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Prepared For:

NRG Energy, Inc.

Economic Impact of Inadequate Generation in ERCOT – Comparison of Resource Adequacy Scenarios

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Summary

In 2003, the electricity system of Texas experienced healthy reserve margins of over 20%, a result of significant investment in new generating capacity in support of a rapid economic expansion. Just a decade later, Texas is again in a period of relatively high economic and electricity demand growth, but the electric system's reserve margin is barely satisfying the target level of 13.75%. Forecasts for the future show a drop well below the target without significant new investment. It is not clear that the needed investment will occur. Investors face headwinds in the current environment of low electricity prices driven by low gas prices, a generation fleet with many highly efficient gas plants at the margin and a large amount of wind energy, and uncertain investment returns in the Electric Reliability Council of Texas' (ERCOT's) energy-only market.

A low reserve margin is indicative of resource adequacy failures, which lead to higher frequencies of reliability events (such as power outages) and electricity price spikes. These resource adequacy issues have real economic costs that could dampen the growth prospects of the Texas economy if not addressed. As policymakers and market participants consider options for addressing the lack of capacity investment, it is important that the economic impact of resource inadequacy is top of mind. It is also important that any potential solutions be evaluated for their ability to restore adequate resources along with their costs relative to their benefits of improved reliability and more moderate electricity prices.

This study provides an economic comparison of two resource adequacy scenarios, one in which the current market rules are retained and one in which the reserve margin is made a requirement. The required reserve margin scenario is represented as implementation of a capacity market, which has been analyzed in some detail by others as the most efficient means to achieve a required reserve margin. The study is based on: 1) existing national-level studies of the economic costs of reliability events, 2) existing forecasts of resource adequacy and energy costs made by ERCOT and its consultant, The Brattle Group, and 3) customized economic modeling that applies the national sector-level cost estimates to the Texas economy.

We find that assuring the reserve margin with an efficient mechanism has a substantial net economic benefit compared to existing market rules. In a representative forecast of the next fifteen years, having a capacity market saves the state $14 billion in Gross State Product (GSP) losses. In extreme weather years similar to 2011, having a capacity market saves the state over 58,000 jobs. We recognize that higher levels of reliability are not free; the cited results net the cost of capacity payments to induce higher reserves against the saving in energy and outage costs. Moreover, consistent with sound market design, we assume that all capacity – old and new, demand-side and generation – is paid on an equivalent basis for its contribution to reliability. Our analysis likely underestimates the full value to the state economy of achieving resource adequacy as it does not quantify two key types of impacts: businesses locating elsewhere due to expectations of future reliability problems and the impacts of power quality (as distinct from actual outages) on quality-sensitive customers, such as high technology facilities.

The Texas Electricity System is Facing Resource Inadequacy in the Coming Years

ERCOT experienced a major expansion in total generating capacity in the early 2000s due to new generation development, expansion of existing sites, and upgrading or repowering units. From 1999 to 2009, over 138 new plants and 279 units were added to the system, a rate of over 25 units per year.[1] Since this generation expansion period, investment has stalled. In 2010 and 2011, only 9 units were added, a rate of 4.5 per year.[2]

This lack of new investment at a time of robust load growth has led to significant concerns about future resource inadequacy in ERCOT. In 2012, ERCOT's Capacity, Demand, and Reserves (CDR) report estimated reserve margins dipping below 10% by 2014.[3] This is far below the target margin of 13.75%, a level which The Brattle Group estimates to be too low to achieve desired reliability levels since its validity assumes that weather as extreme as what occurred in 2011 will never happen again. While recent announcements of two new plants projected to come online in 2014 have bumped the estimated 2014 reserve margin up to the target level, the 2013 CDR report shows drastically reducing reserve margins over time unless significant new and currently unplanned generation is built.[4] The overall mid- to long-term story is expected be the same or still worse after ERCOT potentially updates the reserve margin calculations and increases target levels later this summer.

The ERCOT Reserve Margin Will Fall Well Below the 13.75% Target without New Investments [3]

[1] ERCOT, "Report on Existing and Potential Electric System Constraints and Needs," December 2009.

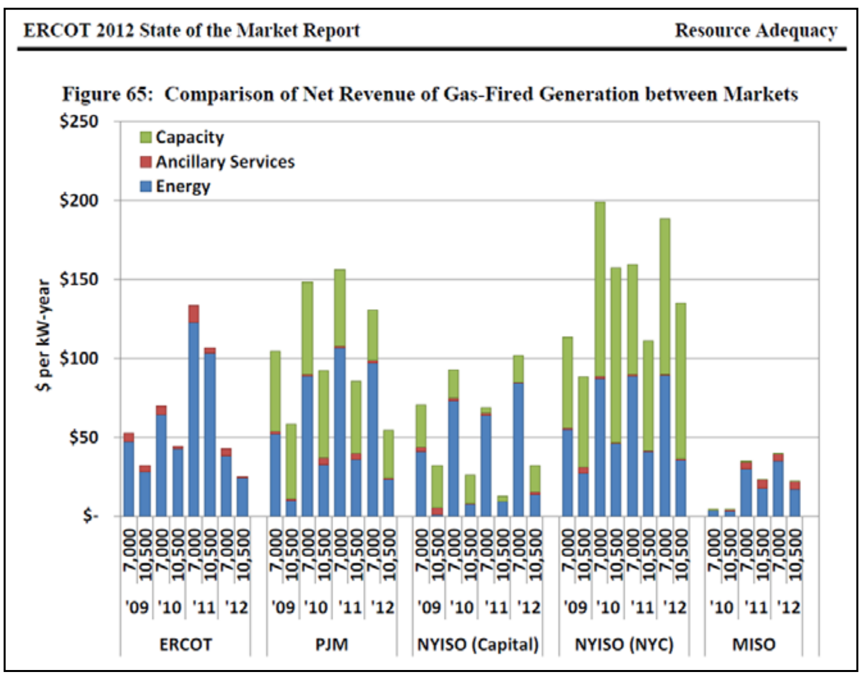
[2] ERCOT, "Report on Existing and Potential Electric System Constraints and Needs," December 2011.

[3] ERCOT, "Report on the Capacity, Demand, and Reserves in the ERCOT Region," May 2012.

[4] ERCOT, "Report on the Capacity, Demand, and Reserves in the ERCOT Region," May 2013.

Generation owners cite a variety of impediments to new investment, such as 1) insufficient energy revenues, 2) market and price distortions driven by incentives for renewables and related new transmission, 3) current regulatory uncertainty, 4) highly uncertain scarcity-related revenues, and 5) impaired liquidity in hedging markets due to extreme volatility. Average electricity prices have been relatively low for several years due to high efficiency gas generators running on exceptionally low priced natural gas and an increase in generation from low variable cost renewables, particularly wind. This has led to a situation in which returns for most new generation investments are estimated to be substantially below required levels. The ERCOT Market Monitor's recent report on the State of the Market[5] ("ERCOT SOM Study") provides an informative analysis of returns for a new gas-fired generator in ERCOT compared to several other markets in the United States. The 2012 revenue of $25 per kW-year for a new gas-fired combustion turbine plant in ERCOT is well below the estimated requirement of $80-$105 per kW-year. The same is true for a combined cycle unit, receiving $42 per kW-year while having a requirement of $105-$135 per kW-year. The following chart is an excerpt from the ERCOT SOM Study.

New Generation Investments in ERCOT Are Unlikely Given Current Revenue Expectations



The chart demonstrates that inadequate returns for new generation are not unique to ERCOT. Other markets also are revenue inadequate, notably the over-supplied MISO and upstate New York markets. However, these other markets have substantial excess capacity, so market signals that do not cause new capacity to be built are appropriate. What is unique to ERCOT is the persistence of revenue inadequacy for new generation capacity at a time when there is an urgent need to construct new capacity. The chart also demonstrates that net

5 ERCOT, "2012 State of the Market Report for the ERCOT Wholesale Electricity Markets," prepared by Potomac Economics, June 2013.

revenues in ERCOT are highly variable, with revenues depending on the number of occasions in which supplies are so tight that prices are orders of magnitude above normal levels for brief periods. Over the four-year period from 2009 to 2012, peaker net revenues range from about $25 per kW-year to more than $125 per kW-year.

Net revenues clearly are insufficient to support new generation in a typical year with the current ERCOT market design. New investments would have to be made based on expectations of either drastically increasing typical year net margins, which are not likely given current gas price forecasts, or reliance on the still greater impact of extreme years on power prices. While the PUCT-approved increasing of the ERCOT system-wide offer cap (SWOC) provides increased revenues during such extreme years, analysis by the ERCOT Market Monitor and in the ERCOT-commissioned study on Investment Incentives and Resource Adequacy ("ERCOT RA Study") [6] suggest that this will not spur enough investment to meet target reserve margins. A more recent study of the latest proposed market rules came to the same conclusion.[7]

One of the concerns raised by potential investors in new generation is that an ERCOT market that achieves revenue adequacy "on average" by increasing shortage prices will not allow projects to be financed at reasonable costs. This need for predictable returns sufficient to support large investments in industries facing uncertain and potentially highly variable future prices is not unique to the electricity sector. For example, there are active projects that, if permitted, will result in several multi-billion dollar investments in liquefaction terminals that will export US natural gas to demand centers around the world. While the price differentials between the US and potential buying countries appear attractive for the foreseeable future, the investors in these terminals are relying on long-term contracts to provide revenue predictability.

There are Policies that are Effective in Achieving Target Reserve Levels

As mentioned, the PUCT has taken steps in the past year to improve revenue adequacy. These have consisted primarily of increases in the offer caps, the effect of which is to increase prices when operating reserves fall to perilously low levels. Further measures are being considered that would broaden somewhat the range of reserve conditions in which scarcity prices would be paid, at least partially. However, there is no assurance that such measures are sufficient. Various studies performed or commissioned by ERCOT demonstrate that they will only meaningfully impact revenue (and hence resource) adequacy in unusually

[6] Samuel Newell, et al. "ERCOT Investment Incentives and Resource Adequacy," The Brattle Group, prepared for ERCOT, 1 June 2012.

[7] Sam Newell and Mike DeLucia, "Additional ORDC B+ Economic Equilibrium Planning Reserve Margin Estimates," The Brattle Group, prepared for ERCOT, July 2013.

adverse weather years such as 2011. Even very high offer caps and relatively broad ranges of reserve conditions in which they are applied will not motivate sufficient new capacity to create resource adequacy as measured either by the currently effective 13.75% reserve target or the one in ten year reliability standard the reserve target is intended to meet.[8] Further, the Independent Market Monitor and others have observed that artificially extending the range of conditions in which scarcity prices are produced creates market inefficiencies arising from "false scarcity." Other commenters have noted that unpredictable and highly variable annual net revenues are inefficient in supporting generation since the cost of capital will be unnecessarily high. However, the core failing of the approach being taken in ERCOT is that it does not mandate that a given reserve margin level will be met, but rather sets a target and seeks to create incentives sufficient for suppliers to take the individual actions that will achieve resource adequacy but not create uneconomic surpluses. History demonstrates that there is no assurance that this result will occur; its success requires a serendipitously correct forecast of the right level of incentive.

The traditional means of achieving electric generation resource adequacy is to mandate a required level of reserves that each load serving entity (retail electricity supplier) must demonstrate that it will meet, either through self-builds or contracts with third party generators. This method became difficult to implement with the vertical de-integration of investor-owned electric utilities and the creation of open retail competition making the size and duration of reserve obligations unpredictable for individual retail suppliers.

The alternative model adopted in most of the US markets in which vertical de-integration and retail access exist is one in which there is a mandated reserve margin (adjusted to reflect outage rates and in some cases allowing a tradeoff between higher reserves and lower costs). This model relies on competitive market incentives to elicit new construction and demand response and to maintain existing economic capacity. The mechanism used to achieve needed capacity levels is a forward centralized capacity market in which the RTO oversees a capacity auction and retail suppliers either must buy or are allocated their pro rata share of capacity. Forward looking capacity markets, which many regard as preferable, use subsequent interim markets to true-up retail suppliers' obligations to their served load. Such markets retain the voluntary nature of building new capacity that exists currently in ERCOT. The key difference is that there is a long-term capacity price to provide the revenues needed to support the mandated reserve margin that are not available from the energy and ancillary services markets. The prices paid for capacity adjust automatically as a function of reserve levels, such that there is a strong incentive to build needed new capacity and a much weaker incentive to build and retain capacity when it is in surplus.

