Utah FOUNDATION **Research Report**

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PEAK LOAD GROWTH ALONG THE WASATCH FRONT:

WHAT'S DRIVING ELECTRICITY DEMAND IN UTAH?

HIGHLIGHTS

- Peak electricity demand has been growing faster than average load demand. Since 1991, the gap between the two has grown by approximately 200 megawatts.
- In 2000, Utahns used 1.6 times the amount of electricity on the peak day than on an average day. This gap must be accommodated by building expensive electric generation capacity.
- Residential peak demand has grown at a compound annual rate of 7.4% since 1996 while commercial peak demand has grown at a rate of 5.2%
- An increasing proportion of Utah homes use central air conditioning, a driving force behind increasing peak loads.
- In Salt Lake City, office space now comprises a larger portion of commercial space than retail. Air conditioning is the largest user of electricity in the commercial sector.
- The strongest predictor of electricity consumption is personal income.

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Until the large power outage this summer across the eastern United States and Canada, the idea of electrical peak load growth as a public policy issue was almost unheard of. Since the power outage, policymakers at all levels of government have started examining the supply and demand of electricity.

This report results from a request by PacifiCorp and attempts to explain the phenomenon driving the growth of electricity consumption within Utah over the past decade. In light of the surge in peak loads during Utah's hot, dry summers, in conjunction with the drought, and set against the backdrop of the catastrophic power outage on the East Coast, PacifiCorp executives were seeking information on the factors behind rapid growth in peak consumption in recent years. PacifiCorp's greatest concern was the increased use of air conditioning in homes. Utah Foundation assembled an advisory board of experts in all areas of the electricity field. This board included consumer advocates and a representative from the small utilities that compete against PacifiCorp to provide electricity in Utah. The authors of this report have distributed its findings to all on the advisory board to ensure that it provides a fair and accurate portrayal of the electricity market in Utah.

All consumption data used in this report are from PacifiCorp customers, but since PacifiCorp provides power to 85% of the market, it is a safe assumption that the municipal and cooperative electricity providers in the state have similar consumption patterns. The rest of the data contained in this report come from governmental agencies, including the Federal Energy Regulatory Commission (FERC) and the U.S. Census Bureau (Census). It should be noted that there are limitations to the data available for examination. Utah Foundation's analysis of residential and commercial growth is limited solely to the Salt Lake Metropolitan Area in the case of residences and Salt Lake County for the commercial sector. Where needed, the authors have noted problems and irregularities with the data.

Any in-depth discussion of electricity necessarily plunges the reader into a sea of acronyms and terminology that might be unfamiliar to those who work outside the energy sector. In order to ensure the reader comes away from this report with a full understanding of Utah's electricity consumption patterns, the next section of this report is a glossary of terms used by experts in the field. This glossary is by no means comprehensive, but is written to provide the reader with simple, easy-to-understand definitions.

Following the glossary, this report will provide a general overview of Utah's electricity consumption, including an examination of each sector as a portion of total demand. The report will then discuss the drivers behind electricity demand, focusing on the three most highly correlated factors: income growth or affluence, population growth, and climate.

Following these sections on usage, the report will analyze the residential housing stock in the Salt Lake Metropolitan Area, how it has grown since 1970, and the types of appliances found in the home. Included in this analysis will be a comparison of these factors between Utah and three other western cities: Denver, Portland, and Phoenix. Following the residential analysis, the report will briefly analyze growth in the commercial and industrial sectors. To conclude this report, the authors will draw all of these pieces together and try to explain how they fit.

DEFINITIONS1

Electricity use generally refers to electricity consumption measured over any period. This includes both *annual consumption* (energy) and *instantaneous load* (power).

Load refers to the amount of electricity that is demanded at any given time on the system, and *peak load* is the maximum electricity demanded from a specified portion of the electrical system, typically averaged over an hour.

End-use or *end-users* refers to the final purpose or group for which electricity is used or demanded.

Customer class categorizes end-users into five types: residential, general service, irrigation, streetlights, and resale.

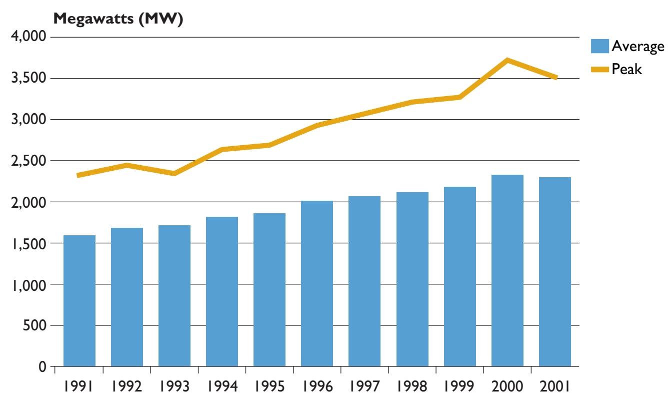
General service encompasses all commercial and industrial users. For purposes of this report, industrial users are those that consume one megawatt or more of power at the peak. Commercial consumers are non-residential customers that consume less than 1 megawatt at the peak. Resale users are other electricity providers that purchase energy from PacifiCorp.

Coincident peak load is a term used to describe the maximum power demanded by the entire system during a defined period. The daily coincident peak occurs when a combination of commercial, industrial, and residential loads places the most demand on the system. In Utah, the highest annual coincident peak happens on one of the hottest days of the year, when residences, offices, retail spaces and industrial firms are demanding a lot of electricity to power air conditioning and other climate devices.

Non-coincident peak load describes the peaks in use by a certain customer class. Non-coincident loads may or may not happen at the same time as coincident peak loads. For example, on a typical summer day, the residential non-coincident peak occurs in late afternoon or early evening as people arrive home from work and begin to cook and use more air conditioning. This is several hours after the coincident, or system peak, which is heavily influenced by business demand.

Load and *demand* are used interchangeably by many analysts. *Load factor* is the ratio of average load over a given period of time to the peak load during that period. An entity with a high load factor will have a demand curve that is essentially flat, meaning the entity requires the same amount of energy at 2 AM as at 2 PM. Entities falling under this category are typically round-the-clock facilities like a manufacturing firm or a hospital. An entity with a low load factor has a demand curve with a definitive peak and valley. Homes are the prime example of low load factor customers; demands shift from hour to hour, day to day, and seasonally, depending on temperature and other factors.

Figure 1: Yearly Average Load Compared to Yearly Peak
365-Day Average vs. Single Day Peak



Source: PacifiCorp

Watt is the basic unit of power. Household power usage is defined in terms of *kilowatts* or 1,000 watts. Industrial customers use power in *megawatts*. One megawatt is equal to 1,000 kilowatts and is that is the amount of energy necessary to power 750 homes. A *gigawatt* is the largest of the units discussed in this report. One gigawatt is equal to 1,000 megawatts.

WHAT IS PEAK DEMAND?

