reaches its peak volume in about October, and gas is drawn down throughout the heating season. About March, gas stocks reach their low point, after which the buildup for winter begins. Last, many salt formation and other high-deliverability sites have been developed by independent storage service providers, who cater to customers that require quick response times, such as electricity generators and gas marketers. The seasonal role that storage plays can be clearly seen in the graph below.

Figure 1: Total Natural Gas in Storage in the US



Source: EIA, Natural Gas Monthly, May 2002 – July 2004

New storage facilities are continuously being constructed. As of May 2006, FERC lists 130 Bcf of new storage projects that are on the horizon (projects where a permit has not yet been requested of FERC) (FERC 2006).

Transmission

The largest capacity pipeline route is from Gulf Coast production (onshore Louisiana and Texas, as well as offshore Gulf of Mexico) to the Midwest and Northeast.

The Western part of the country uses much less gas than does the East. It is served, however, by multiple sources – namely, by pipelines from the Southwest (connecting into Southern California), pipelines from Canada, and pipelines from the Rocky Mountain gas fields.

Pipelines from gas-producing western Canada connect to the Northwestern, Central, Midwestern, and Northeastern parts of the US. A small amount of gas is exported to Mexico.

The current US interstate natural gas pipeline consists of over 200,000 miles of transmission lines with an estimated daily delivery capacity of about 119 Bcf (billion cubic feet) (Tobin 2001). The average daily consumption rate in 2000 was half this amount. This results in a capacity utilization factor of roughly 50%.

International Connections / Imports

Pipelines from gas-producing western Canada connect to the Northwest with a capacity of about 4.6 Bcf/day (billion cubic feet per day), to the Central part of the US with a capacity of 4.2 Bcf/day, to the US Midwest with 4.3 Bcf/day capacity, and into New

England with about 3.5 Bcf/day capacity (Tobin, 2005). The US Southwest has 15 interconnections with Mexico, with an aggregate export capacity of 3.6 Bcf/day (Gaul and Alic 2005).

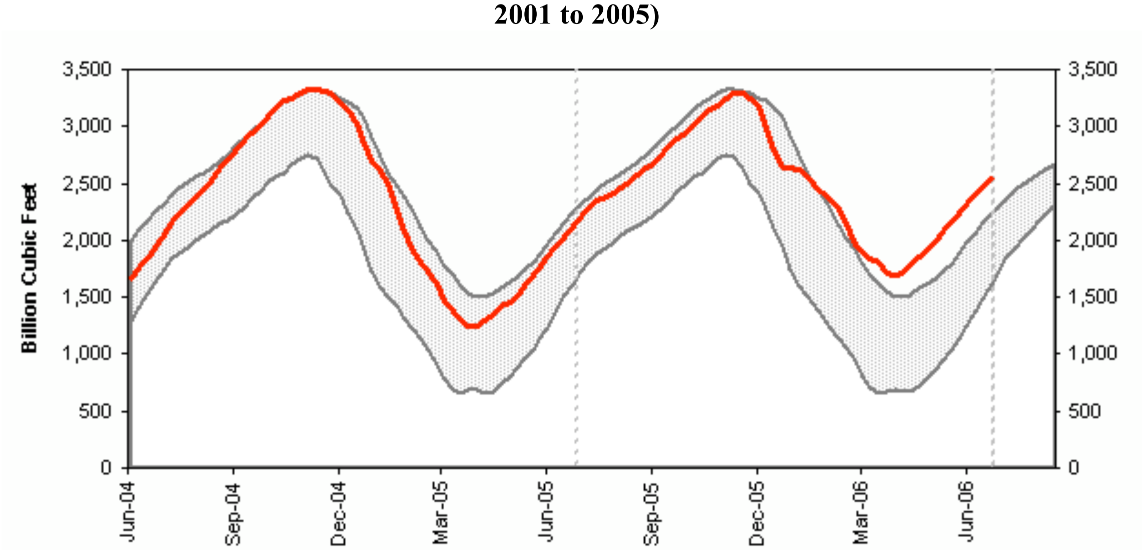
In 2004, net imports to the US were 3.4 Tcf, which is a 4.3% increase over the previous year, but below the 2001 volume of 3.6 Tcf. Net imports from Canada in 2004 were 3.2 Tcf. That same year, the US exported 0.4 Tcf to Mexico. Net LNG imports were about 0.6 Tcf (Gaul and Alic 2005).

Given both the small size of the current and potential volume of imports at existing LNG facilities, we can consider North America essentially a closed system.
Impact of the 2005 Hurricane Season

Hurricanes Katrina and Rita caused about 800 Bcf of natural gas to be shut in (as of June 19, 2006), which is about 22% of annual Gulf production, or almost 4% of annual US natural gas consumption. Natural gas prices skyrocketed to over $15.00 per million Btu (MMBtu) in the aftermath of the hurricanes, and residential consumers paid record prices for natural gas heating in the winter. However, the market was successful in allocating the reduced production among consumers, and no shortages developed.

The hurricane season was followed by a warmer than average winter. High gas prices combined with a mild winter resulted in below-normal consumption, which in turn resulted in the level of working gas in underground storage in the summer of 2006 exceeding the range of working gas in storage over the past five years, as shown in Figure 4.6 below.

Figure 2: Working Gas in Underground Storage (red line) Compared with 5-Year Range (grey area – showing minimum and maximum storage volumes at the same time of year for 2001 to 2005)



Source: EIA, at http://tonto.eia.doe.gov/oog/info/ngs/ngs.html

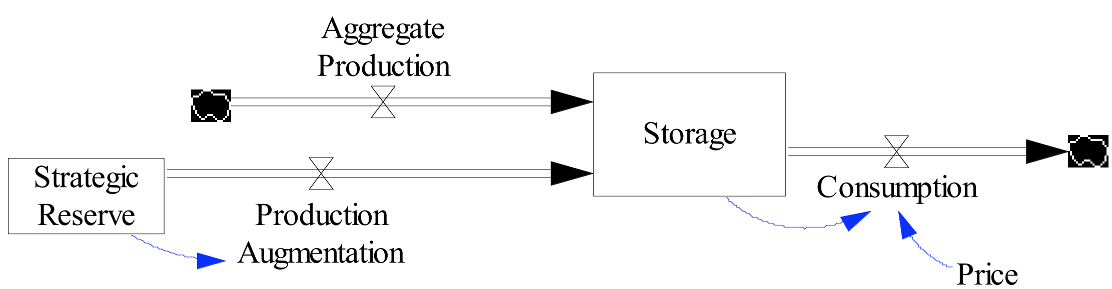
However, perhaps we should plan for a more severe test of nature than the 2005 hurricane season followed by a mild winter brought. If we could determine whether the system could continue to function in the face of, say, a couple of 2005 hurricane seasons back-to-back, with a couple of harsh winters following them, then we would be more confident in judging whether a strategic reserve would be needed or not. It is with this test in mind that a model was created, which will be described below.

