THE DEMAND FOR ELECTRIC POWER: EXAMINING THE QUALITY OF NERC FORECASTS

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EXECUTIVE SUMMARY

- The purpose of this paper is to analyze the forecasts of one potential source of load forecasts— the North American Electric Reliability Council (NERC). NERC collates and summarizes the forecasts of individual utilities in each region, and publishes the results on a diskette entitled Electric Supply and Demand.

- DRI•WEFA has obtained copies of this document and its print-format predecessors going back to 1985. The volumes from 1985 to 2001 provide a total of seventeen consecutive forecasts for most NERC regions and sub-regions, with each forecast looking out ten years.

- Our primary finding is that, for the most part, the NERC forecasts are of good quality. Of the 30 NERC regions for which sufficient data is available, only six exhibit signs of statistically significant bias.

- Four regions, ECAR, MAIN, SERC-SOU, and NERC (US), are biased downward. The remaining two regions, NPCC-NS and NPCC-ONT, are biased upward.

Table 3: NERC Regions Exhibiting Statistically Unbiased Forecasts

Unbiased:	*Unbiased but Consistently Understated*	*Unbiased but Consistently Overstated*
ERCOT	MAAC	NERC (CAN)
MAPP (US)	SERC – TVA	NPCC (CAN)
MAPP (CAN)	SERC – VAC	NPCC – NB
NPCC	WSCC – AZN	NPCC – QUE
NPCC – NE	WSCC (CAN)	SPP
NPCC – NY	NERC (TOTAL)	SPP – N
SERC		WSCC – CNV
WSCC (US)		WSCC – RMP
WSCC – NWP		WSCC (MEX)

- For many purposes it is quite reasonable to use the NERC demand forecasts as they are published. In those cases where statistical bias exists, adjustments should be made prior to using the forecasts. Our analysis provides estimates of the magnitude and direction of the adjustments that would be required before using the biased forecasts.

The Demand for Electric Power: Examining the Quality of NERC Forecasts

HOW GOOD ARE LOAD FORECASTS?

Historically, electric load forecasters have spent very little time reviewing their track records. The standard joke is "I won't be here in twenty years." Like surgeons, we mostly bury our mistakes. This is unfortunate, since understanding how forecasted results differ from actual results can lead to improved forecasts and thus better business decisions.

There is limited data available on utilities' forecasts of their customer's future needs for electric power. While these projections are not strictly held to be confidential, they are generally shared with regulators only as necessary and otherwise not widely circulated. The first ten years of these forecasts are routinely shared with the North American Electric Reliability Council (NERC); they are also contained in the utilities' annual electronic filings with the Federal Energy Regulatory Commission (FERC). The standard reference is NERC's annual review, now only available on diskette, of *Electric Supply and Demand*.

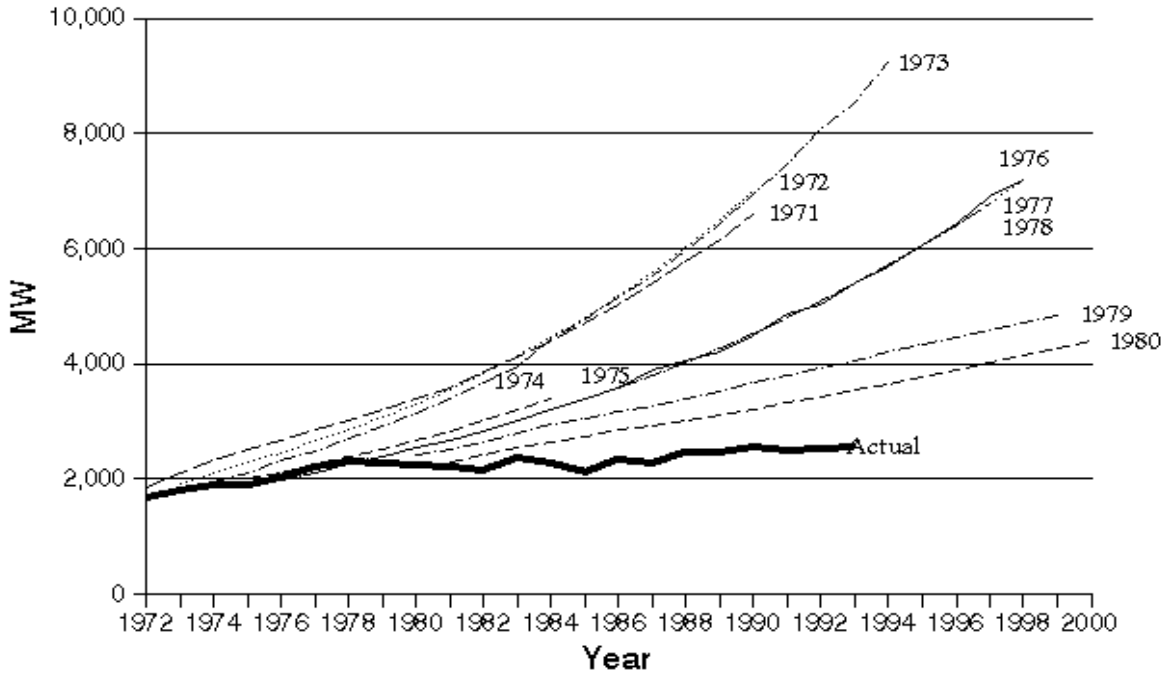
The NERC data is only a collation and summation of the individual utilities' forecasts. NERC does not comment on its member's forecasting techniques or track record. When analyzing the NERC data, it is important to keep in mind that forecasting is itself an economic activity - it is only worthwhile expending more time and resources on a forecast if the benefits outweigh the costs. Quite often the perceived benefits just aren't there. As a result, the quality of these forecasts can vary all over the board.

Forecasts of future power demands and energy sales are much better than they used to be, however, especially since the middle 1980's. Before computing power became generally available, forecasts were prepared by engineers with straight-edges and graph paper. These forecasts were also true consensus forecasts, in the sense that the company's executives had a very strong input - with the result being that the forecasts had an extremely obvious economic development content. The result was the famous "rooster's tail" of the 1970's. Each year the

forecast was revised down, but only slightly, with the out-years just as aggressive as they were the year before.

An example of this "rooster's tail" for one mid-western electric utility is illustrated in Figure 1. When we look back at these forecasts today, it is difficult at best to take them seriously. At the time they were made, however, they were consensus forecasts sharing three key features. First, the experience with these forecasts was typical; similar charts could be drawn for virtually every electric utility in the country.