The rapid growth of peak demand in the past decade has brought it to the fore in discussions on electricity and energy policy. Although the emphasis on addressing peak demand is fairly recent, the issues are as old as the electricity utility system itself.[2] The issues include the long time it takes to plan, design, and build new capacity, the lack of price response in the face of time-varying costs, the large difference between peak demand and average demand, and the necessity for real-time delivery of electricity. These combine to make the connection between system peak demand and system reliability an important driver of public policy in the electric utility sector.[3]

Figure 1 compares both Utah's peak load growth and average load growth from 1991 to 2001 and helps illustrate the problems that electric utilities face. Average load growth can be thought of as basic, predictable growth. Utilities know this growth is going to happen, can reasonably estimate how fast it is going to happen, and can construct power generation and transmission infrastructure accordingly. Peak growth is more variable, and predicting how peak demand is going to behave is difficult. This has consequences for consumers where it matters most – in the cost they pay for electricity.

Electric demand varies constantly. At times of low demand, a utilities' lowest marginal cost plants operate, while at peak demand, almost all of a utilities' power plants must run to meet demand and prevent system outages. This drives up the costs of production. The electric utility industry is also focused on peak demand because the likelihood of system outages is highest during peak times.[4] As a result, utilities must build capacity to serve electricity for the most extreme peak loads, which may only occur for one or two weeks of the year.

Returning to Figure 1, the greater the difference between average load growth and peak load growth, the more dependent utilities become on higher cost electricity to meet the needs of customers. In 2000, when the discrepancy between the average and the peak was the greatest, Utahns used on average 2,329 megawatts of energy a day while on the peak load day they used 3,721 megawatts, 1.6 times the amount of an average day. Since electricity cannot be stored, utility providers have two options. They can fire up the higher cost electricity generating plants to meet that peak demand, or they can buy energy on the "spot" market at rates above the usual going price. Both options are very costly and these costs are ultimately passed on to the consumer.

An analogy using another form of infrastructure highlights this problem further. Building electrical generation capacity to only serve peak loads is akin to expanding I-15 to 10 lanes in each direction to accommodate rush hour traffic. While this may sound like a wonderful idea for rush hour commuters, those 20 lanes will be sparsely populated with vehicles the rest of the day. The costs for building such a highway would be prohibitively high and do not make sense when the need for all 20 lanes is only for a few hours a day. The critical difference between highways and electricity generation is that the flow of electricity cannot simply slow down like traffic during high demand periods; if the electric system becomes overburdened, blackouts result, causing inconvenience, economic costs, and safety problems. Therefore, utilities must build the infrastructure, regardless of the efficiency in cost, in order to meet peak demand.

The average coal-fired power plant that services Utahns produces approximately 400 megawatts (MW) per year and costs $450 million to build. This does not include the cost of transmission lines from the plant to the consumer or the ongoing costs of running the facility. The $450 million price tag is solely the capital cost. Utah Foundation calculates the average gap[5] between peak demand and base demand for July has grown approximately 200 MW from 1991 to 2001 and has been growing more rapidly since 1996. A 200 MW increase necessitates the building of a 400 MW plant to meet current peak demand, as well as anticipated future demand. In addition to this new infrastructure cost, older facilities need to be maintained, upgraded, or replaced when they no longer operate efficiently.

For these reasons, it is imperative to examine peak load growth and the causes behind it. It is also important to determine what type of customers – residential, commercial or industrial – contribute the most to this growth.

EXPLANATION OF ELECTRICITY LOAD DATA

The hourly load data provided by PacifiCorp was disaggregated into six classes of demand: the customer class categories as found in the definition section, namely residential, general service (GS), irrigation, streetlights, and resale; in addition to these is system demand. System demand refers to Utah's total electricity load demand on the PacifiCorp system. The customer class categories are the load demands that each sector contributes to the system load.

Because commercial and industrial class loads were not separated in the hourly load data, commercial and industrial loads were estimated from GS loads by making calculations from the sales schedule. PacifiCorp has defined industrial users as those that consume over one MW of power and commercial customers as those that consume less than one MW. Granted, this classification does not take into account the type of product produced by individual businesses, but most manufacturing and warehousing firms fall into the industrial category, while service-producing businesses usually fall into the commercial category.

This report mainly analyzes three different sets of data derived from PacifiCorp statistics. These data are all interrelated and tell subtly different stories. However, each of these stories is important to determining the nature of peak loads.

The first set looks at the yearly peak, which is the maximum summer coincident peak demand. These data are important because on that single day, electricity needs are the highest, and it is important to determine how that electricity is being used. Although the yearly peak only occurs once a year, utilities must build capacity to meet this single day demand in order to prevent blackouts.

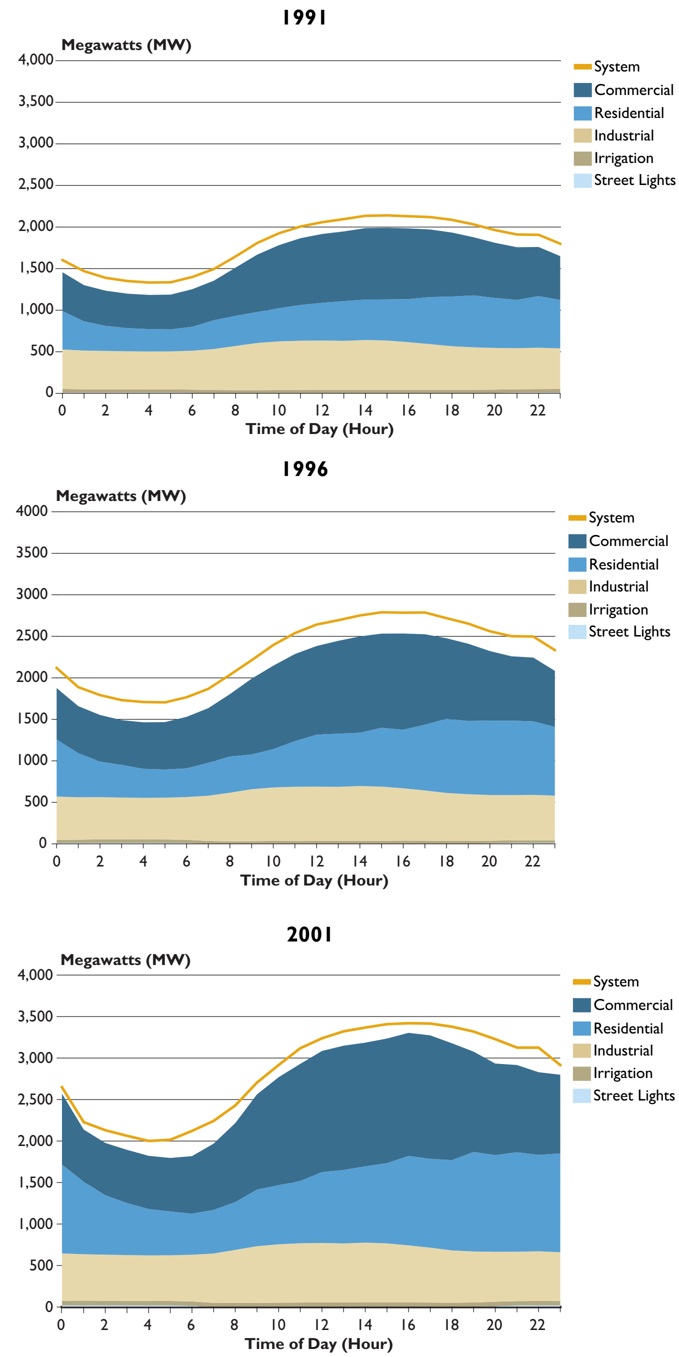
The second set is an average of *business day* loads in July. July loads were selected because they are, on average, higher than all other months of the year. July loads were averaged to mitigate the effects of high and low loads, and were compared with the yearly peak data set to discover whether or not the maximum summer peak patterns significantly deviate from the average summer day.

