An Actor-Network Analysis of the 2011 Texas Power Grid Failure

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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INTRODUCTION

During the first week of February in 2011, Texas suffered severe winter weather that caused a total of 210 individual electricity-generating units to experience either an outage, a derate, or a failure to start (Federal Energy Regulatory Commission [FERC] & North American Electric Reliability Corporation [NERC], 2011, p.1). The loss of generation ultimately resulted in power outages to 3.2 million people (FERC & NERC, 2011, p.1). Right when temperatures were reaching all-time lows and Texas citizens needed electricity and heating the most, the Texas grid system had failed. An almost identical cold weather event resulting in controlled power outages occurred back in 1989. Current scholarship does not establish a clear consensus on who should be held responsible for the power grid failure while also falling short on recognizing how the events of 1989 should have influenced the roles of the parties involved in the Texas power grid system, ultimately leading to a repeat of events in 2011. The Federal Energy Regulatory Commission (FERC) along with the North American Electricity Reliability Corporation (NERC) published a detailed report on the causes of the 2011 event and included recommendations to prevent such an event from happening again. Using this report as my main source of evidence, I will apply the sociotechnical framework of actor-network theory to demonstrate that the Electric Reliability Commission of Texas (ERCOT), the independent system operator for the electric grid in Texas, was responsible for its own demise in the Texas power grid network. I will do this by walking through the process of network formation, also known as translation, to demonstrate why each of the other actors were ultimately not responsible for the grid failure given their defined roles in the network, and where in translation and why ERCOT was responsible for failing to provide reliable electricity to its Texas customers. This analysis will highlight the critical role primary actors play in keeping the network stable, even as other actors in the network become adversaries.

BACKGROUND

Regulated vs Deregulated Energy Markets

Most electric utilities in the United States remain regulated entities that resemble monopolies. They are a region's sole, vertically-integrated electricity provider that own and operate everything from the electricity generators (e.g., natural gas power plants, windmills) to the power lines to the electricity delivered to your home. Utilities in regulated market make money by charging customers a rate of return on infrastructure projects they invest in. State public utility commissions, acting as regulators, determine which infrastructure investments are considered appropriate and oversee how these electric utilities set prices to keep rates reasonable for customers (Cleary & Palmer, 2020). Thus, utilities in a regulated market structure are encouraged to make invests to their infrastructure.

Texas, however, functions under a deregulated power market, where independent electric suppliers own and operate the electricity-generating facilities, while electric utilities only own and operate the transmission and distribution power lines. Retail electric providers purchase electricity from generators and utilities on the wholesale market and resell to customers. This allows customers to choose which electric supplier they want service from and has created market competition for retail electricity prices. Texas also operates an energy-only market, meaning generators only make profit on the hourly electricity they sell on the wholesale market. Under an energy-only market, there is no incentive to make costly investments to infrastructure if it is not required.

ERCOT Interconnection

Texas also differentiates from the rest of the United States by operating a completely independent grid from the rest of the nation, as can be seen from Figure 1. ERCOT is the independent grid operator that manages electric power to more than 26 million Texas customers, representing 90 percent of the state's electric load, more than 46,500 miles of transmission lines, and more than 680 generation units (Electric Reliability Commission of Texas [ERCOT], n.d.). While the rest of the country is regulated by FERC, the Public Utility Commission of Texas (PUCT) is the regulatory body that oversees ERCOT (ERCOT, n.d.).

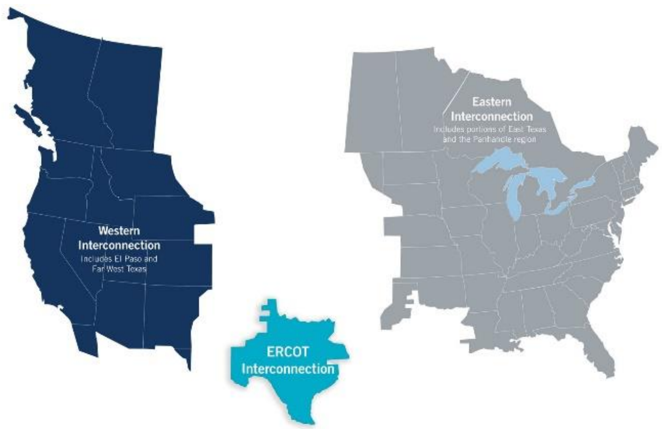

Figure 1. The three power transmission grids of the United States (Electric Reliability Commission of Texas [ERCOT], 2017).

