

**APPENDIX C – METHODOLOGY AND RESULTS FROM ENERGY  
USE MODELING**

Page intentionally blank

**Introduction**

TVA forecasts the long-term energy and peak demand outlook 20 to 25 years into the future. The long-term forecast is built up from individual forecasts of residential, commercial, and industrial sales. These forecasts serve as the basis for planning the TVA power system, budgeting, and financial planning.

TVA stays abreast of issues and procedures relating to energy forecasting and continually incorporates new information into its forecasting process. At TVA, several advanced forecasting models and techniques have been incorporated to form a complete forecasting system from data collection to evaluation of forecast uncertainties. To deal with uncertainty, the forecast does not rely on a single estimate, but provides decision makers with a range of forecasts.

**Accuracy**

The table below summarizes the accuracy of the TVA system energy forecast for five year periods covering target years 1990 through 2002. The annual variance averaged 2.7 percent over the 14-year period. The variances in 2001 and 2002 are due in part to the severe economic slowdown the United States has been experiencing recently and of course were not included in the economic outlook prepared in 1996-97 for the 2001-02 periods.

<b>FISCAL YEAR THE FORECAST WAS PREPARED</b>	<b>TARGET FISCAL YEAR</b>	<b>NET SYSTEM ENERGY FORECAST 5 YEARS AFTER PREPARATION</b>	<b>ACTUAL NET SYSTEM ENERGY FOR YEAR FORECASTED</b>	<b>% DIFFERENCE BETWEEN ACTUAL AND FORECASTED ENERGY</b>
		Gigawatt-hours	Gigawatt-hours	
1985	1990	120,300	121,156	0.7%
1986	1991	122,200	121,531	-0.5%
1987	1992	119,300	122,697	2.8%
1988	1993	128,569	126,402	-1.7%
1989	1994	136,567	130,662	-4.3%
1990	1995	138,709	135,499	-2.3%
1991	1996	137,500	140,026	1.8%
1992	1997	137,100	142,739	4.1%
1993	1998	139,728	145,784	4.3%
1994	1999	151,666	149,692	-1.3%
1995	2000	156,598	153,218	-2.2%
1996	2001	159,363	152,632	-4.2%
1997	2002	160,741	152,195	-5.3%
			Average Absolute Variance	2.7%

### **Use the Best Practices**

The system forecast is built up from its major sectors: residential, commercial, and industrial. The outputs of several models for each sector are systematically compared and trends in key parameters, such as saturation rates and unit energy consumption estimates, are examined.

Large customers who have significant electricity requirements are analyzed individually. In addition, each major industry group, such as paper or machinery, is reviewed annually for changes in technology, finances, competitive structure, etc. Key variables used in the forecast include the economic outlook, electricity, and natural gas prices. Ranges of values for key variables are developed in order to measure the varying impacts on TVA sales.

Econometric modeling is used extensively. The strengths of this approach include the explicit estimation of the historical response of electricity consumption to electricity prices, natural gas prices, and income. Each of TVA's primary classes of customers is considered individually in the models to allow for changing shares of energy use between residential, commercial, and industrial sectors.

Statistically adjusted end-use models are used to measure how much energy consumption will occur from given end-uses such as residential air conditioners, office lighting, and industrial motors. These models can reflect how energy use is changing within sectors. While econometric models are tied to historic data, end-use models allow forecasters to incorporate expected future events such as the introduction of mandated efficiency standards or the arrival of new technologies.

All the methods listed were used in the development of the January base forecast, however only Electricity Forecasting Model (EFM) was needed to estimate the impacts of the rate structure change. An overview of EFM is included below, and similar information is available for all models upon request.

**EFM** is an aggregate time-series econometric model used in the residential, commercial, and industrial sectors.

**Residential Sector:** Consumption per customer is the major variable. The independent variables are average real price of electricity, average real price of natural gas, and real annual per capita income. By multiplying sales per customer by the projected number of residential customers, a forecast for the total sector is derived.

