The Distribution of Wind Power Forecasting Errors from Operational Systems

Photo from Tom Hall, NREL/PIX 06588

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Bri-Mathias Hodge
Erik Ela
Michael Milligan
Transmission and Grid Integration Group
National Renewable Energy Laboratory
Golden, Colorado USA

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Topics

- Introduction
- Statistical Background
- Datasets
- Normal Distribution Comparison
- Persistence Model Comparison
- Distribution Modeling
- Conclusions

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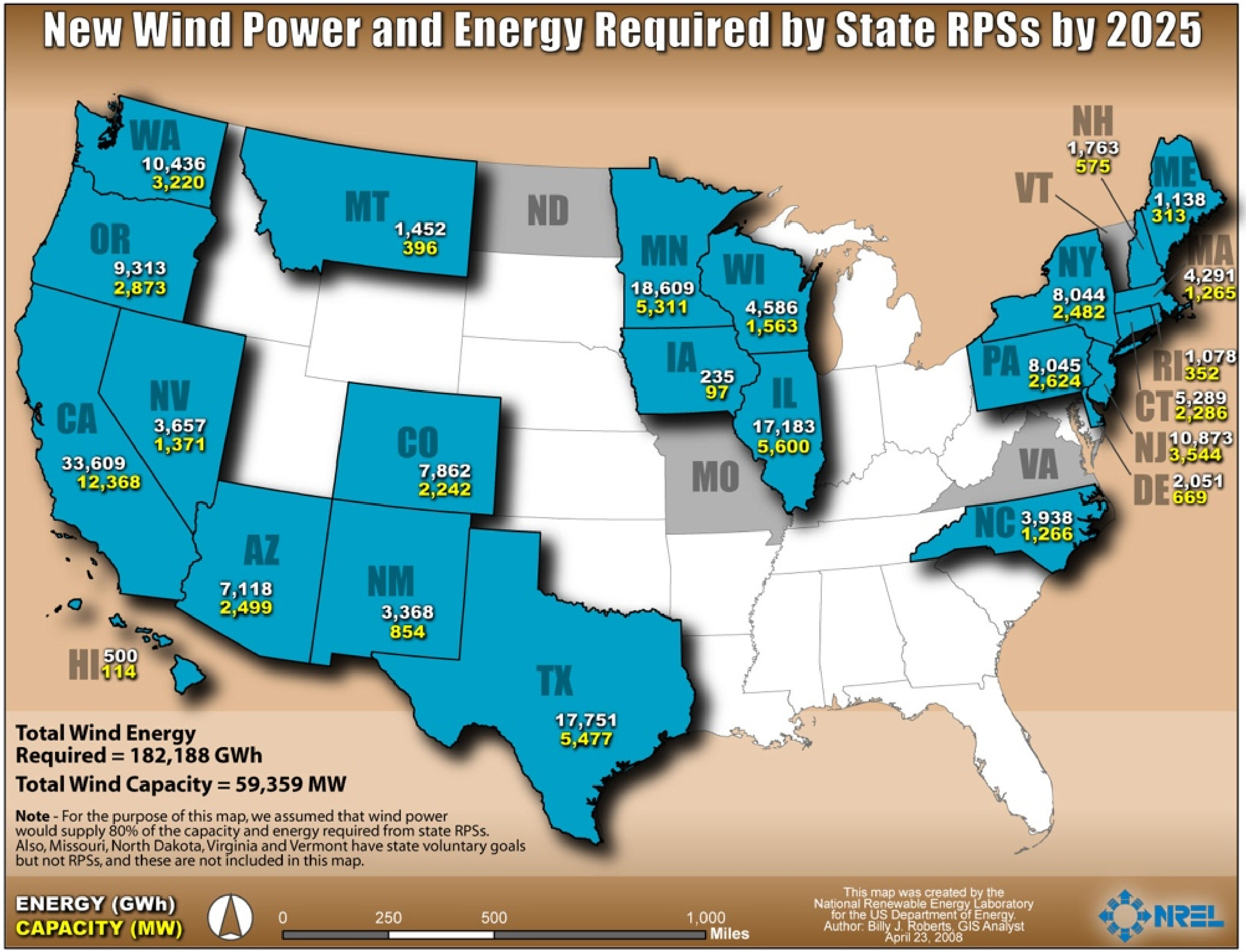
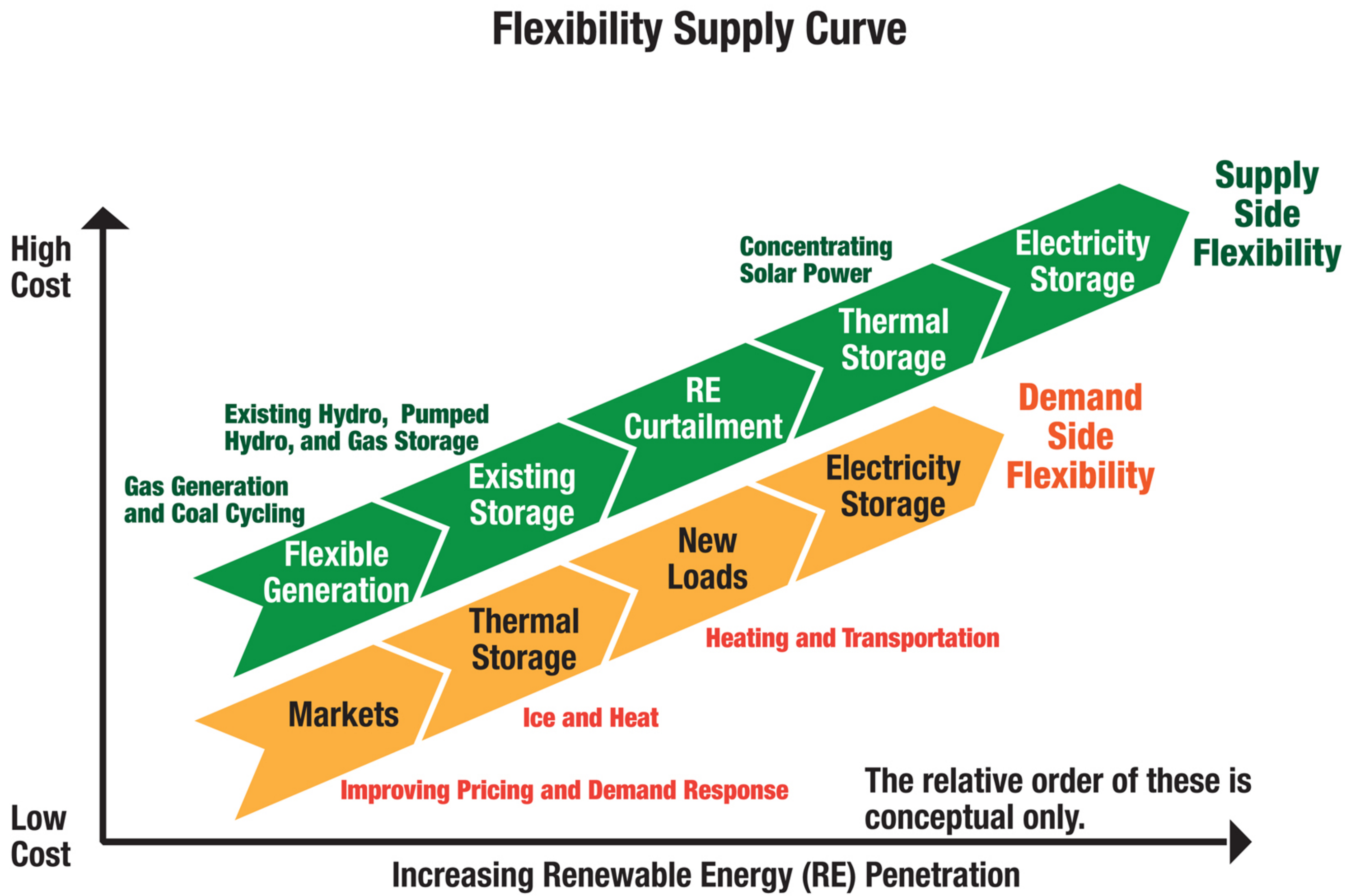
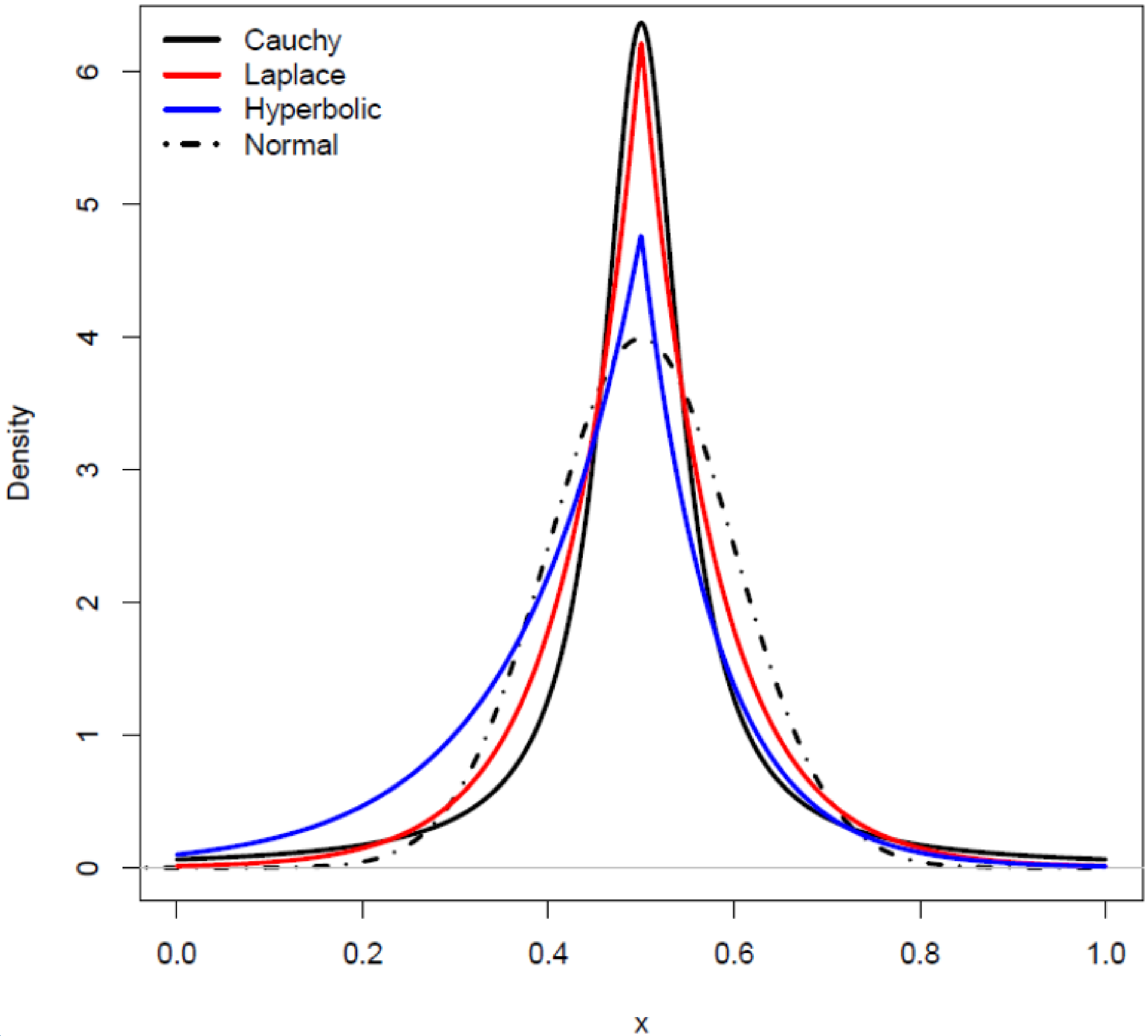
Renewable Energy Portfolio Standards



