RENEWABLES IN THE DESERT SOUTHWEST: SUSTAINABLE, SUITABLE, AND SUPPLEMENTARY

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INTRODUCTION

Testing and resource assessment for Texas, New Mexico, and Oklahoma have shown that renewable energy can provide a significant portion of the energy needs for the region. The Alternative Energy Institute at West Texas A&M University has been collecting resource data since 1978 and placing test projects for specific research topics for renewables at WTAMU and selected field sites. The potential for renewables and how they have merged into the existing grid and community/home/ranch use shows that these technologies have a place in the region of the Texas/Oklahoma panhandles. The potential for power production with reduced use of water is also important for this region.

This paper presents the success stories, the potential downsides, and the lessons learned from 30 years of renewable energy research. The focus is to provide evidence that renewables have a place in the energy plans of the Desert Southwest, and if properly placed and planned, are a long-term sustainable energy solution.

KEYWORDS

renewable, wind energy, sustainability

1. INTRODUCTION

Renewable energy has great potential as a sustainable, reliable resource in the region of the Texas/Oklahoma panhandles. This paper will show the current status and growth rate of the wind energy sector in this region and give some of the concerns that may limit the advance of renewables in the area. It will then explore the large utility grid operation, the concerns with further expansion of non-dispatchable power sources to the grid, and the advantages of reduced volatility and matching current load patterns. Future projects that can connect the separate grids will also be examined. The intention is to show that renewables can and do work, from western New Mexico to the plains of the Texas/Oklahoma panhandles.

2. SUSTAINABLE

Renewable energy has great potential as a sustainable, reliable resource in the region of the Texas/Oklahoma panhandles. Texas, New Mexico, and Oklahoma have been actively pursuing the creation of jobs, industry, infrastructure, and legal precedence for the smooth integration of renewable energy, specifically wind energy, into the electric grid systems. This has been

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slowed by the fact that all three U.S. national grid systems converge in the area which constitutes these states, making interconnection and free flow between grids almost impossible. Figure 1 shows these interconnections.

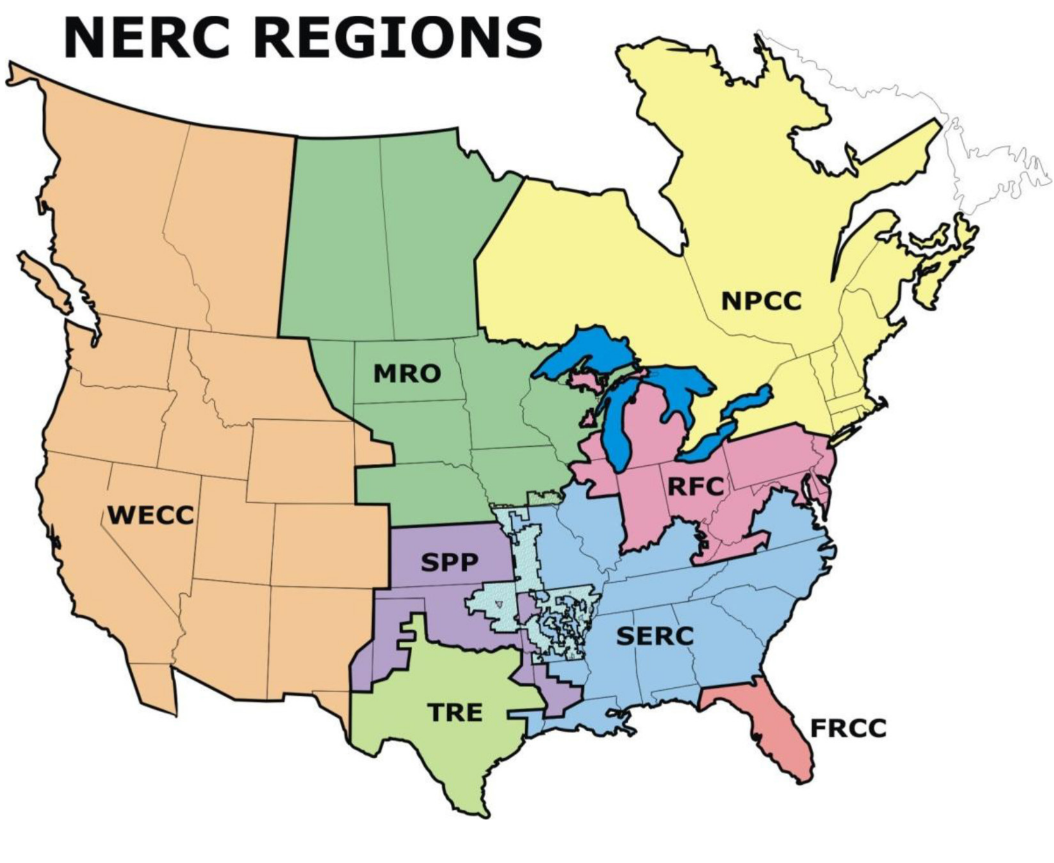
This breaking of the grid into subsections that have no AC-AC connections means that an outage in Ohio does not affect Texas or Oregon, but it also limits the market into which energy can be sold. The result is underutilization of the grids. Renewables can be used at any scale, but the larger installations usually have better return on investment. The home and business scale has shown potential for growth in recent years. Some of the benefits and growth in wind energy use in the region will be shown, and some of the potential hazards that future growth will have to avoid will be presented.

