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VIA ELECTRONIC FILING

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RE: Commonwealth of Virginia, *ex rel.* State Corporation Commission
In re: Virginia Electric and Power Company's Integrated Resource Plan filing pursuant to Virginia Code § 56-597 *et seq.*

Case No. PUR-2018-00065

Dear Mr. Peck,

Please find enclosed for filing in the above-captioned case the Direct Testimony of Dr. William M. Shobe on Behalf of the Sierra Club.

Should you have any questions or concerns regarding the filing, please do not hesitate to contact me directly at (434) 738 – 1863.

Thank you,

Evan D. Johns
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Copied: Service List
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DIRECT TESTIMONY OF
WILLIAM M. SHOBE

ON BEHALF OF
THE SIERRA CLUB

BEFORE THE
STATE CORPORATION COMMISSION OF VIRGINIA
CASE NO. PUR-2018-00065

**Commonwealth of Virginia, *ex rel.* State Corporation Commission,
In re: Virginia Electric and Power Company's Integrated Resource Plan filing
pursuant to Virginia Code § 56-597 *et seq.***

Summary of the Direct Testimony of William M. Shobe

My testimony includes the following conclusions:

1. Since at least 2012, the load forecasts in the Company's annual Integrated Resource Plans have had a clear upward bias due to flaws in its forecasting methodology.

2. This over-forecasting has continued with the 2018 Integrated Resource Plan.

3. The Company's estimates of demand growth are too high even considering rapid growth in data center sales.

4. The Company's demand forecast equations are misspecified, do not properly account for changes over time, include a number of poorly specified proxy variables, and have a poor fit to the data and non-random residuals.

5. I provide a model for forecasting electricity demand that has much better accuracy than the Company's model.

6. The Company's estimated annual growth in total sales of 1.5% is far too high given the available data and anticipated changes in driver variables. Residential demand and commercial demand excluding data centers are both flat or falling even as the rate of economic growth has increased.

7. The Commission should require that, in future plans, the Company separate data center sales from commercial sales. These series should be forecast separately. In the current forecast, the Company does not clearly separate out data center sales but rather develops an "adjustment" to commercial sales for future data center growth based on a series of questionable assumptions.

8. The Company's estimated energy sales (net of sales for resale) in 2033 of 97,459 GWh is too high by at least 10,000 Gwh.

9. Because of its methodological flaws and its poor performance, the Company's forecast cannot serve as an effective guide for resource planning.

Q: Please state your name and your occupation.

A: My name is William M. Shobe. I am a Professor of Public Policy at the University of Virginia's Batten School of Leadership and Public Policy in Charlottesville, Virginia.[1]

Q: Please summarize your experience and expertise in the field of regulatory economics and energy policy.

A: I have a Ph.D. in economics and a law degree. I have a range of undergraduate and graduate classes in statistics, environmental economics and public policy for the past 12 years at the University of Virginia. I have numerous articles on environmental and energy policy design published in peer reviewed scientific journals. Prior to coming to the University of Virginia, I worked in and headed the Economic and Regulatory Analysis division of the Virginia Department of Planning and Budget. In that role, I acted as chairman of the Prison and Jail Headcount Forecasting Committee, and I acted as DPB's lead forecaster for state Medicaid expenditures. I now serve on the Joint Advisory Board of Economists (for state tax revenue forecasting). I previously served for about ten years on the State Advisory Board on Air Pollution.

Q: What is the scope and purpose of your testimony in this case?

A: My testimony concerns the electricity demand forecast in the 2018 Integrated Resource Plan (IRP or Plan) for Virginia Electric and Power Company (the Company).

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1 This testimony does not represent the opinion of the University of Virginia or the Batten School of Leadership and Public Policy. I discuss only my own opinions.

Q: What materials did you review in preparing your testimony?

A: I made a detailed review of the Company's 2018 Integrated Resource Plan and the documentation of its forecasting methodology. I have analyzed the data used by the Company for estimating its sales model. I have also gathered sales data from data reported by the Company to the U.S. Energy Information Administration (EIA). I have also consulted numerous texts and research papers on forecasting methods.

Q: Can you summarize your conclusions about the Company's methodology for forecasting energy demand?

A: The Company's electricity demand forecast is highly inaccurate. The reason that the Company's forecast overstates future demand is because it uses a clearly inappropriate model for estimating demand. The Commission should reject the Company's estimates of future electricity demand because they are biased and methodologically unsound.

Q: What are the implications of your conclusion?

A: The demand forecast drives much of the rest of the analysis in the Company's Plan; all of the rest of the analysis depends quite explicitly on the demand forecast. In particular, the Company uses the results of this sales forecasting model as an input to it load forecasting model. And because the Company uses the forecast for long-term capital planning, a forecast with a large and consistent upward bias will likely result in poor capital planning choices and must be seen a damaging to the public interest. As a result, the Company's entire planning analysis laid out in its Plan is based on an incorrect foundation in expected future demand.

The case of the Brunswick Power Station illustrates why this over-forecasting is so important. In 2013, the Commission granted a CPCN for the Brunswick Power Station.[2] The Company's CPCN application expressly relied on the "inputs and assumptions" from its 2012 IRP.[3] But by the first full year of service for the plant in 2017, the Company's demand forecast was already too high by an amount approximately equal to the entire output of the Brunswick plant for that year.

