The Potential Impact of Inadequate Electric Transmission in Texas

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Contents

Executive Summary

- The dynamic Texas economy and its growing population require increases in electric generation and transmission capacity well beyond what was expected even a few years ago.
    - If not addressed, general unreliability in the Texas electric grid and the resulting inadequate power supplies could constrain economic growth. The risk of inadequate power could become a barrier to entry and expansion for companies looking to establish a presence in the state, and existing businesses cannot function optimally with insufficient electricity.
    - The Perryman Group (TPG) assessed the potential economic impact of inadequate electric transmission in Texas through consideration of plausible scenarios that could occur under conditions that have been put forward by the US Department of Energy.
    - The scenarios reflect varying degrees of shortage severity; the levels of investment needed to avoid these supply inadequacies were also estimated.

- The initial scenario results in an underinvestment in electric transmission of **$3.65 billion** relative to currently anticipated levels and would lead to substantial losses by 2040.
    - The Perryman Group estimates that the total decrease in business activity during 2040 under these conditions would include **$9.7 billion** in gross product and approximately **40,500** jobs.
    - Cumulatively over the 2024-2040 period, the total losses include a projected **$36.8 billion** in gross product and almost **157,000** job-years (including multiplier effects).

- Underinvestment in electric transmission of **$10.41 billion** would occur under the second scenario.
    - The projected total decrease in business activity in 2040 in these circumstances includes an estimated **$22.3 billion** in gross product and approximately **92,900** jobs.
    - Cumulatively over the 2024-2040 period, the total losses include a projected **$113.0 billion** in gross product and almost **487,100** job-years (including multiplier effects).

- The consequences associated with an underinvestment in electric transmission of **$12.66 billion** as determined under this scenario would result in even greater losses in business activity.
    - The estimated losses in 2040 (including related multiplier effects) total a projected **$25.5 billion** in gross product and approximately **106,100** jobs.
    - Cumulatively over the 2024-2040 period, the total losses include a projected **$159.8 billion** in gross product and almost **696,500** job-years (including multiplier effects).

- Business activity generates tax receipts. The reduction in economic growth due to inadequate investment in transmission negatively affects receipts to the State and local taxing entities. The projected fiscal losses associated with inadequate electric transmission infrastructure in 2040 range from **$146.4 million** to**$383.4 million** to the State and **$283.1 million** to **$741.4 million** to local government entities depending on the severity of the resulting shortages. Cumulatively through 2040, losses total a projected **$553.5 million-$2.4 billion** to the State and almost **$1.1 billion-$4.6 billion** to local government entities.
- Falling short in meeting the demand for transmission and, therefore, the availability of electric power generates losses in business activity that are far in excess of the investments needed to sustain expansion.

- Texas is seeing ongoing population expansion and has enormous growth potential in both traditional industries and emerging sectors that require significant and reliable electricity supplies. This potential can only be achieved if the necessary supporting resources are available. Transmission capacity is crucial to ongoing prosperity.

Introduction

The Texas electric grid has been subject to challenges in recent years, from Winter Storm Uri in 2021 to extreme heatwaves during the summer months. While the primary concern is for individuals put in dangerous situations due to inadequate power during these events, there is also an economic cost to consider.

The dynamic Texas economy and its growing population require increases in electric generation and transmission capacity well beyond what was expected even a few years ago.

The dynamic Texas economy and its growing population require increases in electric generation and transmission capacity well beyond what was expected even a few years ago. The state population rose by nearly 474,000 between 2022 and 2023 (about 1,300 people per day) to top 30.5 million. That 1.58% increase more than triples the US rate of gain of 0.49%. In fact, the Lone Star State comprised more than 29% of the total net national increase. The change stemmed from natural increase as well as people moving from other parts of the US and other countries. Since prior to the pandemic (2019), Texas has added 5.20% to its population, significantly above the national pace of 2.03%. In addition, the state has added well over a million jobs during the past few years.

Basic patterns of business expansion have been in place for decades. However, there are profound and unanticipated changes underway which are shifting power demand growth into an entirely new gear. In particular, there has recently been a surge in electricity-intensive industries. Data centers supporting remote work, streaming, and now AI need massive megawatts to operate. Crypto mining is another major user. Electrification of cars and other machines further increases demand. Emerging industries, such as Tesla's gigafactory, LNG facilities along the Gulf Coast, semiconductor manufacturing facilities, and many others also require substantial electric power. In addition, developments on the horizon to deal with climate issues, such as hydrogen production and carbon capture, will require enormous resources.

The Electric Reliability Council of Texas (ERCOT) manages the flow of power to more than 26 million Texas customers (about 90% of the total state

load). During the past Texas Legislature session, changes were implemented enabling ERCOT to consider additions to grid requirements that are known to be coming. Previously, until new customers were added, the related increase in power needs could not be considered.

New planning documents project an additional 40 gigawatts (GW) of load growth by 2030 compared to the prior year's forecast. For context, ERCOT's all-time peak demand was just over 85 GW on an extremely hot day in August 2023. The impetus for this major increase in projected needs is significant increases in large loads being considered (such as for new facilities in high-use industries and greater electrification).

Obviously, Texas will need both generation and transmission capacity. Currently, ERCOT has 1,775 active generation interconnection requests totaling 346 GW planned for the next few years, including 155 GW of solar, 35 GW of wind, 15 GW of gas, and 141 GW facilitated by battery capacity. Benefits of this diversity of sources are that they can be developed and constructed faster and with more location options. However, because 190 GW is from intermittent sources (wind or sun), the additions present significant grid challenges.

The increase in power demand in the state is already causing periods of congestion in key points along the power grid. It will be difficult or impossible to deal with such congestion without substantial additional transmission capacity. In one instance, for example, ERCOT asked for voluntary conservation by large power users in South Texas near a major congestion point and attracted only three applicants with minimal impact on the grid.

Curtailment, an intentional reduction in electricity generation to maintain the supply and demand balance, also impacts the Texas power grid, particularly as wind and solar power production increases. According to a 2023 analysis by the Energy Information Administration (EIA), if no upgrades are made to the transmission system, up to 13% of wind generation and 19% of solar generation could be curtailed by 2035. Most instances of curtailment occur when the energy supply from wind and solar sources is significantly higher than electricity demand.