3. SUITABLE

Wind resource assessment and small wind turbine testing have been primary foci of the Alternative Energy Institute (AEI) since its founding in 1977 [2]. The cooperative programs with the Texas State Energy Conservation Office and the Energy Minerals and Natural Resources Department of New Mexico have both been active in determining where and how often the winds blow across state lands. The documentation of these suitable lands, along with the data that can determine the resource potential, then drives future developments.

AEI has assisted in the installation, repair, and inspection of 8 towers for New Mexico; Pastura, Johnson Mesa (Raton), Frio Draw (Clovis), Tatum, Guadalupe Mountains (Pinon),

FIGURE 1. Electric grid separations of the North American Electric Reliability Corporation (NERC), under the Federal Energy Regulatory Commission (FERC). [1]

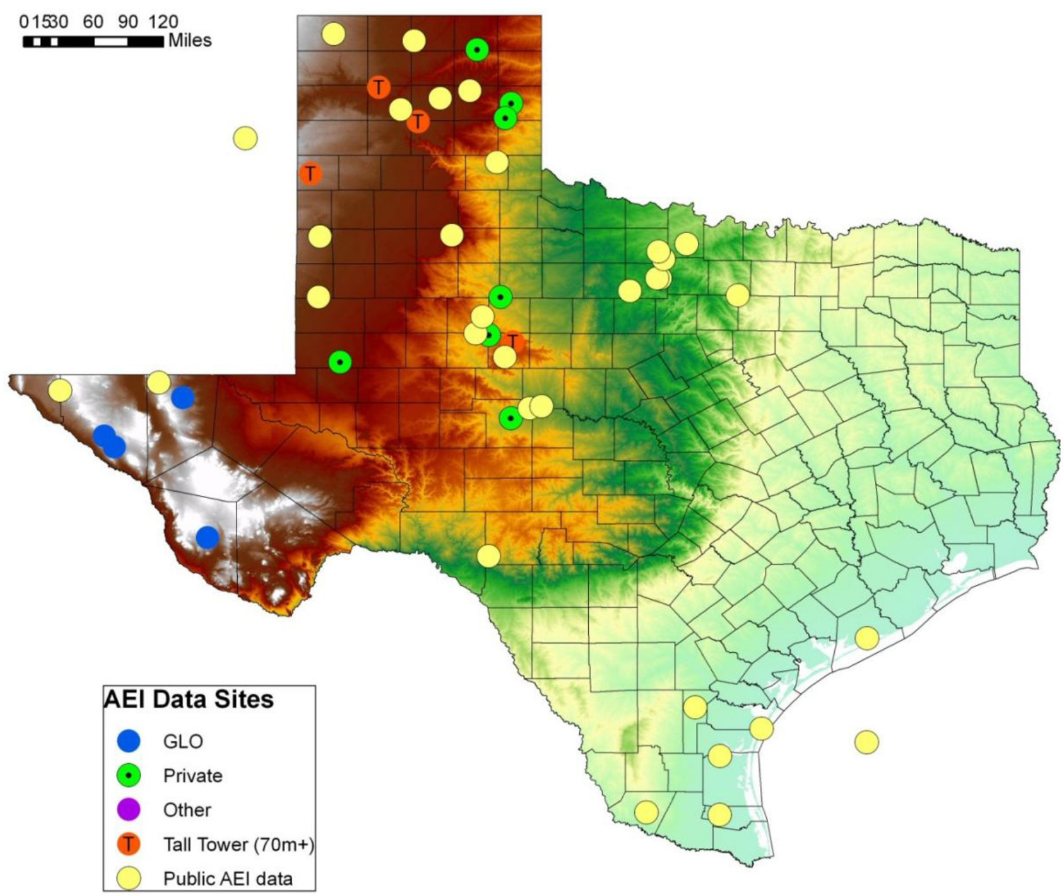


San Juan Mesa (Elida), Mesa Redonda (Tucumcari), and Gallup. Two of these sites have wind farms in operation nearby and discussions are in progress for more. In Texas, AEI has monitored more than 47 sites across Texas from the top of the Panhandle to the Gulf Coast, and as far south as the Rio Grande Valley region (see Fig. 2). AEI has installed and monitored towers in far west Texas, just outside El Paso. The data has drawn developers to the state so that Texas has the most installed wind power capacity in the nation. Locations of selected AEI monitored data sites across Texas are shown in Figure 2. These locations are a mixture of state-supported, private, and local public-supported sites.

Oklahoma sites that AEI has assisted are located near Weatherford, Woodward, and the entire Oklahoma panhandle. Wind farms have been installed in the areas with the longest data collection, and active searches are in place throughout the panhandle for suitable lands. Wind farm growth has placed the region among the forefront of all the United States, with the three states of Oklahoma, Texas, and New Mexico accounting for nearly 1/3 of all the wind energy in the country. Table 1 shows the ranking of these three states [3]. The states compete for position in the rankings for new construction, but all three of the states in the region are in the top 17.