I. HISTORICAL LOAD FORECASTS

Q: How would you describe the accuracy of the Company's recent demand forecasts?

A: Accuracy at forecasting future values is the key standard by which all forecasts must be judged. The measurement of accuracy included two components: (1) whether the forecast is biased—that is, whether it tends to err in one direction—and (2) how large its errors are. The Company's forecast fails on both counts.

The recent history of the Company's energy demand forecast shows a very strong pattern of upward bias. In fact, with only one exception, the Company's forecasts have been high for every year at every forecast horizon since 2012. This means that the Company has routinely over-forecasted demand since at least 2012.

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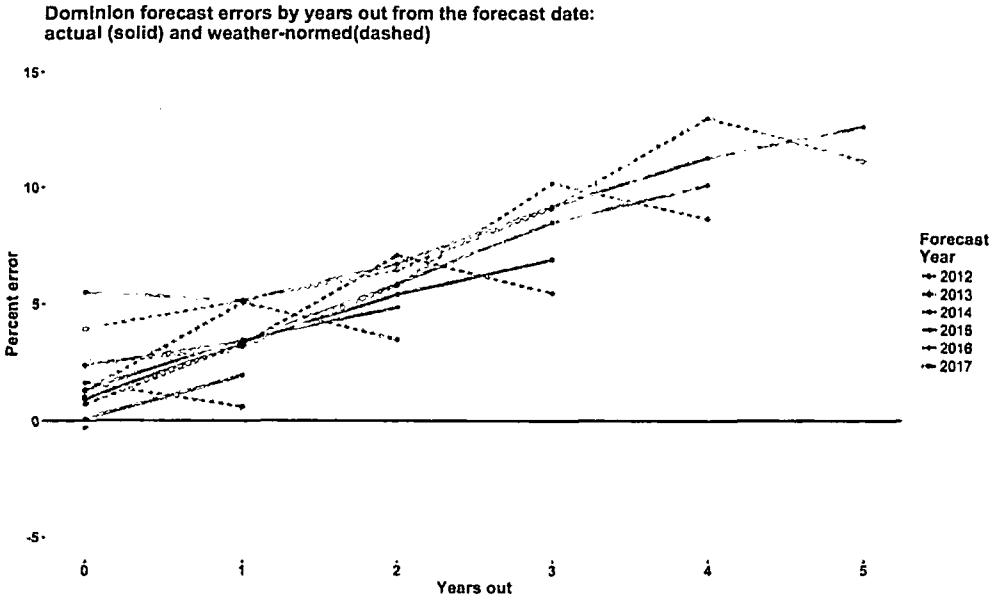
2 *See generally Application of Virginia Electric and Power Company for approval and certification of the proposed Brunswick County Power Station and related transmission facilities*, Case No. PUE-2012-00128, Final Order (August 2, 2013), available at https://bit.ly/2OXGnYc.

3 *See Application of Virginia Electric and Power Company for approval and certification of the proposed Brunswick County Power Station and related transmission facilities*, Case No. PUE-2012-00128, Direct Testimony of Glenn A. Kelly at 3:2–12, (November 2, 2012), available at https://bit.ly/2vznHFX.

The size of the over-forecast rises dramatically with time. As can be seen in Figure 1, not only are all of the Company's forecasts higher than the actual values, the size of the errors escalates rapidly. By just two years out from the forecast date, the Company's errors are at least 5%. This is true whether weather-normalized or actual data is used. This is a substantial error for such short time horizons, and it escalates rapidly with each additional year.