LITERATURE REVIEW

There is a lack of scholarly work analyzing which party was responsible for the controlled firm load shedding on the Texas power grid in 2011. FERC and NERC published a comprehensive report on the events leading up to the cold weather event and the causes of the event itself which I will save as my primary evidence for the analysis section. While the scholarship that does exist on this event identifies adverse actors in the Texas power grid network that contributed to the event, the analysis remains superficial and does not accurately identify the root cause of the network failure.

George Lobsenz, pulling evidence from a report released in May 2011 by Texas Reliability (Texas RE), argues that the large number of planned generator plant outages worsened the power emergency in February 2011 (Lobsenz, 2011). Lobsenz points out that while ERCOT did not call back into service any of the power plants scheduled for maintenance outage prior to the severe weather event of February 2, the Texas grid operator was not at fault because there was no requirement to do so under the state grid’s protocols. Then, the author goes on to say that ERCOT did in fact prepare for what was expected to be record peak winter demand by calling in other generating plants not scheduled for maintenance, but immediately follows in the next paragraph that ERCOT appeared to ignore the "unusually high number of power plant outages scheduled for February 2" (Lobsenz, 2011). The article does not seem to have a clear consensus on whether ERCOT did or did not take the appropriate actions in preventing the eventual firm load shed to millions of Texan customers. More specifically, there is no clear consensus on whether ERCOT is excused or at fault for not calling in generators that were on scheduled maintenance outage given ERCOT protocols.

Angela Nevilla contributes to the discussion shortly after Lobsenz, both writing about the events of February 2011 prior to the release of the FERC and NERC report in August 2011. Nevilla provides a brief summary of the cold weather event that occurred, noting that the bulk power system experienced outages of more than 50 gas and coal fired generating facilities during a period of high demand for electricity. While Nevilla mentions a FERC audit report released in 2010 investigating Texas RE's close relationship with ERCOT, she fails to elaborate on the significance or influence of this close relationship to the causes of this particular event. The author mentions many players involved in the Texas power grid network, but falls short on focusing on a single actor's role or responsibility for the events that transpired in February 2011. In fact, at the very end, Nevilla briefly, but incorrectly, states that "utilities operating in Texas need to focus on providing better oversight of their generation facilities in order to enhance reliability and prevent future widespread outages" (Neville, 2011). As discussed in the Background section, utilities are not responsible for overseeing generation facility activities in Texas' deregulated market and thus, incorrectly places responsibility on utilities for the 2011 events.

CONCEPTUAL FRAMEWORK

The science, technology, and society (STS) framework of actor-network theory (ANT) will enable me to identify the heterogenous entities and relationships that make up the Texas power grid system in order to better understand which actor was primarily responsible for the power system failure in February 2011. ANT distills complex, heterogenous elements with heterogenous relationships into a network of human and non-human actors relevant to that network. French sociologist Michael Callon defined the actor network to be reducible neither to an actor nor to a network (Callon, 1987). Each actor in a network is in itself a network composed of another set of actors and associations. An actor in a network only exists under that network's context through its association with the other actors. Removing an entity would shift the whole structure of the network, giving each actor power in a network solely through its relationship with the other actors and never in and of itself. An important criterion to note of an actor network is that "whatever [the actors'] nature, what counts is that they [and their associations] render a sequence of events predictable and stable" (Callon, 1986). As we will see later, the defined actor roles and associations in the Texas power grid network did not render a sequence of events that was predictable and stable, which led to the ultimate consequence of conducting rolling power outages to millions of customers in Texas. While these concepts of simplification and association are important to understanding an actor network theoretically, Callon's concept of translation allows for actual development, definition, and analysis of a network.

