UNDERSTANDING REGIONAL WIND REGIME VARIATION TO MAXIMIZE PORTFOLIO BENEFIT

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INTRODUCTION

Recent developments in the planning and installation of new long distance transmission lines have created the ability to better diversify renewable energy portfolios by helping utilities and developers combine complementary wind resources to balance regional load profiles in order to mitigate variability.

DNV GL has investigated the monthly dependence between popular wind development regions as well as annual and diurnal wind generation profiles across the United States to illustrate the benefit of a geographically diverse portfolio.

Additionally, net load (Demand – Wind Generation) is calculated from hourly load and generation profiles to show the importance of having a large system ramping capability to deal with periods when the wind and load profiles are largely out of phase and how a broader diversification of wind resource can help to limit major system ramping events.

METHODOLOGY

- 10 popular wind development regions identified through DNV GL industry experience and number of projects built or in development.

- Historical monthly wind index at 80 m calculated for grid points across each region from DNV GL Virtual Met Data service mesoscale model.
- Pearson coefficients calculated through correlation of regional monthly wind indices.
- Modeled hourly wind speeds for each region put through regional power curve and scaled to a wind farm capacity of 1 GW.
- Normalized regional diurnal and annual generation profiles created.
- Normalized load profiles compared to normalized wind generation profiles.
- Calculation of Net Load from modeled wind generation and actual load

Results

Regional Dependencies

- Pearson coefficients calculated from monthly wind indices at each region
- Regional dependencies shown below
- In general a large geographic distribution helps to mitigate project dependencies