Based on true potential, all three of the states are in the top 10 wind resource rated states in the USA; Texas (1), Oklahoma (9), and New Mexico (10) [4]. Texas is estimated to have 1,900,000 Megawatts (MW) potential, Oklahoma could have 517,000 MW, and New

FIGURE 2. Locations of selected AEI monitored data sites across Texas. These locations are a mixture of state supported, private and local public supported sites.



State	Megawatts Installed	US Ranking
Texas	10,394	1
Iowa	4,322	2
California	3,917	3
Illinois	2,742	4
Minnesota	2,718	5
Washington	2,573	6
Oregon	2,513	7
Oklahoma	2,007	8
Colorado	1,805	9
North Dakota	1,445	10
Wyoming	1,412	11
New York	1,403	12
Indiana	1,340	13
Kansas	1,274	14
Pennsylvania	789	15
South Dakota	784	16
New Mexico	750	17
TOTAL	42,188	

TABLE 1. U.S. installed wind energy capacity. [3]

Mexico has resources for 492,000 MW. With US current electrical generation at 1,054,800 MW [5], the region alone could supply three times the U.S. needs if developed fully.

The placement of the wind plants throughout the region has been dispersed by time and position; Figure 3 shows a simple map of wind farms with dots for location. What is most telling is that 70% of the wind capacity has been installed in the past seven years—the years of uninterrupted federal and state supports [3].

Figure 4 shows wind speed prediction maps created for the state and used in the resource assessment guidelines. The areas are the higher wind speed regions of the United States, corresponding to the Midwest and mid south regions. The black box outlines the windy portions of Texas, New Mexico, and Oklahoma. These maps are the basis for most wind power plant development. They are used as a winnowing process, allowing for speedier development of wind sites by focusing efforts in a suitable area. The criteria for a suitable area are available land, adequate wind potential, access to transportation, and power line connection proximity.

Estimates are that the full region of the United States from Texas through the Dakotas would provide five to ten times the total electrical power needed for the whole country if fully developed [2]. While that high a penetration into the grid may never be reached, and the transmission lines themselves would be undersized to handle that current load, it is very reassuring to know that such an inexhaustible resource exists in our borders without need for importation or outside control.

