Determinants of Electricity Demand Growth in Maryland

Introduction

This appendix provides an overview of the basic theoretical foundations upon which forecasts of electricity consumption and peak demand rest, and an analysis of the trends of the key economic and noneconomic determinants of the demand for electricity. The Maryland data presented herein were obtained from the Maryland Department of Planning, the Bureau of Economic Analysis of the U.S. Department of Commerce, and the Bureau of Labor Statistics of the U.S. Department of Labor. Economic variables include income, price of electricity and employment; noneconomic variables include population (which is itself influenced by income and employment) and weather. Historical information is required for estimation purposes, while projected data are necessary to forecast the demand for power, using the statistical relationships between these variables and electricity consumption determined during the estimation process.

This appendix is composed of five sections. The following section presents a brief discussion of the theoretical foundations used for modeling the demand for electricity econometrically. This section sets the stage for the rest of this document, which examines economic and demographic trends for Maryland by region. For the purpose of presentation, the state has been divided into six regions, as shown in Table 1. The section covering the theoretical foundations is followed by a section discussing trends in per capita income, which, in turn, is followed by a section discussing trends in employment. Trends in population and the number of households follow the employment section.

Table 1 Principal Regions in Maryland

Region	Counties	Predominant Electric Distribution Utility
Baltimore	Anne Arundel Baltimore Baltimore City Carroll Frederick Harford Howard	Baltimore Gas and Electric Company
Washington Suburban	Montgomery Prince George's	Potomac Electric Power Company
Southern Maryland	Calvert Charles St. Mary's	Southern Maryland Electric Cooperative
Western Maryland	Allegany Garrett Washington	Potomac Edison Company
Upper Eastern Shore	Caroline Cecil Kent Queen Anne's Talbot	Delmarva Power and Choptank Electric
Lower Eastern Shore	Dorchester Somerset Wicomico Worcester	Delmarva Power and Choptank Electric

Theoretical Foundations for Econometrically Modeling Electricity Demand

"Econometric" forecast studies use the economic theory of demand as the organizing principle to model the demand for electricity. The total demand for any good or service, including electricity, is simply the sum of the demands of the individual consumers in the market. The portion of market demand for residential use of electricity is driven by factors to which individual residential consumers are sensitive. Similarly, for the commercial and industrial sectors of the market demand for electricity, the factors affecting the demand are those to which the producers of goods and services are sensitive.

The residential demand for electricity is assumed to result from the exercise of choice by which the consumer maximizes their usage, subject to a budget constraint. Consumer demand for electricity is taken to be a function of its price, consumer income, weather and the price of related commodities (i.e., substitutes and complements such as natural gas for home heating). It is important to note that electricity, in and of itself, conveys no benefits to the consumer. Rather, the consumer benefits from the services of the stock of appliances that require electricity. These