If not addressed, general unreliability in the Texas electric grid and the resulting inadequate power supplies could constrain economic growth. The risk of inadequate power could become a barrier to entry and expansion for companies looking to establish a presence in the state, and existing

businesses cannot function optimally with insufficient electricity. Even if power is available (such as from renewable sources), the current system cannot always support the extra generation, and congestion occurs in several key locations on the grid. Electric transmission improvement is an important goal as the population of Texas continues to grow, and an unreliable electric infrastructure could result in major economic costs.

The Perryman Group (TPG) was recently asked to assess the potential economic impact of inadequate electric transmission in Texas through consideration of plausible scenarios that could occur under conditions that have been put forward by the US Department of Energy. This report presents the results of TPG's analysis.

Economic Effects

Any economic stimulus, whether positive or negative, leads to dynamic responses across the economy. The Perryman Group has developed complex and comprehensive models over the past four decades to measure these dynamic responses in order to estimate the total economic effects (not only direct, but also indirect and induced) associated with direct sources of stimulus.

> Any economic stimulus leads to dynamic responses across the economy.

In the present instance, The Perryman Group developed three scenarios of potential losses associated with power shortfalls. The scenarios reflect varying degrees of shortage severity; the levels of investment needed to avoid these supply inadequacies were also estimated. These scenarios were determined by (1) comparing projected needs under three sets of conditions related to growth and composition set forth by the US Department of Energy with current grid investment anticipated in the ERCOT region, (2) translating the resulting shortfalls into anticipated constraints on power usage in the private sector, and (3) modeling the potential effects based on anticipated needs and responsiveness to shortfalls across a broad spectrum of industrial segments.

Results are presented as reductions from baseline expectations in 2040 (which assume adequate supplies) on both an annual basis as of that year as well as cumulatively.

The systems used in this analysis are briefly described on the following page, with additional detail in Appendix A. Impact results by industry are included in Appendix B.

Measuring Economic and Fiscal Benefits

Any economic stimulus, whether positive or negative, generates multiplier effects throughout the economy. In this instance, power supply inadequacies would result in losses in direct activity which would, in turn, lead to ripple effects through the economy. Economic activity generates tax receipts to the State and local governments, and the fiscal effects of the economic impacts measured during the course of this study were also quantified. Further detail regarding methods and assumptions is provided in Appendix A.

The Perryman Group's dynamic input-output assessment system and econometric model (the US Multi-Regional Impact Assessment System and the US Multi-Regional Econometric Model, both of which are described in further detail in the Appendices to this report) was developed by the firm about 40 years ago and has been consistently maintained and updated since that time. These fully integrated models have been used in thousands of analyses for clients ranging from major corporations to government agencies and has been peer reviewed on multiple occasions. The impact system uses a variety of data (from surveys, industry information, and other sources) to describe the various goods and services (known as resources or inputs) required to produce another good/service. This process allows for estimation of the total economic impact (including multiplier effects) of the relevant scenarios, with the econometric model permitting consideration of dynamic responses over time. The models used in the current analysis reflect the specific industrial composition and characteristics of the Texas economy.

Total economic effects are quantified for key measures of business activity (further explained in the Appendix). Note that these measures are alternative means of expressing the same effects; they are not additive.

- **Total expenditures** (or total spending) measure the dollars changing hands as a result of the economic stimulus.
- **Gross product** (or output) is production of goods and services that will come about in the area as a result of the activity. This measure is parallel to the gross domestic product numbers commonly reported by various media outlets and is a subset of total expenditures.
- **Personal income** is dollars that end up in the hands of people in the area; the vast majority of this aggregate derives from the earnings of employees, but payments such as interest and rents are also included.
- **Job effects** are expressed as job-years of employment for a temporary stimulus such as construction and jobs for ongoing effects. A job-year is one person working for one year, though it could be multiple individuals working partial years (such as often the case in construction projects) or fewer individuals working multiple years (such as in cumulative effects).

Monetary values were quantified on a constant (2024 dollars) basis to eliminate the effects of inflation.

An initial phase of this assessment involved expanding The Perryman Group's 2040 baseline forecast to a detailed industrial level (more than 400 industries). As noted, these baseline projections assume adequate electric power supplies. The three scenarios described below reflect varying levels of transmission inadequacy and the resulting decrease in economic activity which could be expected compared to the baseline projections.

Scenario 1

The initial scenario results in an underinvestment in electric transmission of **$3.65 billion** relative to currently anticipated level and would lead to substantial losses by 2040.

- The Perryman Group estimates that the total decrease in business activity during 2040 under these conditions would include **$9.7 billion** in gross product and approximately **40,500** jobs.
- Cumulatively over the 2024-2040 period, the total losses include a projected **$36.8 billion** in gross product and almost **157,000** job-years (including multiplier effects).

Potential Economic Costs of Inadequate Electric Transmission in Texas: Scenario 1

	Total Expenditures (Billions of 2024 Dollars)	**Gross Product** (Billions of 2024 Dollars)	**Personal Income** (Billions of 2024 Dollars)	**Employment** (Jobs/Job-Years)
2040 Baseline Projections	$8,437.847	$4,155.693	$2,121.808	16,689,536 Jobs
Losses Due to Inadequate Electric Transmission				
Losses in 2040	($23.690)	($9.745)	($4.995)	(40,522) Jobs
Cumulative Losses Through 2040	($89.572)	($36.844)	($18.885)	(156,983) Job-Years

Note: Baseline private-sector activity in 2040 based on The Perryman Group's most recent projections (assuming adequate supplies of electric power). Annual losses based on The Perryman Group's estimates of potential direct decreases in business activity associated with inadequate power supplies and related downstream effects. A job-year is one person working for one year. Additional explanation of terms and methods may be found elsewhere in this report and in Appendix A. For results by major industry group, see Appendix B.
Source: US Multi-Regional Impact Assessment System, The Perryman Group

Scenario 2

Underinvestment in electric transmission of **$10.41 billion** would occur under the second scenario.