Model and Scenario Description

In order to better understand the dynamics involved and the effect a strategic natural gas reserve would have on the system, an aggregate model of natural gas storage, supply, and demand was created. The model is used to examine the effects a series of natural disasters would have on the natural gas infrastructure and the benefits of a strategic natural gas reserve. The natural gas system is modeled at an aggregate national level and neglects regional effects, such as natural gas transfers between regions.

The model is an aggregate model of the natural gas system at the national level. As shown in Figure 4.7, production from all regions feeds into a single storage area from which national sector aggregated demand is removed. The model was balanced with data by sector (residential, commercial, industrial, and power generation) from the Energy Information Administration. The data used is a four (2001 to 2004) or five year average (2000 to 2004), depending on availability. Data from 2005 onward is not used due to the influence of hurricanes Katrina and Rita.

Figure 3: Model Overview



For the purposes of testing a strategic storage reserve, the model assumes that the reserve contains 750 Bcf of natural gas, is opened one month after the natural disaster and stays open for five months. During this time period, the reserve is used at a rate that matches the current amount of daily production being lost due to the disaster. The storage reserve is not refilled during the course of the model run.

The pricing mechanism assumes that price adjusts as a factor of demand, production, and storage volumes. Price is used to adjust demand to keep the system in balance. A price increase causes a decrease in demand and a price decrease causes demand to increase. The elasticities of demand used are 0.1 for the commercial and residential sectors (Gresham 2002), 0.15 for the power generation sector, and 0.2 for the industrial sector.

The algorithm compares current demand and storage volumes with historic values for those numbers and current production with maximum production capacity and adjusts price to bring the system back into equilibrium. For example, if current volumes in storage are lower than what they have historically been for the current time of year, a reduction in demand is necessary to keep the system in balance, so the price increases. If volumes are higher than historic values, then a demand increase is necessary to keep the system in balance, and the price decreases.

Production and storage are weighted as having a larger effect on the price than demand, with price adjusting in proportion to the ratio between current and maximum production and storage and as the square root of the ratio of current and historic demand. Price is adjusted with a 30 day delay to represent the time it takes to observe the information and make changes to the price.

Baseline Model Run

The baseline run of the model has no disruptions and does not include the effects of price on consumer behavior. As shown in Figure 4.8, the storage levels for the nominal run of the model exhibit similar dynamics to the EIA 5 year storage range shown in Figure 5.1. Also shown in Figure 4.8 is the baseline run of the model with the pricing mechanism turned on. Storage levels are the same for both model runs, as are the consumption levels shown in Figure 4.9. The baseline run of the model with the effects of price on consumer behavior active is considered the 'nominal' run of the model, since it illustrates the dynamics seen in the actual system.

Figure 4: Storage levels for nominal model runs

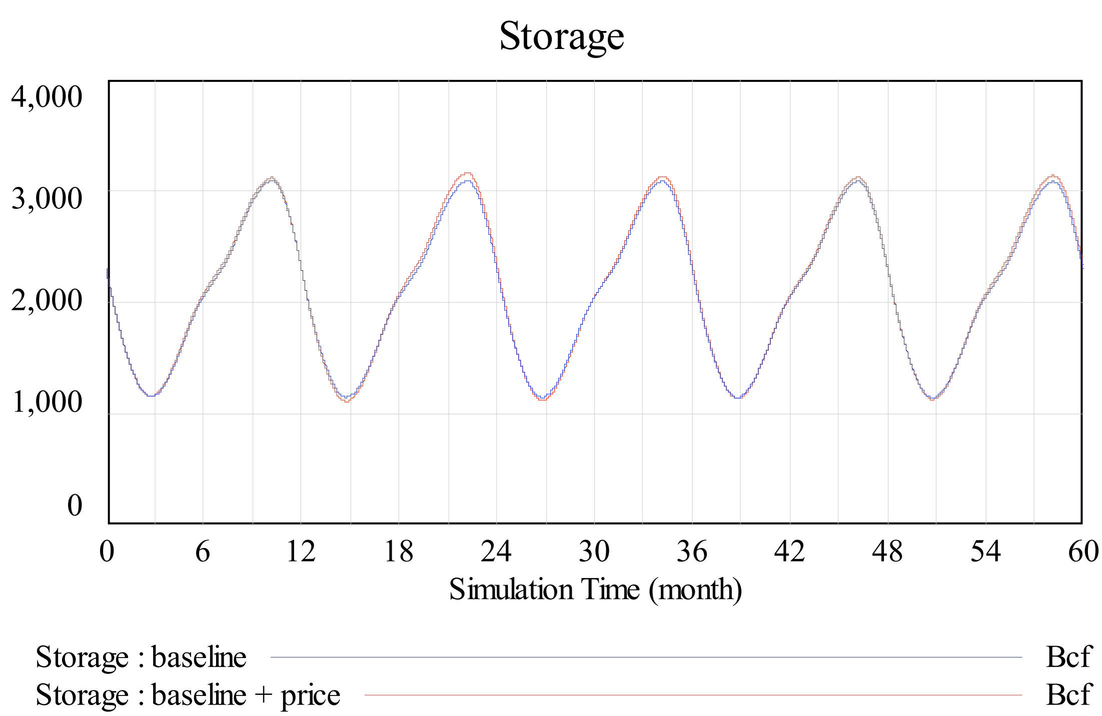
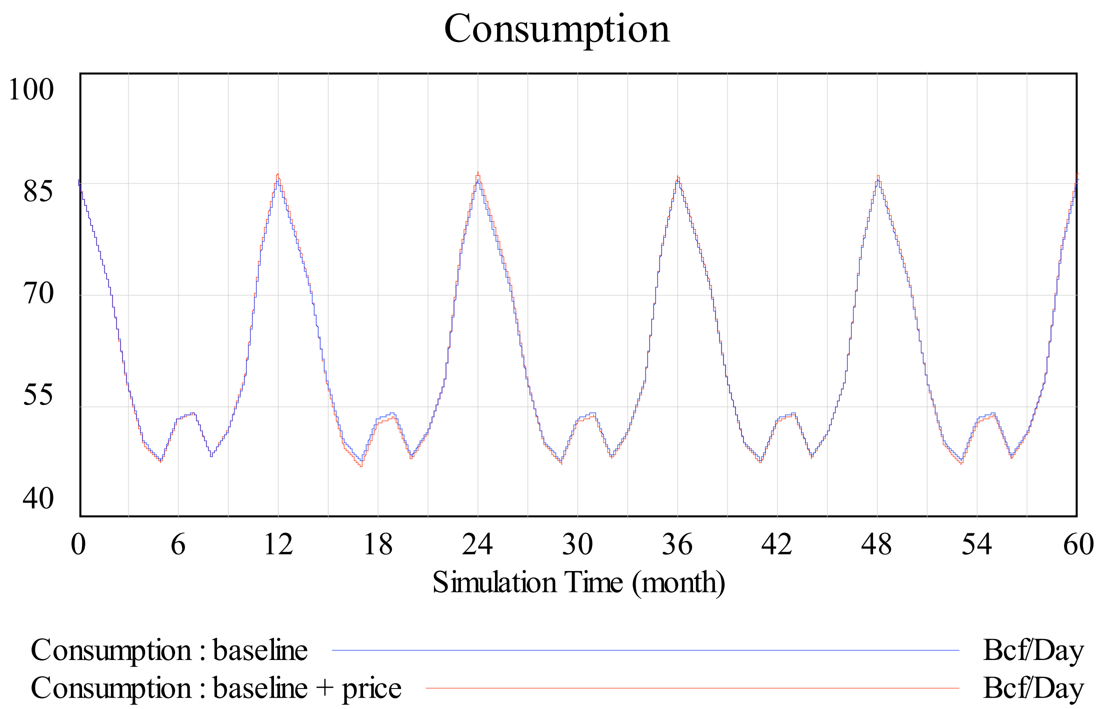