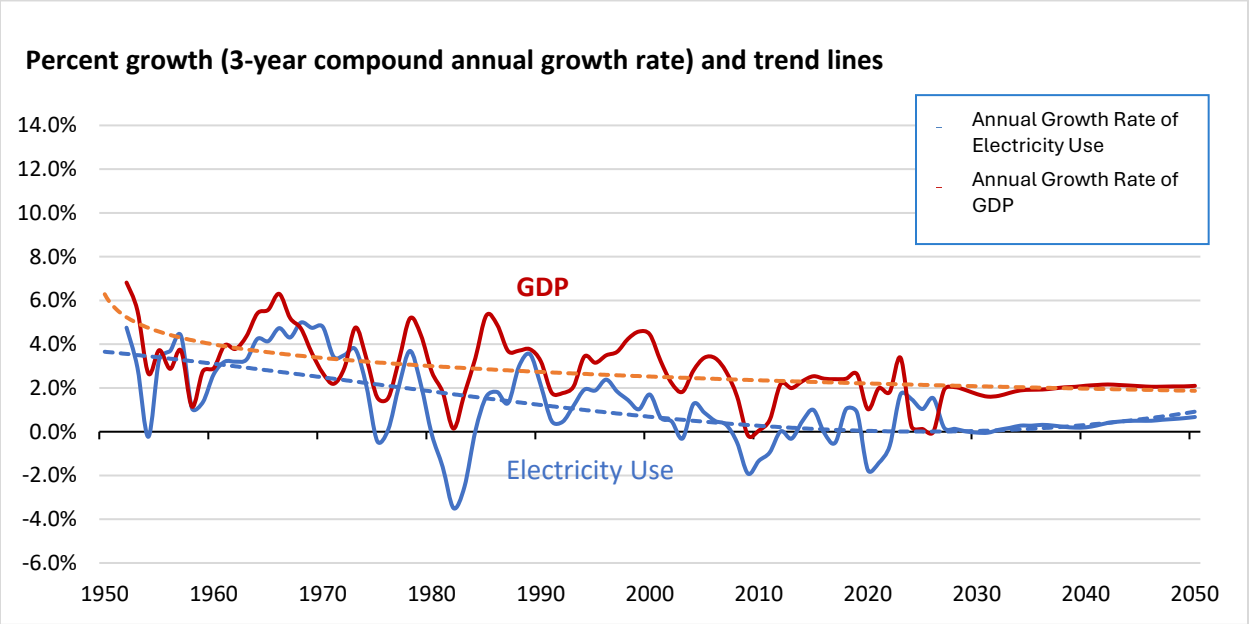
services include space conditioning, refrigeration, cooking, clothes washing and drying, and numerous other services and functions. Consequently, the demand for electricity can be appropriately viewed as a derived demand; that is, it results from the demand for the services provided by electricity-consuming appliances.

For commercial and industrial customers, electricity is a factor of production, i.e., an input. For the profit-maximizing producer, demand for a commodity (including electricity) is driven by its price, the price of related inputs and the level of output. Producer demand for electricity is also driven by other factors, including weather.

Both the residential and nonresidential demand for electric power is discussed above in terms of the individual consumer or producer. The market demand for electric power, for example, in Maryland or within regions in Maryland, is also dependent on the number of consumers (households) and the level of goods and services produced in the region. Because no satisfactory time series of output data is available at a suitably disaggregated level, employment is used as a proxy for output. Commercial and industrial electric sales are projected per employee, which is then multiplied by the number of forecasted employees to project total commercial and industrial demand for electricity.

The growth in electricity use has historically been linked to the level of economic growth. The rate of growth of electricity use nationwide exceeded the rate of increase in the gross domestic product (GDP) in the 1950s by 5 percent. As shown in Figure 1, the differential between the growth in real GDP and the growth in electric use has declined steadily from 1950 until the 1990s, when growth in electric use fell below GDP growth. Similar to the recession in the early 1980s, the differential between GDP growth and growth in electric use during the Great Recession of the late 2000s is minimal.

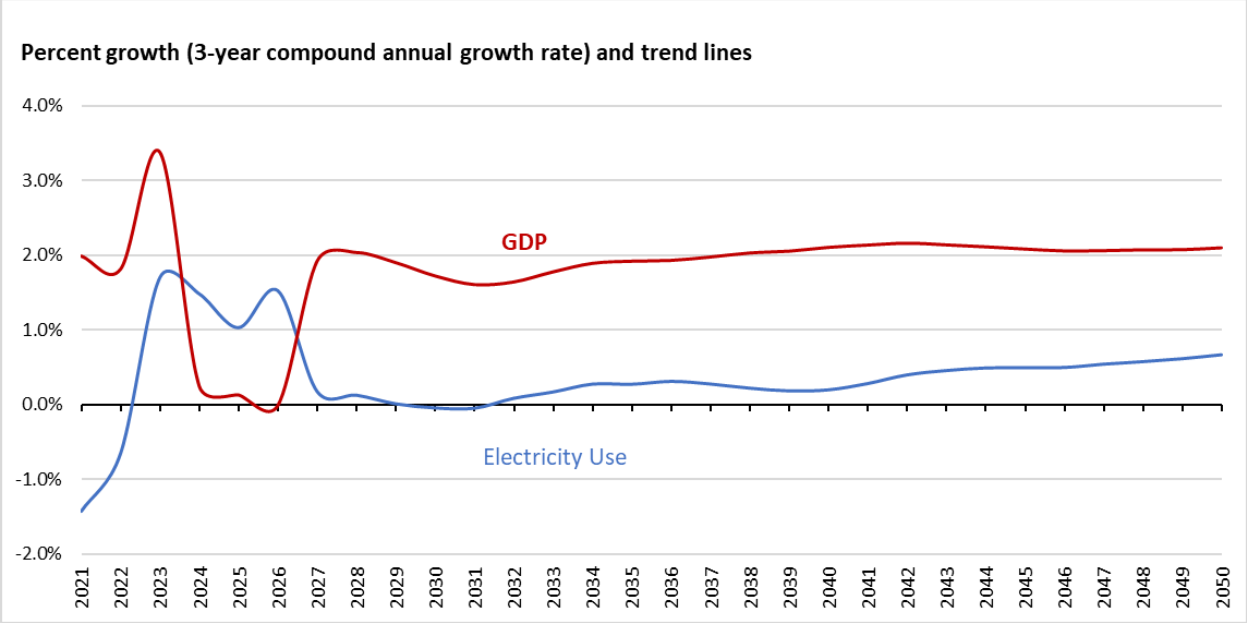
Figure 1 U.S. Electricity Use and Economic Growth, 1950-2050