[8] A June 27, 2013 Brattle Group report, "ORDC B+ Economic Equilibrium Planning Reserve Margin Estimates" notes that the currently planned SWOC and Power Balance Penalty Curve will support an equilibrium reserve margin of approximately 9.2%. The modification of the curve in the "B+ proposal under consideration by the PUCT could increase or decrease it depending on the length of the curve ("X" in the Brattle report) and the extent to which off-line suppliers respond to shortage or near-shortage prices. A small value of X (1375 MW) actually reduced net revenues relative to the existing policy. A higher value of X (2300 MW) would increase it to a range of 10.2% to 13.9%. While this range includes the current target reserve, achieving the upper end of the range requires that suppliers are wholly unresponsive to near term price signals, an assumption that Brattle states is unlikely to be borne out.

All of the existing capacity markets have complex rules for quantifying the amount of capacity value that is attributed to a particular generation or demand side resource. Broadly, its value is a function of its predictable availability at times of system stress. These capacity markets pay the same price for equivalent existing and new capacity.[9] This is consistent with how other markets work: the "law of one price" is that a product has the same value to consumers irrespective of its source. Violation of this rule creates a slippery slope in which existing capacity is held hostage and in many cases requires one-off fixes to keep it open. The ERCOT RA Study addresses this issue: "Trying to differentiate either energy or capacity payments based on a unit's age or environmental characteristics would be inconsistent with a market approach in which all resources sell the same product. Paying new generation higher prices would lead to higher costs, for example when new plants are more expensive than retrofitting existing plants."[10] Recent developments in RTO market rules and FERC policy are intended to block actions that pay above market prices to new capacity in order to drive down prices to existing capacity.

While it is not our intention to advocate for a particular approach to resource adequacy in this paper, the foregoing does illustrate that there are approaches that would address resource adequacy in ERCOT that are demonstrated to be effective. Throughout this study, we evaluated a capacity market as an efficient alternative to current market rules when evaluating potential resource inadequacy issues. This comparison has also been made by The Brattle Group in their study of the Customer Costs for an energy-only market and a 14% reserve margin requirement.[11]

Resource Inadequacy Leads to Reliability Events and Electricity Price Impacts

Low reserve margins are a concern because they increase the probability that high loads (perhaps resulting from unusual peak temperatures) and/or unusually high levels of generation unavailability will lead to outages, voltage fluctuations and, particularly in the ERCOT market, very high prices. For example, the North American Electric Reliability Corporation (NERC) stated in its 2013 Summer Reliability Assessment:[12]

> *Sustained extreme weather could be a threat to supply adequacy this summer. ERCOT may need to declare Energy Emergency Alerts (EEA) if there are*

[9] There are some non-price terms that can vary. For example, PJM allows new capacity to lock in the competitive capacity price determined in an auction for a few years, rather than just the single year available to existing capacity.

[10] Samuel Newell, et al. "ERCOT Investment Incentives and Resource Adequacy," The Brattle Group, prepared for ERCOT, 1 June 2012., p. 116.

[11] Sam Newell, "Customer Cost Comparison," Filed by ERCOT with the PUCT, September 2012.

[12] NERC, "2013 Summer Reliability Assessment," May 2013.

> *higher-than-normal forced generation outages or if record-breaking weather conditions similar to the summer of 2011 lead to higher-than-expected peak demands. Insufficient reserves during peak hours could lead to increased risk of entering emergency operating conditions, including the possibility of curtailment of interruptible load and even rotating outages of firm load.*

Notably, this warning was made notwithstanding that it was based on the expectation that the 2013 ERCOT reserve margin would be only slightly below target levels.

The most noticeable consequence of resource inadequacy is increased frequency, duration and scale of power outages. ERCOT's recently released Loss of Load Study ("ERCOT LOL Study") provides estimates of outages and their characteristics for 2014 and 2016.[13] The estimates vary significantly based on the expected reserve margins. For example, a 2.6% reduction in reserve margin in 2016 is estimated to double the number of events and triple the expected amount of unserved energy.[14] The ERCOT RA Study also estimates future outage events. It shows how an extreme weather year will cause very significant outages even with a high SWOC.

The reserve margin is only one of several metrics that deserves attention when considering resource adequacy. One increasing concern for ERCOT is the age and condition of the portion of its generation fleet that will be relied upon more frequently as the reserve margin decreases. New generation assets generally displace older units that are often more susceptible to outages. Low levels of new construction not only reduce the reserve margin, they further reduce reliability because old units are not retired. This is especially true when the "new" generation brought online is really vintage units brought out of mothball status as has occurred recently in ERCOT. A third of the operating on-grid fleet in Texas is over 30 years old.[15]

Unreliability is only one source of impacts of reserve inadequacy on the Texas economy. Resource inadequacy also causes spikes in electricity prices. Highly volatile prices increase the cost of production for businesses and reduce the real incomes of consumers. Lower reliability will increase prices during periods of low operating reserves (usually, near peak conditions). This is especially the case in the ERCOT market in which prices increase to very high levels during shortage or near-shortage conditions. This occurs in normal weather years but is especially severe in extreme weather years. For some customers, the impact of such prices is immediate. Others are shielded by fixed price contacts. However, this saving is only temporary. The increased hedging costs due to highly variable wholesale prices will be reflected in retail service providers costs and will be passed on to electricity consumers served at fixed prices.

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[13] ECCO International, "2012 ERCOT Loss of Load Study: Study Results," for ERCOT, March 8, 2013.

[14] Unserved energy is the amount of electricity that is demanded but cannot be supplied. This is a common resource adequacy metric. It is presented in the ERCOT LOL Study as Expected Unserved Energy (EUE), measured in MWh/yr.

[15] CRA analysis of Energy Velocity data, as of June 2013.

Studies Show Significant Impacts of Reliability Events on Economic Sectors

To understand the true cost of unreliability (abstracting, for now, from the impact of high prices), the loss of load hours and unserved energy estimates must be converted to economic impact estimates. This is not a simple conversion, and there are only a few well-regarded studies that have made such an attempt. Such studies are generally based on extensive surveys of electricity consumers. The conversion is made difficult by the variability in types of events, event durations, amount of warning, location, and, most importantly, the characteristics of the affected load.

Different segments of the economy have differing costs of outages. For businesses, the main characteristics affecting the outage costs include: electricity intensity of operations, size of firm or facilities, sensitivity of equipment to reliability events, and ability to pass-through production costs. The size of the business is the differentiator most often used by studies. Size is a key variable in the study we selected to guide our cost estimates, a 2009 study by the Department of Energy's (DOE's) Lawrence Berkeley National Laboratory (LBNL).[16] The study shows that larger size firms have the highest costs per outage event. However, these are also the firms most likely to invest in backup generation or other demand response measures to mitigate the impacts of outages. Our analysis for the commercial and industrial sectors was therefore based on LBNL's estimates of costs for medium and small firms.

Residential customers also incur economic costs of outage events, though primarily through indirect impacts, such as decreased wages or employment levels in the commercial and industrial sectors. Residents are also exposed to the less quantifiable human health and comfort impacts, particularly since many outages occur during extreme weather. Our analysis takes no account of such costs.

In addition to outage cost exposure, all sectors of the Texas economy are exposed to impacts of volatile electricity prices, though to varying levels. As with outage costs, large firms are often hedged or have their exposure limited to their backup generation costs. Small firms and residents may be on either variable or fixed rate plans, but, as noted previously, all are eventually impacted if reserve margins are low enough to trigger frequent price spikes.

The Texas Economy Will Experience Less Growth and More Unemployment without an Adequate Reserve Margin

To understand the impacts of resource inadequacy on the Texas economy and how they might be mitigated by a capacity market, we evaluated outage related costs for both an Energy Only scenario and an Energy Plus Capacity scenario. While outage-related costs can

[16] Sullivan et al., "Estimated Value of Service Reliability for Electric Utility Customers in the United States," Lawrence Berkeley National Laboratory, prepared for DOE, June 2009.

be examined separately, our analysis also took into account costs related to achieving higher reserve levels and the related price impacts in the Energy Plus Capacity scenario. Our analysis was based on an example forecast for the next fifteen years, to account for variability in weather. To show the effects of extreme weather, we assumed that one year, 2020, had extreme weather that essentially replicated the conditions in 2011. All other years were assumed to have normal weather. Showing such a weather excursion allowed us to model how the economy adjusts over time to resource inadequacy, including to weather excursions. Obviously the choice of 2020 as the extreme year is not intended as a forecast.

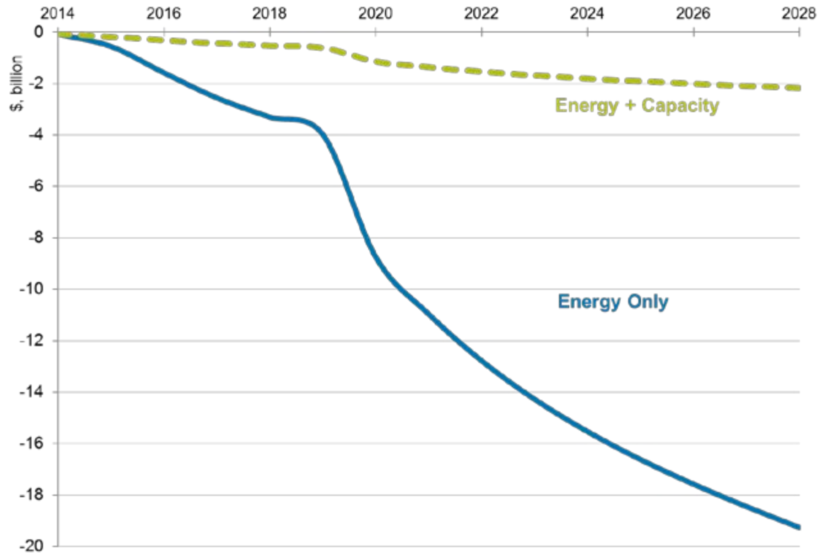
Our analysis was conducted using the state of the art economic modeling tool REMI, developed by Regional Economic Models, Inc. The model captures the indirect impacts of costs to businesses and households. It does so dynamically and with the ability to change factors of production, which actually can reduce the estimated impacts by allowing industries to shift away from electricity use when prices rise. Using this model we estimated impacts to the Texas economy, including GSP, employment levels, and other macroeconomic factors, such as household income.

We focused on outage costs and electricity cost impacts separately. For outage costs, we first combined the estimates from existing studies for outage costs per event and by firm size with data on the Texas economy to estimate the direct outage costs to the economy. For example, we calculated a per event cost to the total Texas economy ranging from $274 million to $507 million for an average event (about 3 hours).

To determine the number of outages in a given year for each scenario, we relied upon the ERCOT LOL Study (for 2014-2016) and the ERCOT RA Study (for 2017-2028). The two scenarios were assumed to have the same outages in 2014 as the capacity market is assumed to lead to investments starting later in that year. We assume the Energy Only market reaches the Brattle-estimated long run equilibrium reserve margin of about 8-9% after several years. By contrast, we estimate the outages in the Energy Plus Capacity scenario will be more in line with the ERCOT LOL Study's estimates for a 13.5% reserve margin, which reduces the outage costs. The ERCOT LOL Study estimates outage events are reduced by 90% when moving from an 8.4% reserve margin to a 13.5% reserve margin and this guided our use of the ERCOT RA Study's estimates for average and extreme years after 2016. The following figure shows a comparison of outage cost impacts on Texas GSP[17] under the two scenarios.

[17] The REMI modeling used the structure of the entire Texas economy in estimating impacts. ERCOT is not the whole of Texas. However, since the loss of load is scaled only to what occurs in ERCOT, the impact of outages on GSP and other measures is scaled down to approximate the ERCOT portion of Texas.

Cumulative Outage Costs are over $17 Billion Lower with a Capacity Market



The other main part of the evaluation of resource inadequacy and potential solutions is the impact on customer electricity costs. We set the Energy Only scenario as the baseline for comparison. In most years, an Energy Plus Capacity scenario will have higher costs associated with capacity payments. In extreme years, the Energy Only scenario may have higher costs as scarcity pricing will become more prevalent due to resource inadequacy. We evaluated both of these effects.