Figure 4.9: Consumption levels for nominal model runs



Scenario One -- 2005 Hurricane Season

The initial testing scenario of the model is a disruption equivalent to the combined effects of hurricanes Katrina and Rita followed by a warmer than average winter. The hurricane effect on production is shown in Figure 4.10. The hurricane disruptions are implemented in the model by a linear drop in Gulf Coast production of 6 Bcf per day to 0 Bcf per day (return to nominal) over the course of 9 months starting in September. The zero time of the model is January 1 of the year, thus month 8 represents the first day of September and month 12 is the start of January of the next year. Base production levels are assumed to be constant unless disrupted.

The warmer than average winter is implemented by decreasing residential and commercial sector demands for natural gas by ten percent for the months of December, January, and February as shown in Figure 4.11.

Figure 5: Production with the Katrina/Rita hurricane disruption

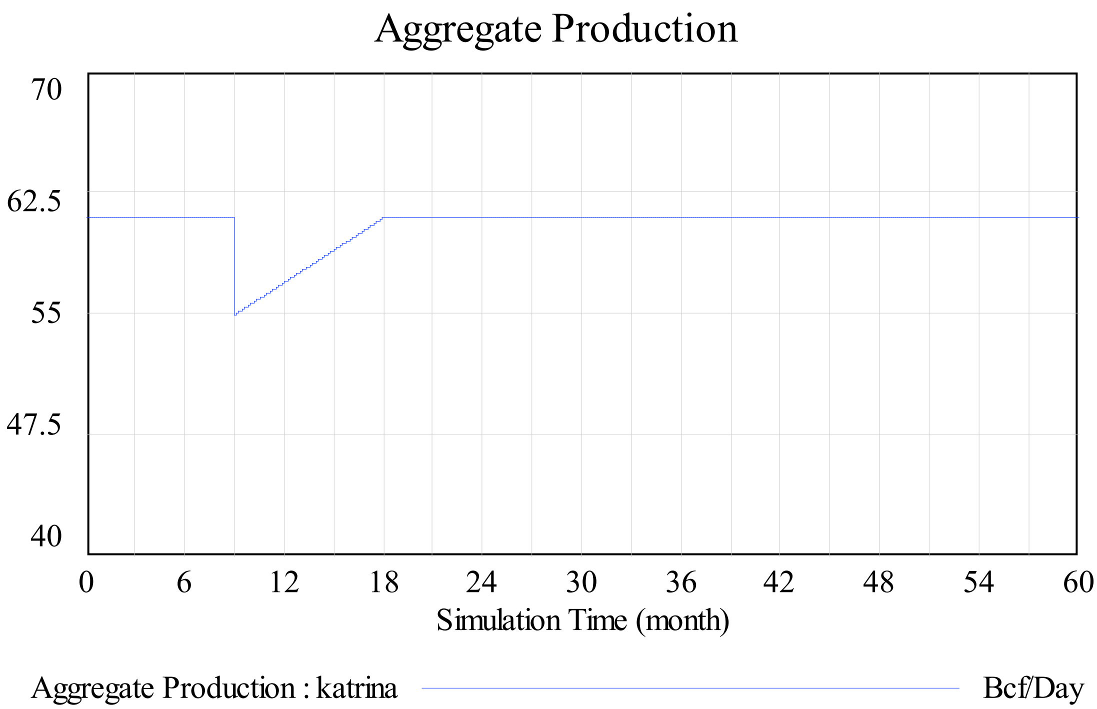
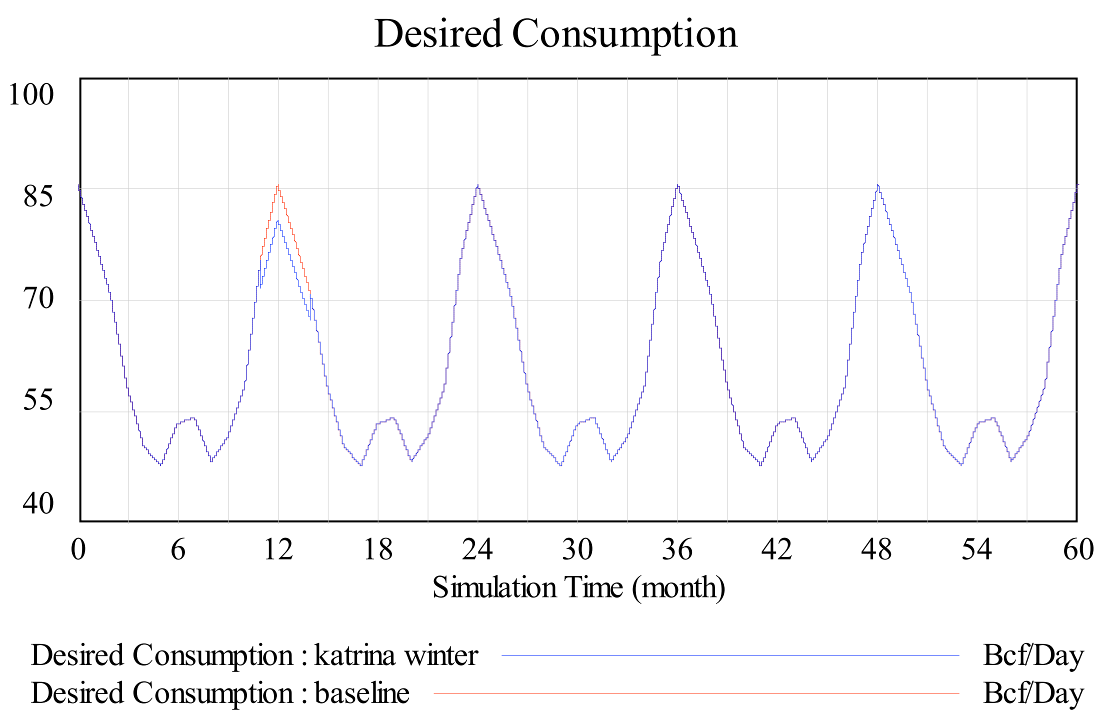


Figure 6: Consumption for Katrina/Rita warmer winter



Scenario Two – Two 2005 Hurricane Seasons and Two Cold Winters

The more severe scenario that is created for use in the model is an 820 Bcf production disruption beginning in September of the first year of the model run, followed by a colder than average winter for the months of December, January, and February. In the second year of the model run, there is another 820 Bcf production disruption, followed by another colder than average winter.