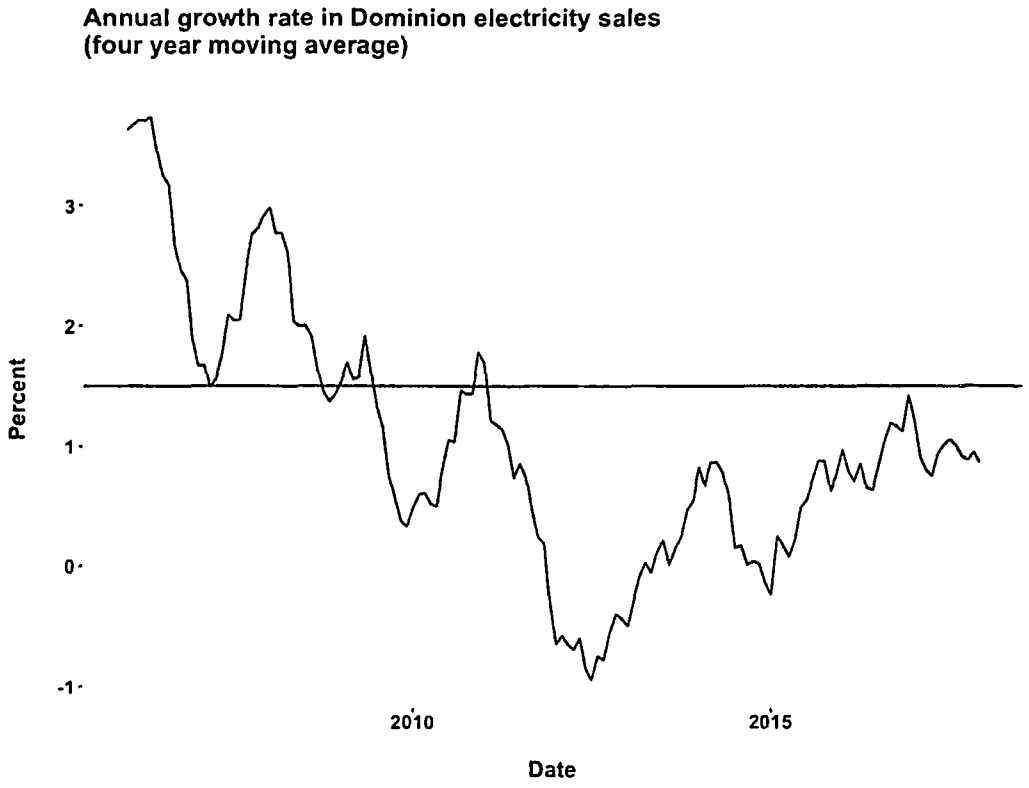


Another way to assess history of the Company's forecast errors is to look at how their forecasts have changed as new data on actual use becomes available. The first few years of the forecasts from the Company's IRPs are graphed below. Each new forecast starts at a value lower than previously forecasted. In spite of this consistent pattern demonstrating the forecasted rate of growth is too high, the Company persists in predicting high rates of growth for the indefinite future. I have provided both the actual data (black line) and weather-normalized data (black dots) for 2001 through 2017.

Even though the rate of growth in demand has fallen dramatically in later years, the slope of the lines representing the Company's forecast have hardly changed. The Company persists in positing that rapid future growth is imminent—but always *only* imminent. The explanation for this annual phenomena lies in the Company's method for estimating and extrapolating from their demand equations. In essence, the Company assumes that the relationship of electricity demand to underlying economic and weather drivers is constant over time. But as discussed in further below, this is a very harmful implicit assumption in the Company's estimation procedure and causes its estimation to have very poor statistical properties.

As I will show in a subsequent section, residential sales and commercial sales excluding data centers are both flat or falling. This only leaves data center growth as a significant source of sales growth in Virginia. But even the Company's own estimates of data

center sales growth are not enough to result in overall sales growth of the magnitudes estimated in the Company's forecast.



Q: What do you see as the key methodological weaknesses of the Company's forecast?

A: The key problem leading to the over-forecasting of demand growth over time is due to model misspecification. The Company has used an incorrect regression equation to estimate the relationship between electricity demand and economic activity. This misspecification bias is most serious in the residential and commercial sector estimates. Other methodological problems with the Company's estimation relate more to short-run, seasonal factors and do not have much effect on the estimated long-run trend in demand growth.

Until last year, the Company used approximately 70 variables for estimating seasonal demand factors. This was done in both the residential and commercial sales forecasts. I noted last year in my testimony that these variables didn't make sense from a methodological perspective and, indeed, running the Company's forecast models with and without these variables did not make any appreciable impact on the growth rate in sales over time.[4]

This year, the Company removed a large number of these variables from their reported results but left them all in the documentation for its model. The profile of variables dropped from the models (and from other sales equations as well) appears highly arbitrary and, more to the point, does not markedly improve the appropriateness or significance of the remaining variables. Again, I have already demonstrated that these variables are so much surplusage in the model and have no demonstrable connection to sales. But the seemingly random removal of some of the variable from last year's model without any explanation further demonstrates the lack of basis in logic for the use of these variables. It clearly undermines the credibility of the modeling effort.

II. RESIDENTIAL DEMAND

Q: How does the Company forecast residential demand?

A: The Company's residential demand model is a simple linear regression model that regresses total monthly residential consumption on a set of predictor variables:

4 *See generally Commonwealth ex rel. State Corporation Commission in re: Virginia Electric and Power Company's Integrated Resource Plan filing pursuant to Virginia Code § 56-597 et seq.*, Case No. PUR-2017-00051, Direct Testimony of William M. Shobe (August 11, 2017), available at https://bit.ly/2M58zKS.

- a constant;
- the stock of non-weather sensitive appliances (as defined by the Company);
- a variable relating residential electric price to real disposable income per capita;
- a set of variables interacting (multiplying) monthly dummies with a seasonally adjusted measure of gross state product and the number of billing days;
- three variables that combine heat, air conditioning appliance stock, price and unemployment;
- three variables that combine cold, heating appliance, price and unemployment
- so-called "Binary Variables to take into Account Trend/Regime Changes;" and
- an autoregressive term to absorb some of the autocorrelation in the error term.

Most of these variables measure seasonal effects within a given year and, as discussed later in my testimony, do not have any influence on growth in demand over time.

Q: How significant are these variables?

A: For statistical significance, smaller is better and, generally speaking, anything greater than 10% is unreliable. In certain circumstances, a forecast may retain variables with a significance level greater than 10% if other information suggests they should be important. A significance level of over 30%, however, means that the variable is essentially worthless and will add considerable variability to the error bands of the forecast.