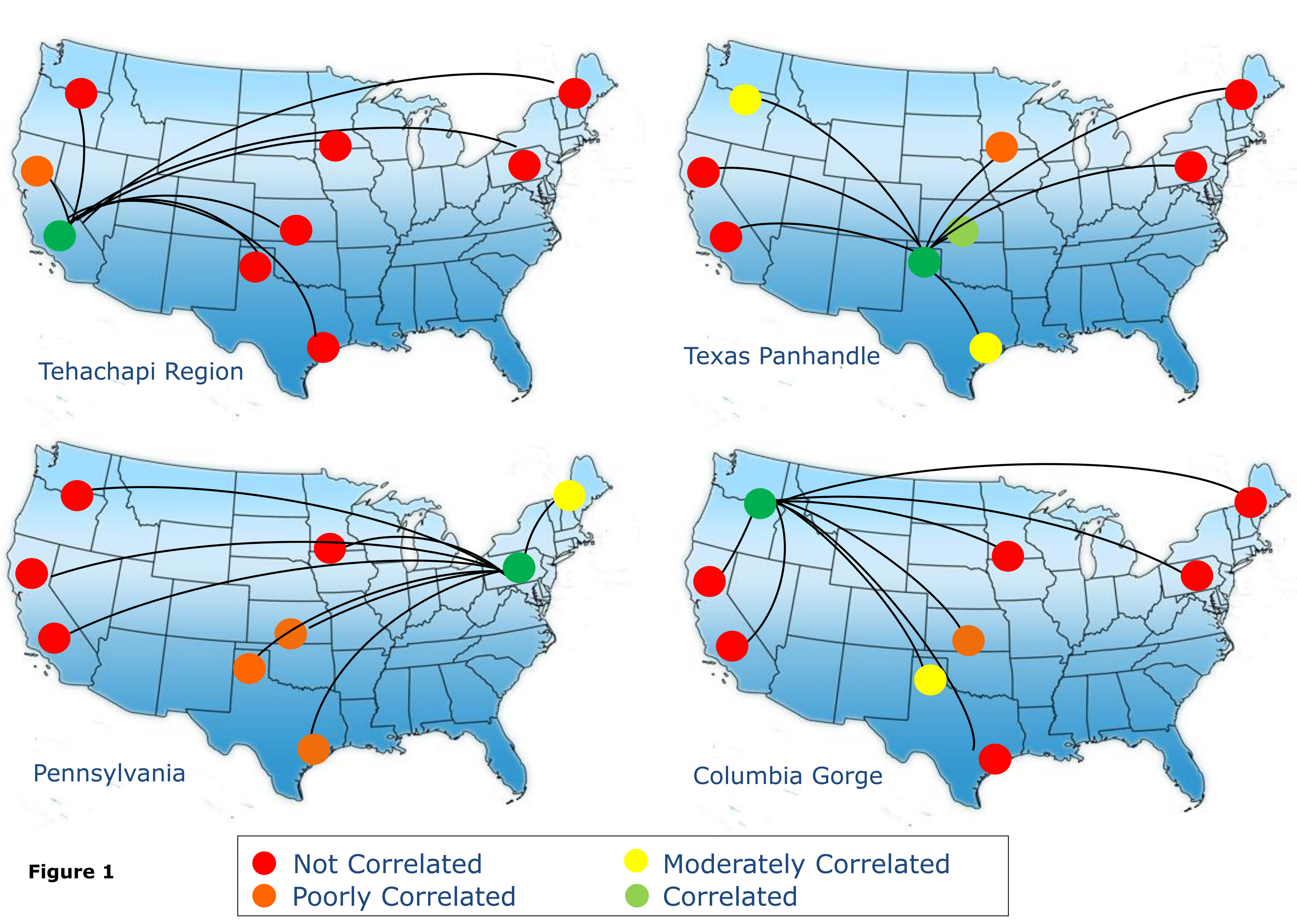


Figure 1

RESULTS

Consideration of annual and diurnal profile variability

- Although long-term data may show nearby regions to be correlated, as is the case in Texas, variations in the annual trends for specific years can be significant across relatively small distances.
- Intra-regional variability of generation profiles between specific wind farm locations is often greater than that between entire regions as shown in the figures below.
- Variability in annual trends can be most notably mitigated over shorter time periods through resource diversification.

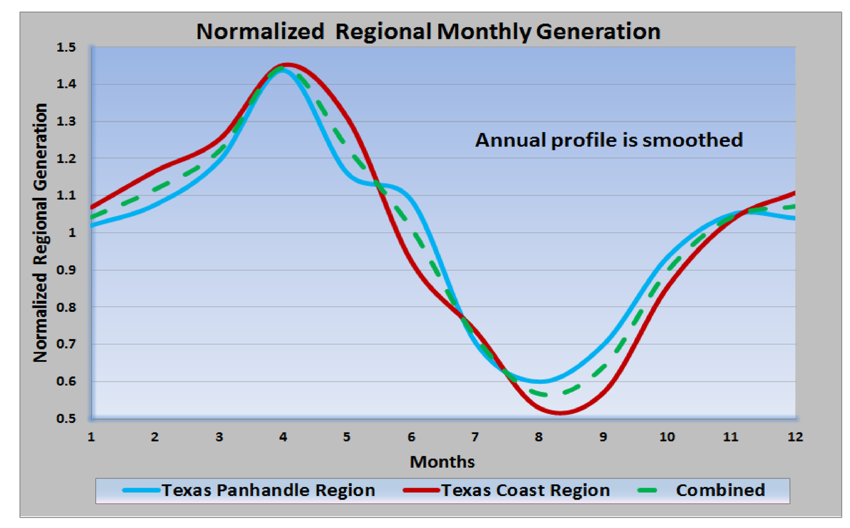
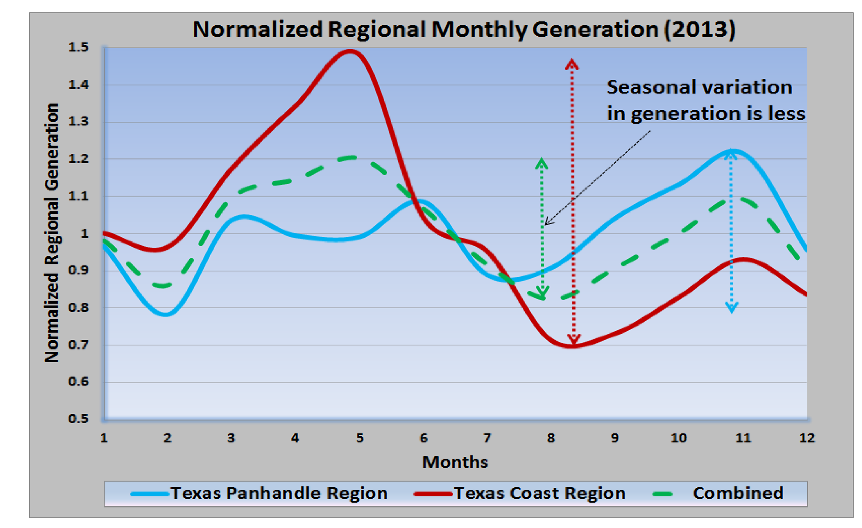