The colder winters are implemented by raising residential and commercial sector demands for natural gas 10 percent for the months of December, January and February as shown in Figure 4.13.

Figure 7: Disruption scenario production

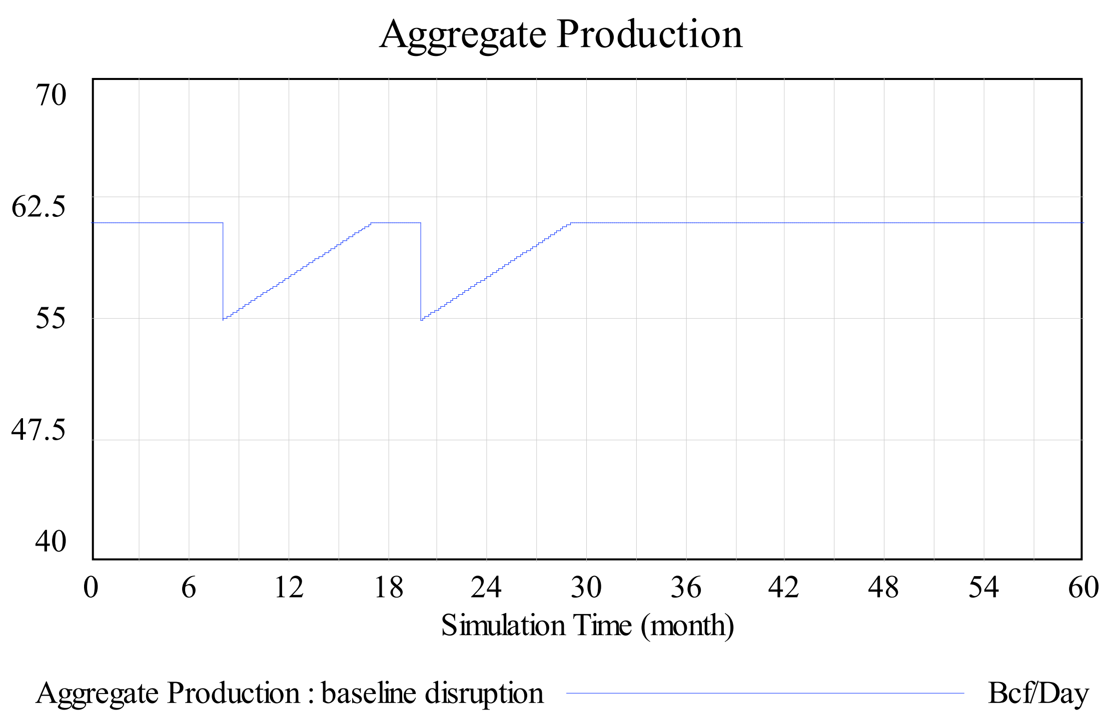
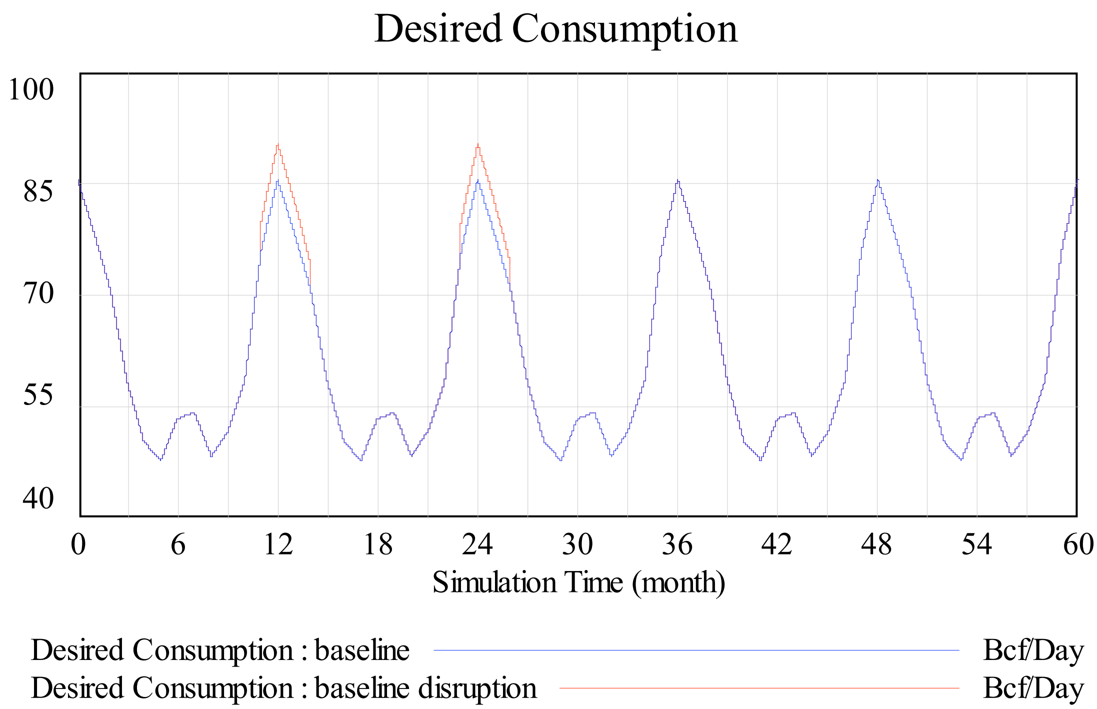