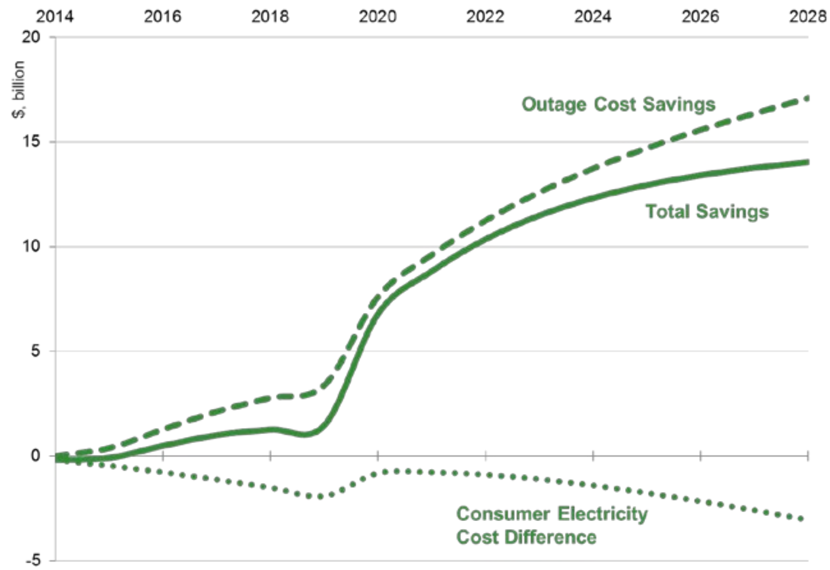
The two main sources of electricity and capacity cost estimates are Brattle Group presentations. The first is the Customer Cost Comparison memorandum that includes a table comparing energy and capacity costs under the two main scenarios. The table indicates that, in an average year, the Energy Only scenario results in $18.3 billion in energy costs and $0 billion in capacity costs. The Energy Plus Capacity scenario results in $14 billion in energy costs and $4.7 billion in capacity costs. The $400 million difference in total costs ($18.7 - $18.3 billion) is the additional customer cost in an average year of a capacity market with a 14% reserve margin target.

For the representative extreme year, we relied on Brattle's comparison of energy costs in an average year to a 2011 weather year.[18] Their estimate for an extreme year was $10 billion higher than an average year for an energy only market with a high SWOC. For a scenario with a capacity market implemented and a high SWOC, the costs were $3 billion higher than an average year. Thus, the capacity market saves customers $7 billion (less the capacity cost of $400 million) in an extreme year.

18 Sam Newell, "Resource Adequacy in ERCOT: 'Composite' Policy Options," Prepared for the Public Utilities Commission of Texas, 25 October 2012. ; filed 19 October 2012.

Examining outage cost impacts and electricity cost impacts together give a more comprehensive view of resource adequacy issues and their potential mitigation through a capacity market. The figure below shows how the additional customer costs associated with capacity costs are far outweighed by outage cost savings and customer cost savings in extreme years, which will be required to produce pricing outcomes that spur investment. The solid line represents overall GSP savings from a capacity market.

Cumulative GSP Savings Total $14 billion by 2028



The other key macroeconomic factor considered was employment. Texas has kept its unemployment rate below the national level, lowering its unemployment rate to 6.4%, compared to a national rate of 7.5%.[19] It has done so through high employment growth to keep up with its increasing labor force. In the past year the Texas economy added over 320,000 jobs. We estimate that the state will need to add an average of over 250,000 jobs per year through 2020 to keep its current unemployment rate. In the extreme weather year of 2020, our analysis shows that resource inadequacy could lead to a loss of 58,000 more jobs in the Energy Only scenario than the Energy Plus Capacity scenario. Over the fifteen year period, the Energy Only scenario leads to 137,000 fewer person-years of employment than the Energy Plus Capacity scenario.

In addition to lost employment, we also estimated income impacts arising from resource inadequacy. By 2016, assuming average weather years, the average Texas household will have $128 less real income per year in the Energy Only scenario due to outages alone. In our extreme weather year, we calculate an income reduction of $644 per household in the Energy Only scenario. In the Energy Plus Capacity scenario, the income loss due to capacity costs is

[19] Bureau of Labor Statistics, Regional and State Employment and Unemployment Summary, 17 May 2013.

actually less than the positive income impact of the electricity price savings that result from avoided scarcity pricing.

The impacts we present likely underestimate impacts of reliability events over multiple years. In addition to "per event" outage costs, the Texas economy is exposed to long-term impacts resulting from firms' production and investment decisions that are driven by long-term reliability expectations. Firms with existing operations can choose to shift a share of production to facilities in other markets, or simply move operations altogether. Businesses often include power reliability in their investment decisions related to production expansion or location of new facilities. For example, as shown in Appendix B, even a single data center locating elsewhere costs the state an average of 1,250 jobs. Relatedly, reliability considerations may impact supply chain decisions, particularly with "just in time" inventory policies. Our analysis looks only at the costs arising directly from reliability events that are assumed to have occurred in the forecast. This ignores the impact of diminished reliability expectations that impact business location decisions. We did not quantify these impacts, which could potentially be greater than the impacts we did model in this study. Including these costs would further tilt the economics in favor of the Energy Plus Capacity scenario.

1. Introduction

Charles River Associates (CRA) was retained by NRG Energy, Inc. (NRG) to assess the economic impacts of potential resource inadequacy in the Electric Reliability Council of Texas's (ERCOT's) electricity market. We were asked to evaluate how the Texas economy would fare under a scenario in which generation capacity is not developed sufficiently to prevent the reliability events, such as load shedding, occurring at rates in excess of the planned one day in 10 year rate. We were also asked to examine a scenario in which the reserve margin becomes a requirement and an efficient solution, in the form of a capacity market, is implemented to address resource inadequacy. The study is designed to inform policymakers and the public of the breadth and degree of economic impacts that represent the costs of not ensuring adequate investment incentives for new capacity. It also compares these costs to the cost of implementing a required reserve level to address resource inadequacy.

Our analysis relies heavily on existing literature on the nature of the ERCOT reliability problem, the related impact on the Texas economy, and the impact of implementing a capacity market. The study concentrates on a set of three key questions critical to understanding the economic impacts of resource inadequacy in Texas:

1. **What are the segments of the Texas economy most exposed to reliability events?** *(Section 2)*

   Texas has a diverse economy with industries that are variably exposed to reliability issues. Some of the most energy-intensive industries are actually less exposed than other industries due to hedging, to adjusting the timing of electricity consumption, and to substantial amounts of self-generation. It is the small and medium sized commercial and industrial customers that are most exposed in the Texas business community. We also identified several specific industries that are highly sensitive to electricity outages due to their high reliability requirements and their high values of lost load (VOLL). Residential customers, often the first targets of load shedding activities and among the least able to respond to price changes, are another key segment of the economy that we considered.

2. **What are the expected scale, duration and frequency of reliability events and the levels of price volatility likely to result from underinvestment in new ERCOT capacity?** *(Section 3)*

   It has been well-publicized that the ERCOT market is facing declining reserve margins as load grows, some existing capacity retires and new investment in capacity is not keeping pace. ERCOT has estimated its reserve margins will shrink to 10% by 2016, well below its current reliability target of 13.75%. A resource adequacy study conducted for ERCOT by The Brattle Group ("ERCOT RA Study") has estimated long-term reserve margins likely attainable under existing policies will be between 6-10%.[20] Even ERCOT's own Capacity, Demand and Reserve (CDR) report forecasts reserve margins dropping below 5% in the next decade without significant new investment.[21] Low reserve margins translate to higher likelihood of reliability events, such as load shedding. We rely on existing literature, including ERCOT's recent Loss of Load Study ("ERCOT LOL Study")[22] and the ERCOT RA Study, to estimate the scale, duration and frequency of reliability events.

3. **What are the industry-level, household-level and overall economic impacts of expected resource inadequacy in Texas under current market rules versus with a capacity market?** *(Section 4)*

Reliability events have significant economic consequences, both in the segments of the economy directly exposed to the events, as well as elsewhere in the economy due to ripple effects through supply chains and in the labor market. We calculated total economic impacts, in terms of employment and GSP, for a representative forecast of the next 15 years that includes both average and atypical weather years. We analyzed two scenarios: one in which the current market rules prevail ("Energy Only") and one in which a forward capacity market is implemented ("Energy Plus Capacity").

The impacts were calculated through economic modeling. We found that over the next 15 years, a functioning capacity market prevents the loss of over $14 billion in GSP, net of cost. With current market rules prevailing, resource inadequacy could lead to a loss of up to 58,000 more jobs in an extreme weather year than if a capacity market were implemented. With a capacity market in place, the 15-year total job loss could be reduced by more than 137,000 job years.

[20] Samuel Newell, et al. "ERCOT Investment Incentives and Resource Adequacy," The Brattle Group, prepared for ERCOT, 1 June 2012.

[21] ERCOT, "Report on the Capacity, Demand, and Reserves in the ERCOT Region," May 2013.

[22] ECCO International, "2012 ERCOT Loss of Load Study: Study Results," for ERCOT, March 8, 2013.

2. The Texas Economy's Exposure to Resource Inadequacy

This section of the report begins by discussing the ways in which commercial and industrial firms (2.1) and residential customers (2.2) are exposed to both reliability events and increases in electricity prices. We then provide a background on the Texas economy and its growth trajectory (2.3), which helps inform a discussion of which industries in Texas are most exposed to reliability events and increases in electricity prices (2.4).

2.1. Commercial and Industrial Exposure

Each business operating in Texas has a different level of exposure to electricity reliability and pricing issues. The levels of exposure are driven by a variety of industry and firm-level characteristics, such as:

- **Electricity intensity of operations.** Generally, firms for which electricity costs are a high percentage of production costs are more exposed to price impacts. A business' exposure to outage costs may be less dependent on its level of electricity expenditures, and more dependent on the productivity of electricity in its operations. For example, electricity costs represent about 1.5% of the average restaurant's production costs,[23] yet significant outages could have much greater impacts to the restaurants' operations due to spoilage, lost business and costs for unproductive labor.

- **Size of firm.** While large firms spend more on electricity and have higher values of lost load, they are also the least exposed to price spikes and reliability events as they are more likely to have more sophisticated electricity buying operations and are invested in backup generation options. Large firms are often not exposed to rolling outages as they are either protected through outage plans by their electricity providers or are connected directly to high voltage grids and are not called upon to shed load as much as other customers that are connected to the distribution system. It is therefore the small and medium sized firms that experience the highest outage costs for reliability events and price spikes. While Retail Electric Providers (REPs) in Texas have made efforts to mitigate some of the price volatility risks for their small business and residential customers, the options are limited until major technological advances and upfront capital expenditures are made on the demand side. The REPs cannot directly mitigate the outage cost risk for their customers.

- **Sensitivity of equipment to reliability events.** Advanced manufacturing machinery and many digital economy support systems can be highly sensitive to both power quality and availability issues. Businesses dependent on these machines and systems could be exposed to lost production and repair costs resulting from reliability

[23] REMI data, based on Bureau of Economic Analysis' industry Input-Output tables.

events. Many of these firms may also be exposed to high restart costs if their machines and systems shut-off when voltage sags or power is briefly lost.

- **Ability to pass through costs.** Firms in Texas compete in local, state, national and international markets. They may have differentiated or commodity products with a variety of transportation costs and expected margins. Some firms can pass on outage costs to consumers, while most cannot.

- **Utilization of Electricity Consuming Resources.** While some firms operate at full capacity year-round, others may have lower utilization of resources and can work around outages or make up lost production more easily.

Business Outage Impacts

The different ways in which commercial and industrial firms are affected by power outages have been studied extensively, particularly in the 1980s and 1990s in the United States and more recently in developing countries and other countries dealing with major power issues. As with levels of exposure to outage costs, types of outage impacts also vary by industry and firm. These impacts all lead to outage costs, which are discussed in Section 4.2. Table 1 is a list of the types of impacts to firms.