- The projected total decrease in business activity in 2040 in these circumstances includes an estimated **$22.3 billion** in gross product and approximately **92,900** jobs.
- Cumulatively over the 2024-2040 period, the total losses include a projected **$113.0 billion** in gross product and almost **487,100** job-years (including multiplier effects).

Potential Economic Costs of Inadequate Electric Transmission in Texas: Scenario 2

	Total Expenditures (Billions of 2024 Dollars)	Gross Product (Billions of 2024 Dollars)	Personal Income (Billions of 2024 Dollars)	Employment (Jobs/Job-Years)
2040 Baseline Projections	$8,437.847	$4,155.693	$2,121.808	16,689,536 Jobs
Losses Due to Inadequate Electric Transmission				
Losses in 2040	($54.330)	($22.348)	($11.455)	(92,930) Jobs
Cumulative Losses Through 2040	($274.723)	($113.004)	($57.921)	(487,069) Job-Years

Note: Baseline private-sector activity in 2040 based on The Perryman Group's most recent projections (assuming adequate supplies of electric power). Annual losses based on The Perryman Group's estimates of potential direct decreases in business activity associated with inadequate power supplies and related downstream effects. A job-year is one person working for one year. Additional explanation of terms and methods may be found elsewhere in this report and in Appendix A. For results by major industry group, see Appendix B.
Source: US Multi-Regional Impact Assessment System, The Perryman Group

Scenario 3

The consequences associated with an underinvestment in electric transmission of **$12.66 billion** as determined under this scenario would result in even greater losses in business activity.

- The estimated losses in 2040 (including related multiplier effects) total a projected **$25.5 billion** in gross product and approximately **106,100** jobs.
- Cumulatively over the 2024-2040 period, the total losses include a projected **$159.8 billion** in gross product and almost **696,500** job-years (including multiplier effects).

Potential Economic Costs of Inadequate Electric Transmission in Texas: Scenario 3				
	Total Expenditures (Billions of 2024 Dollars)	**Gross Product** (Billions of 2024 Dollars)	**Personal Income** (Billions of 2024 Dollars)	**Employment** (Jobs/Job-Years)
2040 Baseline Projections	$8,437.847	$4,155.693	$2,121.808	16,689,536 Jobs
Losses Due to Inadequate Electric Transmission				
Losses in 2040	($62.046)	($25.522)	($13.081)	(106,128) Jobs
Cumulative Losses Through 2040	($388.490)	($159.801)	($81.906)	(696,485) Job-Years

Note: Baseline private-sector activity in 2040 based on The Perryman Group's most recent projections (assuming adequate supplies of electric power). Annual losses based on The Perryman Group's estimates of potential direct decreases in business activity associated with inadequate power supplies and related downstream effects. A job-year is one person working for one year. Additional explanation of terms and methods may be found elsewhere in this report and in Appendix A. For results by major industry group, see Appendix B.
Source: US Multi-Regional Impact Assessment System, The Perryman Group

Fiscal Effects

Business activity generates tax receipts. The reduction in economic growth due to inadequate investment in transmission negatively affects receipts to the State and local taxing entities. For example, a portion of the estimated lost retail sales (which is included in Appendix B) would have been taxable. In addition, the level of economic activity affects property tax values. Lower levels of income decrease housing demand, leading to lower taxable values as well as additional need for houses. Decreased retail sales and incomes diminish the need for commercial space such as restaurants, retail outlets, and personal service facilities.

To the extent that inadequate transmission constrains economic activity, taxes correspondingly decline, decreasing the resources available to meet critical public needs.

Reduced property values negatively affect taxes to counties, cities, school districts, and other local taxing entities. Lower rates of production and other activity in various sector result in reduced franchise and corporate taxes. To the extent that inadequate transmission constrains economic activity, taxes correspondingly decline, decreasing the resources available to meet critical public needs.

The projected fiscal losses associated with inadequate electric transmission infrastructure in 2040 range from **$146.4 million** to **$383.4 million** to the State and **$283.1 million** to **$741.4 million** to local government entities depending on the severity of the resulting shortages. Cumulatively through 2040, losses total a projected **$553.5 million-$2.4 billion** to the State and almost **$1.1 billion-$4.6 billion** to local government entities.

The Potential Fiscal Cost of Inadequate Transmission		
	State of Texas (Millions of 2024 Dollars)	**Local Government Entities** (Millions of 2024 Dollars)
Scenario 1		
Losses in 2040	($146.401)	($283.098)
Cumulative Losses Through 2040	($553.530)	($1,070.369)
Scenario 2		
Losses in 2040	($335.749)	($649.243)
Cumulative Losses Through 2040	($1,697.721)	($3,282.909)
Scenario 3		
Losses in 2040	($383.430)	($741.445)
Cumulative Losses Through 2040	($2,400.775)	($4,642.414)

Note: Tax losses based on the estimated potential decreases in business activity as described in this study.
Source: US Multi-Regional Impact Assessment System, The Perryman Group

Conclusion

The Texas economy is a center for growth, attracting new residents and major corporate locations and expansions at a rate outpacing other parts of the country. As a result, the need for electric power is growing, and investments in electric transmission are essential. The emergence of high-use industries and electrification further increases the demand.

Falling short on meeting the demand for transmission and, therefore, the availability of electric power generates losses in business activity that are far in excess of the investments needed to sustain expansion.

Substantial new infrastructure is planned, and it is crucial that these projects are facilitated and supported. The Perryman Group's analysis clearly indicates that falling short on meeting the demand for transmission and, therefore, the availability of electric power generates losses in business activity that are far in excess of the investments needed to sustain expansion. Texas is seeing ongoing population expansion and has enormous growth potential in both traditional industries and emerging sectors that require significant and reliable electricity supplies. This potential can only be achieved if the necessary supporting resources are available. Transmission capacity is crucial to ongoing prosperity.

Appendix A: Methods Used

US Multi-Regional Impact Assessment System

The US Multi-Regional Impact Assessment System (USMRIAS) measures multiplier effects of economic stimuli. The USMRIAS was developed and is maintained by The Perryman Group. This model has been used in thousands of diverse applications across the country and has an excellent reputation for accuracy and credibility; it has also been peer reviewed on multiple occasions and has been a key factor in major national and international policy simulations.