Source: U.S. Bureau of Economic Analysis; U.S. Energy Information Administration, Annual Energy Outlook for 2021 and Bureau of Economic Analysis Historical GDP.

The U.S. Energy Information Administration (EIA) reports in its 2023 Annual Energy Outlook (AEO) that it anticipates stable growth in U.S. electric power demand through 2050 in all cases, due to increasing electrification and economic growth. In the long term, average electric use is projected to grow around 0.47 percent per year from 2023 through 2050, compared to average real GDP growth of 1.83 percent over the same period (illustrated in Figure 2). Over the next three decades, EIA projects that electricity use will continue to grow; however, the rate of growth will slow over time.

Figure 2 Projected U.S. Electricity Use and Economic Growth, 2021-2050



Source: U.S. Energy Information Administration, Annual Energy Outlook for 2023.

Per Capita Income Trends

Income is an important determinant of the residential demand for electricity, and changes in income will affect the quantity of electricity purchased. Changes in income affect electric power consumption in two ways. First, a change in income will induce a change in the intensity of use of the existing stock of electricity-consuming appliances; for example, consumers will reevaluate the intensity of use of a more constrained budget if there is a decline in income. This can be manifested in higher air conditioning settings or the use of lower-wattage lamps for electricity requirements. Second, an income change will induce changes in the stock of electricity-consuming appliances as it impacts consumers purchasing energy-efficient devices. As income changes, therefore, the electricity demand will rise or fall.

Real (i.e., inflation-adjusted) per capita income can be used as an explanatory variable for residential per-customer electricity consumption. Real per capita income figures are reported in Table 2 for the Maryland regions defined in Table 1. Table 2 summarizes historical and projected

data as well as average annual growth rates for the period 2000 through 2025. As shown by the historical data, the rate of income growth has remained constant or has slowed for all regions in Maryland. For the state as a whole, growth in real per capita income declined to 0.73 percent per year between 2005 and 2010, compared to an average annual growth rate of 2.23 percent between 2000 and 2005. All regions of the state, except for Southern Maryland (owing to its proximity to Washington, D.C. and federal government employment opportunities, which drive up wages and the in-migration of relatively high-income households), saw considerable decreases in the rate at which income grew during the 2005-2010 time period relative to 2000-2005. The Upper Eastern Shore region saw a decline in inflation-adjusted income between 2005 and 2010. This slowing was a product of the severe economic downturn and associated job losses affecting numerous Marylanders who lost their incomes, and economic conditions placed downward pressure on wages as the competition for available jobs became more intense.

From 2010 to 2015, the rate of real per capita income growth increased relative to the 2005-2010 period. A forecast prepared by the Maryland Department of Planning for 2015-2020 shows that as the nation (and Maryland) emerges from the recession and the economy once again begins to grow, income will follow the economy's upward trajectory. Income growth is projected to once again slow (but is not negative) between 2015 and 2020 as the economy returns to steady-state rates of growth lower than those expected during the rebound period that follows the recession.

