# Texas Electricity Blackouts Enabled by Feedback Loops; Reliance on Competition

Posted by Gail the Actuary on February 10, 2011 - 11:07am

Many days after the winter storm hit Texas, outages are still continuing in parts of Texas. We don't have all the answers yet, but let me tell you what I have pieced together about what has happened. One of the issues is direct and indirect feedbacks, as outlined in the graphic below, and described further in this post.

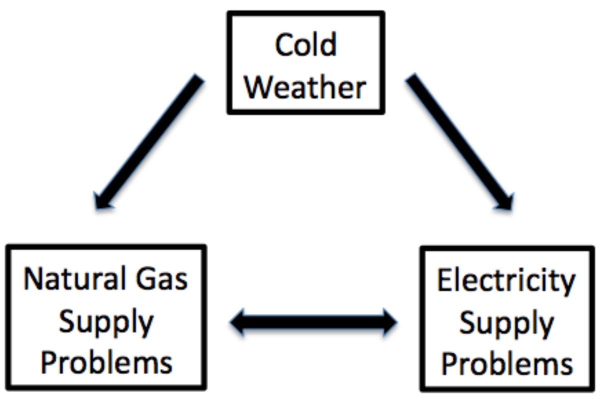


*Figure 1. Cold weather affected both natural gas supply and electricity. In addition, a shortage of natural gas interrupted electricity supply, and electricity outages reduced natural gas availability.*

Another issue is electricity deregulation in Texas. The competitive marketplace produces a situation not all that different from the situation in which BP operated that led to the oil spill in the Gulf of Mexico. Under Texas' structure, there are many entities, each concerned primarily with its own bottom line. In this environment, cost cutting in the name of profitability is rewarded, but can lead to power outages. Integration with the many other units involved in electricity generation, while possible in theory, is extremely difficult in practice in times of market stress. The competitive marketplace provides price integration, but leads to a greater chance of cascading failure, since each company can be expected to look out for itself, leaving regulators with an expanded role in making certain that the system as a whole functions properly.

We are now considering adding more wind to the electric grid, as well as adding natural gas and electric vehicles. These will all have the effect of making the organization more complex. Each entity will be working to optimize its own profitability, with little focus on the overall success of the system. The failure of the Texas grid system in cold weather should act as a caution to those who expect that the integration of even more types of providers into the natural gas/electricity system can be done with few problems.

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## Feedback Loop Issues

What happened in Texas was that two coal fired power plants tripped offline, related to freezing water pipes, and this started a whole cascade of other effects. In the next sections, I describe this situation, and the feedbacks, in more detail.

### Cold Affected Electricity Supplies

Cold weather had direct impacts on electricity production. In the Globe Newswire, we read that frozen pipes in two inadequately weatherized coal-fired power plants were the immediate cause of the crisis. Coal fired power plants tend to be large. Taking two of them off-line simultaneously can be disruptive in and of itself.

There were other weather-related issues. According to the Star-Telegram,

> Trip Doggett, president and CEO of ERCOT, said there was no one reason that power failed Wednesday at 50 electrical generating plants. Instead, he said, there were a variety of reasons and no pattern emerged either geographically or by provider. Frozen pipes, valves and monitoring systems were just some of the reasons, he said.

### Cold Affected Natural Gas Supplies

This happened in three different ways:

1. Newly pumped natural gas supplies lower

Cold weather affected the amount of natural gas extracted. Platts reports:

> US production for Thursday' gas day would be about 57.5 Bcf, Bentek said, down from more than 62 Bcf a week ago -- before the emergence of the cold front that left a large swath of the US with snow on the ground.
>
> "There's a pretty sizeable amount. The cold has shown a large effect in more than just Texas. We are seeing freeze-offs or lower production in the Rockies, the Anadarko [field] in Texas and Oklahoma, East Texas and the Texas Gulf Coast," senior Bentek analyst Matt Marshall said.
>
> Freeze-offs occur when low temperatures crystallize the small amounts of water produced with natural gas, forcing blockages at the wellhead, and are most common in extreme and prolonged cold snaps.

Platts also says, "Much of the production loss was centered around Texas, where more than 2 Bcf was lost, according to Bentek data."

2. Stored natural gas supplies didn't give enough "boost"

Normally, natural gas supplies come from a combination of natural gas that is just now being stored, plus natural gas that has been set aside in storage during the time of year when demand was low. But the amount that is available from storage hasn't been enough, since many states are now reporting low supply.

There are really two different functions that natural gas from storage can provide. It can (1) add to total supply, as long as there is natural gas in storage and it can (2) supplement daily needed amounts. It is clear that storage is not adequate for supplementing daily needed amounts, even though the caverns may appear to have plenty left in them. This is an issue of the "size of the tap" versus the "size of the tank". It doesn't matter if a natural gas tank is full, if users can't get much out on a daily basis.