Table 1: Types of Outage Impacts, Commercial and Industrial Firms

	Type of Outage Impacts[24]		
Direct	Opportunity cost of idle resources	Shutdown and restart costs	Spoilage
	Damage to systems and machinery	Health and safety effects	Lost sales/production
Indirect	Supply chain delays and cost increases	Lost sales to affected customers	

Source: Munasinghe and Sanghvi, CRA analysis

In addition to "per event" outage costs, the Texas economy is exposed to long-term costs resulting from firms' production and investment decisions that are driven by long-term reliability expectations. Firms with existing operations can choose to shift a share of production to facilities in other markets, or simply move operations altogether. Businesses often include power reliability in their investment decisions related to production expansion or location of new facilities. Firms may also adjust their supply chains, moving vulnerable portions out of state. For example, a recent study found that industrial firms in China with

[24] Relies heavily on: Munasinghe, M., and A. P. Sanghvi, "Reliability of Electricity Supply, Outage Costs and Value of Service: An Overview." Energy Journal, 9. 1988.

long-term expected outages did not adopt backup generation at expected levels, but rather shifted factors of production elsewhere, including going from “make” to “buy” for materials.[25] This type of phenomenon would have large supply chain impacts if seen in Texas. While large industrial firms may avoid many direct outage costs, they may shift some of their supply chain and intermediate business activities out-of-state.

Business Electricity Price Impacts

In electricity markets that have high scarcity prices but inadequate generation capacity to meet required reserve margins, some outages may be prevented by reducing near-peak outages and through load suppression, but peak electricity prices will generally be higher and more frequent, especially during extreme weather years than in markets with lower scarcity prices. Many large firms are able to hedge these costs (at a price). Small and medium businesses are not as capable of managing price spikes, both due to a lack of hedging experience and a lack of technology allowing near real-time response to increased prices. REPs can manage risks on their customers’ behalf (at a price), but the more volatile prices are, the harder and more expensive it is to hedge scarcity-related price risks in the ERCOT energy market. Texas does have some programs aimed at helping smaller businesses achieve demand response activities, but these programs are estimated to take several years, if not decades, to implement at scale. In the meantime, the businesses remain exposed to electricity price increases.

Prices are also impacted by increased electric system costs related to resource inadequacy. Reduced reserve margins limit the flexibility of system operators to control transmission congestion through unit redispatch. This reduced system flexibility increases the need for transmission upgrades to resolve system congestion.[26] The upgrade costs are ultimately passed to consumers. We do not reflect such costs in our analysis.

2.2. Residential Exposure

As with the commercial and industrial sectors, households in Texas have varying levels of exposure to outage events and electricity prices due to several factors. These include location, number of occupants, presence of individuals with health conditions, energy consumption, and access to alternate forms of power. The variation in costs of exposure to outage risk is lower than in the commercial and industrial sectors.

[25] Fisher-Vanden, Mansur and Wang, “Costly Blackouts? Measuring Productivity and Environmental Effects of Electricity Shortages,” National Bureau of Economic Research, January 2012.

[26] ERCOT, “ERCOT Long-Term System Assessment,” 28 December 2012.

Residential Outage Impacts

Because households as such are not directly productive segments of the economy, the per event outage costs to residential customers are not particularly high. There are a growing number of exceptions to this due to an increase in at-home participation in the digital economy. However, the main residential direct consequences of an outage event are health and comfort related, particularly as shortage events in Texas are most likely when temperatures are very high. The majority of household economic losses from outage events is indirect and is captured in commercial and industrial impacts. The primary residential impacts are in the form of both decreased income and employment levels resulting from business impacts. There are residential economic costs for household backup generation and other such expenses, but these are less important than the indirect income and employment costs.

Residential Electricity Price Impacts

The residential sector is generally not as directly exposed to the price impacts of resource inadequacy related events in the short term. A large number of residential customers are on fixed rate plans of six months to a year or more, and are thus insulated from short-term price swings. Many REPs do offer variable and indexed rates which are influenced by price spikes. Many Texas households have selected these variable and indexed rates to take advantage of low initial prices. These customers are the most exposed to reliability events that cause price spikes and the resulting impacts on retail product pricing.

Contract prices in a market with resource inadequacy will be higher than if there is a much lower risk of price excursions. Hedging the risk of prices rising by orders of magnitude is expensive, whether the hedge is via a financial product or imbedded in bilateral contracts with generators. Hedging shifts but does not eliminate the risks and the hedge provider must be compensated for taking the risks and bearing the cost of price excursions. Necessarily, these costs will impact the prices of fixed price contracts that shield customers from directly paying real time prices.

The approximately 25% of Texas' residential customers that are served by electric cooperatives and city-owned utilities do not participate in the competitive market but are still exposed to price impacts. Many municipal electricity suppliers have Power Supply Agreements (PSAs) that allow pass-through of over and under-recovery due to energy cost changes. Their wholesale contract prices are also impacted by the cost of hedging and bilateral purchases of electricity similar to costs borne by competitive retail providers. While such customers may be somewhat insulated from the cost of unreliability in the near term, their suppliers' costs ultimately will reflect market levels. Moreover, transmission-system level outages do not discriminate between such customers and others.

Households are also less able to manage price risks through consumption behavior than large commercial and industrial firms that have time-of-use pricing and experience in responding to real-time price signals. There are several pilot programs to change this, some of which have established small amounts of callable residential load, such as cycling of thermostats during scarcity periods. This does not represent a large portion of the residential sector's electricity consumption and likely will not for the foreseeable future. This remains true despite the high penetration of advanced meters in Texas.

The primary economic impact of higher electricity prices in the residential sector is a reduction in real disposable income of households. This reduces their consumption and hence the demand for products and services in other sectors of the economy. This has a ripple effect throughout the Texas economy that our analysis seeks to capture.

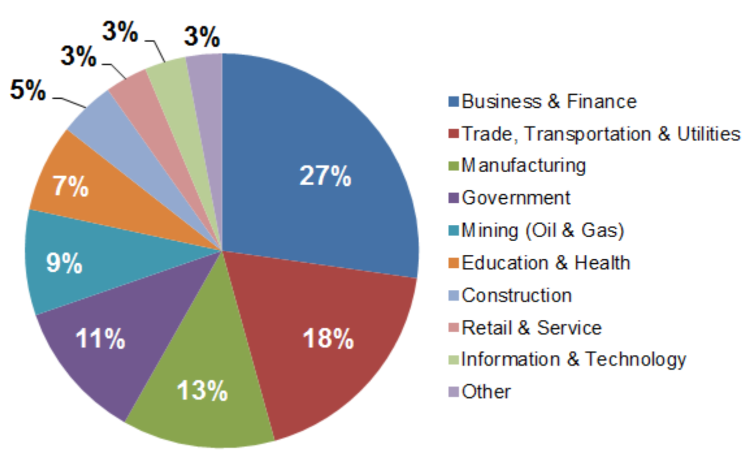
2.3. Background on the Texas Economy

It is important to understand the composition and trajectory of the state economy to understand its exposure to resource inadequacy. This sub-section presents some leading macroeconomic indicators for the economy and discusses the industries and types of firms that are contributing to the economy's growth. We focus on GSP and employment.

Gross State Product

The Texas economy has fared well in the past few years compared to the national economy. From 2008 to 2012, the US GDP grew at an average annual rate of 0.8% while the Texas GSP grew at an average annual rate of 2.1%.. Despite a well-known presence of heavy industry, the economy is fairly diverse. Figure 1 shows the sectoral contribution to Texas GSP in 2012.

Figure 1: Contribution to Texas GSP by Sector, 2012

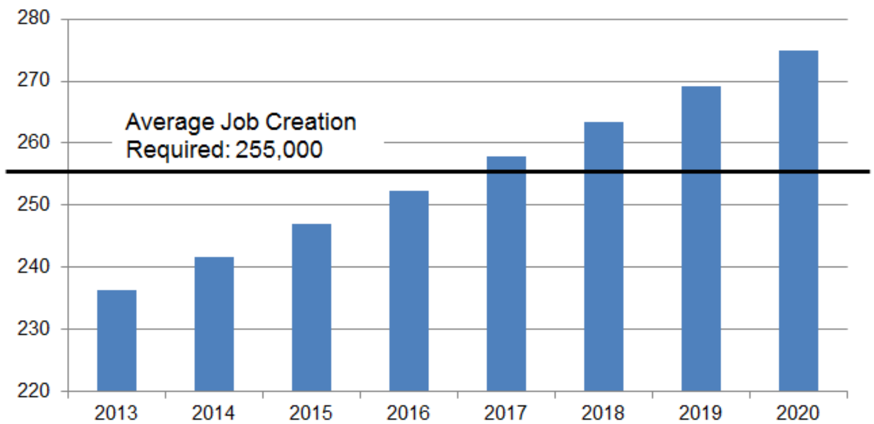


Source: Texas Ahead, CRA Analysis

Employment

The Texas economy currently employs over 11 million people. It is rapidly adding new jobs to accommodate a growing population. In the past year the economy added over 320,000 jobs, lowering its unemployment rate to 6.4%, which is lower than the national rate of 7.5%.[27] The state must maintain this high pace of employment growth as population is expected to continue to grow at a higher rate than in the rest of the US. Given the state's current labor participation rates and expected population growth, Texas must create an average of 255,000 jobs per year through 2020 to maintain current unemployment levels. Any threats to job growth, such as those from resource inadequacy, are therefore important considerations. Figure 2 shows the required job creation by year.

Figure 2: Texas Annual Employment Addition Requirements through 2020 (thousands)



Source: Texas State Data Center, Bureau of Labor Statistics, CRA Analysis

In addition to examining the overall employment levels in the economy, it is important to review which sectors of the economy are responsible for the most employment and which are experiencing the most employment growth (or decline). Table 2 shows the industry breakdown of total employment and annual growth in Texas. A large share of the jobs is in the service sectors. The industries that are "punching above their weight" in terms of contributing employment growth include Leisure & Hospitality and Construction. The only sector that lost jobs in the past year is Manufacturing, though that is positioned to change if the manufacturing renaissance driven by low natural gas prices is realized in Texas.

[27] Bureau of Labor Statistics, Regional and State Employment and Unemployment Summary, 17 May 2013.

Table 2: Texas Employment Growth Rate by Sector, March 2012-March 2013

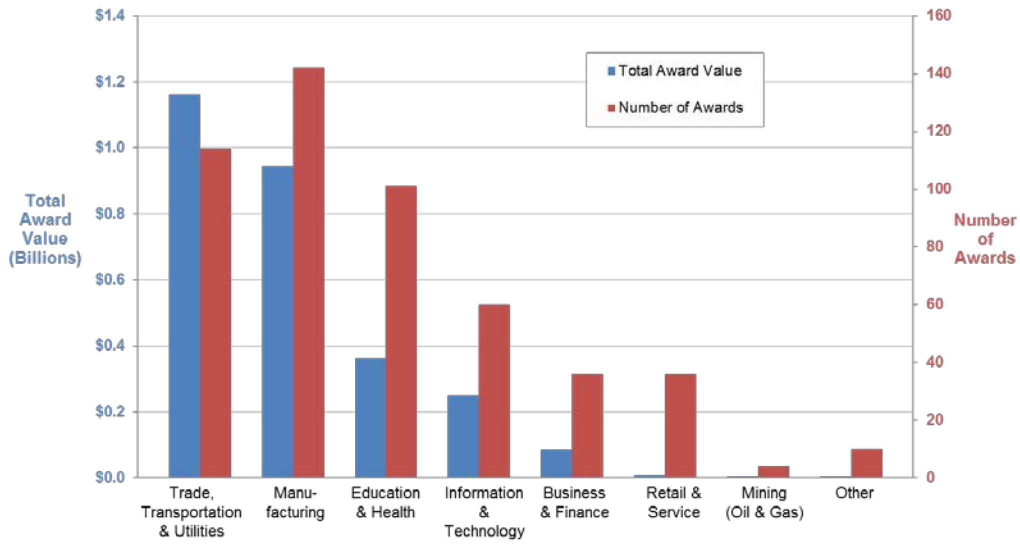
Industry	Total (as of Mar-13)		Annual Additions (Mar-12 to Mar-13)	
	Employment (thousands)	% of Total	Employment (thousands)	% of Total
Business & Finance	2,103	*19*	65	*20*
Retail & Service (Leisure & Hospitality)	1,129	*10*	63	*20*
Trade, Transportation & Utili-ties	2,197	*20*	59	*18*
Education & Health	1,498	*13*	50	*15*
Construction	609	*5*	36	*11*
Mining (Oil & Gas)	280	*3*	16	*5*
Other	388	*3*	13	*4*
Government	1,833	*17*	13	*4*
Information & Technology	198	*2*	1	*0.3*
Manufacturing	856	*8*	-6	*-2*
Total	**11,097**	*100%*	**323**	*100%*

Source: Texas A&M Real Estate Center, CRA Analysis

Growth Sectors

The previous table shows which sectors recently contributed the most employment to the Texas economy, identifying which sectors have experienced the highest growth in the past year. It is also important to understand which sectors, or subsectors, have been identified as keys to future economic growth regardless of whether they grew significantly in the past. One way to identify these sectors is to examine where the Texas government is investing in private sector growth through incentive programs. This also gives an indication of which industries have expansion opportunities that are nearly on the margin, and could therefore locate elsewhere if the Texas business climate changes. Figure 3 shows recent government incentives directed at growth industry groups.