Table 2 Historical and Projected Per Capita Income for Maryland, 2010-2035

	Per Capita Income (2009 $)						Average Annual Growth Rates				
Region	2010	2015	2020	2025	2030	2035	'10-'15	'15-'20	'20-'25	'25-'30	'30-'35
Maryland	$49,221	$52,000	$56,854	$60,112	$62,541	$64,943	1.10%	1.80%	1.12%	0.80%	0.76%
Baltimore	$48,850	$52,498	$57,965	$61,589	$64,254	$66,890	1.45%	2.00%	1.22%	0.85%	0.81%
Washington Suburban	$54,395	$56,155	$60,675	$63,808	$66,132	$68,405	0.64%	1.56%	1.01%	0.72%	0.68%
Southern Maryland	$44,827	$46,626	$51,162	$54,298	$56,769	$59,343	0.79%	1.87%	1.20%	0.89%	0.89%
Western Maryland	$34,428	$36,452	$40,332	$42,947	$44,916	$46,850	1.15%	2.04%	1.26%	0.90%	0.85%
Upper Eastern Shore	$42,110	$46,155	$50,940	$54,017	$56,414	$58,700	1.85%	1.99%	1.18%	0.87%	0.80%
Lower Eastern Shore	$35,873	$37,824	$41,320	$43,592	$45,490	$47,455	1.06%	1.78%	1.08%	0.86%	0.85%

Source: Prepared by the Maryland Department of Planning, Planning Data Services, January 2015.

Employment Trends

Nonresidential demand from commercial and industrial electricity consumers is largely driven by their economic output (e.g., customers served, quantities manufactured, etc.). Higher output implies some additional use of electricity. Output data at the county level are not available consistently, hence, a proxy for output needs to be used. Nonfarm employment has typically been relied upon for this purpose. Under the necessity to have adequate numbers of employees to achieve a desired level of output, it is a sound alternative and it is not subject to data consistency problems. Employment data at the regional level are reported in Table 3.

Table 3 Historical and Projected Employment for Maryland, 2010-2035

	Total Jobs (thousands)						Average Annual Growth Rates			
Region	2010	2015	2020	2025	2030	2035	'10-'20	'20-'25	'25-'30	'30-'35
Maryland	3,345	3,603	3,536	3,684	3,858	3,947	1.12%	0.82%	0.93%	0.46%
Baltimore	1,627	1,765	1,736	1,804	1,888	1,930	1.31%	0.76%	0.92%	0.44%
Washington Suburban	1,197	1,297	1,276	1,337	1,399	1,429	1.30%	0.94%	0.90%	0.43%
Southern Maryland	156	159	159	166	175	182	0.43%	0.83%	1.12%	0.72%
Western Maryland	136	141	130	134	139	141	-0.82%	0.46%	0.74%	0.42%
Upper Eastern Shore	115	122	120	126	135	139	0.71%	1.05%	1.36%	0.60%
Lower Eastern Shore	114	118	115	118	123	126	0.08%	0.57%	0.75%	0.55%

Source: Historical data from the U.S. Bureau of Economic Analysis, Tables CA25 and CA25N.
Projections from 2025 to 2050 prepared by the Maryland Department of Planning, Planning Data Services, October 2022.

As shown in Table 3, while almost every region of the state has seen consistently positive employment growth over the past decade, the Lower Eastern Shore and Western Maryland were the hardest hit by the recession and the global pandemic, with Western Maryland seeing a -0.82% in average annual growth rates between 2010 and 2020. Growth between 2020 and 2030 is projected to be most rapid in the Southern Maryland and Upper Eastern Shore regions and slowest in Western Maryland and the Lower Eastern Shore. Overall employment trends for the state tend to track those in the Baltimore and Washington, D.C. suburban regions as these areas contain the largest number of jobs. Both the Baltimore and Washington, D.C. suburban regions, and subsequently the State of Maryland in aggregate, are projected to see similar growth rates through 2035.