Renewable Generation Integration Background



Statistical Background



- Skewness – 3rd Statistical Moment

$$\gamma = E\left[\left(\frac{X-\mu}{\sigma}\right)^3\right]$$

- Kurtosis – 4th Statistical Moment

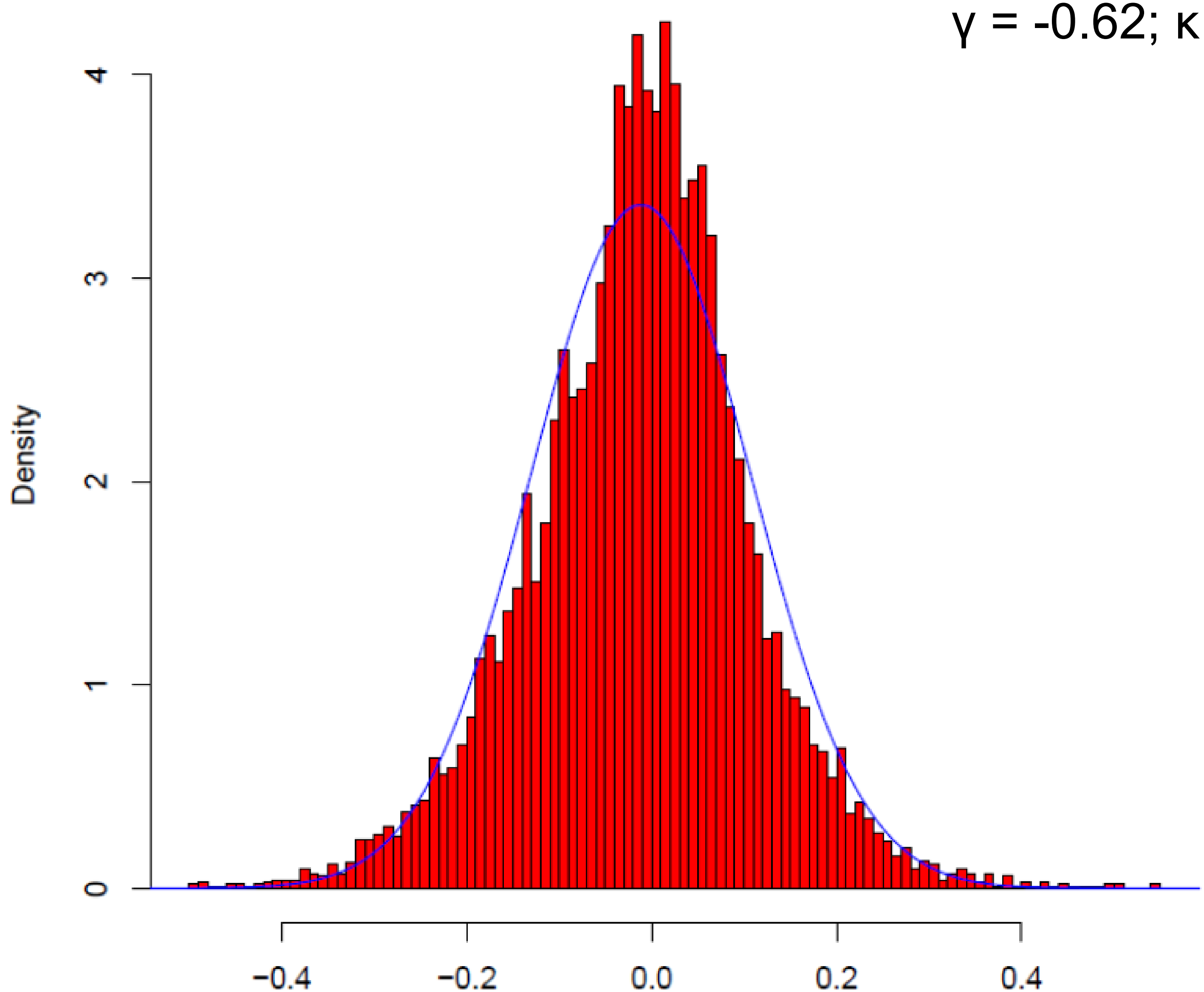
$$\kappa = \frac{E(\varepsilon^4)}{\sigma^4}$$