The "seasonal variables" do a very poor job at capturing seasonal effects. Most of the heat- and cold-related variables are statistically insignificant. None of the variables combining hot weather and unemployment, for example, are significant at better than

32% confidence. These variables are completely worthless at best. Similarly, only two of the six hot weather/electricity price variables reach 10%. While removing some of the offending variables from last year's models might be seen as a marginal improvement by reducing the number of clearly extraneous variables in the model, their removal does not address the difficulty with the misspecification of the trend variables as I will discuss shortly. The Company has not explained how or why it chose to remove the variables it did, and the model documentation the Company has provided this year continues to discuss the omitted variables as if they are still in the model.

Q: How could the Company remedy this weakness in its model?

A: Using interactions between unrelated variables, as is done with these weather-related variables changes their meaning in the regression and reduces their usefulness in the forecast (as indicated by their generally low significance). Directly including hot and cold weather variables, such as population-weighted degree-days, would be an improvement. All of the current set of interaction variables should be removed from the regression.

Q: What other problems do you see with the model specification?

A: The sales regression models us a set of monthly dummy variables interacted with (*i.e.*, multiplied by) a measure of state gross domestic product. This is non-standard and, frankly, methodologically flawed. The gross state product variable is provided to the Company by Moody's and is a seasonally adjusted variable. In the case of a monthly variable, seasonal adjustment is accomplished by regressing a monthly variable on monthly dummy variables to smooth out any variation in the monthly variable that is

due the different levels of economic activity as between months. The resulting seasonally adjusted variable is stripped of any special variation due to particular months; it reflects an average response across months.

Suppose you then take a seasonally adjusted variable and interact it with a monthly dummy, as the Company does in its model. It is like saying, how will the average monthly value's impact on the forecast change if the month is December (1) or not December (0). The answer is: it won't because it's an average across months. The residual significance of these interacted dummies in the sales regression equations is likely due mostly to the association of month dummies with heating and cooling demand, which is not well represented elsewhere in the Company's sales model.

III. WEATHER VARIABLES

Q: How does the Company's forecast account for weather?

A: The Company attempts to explain seasonal effects on power usage by making linear combinations of multiple weather variables (multiplying a two together and then adding this product to other variables) and using them as regression variables. The Company justifies these transformations by claiming they account for the nonlinear effect that seasonal variation has on electricity demand. Their transformations attempt to weight different regions within the DOM zone with their realized weather conditions.

Q: Is this approach effective?

A: If a variable is relevant in a model it can be included on its own; there is no fundamental need to have every variable appear as an interaction term. The result of this is many statistically insignificant interaction terms that carry no clear meaning. There must be

valid reasoning behind a decision to include statistically insignificant variables in a model, let alone have a model that consists of mostly statistically insignificant interaction terms.

While these poorly specified weather-related variables add to the overall variance of the forecast, they don't really have much of an effect on the long-term trend. There is nothing wrong with having both types of variables specified in a linear model, but the Company's models contain a substantial number of meaningless seasonal variables. These variables do not dictate the forecast path and do not contribute to the model in any positive way. They end up detracting from the forecast by pulling random variation from trend, which takes meaning from the coefficients. In statistics, models with fewer parameters are preferable to those with more when those extra parameters are not actually adding any explanatory power to the model.

Last year, I estimated the Company's own sales models with only the trend variables, leaving out all of the interacted, weather terms. This did not appreciably change the forecast in the long-run. Properly specified seasonal variables are useful for capturing within-year effects, but they do not really change the estimated growth in response to changing economic variables. The only relevant factors in determining the energy requirement are the trend variables and the assumptions made about them in the forecasting period.

IV. TREND VARIABLES

Q: Can you describe the key weaknesses of the Company's current model?

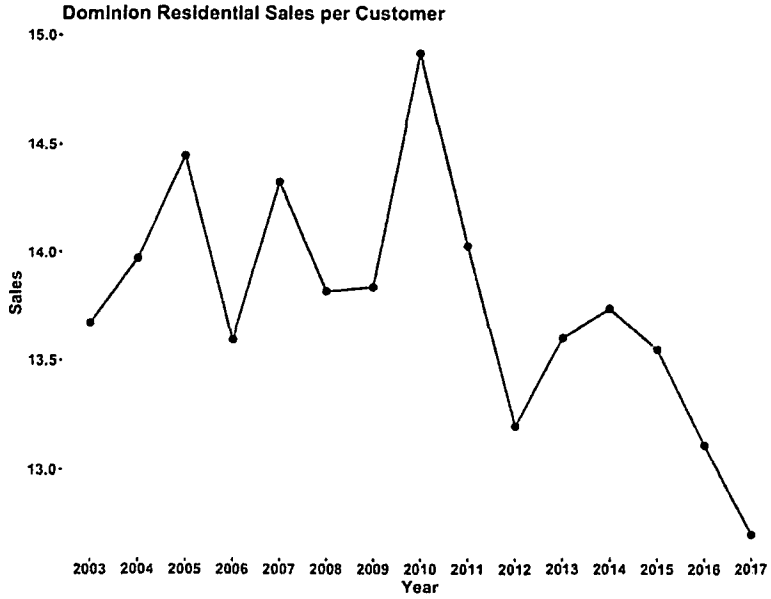
A: The biggest problem with the Company's residential demand equation is that it is premised on a fixed relationship between the stock of appliances and electricity demand. The Company's model has no effective way of accommodating changes in how much electricity it takes to provide given services in the home, so the regression estimates essentially reflect the average responsiveness over the entire time window that the Company uses in its estimation. When your model is not stable, too much data can be a curse.