Figure 3: Sectoral Investments by the Texas Government's Enterprise Fund



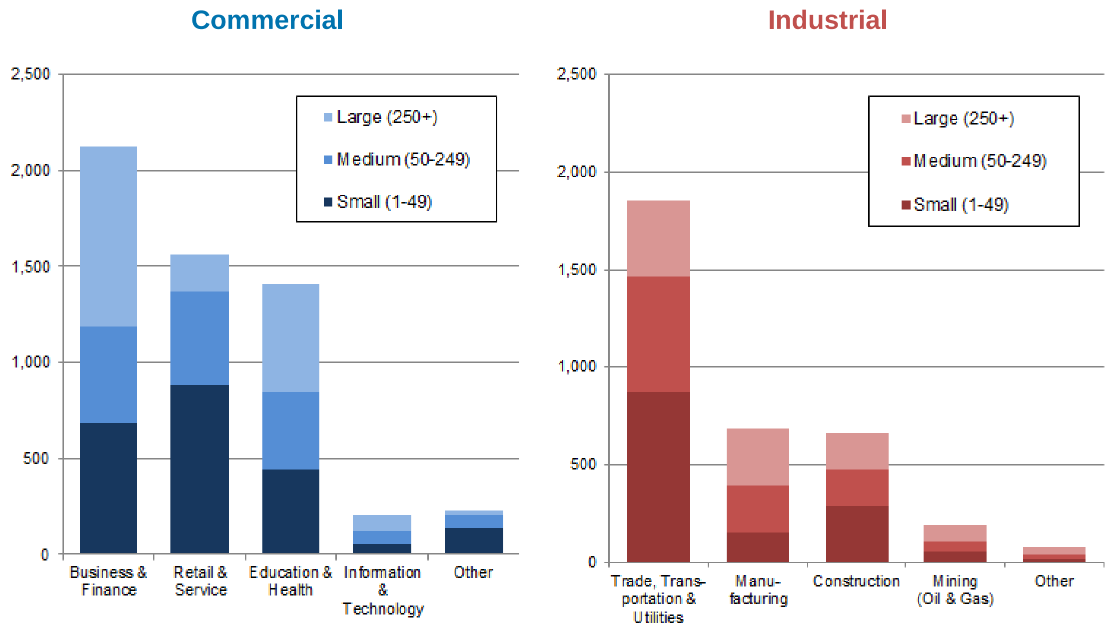
Source: Texas Enterprise Fund, 2013 Legislative Report

2.4. Exposed Segments of the Texas Economy

The previous sub-section identified the sectors of the Texas economy that contribute the most to GSP, employ the most Texans, and have been identified as prospects for growth. This sub-section explores which segments of the Texas economy are the most exposed to power outages and price impacts due to resource inadequacy, starting with business sectors. It is important to identify industries that are both critical to the future of the Texas economy and are exposed to resource inadequacy.

As mentioned in Section 2.1, the most exposed commercial and industrial firms are the small and large enterprises that are either electricity intensive in terms of costs or otherwise heavily dependent on electricity for production. We evaluated employment across industries divided into small (1-49 employees), medium (50-249 employees) and large (250+ employees) establishments. Small and medium firms represent a larger share of employment in the commercial sector (70%) than they represent in the industrial sector (62%). This is important as over 80% of all employment is in the commercial sector. This suggests a large share of Texas employees (69%) are in firms potentially exposed to resource inadequacy beyond hedging and self-generation costs.

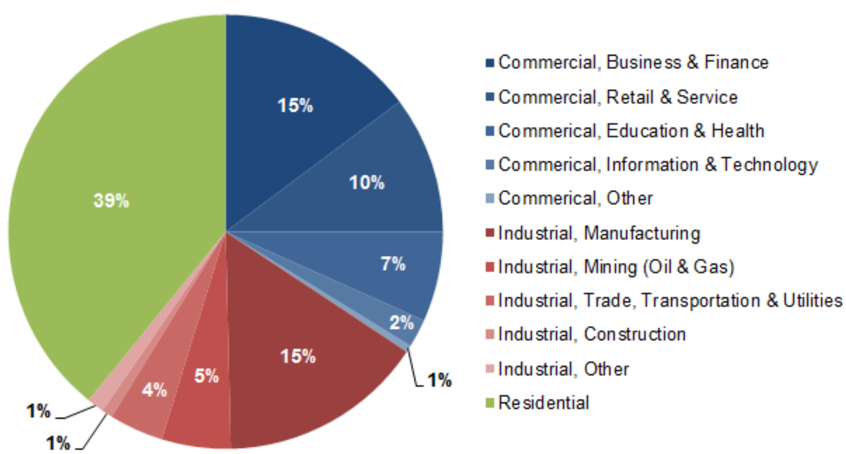
Figure 4: Employment by Sector, Industry Group, and Establishment Size (thousands of employees)



Source: US Census Bureau, CRA analysis

It is also important to understand which sectors and industries of the Texas economy are exposed to resource inadequacy due to their share of electricity consumption. As dis-cussed before, this is only one characteristic of many that determine the level of exposure, but it is an important one and is used later in this study to help inform impact modeling. Figure 5 shows the share of 2011 total electricity demand by sector. The residential sector consumes the most electricity in ERCOT (39%), followed by the commercial sector (35%) and the industrial sector (26%).

Figure 5: Electricity Demand by Sector and Industry Group



Source: US Census Bureau, CRA Analysis

In addition to this top-down review of Texas sectors to determine levels of exposure to resource inadequacy, it is also possible to examine individual industries in a bottom-up approach. Such an analysis was not in the scope of this study, nor has it been conducted at a Texas level in any existing study. This would require extensive industry-level analyses, most likely informed by surveys and modeling. Even the most expansive, survey-based studies conducted in this field to date have only focused on large segments of the economy, such as the commercial, industrial and residential sectors.

3. Resource Inadequacy in ERCOT

Before impacts can be estimated, the actual resource adequacy issues must be examined and quantified for analysis. This section begins with a focus on estimates of reliability events (3.1) and their costs (3.2). It then focuses on estimated electricity price increases and volatility (3.3).

3.1. Expected Reliability Events

Reliability events are often characterized by frequency, duration and size. We relied upon existing studies to estimate future reliability events and their characteristics.

The March 2013 ERCOT Loss of Load Study ("ERCOT LOL Study") presented the results of extensive simulations based on actual system and reliability data from ERCOT.[28] The study is considered the most detailed forecast of reliability events in ERCOT for 2014 and 2016. We therefore based our analysis on estimates in this study for those two years, as well as an interpolated estimate for 2015. We examined results corresponding to reserve margins estimated in the latest CDR report.[29] The categories of estimates in the ERCOT LOL Study include:

- Loss of Load Events (LOLEV) - Indicates the expected number of loss-of-load events that will occur in a given timeframe.
- Loss of Load Hours (LOLH) - Indicates how many loss-of-load hours are expected to occur in a given timeframe.
- Outage Duration - Indicates the average length of a loss-of-load event within a given timeframe.
- Expected Unserved Energy (EUE) - indicates the expected load energy that will not be served, within a given timeframe.

[28] ECCO International, "2012 ERCOT Loss of Load Study: Study Results," for ERCOT, 8 March 2013.

[29] 13.8% in 2014 corresponds to the ERCOT LOL Study estimates for 13% RM. 10.4% in 2016 corresponds to ERCOT LOL Study estimates for 8.4% RM.

The ERCOT RA Study conducted by The Brattle Group also forecasts events, though not for specific years, but rather for an average year and an extreme weather year (based on 2011 weather). It evaluates each assuming the 2012 offer cap of $3,000/MWh ("Low SWOC") and assuming a $9,000/MWh offer cap ("High SWOC"). The High SWOC is currently a policy goal and will be reached in 2015, unless there is a policy change, and was therefore assumed to correspond to the scenario with current market rules.

The reliability event estimates from each study are presented in Table 3. Not all categories covered in the ERCOT LOL Study were provided in the ERCOT RA Study. The tan shaded cells in the table are either estimated or calculated based on CRA assumptions. For example, the size of event in an average year (1,500 MW) was estimated as the average event size in the ERCOT LOL Study. The size of event in the extreme weather year (2,500 MW) was estimated based event sizes in the ERCOT LOL Study for low reserve margins, adjusted for the size of an actual February 2011 event that reached 4,000 MW.[30]

Table 3: Frequency, Duration and Size of Reliability Events from Relied Upon Studies

		ERCOT LOL Study			ERCOT RA Study	
		2014	2016		Average Year	2011 Weather
Reserve Margin	***%***	***13.0%***	***8.4%***	***13.5%***		
Loss of Load Events	# of events	0.4	3.7	0.4	0.9	12.4
Loss of Load Hours	# of hours	0.98	9.6	1.0	2.3	34
Average Outage Duration	Hours/event	2.4	2.6	2.4	2.6	2.7
Expected Unserved Energy (EUE)	MWh	1,310	15,311	1,280	3,450	85,000
	MW/event	1,350	1,598	1,280	1,500	2,500

Sources: ECCO International, The Brattle Group, CRA analysis (in tan shade)

Implementing a capacity market and consequently increasing the assumed reserve margin does not completely eliminate reliability events, but it does significantly decrease their frequency, duration and size. To estimate reliability events for the scenario in which a capacity market has been implemented, we used the same sources but adjusted the estimates to reflect a higher reserve margin. The estimate for 2014 was identical to the estimate under current market rules, based on the assumption that a capacity market would take time to noticeably impact the reserve level. For 2016, we used the ERCOT LOL Study's estimate for a 13.5% reserve margin. For all other years, we assumed the same percentage difference between scenarios as estimated in the ERCOT LOL Study for 2016. We applied this percentage to the ERCOT RA Study's estimates for both average years and extreme

[30] FERC/NERC, "Report on: Outages and Curtailments During the Southwest Cold Weather Event of February 1-5, 2011," August 2011.

weather years. This led to reductions in expected unserved energy to about 10% of their levels under current market rules.

3.2. Costs of Reliability Events

The impacts related to reliability events are based on costs experienced by the various segments of the economy. Translating reliability event characteristics into costs requires estimates of costs per event, costs per duration or costs per unserved kWh. There have been several academic studies on each, but the authoritative source is a 2009 study by the US Department of Energy's Lawrence Berkeley National Laboratories (LBNL) Office of Electricity Delivery and Energy Reliability.[31] The 2009 study builds on multiple previous LBNL studies, as well as a significant literature review and statistical analysis of surveys conducted by a variety of US utilities.

Table 4 is the key table from the LBNL study (converted to real 2012 dollars) that informs our later analysis of reliability event impacts. It provides costs by duration for medium and large commercial and industrial (C&I) customers, small C&I customers and residential customers.