Datasets

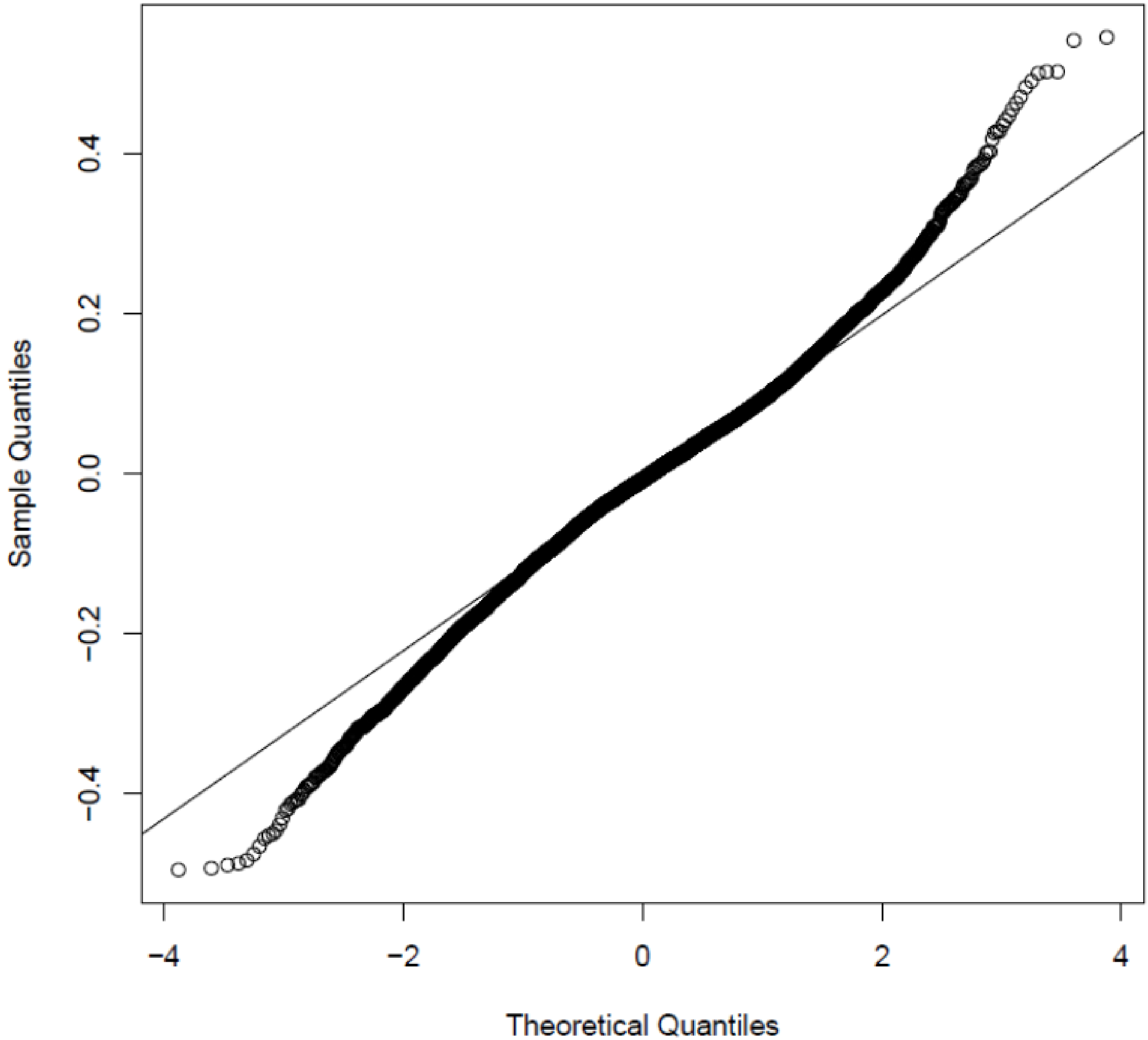
- ERCOT data
  - Day-ahead forecasts
  - Hourly power output
  - 13 months of data
  - Forecasts made at 16:00 the day prior
  - ~ 9,000 MW wind capacity
- Xcel Energy data
  - Forecasts produced every 15 minutes for the next 72 hours
  - Hourly power output
  - 3 months of data
  - Single wind plant ~ 300 MW capacity