Figure 2



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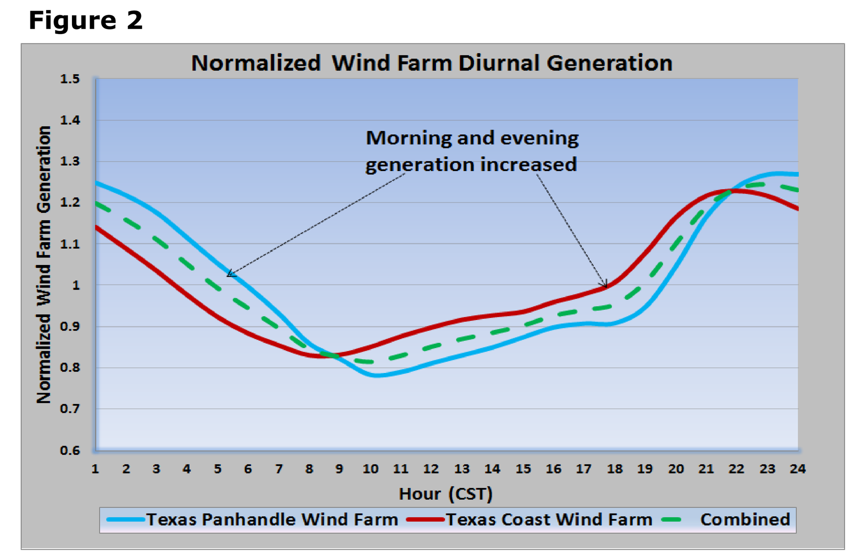

Figure 4

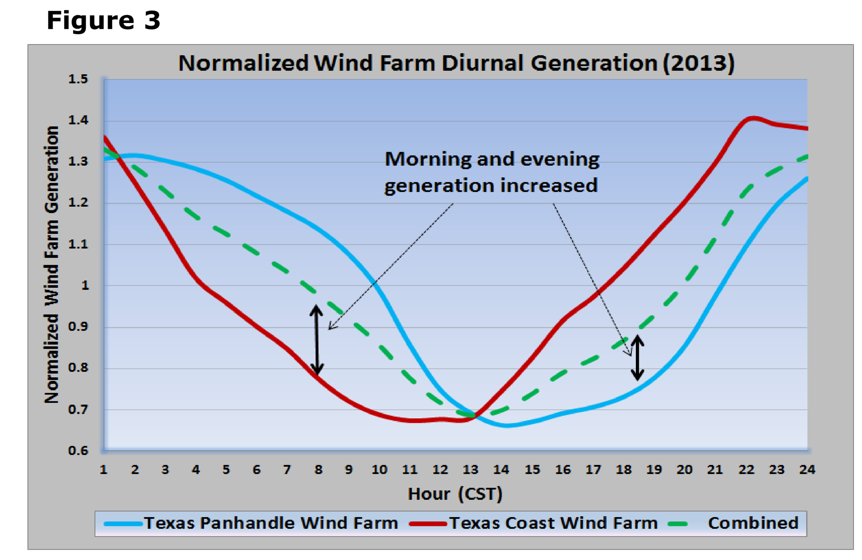

Figure 5

Each profile shown in the figures above represents the annual wind generation profile for a 1 GW wind farm in both the Texas Panhandle and Texas coast. The Combined wind farm represents the combination of hypothetical 500 MW wind farms in the Texas Panhandle and coast.

- Although the 10-year average diurnal profile is not significantly different between regions the average variation can still be mitigated by resource diversification.
- Even though the long-term average profiles between nearby regions may be similar the variability between the potential generation at specific wind farm locations can be significant for any single year.