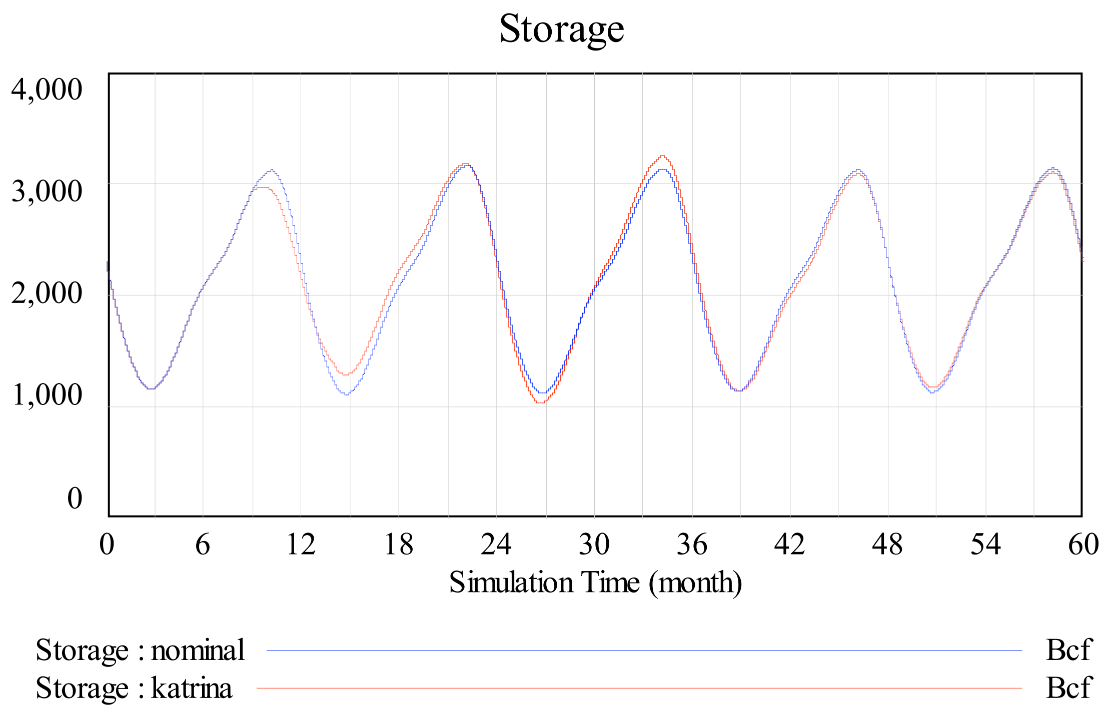
Figure 8: Consumer demand with two colder than average winters



Simulation Results

The model is first used to simulate the combined effects of Katrina and Rita and a warmer than average winter (10 percent reduction in demand) for comparison to current data for storage levels which are higher than normal, as shown in Figure 4.14. As shown in the results in Figure 4.14, storage levels increase to higher than nominal after the hurricane season and then begin to return to normal.

Figure 9: Katrina/Rita and warmer winter historical example



Figures 4.15 and 4.17 show the comparison runs of the model for the nominal model run without disruption, the disruption run, and for the disruption with the strategic reserve enabled. The results of the pricing mechanism on the disrupted scenario is the run labeled "nominal disruption" shown in Figures 5.7 and 5.8. Price increases when nominal production and storage levels decrease and as demand increases. This causes shortages of natural gas to drive the price up, and drive down consumption according to the elasticity of the different consuming sectors.

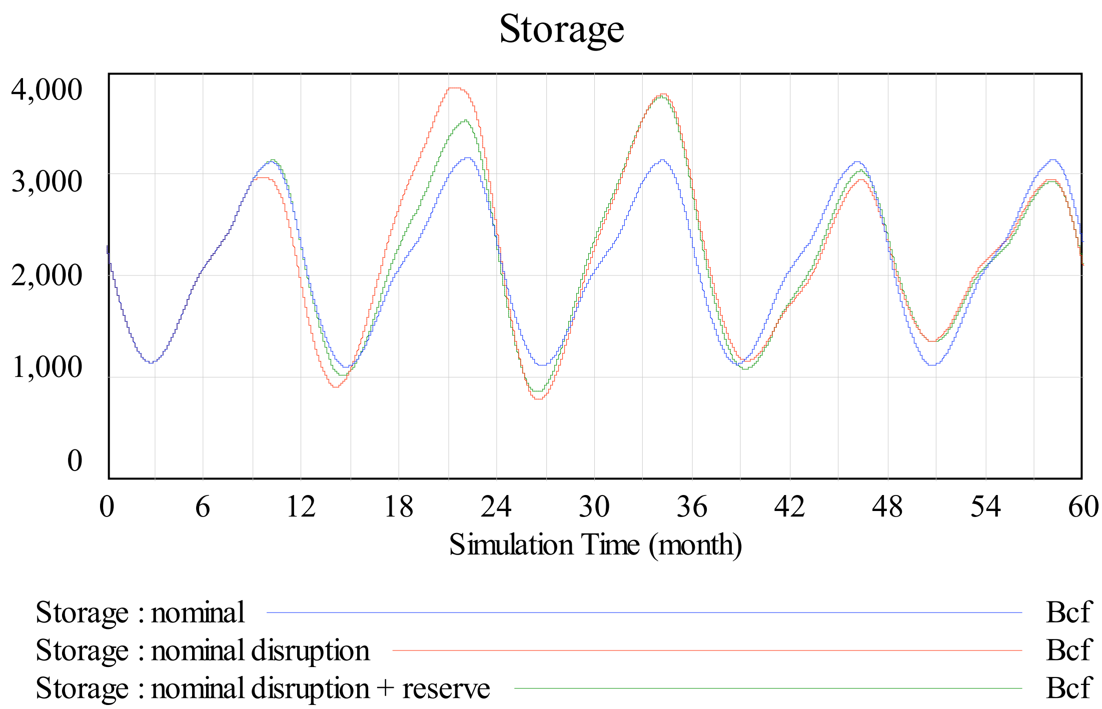
Higher prices drive down consumption levels after the hurricanes, resulting in lower demand and an increased amount in storage. Since demand is curtailed there is no shortfall in available natural gas. By the onset of the second hurricane there is excess natural gas in storage, which drives the price down and consumption up to cause the system to begin to return to its nominal levels.

Therefore, in the face of both the test given by the 2005 hurricane season, as well as the simulated test of two 2005 hurricane seasons and two cold winters, the US natural gas system seems to be resilient.

Effect of a Strategic Reserve

A strategic natural gas reserve is introduced for the "nominal disruption + reserve" run shown in Figures 4.15 and 4.17. The strategic reserve contains 750 Bcf of natural gas and is opened one month after the hurricanes, and allowed to remain open for five months. During that time period, natural gas is moved from the strategic reserve to normal storage to match the current production that is still shut-in due to the hurricane. The use of the strategic storage reserve is shown in Figure 5.11.

Figure 10: Natural gas daily storage levels.



The strategic reserve is fed directly into storage at a rate to make up for the currently lost production due to the hurricane. By the end of the first five months of usage of the reserve, about 200 Bcf remain. This reserve is quickly used up once it is again opened for the second hurricane season and lasts for a little over a month. After this point storage levels start to fluctuate similarly to the run without a reserve.