ERCOT Day-Ahead Histogram

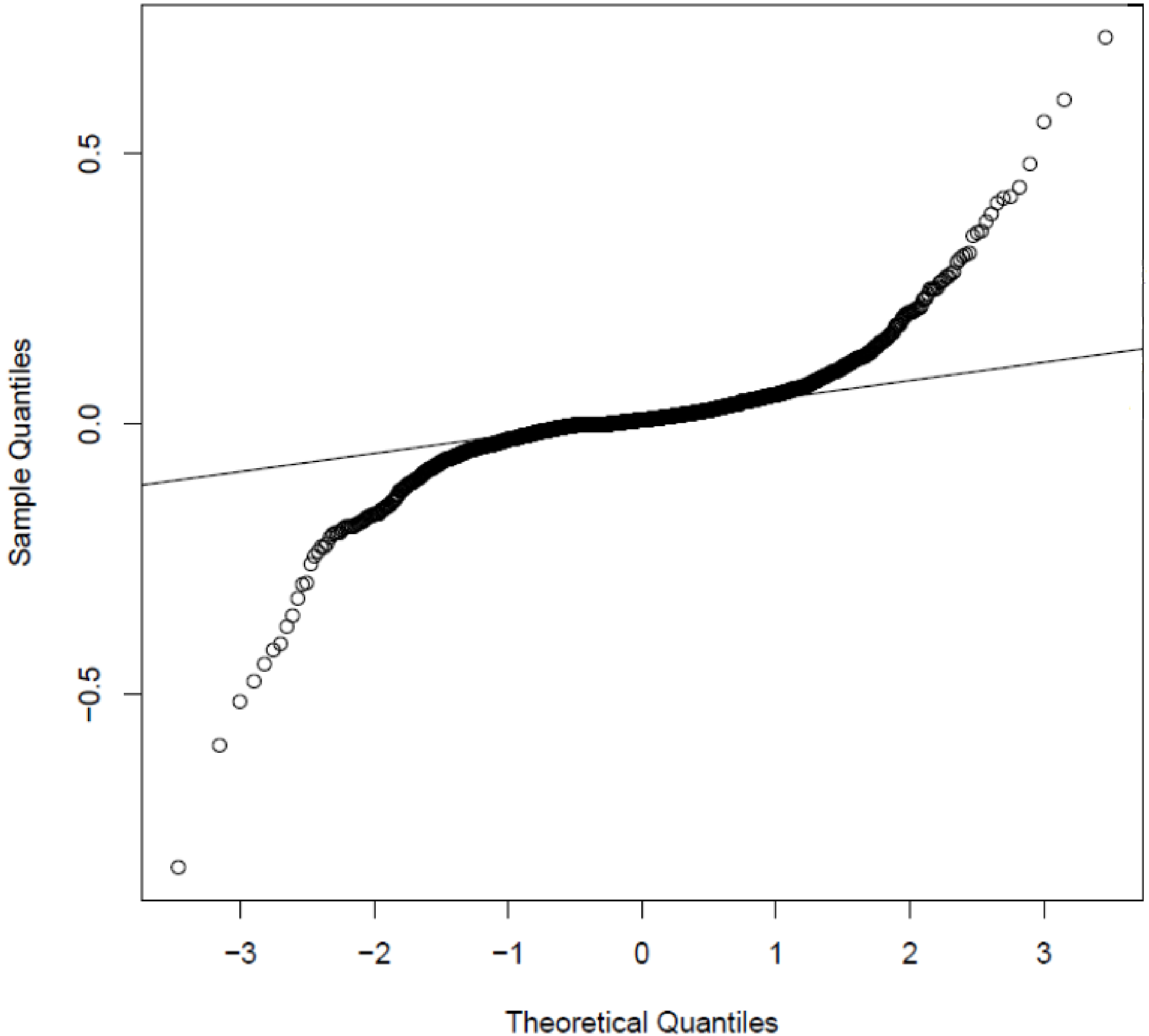
γ = -0.62; κ = 1.03



ERCOT Day-Ahead Normal Q-Q Plot

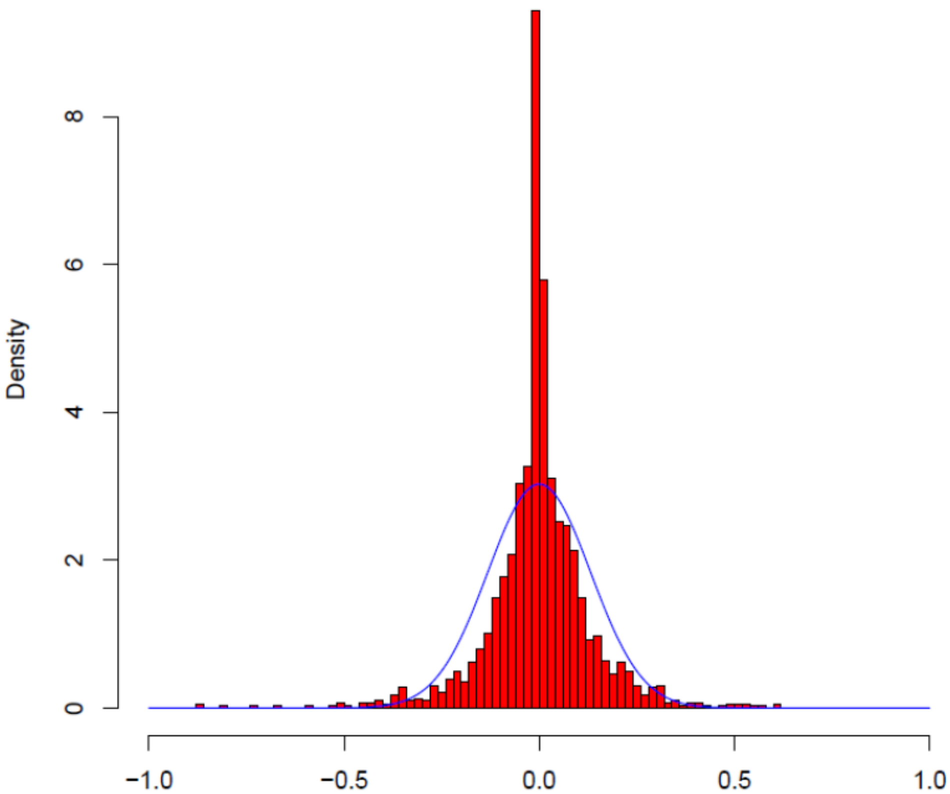


Xcel Plant 1-Hour Normal Q-Q Plot



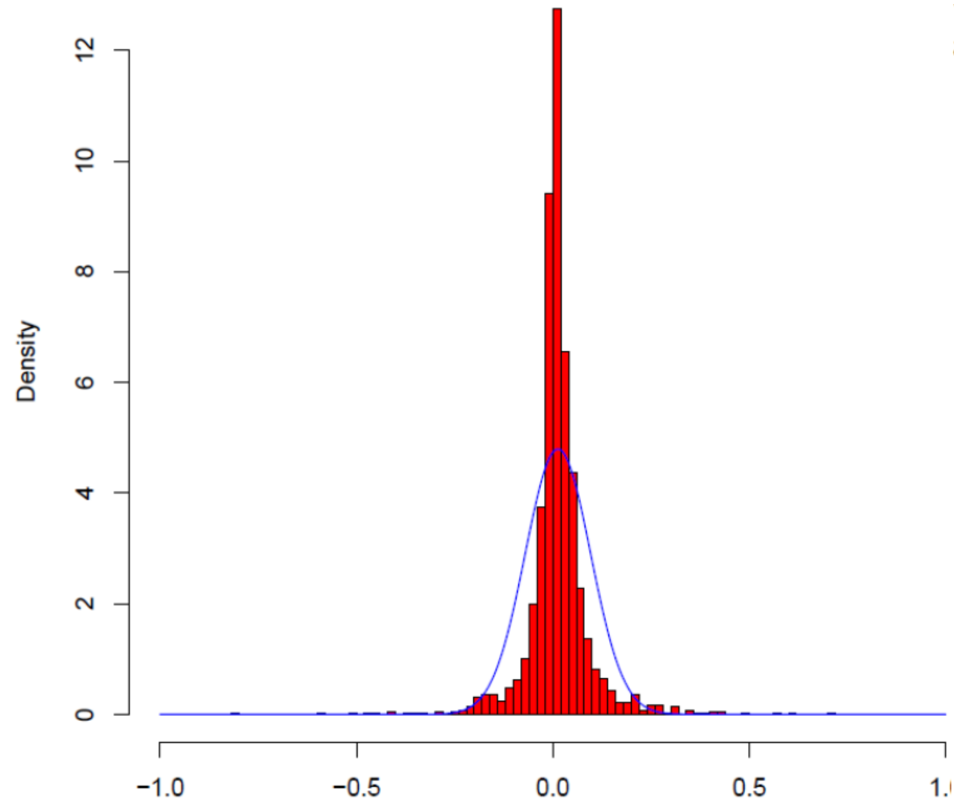
Xcel Hour-Ahead Persistence Comparison