Translation forms and maintains an actor-network through the four phases consisting of problematization, interessement, enrolment, and mobilization. In problematization, the primary actor defines a problem or goal the individual or group wishes to address and identifies the necessary accompanying actors that must be recruited to solve said problem or accomplish said goal. Since the joint actors are entering the network through their relationship to the network's goal defined by the primary actor, the primary actor is considered to be the central node of the network, or the "obligatory passage point" (Callon, 1986). Next, interessement requires the primary actor to actively recruit the identified actors by persuading them that their interests align with the primary actor's goal and vice versa. Proper alignment of interests is critical to prevent actors from being persuaded to detach from the network and join a separate, competing network (Callon, 1986). Enrolment is when the primary actor defines the recruited actors' roles, establishes the associations between the recruited actors within the network, and assigns these roles and associations, while the other actors accept their position in the network and perform their assigned roles. An important point to note about the fluid transition between interessement and enrolment is that entities cannot be expected to formulate their identity and goals in a totally independent manner; they are instead **"formed and adjusted only during action"** (Callon, 1986). Lastly, mobilization is when the primary actor assumes their role as the director of the network, which begins to stabilize as all the actors work as intended to meet the network's goal (Callon, 1986). By applying the process of translation to the Texas power grid network, I will be able to identify the primary actor, the associated goal of the network, and determine who and at what point of translation did the network fail.

ANALYSIS OF THE TEXAS POWER GRID NETWORK

Network Formation

Using Callon's process of translation, I will reconstruct a cohesive network representative of the Texas power grid system. As the independent system operator for Texas, ERCOT defines their mission to be "serving the public by ensuring a reliable grid, efficient electricity markets, open access and retail choice" (Electric Reliability Commission of Texas [ERCOT], n.d.). Therefore, ERCOT is the primary actor in the Texas power grid network with the defined network goal of providing reliable electricity to customers. The next step in problematization is to identify which actors need to be recruited to assist ERCOT in their mission. Figure 2 shows a graphical representation of the actors involved in the complex network that is the Texas power grid system.

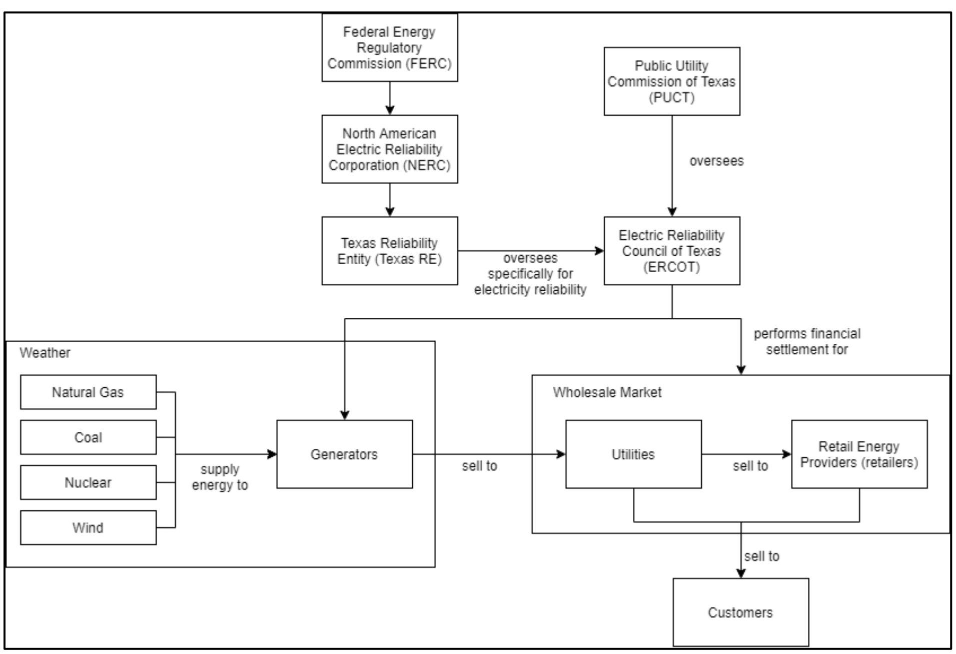

Figure 2. Texas power grid network.