Figure 1: Load Forecasting Track Record – Mid-Western Utility (1971-1980)

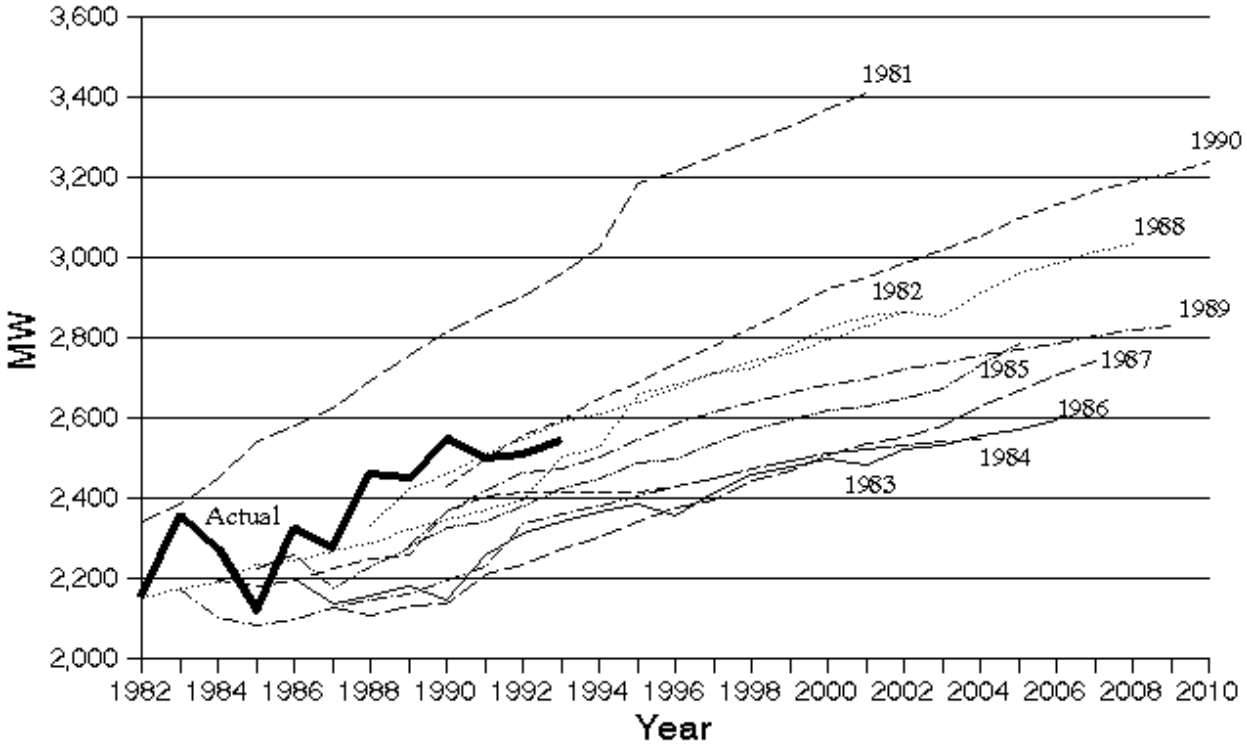


Second, they were sincere, reflecting an honest optimism about the economic development potential of the franchise. Remember, this was before the second oil shock, before the effects of the first oil shock were fully known, and before the rapid economic growth enjoyed during the Vietnam War was choked off by double-digit inflation and interest rates.

Finally, these were without question responsible forecasts produced using “best practice” methods. Computational resources were severely limited. Access to mainframe computing power was restricted and prohibitively expensive. Where utilities owned mainframes, customer billing frequently took priority over all other applications. Statistical software was in its infancy, and analysts simply did not have access to routines capable of solving large simultaneous systems of equations based upon time-series data. Many of the econometric techniques used today had only just been developed in academia, and were not yet understood in industry. Even the vendors of economic forecasts were not prepared to help - most macroeconomic forecasters of the time felt that it was impossible and hence unprofessional to attempt twenty-year forecasts of the macroeconomy. Finally, there was no motivation to use better forecast methods. To our knowledge, it was not until 1977 that the Florida Public Service Commission became the first regulatory agency in the nation to order that utilities use econometric or statistical forecasting techniques.

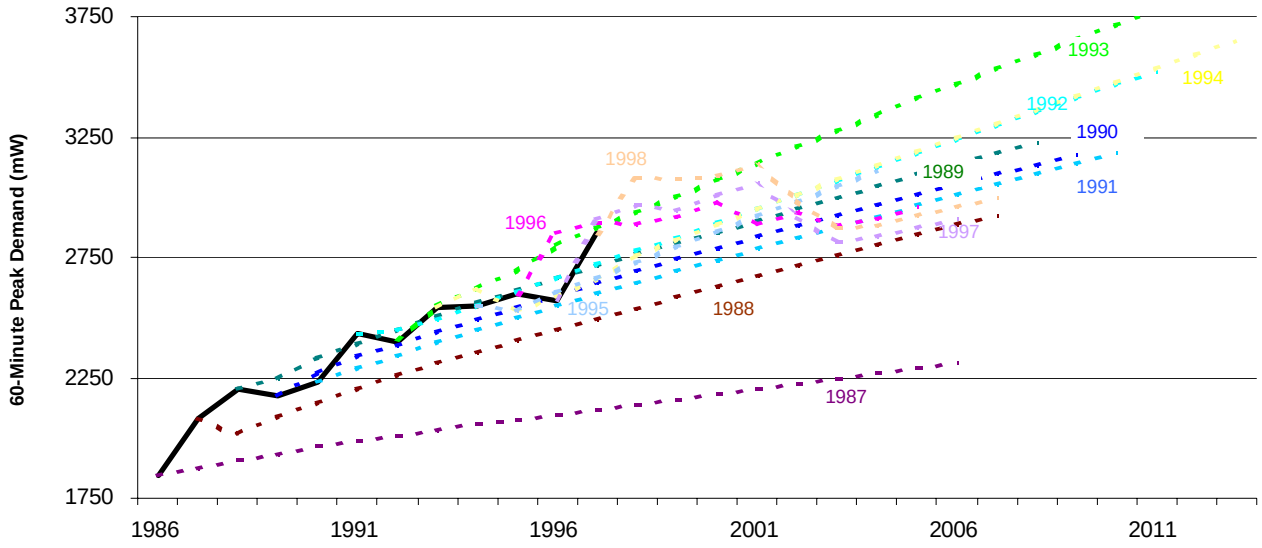
Figure 2 illustrates the demand forecasts prepared during the decade of the 1980s by this same mid-western utility. The forecast for 1981 was the last consensus forecast prepared using non-quantitative methods. The 1982 forecast was prepared by an outside consultant, and the remaining forecasts were prepared in-house utilizing updated versions of the 1981 model. With respect to Figure 2, two things should be noted. First, the scale of the left axis is greatly compressed relative to Figure 1, reflecting much more modest expectations for long-term load growth. Second, while these forecasts do tend to be consistently too low, they are not all too low and they come much closer to actually being unbiased.

Figure 2: Load Forecasting Track Record – Mid-Western Utility (1981-1990)



It is important to observe that the patterns that existed in the above mid-western utility are typical and can be found anywhere in the country. Figure 3 presents this same data for a small mid-Atlantic utility.