These large areas of resources, coupled with federal, regional, and state supports, and the work of developers with land owners, have produced the largest growth market in any energy sector. Wind energy in the United States has grown at 20–25% since 2005. The longest

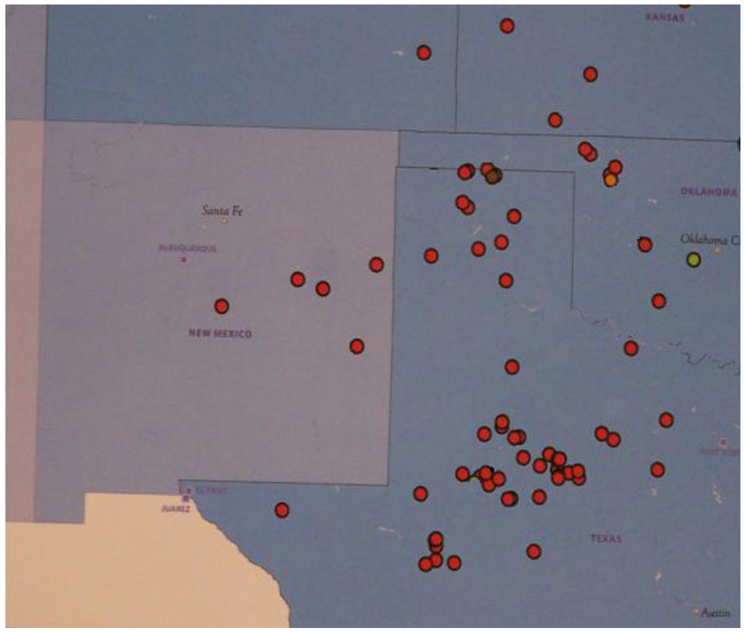
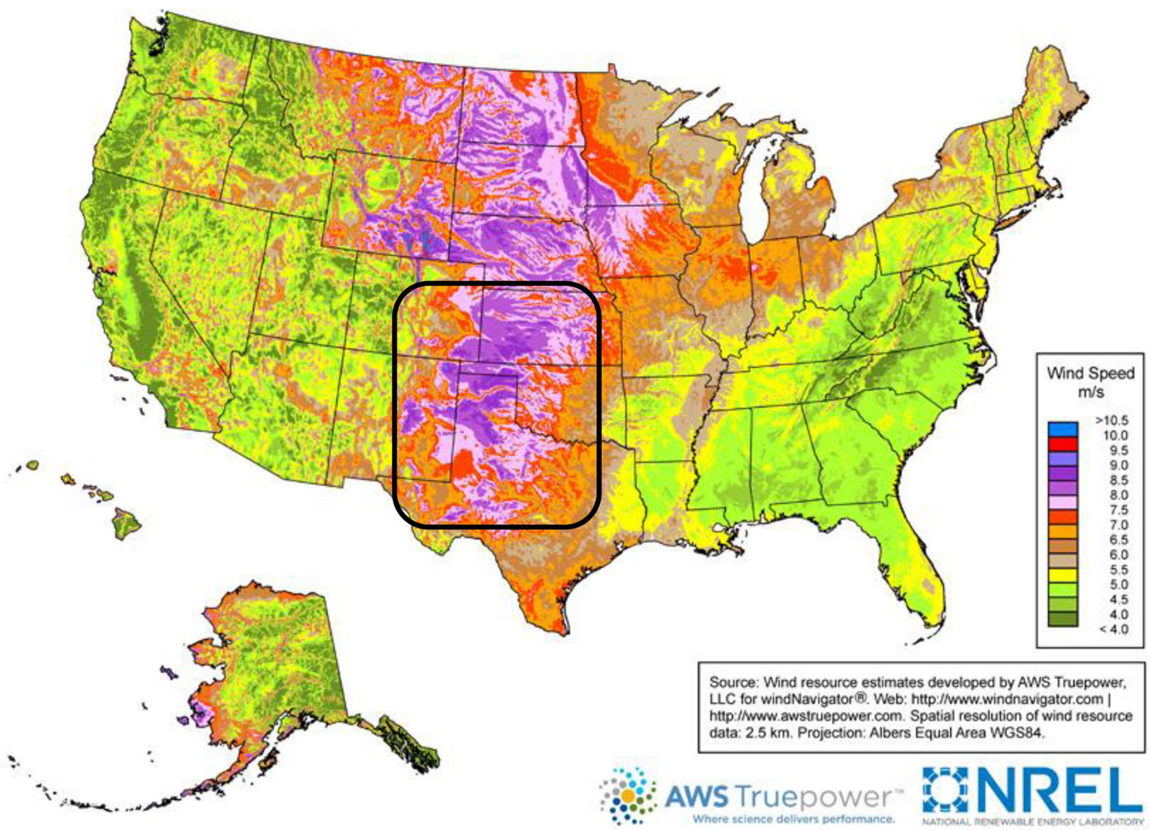