Persistence Model



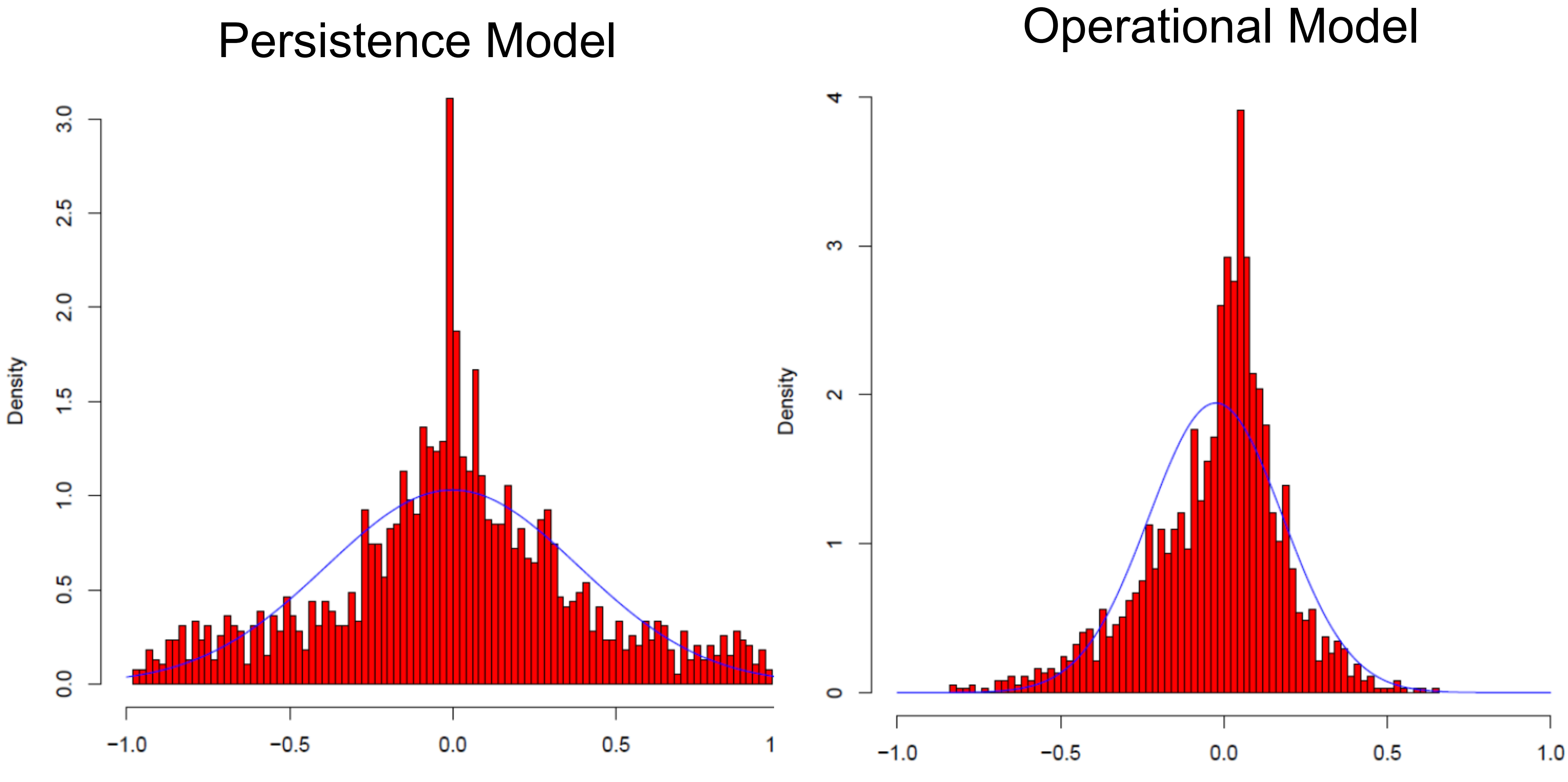
$\gamma = -0.51; \kappa = 5.97$

Operational Model



$\gamma = -0.01; \kappa = 17.62$

Xcel 24-Hour-Ahead Persistence Comparison



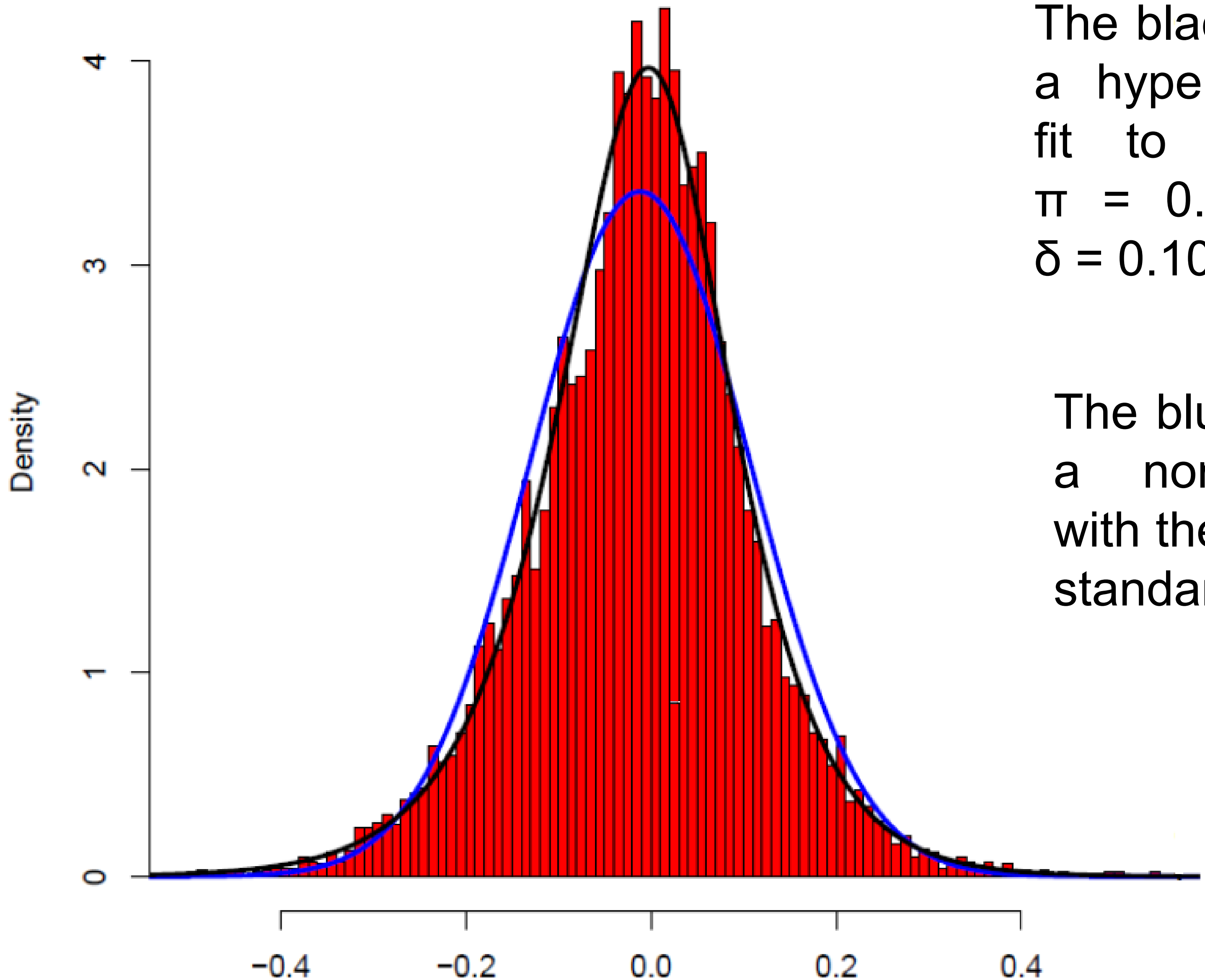
γ = -0.03; κ = 0.15

γ = -0.65; κ = 1.05

Persistence Comparison – Multiple Timescales

	Persistence		Operational	
Timescale	**Skewness**	**Kurtosis**	**Skewness**	**Kurtosis**
15 Minutes			-0.68	30.64
30 Minutes			-1.36	30.88
1 Hour	-0.51	5.97	-0.01	17.62
3 Hour	-0.21	1.81	-0.88	1.97
24 Hour	-0.03	0.15	-0.65	1.05
72 Hour	-0.03	0.06	-0.56	0.84