Table 4: Outage Costs by Customer Type and Duration (converted to 2012$)

Customer Type	Unit	Interruption Duration				
		Momentary	30 minutes	1 hour	4 hours	8 hours
Medium and Large C&I	Cost Per Event	$12,484	$16,682	$21,621	$62,853	$99,704
	Cost Per Average kW	$15.29	$20.50	$26.55	$77.10	$122.33
	Cost Per Un-served kWh	$183.82	$40.88	$26.55	$19.33	$15.29
Small C&I	Cost Per Event	$466	$648	$869	$2,863	$5,063
	Cost Per Average kW	$212	$295	$396	$1,305	$2,308
	Cost Per Un-served kWh	$2,549	$590	$396	$326	$288
Residential	Cost Per Event	$2.87	$3.50	$4.14	$8.28	$11.36
	Cost Per Average kW	$1.91	$2.34	$2.76	$5.42	$7.54
	Cost Per Un-served kWh	$22.94	$4.67	$2.76	$1.38	$0.96

Source: Lawrence Berkeley National Laboratory

Notice that different durations have different costs per kWh of un-served demand. One cannot simply estimate the total costs in a year by assuming an average duration. Our approach involved developing a frequency of durations that led to an average duration of approximately three hours (as seen in Table 3). We weighted our distribution toward 30

[31] Sullivan et al., "Estimated Value of Service Reliability for Electric Utility Customers in the United States," Lawrence Berkeley National Laboratory, prepared for DOE, June 2009.

minute events based on a review of load shedding procedures of several REPs, as well as reported 40 minute durations of load shedding events in February 2011.[32]

3.3. Expected Electricity Prices and Volatility

The second manifestation of resource adequacy issues is in electricity price impacts, as introduced in Sections 2.1 and 2.2. Resource inadequacy can impact prices in several ways:

- More frequent, and often higher, scarcity pricing – The lower the reserve margin, the more often scarcity conditions will exist. During these periods, the wholesale price of electricity will be influenced by the system-wide offer cap, which is generally much higher than non-scarcity prices. As these scarcity prices are hit more frequently, customers that have time-of-use and variable pricing, but do not curtail demand, see major price increases. We assumed that both scenarios have the same offer cap levels, so the difference in electricity price that results from resource inadequacy is mostly driven by the frequency that prices rise to and near the cap.

- More expensive hedging products and bilateral contracts for REPs – In addition to higher peak prices, customers may also face higher contract electricity prices due to the increased risk of price spikes, as explained in Section 2.2.

In an average year with mild weather and few major generator outages, a market with a relatively small reserve margin may see only minor price impacts from scarcity events. In these years, the Energy Plus Capacity scenario may have higher customer costs once capacity costs are included. To evaluate the relative electricity costs in average years for each scenario, we relied on the Brattle-produced Customer Cost Comparison memorandum that includes a table comparing energy and capacity costs.[33] The table indicates that, in an average year, the Energy Only scenario results in $18.3 billion in energy costs and $0 billion in capacity costs. The Energy Plus Capacity scenario results in $14 billion in energy costs and $4.7 billion in capacity costs. The $400 million difference in total costs ($18.7 - $18.3 billion) is the additional customer cost in an average year of a capacity market with a 14% reserve margin target.

In extreme weather years, the price impact from resource inadequacy can be quite large. A Brattle Group presentation from October 2012 provided additional results of modeling not found in the original ERCOT RA Study.[34] The presentation included a chart, shown as Figure 6, which compared total electricity costs for customers in both average and 2011 weather

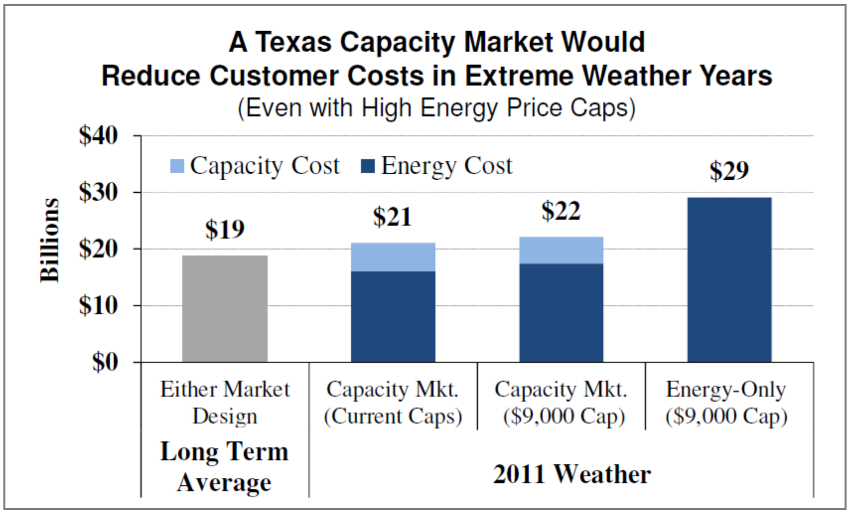
[32] FERC/NERC, "Report on: Outages and Curtailments During the Southwest Cold Weather Event of February 1-5, 2011," August 2011.

[33] Sam Newell, "Customer Cost Comparison," Filed by ERCOT with the PUCT, September 2012.

[34] Sam Newell, "Resource Adequacy in ERCOT: 'Composite' Policy Options," Prepared for the Public Utilities Commission of Texas, 25 October 2012.

years, based on a variety of assumptions.[35] It shows that when there is a high scarcity price and resource inadequacy, costs can be much higher in extreme weather years than average years. Total customer costs are shown to be $10 billion (over 50%) higher in extreme weather years in an energy-only market.

Figure 6: Customer Costs (Wholesale) from Brattle Group presentation



Source: Brattle Group

For a scenario with a capacity market implemented and a high SWOC, the costs were $3 billion higher than an average year. Thus, the capacity market saves customers $7 billion (less the capacity cost of $400 million) in an extreme year.

4. Quantifying Impacts on the Texas Economy

This section translates the estimates of reliability events and electricity price changes from the previous section into economic impacts to compare the two scenarios. It begins with a description of the modeling approach (4.1) and then summarizes our two scenarios that are evaluated for impacts (4.2). We then present the results of our study (4.3) and compare them to other studies and possible methodologies (4.4).

[35] "Assumes energy costs are 75% hedged. Capacity prices are assumed to be the same "Net CONE" across weather years. The $9,000 Cap Scenario includes a $300,000 PNM threshold, a $4,500 Low Cap, and a gradually sloping scarcity pricing function." Note that the assumption of 75% hedging (and no reflection of adverse weather impacts in hedging costs) dampens the effect of the energy only market on the price excursion.

4.1. Economic Modeling Methodology

Outage costs and electricity price changes have impacts that ripple through the economy in a variety of ways. Simply presenting the direct outage costs estimated from surveys misses the supply chain impacts and changes to labor income, government receipts and a variety of other impacts throughout the economy. Some studies use static models to estimate impacts, but these are not adequate for large costs that impact the majority of economic sectors and occur over multiple years. For this reason, we selected the advanced, dynamic economic modeling tool REMI for our analysis. For a detailed description of REMI, see Appendix A.

Note that using a dynamic model does not necessarily increase estimated impacts. On the contrary, it allows for substitutions of factors of production, so reductions in electricity usage due to price increases can be substituted by increased expenditures on labor or use of additional capital. The version of REMI we used includes 160 sectors. We selected this level of disaggregation to capture the variable ways in which sectors are impacted by reliability events.

As noted previously, a major effect of resource inadequacy that is not captured by our analysis is the effect of outage events on expectations of future outages. Our analysis only focuses on the near-term impacts of outages that are experienced, and misses the impacts of such outages on businesses and individuals deciding to move into or expand operations in ERCOT. Such impacts may be very large. To provide an analogy, the high US gas prices of a few years ago likely reduced the output from facilities using gas as a feedstock. However, a still larger, but more lagged impact likely was the closure of facilities and the shifting of production overseas. This latter type of investment decision impact is the impact of unreliability that we were not able to capture in our analysis.

We used different methodologies for modeling outage costs and electricity price impacts.

<u>Outage Costs</u>

Sections 3.1 and 3.2 described the data sources for estimating reliability event characteristics and mapping them to outage costs. Outage costs were estimated for small and medium firms based on the LBNL table. Large firms were simply excluded from the analysis and assumed to have no outage costs, which is an assumption that will lead to underestimating outage cost impacts.

We were able to calculate total annual direct outage costs for each of the years presented in the ERCOT LOL Study and for the average and extreme years as presented in the Brattle Study. This was done applying the costs per unserved kWh from the LBNL Study. Table 5 shows these costs on an annual and per event basis. Note that in reality there are large variations in the costs per event. This table only shows the cost per average reliability event caused by resource adequacy issues, which is about three hours in duration.

Table 5: Annual and Per Event Outage Costs to Texas Economy

		2014	2016		Average Year		2011 Weather	
Scenario		Both	Energy Only	Energy + Capacity	Energy Only	Energy + Capacity	Energy Only	Energy + Capacity
Loss of Load Events	# of events	0.4	3.7	0.4	0.9	0.1	12.4	1.4
Annual Direct Cost	$ million	110	1,200	108	274	25	6,300	570
Direct Cost per Average Event	$ million	274	324	260	305	250	507	405

To determine the number of outages in a given year for each scenario, we relied upon the ERCOT LOL Study (for 2014-2016) and the ERCOT RA Study (for 2017-2028). The two scenarios were assumed to have the same outages in 2014 as the capacity market is assumed to lead to investments starting later in that year. We assume the Energy Only market reaches the Brattle-estimated long run equilibrium reserve margin of about 8-9% after several years. By contrast, we estimate the outages in the Energy Plus Capacity scenario will be more in line with the ERCOT LOL Study's estimates for a 13.5% reserve margin, which reduces the outage costs. The ERCOT LOL Study estimates outage events are reduced by 90% when moving from an 8.4% reserve margin to a 13.5% reserve margin and this guided our use of the ERCOT LOL Study's estimates for average and extreme years after 2016.

To assign outage costs to each of the 160 sectors, we first used US Census data to determine the share of each sector represented by small, medium and large firms, based on employment levels in Texas. We also determined the electricity consumption and expenditures from EIA data for Texas.[36] We then determined electricity consumption by small and medium firms in each industry, which then allowed proportional distribution of the outage costs by sector. These costs were evaluated in REMI as production cost changes. Residential outage costs were modeled as reductions in general consumer spending.

Electricity Prices

Section 3.3 presented our approach to evaluating the relative difference in consumer electricity costs for the two scenarios. We modeled the Energy Only scenario as the baseline and the Energy Plus Capacity scenario was evaluated for its differences from the baseline. We assumed that the difference in scenario prices represent a proportional adjustments in the wholesale electricity price, which would translate differently into different segments of the economy based on the retail markup. We examined historical markups as reported by EIA to determine an average adder for residential, commercial and industrial retail prices. Any percentage change in wholesale price would be multiplied by the wholesale share of the retail price to determine the total percentage change in retail price.

[36] We based distribution of impacts to industries according to data on the Texas economy even though the impacts themselves are focused on the ERCOT market, which does not represent all of Texas. We determined that this does not introduce significant error into the estimates as the entire Texas economy is not significantly different from the ERCOT-served portion of the Texas economy.

Electricity cost changes were applied to electricity expenditures for each of the 160 sectors, based on whether they are commercial or industrial. The change in electricity costs were modeled as such in REMI. For the residential sector, they were simply modeled as percentage change in electricity expenditures, which is a direct input to REMI.

4.2. Loss of Load and Electricity Price Scenarios

One major deficiency of many similar studies is the focus on a single representative year for impact calculations. Even advanced simulations that lead to a single estimate of average impacts misses a key aspect of economic damages from resource inadequacy: that the economy lags in recovery and therefore impacts can span between years. To capture this phenomenon, we modeled the 15 year period from 2014 to 2028. We selected this length of time to be able to capture a 1-in-15 type weather year, which is the high end of estimates for the frequency of 2011 type years.[37] We modeled the two scenarios over this time period. Table 6 illustrates the differences in these scenarios.

Table 6: Scenario Assumptions for 15-year Modeling Period

Year(s)		2014	2016	2017-2019	2020	2021-2028
Weather		Average			Extreme	Average
Energy Only	Offer Cap	Increasing SWOC		High SWOC		
	Outage Costs per Year ($million)	$110	$1,200	$274	$6,300	$274
	Electricity price change	Baseline				
Energy + Capacity	Offer Cap	Increasing SWOC		High SWOC		
	Outage Costs per Year ($million)	$110	$110	$25	$570	$25
	Electricity price change	Add 1% to 1.7%			Less 6.5% to 11%	Add 1% to 1.7%

Source: CRA assumptions based on ERCOT LOL Study, ERCOT RA Study, LBNL Study, and data on Texas economy. Range in electricity price increases based on retail markups for Residential, Commercial and Industrial sectors.