FIGURE 3. Wind farm sites (dots) for the region.

FIGURE 4. Wind speed at 80 meters above ground level, estimates from AWS Truepower for Wind Powering America/National Renewable Energy Laboratory. [6]



sustained growth of utility scale wind use in our history. This shows that when all the conditions are right—when land is available, when wind resource is productive, when pricing is acceptable, when the support conditions are sufficient, when credit is readily accessible—wind will grow to meet the existing ability of the utilities to accept it.

This unprecedented growth is best shown in Figure 5, showing the U.S. wind installed capacity where the majority of wind installations have occurred in the past seven years. This is the only time in history that Federal policies have supported wind growth without interruption.

Regional growth is going to be tempered by the area's resources. Wires for the transmission of the power to the load areas of the region are a constraint, but Figure 6 shows some of the proposed lines and the growth into the grid systems.

The Summary of Texas Resources [7] listed several of the concerns and problems facing expanded use of renewables. The Executive Summary portion of the document showed the following to be the concerns for the state:

- Accommodating Intermittency
- Delivering Renewable Energy to Markets
- Valuing Distributed Generation
- Incorporating Energy Storage
- Economics of Renewable Energy Investments
- How Carbon Changes the Picture
- Government Subsidies
- Jobs and Economic Development
- Resource Allocation Consequences and Tradeoffs

FIGURE 5. Total U.S. installed wind capacity in megawatts, 1999 to 2011. [3]