Patterns of energy use in the home have been changing dramatically in recent years. This has led to a drop in energy use per customer (or per household). Improved energy efficiency of appliances and lighting have begun to have a dramatic effect on the growth in demand even as the number of households expands. What is important to remember is that the regression equation that the Company estimates has baked into it a fixed relationship between the number of households and energy demand for the last 29 years. The assumption is that this relationship is the same today as it was in the 1980s. This is not a harmless assumption, it is a mathematical assumption that the coefficient on the stock of appliances or any other measure of households is the same in 1987 as it is in 2017. This assumption is false and it results in the Company consistently over-forecasting demand. The amount of electricity used by households is changing rapidly.

This point was confirmed by the Company's own testimony in its 2017 IRP proceeding. During the hearing in that case, Company Witness Fox testified that his own forecast of

Company sales would have been lower had he used the latest available data on building energy intensity.[5] Changes in building energy intensity are precisely the kind of changes that shift the coefficient on the trend parameters in the sales regressions.

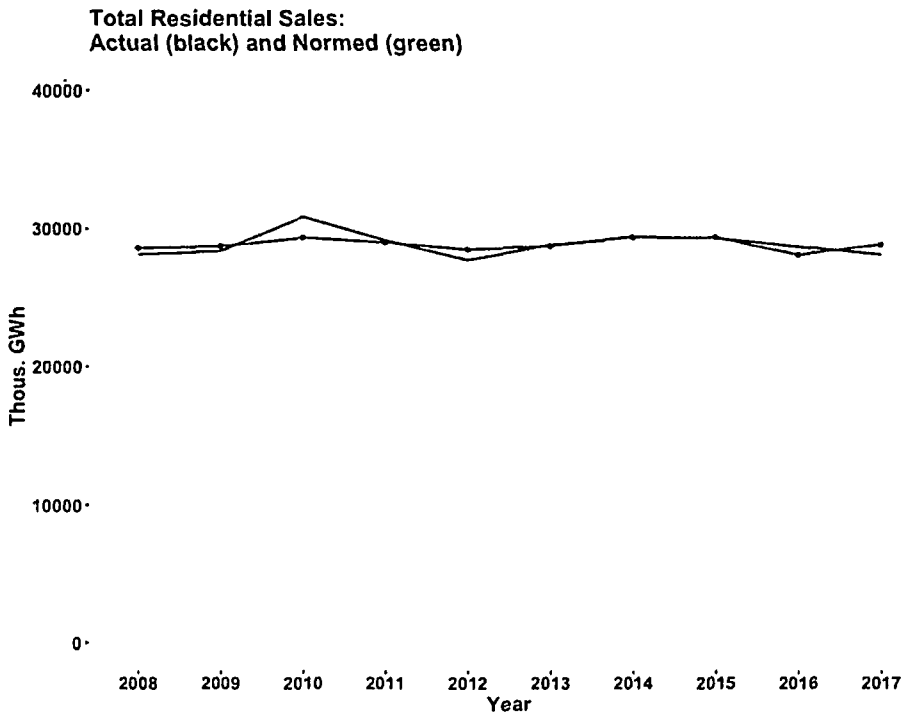
The next figure shows monthly residential sales per customer for the Company. The decline began around 2007 and has accelerated as Virginia's economic growth has accelerated in recent years.



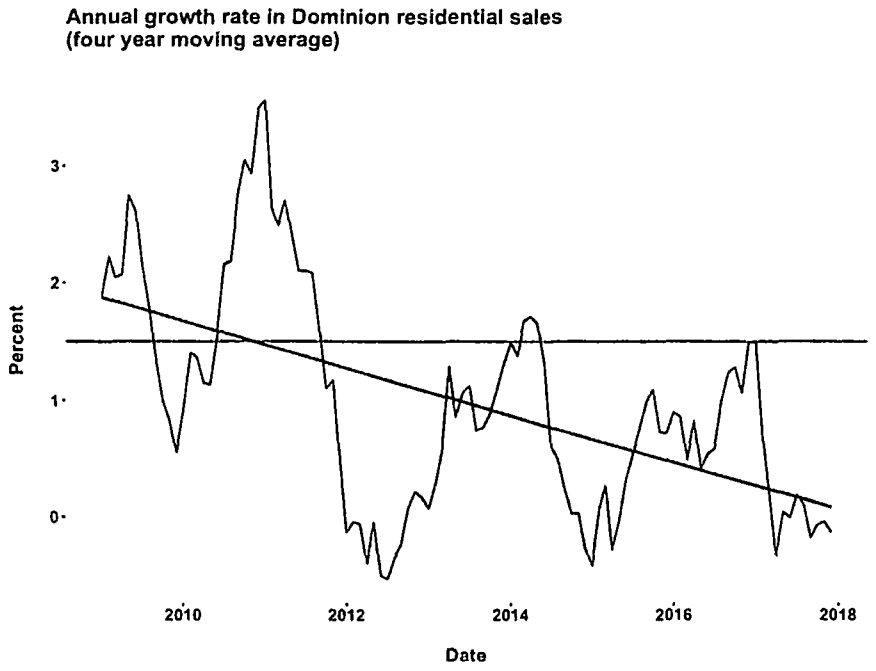
This decline has, in recent years, roughly offset increases in the number of customers. This can be seen in the following graph of total Company residential sales per year each year since 2008. Weather-normalized residential sales in 2017 were virtually identical to those in 2008. This is in spite of considerable growth in economic activity and in the