Figure 11: Use of the strategic storage reserve during disruption

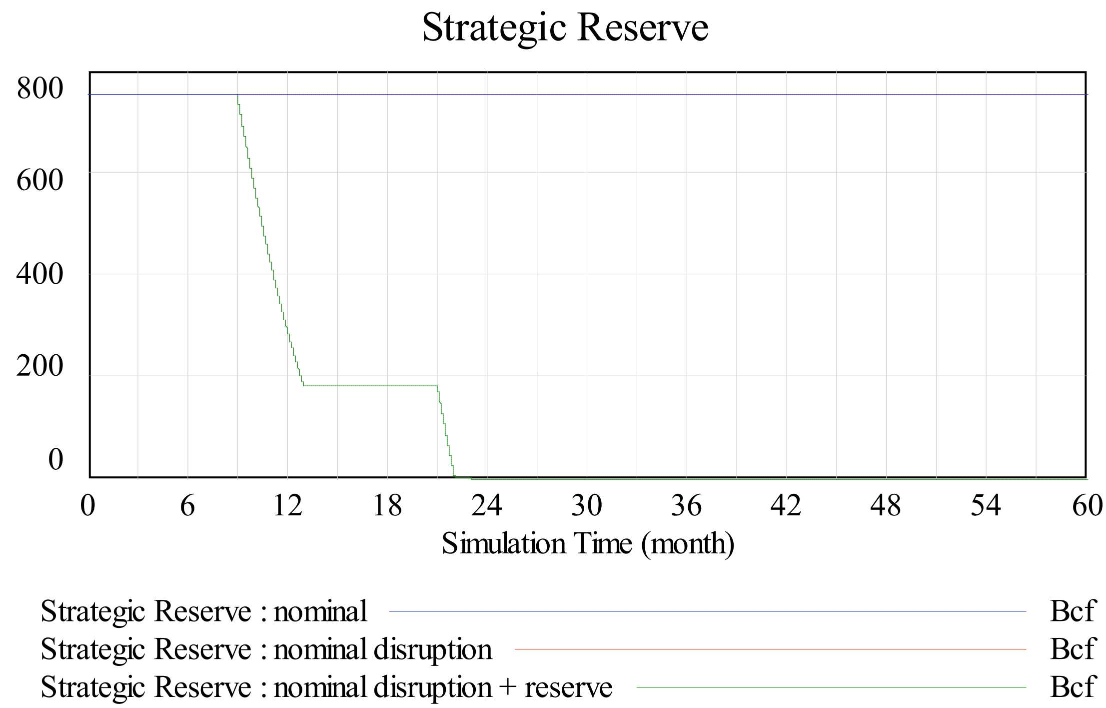
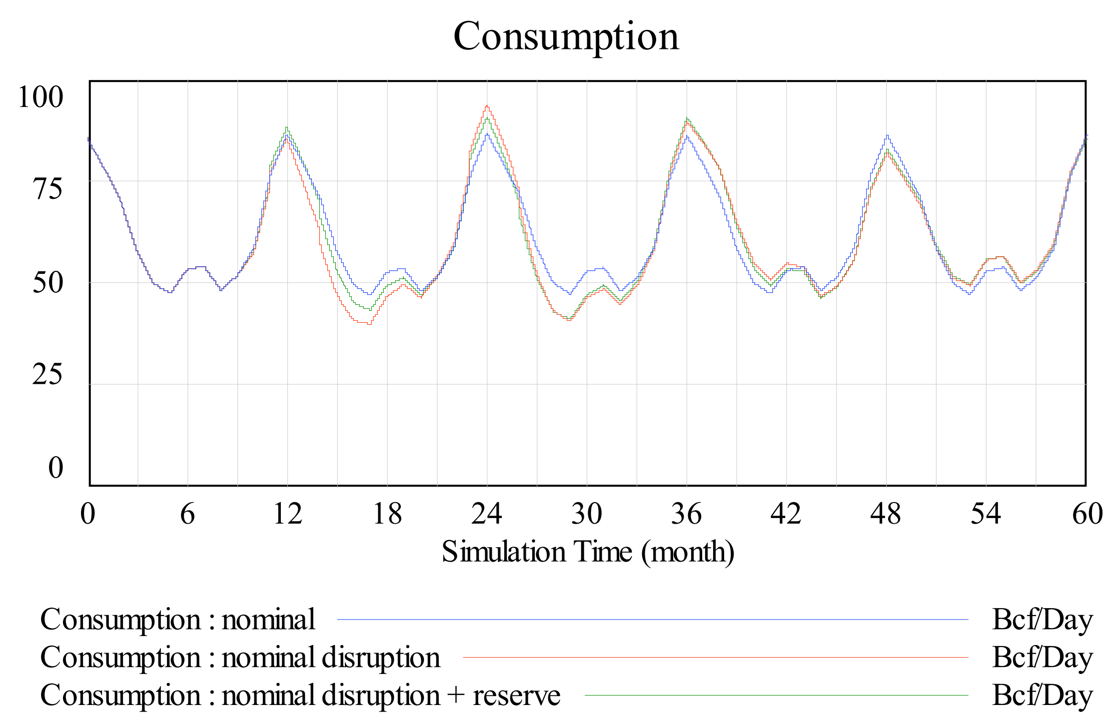
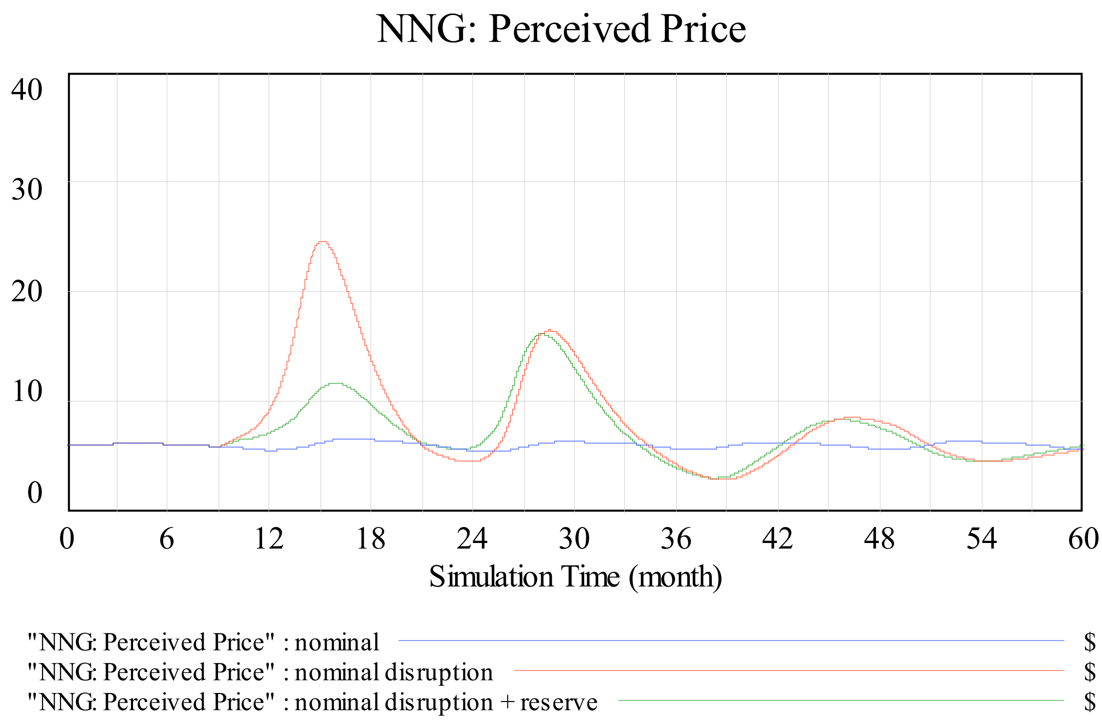


Figure 12: Natural gas daily consumption levels.