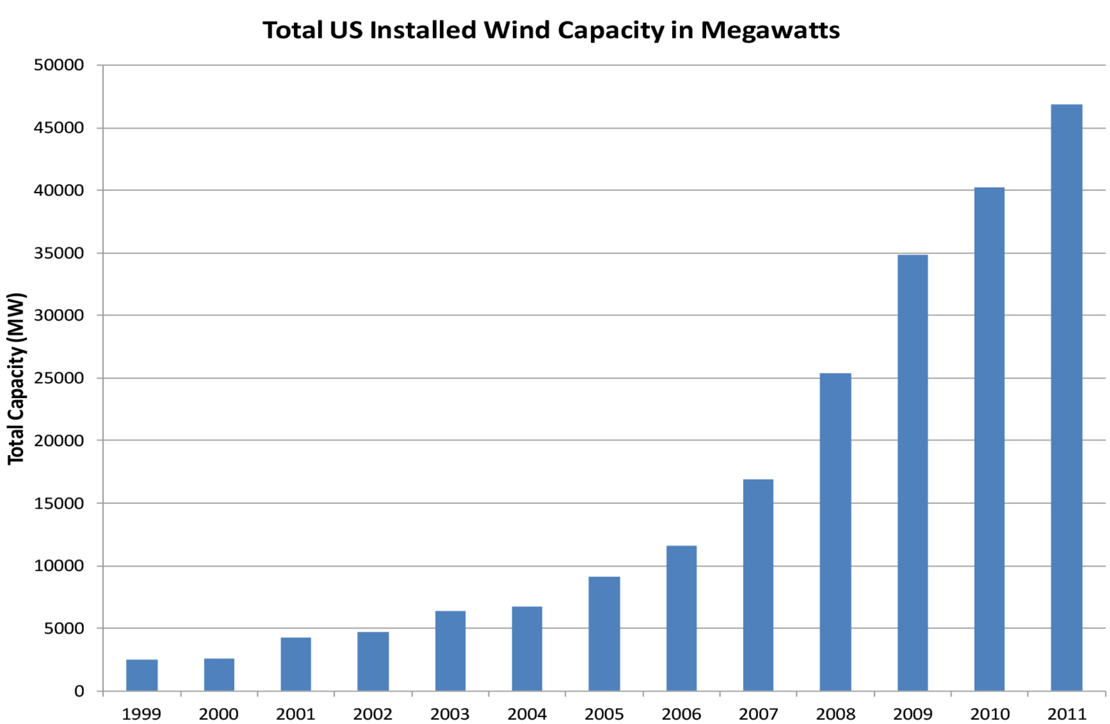
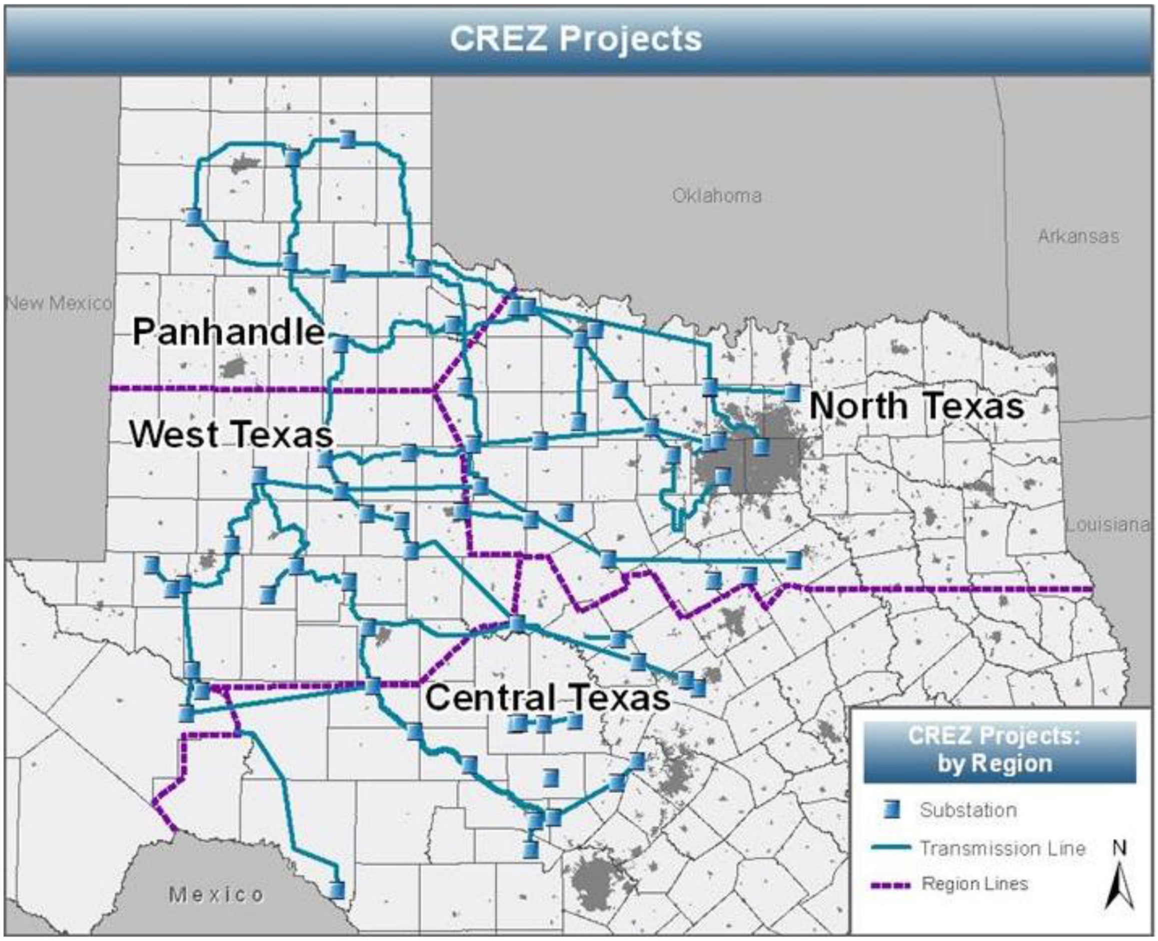