The basic modeling technique is known as dynamic input-output analysis, which essentially uses extensive survey data, industry information, and a variety of corroborative source materials to create a matrix describing the various goods and services (known as resources or inputs) required to produce one unit (a dollar's worth) of output for a given sector. Once the base information is compiled, it can be mathematically simulated to generate evaluations of the magnitude of successive rounds of activity involved in the overall production process.

There are two essential steps in conducting an input-output analysis once the system is operational. The first major endeavor is to accurately define the levels of direct activity to be evaluated. In this instance, studies related to the economic impact of electricity shortfalls were utilized in developing scenarios of direct effects by detailed (more than 400) industrial category. The three scenarios reflect varying degrees of shortfall. These potential shortfalls are allocated across this spectrum of private industries based on relative power usage and empirical analysis from academic literature regarding the responsiveness of gross product to power constraints. The cost estimates for incremental resources were based on the unit costs associated with current expansion initiatives within ERCOT.[1]

The second phase involves model simulation to determine total (not only direct, but also indirect and induced) effects of the potential shortfalls, which is accomplished in this

[1] US Department of Energy, "National Transmission Needs Study," October 2023; Rhodes, Joshua D., PhD, "ERCOT 2040: A Roadmap for Modernizing Texas' Electricity Infrastructure," July 2023; Thomas, Douglas and Dr. Juan Fung, "Measuring Downstream Supply Chain Losses Due to Power Disturbances," National Institute of Standards and Technology, US Department of Commerce, October 2022.

instance through the use of total requirements coefficients related to power usage. Additional detail is provided in the following sections.

Model Simulation

The direct inputs were then implemented in a series of simulations of the USMRIAS to measure total (not only direct, but also indirect and induced) economic effects of the direct stimulus. The systems used reflect the unique industrial structure of Texas economy.

The USMRIAS is somewhat similar in format to the Input-Output Model of the United States which is maintained by the US Department of Commerce. The model developed by TPG, however, incorporates several important enhancements and refinements. Specifically, the expanded system includes (1) comprehensive 500-sector coverage for any county, multi-county, or urban region; (2) calculation of both total expenditures and value-added by industry and region; (3) direct estimation of expenditures for multiple basic input choices (expenditures, output, income, or employment); (4) extensive parameter localization; (5) price adjustments for real and nominal assessments by sectors and areas; (6) comprehensive measurement of the induced impacts associated with payrolls and consumer spending; (7) embedded modules to estimate multi-sectoral direct spending effects; (8) estimation of retail spending activity by consumers; and (9) comprehensive linkage and integration capabilities with a wide variety of econometric, real estate, occupational, and fiscal impact models.

The impact assessment (input-output) process essentially estimates the amounts of all types of goods and services required to produce one unit (a dollar's worth) of a specific type of output. For purposes of illustrating the nature of the system, it is useful to think of inputs and outputs in dollar (rather than physical) terms. As an example, the construction of a new building will require specific dollar amounts of lumber, glass, concrete, hand tools, architectural services, interior design services, paint, plumbing, and numerous other elements. Each of these suppliers must, in turn, purchase additional dollar amounts of inputs. This process continues through multiple rounds of production, thus generating subsequent increments to business activity. The initial process of building the facility is known as the *direct effect*. The ensuing transactions in the output chain constitute the *indirect effect*.

Another pattern that arises in response to any direct economic activity comes from the payroll dollars received by employees at each stage of the production cycle. As workers are compensated, they use some of their income for taxes, savings, and purchases from external markets. A substantial portion, however, is spent locally on food, clothing, health care services, utilities, housing, recreation, and other items. Typical purchasing

patterns in the relevant areas are obtained from the Center for Community and Economic Research *Cost of Living Index*, a privately compiled inter-regional measure which has been widely used for several decades, and the *Consumer Expenditure Survey* of the US Department of Labor. These initial outlays by area residents generate further secondary activity as local providers acquire inputs to meet this consumer demand. These consumer spending impacts are known as the *induced effect*. The USMRIAS is designed to provide realistic, yet conservative, estimates of these phenomena.

Sources for information used in this process include the Bureau of the Census, the Bureau of Labor Statistics, the Regional Economic Information System of the US Department of Commerce, and other public and private sources. The pricing data are compiled from the US Department of Labor and the US Department of Commerce. The verification and testing procedures make use of extensive public and private sources.

Impacts are typically measured in constant dollars to eliminate the effects of inflation. In this instance, the analysis of losses was estimated using the total requirements coefficients of the model, thus capturing overall upstream and downstream effects.

The USMRIAS is also integrated with a comprehensive fiscal model, which links the tax payments by industry to the specific rates and structures associated with the relevant State and local governmental authorities.

Measures of Business Activity

The USMRIAS generates estimates of total economic effects on several measures of business activity. Note that these are different ways of measuring the same impacts; they are not additive.

The most comprehensive measure of economic activity is **Total Expenditures**. This measure incorporates every dollar that changes hands in any transaction. For example, suppose a farmer sells wheat to a miller for $0.50; the miller then sells flour to a baker for $0.75; the baker, in turn, sells bread to a customer for $1.25. The Total Expenditures recorded in this instance would be $2.50, that is, $0.50 + $0.75 + $1.25. This measure is quite broad but is useful in that (1) it reflects the overall interplay of all industries in the economy, and (2) some key fiscal variables such as sales taxes are linked to aggregate spending.

A second measure of business activity is **Gross Product**. This indicator represents the regional equivalent of Gross Domestic Product, the most commonly reported statistic regarding national economic performance. In other words, the Gross Product of Texas is the amount of US output that is produced in that state; it is defined as the value of all final goods produced in a given region for a specific period of time. Stated differently,

it captures the amount of value-added (gross area product) over intermediate goods and services at each stage of the production process, that is, it eliminates the double counting in the Total Expenditures concept. Using the example above, the Gross Product is $1.25 (the value of the bread) rather than $2.50. Alternatively, it may be viewed as the sum of the value-added by the farmer, $0.50; the miller, $0.25 ($0.75 - $0.50); and the baker, $0.50 ($1.25 - $0.75). The total value-added is, therefore, $1.25, which is equivalent to the final value of the bread. In many industries, the primary component of value-added is the wage and salary payments to employees.