Finally, in order to roughly adjust for temperature, the third set takes the peak demand from similar temperature days in July. The July days that were selected were days that had a high temperature between 99 and 100 degrees Fahrenheit and a low temperature between 64 and 67 degrees Fahrenheit. These temperatures occurred in all years between 1991 and 2001 with the exception of 1993. Temperatures in 1993 were extremely low and were therefore excluded from the temperature-adjusted data set. Because the time of day a peak load occurs fluctuates, the data for the July average and temperature-adjusted set includes loads from 3 PM to 5 PM. This range encompasses the time period in which peak loads occur.

FINDINGS

System peak demand occurs as a result of the aggregate increase in residential, commercial, and industrial loads. Summer daily peak loads

Figure 2: Hourly Electricity Loads on High-Demand Days
July Averages, 1991, 1996, and 2001

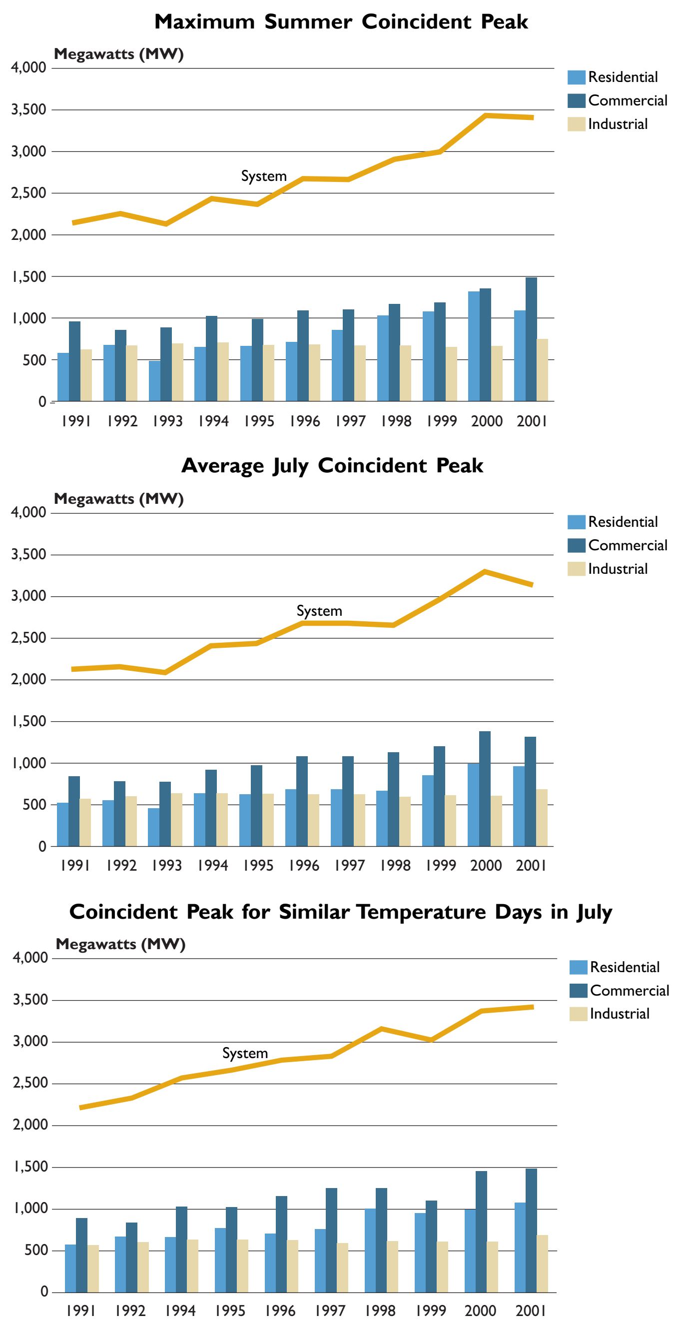


Source: Ibid.

occur during weekdays, usually in the late afternoon to early evening (2 PM – 6 PM), while in the winter, peak demand fluctuates and occurs in the evening (7 PM – 8 PM) or sometimes during the middle of the day. Figure 2 illustrates the hourly load shape as it occurs for similar July temperature days in 1991, 1996, and 2001. Loads shapes change across two dimensions – during a day and across seasons of the year. Residential buildings, for example, have a definite peak and trough during the day, and the time of day these peaks and troughs occur depends on the season. The magnitude of the peak and trough will also vary depending on the season and the customer class. Industrial customers, for example, have very little peak or trough throughout a day, and there is little change from season to season.

Annual consumption peaks in Utah, the highest loads of the year, occur on the hottest days of the summer. The highest system peak loads usually occur towards the latter half of July and early August. Not surprisingly, the highest peak load day typically occurs on the hottest day of the year. Over the time period studied, Utah's electrical demand behavior has become increasingly peak-oriented. Figure 1 shows that the state's peak loads have been growing faster than the

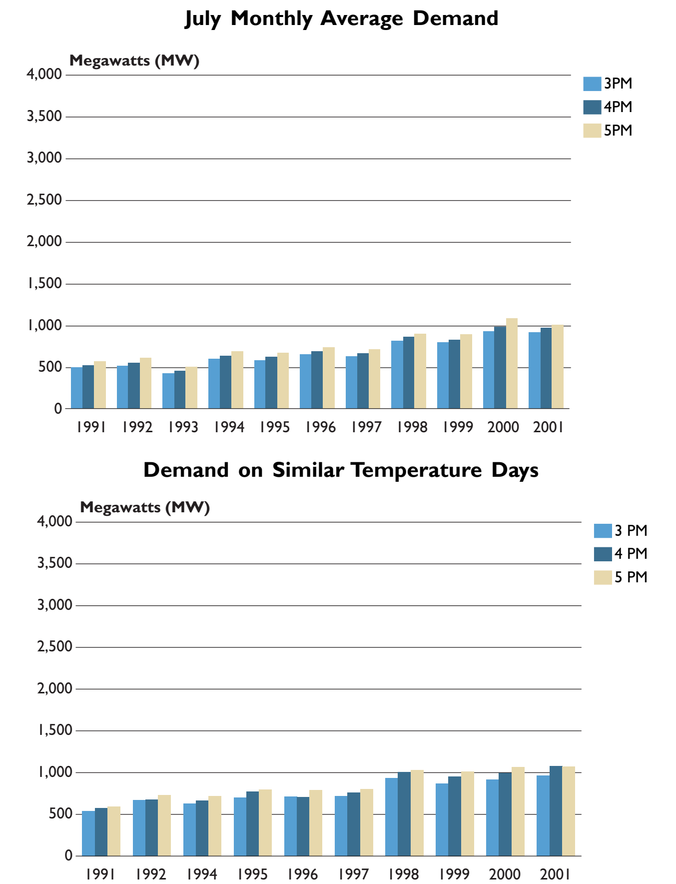
Figure 3: Sectors' Contributions to Peak Load Growth
1991 to 2001



* 1993 is not included in this graph because it was such a cool summer that no similar temperature day could be identified.

Source: Ibid.