5 *See Commonwealth ex rel. State Corporation Commission in re: Virginia Electric and Power Company's Integrated Resource Plan filing pursuant to Virginia Code § 56-597 et seq.*, Case No. PUR-2017-00051, Transcript of Proceedings Volume II at 473:10 (Testimony of Company Witness Fox) (September 27, 2017), available at https://bit.ly/2Ooj8p4.

number of customers. There is simply no evidence of any significant upturn in the growth of residential demand.



The following graph shows the four-year moving average growth rate in Company residential electricity sales, represented as a black line. The horizontal red line gives 1.5% as a visual benchmark. The downward-sloping blue line is the best-fit line. As of late 2017, the growth rate in the Company's residential sales was hovering right around zero—that is, no net growth in sales for the past four years, including the last two years of relatively robust growth in customers and in the economy.



So we can conclude that the Company's model, which has forecasted growth in residential sales in each year since at least the 2012 IRP, must be failing to capture significant changes in the relationship between customers, economic activity and residential sales. The Company model results are simply not credible on either theoretical or empirical grounds. The probability is vanishingly small that the Company's residential sales will increase by 1.4% per year over the forecast horizon.

It is worth recalling from last year's IRP proceedings before the Commission, that the Company proffered a purportedly confirmatory forecast from an outside firm. Even though that firm chose to use outdated data that artificially inflated its forecast, it still did not produce a residential demand forecast as high as the Company's. Company

Witness Eric Fox agreed that, had he used the most recent data available, his forecast would have been even lower.[6]

V. THE APPROPRIATE RESPONSE TO MODEL MISSPECIFICATION

Q: What would be an effective way to respond to this model misspecification?

A: The Company's regression equation assumes a fixed coefficient on economic trend variables, when this assumption is clearly falsified by the data. It is also clear that this misspecification is leading to over-forecasting of demand because of changes in the energy intensity of economic activity. There are statistical tests for this model misspecificaton. These are tests for parameter stability in the regression coefficients. One of the most used tests of parameter stability is the Andrews structural break test. The Andrews test clearly shows a large and statistically significant change in the amount of electricity used per unit of economic activity starting around 2008. I also use a rolling regression to show how the coefficient on economic activity has fallen since at least the 2012 forecast period. These tests both show significant declines in the coefficients on variables economic activity.

It is very important to note that this is not due to incomes falling during the recession. The trend variables change with the recession, but there is no reason to believe that the underlying relationship between economic activity and electricity use is fundamentally

6 *See Commonwealth ex rel. State Corporation Commission in re: Virginia Electric and Power Company's Integrated Resource Plan filing pursuant to Virginia Code § 56-597 et seq.*, Case No. PUR-2017-00051, Transcript of Proceedings Volume II at 473:10 (Testimony of Company Witness Fox) (September 27, 2017), available at https://bit.ly/2Ooj8p4.

changed by the recession. Even as Virginia's economy has recovered from the recession, demand growth has not responded the way it would have if the responsiveness of demand to economic activity had not fallen as it has in recent years. Faster economic growth does not imply the same level of electricity demand growth that it did in the past.

There are a number of ways to address the problem of changing coefficients. A commonly used approach is simply to stop using old data that is no longer consistent with the most recent data. Other approaches involve estimating models that update the value of the regression coefficient over time as responsiveness changes.

VI. COMMERCIAL DEMAND

Q: How does the Company forecast commercial demand?

A: Commercial demand comprises two distinct parts: data centers and other commercial demand excluding data centers. Last year, total commercial demand was estimated with a regression specification similar to the one used for residential sales. Then the Company added an adjustment for future data center growth. There appeared to be substantial double-counting in last year's forecast. This year, the Company changed the way it forecasts data centers and the remainder of commercial demand by separating the two forecasts.

Q: What is your opinion of this new method?

A: Separating these two forecasts is a huge step forward—especially since data centers is currently the only segment of sales that is showing any significant growth. Unfortunately, the Company's approach to forecasting data centers appears very *ad hoc*

inspires little confidence in the accuracy of its results. Rather than extracting data center load from the historical commercial series and treating it separately, the Company has three separate pieces—none of which appear to be correctly specified—which it then knits together in a way that it fails to justify with any analysis whatsoever.

Q: Can you describe the method in greater detail?

A: First, the company estimates its standard sales regression on historical commercial sales data. This model in poorly specified, as I demonstrated in previous testimony before the Commission. It suffers from the same nonsense variable problem as the residential equation and the same fixed trend coefficient specification. Since these problems are the same as for the residential model, I will not bother to go over the same points again. A key point to remember, though, is that this historical commercial sales data includes data center sales. Thus, any trend estimates based on this data, already has data center growth in the estimated trend coefficient, even if that estimate is off due to specification problems. Given this, any estimate of future data center growth must account for the unknown proportion of estimated growth that is due to previous data center sales growth. How the Company handles this is very poorly documented, and what is there is not convincing.