Figure 3: Load Forecasting Tack Record – Mid-Atlantic Utility (1987-1998)



Today, long-term load forecasting is receiving less emphasis among electric utilities since the construction of generating plant with long gestation periods (e.g., nuclear or steam coal) is generally not planned. Executive committees focus much more narrowly on sales, revenues and especially margins, with the time horizon largely set by the two year operating budget. Many load forecasters believe that they will soon be told to stop looking out twenty years or that they will be reassigned altogether to new planning responsibilities. Competition is generally expected to quickly change the face of utility planning such that planning for the construction of new generating capacity will become much more like planning for the construction of a new commodity chemical plant.

THE NERC FORECASTS AND THEIR ACCURACY

With the above discussion in mind, it is important to assess the quality of the NERC forecasts before they are used in economic analyses. Specifically, it is important to determine the accuracy of the forecasts and whether or not they are statistically unbiased (i.e. neither consistently too high or too low).

As mentioned above, the standard reference is NERC's annual review of *Electric Supply and Demand*. We have obtained copies of this document and its print-format predecessors going back to 1985. The volumes from 1985 to 2001 provide a total of seventeen consecutive forecasts for each region, with each forecast looking out ten years.

Unfortunately, NERC provides very little information on the prospective demand for actual power. NERC computes and reports non-coincident peak demands by sub-region. Non-coincident peak demands are much larger than coincident peak demands and overstate the need for capacity; coincident peak demands are not available, however, on a forecast basis, and are difficult to construct for recent history. As a result, the only reliable data available is the sum of annual net energies for load expected by NERC member utilities.

The first important question to be addressed is whether these forecasts of net energy for load are of good quality. For each NERC region and sub-region, DRI-WEFA has computed the mean expected error and standard deviation of the forecasts from one- to ten-periods into the future. The results of these calculations, for 1-step through 10-step forecasts, appear in Table 1. With published ten-year forecasts for 1985 through 2001, we have measurable experience with sixteen one-year forecasts, fifteen two-year forecasts, fourteen three-year forecasts, etc.

The mean expected error of the forecast for net energy for load is used to determine if the forecasts are consistently too high or too low. It is calculated as the average of the difference between the forecasted and actual values of net energy for load n-steps ahead. So, the mean expected error for the one-step forecast is the average of the errors of sixteen individual NERC annual forecasts. If these mean expected errors are always too high or always too low, we can say that they are consistently biased in one direction. However, there is more to consider before concluding that the bias is something to worry about. The standard error of the forecast should also be analyzed to determine the spread, or distribution of the mean expected errors. A t-score can be calculated by dividing the mean expected error by the standard error of the forecast. If the standard errors are sufficiently large, a t-test will reveal that there is significant statistical bias

present in the mean expected errors of the forecasts. When such statistically significant bias is present, the forecasts need to be adjusted before use in economic analysis.

Table 1
Forecast and Forecast Accuracy of Throughput by NERC Region (tWh)

United States

NERC - US	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	CAG 00-10 (%)
2001 Forecast - Net Load	3,639.0	3,754.8	3,834.8	3,922.5	3,998.9	4,079.2	4,159.4	4,235.4	4,315.6	4,392.4	4,463.2	2.06
Mean Expected Error		-12.6	-23.2	-44.7	-61.2	-72.2	-79.9	-89.0	-96.1	-110.7	-126.3	
Std. Error of Forecast		37.5	52.9	59.6	53.3	40.8	29.2	38.9	58.1	57.8	65.1	
t-score		-0.34	-0.44	-0.75	-1.15	-1.77	-2.74	-2.29	-1.65	-1.92	-1.94	
n		16	15	14	13	12	11	10	9	8	7	
ECAR												
2001 Forecast - Net Load	546.0	580.2	591.4	600.8	610.8	619.8	630.6	641.7	651.9	661.3	671.1	2.09
Mean Expected Error		-2.2	-2.2	-7.3	-12.7	-16.2	-21.2	-25.7	-30.1	-35.6	-40.4	
Std. Error of Forecast		9.9	16.6	15.4	12.8	12.7	10.8	13.7	18.0	18.4	17.1	
t-score		-0.23	-0.13	-0.47	-0.99	-1.27	-1.97	-1.87	-1.67	-1.94	-2.36	
n		16	15	14	13	12	11	10	9	8	7	
ERCOT												
2001 Forecast - Net Load	286.3	270.8	276.6	283.8	292.3	299.8	307.9	315.4	323.2	331.2	339.4	1.72
Mean Expected Error		-2.5	-3.1	-3.6	-3.4	-1.6	0.3	2.8	5.9	8.3	11.1	
Std. Error of Forecast		5.6	8.4	11.0	14.0	16.0	18.4	20.2	21.1	22.2	25.6	
t-score		-0.44	-0.36	-0.33	-0.24	-0.10	0.02	0.14	0.28	0.37	0.43	
n		16	15	14	13	12	11	10	9	8	7	
FRCC												
2001 Forecast - Net Load	196.6	203.1	209.4	216.2	220.9	225.6	230.9	235.5	240.3	244.9	249.7	2.42
Mean Expected Error		-1.4	-3.3	-1.3	na	na	na	na	na	na	na	
Std. Error of Forecast		3.5	2.7	na	na	na	na	na	na	na	na	
t-score		-0.40	-1.25	na	na	na	na	na	na	na	na	
n		4	3	2	1	0	0	0	0	0	0	
MAAC												
2001 Forecast - Net Load	262.3	265.9	270.1	275.7	280.8	284.8	289.2	293.0	297.2	300.9	304.7	1.51
Mean Expected Error		-1.8	-2.2	-3.0	-3.3	-3.0	-2.3	-2.5	-2.1	-2.5	-3.0	
Std. Error of Forecast		4.0	6.8	9.1	10.3	10.2	10.4	11.9	13.2	14.7	14.5	
t-score		-0.46	-0.33	-0.33	-0.32	-0.29	-0.22	-0.21	-0.16	-0.17	-0.21	
n		16	15	14	13	12	11	10	9	8	7	
MAIN												
2001 Forecast - Net Load	259.6	265.4	269.4	276.0	280.2	284.6	288.7	292.4	296.7	300.2	304.4	1.61
Mean Expected Error		-1.7	-3.2	-4.7	-8.6	-10.1	-11.2	-12.3	-13.1	-15.5	-17.9	
Std. Error of Forecast		9.3	10.4	11.6	5.1	5.6	5.8	5.6	6.6	6.4	5.7	
t-score		-0.19	-0.31	-0.41	-1.67	-1.78	-1.92	-2.21	-1.99	-2.43	-3.15	
n		16	15	14	13	12	11	10	9	8	7	