Figure 4: Residential Loads in July During System Peak Hours



* 1993 is not included in this graph because it was such a cool summer that no similar temperature day could be identified.

Source: Ibid.

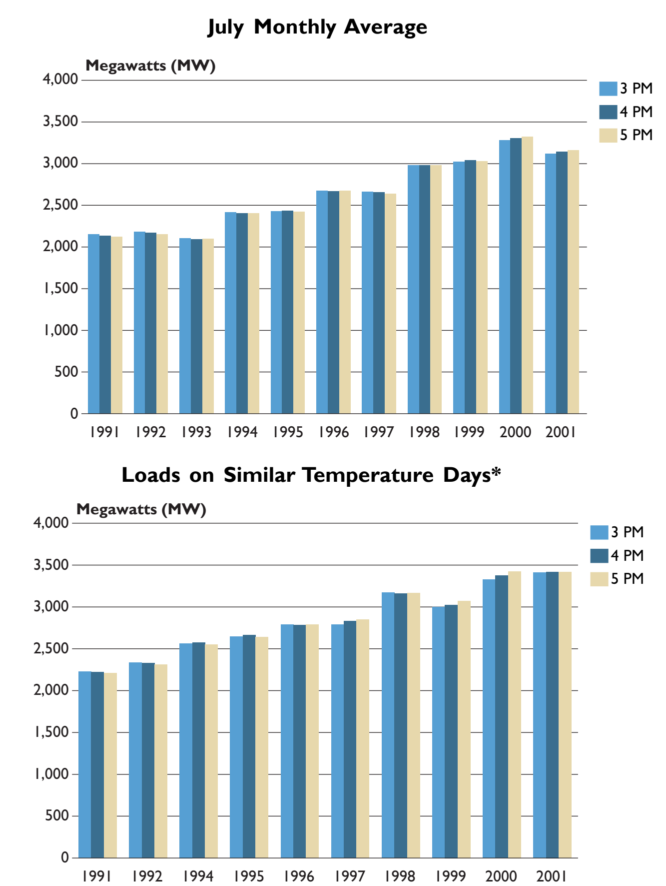
yearly average load. In electrical terms, this means that the yearly load factor has been decreasing.

Figure 3 demonstrates the peak demand growth from 1991 to 2001 and how the residential, commercial, and industrial class loads contribute to the total system demand. The first graph shows that on the peak load day during July, the demands of residential customers have been growing faster than the other classes, especially since 1996. In 2000, on the peak load day, residences demanded almost as much energy as commercial customers. In 2001, residential demand dropped to levels slightly above those of 1999; however, those demands were still 53.2% greater than they had been in 1996. In annualized terms, residential peak demand has grown since 1996 at a rate of 7.4% a year, while commercial has grown at a rate of 5.2%.

The second graph can be used to compare this growth to the average of all business days in July, to determine if the demands on the peak load day are typical of those during the rest of the month. This graph shows that growth in residential demand during July does not accelerate until 1999, while commercial has its strongest growth in 2000. The differences between these two graphs are of great importance. In 1996, when residential peak growth started to rise, the amount of energy used by homes on the peak load day was only 3% higher than on an "average" July day. By 1998, that difference had grown to 54.7%. In 1999, when residential usage during "average" days began to climb, the difference between the peak and those averages began to decline. This increase to the amount of energy used on an "average" day puts greater overall demands on the system. In the highway analogy, it means that traffic is getting heavier at times other than rush hour, and it may be necessary to think about curbing overall growth or expanding the highway.

Another indicator of the impact of residential customers on the overall system is the time at which the peak occurs. The large growth in demand within the residential sector, coupled with the fact that residential use peaks later in the day, shown in Figure 4, seems to be pushing the system coincident peak time later in the day than it has historically occurred, as indicated in Figure 5. In 1991, system peak usually occurred at 3 PM. In 1995, system peaks started to occur more frequently at 4 PM, and by 2000, system peaks occurred more often at 5 PM. In 2001, the last year for which data are available, system peaks occurred more often at 4 PM and 5 PM. Commercial and industrial loads, have continued to peak at 3 PM, and therefore are not the drivers for the shift in peak times. This suggests that residential customers are becoming a larger portion of peak demand than they have been in the past.

Figure 5: July System Peak Loads
1991 to 2001



* 1993 is not included in this graph because it was such a cool summer that no similar temperature day could be identified.

Source: Ibid.

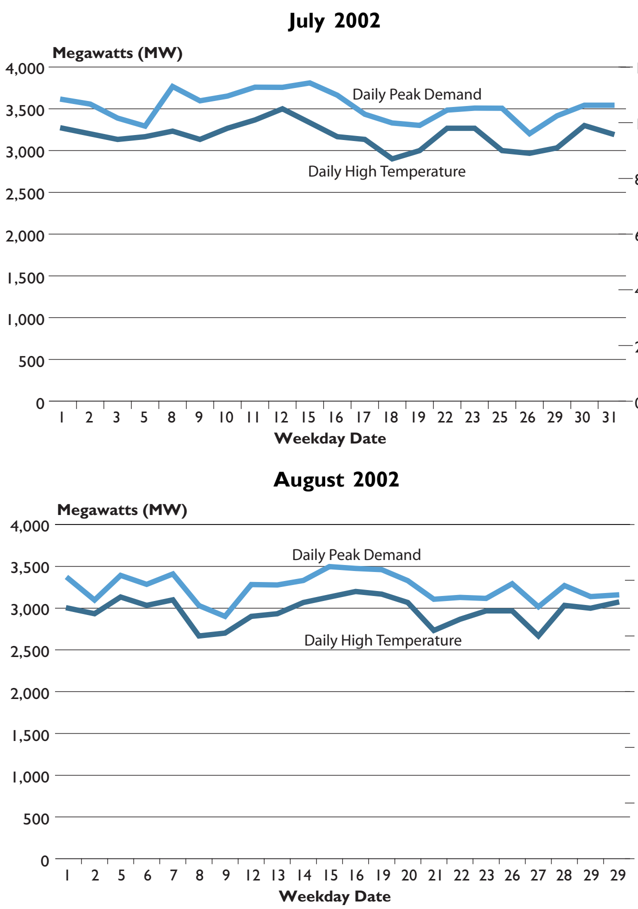
It is important, therefore, to investigate what is driving peak demand, especially in residences. By understanding the underlying causes of increased energy use, policymakers can determine what course of action to take in order to supply future demand. Courses of action could include any or all of the following: increasing conservation efforts, increasing rates, and/or building new infrastructure.

DRIVERS OF PEAK DEMAND

Weather tends to be the most important driver of peak demand. For utilities in warmer regions of the U.S., air conditioning loads drive peak demand on the hottest summer afternoons. For colder regions, peak demand is in the winter and is driven by the demand for electric heating on the coldest mornings of the year.[6] Utah has significant winter and summer peaks because of the extremes in temperature during colder and warmer months. Months with the most moderate temperatures (e.g., April, May) have the lowest peak loads.

The California Energy Commission (CEC) estimates that for California, extreme summer weather can cause up to a 5% to 8% increase in peak load compared to a typical year. Utah data shows that in years where a hot summer follows a cool one, the weekday average peak has grown by as much as 15.5% (1993-1994). This is significantly higher than the average annual growth rate for the last ten years, which is about 4%. Figure 6 illustrates that peak loads are largely determined by temperature. The highest peak loads coincide with the hottest days of the year.