Storage levels rise higher after the hurricanes in the run without the strategic reserve as a result of higher price volatility. Without the strategic reserve, production levels are below normal as is the amount in storage, this drives price upward and curtails demand so that more natural gas ends up in storage. With the strategic reserve active, production levels are lowered, but storage levels remain much closer to nominal causing a smaller price increase. The lower price increase results in less curtailment of demand, so less excess natural gas in storage.

Figure 13: Natural gas pricing



Once the system is disrupted, use of a strategic reserve causes the storage and consumption levels to start to return to their normal levels faster than without the strategic reserve. It should be noted that natural gas price, which here is expressed in dollars per MMBtu, is not meant to be a forecast of actual natural gas prices. Regardless of the precise value, in this model high natural gas prices depress demand, while low prices encourage it.

Mitigating Negative Consequences: What are we Concerned About, and What can be Done?

Economic Consequences versus Physical Shortages

When prices are allowed to increase following a supply disruption, such that demand is decreased enough to be equal to the decreased supply, then no shortage occurs, but there can be considerable price spikes and an increase in cost to consumers. This is in fact what we observed in the wake of Hurricanes Katrina and Rita – US natural gas production on an annual basis was reduced by about 3%, which caused a sharp increase in price, but did not result in a shortage.

At the same time, it is possible that supply could be reduced so suddenly and drastically that the entire system (or large parts of it) would be brought to a halt; in this case no amount of price increase would be sufficient to prevent shortages. This was very nearly the case with petroleum product supplies to the East Coast in the aftermath of Katrina, when the Colonial petroleum product pipeline was shut down for 55 hours due to power outages at several of their pumping stations. Most fuel depots have just three to five days of supplies (Cummins and Gold 2006).

Clearly, running out of natural gas would be a much greater national security concern than having to endure increased costs that successfully ration smaller volumes.
We believe that a difficult hurricane season that greatly disrupts natural gas production in the Gulf is the worst natural disaster that we can reasonably expect. And apart from a few local exceptions, we believe that such a disaster is much more likely to result in increased economic costs (from potentially dramatic increases in the spot market price for natural gas) than in a regional or national shortage.

Results of modeling, as described in Section 5, also support the contention that even after a couple of damaging hurricane seasons and cold winters, if price is allowed to be set freely then the market should be able to cope without having emergency reserves. Nevertheless, it makes sense to explore what options there are for having additional supplies of natural gas on hand in case of an emergency, how much it would cost, and how long it would take to obtain such a reserve.

Parallels Between the Strategic Petroleum Reserve and a Potential Natural Gas Reserve

In order to assist our analysis of whether establishing a strategic natural gas reserve makes sense, it would help to first review the rationale behind establishing the Strategic Petroleum Reserve and the rules for accessing the stored petroleum.

The US Strategic Petroleum Reserve (SPR) is comprised of crude oil storage in five salt dome caverns in Texas and Louisiana. The SPR oil can be withdrawn at a rate of 4.3 million barrels per day (m bbl/day) for the first 90 days of withdrawal, with declining rates afterwards (Bamberger 2006).

The origins of the SPR stem from the 1973 Arab oil embargo on the US. As a result of US support for Israel in the 1973 Yom Kippur war, Arab oil producers embargoed the US, in order to create a clear supply shock and show that they had leverage over the US. The embargo resulted in a dramatic increase in world crude oil prices, and the supply reduction coupled with price controls in the US led to gas lines and shortages.

As a result of this experience, Congress authorized the SPR in the Energy Policy and Conservation Act (EPCA, PL 94-163) in 1975 to help prevent a repeat of the situation. Though it was understood that no amount of strategic storage could completely isolate the US from the price of oil in a crisis, the logic was that such storage could help blunt the magnitude of the market response. Moreover, strategic stocks would buy time for the crisis to resolve itself, or time for the US to seek a resolution to the crisis before it escalated. It was also hoped that the existence of strategic stocks would discourage oil exporters from using oil embargoes as a weapon.

Apart from fears of a possible petroleum shortage, the "economic dislocation" (Bamberger 2006) caused by the Arab oil embargo was very real – and there was the desire to prevent this from happening in the future. We interpret "economic dislocation" to mean the power of petroleum exporting countries to affect a dramatic increase in crude oil prices, and in so doing, affect a transfer of wealth from petroleum importing nations. In thinking about a Natural Gas Strategic Reserve (NGSR), we should first point out the areas of difference with the SPR.

First, North America does not rely on natural gas imports in the way that it relies on crude oil imports. As North America consumed 27.7 Tcf of natural gas and imported 650 Bcf of LNG in 2004, total imports comprised only about 2% of all natural gas consumed. Therefore, at present, there is no need to have stocks to tide the US over in case of an embargo, or to have stocks that could act to discourage an embargo, simply because an embargo would have virtually no effect.

Second, with crude oil, large increases in oil prices amount to a tax on US residents by petroleum exporting nations (Bernanke 2006). Increases in natural gas prices, on the other hand, go largely to domestic producers. Since wealth largely stays within and therefore is taxed within the US, natural gas price increases are of a different nature and may be of less concern to policymakers.

Establishing a Natural Gas Strategic Reserve (NGSR)

As the 2005 hurricane season was unusual in its severity, and other natural disasters would either have a much lower impact or are highly unlikely (such as an earthquake in the New Madrid Seismic Zone), we believe that it is reasonable to compare the size of a potential NGSR with the amount of natural gas production shut-in due to Hurricanes Katrina and Rita.

We therefore propose that the volume of working gas in the NGSR should be large enough to make up for lost production for the 2005 Hurricane Season, and that location of the storage (as long as it can get gas on pipelines headed to the Midwest and Northeast) is not so important. Since the lost production will be in the Gulf, it makes sense to place storage in the same area. Given the proximity to major transmission lines, the geology that lends itself to salt cavern development, and the number of spent oil and gas fields, placing storage in the area would likely be cost-effective.

Moreover, we do not believe the nature of the storage to be especially important. What is necessary is to be able to replace lost production by the end of the winter season, not to immediately replace all lost production. In other words, if Gulf production is reduced by 9 Bcf the first week after the storm, by 8 Bcf the second week, and then fully restored by the third week, then it is only necessary to make up the lost 17 Bcf by the end of winter – it need not be done in the exact same two weeks that production was shut in.

Exactly how much natural gas production was lost as a result of the 2005 hurricane season? From August 26, 2005 through June 19, 2006, about 800 Bcf of natural gas was shut in, which is equivalent to 22% of the yearly production of gas in the US Gulf. And as of June 19, 2006, 9% of the normal daily production of 10 Bcf remained shut-in (MMS 2006).

How much would it cost?