MAPP	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	CAG 00-10 (%)
2001 Forecast - Net Load	146.0	149.0	152.7	155.7	158.8	161.7	164.7	167.4	170.4	173.1	176.1	1.90
Mean Expected Error		1.2	0.3	-1.2	-2.7	-3.5	-4.5	-4.3	-5.0	-6.0	-7.3	
Std. Error of Forecast		5.6	6.5	6.6	6.2	6.0	4.5	4.1	5.9	7.8	8.9	
t-score		0.21	0.04	-0.18	-0.43	-0.58	-0.99	-1.05	-0.85	-0.77	-0.83	
n		16	15	14	13	12	11	10	9	8	7	
NPCC												
2001 Forecast - Net Load	281.5	286.0	290.1	295.3	299.1	303.2	306.8	310.1	313.8	317.3	320.9	1.32
Mean Expected Error		-1.6	-2.3	-2.0	-1.4	0.1	2.4	4.6	7.2	9.5	12.1	
Std. Error of Forecast		3.6	6.2	9.0	10.8	11.7	11.7	13.0	13.6	15.1	14.6	
t-score		-0.44	-0.37	-0.23	-0.13	0.01	0.20	0.35	0.53	0.63	0.83	
n		16	15	14	13	12	11	10	9	8	7	
NPCC - NE												
2001 Forecast - Net Load	124.9	127.2	130.2	131.9	133.9	136.3	138.4	140.2	142.4	144.5	146.5	1.61
Mean Expected Error		-0.4	-0.7	-0.6	-0.3	0.6	2.1	3.8	5.5	6.5	8.1	
Std. Error of Forecast		1.6	3.2	4.8	6.0	6.5	6.6	6.8	6.8	7.9	8.1	
t-score		-0.25	-0.23	-0.12	-0.05	0.10	0.32	0.56	0.80	0.83	1.00	
n		16	15	14	13	12	11	10	9	8	7	
NPCC - NY												
2001 Forecast - Net Load	156.6	158.8	159.9	163.4	165.2	166.9	168.5	169.9	171.4	172.8	174.3	1.08
Mean Expected Error		-1.2	-1.5	-1.5	-1.1	-0.6	0.3	0.8	1.8	2.9	4.0	
Std. Error of Forecast		2.5	3.4	4.7	5.4	5.7	6.2	7.3	7.7	8.1	7.7	
t-score		-0.48	-0.45	-0.32	-0.20	-0.10	0.04	0.11	0.23	0.36	0.52	
n		16	15	14	13	12	11	10	9	8	7	
SERC												
2001 Forecast - Net Load	803.2	853.2	875.1	898.5	915.9	938.9	958.5	977.3	997.9	1017.2	1028.2	2.50
Mean Expected Error		1.6	-0.5	-4.3	-2.4	9.7	9.5	6.6	4.9	2.9	1.6	
Std. Error of Forecast		53.6	56.5	61.8	67.4	50.7	53.5	61.8	62.5	62.3	56.1	
t-score		0.03	-0.01	-0.07	-0.04	0.19	0.18	0.11	0.08	0.05	0.03	
n		16	15	14	13	12	11	10	9	8	7	
SERC - ENT												
2001 Forecast - Net Load	137.3	144.8	145.7	143.1	146.6	149.2	152.3	154.6	157.9	160.6	163.1	1.74
Mean Expected Error		2.4	-4.7	na	na	na	na	na	na	na	na	
Std. Error of Forecast		0.6	na	na	na	na	na	na	na	na	na	
t-score		4.02	na	na	na	na	na	na	na	na	na	
n		3	2	1	0	0	0	0	0	0	0	

SERC - SOU	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	CAG 00-10 (%)
2001 Forecast - Net Load	210.0	243.1	250.9	257.3	262.9	273.5	280.0	286.0	292.4	299.4	299.7	3.62
Mean Expected Error		2.1	-1.4	-5.4	-7.7	-9.7	-11.2	-13.7	-16.8	-19.5	-22.1	
Std. Error of Forecast		7.7	7.5	5.2	4.9	4.9	4.6	5.3	5.9	4.7	5.2	
t-score		0.27	-0.19	-1.04	-1.58	-1.97	-2.45	-2.58	-2.82	-4.12	-4.25	
n		16	15	14	13	12	11	10	9	8	7	
SERC - TVA												
2001 Forecast - Net Load	160.5	163.2	168.9	172.1	175.5	178.7	181.7	185.1	188.5	191.3	192.2	1.81
Mean Expected Error		-0.3	-0.4	-0.5	-0.7	-1.6	-2.3	-3.6	-4.2	-5.4	-6.7	
Std. Error of Forecast		3.4	4.6	5.5	5.8	5.7	6.4	7.0	8.7	8.4	8.1	
t-score		-0.08	-0.09	-0.09	-0.11	-0.28	-0.36	-0.51	-0.48	-0.64	-0.82	
n		16	15	14	13	12	11	10	9	8	7	
SERC - VAC												
2001 Forecast - Net Load	295.3	302.2	309.5	326.0	330.9	337.5	344.4	351.6	359.1	366.0	373.2	2.37
Mean Expected Error		-1.7	-2.4	-5.0	-5.0	-6.5	-7.3	-9.2	-10.6	-12.6	-14.8	
Std. Error of Forecast		5.9	6.5	9.4	7.7	7.1	6.5	7.6	9.8	10.7	9.1	
t-score		-0.28	-0.36	-0.53	-0.65	-0.92	-1.12	-1.20	-1.08	-1.18	-1.63	
n		16	15	14	13	12	11	10	9	8	7	
SPP												
2001 Forecast - Net Load	193.7	191.2	193.7	197.9	202.1	206.5	211.1	214.9	219.5	224.5	229.1	1.69
Mean Expected Error		3.5	11.5	19.0	28.6	29.7	31.4	33.8	37.7	42.8	51.5	
Std. Error of Forecast		34.0	47.0	58.6	66.7	67.8	69.0	69.8	70.7	72.0	68.7	
t-score		0.10	0.25	0.32	0.43	0.44	0.46	0.48	0.53	0.59	0.75	
n		16	15	14	13	12	11	10	9	8	7	
SPP - N												
2001 Forecast - Net Load	59.4	60.1	61.7	63.0	64.3	65.8	67.4	68.9	70.6	72.2	73.8	2.19
Mean Expected Error		0.2	0.9	1.6	2.5	2.2	1.8	1.5	1.0	0.9	2.0	
Std. Error of Forecast		4.8	6.6	8.3	10.1	9.9	10.0	10.5	10.1	11.2	10.6	
t-score		0.04	0.14	0.19	0.25	0.23	0.18	0.15	0.10	0.08	0.19	
n		16	15	14	13	12	11	10	9	8	7	
SPP - S												
2001 Forecast - Net Load	134.2	131.1	132.0	134.9	137.7	140.7	143.7	146.0	149.0	152.3	155.2	1.46
Mean Expected Error		na	na	na	na	na	na	na	na	na	na	
Std. Error of Forecast		na	na	na	na	na	na	na	na	na	na	
t-score		na	na	na	na	na	na	na	na	na	na	
n		1	0	0	0	0	0	0	0	0	0	