Figure 6: Daily High Temperature and Daily Peak Demand



Temperature measured at Salt Lake City Airport.
Sources:

Daily temperature patterns largely reflect the residential load shapes. Hot and dry conditions prevail during summer days in Utah, while night time temperatures are usually cool enough that artificial cooling is not used. Even after the hottest days, nights are usually cool over the state. The daily temperature swings are reflected in the significant fluctuations in load between daytime and nighttime as shown in Figure 2 above. Residences in hot and humid states, where daytime and nighttime temperatures differ only slightly, tend to have higher load factors, and thus more consistent loads throughout the day because they are likely to leave their air conditioners on day and night. Although having higher load factors means that residential consumption is considerably higher in those states than consumption in states like Utah, the utility companies in those states do not struggle with the peak load problem that Utah has and can more easily build supply to meet demand.

Temperature patterns also affect commercial usage and demand patterns, but more on a seasonal basis than a daily basis. Comparisons of the graphs in Figure 2 show that the commercial contributions to actual peak are not significantly higher than contributions to average peak demand. Meanwhile, industrial loads are the least affected by seasonal and daily demand.

On average, statewide summer temperatures from 1992 to 2001 were considerably higher than summer temperatures from 1981 to 1991. In fact, average July and August statewide temperatures are over one degree hotter in the last ten years than in the previous decade, based on NOAA data. And temperatures have been considerably hotter in the last five years (1996 – 2001) than they have been in the previous five-year period.

The above average temperatures of the last five years may contribute to the explanation of why the gap between actual and average residential peaks has grown in the last five summers. Because residences are the most sensitive to daily temperature patterns, it is likely that record high temperatures would lead to extreme peak loads and a large deviation from the norm.

Temperature patterns are, however, unpredictable, and despite above average temperatures in recent years, a reversal of climate patterns could easily occur in coming years. The unpredictability of yearly climate patterns was the basis for the rationale in comparing similar July temperature days for summer coincident peak demand (Fig. 3). The figure shows that despite accounting for temperature, peak demand has increased significantly in the last ten years.

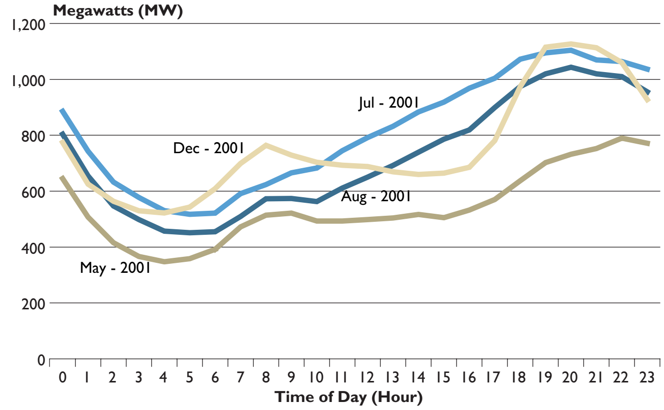
Setting weather aside, the most important drivers of peak demand are demographics and economic growth. As more homes are built to accommodate growth, and as people become more affluent, the lifestyle choices made affect electricity consumption.[7]

Figure 7: Demographic and Household Changes
Utah and the United States

Division/State	Population (Census Figures) 1990 (thousands)	Population 2000 (thousands)	Population Average Annual Growth Rate 1990-2000	Households (Census Figures) 1990 (thousands)	Households 2000 (thousands)	Households Average Annual Growth Rate 1990-2000	Rank by Average Annual Growth Rate 1990-2000 Households	Rank by Average Annual Growth Rate 1990-2000 Population
United States	248,710	281,422	1.2%	91,947	105,480	1.4%		
Mountain States	13,659	18,172	2.9%	5,034	6,712	2.9%		
Arizona	3,665	5,131	3.4%	1,369	1,901	3.3%	2	2
Colorado	3,294	4,301	2.7%	1,283	1,658	2.6%	5	3
Idaho	1,007	1,294	2.5%	361	470	2.7%	4	5
Montana	799	902	1.2%	306	359	1.6%	18	20
Nevada	1,202	1,998	5.2%	466	751	4.9%	1	1
New Mexico	1,515	1,819	1.8%	543	678	2.2%	7	12
Utah	1,723	2,233	2.6%	537	701	2.7%	3	4
Wyoming	454	494	0.9%	169	194	1.4%	25	32
Other States								
Alabama	4,041	4,447	1.0%	1,507	1,737	1.4%	21	25
Alaska	550	627	1.3%	189	222	1.6%	17	17
Arkansas	2,351	2,673	1.3%	891	1,043	1.6%	19	19
California	29,760	33,872	1.3%	10,381	11,503	1.0%	35	18
Connecticut	3,287	3,406	0.4%	1,231	1,302	0.6%	50	47
Delaware	666	784	1.6%	248	299	1.9%	14	13
D.C.	607	572	-0.6%	250	248	-0.1%	51	51
Florida	12,938	15,982	2.1%	5,135	6,338	2.1%	9	7
Georgia	6,478	8,186	2.4%	2,367	3,006	2.4%	6	6
Hawaii	1,108	1,212	0.9%	356	403	1.3%	28	31
Illinois	11,431	12,419	0.8%	4,202	4,592	0.9%	41	34
Indiana	5,544	6,080	0.9%	2,065	2,336	1.2%	30	27
Iowa	2,777	2,926	0.5%	1,064	1,149	0.8%	45	43
Kansas	2,478	2,688	0.8%	945	1,038	0.9%	39	35
Kentucky	3,685	4,042	0.9%	1,380	1,591	1.4%	22	28
Louisiana	4,220	4,469	0.6%	1,499	1,656	1.0%	38	40
Maine	1,228	1,275	0.4%	465	518	1.1%	33	46
Maryland	4,781	5,296	1.0%	1,749	1,981	1.3%	29	23
Massachusetts	6,016	6,349	0.5%	2,247	2,444	0.8%	43	41
Michigan	9,295	9,938	0.7%	3,419	3,786	1.0%	36	39
Minnesota	4,375	4,919	1.2%	1,648	1,895	1.4%	23	21
Mississippi	2,573	2,845	1.0%	911	1,046	1.4%	24	24
Missouri	5,117	5,595	0.9%	1,961	2,195	1.1%	32	30
Nebraska	1,578	1,711	0.8%	602	666	1.0%	37	37
New Hampshire	1,109	1,236	1.1%	411	475	1.4%	20	22
New Jersey	7,730	8,414	0.9%	2,795	3,065	0.9%	40	33
New York	17,990	18,976	0.5%	6,639	7,057	0.6%	48	42
North Carolina	6,629	8,049	2.0%	2,517	3,132	2.2%	8	9
North Dakota	639	642	0.1%	241	257	0.7%	47	50
Ohio	10,847	11,353	0.5%	4,088	4,446	0.8%	42	44
Oklahoma	3,146	3,451	0.9%	1,206	1,342	1.1%	34	26
Oregon	2,842	3,421	1.9%	1,103	1,334	1.9%	13	11
Pennsylvania	11,882	12,281	0.3%	4,496	4,777	0.6%	49	48
Rhode Island	1,003	1,048	0.4%	378	408	0.8%	44	45
South Carolina	3,487	4,012	1.4%	1,258	1,534	2.0%	10	15
South Dakota	696	755	0.8%	259	290	1.1%	31	36
Tennessee	4,877	5,689	1.6%	1,854	2,233	1.9%	15	14
Texas	16,987	20,852	2.1%	6,071	7,393	2.0%	11	8
Vermont	563	609	0.8%	211	241	1.3%	27	38
Virginia	6,187	7,079	1.4%	2,292	2,699	1.6%	16	16
Washington	4,867	5,894	1.9%	1,872	2,271	2.0%	12	10
West Virginia	1,793	1,808	0.1%	689	736	0.7%	46	49
Wisconsin	4,892	5,364	0.9%	1,822	2,085	1.4%	26	29

Source: U.S. Bureau of the Census.