Beginning with human actors, though ERCOT does not actively recruit the PUCT into the network, they are recruited through Texas Legislature that requires PUCT to regulate and oversee that ERCOT is complying with industry statutes and rules (Public Commission of Texas [PUCT], n.d.). The relationship between PUCT and ERCOT is thus regulatory in nature. Once a single actor under a regulated market scheme, utilities and generators are split into two separate actors under a deregulated market. ERCOT recruits both actors to the network as they are both essential to the mission of providing electricity to customers. Generators own and operate the actual facilities that generate electricity, such as natural gas and coal power plants, nuclear power plants, and wind turbines. Generators are considered both a human actor (i.e., the company and employees) and a non-human actor (e.g., the technical equipment, power plant infrastructure, wind turbines). Generators then sell that electricity on the wholesale market (which ERCOT manages) to utilities and retail energy providers. Utilities own and operate the transmission and distribution power lines that transport the electricity from generating facilities to customer homes. Utilities can also be considered both a human actor (i.e., the company and employees) and a non-human actor (i.e., the power lines and infrastructure). Retail energy providers volunteer to participate in a deregulated power grid network because of the potential to make profit from buying wholesale electricity and reselling retail electricity to customers just like in any other commodity market. Lastly, since the network goal is to provide electricity to customers, customers are a relevant actor in the network, but have minimal influence on the network's internal functioning.

Other auxiliary human actors in the Texas power grid network include Texas Reliability Entity (Texas RE), the Regional Entity for ERCOT under NERC, which is itself under FERC. Texas RE and NERC oversee ERCOT for electricity reliability purposes (Neville, 2011). Non-human actors included in this network are the natural resources needed to run generators, mainly natural gas, coal, nuclear, and wind, as well as weather.

Contrary to other networks, interessement under a government-regulated network is not as voluntary. Certain systems, such as healthcare, public transportation, or the electric grid require largescale implementation to function properly and efficiently and warrant government intervention. Therefore, certain actors might participate in such a network out of obligation and whose interests cannot be swayed to another network because there is no other network to join. Such actors in the Texas power grid network are the regulatory bodies of government: PUCT, Texas RE, NERC, and FERC. Nonetheless, there is some interessement that occurs in the Texas power grid network. Due to the deregulated market, generators, utilities, and retail energy providers are persuaded into the network because of the potential to make money by participating in the wholesale market. Though utilities do not make profit from operating the transmission and distribution lines, they can still purchase wholesale electricity and resell at retail rates (much like in the regulated market of the past, but now they have competition from retail energy providers). ERCOT does not need to do anything to persuade customers to align themselves with the network goal because customers are the network's subject of interest. Electricity has become an essential in today's world. Customers rely heavily on electricity and desire this service, and thus agree to participate in this network.

Defining and assigning actor roles and associations during the enrolment phase is meticulously conducted in this network due to government regulation. Roles are explicitly defined in writing through many contracts and legislature. ERCOT, the primary actor of the network in question, has protocols that "set forth the procedures and processes used by ERCOT and its market participants for the orderly functioning of the ERCOT system and market" and contain "policies for scheduling, operations, planning, reliability, and settlements, as well as ERCOT's rules, guidelines, procedures, and standards." (FERC & NERC, 2011, p. 55) Finally, mobilization occurs with the signing of contracts and the passing of legislature that puts into place the assigned roles and associations between all the human actors of the Texas power grid network.

Network Failure

During the first week of February 2011, Texas experienced unusually cold and windy weather with lows in the teens for five consecutive mornings (FERC & NERC, 2011, p.1). Given that Texas normally experiences a mild to hot climate, many of their facilities are not weatherized for such cold conditions. The majority of the problems experienced by the 210 generators that failed to properly operate during the event can be attributed to cold weather-related causes, including frozen sensing lines, frozen equipment, frozen water lines, frozen valves, and the like (FERC & NERC, 2011, p.8). The first actor to go rogue and become an adversary to the network is weather, which then impacted both the natural gas and generator technical equipment, the other non-human actors in the network. Though not given an explicitly defined role, weather in Texas is expected to behave a certain way and the network forms and functions around that expectation. However, weather is an uncontrollable, non-human actor. The other actors must utilize their defined roles to work around weather, adjusting their functions when weather becomes an adversary to ensure the stability of the network. While cold weather certainly initiated the events which eventually led to power outages across Texas, it was not the causal actor for the network's failure.