The economic downturn resulting from the Covid-19 Pandemic continues to greatly affect employment, as well as energy consumption, and considerably slowed employment growth rates. Maryland's unemployment rate rose from 2.9 percent in December 2019 to an all-time high of 9.1 percent in May 2020. However, Maryland has still fared better than the United States as a whole. The nationwide unemployment rate in April 2020 was 14.8 percent. In March 2024, four years out from the start of the pandemic, the unemployment rate for the nation was down to 3.8 and Maryland was down to 2.9 percent.[1,2] Despite the sharp increase in unemployment in Maryland and the nation in 2020, total employment is projected to increase by 5.3% from 2021 to 2031 according to the Bureau of Labor Statistics.[3]

Population Trends

Population is an important causal variable because population trends determine (in large part) the number of residential customers. Both the number of households and household size play a role in influencing electricity demand. The number of households affects the number of residential customers purchasing electricity, and changes in average household size can affect usage per

[1] Unemployment Rate (UNRATE) | FRED | St. Louis Fed (stlouisfed.org)

[2] Local Area Unemployment Statistics (LAUS) - Office of Workforce Information and Performance (OWIP) (state.md.us)

[3] Projecting Employment during Pandemic Recovery : U.S. Bureau of Labor Statistics (bls.gov)

customer. Larger numbers of customers mean higher demand, and smaller household sizes (for a given total population) will typically result in higher demand. While smaller households use less electricity in absolute terms, the relationship between size and usage does not scale linearly, as household electricity uses (such as heating and lighting) decline at rates lower than the decline in the number of household members. Population growth and the rate of household formation are closely related, and both affect the residential use of electricity. However, household size has seen a slow but steady decline (in Maryland and the United States as a whole) as cultural and societal norms change over time. Deferred marriage and the decision to limit or forgo child-rearing have steadily lowered the size of the average household. Accordingly, population increases lead to increases in the number of households (and hence residential customers), although these rates of change need not coincide due to changes in the size of households. Population and household data are reported in Tables 4 and 5.

Population data at regional and state levels are reported in Table 4. The table summarizes historical and projected data, as well as average annual rates of growth for the period 2010-2035. The population growth rates have been positive since 2000 for every region of Maryland except the western region which decreased slightly between 2010 and 2020. The state's population growth slowed from 2015 to 2020 to 0.31 percent per year, compared to the first half of the decade which experienced an annual growth rate of 0.71 percent. The state's population is projected to rebound and resemble its 2010 to 2015 growth rate between 2020 to 2025, at 0.68 percent, and is projected to maintain a similar annual growth rate going forward. While following these trends generally, the outer regions of the state, including Southern Maryland and the Upper and Lower Eastern Shore are projected to experience a more rapid population growth than that of the rest of the state from 2020 onward. The rates of population growth are uneven across the state. Historically, the largest growth rates were reported for Southern Maryland and the smallest rates for Western Maryland. However, Baltimore's growth rate is projected to be significantly lower than that experienced for Western Maryland over the 2020-2035 period.

Table 4 Historical and Projected Population for Maryland, 2010-2035

Region	Total Population (thousands)						Annualized Growth Rates				
	2010	2015	2020	2025	2030	2035	'10-'15	'15-'20	'20-'25	'25-'30	'30-'35
Maryland	5,774	5,983	6,177	6,390	6,577	6,755	0.71%	0.31%	0.68%	0.58%	0.54%
Baltimore	2,663	2,738	2,795	2,881	2,940	3,003	0.55%	0.19%	0.41%	0.42%	0.36%
Washington Suburban	2,069	2,183	2,301	2,384	2,463	2,532	1.09%	0.41%	0.71%	0.66%	0.56%
Southern Maryland	340	358	373	394	414	433	0.99%	0.85%	1.10%	0.98%	0.93%
Western Maryland	253	252	252	258	266	275	-0.03%	-0.05%	0.50%	0.63%	0.63%
Upper Eastern Shore	240	241	244	252	262	272	0.09%	0.32%	0.65%	0.79%	0.77%
Lower Eastern Shore	209	211	213	222	232	240	0.19%	0.31%	0.83%	0.85%	0.71%

Source: Projections for the Baltimore region based on Round 9 from the Baltimore Metropolitan Council of Government's Cooperative Forecasting Committee. Projections for the Washington suburban region based on Round 9.2A of the Metropolitan Washington Council of Governments Cooperative Forecasting Committee. Aggregated data prepared by the Maryland Department of Planning, December 2022