Natural gas storage is expensive, and is normally only created where naturally occurring caverns can be adapted for this use. No one would seem to have economic incentive to create gas storage if it will only be needed very rarely, and of course, adding such storage would add to the overall cost of natural gas. I don't know the details of US natural gas storage. It may that to provide adequate short-term supplementation, one would need more, smaller storage locations, closer to where supplementation is needed.

3. Everybody was using the same natural gas

There are multiple users for natural gas:

1. Homes heating with natural gas,
2. Businesses heating and cooking with natural gas,
3. Industrial users other than electricity users, who use electricity in their processes, and
4. Electricity users.

Of course, all of the gas for these many types of users flows together through the same pipelines, until at the very end, when it goes to its individual destination. When it gets cold outside, at least three of the four users listed above are likely to have rising demand for natural gas: people heating their homes with natural gas need more gas for heat; businesses heating their establishments need more gas; and electric power plants need more gas.

One of the questions that comes up is whether the pipelines are of sufficient size to accommodate all of this demand simultaneously. Each new user plugs in, assuming that there will be enough. And there is, until it gets cold out. (We have been told that wind actually performed well during the initial day of the storm. If this had not been the case, the electricity shortfall would have been even worse.) It seems like adequacy of pipeline size should be something that is analyzed.

According to the Star-Telegram,

> Fraser said that when several coal-fired electricity plants failed, providers turned to natural-gas-fired plants to fill the gap.
>
> Except that didn't work because Atmos had curtailed its supply of natural gas to industrial customers, including natural-gas-fired power plants, he said. Atmos did exactly as its protocol called for, he said, to make sure that residential and commercial users had enough gas pressure.
>
> "We didn't have enough gas pressure available to bring up the power plants," Fraser said. "In a high-volume usage, the first ones they cut off are the power plants."
>
> This quirk in the system was unknown to Fraser and perhaps others in state government, probably because no winter storm had so taxed both the electricity grid and the natural gas supply.

So cutting off the electrical providers at the same time as other industrial users when there isn't enough to go around is a problem that needs to be looked at. The Northeast had a similar conflict between homeowners and electric power plants during cold weather in 2004, according to the Wall Street Journal. It made a change to permit electricity generators to be able to request more supply.

### Short Natural Gas Supply Reduced Ability to Make Electricity

This is one of my arrows on the diagram at the top of the post. Pretty clearly, if natural gas pressure in pipelines is low, gas-fired electricity cannot be brought up, and this is a problem.

### Lack of Electricity Affected Natural Gas Supply

This is my arrow going the other direction. When there are electricity outages, then natural gas pipelines that use electricity to pressurize their gas lose this ability, tending to put even more electric power plants out of commission. According to the Wall Street Journal,

> Some natural-gas pipelines were unable to move gas to power plants because they had lost electricity and "they didn't have a backup system to pressure the lines," said State Sen. Troy Fraser, chairman of the Natural Resources Committee, who plans to hold hearings on the incident.

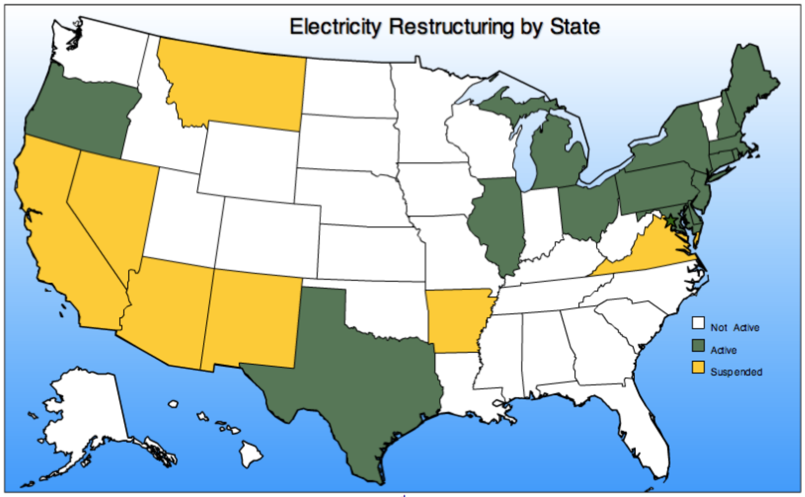
I wonder about the feasibility of retrofitting natural gas pipelines to have natural gas as a back-up to electricity for pressurizing their supplies. It would seem as though this option could more easily be added on new pipelines.

With arrows going both ways between natural gas supply and electricity supply, there is clearly a potential for escalation, through an unintended feedback loop.

## Texas Deregulation of Utility System

Texas is one of the states that replaced the monopoly system of utilities with a system of competing sellers, under what is termed "restructuring". Quite a number of states tried this approach and abandoned it (shown in gold on Figure 2). Texas is one of the states (in green) that kept this approach. It is striking that Texas had problems during cold weather, and other states nearby without restructuring did not.

- The map below shows information on the electric industry restructuring. Click on a State for details.
- Restructuring means that a monopoly system of electric utilities has been replaced with competing sellers.