Figure 8: Residential Loads in Salt Lake City
Selected Months



Source: PacifiCorp.

Total customer growth in Utah averaged 2.9% in the period from 1992 to 2002, which is the highest growth rate for PacifiCorp supplying states (Utah, Oregon, Washington, California, Idaho, and Wyoming). The average annual growth in the number of households during that period was about 2.6%. Customer growth has slightly outpaced population growth.

Economic drivers seem to be the best indicator for growth patterns in electricity consumption and average demand. Regression analysis comparing electricity usage (consumption and summer peaks) to gross state product (GSP) and per capita personal income (PCPI) showed very high correlation between electricity usage patterns and economic growth patterns (GSP and PCPI in constant 2002 dollars). Throughout the 1990s Utah's gross state product grew rapidly at an average annual growth rate of 5.7%, outpacing growth in electricity consumption and peak demand.

Economic growth began slowing in 2001, and the growth in electricity consumption and peak demand have followed suit. Summer peak loads saw negative growth in 2001, as seen in Figure 3, despite averaging above average temperatures. Typically, peak demand grows from year to year when summer temperatures rise, especially in the residential sector, but during 2001, average residential peak loads fell. This decline in peak demand during a very hot summer is likely explained by the recession, by conservation efforts made on the part of households, and by businesses in response to declining income and profits. However, the summer of 2001 also saw intensive public service campaigns and demand side management efforts on the part of electrical utilities, suggesting there may be other factors contributing to the anomaly of 2001.

It is important to examine the demographic and economic factors influencing residential consumption in Utah to try to determine if residents in the state are using electricity differently than those in other areas. This analysis can assist policy makers in determining strategy for dealing with the growth shown above. The rest of this report will examine the factors influencing residential consumption, with a brief analysis of commercial and industrial consumption at the end.

FACTORS INFLUENCING RESIDENTIAL CONSUMPTION

The population explosion that occurred in the West in general, and in Utah more specifically, has been well documented. As Figure 7 shows, Utah was the fourth fastest growing state in the United States during the 1990s, and all five of the fastest growing states during the decade were in the mountain west. This statistic extends to the growth in the number of households during the 1990s.

Electricity is a commodity that travels virtually seamlessly between states. Because of this, while local and statewide growth puts additional stresses on the electric grid, sustained regional growth increases that stress significantly. Technological innovation seen during the decade has increased the number of electrical items in an average household. These appliances, when taken together, also increase the stress on electrical infrastructure. Additionally, Utah is known for its large families. More people within a household use more electricity. Finally, the numbers of central air conditioners and electric heating units that regulate household temperature have increased.

For these reasons, Utah Foundation looked at data gathered by the Census during its Annual Survey of Households to see if the growth in residential peak loads was driven by the growth in the residential population, the increase in the use of electrical appliances, a combination of these factors, or if the survey suggested something else.

Three points about the Annual Survey of Households are in order before looking at the data:

1. Data are only available for the Salt Lake Metropolitan Statistical Area or MSA. This area includes all of Salt Lake, Davis, and Weber Counties and accounts for approximately 60% of all households in Utah. While it is unfortunate that data are not available for Utah County (which accounts for an additional 14% of households) the factors that drive electricity usage (cooking, heating and, cooling) are not likely to be significantly different across the Wasatch Front, making Salt Lake a reasonable proxy for usage.

2. Cities used in the sample rotate, so yearly data are not available for each metro area; however it does provide consistent data over time.

3. A calculation error in the sample was discovered after the 1990 Census. Each decennial census includes an actual count of households, and an estimation of specific characteristics based on the long-form of the census (which is given to one in six households). In times of rapid growth, however, these calculations from the long form can underestimate actual numbers. With the discovery of this error, data from the Annual Survey of Households, and other reports that utilize census estimates, revised their estimates as of 1990. For the purposes of this usage of the data set, this boils down to number in the late 80s being abnormally high, and then being readjusted to more accurate levels in the early 90s. This correction is evident in the figures that will follow.

As was mentioned in earlier data, peak loads vary over the year, with the highest peak loads occurring in the summer, rather than winter. Additionally, the gap between load and peak load is greatest during the summer. However, this is referring specifically to the "system wide" peak, or the point at which commercial, industrial, and residential usage all combine to use the most electricity. In addition to the system wide peak, commercial, industrial, and residential sectors each have independent electricity peaks. Figure 8 shows the residential peak for 2001 in Salt Lake City. Interestingly, it peaks in the winter, not the summer. This suggests that residential electricity usage is on a different cycle than the system as a whole. For this reason, while air conditioning is one of the focal points of our analysis, other uses, such as the use of electricity for heating and cooking, were taken into account to exclude them as the drivers of peak loads.

Specific to the growth in the use of air conditioning, it is important to analyze the number of air conditioners that have been retrofitted over time, as well as the total number of housing units with air conditioning,

Figure 9: Household Electric Equipment Concentration
Salt Lake MSA

	1988	% Units with:	1998	% Units with:	AAGR 1988-1998	% Growth Over 10 Years	Change in Concentration 1988-1998
Housing Units	379,900		444,000			16.9%	
Electric Heat	25,400	6.7%	42,300	9.5%	5.2%	66.5%	2.8%
Electric Cooking	313,300	82.5%	345,200	77.7%	1.0%	10.2%	-4.7%
Refrigerator	371,700	97.8%	439,600	99.0%	1.7%	18.3%	1.2%
Dishwasher	230,700	60.7%	317,600	71.5%	3.2%	37.7%	10.8%
Washing Machine	289,200	76.1%	351,700	79.2%	2.0%	21.6%	3.1%
Clothes Dryer	276,800	72.9%	349,900	78.8%	2.4%	26.4%	5.9%
Central Air	108,400	28.5%	167,100	37.6%	4.4%	54.2%	9.1%
Room Unit	49,300	13.0%	75,600	17.0%	4.4%	53.3%	4.0%

Source: U.S. Bureau of the Census.