**Commercial Sector:** Divided into six subsectors - regulated industries, wholesale/retail trade, finance/insurance and real estate, service, government, and unclassified.

Electricity demand is derived for each sector based on gross regional product, employment, the real price of electricity, and the real price of natural gas.

**Industrial sector:** Divided into subsectors for food, machinery, paper, textiles, chemicals, primary metals, other nondurable goods, and other durable goods. The dependent

variable is energy use, and the independent variables are gross regional product, employment, the real price of electricity, and the real price of natural gas.

### **Use of Best Information**

This includes the use of TVA's own economic forecast for the TVA service area, which is based on the national economic forecast done by *The Global Insight* forecasting group. TVA develops, in conjunction with outside consultants, electric price and natural gas price forecasts for the power service territory. The forecasting group also uses econometric models with weather data from the National Oceanic and Atmospheric Administration to remove the impacts of nonnormal weather from the energy history to better estimate the historical change in energy use. The TVA forecasting staff gathers information from all its large, directly served customers each year and maintains a database of information for each industry sector represented in the Valley. This information is augmented with information from TVA's industrial marketing representatives to develop a forecast for each customer.

### **Explicit Treatment of Uncertainty**

The treatment of uncertainty includes developing several alternative energy forecasts based on scenarios including high- and low-economic growth. Energy forecasts are also developed for scenarios that include different electric rates or, as in this study, different rate structures. The forecasting group also uses a model to incorporate several uncertainties and estimate their collective impact on energy demand. The January 2003 forecast used as the basis is developed using the expected values of the key variables and therefore can be considered a midrange or expected value forecast.

### **Continuous Improvement**

The forecasting procedure is reviewed annually and improvement and changes are made as they become apparent. Recent improvement includes updating the system peak model to incorporate the changing behavior of customers due to new rates, particularly those which include interruptible options. The basic end-use energy models were retired in 2001 and replaced with statistically adjusted end-use models.

**Table C-1 – Complete listing of sales for each case (in Gigawatt-hours):**

Year	Base	Case 2	Difference	Case 3	Difference	Case 4	Difference	Case 5	Difference
2004	166,858	167,082	224	167,041	183	166,942	84	167,051	193
2005	170,259	170,582	322	170,500	241	170,364	105	170,501	242
2006	172,787	173,181	394	173,077	290	172,910	123	173,072	285
2007	175,823	176,264	441	176,148	325	175,960	137	176,136	313
2008	179,247	179,731	484	179,609	362	179,401	154	179,588	341
2009	182,709	183,233	524	183,108	399	182,880	171	183,077	368
2010	186,564	187,125	561	186,999	434	186,752	187	186,956	392
2011	187,851	188,440	589	188,312	461	188,050	200	188,262	411
2012	189,292	189,908	616	189,778	486	189,503	211	189,720	428
2013	190,820	191,458	638	191,326	506	191,041	220	191,262	442
2014	192,526	193,183	657	193,049	523	192,754	228	192,979	453
2015	194,223	194,898	675	194,761	538	194,458	235	194,686	463
2016	198,191	198,882	691	198,743	552	198,433	241	198,663	472
2017	202,092	202,798	706	202,656	565	202,339	247	202,572	480
2018	206,014	206,735	721	206,590	576	206,266	252	206,502	488
2019	210,045	210,782	737	210,634	589	210,303	258	210,541	496
2020	214,171	214,925	755	214,774	603	214,434	263	214,675	504
2021	217,920	218,694	774	218,539	619	218,190	270	218,435	515
2022	221,659	222,455	796	222,295	637	221,936	278	222,185	526
2023	225,198	226,016	818	225,852	653	225,483	284	225,735	537
2024	229,019	229,860	840	229,690	671	229,311	292	229,568	549
2025	232,925	233,789	864	233,615	690	233,225	300	233,485	560