The second set of commercial sales estimates, referred to by the Company as its "Internal Forecast," are for data centers: five secret equations for five particular (presumably large) data centers and a sixth equation for all other data centers. The sixth equation is essentially a simple regression, giving a constant additional 21 MWh of growth in data center demand each month for the next five years. This regression was

estimated on data from 2013 to 2017—which has some logic, since the objective is to capture recent growth.

The third equation is some version of the Bass Diffusion Model (BDM). The BDM was invented to predict the rate of adoption by consumers of new products. It posits a logistic adoption path that starts slow, increases in speed as word-of-mouth spurs greater adoption, and then slows as the market becomes saturated by the new product.

Q: Do you think the BDM is appropriate in this context?

A: No. BDM was not intended to be applied to an intermediate good that is an input to the production of many different final goods or services. The Company's reliance on the BDM here is akin to using the BDM to illustrate the "adoption" of oil as a fuel, or electricity, or concrete. It makes no sense to apply a logistic adoption model to a product that will be used as an input to various production processes. Consider that one of the essential terms in the BDM is a measure of the maximum number of adopters. Any application of such a parameter to the data center industry is fundamentally flawed.

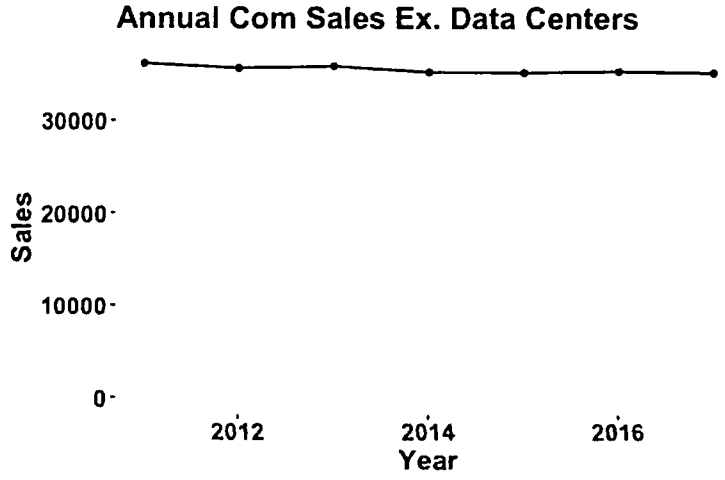
This demonstrates the need for the Commission to require that, in future Integrated Resource Plans, the Company (1) back out data center sales from commercial sales and (2) provide a fully documented, separate forecast of data center demand. That the Company has made a start at this separation is a good sign. This first attempt is, however, an inauspicious one. Furthermore, the documentation provided does not allow the Commission, its staff, the parties, or the public to independently assess

whether the Company has truly eliminated double-counting and, consequently, whether the data center forecast is as accurate as it can be.

Q: What is your conclusion about the growth of commercial sales excluding data centers?

A: Commercial sales excluding data centers is steady or declining even in the face of increased population and increased economic activity. There is no reason to believe that this series will suddenly start exhibiting rapid growth.

To assess the likely growth rate in non-data center commercial sales, I subtracted the monthly data center sales (mid-2010 forward) the Company provided in Attachment Staff Set 2-16 (KS) from the historical commercial sales series. The results from 2011 to 2017 are depicted in the following figure.



Commercial sales excluding data centers has been falling slowly since 2011. Improvements in lighting efficiency and energy management generally are partly responsible for this reduction, as more efficient technologies are applied to both new

and old building stock. There is also almost certainly some substitution of data center services for some of the non-data center commercial services.

VII. AN ALTERNATIVE FORECAST

Q: Can you suggest an alternative forecast that outperforms the Company's forecast?

A: Yes. I have estimated an alternative model that routinely outperforms the Company's model in terms of both its fit to existing data and its out-of-sample forecast accuracy. I do not assert that this is the best available model—only that it is not hard to produce a mode that outperforms the Company's model. My model uses the following variables:

- Dependent variable: Total electricity sales
- Trend variable: the Philadelphia Federal Reserve Bank Coincident Economic Activity Index for Virginia
- Monthly heating and cooling degree-days for Virginia weighted by population; available from the National Oceanic and Atmospheric Administration.
- Monthly dummies for residual seasonality

In testimony on the Company's prior IRPs, I have discussed the importance of testing for structural breaks and of the importance of not using pre-break data in fixed coefficient statistical models.[7] The data show a clear structural break in 2008, so data before this date should not be used in a simple fixed coefficient model or should be given a lower weight. While it would be fine to use all of the data since the structural

7 *See, e.g., Commonwealth ex rel. State Corporation Commission in re: Virginia Electric and Power Company's Integrated Resource Plan filing pursuant to Virginia Code § 56-597 et seq.*, Case No. PUR-2017-00051, Direct Testimony of William M. Shobe at 17 (August 11, 2017), available at https://bit.ly/2M58zKS.

break, I use a rolling six-year data window for my estimates: January 2011 through December 2017. This provides enough data for relatively precise estimation, but responds quickly to changes in the underlying model.