The third gauge of economic activity used in this evaluation is **Personal Income**. As the name implies, Personal Income is simply the income received by individuals, whether in the form of wages, salaries, interest, dividends, proprietors' profits, or other sources. It may thus be viewed as the segment of overall impacts which flows directly to the citizenry.

The final aggregates used are **Jobs and Job-Years,** which reflect the full-time equivalent jobs generated by an activity. For an economic stimulus expected to endure (such as the ongoing operations of a facility), the Jobs measure is used. It should be noted that, unlike the dollar values described above, Jobs is a "stock" rather than a "flow." In other words, if an area produces $1 million in output in 2022 and $1 million in 2023, it is appropriate to say that $2 million was achieved in the 2022-23 period. If the same area has 100 people working in 2022 and 100 in 2023, it only has 100 Jobs. When a flow of jobs is measured, such as in a construction project or a cumulative assessment over multiple years, it is appropriate to measure employment in Job-Years (a person working for a year, though it could be multiple individuals working for partial years). This concept is distinct from Jobs, which anticipates that the relevant positions will be maintained on a continuing basis.

US Multi-Regional Econometric Model

The US Multi-Regional Econometric Model was utilized for both the baseline forecast and the dynamic simulations over time.

Overview

The US Multi-Regional Econometric Model was developed by Dr. M. Ray Perryman, President and CEO of The Perryman Group (TPG), about 40 years ago and has been consistently maintained, expanded, and updated since that time. It is formulated in an internally consistent manner and is designed to permit the integration of relevant global, national, state, and local factors into the projection process. It is the result of

four decades of continuing research in econometrics, economic theory, statistical methods, and key policy issues and behavioral patterns, as well as intensive, ongoing study of all aspects of the global, US, state, and metropolitan area economies. It is extensively used by scores of federal and State governmental entities on an ongoing basis, as well as hundreds of major corporations. It can be integrated with The Perryman Group's other models and systems to provide dynamic projections.

This section describes the forecasting process in a comprehensive manner, focusing on both the modeling and the supplemental analysis. The overall methodology, while certainly not ensuring perfect foresight, permits an enormous body of relevant information to impact the economic outlook in a systematic manner.

Model Logic and Structure

The Model revolves around a core system which projects output (real and nominal), income (real and nominal), and employment by industry in a simultaneous manner. For the purposes of illustration, it is useful to initially consider the employment functions. Essentially, employment within the system is a derived demand relationship obtained from a neo-Classical production function. The expressions are augmented to include dynamic temporal adjustments to changes in relative factor input costs, output and (implicitly) productivity, and technological progress over time. Thus, the typical equation includes output, the relative real cost of labor and capital, dynamic lag structures, and a technological adjustment parameter. The functional form is logarithmic, thus preserving the theoretical consistency with the neo-Classical formulation.

The income segment of the model is divided into wage and non-wage components. The wage equations, like their employment counterparts, are individually estimated at the 3-digit North American Industry Classification System (NAICS) level of aggregation. Hence, income by place of work is measured for approximately 90 production categories. The wage equations measure real compensation, with the form of the variable structure differing between "basic" and "non-basic."

The basic industries, comprised primarily of the various components of Mining, Agriculture, and Manufacturing, are export-oriented, i.e., they bring external dollars into the area and form the core of the economy. The production of these sectors typically flows into national and international markets; hence, the labor markets are influenced by conditions in areas beyond the borders of the particular region. Thus, real (inflation-adjusted) wages in the basic industry are expressed as a function of the corresponding national rates, as well as measures of local labor market conditions (the reciprocal of the unemployment rate), dynamic adjustment parameters, and ongoing trends.

The "non-basic" sectors are somewhat different in nature, as the strength of their labor markets is linked to the health of the local export sectors. Consequently, wages in these industries are related to those in the basic segment of the economy. The relationship also includes the local labor market measures contained in the basic wage equations.

Note that compensation rates in the export or "basic" sectors provide a key element of the interaction of the regional economies with national and international market phenomena, while the "non-basic" or local industries are strongly impacted by area production levels. Given the wage and employment equations, multiplicative identities in each industry provide expressions for total compensation; these totals may then be aggregated to determine aggregate wage and salary income. Simple linkage equations are then estimated for the calculation of personal income by place of work.

The non-labor aspects of personal income are modeled at the regional level using straightforward empirical expressions relating to national performance, dynamic responses, and evolving temporal patterns. In some instances (such as dividends, rents, and others) national variables (for example, interest rates) directly enter the forecasting system. These factors have numerous other implicit linkages into the system resulting from their simultaneous interaction with other phenomena in national and international markets which are explicitly included in various expressions.

The output or gross area product expressions are also developed at the 3-digit NAICS level. Regional output for basic industries is linked to national performance in the relevant industries, local and national production in key related sectors, relative area and national labor costs in the industry, dynamic adjustment parameters, and ongoing changes in industrial interrelationships (driven by technological changes in production processes).

Output in the non-basic sectors is modeled as a function of basic production levels, output in related local support industries (if applicable), dynamic temporal adjustments, and ongoing patterns. The inter-industry linkages are obtained from the input-output (impact assessment) system which is part of the overall integrated modeling structure maintained by The Perryman Group. Note that the dominant component of the econometric system involves the simultaneous estimation and projection of output (real and nominal), income (real and nominal), and employment at a disaggregated industrial level. This process, of necessity, also produces projections of regional price deflators by industry. These values are affected by both national pricing patterns and local cost variations and permit changes in prices to impact other aspects of economic behavior. Income is converted from real to nominal terms using relevant Consumer Price Indices, which fluctuate in response to national pricing patterns and unique local phenomena.

Several other components of the model are critical to the forecasting process. The demographic module includes (1) a linkage equation between wage and salary (establishment) employment and household employment, (2) a labor force participation rate function, and (3) a complete population system with endogenous migration. Given household employment, labor force participation (which is a function of economic conditions and evolving patterns of worker preferences), and the working-age population, the unemployment rate and level become identities.