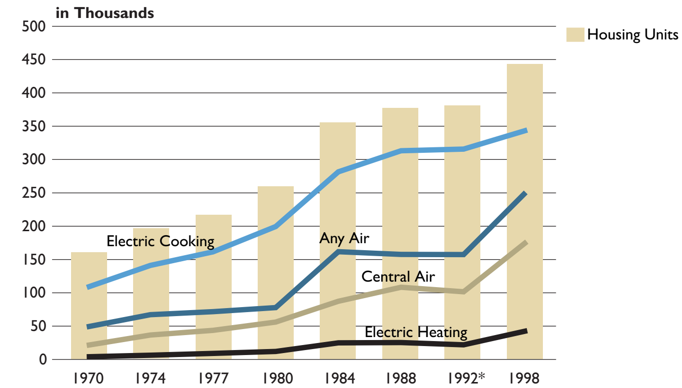
and the percentage of new units built with central air conditioning systems. Retrofitted air conditioners are most likely found in older homes, and while the air conditioner itself may be an efficient user of electricity, the home is not. The older a house is, the less likely it is to have state-of-the-art insulation, double-paned windows, etc. Therefore, the use of air conditioning in such an environment is less likely to be as efficient as in a newer model built specifically for air conditioning.

SALT LAKE CITY

The number of housing units in Utah has seen an almost three-fold increase since the 1960s. Additionally, technological innovation has increased significantly and the economic boom experienced in Utah during the 1990s provided Utahns the means to accumulate and access that technology. Furthermore, that economic boom contributed to an increase in the median square footage of housing units, while the number of people occupying those units held steady or decreased. The confluence of these factors has created a strong increase in the acquisition of electric appliances in the residential sector.

Figure 9 details the percentage of households that utilize certain types of electrical equipment in 1988 and 1998 to illustrate this trend. The

Figure 10: Drivers of Household Electricity Demand
Number of Units, Salt Lake MSA



*1992 was readjusted by the Census Bureau and is not linearly consistent with prior year data.
Source: Ibid.

percentage of households with refrigerators, dishwashers, washing machines, clothes dryers, central air conditioning, and room unit air conditioning all increased. Dishwashers (10.8%), central air conditioners (9.1%), and clothes dryers (5.9%) saw the largest growth. These three devices are arguably the most luxurious of those tracked in the survey. This suggests a correlation with the strong economic growth during the decade.

Figure 10 graphs the number of houses utilizing electricity as their source of heating, cooking, or cooling fuel compared to the overall number of housing units. All of the growth curves have kept pace with the overall growth in units except air conditioning, which grew more rapidly during the 1990s than heating, cooking, or total housing units.

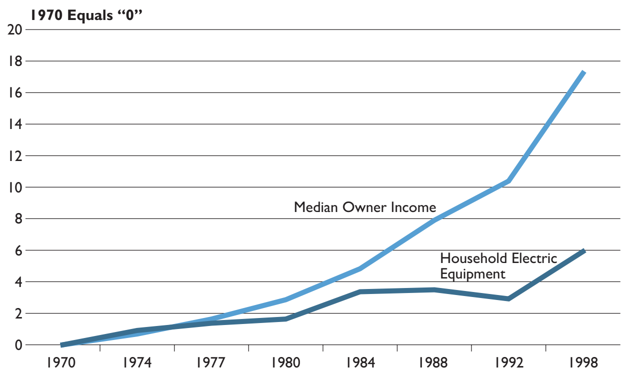
Figure 11 highlights the similarities and differences in housing unit characteristics for all the metro areas included in this report. Comparing Salt Lake to the other areas, the growth in the number of housing units is second only to Phoenix, and Salt Lake homes have the largest average square footage. The majority of homes in Salt Lake have air

Figure 11: Housing Unit Characteristics
By Metropolitan Statistical Area

	Housing Units	Average Sq. Footage*	Units With Air Conditioning: Any Air	Central Air	Room Units	% Units w/ Any Air
Salt Lake City						
1970	163,000	1,888	49,500	21,700	27,800	30%
1998	444,000	2,151	251,800	176,200	75,600	57%
CAGR**	3.6%	0.9%	6.0%	7.8%	3.6%	
Denver						
1970	392,100	1,890	70,400	25,800	44,600	18%
1998	771,900	2,020	311,300	198,400	112,900	40%
CAGR**	2.7%	0.7%	6.1%	8.5%	3.8%	
Phoenix						
1970	317,000	1,469	225,400	181,500	43,900	71%
1998	1,316,400	1,758	1,242,900	1,211,800	31,100	94%
CAGR**	4.5%	1.1%	5.5%	6.1%	-1.1%	
Portland						
1970	357,400	1,588	31,200	10,000	21,200	9%
1998	809,300	1,769	354,000	232,400	121,600	44%
CAGR**	2.6%	0.7%	7.9%	10.3%	5.6%	

* Sq Footage was not measured until the 1984-1986 round of surveys.
** Compound Annual Growth Rate.
Source: Ibid.

Figure 12: Income Growth Compared to Household Electric Equipment Acquisition
Salt Lake MSA



Source: Ibid.

conditioning (57%), yet the acquisition rate has been slower than in Portland or Denver. A portion of the differences between metro areas may be explained by the rate of growth in household income among residents of each city. Figure 12 illustrates this trend by looking at electric equipment acquisition and income. While the gap between them has widened over time, the two curves exhibit similar patterns.

Utah Foundation further broke down this electricity usage by its purpose in the home, focusing specifically on heating, cooling, and cooking. In addition to these demands being consistently measured by the Annual Survey of Housing, they also represent energy usage where electricity is optional (homes can be cooled with a swamp cooler or heated with a gas furnace, for example), thus they more accurately track whether increased energy consumption is the result of population growth, increased reliance on technology that utilizes electricity, or both, as shown in Figure 10. Figure 10 shows that electricity is the most common cooking fuel. 78% of Salt Lake City housing units use electricity as their primary cooking fuel. However, this has fallen off from an all-time high of 82% in 1992. Electric cooking has the slowest growth rate of any of the electricity usages studied.

Electric heating, however, is in the opposite position. The percentage of Utahns using electricity as the primary fuel to heat their homes is still small at 9.5% However, as Figure 10 shows, it is by far the fastest growing electric appliance acquired for Salt Lake City residences, and the number of units in service has tripled since 1970. This offers partial explanation for the seemingly anomalous peak of residences during the winter months that practically eclipses their much larger commercial counterparts. The increased use of electricity, a comparatively less efficient means of heating a residence, as a primary heating source, in addition to the added electrical use during the holidays, could prove problematic, if its usage continues to double every decade.

Air conditioning resides somewhere between these two extremes. Approximately 57% of households currently use some form of electrically powered air conditioning. Of those, 37% rely on central air conditioning systems, which use significantly more energy than their room-unit counterparts. In conjunction with the increased median square footage of households since the 1970s, and the tendency of the electrical grid to peak during the summer months, the difference in the numbers suggests that residences could be one of the driving factors of peak demand. Figure 8 supports this by showing that residential peaks in Salt Lake City during the summer months are around 6 PM. As was shown earlier in Figure 5, the summer system peak has been moving later in the day, suggesting a convergence of demand by commercial and residential customers.

Of the MSAs studied, Salt Lake City is the second fastest growing in terms of housing units. In 1998, new housing units in Salt Lake City accounted for 19% of all central air conditioners and 44% of the growth in central air conditioning since 1992. Retrofits accounted for the rest of the growth during this period.

In order to determine if Salt Lake City's growth rates for electrical technology, electricity usage, and household size were anomalous, two other Metro Statistical Areas (MSAs) in the West were analyzed and compared to Salt Lake City. These cities were Portland and Denver. Additionally, the exceptional growth of Saint George in Washington County, and its significant climatic differences from the Wasatch Front led to an analysis of the Phoenix Metro Area. While the differences in the size of the population in Phoenix and Saint George are significant, the primary factor that drives air conditioning usage is, of course, temperature, and Phoenix is the only MSA surveyed by the Census with a climate similar to Saint George.