FIGURE 6. Competitive Renewable Energy Zone Line Plan. [11]



These should be taken as general considerations for the region. The largest obstacle for greater use of renewables has always been intermittency—the sun and wind are not continuous sources of energy. The interconnection of resource-rich areas to the load centers requires infrastructure. Placing a value on having energy coming from multiple locations along the grid rather than the hub and spoke delivery system now used has to be considered. This method creates higher confidence in the ability of utilities to deliver power to any section of the grid, but historically, the funds to spread energy plants across a grid have not been available.

Concerns about storage methods have plagued renewables. The typical battery storage systems will double the initial cost of a wind or solar plant, and it has not been proven to double the value to the utilities from that increased investment [8]. Overall return on investment for any renewable is debatable. Opponents claim that without the federal supports and state mandates, renewables would not stand alone.

The long term economic benefit to a region is also in the secondary supply business and the jobs on site. For every 2.5 MW installed, there is one full time job in maintenance and operations that stays in the region [9]. These local dollars are then churned in the local economies.

The lack of adequate transmission lines for additional renewable growth was considered to be the greatest near-term concern in Texas. The Public Utility Commission (PUC) of Texas addressed this in 2007 with the Competitive Renewable Energy Zones, where every region of the state was assigned a rating based on the installation cost for a set MW capacity and the cost expected to deliver that energy to the ERCOT grid [10]. The value of the total energy expected over the life of the wind plants is then compared to the expected installed cost and transmission line extension or upgrade. The results of the competitive process were used to choose new routes for wires or expansion of existing service. Figure 6 shows the resulting zones with the schematic paths for new wires. The Public Utility Commission of Texas agreed to this plan after comparing 28 different zones across Texas.

Regionally, delivering the energy to three distinct grids is a difficulty. The region has all three major grids serving it, placing it at the edge of every major grid in the United States.

Within a grid, the fluctuations are well defined for most load cases and conditions, but rare events such as the ERCOT incident in Feb. 2008 [12] show that when models are not accurate, incorporating wind energy with rapid change makes maintaining grid stability difficult for local utilities. The events of that day were caused by an older version of forecast modeling and an exceeding of the State energy needs compared to the capacity of the State's generation. The report [4] says:

> **Wind Energy Forecasting.** One portion of the incorrect amount of available capacity given by the Qualified Scheduling Entities (QSE) during this event (although by no means the only one) was the assessment of wind power availability. As has been stated a number of times following this event, the forecast of wind power coming from ERCOT's contracted forecast provider was very accurate in its prediction. Unfortunately, this wind forecast had not yet been integrated into ERCOT's system operations on February 26th. Instead, the scheduling of wind resources was done based on their corresponding QSE's resource schedules that are given to ERCOT both a day ahead and about an hour before the operating hour. While the use of the forecast is an obvious lesson learned and has been anticipated for quite a while at ERCOT, the way by which it is used can be just as important as the forecast itself.

New models have proven to approximate more closely the expected wind performance (up to 24 hours ahead of time), and now are in use so that similar problems will be avoided in the future.

4. SUPPLEMENTARY

Renewable energy needs to fit the loads. Not every wind turbine will be megawatt-scale, and not every solar plant will be a 10 MW high-temperature facility like the one in California shown in Figure 7. AEI has installed and operated renewable energy systems from 50 watts to 500 kilowatts, the range of sizes that will be used for field, home, ranch, and small business uses. Large-scale irrigation testing has also been done in cooperation with the United States Department of Agriculture, Agriculture Research Service, Bushland, Texas. Small wind testing has continued since the first turbines were built and installed at the West Texas State University, Nance Ranch. The swine facility was home for the first AEI owned units in 1978, as shown in Figure 8. Previous field testing had occurred on farm lands for water pumping using different pumping methods (bubbled water lift pumps). AEI developed modern electric wind pumping control systems once the concepts of variable voltage/variable speed operation of conventional pumps were compatible with wind-driven electricity.