WSCC	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	CAG 00-10 (%)
2001 Forecast - Net Load	663.9	689.9	706.5	722.6	738.0	754.5	771.1	787.7	804.7	821.9	839.6	2.38
Mean Expected Error		4.2	4.5	3.2	0.6	-0.5	-0.5	0.3	0.9	0.7	-2.1	
Std. Error of Forecast		8.3	11.7	13.6	13.3	12.2	11.0	10.5	9.4	9.5	11.1	
t-score		0.50	0.38	0.23	0.05	-0.04	-0.05	0.03	0.10	0.07	-0.19	
n		16	15	14	13	12	11	10	9	8	7	
WSCC - AZN												
2001 Forecast - Net Load	104.4	114.3	118.4	122.0	124.6	128.4	132.0	135.4	139.0	142.6	146.5	3.44
Mean Expected Error		-2.0	-2.9	-4.6	-6.8	-7.8	-8.6	-9.2	-10.2	-11.3	-12.9	
Std. Error of Forecast		4.9	6.7	7.8	9.0	9.7	10.2	9.5	9.0	8.6	7.9	
t-score		-0.41	-0.43	-0.59	-0.76	-0.80	-0.84	-0.97	-1.13	-1.32	-1.64	
n		16	15	14	13	12	11	10	9	8	7	
WSCC - CNV												
2001 Forecast - Net Load	266.9	276.2	283.2	290.5	297.9	305.5	313.3	321.1	329.0	337.1	345.4	2.61
Mean Expected Error		3.1	3.3	4.7	6.4	7.7	9.3	11.0	12.3	13.8	14.7	
Std. Error of Forecast		6.0	8.9	10.8	11.4	12.1	12.5	11.5	12.1	11.4	11.6	
t-score		0.53	0.37	0.43	0.56	0.63	0.74	0.96	1.02	1.21	1.27	
n		16	15	14	13	12	11	10	9	8	7	
WSCC - NWP												
2001 Forecast - Net Load	241.1	248.8	252.6	256.3	260.2	264.2	268.3	272.4	276.6	280.9	285.2	1.69
Mean Expected Error		2.9	3.6	2.7	0.8	-0.7	-1.7	-2.0	-2.0	-2.8	-5.2	
Std. Error of Forecast		5.1	6.8	8.2	7.9	7.9	8.2	7.3	6.5	7.1	4.5	
t-score		0.58	0.53	0.33	0.10	-0.09	-0.21	-0.28	-0.31	-0.39	-1.16	
n		16	15	14	13	12	11	10	9	8	7	
WSCC - RMP												
2001 Forecast - Net Load	51.5	50.6	52.2	53.9	55.2	56.4	57.6	58.8	60.0	61.3	62.5	1.96
Mean Expected Error		0.1	0.5	0.4	0.3	0.3	0.5	0.6	0.8	0.9	1.3	
Std. Error of Forecast		1.6	1.7	1.9	2.3	2.8	3.0	3.7	3.5	4.1	4.1	
t-score		0.07	0.26	0.20	0.13	0.10	0.17	0.16	0.23	0.23	0.32	
n		16	15	14	13	12	11	10	9	8	7	

Canada

NERC - CANADA	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	CAG 00-10 (%)
2001 Forecast - Net Load	498.8	501.4	512.6	520.3	529.1	536.6	544.0	552.6	561.0	567.4	574.8	1.43
Mean Expected Error		-0.2	2.8	-27.1	7.0	11.9	17.0	20.6	24.7	26.2	27.7	
Std. Error of Forecast		9.8	15.5	116.4	25.2	26.6	24.2	24.4	23.7	25.1	25.1	
t-score		-0.02	0.18	-0.23	0.28	0.45	0.70	0.84	1.04	1.04	1.10	
n		16	15	14	13	12	11	10	9	8	7	
MAPP												
2001 Forecast - Net Load	39.0	38.0	39.0	39.8	40.4	40.8	41.4	41.9	42.3	42.6	42.9	0.97
Mean Expected Error		-0.4	-0.4	-0.4	-0.4	-0.3	0.0	0.2	0.4	0.6	0.7	
Std. Error of Forecast		1.2	1.7	1.7	1.9	2.2	1.9	1.6	1.3	1.2	1.3	
t-score		-0.31	-0.22	-0.21	-0.22	-0.15	0.00	0.11	0.36	0.51	0.52	
n		16	15	14	13	12	11	10	9	8	7	
NPCC												
2001 Forecast - Net Load	346.3	350.7	357.8	362.2	368.0	371.6	375.5	379.8	384.2	387.5	391.5	1.23
Mean Expected Error		0.9	3.8	6.2	9.6	14.5	19.3	22.5	26.1	27.1	28.7	
Std. Error of Forecast		8.1	13.6	18.4	21.9	23.5	22.1	22.7	22.5	22.8	22.3	
t-score		0.11	0.28	0.34	0.44	0.62	0.87	0.99	1.16	1.19	1.29	
n		16	15	14	13	12	11	10	9	8	7	
NPCC - NB												
2001 Forecast - Net Load	15.0	15.2	15.6	15.8	16.0	15.7	15.2	15.1	15.1	15.2	15.3	0.21
Mean Expected Error		0.1	0.2	0.2	0.3	0.4	0.6	0.7	0.9	1.0	1.1	
Std. Error of Forecast		0.3	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1.2	1.3	
t-score		0.34	0.33	0.33	0.40	0.51	0.76	0.79	0.86	0.86	0.83	
n		16	15	14	13	12	11	10	9	8	7	
NPCC - NS												
2001 Forecast - Net Load	11.3	11.4	11.7	12.0	12.2	12.4	12.5	12.6	12.7	12.9	13.1	1.52
Mean Expected Error		0.1	0.1	0.2	0.3	0.4	0.5	0.7	0.8	1.0	1.2	
Std. Error of Forecast		0.3	0.4	0.5	0.6	0.7	0.8	0.8	0.9	0.8	0.5	
t-score		0.18	0.26	0.43	0.48	0.55	0.57	0.79	0.92	1.33	2.65	
n		15	14	13	12	11	10	9	8	7	6	
NPCC - ONT												
2001 Forecast - Net Load	146.9	149.9	152.1	154.0	156.2	157.6	159.3	161.2	163.6	164.8	166.4	1.25
Mean Expected Error		0.7	1.8	3.5	5.5	8.4	11.3	14.0	17.2	19.2	20.9	
Std. Error of Forecast		3.6	6.6	9.0	10.9	11.6	11.2	11.0	9.0	8.1	7.4	
t-score		0.18	0.28	0.39	0.51	0.73	1.01	1.28	1.91	2.37	2.83	
n		16	15	14	13	12	11	10	9	8	7	