Household data for the state are shown in Table 5. The table shows a summary of historical and projected data, as well as average annual rates of growth for the period 2010-2035. Household growth rates differ from population growth rates due to population demographics and differences in household size. Because of this, household growth captures certain variables, such as the establishment of new households by young adults or the movement of childless couples into the region, which a raw population statistic fails to convey. On average, areas with high household sizes will see higher increases in electricity demand from household growth. Inspecting the rate of change in household size can convey the type of households being added. For example, Southern Maryland is expected to see the highest growth rates in both population and housing in the state. However, it will also see the most rapid decline in household size, suggesting that the households being added may be smaller, and subsequently elicit different changes in electricity demand.

Since 2015, household size in all six Maryland regions has been declining or flat, and the decline is forecast to continue through 2025, at which point most household sizes remain static. For the state, the average household size was 2.65 people in 2020; however, household size is expected to decrease slightly to 2.61 people by 2035.

Table 5 *Historical and Projected Number of Households and Average Size of Households in Maryland, 2000-2035*

	Number of Households (thousands)						Annualized Growth Rates				
Region	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**'10-'15**	**'15-'20**	**'20-'25**	**'25-'30**	**'30-'35**
Maryland	2,156	2178	2,334	2,315	2,392	2,461	0.20%	0.51%	0.71%	0.66%	0.57%
Baltimore	1,021	1,020	1,046	1,071	1,098	1,120	-0.02%	0.51%	0.48%	0.50%	0.40%
Washington Suburban	746	766	782	816	845	871	0.53%	0.43%	0.83%	0.70%	0.62%
Southern Maryland	120	125	133	143	151	158	0.88%	1.28%	1.38%	1.14%	0.96%
Western Maryland	97	95	96	100	103	106	-0.33%	0.22%	0.65%	0.70%	0.63%
Upper Eastern Shore	91	92	94	99	104	110	-0.04%	0.50%	0.98%	1.04%	1.12%
Lower Eastern Shore	82	80	82	87	91	95	-0.33%	0.44%	1.14%	0.97%	0.73%
	Household Size						**Annualized Growth Rates**				
Maryland	2.61	2.68	2.65	2.63	2.61	2.61	0.53%	-0.22%	-0.15%	-0.15%	0.00%
Baltimore	2.54	2.62	2.57	2.56	2.54	2.53	0.62%	-0.38%	-0.08%	0.16%	-0.08%
Washington Suburban	2.73	2.81	2,80	2.77	2.75	2.75	0.58%	-0.07%	-0.22%	-0.14%	0.00%
Southern Maryland	2.80	2.82	2.76	2.72	2.70	2.69	0.14%	-0.43%	-0.29%	-0.15%	-0.07%
Western Maryland	2.43	2.47	2.43	2.42	2.42	2.42	0.33%	-0.33%	-0.08%	0.00%	0.00%
Upper Eastern Shore	2.58	2.58	2.56	2.53	2.52	2.50	0.00%	-0.16%	-0.24%	-0.08%	-0.16%
Lower Eastern Shore	2.42	2.48	2.47	2.45	2.45	2.45	0.49%%	-0.08%	-0.16%	0.00%	0.00%

Source: Historical data from the U.S. Census. Forecasts prepared by the Maryland Department of Planning, December 2020. planning.maryland.gov/MSDC/Documents/popproj/AVGHHSizeProj.pdf

Summary

This appendix provides a review of the theoretical and demographic foundations used for modeling the demand for electricity econometrically. In doing so, emphasis is placed on some of the key determinants of the demand for electric power. The determinants of demand are classified into residential and nonresidential, as well as into economic and noneconomic for purposes of exposition. Per capita income is an explanatory economic variable that influences the residential demand for electricity; population, the number of households and average household size are noneconomic explanatory variables affecting residential electricity consumption. This appendix also shows trends in employment, which affect the nonresidential demand for electricity. Selected data on these determinants of demand are reported and trend analyses are presented. The broad conclusion to emerge from these trends is that electricity demand should continue to grow in Maryland.