[37] Samuel Newell, et al. "ERCOT Investment Incentives and Resource Adequacy," The Brattle Group, prepared for ERCOT, 1 June 2012.

4.3. Overall Economic Impacts

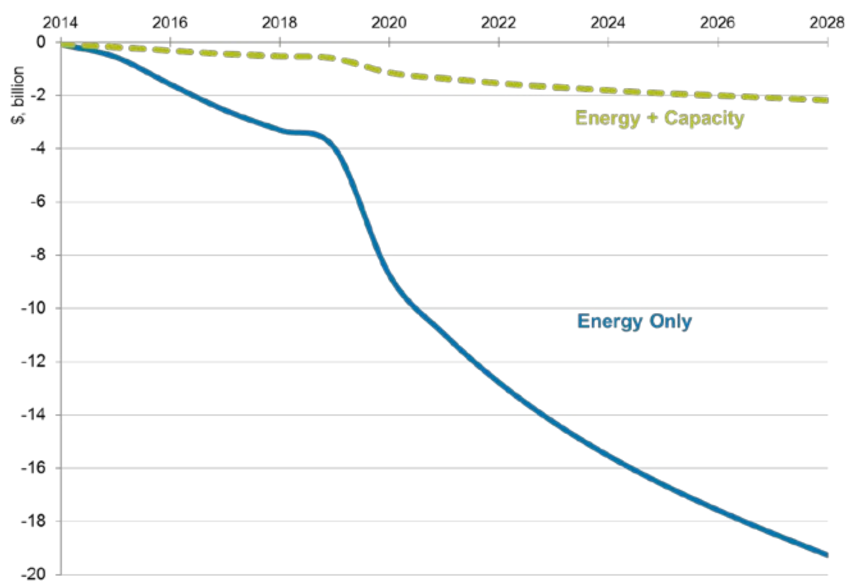
The following are results of our modeling for three key macroeconomic indicators: GSP, employment, and household income.

Gross State Product (GSP) Impacts

The first GSP impact evaluated is outage costs. The following table shows a comparison of outage cost impacts on Texas GSP[38] under the two scenarios.

Figure 7: Comparative GSP Loss Due to Reliability Events ($ billion)

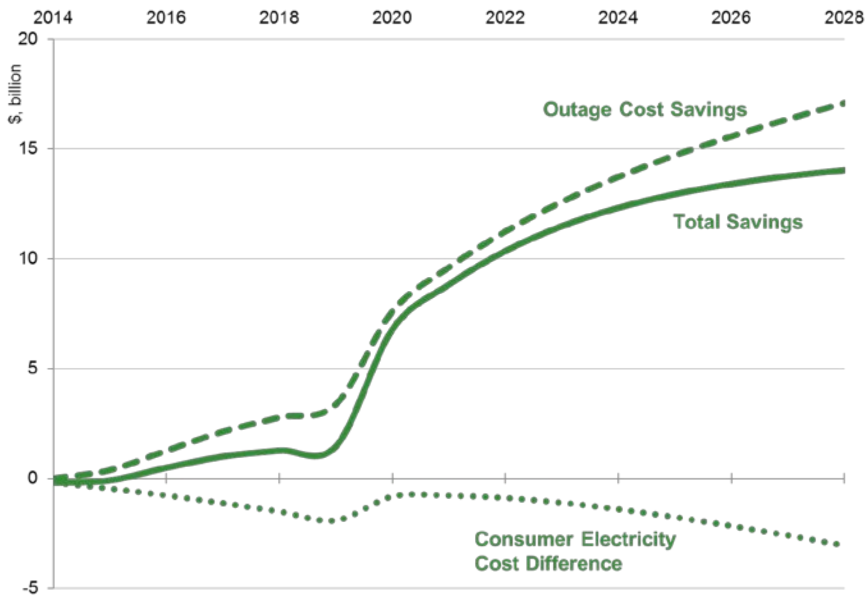
Source: CRA Analysis



These outage cost impacts to GSP can be combined with the consumer electricity cost impacts to GSP for a comprehensive view of resource adequacy issues and their potential mitigation through a capacity market. Figure 8 shows how the additional customer costs associated with capacity costs are far outweighed by outage cost savings and customer cost savings in extreme years, which will be required to produce pricing outcomes that spur investment. The solid line represents overall GSP savings from a capacity market. By 2028, the capacity market has saved Texas $14 billion in GSP losses ($17.1 billion in outage cost savings less $3.1 billion in additional electricity costs).

[38] The REMI modeling used the structure of the entire Texas economy in estimating impacts. ERCOT is not the whole of Texas. However, since the loss of load is scaled only to what occurs in ERCOT, the impact of outages on GSP and other measures is scaled down to approximate the ERCOT portion of Texas.

Figure 8: Cumulative GSP Impacts for Each Scenario ($ billion)

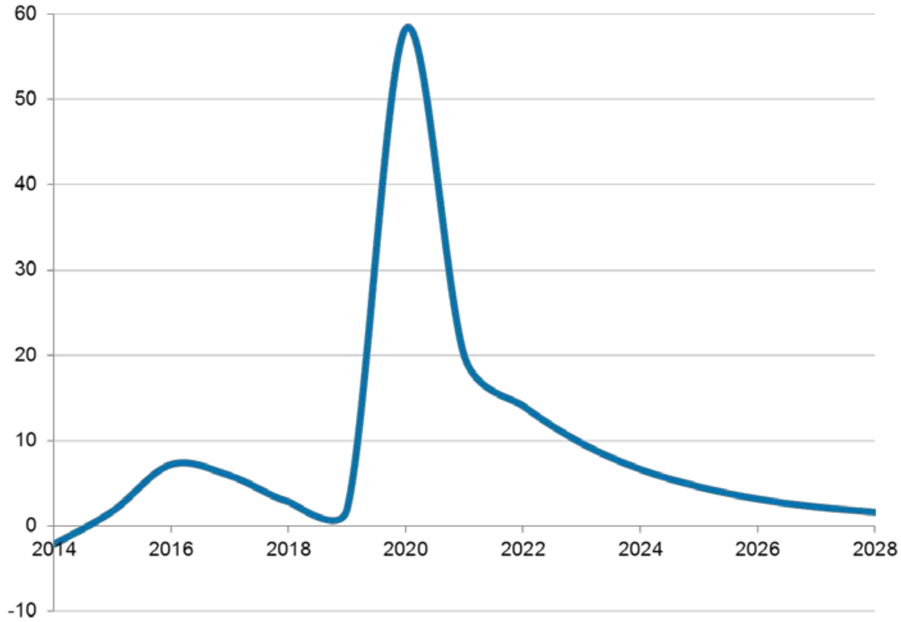


Employment Impacts

Our analysis shows that, in the extreme weather year of 2020, resource inadequacy could lead to a loss of 58,000 more jobs in the Energy Only scenario than the Energy Plus Capacity scenario. Over the fifteen year period, the Energy Only scenario leads to 137,000 fewer job-years of employment than the Energy Plus Capacity scenario.

Figure 9 shows the annual difference in employment impacts for the two scenarios. It shows that a capacity market can save nearly 60,000 job-years in extreme years. The losses are expressed in job-years, which do not necessarily represent number of employees. For example, two half-time workers can be represented by one job-year. Because of lags built into the model, employment does not quickly and fully recover to pre-2020 levels for either scenario, though much of the impact is only transitory.

Figure 9: Avoided Job Losses from a Capacity Market (# of job years)



Source: CRA Analysis

<u>Household Income Impacts</u>

In addition to lost employment, we also estimated income impacts arising from resource inadequacy. By 2016, assuming average weather years, the average Texas household will have $128 less real income per year in the Energy Only scenario due to outages alone. In our extreme weather year, we calculate an income reduction of $644 per household in the Energy Only scenario. In the Energy Plus Capacity scenario, the income loss due to capacity costs is actually less than the positive income impact of the electricity price savings.

4.4. Comparison to Other Studies/Methods

The study presented in this report involved the use of several existing studies to support our estimation of economic impacts or resource adequacy issues in Texas. There are other studies and methods that could have been used to support similar calculations, though we deemed these less reliable. This sub-section presents high-level reviews of a few other studies and methods that provide framing for our results.

- **Electric Power Research Institute (EPRI) Study (2001)**[39]

  Description - This study, conducted via a survey method, was the "first systematic effort to estimate the national economic cost of power interruptions including power quality."[40] A clear strength of this study is that it also includes the impacts of power quality issues, which are an often overlooked impact of resource inadequacy (they are not measured in this report). As reserve margins shrink, capacity that could have been used for frequency regulation and other power quality services could be committed more frequently to running to meet load. A drawback to using this study is that it is not solely related to resource inadequacy.

  EPRI estimated the total annual cost of outages for all business sectors in the United States as $119 billion per year ($150 billion in 2012 dollars). The West South Central region had estimated costs of $11-18 billion dollars per year ($14-22 billion in 2012 dollars). This region includes Texas, Oklahoma, Louisiana and Arkansas.

  Applied to Texas - ERCOT represents about 60% of the electricity consumption of West South Central region and Texas as a whole represents over 70% of the GDP, suggesting an EPRI estimate of the Texas impacts of about $8-15 billion, solely from business sector direct impacts but including all causes of outages and reliability issues. [41,42]

- **Estimating Impacts with VOLL**

  Description - A common calculation of direct economic impacts from reliability events in a year involves multiplying annual un-served load by the assumed VOLL. ERCOT recently submitted a report on VOLL in Texas to the PUCT.[43] Prepared by London Economics International, the report did not settle on a VOLL estimate. Rather, it presented a literature review and macroeconomic analysis that provide some comparisons for a recommended survey-approach estimation of VOLL. The studies referenced in the VOLL study include those used for cost estimates in this study.

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39 Primen (EPRI), "The Cost of Power Disturbances to Industrial and Digital Economy Companies," 29 June 2001.

40 LaCommare and Eto, "Understanding the Cost of Power Interruptions to U.S. Electricity Consumers" Lawrence Berkeley National Laboratory, September 2004, p13.

41 EIA. "Electric Sales, Revenue, and Average Price. Table 2: Sales to Bundled and Unbundled Consumers by Sector, Census Division, and State." 27 September 2012.

42 BEA, "Widespread Economic Growth in 2012. Table 4: Current-Dollar GDP by State." 6 June 2013.

43 ERCOT, "Value of Lost Load Literature Review and Macroeconomic Analysis," prepared by London Economics International, LLC,

VOLL has been estimated by several studies for different geographic regions, most recently and relevantly in a 2006 study for MISO.[44] This study estimated the value to consumers of uninterrupted electrical energy service. It provided a heavily-caveated list of outage damage costs by major industry group and sector by duration. For example, for a 1-hr duration, the study found VOLLs of $730-$2,510/MWh for residential customers, $15,000-$50,000/MWh for small commercial and industrial ("C&I") customers, and $16,000-$78,000/MWh for large C&I customers.[45] The current MISO VOLL is set at $3,500/MWh,[46] which is a weighted and adjusted version of the industry group VOLLs. The MISO's VOLL is considerably lower than the VOLL used by the Australian Energy Market Commission, which in 2010 raised its VOLL to $12,000 ($12,500 AUD).[47]

Applied to Texas - When evaluating SWOCs, ERCOT worked with economist William Hogan, evaluating prices using VOLL estimates of $5,000, $7,000 and $9,000/MWh.[48] Applying these VOLL estimates to the ERCOT LOL Study's estimate of un-served demand leads to total cost estimates of $7-12 million in 2014 and $77-138 million in 2016. For an upper bound, an extreme weather year with Low SWOC results in $1-2 billion in direct costs for the year.

- **Industry Specific Studies**

Description - As mentioned earlier, outage costs can vary significantly between industries. Only a few major economy-wide studies have examined impacts at the industry level, and even those studies have used highly aggregated industry groups that may mute impacts in specific industries. There have only been a few industry-specific studies of outage costs produced for public consumption. We did not identify any specifically focused on resource inadequacy related outages.