After ERCOT first encountered a severe cold weather event in 1989, PUCT recommended equipment weatherization improvements. While the generators were encouraged to winterize to better confront severe weather events (acting as adverse non-human actors in the network), these recommendations were not mandatory. Additionally, generators are not encouraged to make such investments. As opposed to how utilities make a profit in a regulated market (see Background section), Texas' energy-only deregulated market does not incentivize generators to make investments such as implementing winterization because generators do not make a profit from costly investments. Generators are encouraged to reduce cost in order to increase their profit margins since they only recover their capital costs through payments for hourly energy on the energy-only market (FERC & NERC, 2011, p.20). Given that PUCT's winterization recommendations were not mandatory, generators ultimately did not go against their original roles assigned by ERCOT; therefore, they cannot be held responsible for the Texas power grid network failure in 2011. Since the grid failure occurred at the generating facilities, utilities and retailer energy providers cannot be held as responsible actors either since they did not receive electricity from the generators to distribute and sell to customers.

Going into the cold weather event, ERCOT forecasted expected customer demand for the approaching event and compared it with its generation capacity at the time. Demand on the Texas power grid peaks during the hot summer months due to air-conditioning needs, so generators typically schedule maintenance outages during the winter months. Knowing that there would be 11,566 MW of generation capacity on scheduled maintenance, ERCOT still had full reason to believe that the generation capacity could meet demand while also having enough reserve capacity required by NERC to ensure system integrity. However, the cold weather caused many technical failures and unexpectedly knocked off much more generating capacity than ERCOT had expected. By the end of the night of February 1, ERCOT had to call in all reserve generation capacity (FERC & NERC, 2011, p.58). ERCOT did not, however, call in the generators that were on scheduled maintenance. The reserve generators also experienced the same weather-related failures and there wasn't enough capacity to preserve system frequency for the early morning of February 2. ERCOT reached the dire situation of having to shed a total load of 4000 MW to 3.2 million customers in order to avoid catastrophic system failure. Given the dire situation ERCOT found itself in, why didn't they recruit the generators that were scheduled for maintenance when they needed extra generation capacity? The following excerpt from FERC's analysis report on the 2011 event explains why:

> "ERCOT does not have the authority to prohibit generators from scheduling such outages or from taking them as scheduled…ERCOT also does not have authority under its Protocols to require generators that are on planned outage to come back into service early (assuming the generator is even in a condition to do so). Nor are there any market mechanisms to compensate generators for any costs associated with delaying or coming back early from a scheduled outage." (FERC & NERC, 2011, p.53)

As the primary actor, ERCOT is responsible for properly defining and assigning roles to themselves and the other actors in the network to ensure the network's success. As mentioned earlier, these roles are defined in official, written documents. The events of 2011 were not without precedent. In fact, the events of 2011 mirrored almost exactly the events of 1989 with the majority of the problems experienced in 2011 from failures of the very same type of equipment experienced by the very same generators back in 1989 (FERC & NERC, 2011, p.178). While ERCOT can be excused for their inability to anticipate the causes and properly respond to the events 1989, ERCOT failed to recognize the important characteristic of enrolment previously noted: **roles and associations are defined and adjusted in action**. Actor roles and associations in a network are adjusted dynamically. The "action" Callon refers to can be identified as the change in weather's role within the network. Prior to 1989, weather's role was simply a context under which the Texas power grid network functioned. Weather had never caused the network to fail before 1989. The events of 1989 proved that weather had the potential of being an adversary to the network. As the primary actor in charge of the phase of enrolment, ERCOT failed by not properly adjusting their role as grid operator in the network by assigning themselves, through written protocols, the ability to call generators back online from scheduled maintenance when needed.

CONCLUSION

In this paper, I have applied the actor-network theory framework to the Texas power grid system in order to identify the actor responsible for the events in 2011 that lead to power outages for 3.2 million people. I presented background information on Texas' unique deregulated energy market and independent electric grid in order to understand the context behind the events that transpired. A comprehensive analysis of the process of translation identified ERCOT as both the primary actor that formed the Texas power grid network and the actor responsible for the network failure in 2011. ERCOT specifically failed during the enrolment phase when they neglected to readjust actor roles and associations after the non-human actor weather had proved in 1989 to potentially be an adversary in the network. This new understanding of the Texas power grid network can help the reader be more sensitive to the importance of proper actor role definition and associations. Additionally, the analytical process I applied to the 2011 Texas power grid failure, especially in relation to the events of 1989, might be beneficial to scholars now analyzing the power grid failure that just occurred in Texas this past February 2021.

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