NPCC - PEI	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	CAG 00-10 (%)
2001 Forecast - Net Load	1.0	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.4	2.84
Mean Expected Error		0.0	0.0	0.0	0.0	-0.1	-0.1	na	na	na	na	
Std. Error of Forecast		0.0	0.0	0.0	0.0	0.0	na	na	na	na	na	
t-score		-0.55	-0.91	-2.68	-3.99	-3.30	na	na	na	na	na	
n		7	6	5	4	3	2	1	0	0	0	
NPCC - QUE												
2001 Forecast - Net Load	172.2	173.1	177.2	179.3	182.4	184.7	187.3	189.7	191.4	193.2	195.4	1.27
Mean Expected Error		0.6	2.3	3.1	4.5	6.5	8.3	8.7	9.1	8.1	8.0	
Std. Error of Forecast		4.0	6.3	8.5	9.8	10.9	11.3	12.0	12.5	11.7	11.0	
t-score		0.15	0.37	0.37	0.46	0.59	0.74	0.73	0.73	0.69	0.72	
n		16	15	14	13	12	11	10	9	8	7	
WSCC												
2001 Forecast - Net Load	113.5	112.7	115.9	118.3	120.8	124.3	127.1	130.9	134.5	137.3	140.3	2.14
Mean Expected Error		-0.7	-0.7	-1.5	-2.2	-2.3	-2.3	-2.1	-1.8	-1.5	-1.7	
Std. Error of Forecast		2.2	2.7	2.8	3.3	3.5	3.6	2.9	2.5	2.4	2.4	
t-score		-0.32	-0.24	-0.54	-0.67	-0.65	-0.64	-0.73	-0.74	-0.63	-0.72	
n		16	15	14	13	12	11	10	9	8	7	

Mexico

WSCC - MEXICO												
2001 Forecast - Net Load	8.7	9.5	10.1	10.7	11.5	12.2	13.1	14.0	15.0	16.0	17.2	7.06
Mean Expected Error		0.0	0.1	0.0	0.1	0.1	0.3	0.4	0.6	0.6	0.4	
Std. Error of Forecast		0.3	0.4	0.4	0.5	0.7	0.6	0.7	0.7	0.8	0.8	
t-score		0.12	0.19	0.12	0.10	0.21	0.47	0.58	0.80	0.74	0.49	
n		15	14	13	12	11	10	9	8	7	6	

Total

NERC - TOTAL												
2001 Forecast - Net Load	4,146.5	4,265.7	4,357.4	4,453.6	4,539.5	4,628.1	4,716.5	4,802.1	4,891.6	4,975.8	5,055.1	2.00
Mean Expected Error		-12.9	-20.5	-40.5	-54.4	-60.5	-63.0	-68.5	-71.5	-84.6	-98.4	
Std. Error of Forecast		43.4	64.2	76.6	73.5	61.5	43.9	48.6	59.3	67.0	72.9	
t-score		-0.30	-0.32	-0.53	-0.74	-0.98	-1.44	-1.41	-1.21	-1.26	-1.35	
n		16	15	14	13	12	11	10	9	8	7	

Tables 2 and 3 summarize the information contained in Table 1 above, providing an overview of the quality of the NERC estimates of system throughput. Table 2 lists those few NERC regions with forecasts that exhibit statistically significant bias.

Table 2: NERC Regions Exhibiting Statistically Significant Forecast Bias

Understated:	***Overstated:***
NERC (US)	NPCC – NS
ECAR	NPCC – ONT
MAIN	
SERC – SOU	

From Table 2, we see that there are four NERC regions (all in the US) with forecasts that are consistently biased downward in the outer years of the forecast period. There are two regions (both in Canada) with forecasts that are consistently biased upward in the outer years of the forecast.

Table 3 lists the NERC regions with forecasts that are statistically unbiased. Nine regions are completely unbiased and exhibit no signs of being consistently too large or too small. Six regions have unbiased forecasts that are consistently too small, based on the mean expected errors. Finally, nine regions exhibit forecasts that are statistically unbiased but are consistently too large.

Table 3: NERC Regions Exhibiting Statistically Unbiased Forecasts

Unbiased:	***Unbiased but Consistently Understated***	***Unbiased but Consistently Overstated***
ERCOT	MAAC	NERC (CAN)
MAPP (US)	SERC – TVA	NPCC (CAN)
MAPP (CAN)	SERC – VAC	NPCC – NB
NPCC	WSCC – AZN	NPCC – QUE
NPCC – NE	WSCC (CAN)	SPP
NPCC – NY	NERC (TOTAL)	SPP – N
SERC		WSCC – CNV
WSCC (US)		WSCC – RMP
WSCC – NWP		WSCC (MEX)

Examination of the results presented in Tables 1 - 3 yields one very important observation. With a very few exceptions, utilities' forecasts of their customers' needs are generally unbiased, that is, they are equally likely to be too high as too low. Given our earlier discussion of the "rooster tails" observed during the 1970s, this is a truly remarkable result.

It is also important to note that these results do not remain constant over time. The last time that DRI-WEFA performed this analysis (in 1998), the results were slightly different. Of the 22 regions analyzed at that time, only three - ECAR, ERCOT, and SERC-SOU – exhibited significant statistical bias. This time around, with six additional years of forecasts, ERCOT is completely unbiased. Similarly, in 1998 NPCC-ONT was unbiased, whereas today it is biased upward. Of the remaining 19 regions analyzed last time, nine showed no signs of bias, five showed signs of consistent underforecasting while being unbiased, and the remaining five were unbiased but showed signs of consistent overforecasting.

In the case of ERCOT, this suggests that the forecasts of the utilities in region have improved tremendously over the past six years. For example, when this analysis was last done, ERCOT had mean errors of 9.6 tWh for a five-year forecast and 43.7 tWh for a ten-year forecast. This compares with –1.6 tWh for a five-year forecast and 11.1 tWh for a ten-year forecast this time.

INTERPRETING THE RESULTS

NERC Regions: United States

Of the 22 US NERC regions and subregions for which forecasts are published, only ECAR, MAIN, and SERC-SOU show signs of statistically significant bias[1]. Together, these three regions account for 28% of total US throughput in 2000 and nearly 29% in 2010. The statistically significant downward bias in the forecasts for these regions, as well as the consistently low forecasts in several other regions, results in the NERC forecasts for the entire US being downward biased as well.

[1] There are not enough forecasts available to draw conclusions for the following US regions: FRCC, SERC-ENT, and SPP-S.

Overall, the aggregate forecast for the NERC-US is consistently too low, with the latter years of the forecast showing statistically significant downward bias. Annual growth in net energy for load is expected to be just over 2% from a base of 3,639.0 tWh in 2000 to 4,463.2 tWh in 2010. Looking at the mean expected error indicates that the forecasts are consistently too low, by an average of 12.6 tWh in a one-year forecast, 72.2 tWh in a five-year forecast, and 126.3 tWh in a 10 year forecast. What this means is that, on average, we expect that the forecast for 2005 is 1.8% too low and the forecast for 2010 is 2.8% too low. With standard errors of the forecast ranging from 29-65 tWh, the standard errors are large enough to make these mean errors significant under a t-test for the 2005-2010 period. Thus, these forecasts must be adjusted before they are used in any analytical work.