FIGURE 7. Power Tower systems, heliocentric mirrors focus on the tower and super hot transfer fluids then power a steam plant at the bottom of the tower. [13]

FIGURE 8. (left) Drs. Vaughn Nelson, Earl Gilmore and Robert Barieau in front of the first wind units under test at AEI. (right) Patrick Acker repairing the Dakota Wind and Sun unit at the same location.

FIGURE 9. AEI personnel repairing a turbine at the Wind Test Center, WTAMU.

The original test facility had two hand-made units and a production 4 kW electric wind turbine—the Dakota Wind and Sun—modeled after the 1940s style Jacobs wind turbine. Figure 8 shows the founders of AEI with the wind turbines and the Dakota being examined.

The systems tested at the Wind Test Center were both prototypes and production units. The testing here lead to improvements in manufacturing, proof of concepts for new ideas, and the long-term operation (more than 18 years) on the Bergey 10 kW shown in Figure 9.

The ongoing demonstration projects are a 50 kW wind turbine to supplement power needs at the WTAMU research feedlot and a 48 kW solar system. The solar system has a 40 kW fixed array and an 8 kW tracking system to compare both solar systems and document the effectiveness in supplying power to the Palo Duro Research Facility near the WTAMU campus. Both these demonstration projects and the two years of data display costs are funded by the Texas State Energy Conservation Office, using the American Reinvestment and Recovery Act funds.

5. SUMMARY AND CONCLUSION

The use of renewables has restarted. At one time, all energy came from sustainable, accessible energy sources ultimately powered by the sun. The concentrated energy sources that have been used so readily in the past are not sustainable in the long-term. There is a push to return to using a mixture that maintains living standards while using wind and solar energy to create a long-term sustainable source of energy. This paper has shown that the region has renewable energy resources and that they can be mixed with conventional energy and distributed using the existing grid. The enormous wind energy potential of this region—larger than the consumption of the nation—makes wind energy development a viable future source for expanding energy needs. Also, the access that this region has to all major electrical grids in the nation increases the attractiveness of wind energy development in this area.

The concerns that utilities have with the uncontrolled growth of renewables on the power grid and the planning and preparation that must be done to keep the grid safe and stable have been considered. PUCoT has created a grid augmentation plan, which is being implemented, and it addressed these concerns. Small systems will work as well as the utility grade ones. The only challenge is matching resources to loads with acceptable conversion efficiency.

REFERENCES

1. Corporation NAER. Regional Entities. http://www.nerc.com/page.php?cid=1%7C9%7C1192012.
2. Nelson V, Clark, N. Thirty-years of small wind testing AEI-ARS cooperative program results. Windpower 2010 Conference and Exhibition. Dallas, Texas 2010.
3. Energy USDo. Wind Powering America: U.S. Installed Wind Capacity. U.S. Department of Energy; 2012.
4. AWEA. U.S. Wind Resource Even Larger Larger Than Previously Estimated. Windpower Monthly 2010.
5. Administration USEI. Electric Net Summer Capacity: Total (All Sectors), Selected Years, 1949–2011. In: Review AE, editor.2011.
6. Energy USDo. Utility-Scale Land-Based 80-Meter Wind Maps. U.S. Department of Energy; 2012.
7. Frontier Associates L. Texas Renewable Energy Resource Assessment. Texas State Energy Conservation Office, Austin, TX; 2008.
8. Greg Martin JL. Renewable Energy Generation and Storage For Agricultural Use in the San Luis Valley. University of Colorado at Boulder; 2007.
9. Wei M, Patadia S, Kammen DM. Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US? Energy Policy. 2010;38:919–31.
10. Diffen BH. Competitive Renewable Energy Zones: How the Texas Wind Industry is Cracking the Chicken & Egg Problem. Rocky Mountain Mineral Law Foundation Journal. 2009;46.
11. Texas PUCo. Project Information. CREZ Transmission Program Information Center. http://www.texascrez projects.com/projects.aspx 2013.
12. Ela E, Kirby, B. ERCOT Event on February 26, 2008: Lessons Learned. National Renewable Energy Laboratory, Golden Colorado. 2008.
13. International NR. San Francisco Solar Power, CA, United States of America. 2012.