The population system uses Census information, fertility rates, and life tables to determine the "natural" changes in population by age group. Migration, the most difficult segment of population dynamics to track, is estimated in relation to relative regional and extra-regional economic conditions over time. Because evolving economic conditions determine migration in the system, population changes are allowed to interact simultaneously with overall economic conditions. Through this process, migration is treated as endogenous to the system, thus allowing population to vary in accordance with relative business performance (particularly employment).

Real retail sales is related to income, interest rates, dynamic adjustments, and patterns in consumer behavior on a store group basis. It is expressed on an inflation-adjusted basis. Inflation at the state level relates to national patterns, indicators of relative economic conditions, and ongoing trends. As noted earlier, prices are endogenous to the system.

A final significant segment of the forecasting system relates to real estate absorption and activity. The short-term demand for various types of property is determined by underlying economic and demographic factors, with short-term adjustments to reflect the current status of the pertinent building cycle. In some instances, this portion of the forecast requires integration with the US Multi-Regional Industry-Occupation System which is maintained by The Perryman Group. This system also allows any employment simulation or forecast from the econometric model to be translated into a highly detailed occupational profile.

The overall US Multi-Regional Econometric Model contains numerous additional specifications, and individual expressions are modified to reflect alternative lag structures, empirical properties of the estimates, simulation requirements, and similar phenomena. Moreover, it is updated on an ongoing basis as new data releases become available. Nonetheless, the above synopsis offers a basic understanding of the overall structure and underlying logic of the system.

Model Simulation and Multi-Regional Structure

The initial phase of the simulation process is the execution of a standard non-linear algorithm for the state system and that of each of the individual sub-areas. The external assumptions are derived from scenarios developed through national and international models and extensive analysis by The Perryman Group.

Once the initial simulations are completed, they are merged into a single system with additive constraints and interregional flows. Using information on minimum regional requirements, import needs, export potential, and locations, it becomes possible to balance the various forecasts into a mathematically consistent set of results. This process is, in effect, a disciplining exercise with regard to the individual regional (including metropolitan and rural) systems. By compelling equilibrium across all regions and sectors, the algorithm ensures that the patterns in state activity are reasonable in light of smaller area dynamics and, conversely, that the regional outlooks are within plausible performance levels for the state as a whole.

The iterative simulation process has the additional property of imposing a global convergence criterion across the entire multi-regional system, with balance being achieved simultaneously on both a sectoral and a geographic basis. This approach is particularly critical on non-linear dynamic systems, as independent simulations of individual systems often yield unstable, non-convergent outcomes.

It should be noted that the underlying data for the modeling and simulation process are frequently updated and revised by the various public and private entities compiling them. Whenever those modifications to the database occur, they bring corresponding changes to the structural parameter estimates of the various systems and the solutions to the simulation and forecasting system. The multi-regional version of the econometric model is re-estimated and simulated with each such data release, thus providing a constantly evolving and current assessment of state and local business activity.

The Final Forecast

The process described above is followed to produce an initial set of projections. Through the comprehensive multi-regional modeling and simulation process, a systematic analysis is generated which accounts for both historical patterns in economic performance and inter-relationships and the best available information on the future course of pertinent external factors. While the best available techniques and data are employed in this effort, they are not capable of directly capturing “street sense,” i.e., the contemporaneous and often non-quantifiable information that can materially affect economic outcomes. In order to provide a comprehensive approach to the prediction of

business conditions, it is necessary to compile and assimilate extensive material regarding current events and factors both across the state of Texas and elsewhere.

This critical aspect of the forecasting methodology includes activities such as (1) daily review of hundreds of financial and business publications and electronic information sites; (2) review of major newspapers and online news sources in the state on a daily basis; (3) dozens of hours of direct telephone interviews with key business and political leaders in all parts of the state; (4) face-to-face discussions with representatives of major industry groups; and (5) frequent site visits to the various regions of the state. The insights arising from this "fact finding" are analyzed and evaluated for their effects on the likely course of the future activity.

Another vital information resource stems from the firm's ongoing interaction with key players in the international, domestic, and state economic scenes. Such activities include visiting with corporate groups on a regular basis and being regularly involved in the policy process at all levels. The firm is also an active participant in many major corporate relocations, economic development initiatives, and regulatory proceedings.

Once organized, this information is carefully assessed and, when appropriate, independently verified. The impact on specific communities and sectors that is distinct from what is captured by the econometric system is then factored into the forecast analysis. For example, the opening or closing of a major facility, particularly in a relatively small area, can cause a sudden change in business performance that will not be accounted for by either a modeling system based on historical relationships or expected (primarily national and international) factors.

The final step in the forecasting process is the integration of this material into the results in a logical and mathematically consistent manner. In some instances, this task is accomplished through "constant adjustment factors" which augment relevant equations. In other cases, anticipated changes in industrial structure or regulatory parameters are initially simulated within the context of the Multi-Regional Impact Assessment System to estimate their ultimate effects by sector. Those findings are then factored into the simulation as constant adjustments on a distributed temporal basis. Once this scenario is formulated, the extended system is again balanced across regions and sectors through an iterative simulation algorithm analogous to that described in the preceding section.