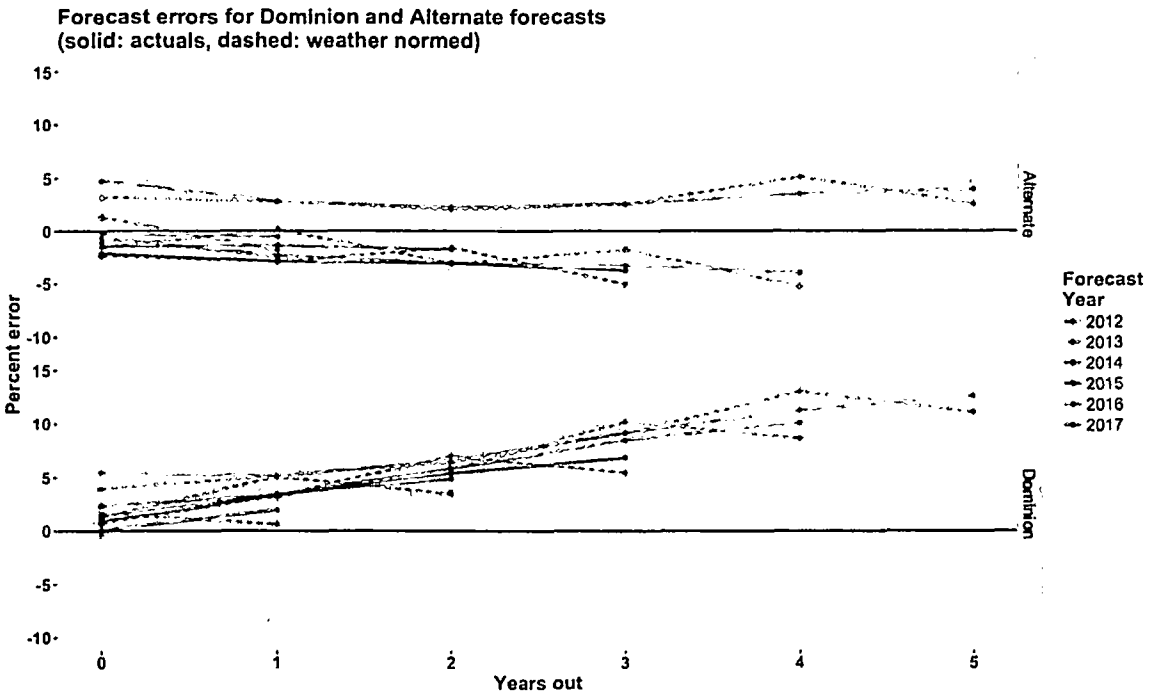
The fit of this model is excellent. The R-squared and Adjusted R-squared are better than 99%. All of the estimated regression coefficients are highly significant and of the expected sign. The table below displays the regression output.

Table 1:

	Dependent variable:
	sales
vn_indx	0.416***
	(0.006)
heating_per_day	2.739***
	(0.170)
cooling_per_day	5.308***
	(0.478)
Jan	99.342***
	(9.210)
Feb	102.785***
	(8.942)
Mar	97.556***
	(8.310)
Apr	100.625***
	(7.717)
May	114.908***
	(7.616)
Jun	128.745***
	(8.275)
Jul	130.507***
	(9.318)
Aug	120.157***
	(8.612)
Sep	121.987***
	(7.873)
Oct	104.858***
	(7.756)
Nov	90.020***
	(8.390)
Dec	97.715***
	(8.769)
Observations	84
R^2	1.000
Adjusted R^2	1.000
Residual Std. Error	4.349 (df = 69)
F Statistic	12,681.370*** (df = 15; 69)
Note:	*p<0.1; **p<0.05; ***p<0.01

The forecasting errors for this model are much lower than the errors from the Company's forecasts as published in its IRPs since 2012. In the following figure, my forecast errors are labeled CCPS. Errors are provided against both actuals and weather-normalized values. Either way, my model out-performs the Company's model by any measure of forecast quality.

The following figure shows forecast errors for all forecasts from 2012 to 2017. The errors are displayed in both weather normalized (dashed) and non-normalized (solid) values.



A table of forecast error rates (mean absolute percent error) by years out is below:

		Alternative Forecast		Dominion	
FC Year	Years out	MAPE	MAPE normed	MAPE	MAPE normed
2017	0	1.7	1.89	1.88	1.7
2016	1	1.96	2.04	3.46	3.45
2015	2	2.52	2.43	5.69	5.68
2014	3	3.2	3.1	8.18	8.24
2013	4	3.75	5.18	10.68	10.8
2012	5	3.98	2.61	12.61	11.12

Based on this model, a reasonable central forecast of total Company sales (excluding sales for resale) over the next 15 years is in the following table:

Alternate Forecast of Total Company Sales	
Year	Total Sales
2018	77332
2019	77775
2020	78460
2021	78694
2022	79169
2023	79656
2024	80389
2025	80663
2026	81184
2027	81717
2028	82504
2029	82821
2030	83392
2031	83977
2032	84823
2033	85187

VIII. CONCLUSION

Q: Does this conclude your testimony?

A: Yes.

CERTIFICATE OF SERVICE

I, Evan D. Johns, hereby certify that, on August 10, 2018, I deposited true copies of the foregoing into the United States mail, postage prepaid and addressed to the following:

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