ECAR is expecting nearly 2.1% annual growth in net energy for load, from a 2000 base of 546.0 tWh to a 2010 value of 671.1 tWh. Similar to the aggregate US forecasts, ECAR forecasts of net energy for load have been consistently too low over time, by an average of 2.2 tWh in a one-year forecast, 16.2 tWh in a five-year forecast and 40.4 tWh in a ten-year forecast. With relatively large standard errors of the forecast ranging from 10-18 tWh, the forecasts beyond five periods out show clear indications of statistically significant forecast bias. We can be certain that the ECAR energy forecast for 2005 is too low by as much as 2.6% and by 6% in 2010. Again, these forecasts must be adjusted for use in analytical work.

MAIN is another region in which the NERC forecasts are consistently too low. Annual growth for this region is expected to be 1.6%, from a base of 259.6 tWh in 2000 to 304.4 tWh in 2010. Looking at the mean expected errors indicates that a one-year forecast is too low by 1.7 tWh, a five-year forecast is too low by 10.1 tWh, and a ten-year forecast is too low by 17.9 tWh. With standard errors ranging from 5 to nearly 7 tWh, the forecasts beyond four periods out show statistically significant downward bias based on a t-test.

SERC-SOU is the third and final region in the US with statistically significant bias in its forecasts. At a 3.6% annual rate, this region is expected to experience the fastest growth of any

US NERC region through 2010, growing from a base of 210.0 tWh in 2000 to 299.7 tWh in 2010. Based on the standard errors of the forecast, this growth is consistently understated in the second through tenth years of the forecast. A five-year forecast is consistently too low by 4.9 tWh, while a ten-year forecast is too low by 5.2 tWh. This implies that the 2005 forecast is 3.5% too low, and the 2010 forecast is 7.4% too low. With standard errors ranging from 4.6-5.9 tWh, the forecasts beyond four periods out show statistically significant downward bias based on a t-test.

ERCOT is expecting 1.7% annual growth in net energy load, from a base of 296.3 tWh in 2000 to a value of 339.4 tWh in 2010. This forecast is unbiased over the entire forecast period, with the standard error of the forecast ranging from approximately 16-26 tWh in the last five years of the forecast.

MAAC (PJM) is expecting 1.5% annual growth in net energy for load, from a 2000 base of 262.3 tWh to a 2010 value of 304.7 tWh. MAAC forecasts of net energy for load have been consistently too low, by an average of 1.8 tWh in a one year forecast, 3.0 tWh in a five year forecast, and 3.0 tWh in a 10 year forecast. In other words, we can be fairly sure that the MAAC energy forecast for 2005 is too low by just over 1%, and the energy forecast for 2010 is too low by about 1%. However, since the standard errors, which range from 4-15 tWh, are not large enough to make these mean errors significant under a t-test, there is no need to adjust the forecast for use in analytical work.

MAPP is expecting a 1.9% annual increase in net energy for load, from 146.0 tWh in 2000 to 176.1 tWh in 2010. This forecast is unbiased over the entire forecast period, with the standard error of the forecast ranging from approximately 4-9 tWh over the entire forecast period.

NPCC-NE (NEPOOL) is expecting growth of 1.6% annually, from a 2000 base of 124.9 tWh to a 2010 value of 146.5 tWh. NPCC-NY (NYPOOL) is expecting 1.1% annual growth in net energy for load, from a 2000 base of 156.6 tWh to a 2010 value of 174.3 tWh. Both of these forecasts appear to be unbiased in that the errors in the forecast are not significantly different from zero.

The standard error of the forecast in the out-years is fairly stable at about 6-8 tWh. With both of the sub-region forecasts unbiased, the aggregate forecast for NPCC is itself unbiased. Standard errors for the outer years of the forecast range from 11-15 tWh.

SERC-TVA is expecting annual growth in net energy for load of 1.8% from 160.5 tWh in 2000 to 192.2 tWh in 2010. SERC-VAC is expecting a faster growth rate of 2.4% from a base of 295.3 tWh to 373.2 tWh over the same period. The mean expected errors for these two regions indicate that the forecasts of net energy for load are consistently understated. For SERC-TVA, the forecast is too low by 0.3 tWh for a one-period forecast, 1.6 tWh for a five-year forecast, and 6.7 tWh for a ten-year forecast. For SERC-VAC, a one-year forecast is too low by 1.7 tWh, a five-year forecast is too low by 6.5 tWh, and a ten-year forecast is too low by 14.8 tWh. However, with standard errors ranging from roughly 6-11 tWh, the bias is never statistically significant in either region.

In aggregate, the SERC region is expecting growth in net energy for load of 2.5% from 803.2 tWh in 2000 to 1028.2 tWh in 2010. SERC is the largest of the US NERC regions. Overall, the forecast for SERC is statistically unbiased over the entire forecast period. The standard errors are in the 50-62 tWh range.

SPP and SPP-N are two regions in which the forecasts are consistently too high. The entire SPP region is expecting annual growth in net energy for load of 1.7% over the 2001-2010 forecast period. Throughput is expected to grow from a base of 193.7 tWh in 2000 to 229.1 tWh in 2010. The mean expected error for the SPP forecast is too large, on average, by 3.5 tWh for a one-year forecast, by 29.7 tWh for a five-year forecast, and by 51.5 tWh for a ten-year forecast. This suggests that the forecast for 2005 is 14% too high and a whopping 22% too high in 2010. However, with standard errors in the 68-72 tWh range, there is no evidence of significant statistical bias in the estimates.

The results for SPP-N are not as dramatic. This region is expecting growth of 2.2% from 59.4 tWh to 73.8 tWh from 2000-2010. The forecasts are too high by 1-2 tWh over the forecast

horizon. This translates into a 2005 forecast that is too large by 3.3% and a 2010 forecast that is too large by 2.7%. Based on a t-test, standard errors of the forecast in the 10-11 tWh range do not lead to the conclusion of bias.

Overall, the aggregate forecast for WSCC is statistically unbiased. The WSCC region is expecting strong growth in net energy for load of 2.4% over the 2000-2010 forecast horizon. Throughput is expected to grow from a base of 663.9 tWh to 839.6 tWh. The standard error of the forecast is stable in the 8-13 tWh range. WSCC-NWP is also unbiased, with throughput expected to grow at an annual rate of 1.7%, from 241.1 in 2000 to 285.2 in 2010. The standard errors of the forecast are stable, in the range of 5-8 tWh.

WSCC-AZN is expecting strong growth over the forecast horizon. Net energy for load is expected to grow from 104.4 in 2000 to 146.5 in 2010. This translates into an annual growth rate of 3.4%. The forecast for WSCC-AZN is consistently too low by an average of 2 tWh for a one-year forecast, 7.8 tWh for a five-year forecast, and 12.9 tWh for a ten-year forecast. However, with standard errors of the forecast ranging from 5-10 tWh, the bias is not statistically significant.