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Source: Energy Information Administration

*Figure 2. EIA Map of Electricity Restructuring by State, September 2010*

While economists like the idea of restructuring, physicists have major doubts about it. Eric Lerner, in [The Industrial Physicist, says]:

> Experts widely agree that such failures of the power-transmission system [blackouts] are a nearly unavoidable product of a collision between the physics of the system and the economic rules that now regulate it. To avoid future incidents, the nation must either physically transform the system to accommodate the new rules, or change the rules to better mesh with the power grid's physical behavior.

Lerner also writes,

> The vast system of electricity generation, transmission, and distribution that covers the United States and Canada is essentially a single machine—by many measures, the world's biggest machine.

The problem is that it is very difficult to keeping all the parts of this huge electrical machine working together properly under deregulation. When the system was originally designed, there were many vertically integrated electric utilities, with only a small amount of interconnection, each managing its own piece of the "machine".

But now we have stresses in many different directions. We are trying to trade electricity long-distance, over transmission lines that were not really designed for this purpose. We are gradually bringing the electrical system closer to other systems--the natural gas system, the system for charging electric vehicles, and the system of delivering natural gas to vehicles, for example, so that these systems become interconnected with the huge electrical machine as well. They need to function together as a unit, or there will be the possibility of cascading failures. We have just seen how there can be feedbacks between the electrical and natural gas systems, and there no doubt will be feedbacks with other systems, as they are grow and become more integrated with the electrical system.

One of the stresses under deregulation is the fact that instead of vertically integrated utilities, we now have a much larger number of independent entities, each looking out for its own profitability, but not having a great deal of concern about making the system as a whole work together well. The economic incentive for each of these units is to cut costs as much as possible. For example, units have an economic incentive to cut corners on details like making certain that the unit can operate in any kind of weather. Units cannot be expected to have much concern about how their action contributes to the smooth operation of the whole. They certainly will not spend much time looking for feedback loops among different systems, such as the ones discussed above.

Without vertically integrated utilities with a concern for keeping everything going as smoothly as possible, and rates that allow the companies to spend as much as needed on preventive maintenance, the regulator suddenly has a much greater role. The regulator must anticipate everything that can go wrong among the many different types of entities, and set up regulations to prevent such failures. At some point, this task becomes impossibly difficult.

## Looking ahead

Where does this all lead? It seems to me that the United States is headed for more electrical blackouts, as we try to press our grid system to do more and more (for example, charge autos at night) and add additional unconnected parts (such as wind turbines) to the system. States that use a competitive pricing approach, such as Texas and the other states in green on Figure 2, are especially at risk because of the financial incentives of individual units to cut corners, and the lack of overall co-ordination, except through regulators. The limits under the laws of physics can be expected to become more and more apparent.

Not only are we likely to have more electricity outages in the future, but the outages are likely to spill over into other systems as well. Natural gas pipelines affected by electricity outages will stop pumping, if they are electrically operated, as they were in Texas. Pipelines carrying gasoline and diesel to their destinations will also stop pumping, if they are located in blackout areas. If gasoline stations are affected by blackouts, their electrical pumps will not work, so customers will not be able to buy gasoline and diesel, even if the service station's tanks are full.

There is no easy fix for the problem. We clearly need to look into the feedbacks that are causing our current outages, but doing this is not likely to solve our long-term problem, since that is "fighting the last war". We also need to be looking for potential feedback loops that are likely to cause different problems in the future.

Eliminating competitive pricing in Texas and other states with the system would seem to be helpful in preventing future blackouts. Eliminating competitive pricing may make integration of wind and solar into the overall electrical system more difficult, but if we want to have a system without major blackouts, we will need to make the health of the overall system a priority. This will likely mean going back to more of a regulated utility model, to the extent this is practical. It may also mean scaling back plans to add wind, solar, electric vehicles, and natural gas vehicles to the system, so that only the amount that the system can readily accommodate is added, given local constraints such as the size of natural gas pipelines and the amount of natural gas storage capacity available for short-term supplementation.

We also need to be doing more real-life testing, so we can figure out what feedback loops are likely to be in an integrated system. We really don't know how the system will work when it starts reaching its limits. For example, we have built a huge number of "peak demand" natural gas electrical generating units, but I doubt that anyone has really tested running them simultaneously, especially when the weather is very warm, which is one time when we are likely to need them.

We recently have experienced a period of over fifty years when the electrical grid was "up" most of the time, and almost everyone has come to take its existence for granted. I think the time has come for a much more conscious awareness of our electrical system's limits; we need to start making decisions with its integrity as a first priority. The Texas power outage fiasco has not turned into the equivalent of BP's oil spill, but if we continue down the path we are headed, we could easily find ourselves with electrical outage problems much worse than the oil spill.

See also: Will the US Electric Grid be Our Undoing?

Average Retail Price of Electricity TX LA

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