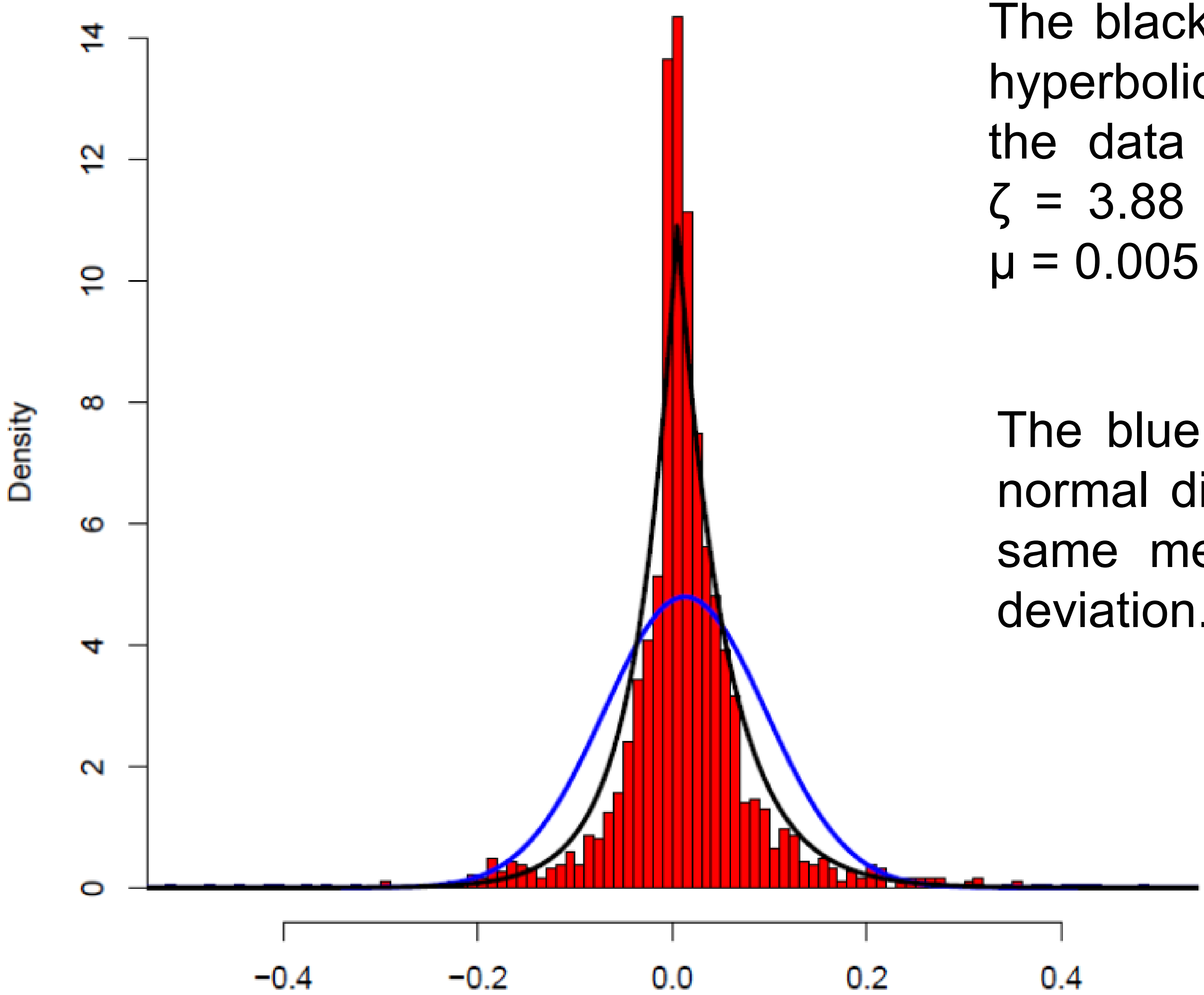
Distribution Modeling - ERCOT



The black line represents a hyperbolic distribution fit to the data with: π = 0.083, ζ = 1.601, δ = 0.105, μ = 0.006.

The blue line represents a normal distribution with the same mean and standard deviation.

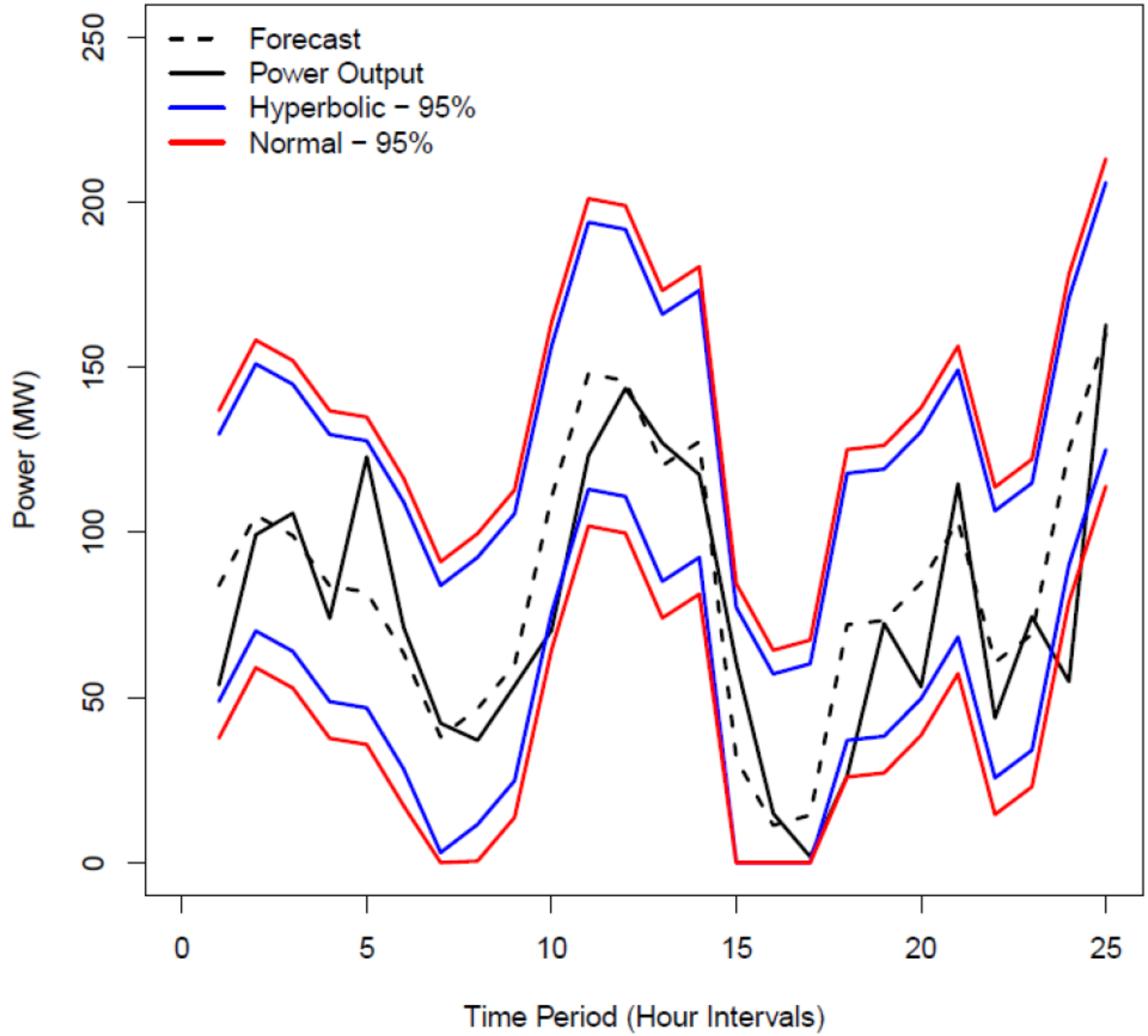
Distribution Fitting - Xcel 1-Hour-Ahead



The black line represents a hyperbolic distribution fit to the data with: π = 0.087, ζ = 3.88 E^{-5}, δ = 1.76 E^{-6}, μ = 0.005.

The blue line represents a normal distribution with the same mean and standard deviation.

Forecasting Error Distributions Implications



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Questions?

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