Appendix B: Results by Industry

The Baseline Private-Sector 2040 Economic Outlook

Results by Industry

Industry	Total Expenditures	Gross Product	Personal Income	Jobs
Agriculture	+$35,441.3 m	+$14,031.4 m	+$6,451.3 m	+92,519
Mining	+$943,312.4 m	+$390,045.5 m	+$97,236.7 m	+267,174
Utilities	+$266,823.8 m	+$55,840.4 m	+$22,756.4 m	+65,829
Construction	+$330,060.2 m	+$179,578.8 m	+$111,292.5 m	+1,154,458
Manufacturing	+$1,885,695.0 m	+$643,859.4 m	+$343,088.2 m	+1,248,286
Wholesale Trade	+$408,085.2 m	+$324,393.2 m	+$167,904.4 m	+853,694
Retail Trade*	+$398,408.3 m	+$327,722.1 m	+$176,155.6 m	+3,617,861
Transportation & Warehousing	+$224,581.3 m	+$138,527.8 m	+$73,449.5 m	+853,025
Information	+$274,741.7 m	+$195,407.9 m	+$81,238.5 m	+187,858
Financial Activities*	+$2,257,020.6 m	+$864,303.3 m	+$285,578.2 m	+1,228,650
Business Services	+$834,017.9 m	+$622,744.7 m	+$473,594.4 m	+3,111,428
Health Services	+$272,549.8 m	+$231,150.0 m	+$163,813.9 m	+2,018,560
Other Services	+$307,109.0 m	+$168,088.3 m	+$119,248.0 m	+1,990,195
Total, All Industries	**+$8,437,846.6 m**	**+$4,155,692.8 m**	**+$2,121,807.6 m**	**+16,689,536**

Source: US Multi-Regional Impact Assessment System, The Perryman Group
Notes: Monetary values given in millions of 2024 US dollars per year. Components may not sum due to rounding. Retail Trade includes Restaurants, Financial Activities includes Real Estate.

The Potential Annual 2040 Economic Costs of Inadequate Electric Transmission in Texas: Scenario 1

Results by Industry

Industry	Total Expenditures	Gross Product	Personal Income	Jobs
Agriculture	-$103.3 m	-$40.9 m	-$18.8 m	-270
Mining	-$6,169.2 m	-$2,550.9 m	-$635.9 m	-1,747
Utilities	-$1,745.0 m	-$365.2 m	-$148.8 m	-431
Construction	-$2,158.6 m	-$1,174.4 m	-$727.8 m	-7,550
Manufacturing	-$8,148.6 m	-$2,991.9 m	-$1,728.6 m	-6,325
Wholesale Trade	-$667.2 m	-$530.4 m	-$274.5 m	-1,396
Retail Trade*	-$651.4 m	-$535.8 m	-$288.0 m	-5,915
Transportation & Warehousing	-$1,468.8 m	-$906.0 m	-$480.4 m	-5,579
Information	+$3,423.2 m	+$2,434.7 m	+$1,012.2 m	+2,341
Financial Activities*	-$3,690.2 m	-$1,413.1 m	-$466.9 m	-2,009
Business Services	-$1,363.6 m	-$1,018.2 m	-$774.3 m	-5,087
Health Services	-$445.6 m	-$377.9 m	-$267.8 m	-3,300
Other Services	-$502.1 m	-$274.8 m	-$195.0 m	-3,254
Total, All Industries	**-$23,690.5 m**	**-$9,744.8 m**	**-$4,994.7 m**	**-40,522**

Source: US Multi-Regional Impact Assessment System, The Perryman Group
Notes: Monetary values given in millions of 2024 US dollars per year. Components may not sum due to rounding. Retail Trade includes Restaurants, Financial Activities includes Real Estate.

The Potential Cumulative Economic Costs Through 2040 of Inadequate Electric Transmission in Texas: Scenario 1

Results by Industry

Industry	Total Expenditures	Gross Product	Personal Income	Job Years*
Agriculture	-$390.6 m	-$154.6 m	-$71.1 m	-1,045
Mining	-$23,325.3 m	-$9,644.7 m	-$2,404.4 m	-6,769
Utilities	-$6,597.8 m	-$1,380.8 m	-$562.7 m	-1,668
Construction	-$8,161.4 m	-$4,440.4 m	-$2,751.9 m	-29,250
Manufacturing	-$30,809.3 m	-$11,312.0 m	-$6,535.7 m	-24,502
Wholesale Trade	-$2,522.7 m	-$2,005.3 m	-$1,037.9 m	-5,407
Retail Trade*	-$2,462.9 m	-$2,025.9 m	-$1,089.0 m	-22,916
Transportation & Warehousing	-$5,553.2 m	-$3,425.4 m	-$1,816.2 m	-21,612
Information	+$12,942.9 m	+$9,205.5 m	+$3,827.1 m	+9,068
Financial Activities*	-$13,952.3 m	-$5,342.9 m	-$1,765.4 m	-7,782
Business Services	-$5,155.7 m	-$3,849.7 m	-$2,927.6 m	-19,708
Health Services	-$1,684.8 m	-$1,428.9 m	-$1,012.7 m	-12,786
Other Services	-$1,898.5 m	-$1,039.1 m	-$737.2 m	-12,606
Total, All Industries	**-$89,571.5 m**	**-$36,844.1 m**	**-$18,884.6 m**	**-156,983**

Source: US Multi-Regional Impact Assessment System, The Perryman Group
Notes: Monetary values given in millions of 2024 US dollars. A job-year is equivalent to one person working for one year. Components may not sum due to rounding. Retail Trade includes Restaurants, Financial Activities includes Real Estate.

The Potential Annual 2040 Economic Costs of Inadequate Electric Transmission in Texas: Scenario 2

Results by Industry

Industry	Total Expenditures	Gross Product	Personal Income	Jobs
Agriculture	-$236.9 m	-$93.8 m	-$43.1 m	-618
Mining	-$14,148.2 m	-$5,850.1 m	-$1,458.4 m	-4,007
Utilities	-$4,001.9 m	-$837.5 m	-$341.3 m	-987
Construction	-$4,950.4 m	-$2,693.4 m	-$1,669.2 m	-17,315
Manufacturing	-$18,687.7 m	-$6,861.4 m	-$3,964.3 m	-14,505
Wholesale Trade	-$1,530.2 m	-$1,216.3 m	-$629.6 m	-3,201
Retail Trade*	-$1,493.9 m	-$1,228.8 m	-$660.5 m	-13,566
Transportation & Warehousing	-$3,368.4 m	-$2,077.7 m	-$1,101.6 m	-12,794
Information	+$7,850.6 m	+$5,583.7 m	+$2,321.4 m	+5,368
Financial Activities*	-$8,462.9 m	-$3,240.8 m	-$1,070.8 m	-4,607
Business Services	-$3,127.2 m	-$2,335.0 m	-$1,775.8 m	-11,667
Health Services	-$1,022.0 m	-$866.7 m	-$614.2 m	-7,569
Other Services	-$1,151.5 m	-$630.3 m	-$447.1 m	-7,462
Total, All Industries	**-$54,330.5 m**	**-$22,348.2 m**	**-$11,454.6 m**	**-92,930**

Source: US Multi-Regional Impact Assessment System, The Perryman Group
Notes: Monetary values given in millions of 2024 US dollars per year. Components may not sum due to rounding. Retail Trade includes Restaurants, Financial Activities includes Real Estate.