System Ramping and the Importance of Reserves

- Wind generation is highly variable so the system is forced to become increasingly flexible.
- Sufficient operating reserves are necessary to accommodate fluctuations in wind.
- Diversification can help to mitigate system ramping

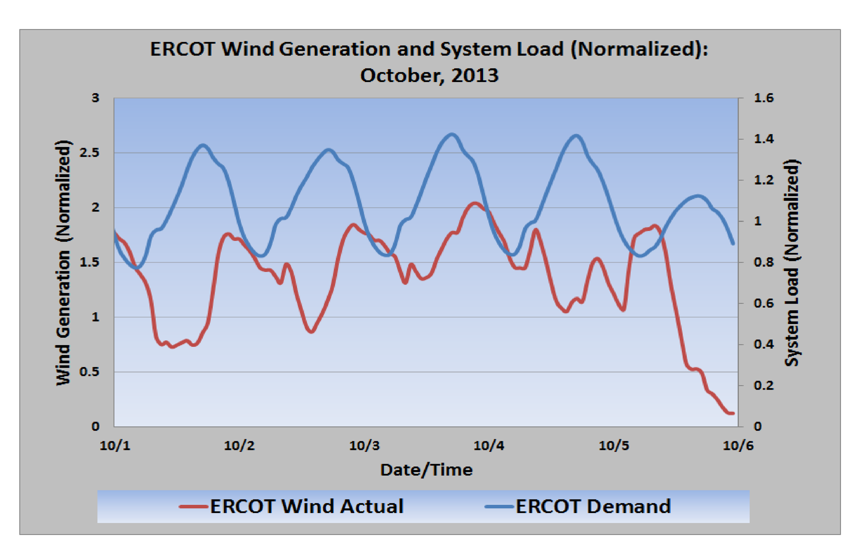

Figure 6

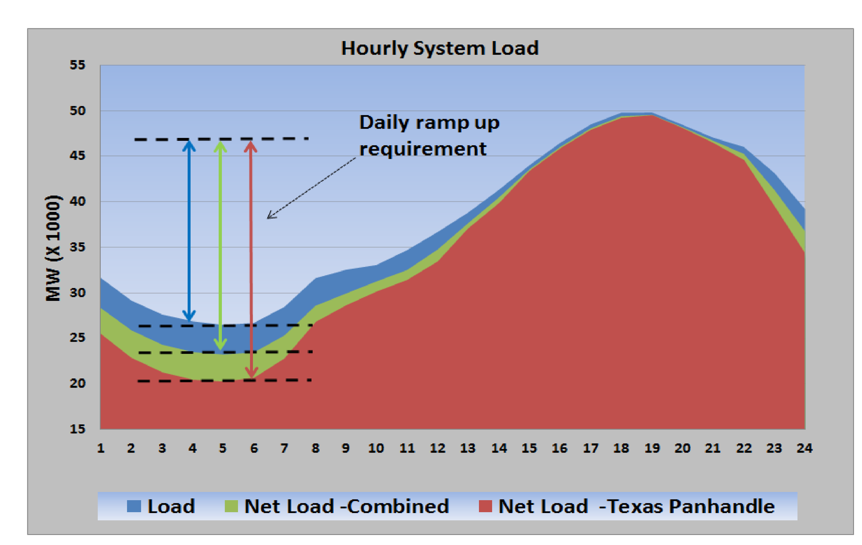

Figure 7

Although increased wind on a system incurs a greater stress on the system (due to ramping), diversification of the wind generation feeding into the system can help to reduce the ramping requirement, potentially lowering the integration cost when compared to the same amount of wind in a single location.

CONCLUSIONS

- Quantification of seasonal relationships is essential to portfolio diversification and is not always dependent on project proximity.
- Similarity of annual profiles does not mean similar monthly relationships.
- Although nearby regions have similar profiles and relationships on average specific project locations within the regions can be highly variable.
- Additional transmission important to allow for diverse wind regimes for resource planning.
- Resource diversification may help to reduce system stress and lower integration costs when compared to wind from a single location.