One interesting industry-specific study is focused on outage costs for data centers.[49] It is not directly tied to power outages, but data center outages are more likely in areas with low power reliability. Their backup systems are more likely to fail the more often they are relied upon. The study estimates that 30-40% of data center outages are related to backup power systems and that these events have an average impact of $500,000.

44 Centolella, Paul, "Estimates of the Value of Uninterrupted Service for The Mid-West Independent System Operator," SAIC, 2006.

45 ibid

46 MISO, FERC Electric Tariff, Volume No. 1, Schedule 28. Version: 3.0.0, Effective: 1 May 2012.

47 The Australian Energy Market Commission , "National Electricity Amendment (NEM Reliability Settings: VoLL, CPT and Future Reliability Review) Rule 2009," May 2009.

48 William Hogan and ERCOT Staff, "Back Cast of Interim Solution B+ to Improve Real-Time Scarcity Pricing," 21 March 2013.

49 Ponemon Institute, "Calculating the Cost of Data Center Outages," Sponsored by Emerson Network Power, 1 February 2011.

Applied to Texas - The large potential outage costs factor into investment and location decisions in the data center industry. This is important given Texas' active economic interests in expanding the presence of the industry in the state. As a sign of this interest, the Texas Legislature recently approved legislation "to create a temporary sales tax exemption intended to attract major data center projects to Texas."[50] Using industry-specific cost estimates for analysis of total costs in Texas is unfortunately not an option at this point given the lack of existing data.

- **Individual Blackout Events**

  Description - There have been several studies focused on the economic impacts of individual blackout events that provide some indication of the value of lost load. These are generally focused on events of significant duration and are region-specific (none are focused on Texas), but the values are still informative. The following bullets describe a few of these studies:

  - Northeastern US and Ontario, Canada (2003) – Around 2pm on August 14, 2003, an overloaded 345 kV overhead transmission line made contact with a tree in northeast Ohio. Due to a software malfunction and other issues, multiple high-voltage lines failed and multiple major generators automatically dropped offline in response to the loss of power demand, resulting in the loss of nearly 62 GW of electric generation serving more than 50 million people. Multiple studies have attempted to quantify the economic losses caused by the blackout, which left some customers without power for up to two days. A report by ICF Consulting used information about the 1977 New York City blackout to estimate the cost of the August 2003 blackout at $6.8 to $10.3 billion (2003$).[51] This estimate reflects economic losses due to lost production and wages as well as the spoilage of goods. It also reflects indirect losses that occurred as secondary effects of the direct costs, which tend to occur over time. Another study by Anderson Economic Group estimated the total losses due the blackout at $4.5 to $8.2 billion (2003$), or an average of $6.4 billion.[52] This includes approximately $4.2 billion in lost wages and profits to workers and investors, between $380 and $940 million in spoiled goods and commodities, $15 to $100 million in extra costs to government agencies, and $1 to $2 billion is additional costs for the affected utilities.

  - San Diego, California (2011) – On September 8, 2011, a power outage left nearly all of San Diego, County, California, without power for roughly 12 hours. The outage affected primarily the service area of San Diego Gas & Electric (SDG&E), which serves roughly 3.5 million people – most of whom lost power. A study by the National University System Institute for Policy Research (NUSIPR) estimated direct economic

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[50] Jason Verge, "Texas Data Center Tax Incentives on the Horizon," Data Center Knowledge, 29 May 2013.

[51] ICF, "The Economic Cost of the Blackout: An issue paper on the Northeastern Blackout," 14 August 2003.

[52] Patrick Anderson and Ilhan Geckil, "Northeast Blackout Likely to Reduce US Earnings by $6.4 billion," Anderson Economic Group, 19 August 2003.

losses at between $97 and $118 million. This estimate includes roughly $15 million in perishable food losses, $15 million in government overtime paid to emergency response workers, and roughly $70 million in losses in income and wages to businesses and workers.[53]

Applied to Texas – These studies are focused on specific events in specific regions, and therefore the estimates are not directly applicable to Texas. However, they are still illustrative of the large scale of impacts possible from single events.

Overall, our review of existing studies suggests that our economic impact estimates are of a scale expected for the size of the Texas economy and the amount of reliability events evaluated.

[53] National University System Institute for Policy, "Economic Impact of September 9th Power Outage: Conservatively Estimated at $97 to $118 million," September 2011.

Appendix A: About the REMI PI+ Regional Model [54]

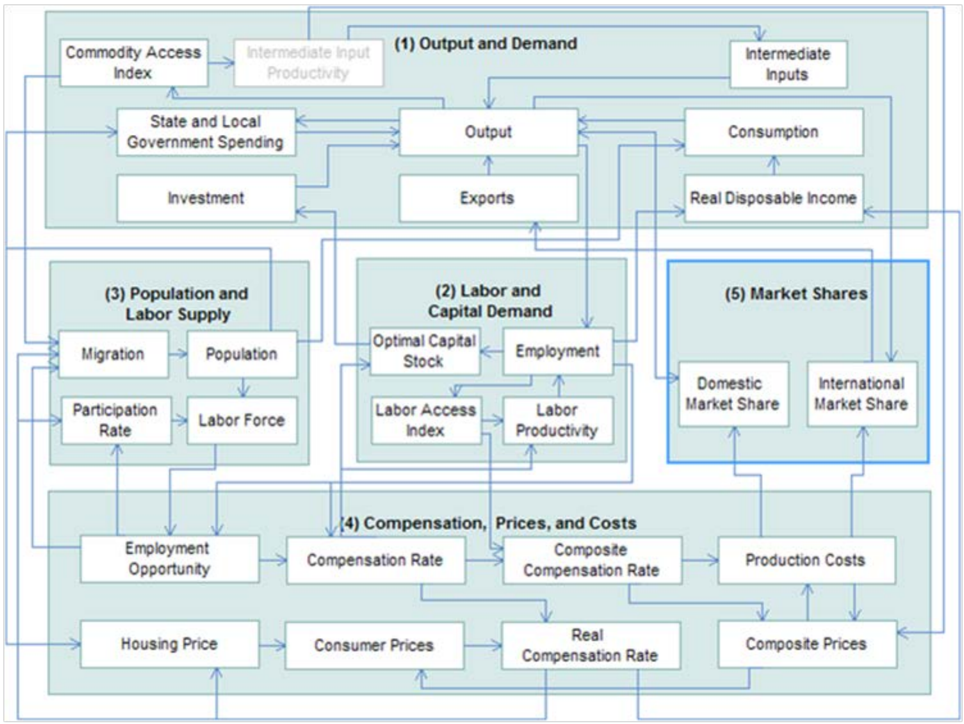
For this study, CRA used a 1-region, 160-sector build of the counties of Texas agglomerated to create a state-level model. The PI+ model is the "core" of REMI capabilities. The research behind it included four different quantitative methodologies from regional science and economics, which compensated for their individual weaknesses and highlighted their strengths. They included input-output (IO) tabulation, which captured the effects of inter-industry transactions, technological relationships, and multipliers. PI+ also included a computable general equilibrium (CGE) component, which accounted for the "long-term" impact of policies once all related markets in products, housing, labor, and others have had a chance to return to an equilibrium or "clear." These two types of models only allowed for a "before" and an "after" simulation, however, which was why PI+ included an econometric component. The econometrics gave a time component, including speed of adjustment, behavioral responses, elasticities, and statistical parameters. The last methodology was New Economic Geography (NEG), which took account of labor pooling, the clustering of industry supply chains, and the spatial elements of a regional economy and its tendency to organize into localized production units.

The research behind the REMI PI+ model appeared in peer-reviewed journals, and REMI used the federal statistical agencies as data sources when building the software. Data came from the Bureau of Economic Analysis (BEA), Bureau of Labor Statistics (BLS), the US Census Bureau, and the Energy Information Administration (EIA). A macroeconomic forecast came from the Research Seminar in Quantitative Economics (RSQE) at the University of Michigan, which drove many of the county-level or state-level trends in the short-term of the model through the forthcoming business cycle. After that, the REMI model used the BLS' long-term forecast of national growth by industry and in the labor force. The county-level data from these sources allowed for PI+ to have a customized geography at the sub-national or sub-state basis, but the model here included the discreet state of Texas in the inputs and results. The journals included the Journal of Regional Science, the American Economic Review, and the Review of Economics and Statistics.

The model existed in a block structure (see figure below). Block 1, at the top, represented the economy of the region with final demand and production. These included the various components of GDP, including the spending by governments, investment, net exports, and consumption. Block 2 represented the firm perspective on the economy, where demand turned into sales orders and firms made decisions about the most efficient way to produce. The model optimized their choices with a Cobb-Douglas production function amid labor, capital, and fuel as factors of production. Block 3 represented households in the economy. This included their demographics, their participation in the labor market, their location decisions, non-pecuniary amenity, and their consumption of food, housing, healthcare, and everything else to fulfill their wants and needs. Block 4 was where households and businesses came together in the marketplace, and it included labor market concepts like

[54] Description provided by Regional Economic Models, Inc.

employment opportunity and compensation rates, cost of living factors such as real estate and housing prices, and the cost of doing business for an industry in any given region. These then flowed into Block 5, which measured competitiveness against other regions (domestic and international), the ability to export, and the aptitude to keep imports from competitors away from a geographic arena.



The PI+ model had two purposes: forecasting and analysis via simulations. The forecasting works by building the government's data into the structure and allowing it to run until the sunset in 2060. REMI builds this "base case" so users can have a forecast of their regional economy, the chance to analyze the internal trends of the model, and to have something to compare against when performing their simulations. The simulations allow the user to make exogenous—"coming from outside"—changes through the above structure in what PI+ calls "policy variables." These changes represented the effect of their policy and can include production, price changes, and other factors. For example, a Boeing 737 line moving to an area will produce a large amount of output. The model represents it above, and then it hires the workers, pays them their wages, has them spend it, and redirects the capital portion of production into investment and intermediate demand to other industries (such as aluminum providers, design and engineering firms, or accounting services). From there, the model generates a new simulation and compares it against the old case to give an "impact" to the forecast for the regional economy. This impact, or difference, is the estimated implication of the policy in question.

Appendix B: Economic Impact of Data Centers

As discussed in the report, is difficult to reliably model the long-term loss of employment and investment in Texas that results from businesses shifting operations outside of the state. This Appendix provides some perspective by examining some industries that are particularly sensitive to electricity reliability and cost, such as data housing, processing and storage. Texas is aggressively courting these industries through a combination of tax incentives and investment support. The Governor's office has even touted the low cost of power and lack of service outages as key selling points for the location of these facilities within the state.[55]

While we have not modeled the business decisions that would lead to estimates of the number of facilities that would not be built in the state due to resource inadequacy, it helps to understand the scale of the economic impact of these facilities. The table below summarizes a non-exhaustive list of corporate announcements, beginning in 2000, from firms locating data centers in Texas where the total investment and jobs created are known. It illustrates the potential losses to employment and investment that may occur in Texas if firms from this industry decide to move operations outside of the state due to long-term uncertainty about the cost and reliability of electricity. The average investment size is almost $175 million and the facilities directly create an average of almost 500 jobs. The estimated employment multiplier for the Data Processing and Hosting industry is 2.5, [56] suggesting a total of 1,250 total jobs in Texas related to an average data center.

Select New Investment & Job Announcements in Texas for Data Storage, Processing, and Hosting Facilities

Company	Product / Service	Investment (Million USD)	Direct Job Creation
Rackspace	Web Hosting	112	4,000
E-Bay	E-Commerce	5	1,050
T-Mobile USA	Voice & Data Networks	18	850
TEKsystems Global Services	IT Outsourcing	5	500
Health Management Systems	Healthcare Data Services	18	350
CGI Technologies	IT Outsourcing	7	350
Cisco Systems	Internet Data, Video	5	300

55 Office of the Governor. "Texas Information Technology Services Industry Report," Texas Department of Economic Development and Tourism, 2012.

56 IMPLAN, 2011 data, Sector 352.

Hewlett-Packard	Data Center	430	140
Hewlett-Packard	Data Center	300	140
Wind Data	Data Center	210	130
VCE Co.	Infrastructure as a Service	40	130
Health Care Services Corp.	Data Center	500	100
Citibank	Data Processing Center	200	100
Christus Health	Data Center	24	80
Microsoft	Data Center	550	75
Oracle Corp.	Data Center	80	45
Citicorp	Data Center	450	30