A typical two-cycle depleted reservoir storage field costs about $5 million to $6 million per Bcf of working gas storage, and salt cavern storage able to cycle six to twelve times a year costs about $10 million to $12 million per Bcf along the Gulf coast, and as much as $25m per Bcf in the West and the Northeast (FERC 2004).

If we assume that about 750 Bcf of additional working capacity in storage is needed, and that this additional storage will be concentrated along the Gulf coast as well as the Midwest and Northeast, and that 80% will be in the form of depleted reservoir storage and the remaining 20% in the form of salt cavern storage, then this yields a price for storage construction of roughly $5b USD.

However, there is also the cost of purchasing base gas. If we assume that the depleted reservoir storage facilities will require 50% base gas, and the salt cavern facilities will require 25% base gas, then to have 750 Bcf of working gas it will be necessary to have an additional 650 Bcf in base gas. If we take a natural gas spot price of about $6 per million

Btu (MMBtu) as the average price at which the storage gas could be purchased, then the cost of the base gas is about $4 billion USD, and the cost of the working gas is about $4.6 billion USD.

The total cost, then, for constructing the storage facilities and filling them with gas should be close to $14 billion USD.

How Long Would it Take to Build and Fill?

The amount of time it takes to construct a storage facility depends on specific site. Key factors are the type of surface facilities needed, the proximity to pipeline infrastructure, and permitting and environmental issues.

If we assume that the storage fields constructed would have the same average size as existing fields, then this means that roughly 30 facilities would need to be constructed. (This is so because there are currently about 400 facilities that can store about 8000 Bcf of natural gas – and if we want to add about 1400 Bcf of gas in storage, this would roughly equal 30 facilities using the same ratio). It is likely that the first facility would be finished in about two years, and that the last facility would be finished in about five years.

Filling the completed storage facilities with natural gas is another matter. The North American natural gas network is essentially a closed system at present, since only 2% of the continent's natural gas supply is imported. Moreover, North American natural gas production has reached a plateau, and it is difficult to see how the level of production could be increased. Since the amount of production and imports are essentially fixed, the extra natural gas demanded by a new strategic stockpile would have to come from the reduced consumption of others. In a market, this means that prices would have to increase in order to allocate the same level of supply to a greater level of demand.

The very act of creating a strategic natural gas reserve, depending on how quickly the reservoirs were to be filled, would therefore act to increase natural gas prices.
The same issues are at work in making deposits to the SPR. In April 2006, President Bush suspended the replenishment of the SPR, which released oil in the aftermath of Hurricane Katrina in September 2005, so as to minimize the impact of the additional demand on the world oil price (McKinnon, Fialka et al. 2006).

In order to minimize the impact on natural gas prices, it would make sense to stock the reserve with gas when natural gas volumes in storage are higher than average, and to refrain from stocking it when volumes in storage are lower than average. If we assume that about 350 Bcf of extra demand per year could be accommodated without undue pressure on gas prices, then this would mean it would take four years to completely fill the NGSR.

Taking into account the time for construction, this would mean that it would take about three years for the first storage facilities, and about six years for the last facilities, to be built and filled with gas.

Evaluating Based on Tomorrow's Infrastructure

When evaluating the need for an NSGR, we should evaluate not how it would interact with today's natural gas infrastructure, but with the infrastructure of five years from now (as it will take this long to get the new facilities built and operational). While it is not easy to predict how the system will look in five years, we can make some educated guesses about the basics of the system. North American production should be about the same as today, as new sources are being found at about the same rate old ones are depleting. New LNG terminals will go into service, and exporting countries will develop more LNG exporting capacity. At the same time, more natural gas-fired power plants will be built. In short, demand should be higher, domestic supplies should be similar, and the balance will be made up with imports.

In the distant future, when natural gas imports comprise a large fraction of North America's consumption, then an NGSR may make sense for the same reasons that the SPR makes sense today. In five years' time, it is unlikely that the fraction of imported natural gas in North America will exceed 5%. By 2030, that fraction is projected to be about 16% (EIA 2006). Given that the US has only about 3% of worldwide natural gas reserves, the percent of imports will most likely continue to increase over time.

Conclusions

The 2005 hurricane season had a significant impact on the US' energy infrastructure, of which the natural gas system is a vital component. The recent hurricanes lead us to question how vulnerable the sector is to other types of natural disasters, and whether anything can or should be done to mitigate the effects of a future disaster.

Hurricanes Katrina and Rita caused about 800 Bcf of natural gas to be shut in, which is about 22% of annual Gulf production, or almost 4% of annual US natural gas consumption. Natural gas prices skyrocketed to over $15.00 per million Btu (MMBtu) in the aftermath of the hurricanes, and residential consumers paid record prices for natural gas heating in the winter. However, the market was successful in allocating the reduced production among consumers, and no shortages developed. As a result of both high gas prices and a mild winter, natural gas volumes in storage stood at a record high in the summer of 2006.

Modeling Scenarios: Hurricanes and a NGSR

As the 2005 hurricane season was the worst to date for Gulf oil and natural gas production, we believe it reasonable to assume that the worst hurricane season we can reasonably expect in the future will have an impact on production similar to the 2005 hurricane season. It is possible, however, to have a couple such seasons back-to-back, followed not by mild but severe winters.

After building a model to simulate the US natural gas system in aggregate, we simulated a scenario of a hurricane season similar to the 2005 season, followed by a colder than normal winter, and then a repeat of the hurricane season and cold winter the following year. We found, given our assumptions on the elasticity of demand, that the market is successful in dealing with this scenario. In this scenario, the price increases following the disruptions cause more conservation of gas than necessary to offset the disruptions; leading to higher levels of storage than before the disruptions.

Adding a NGSR in the scenario helps to keep prices low, but results in lower overall storage levels going into the next year – since prices stayed low and there was no reason for consumers to conserve. In the second hurricane season, the NGSR is able to help only a small amount, and then is exhausted, since it was not refilled between seasons.

The Role of a Natural Gas Strategic Reserve

We have calculated that creating strategic reserves of 750 Bcf would require construction of about 30 storage facilities, at the cost of about $14 billion (total construction cost including base gas and working gas).

Even though having the reserves would likely dampen price increases following a production disruption, the reserve would have to be refilled after it was used, which would in turn put pressure on natural gas prices. Given that the North American natural gas system is essentially a closed system, gas to refill the reserve currently could not come from abroad, and could not come from excess domestic production (as excess production capacity does not exist), but could only come from reduced consumption by other consumers.

Moreover, the reasons for the establishment of the Strategic Petroleum Reserve (SPR) should be taken into account. It was considered that having the reserve would discourage other countries from using oil embargoes as an economic weapon, and that having a reserve would allow the US the time to wait out or resolve the crisis in a position of strength. Neither of these reasons applies to a potential NGSR, since as of 2005, North America imports only about 2% of the total volume of natural gas consumed.

In short, if keeping natural gas prices low in the aftermath of large, sudden production decreases is a key objective, then an NGSR can be considered. If the more stringent criterion of avoiding natural gas shortages is applied, then the justification for an NGSR is questionable.

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