The Potential Cumulative Economic Costs Through 2040 of Inadequate Electric Transmission in Texas: Scenario 2

Results by Industry

Industry	Total Expenditures	Gross Product	Personal Income	Job Years*
Agriculture	-$1,197.8 m	-$474.2 m	-$218.0 m	-3,241
Mining	-$71,540.6 m	-$29,581.0 m	-$7,374.4 m	-21,003
Utilities	-$20,235.9 m	-$4,234.9 m	-$1,725.8 m	-5,175
Construction	-$25,031.7 m	-$13,619.2 m	-$8,440.4 m	-90,752
Manufacturing	-$94,494.6 m	-$34,694.9 m	-$20,045.4 m	-76,023
Wholesale Trade	-$7,737.3 m	-$6,150.5 m	-$3,183.5 m	-16,777
Retail Trade*	-$7,553.8 m	-$6,213.6 m	-$3,339.9 m	-71,100
Transportation & Warehousing	-$17,032.2 m	-$10,505.9 m	-$5,570.4 m	-67,056
Information	+$39,697.0 m	+$28,234.1 m	+$11,738.0 m	+28,135
Financial Activities*	-$42,793.0 m	-$16,387.1 m	-$5,414.5 m	-24,146
Business Services	-$15,812.9 m	-$11,807.2 m	-$8,979.3 m	-61,148
Health Services	-$5,167.5 m	-$4,382.6 m	-$3,105.9 m	-39,670
Other Services	-$5,822.8 m	-$3,186.9 m	-$2,260.9 m	-39,112
Total, All Industries	**-$274,723.1 m**	**-$113,003.9 m**	**-$57,920.6 m**	**-487,069**

Source: US Multi-Regional Impact Assessment System, The Perryman Group
Notes: Monetary values given in millions of 2024 US dollars. A job-year is equivalent to one person working for one year. Components may not sum due to rounding. Retail Trade includes Restaurants, Financial Activities includes Real Estate.

The Potential Annual 2040 Economic Costs of Inadequate Electric Transmission in Texas: Scenario 3

Results by Industry

Industry	Total Expenditures	Gross Product	Personal Income	Jobs
Agriculture	-$270.5 m	-$107.1 m	-$49.2 m	-706
Mining	-$16,157.4 m	-$6,680.9 m	-$1,665.5 m	-4,576
Utilities	-$4,570.3 m	-$956.5 m	-$389.8 m	-1,128
Construction	-$5,653.4 m	-$3,075.9 m	-$1,906.3 m	-19,774
Manufacturing	-$21,341.6 m	-$7,835.8 m	-$4,527.3 m	-16,565
Wholesale Trade	-$1,747.5 m	-$1,389.1 m	-$719.0 m	-3,656
Retail Trade*	-$1,706.0 m	-$1,403.3 m	-$754.3 m	-15,492
Transportation & Warehousing	-$3,846.7 m	-$2,372.8 m	-$1,258.1 m	-14,611
Information	+$8,965.6 m	+$6,376.7 m	+$2,651.0 m	+6,130
Financial Activities*	-$9,664.8 m	-$3,701.0 m	-$1,222.9 m	-5,261
Business Services	-$3,571.4 m	-$2,666.7 m	-$2,028.0 m	-13,323
Health Services	-$1,167.1 m	-$989.8 m	-$701.5 m	-8,644
Other Services	-$1,315.1 m	-$719.8 m	-$510.6 m	-8,522
Total, All Industries	**-$62,046.2 m**	**-$25,521.9 m**	**-$13,081.4 m**	**-106,128**

Source: US Multi-Regional Impact Assessment System, The Perryman Group
Notes: Monetary values given in millions of 2024 US dollars per year. Components may not sum due to rounding. Retail Trade includes Restaurants, Financial Activities includes Real Estate.

The Potential Cumulative Economic Costs Through 2040 of Inadequate Electric Transmission in Texas: Scenario 3

Results by Industry

Industry	Total Expenditures	Gross Product	Personal Income	Job Years*
Agriculture	-$1,693.9 m	-$670.6 m	-$308.3 m	-4,635
Mining	-$101,166.7 m	-$41,830.9 m	-$10,428.3 m	-30,033
Utilities	-$28,615.9 m	-$5,988.7 m	-$2,440.5 m	-7,400
Construction	-$35,397.7 m	-$19,259.2 m	-$11,935.7 m	-129,771
Manufacturing	-$133,626.3 m	-$49,062.5 m	-$28,346.6 m	-108,710
Wholesale Trade	-$10,941.4 m	-$8,697.5 m	-$4,501.8 m	-23,991
Retail Trade*	-$10,681.9 m	-$8,786.7 m	-$4,723.0 m	-101,670
Transportation & Warehousing	-$24,085.5 m	-$14,856.6 m	-$7,877.2 m	-95,887
Information	+$56,136.1 m	+$39,926.4 m	+$16,598.9 m	+40,231
Financial Activities*	-$60,514.3 m	-$23,173.3 m	-$7,656.8 m	-34,528
Business Services	-$22,361.3 m	-$16,696.8 m	-$12,697.8 m	-87,438
Health Services	-$7,307.5 m	-$6,197.5 m	-$4,392.1 m	-56,726
Other Services	-$8,234.1 m	-$4,506.7 m	-$3,197.2 m	-55,929
Total, All Industries	**-$388,490.4 m**	**-$159,800.7 m**	**-$81,906.4 m**	**-696,485**

Source: US Multi-Regional Impact Assessment System, The Perryman Group
Notes: Monetary values given in millions of 2024 US dollars. A job-year is equivalent to one person working for one year. Components may not sum due to rounding. Retail Trade includes Restaurants, Financial Activities includes Real Estate.