The two remaining regions in the US WSCC region, WSCC-CNV and WSCC-RMP, are also statistically unbiased, although these forecasts are consistently too high. WSCC-CNV is expecting growth in net energy for load of 2.6% per year. Throughput is forecasted to increase from 266.9 tWh in 2000 to 345.4 in 2010. These forecasts are consistently too high by an average of 3.1 tWh for a one-year forecast, 7.7 tWh for a five-year forecast, and 14.7 tWh for a ten-year forecast. WSCC-RMP is expecting slightly slower growth of 2% over the 10-year forecast horizon, from 51.5 in 2000 to 62.5 in 2010. This region's forecast is consistently too high by an average of 0.1 tWh for a one-year forecast, 0.3 tWh for a five-year forecast, and 1.3 tWh for a ten-year forecast. Using the standard error of the forecasts to perform a t-test indicates that these forecasts are statistically unbiased. Thus, no adjustment needs to be made for use in analytical work.

NERC Regions: Canada

Of the nine NERC regions and subregions in Canada for which forecasts are published, only two exhibit statistically significant evidence of bias – NPCC-NS and NPCC-ONT[2]. In total, the forecast of growth in net energy for load in the NERC regions in Canada is lower than in the US (1.4% annual growth vs. 2.1%). Net energy for load in Canada is expected to increase from 498.8 in 200 to 574.8 in 2010. Although the outer years of the forecast for Canada appear to be systematically overstated, there is no statistical evidence of bias.

NPCC-NS is expecting annual grow in net energy for load of 1.5% from a base of 11.3 tWh in 2000 to 13.1 tWh in 2010. The forecasts are consistently overstated, by an average of 0.1 tWh for a one-year forecast, 0.4 tWh for a five-year forecast, and by 1.2 tWh for a ten-year forecast. This means that a five-year forecast is 3.2% too high, and a ten-year forecast is too high by 9.2%. However, it is only the ten-year forecast that exhibits statistically significant bias.

The NPCC-ONT forecast is also consistently overstated. This region is expecting annual growth in net energy for load of nearly 1.3% over the forecast horizon. In 2000, net energy for load was 146.9 tWh. By 2010, it is expected to be 166.4 tWh. On average, the NPCC-ONT forecast is overstated by an average of 8.4 tWh for a five-year forecast and by 20.9 tWh for a ten-year forecast. This translates into an overstatement of 5.3% and 12.6%, respectively. However, it is only the eight-year and later forecasts that show signs of significant statistical bias. These need to be corrected before using the forecasts for business decisions.

The rest of the NERC regions in Canada show no signs of significant statistical bias. The MAPP region is expecting annual growth in net energy for load of 1%, from a base of 39 tWh in 2000 to 42.9 tWh in 2010. The MAPP forecast is not consistently too high or too low, and the standard errors of the forecast are consistently very small - always less than 1 tWh.

All of the Canadian NPCC subregions exhibit consistent overforecasting. As a whole, the NPCC region is expecting growth in net energy for load of 1.2%. Throughput is expected to increase

from a base of 346.3 tWh to 391.5 in 2010. These forecast results are too large by 14.5 tWh in 2005 and 28.7 tWh in 2010, or by 3.9% and 7.3%, respectively. Nevertheless, since the standard errors of the forecast are not large enough to make these mean errors significant under a t-test, the forecasts are not statistically biased.

At just 0.2% per year, NPCC-NB earns the distinction of being the slowest growing NERC region over the 2000-2010 period. Throughput is expected to increase from 15 tWh in 2000 to 15.3 tWh in 2010. Examining the mean expected errors reveals that even this slow growth is likely overstated. A five-year forecast is too high by an average of 0.4 tWh, while a ten-year forecast is too high by an average of 1.1 tWh. With standard errors ranging from 0.3-1.3 tWh, the mean expected errors are never significant using a t-test. Thus, the forecasts are statistically unbiased.

NPCC-QUE is expecting 1.3% annual growth in net energy for load, from a 2000 base of 172.2 tWh to a 2010 value of 195.4 tWh. These forecasts are overstated by an average of 6.5 tWh for the five-year forecast and by 8 tWh for the ten-year forecast. The standard errors of the forecast are relatively steady in the out-years of the forecast, ranging from 11-12 tWh. As a result, there are no signs of statistical bias.

WSCC is the one Canadian NERC region with forecasts that are consistently too low. Net energy for load is expected to increase from 113.5 tWh in 2000 to 140.3 in 2010, an annual growth rate of 2.1%. On average, the forecast is too low by 2.3 tWh for a five-year forecast and by 1.7 tWh for a ten-year forecast. With standard errors ranging from 2.2-3.6 tWh, there is no evidence of statistical bias for the WSCC forecasts.

NERC Regions: Mexico

In Mexico, WSCC is the only NERC region. This region is expecting strong growth. From 2000-2010, net energy for load is expected to increase from 8.7 tWh to 17.2 tWh, an annual

[2] There are not enough forecasts available to draw conclusions for the NPCC-PEI region.

growth rate of nearly 7.1%. Analysis of the mean expected errors indicates that the forecasts are slightly too high. A five-year forecast is too high by an average of 0.1 tWh, while a ten-year forecast is too high by 0.4 tWh. This means that the 2005 forecast is about 0.8% too high and the 2010 forecast is 2.3% too high. However, with standard errors ranging from 0.3-0.8 tWh, the forecasts are statistically unbiased. As a result, the forecasts can be used 'as is' in analytical work.

NERC: Total

Net energy for load for all of NERC (US, Canada and Mexico combined) is expected to grow by an average annual rate of 2%, from a bsae of 4,146.5 tWh in 2000 to 5,055.1 tWh in 2010. From Table 1, it is evident from the mean expected errors that these forecasts are consistently too low. For example, a one-year forecast is too low by an average of 12.9 tWh, a five year forecast is too low by an average of 60.5 tWh, and a ten-year forecast is too low by 98.4 tWh. This suggests that the five-year forecast is 1.3% too low, while the ten-year forecast is approximately 2% too low. Although the forecast for all of the NERC regions combined is systematically underforecasted, there is no evidence of significant statistical bias.

Conclusions

The purpose of this paper was to analyze the quality of NERC demand forecasts. Based on the evidence presented above, it is clear that, overall, the NERC forecasts are of good quality. Of the 30 regions for which there is sufficient data available for analysis, we find that only six exhibit signs of significant statistical bias. Of these, the forecasts for ECAR, MAIN, SERC-SOU, and NERC (US) all exhibit statistically significant downward bias, while two Canadian regions, NPCC-NS and NPCC-ONT exhibit significant upward bias.

This result suggests that, for many purposes, it is quite reasonable to use the NERC demand forecasts as they are published. In those cases where statistical bias exists, adjustments should be made prior to using the forecasts. The analysis above provides estimates of the magnitude and direction of the adjustments that would be required before using the biased forecasts.