DENVER

Denver is unique among the metro areas analyzed for two reasons. First, its climate is most similar to the Salt Lake City MSA. Second, it has followed a fundamentally different growth pattern than any of the other MSAs examined. Denver's fastest period of growth was during the early 1970s. While it still grew a great deal in the 1990s (from 745,000 housing units at the start of the decade to approximately 926,566 housing units by the end of the decade) the Annual Average Growth Rate (AAGR) of housing units from 1970 to 2000 was approximately 2.8% and the AAGR during the 1990s was significantly slower at 1.9%. During that decade, Denver was the slowest growing of the MSAs examined for this report.

Figure 13 details Denver's use of various household electrical appliances, comparing 1986 and 1995. Denver's acquisition rate is similar to that in Salt Lake, in that clothes dryers, air conditioners, and dishwashers grew at the highest rates during a similar period. However, the nine-year differences in Denver were smaller and prioritized "luxuries" differently. Clothes dryers were the fastest growing (7.2%), followed by air conditioners (5.8%), and finally dishwashers (2.4%).

Another significant difference can be seen by looking at the proportion of housing units using electricity as their primary fuel source for cooking, heating, and cooling as shown in Figure 14. Whereas Salt Lake City has seen an increase in all types of air conditioning units,

Figure 13: Household Electric Equipment Concentration
Denver MSA

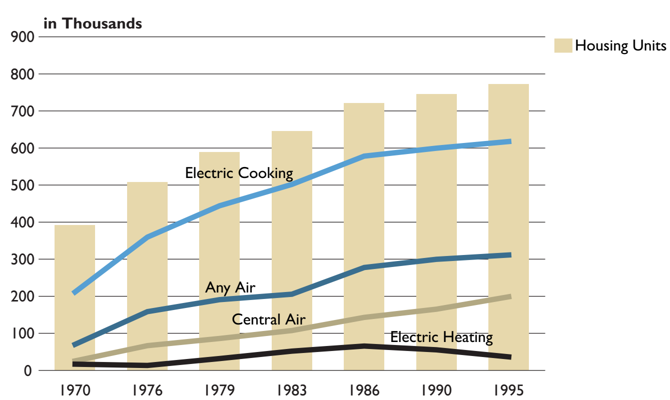
	1986	% Units with:	1995	% Units with:	AAGR 1986-1995	% Growth Over 10 Years	Change in Concentration 1986-1995
Housing Units	721,300		771,900			7.0%	
Electric Heat	65,600	9.1%	36,600	4.7%	-5.7%	-44.2%	-4.4%
Electric Cooking	578,100	80.1%	617,500	80.0%	0.7%	6.8%	-0.1%
Refrigerator	719,200	99.7%	762,800	98.8%	0.6%	6.1%	-0.9%
Dishwasher	490,800	68.0%	580,500	75.2%	1.7%	18.3%	7.2%
Washing Machine	541.300	75.0%	577,900	74.9%	0.7%	6.8%	-0.2%
Clothes Dryer	491,200	68.1%	544,300	70.5%	1.0%	10.8%	2.4%
Central Air	143,200	19.9%	198,400	25.7%	3.3%	38.5%	5.8%
Room Unit	134,300	18.6%	112,900	14.6%	-1.7%	-15.9%	-4.0%

Source: Ibid.

Denver has seen an increase in the use of central air conditioners and a coinciding decline in the use of room units. Given the vast differences in the quantity of housing units in these two MSAs, it is worth noting that while Denver only added 33,300 central air conditioners during this period, Salt Lake City added a 74,600. Denver's MSA is more than double the size of Salt Lake City's, so this is not an insignificant difference.

This difference cannot be attributed to a saturation of the central air conditioning market (as will be seen in Phoenix, for example). There is still a gap between the percentage of homes in Denver and Salt Lake City using air conditioners, despite the similar climate in both areas. Taking into account that the average high[8] July temperature differential between Salt Lake and Denver is only 2 degrees, other possible explanations for this difference are in order. One possible alternative is found in Figure 15, which shows that while Denver has followed a similar growth curve comparing income and equipment acquisition, the final gap between the two is smaller than that seen in Salt Lake City (10.9 and 11.3, respectively). However, when the ratio between growth in acquisition and growth in income is compared between the two cities, both come out to approximately .3, indicating that they are following a similar path, but are just at different points in that path. This strengthens the aforementioned hypothesis that growth in electricity use and growth in the income of homeowners are correlated.

Figure 14: Drivers of Household Electricity Demand
Number of Units, Denver MSA



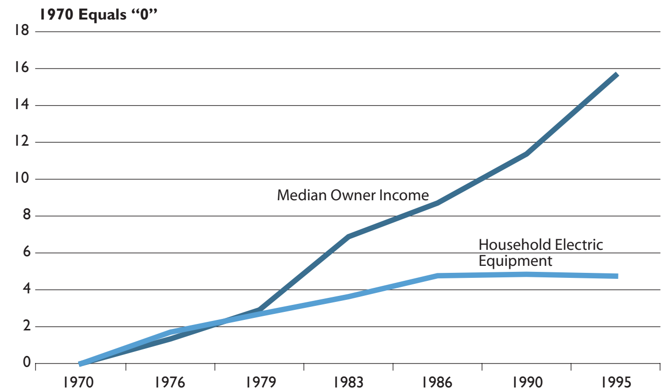
Source: Ibid.

Finally, as Figure 14 shows, the growth of various uses of electricity in Denver is sharply different from Salt Lake City. It appears that the growth of electricity as a primary heating source, for example, peaked in the 1980s and has fallen in recent years. Electricity as a source of cooking fuel looks similar to the growth rate in Salt Lake City and has most likely reached a saturation point. The growth rate, however, in central air conditioning has grown faster in recent years. Although it is not yet utilized by the same proportion of housing units as in Salt Lake City (35% of households and 40% of households, respectively), it is growing at a much faster rate.

PORTLAND

The Portland MSA was added to this analysis because, unlike the other MSAs in this study, it is part of the same grid as Salt Lake City.

Figure 15: Income Growth Compared to Household Electric Equipment Acquisition
Denver MSA



Source: Ibid.

In other words, significant growth in both Portland and Salt Lake City directly affects both the company-wide peak for PacifiCorp and future grid needs in terms of transmission and generation capacity. Additionally, Portland's housing units grew at an average annual rate of 2.4% during the 1990s. This is close to Salt Lake's 2.8% growth rate.

In terms of the percentage of households utilizing various forms of electrical equipment in the last twelve years, Portland holds the distinction of having the most significant changes as shown in Figure 16. Similar to the other MSAs analyzed, Portland saw the biggest increases in "luxury" items, and, in fact, saw rates of change that dwarfed those of its counterparts. For example, the use of central air conditioning was picked up by an additional 16.2% of its housing units, compared to 9.1% in Salt Lake City, and 5.8% in Denver. Similarly, a dishwasher was added by 11.5% of the population and clothes dryers by 7.7% of the population.

Once again, temperature cannot account for the rapid growth of central air conditioning in Portland. Its average high temperature is eight degrees lower than Denver's and 10 degrees lower than Salt

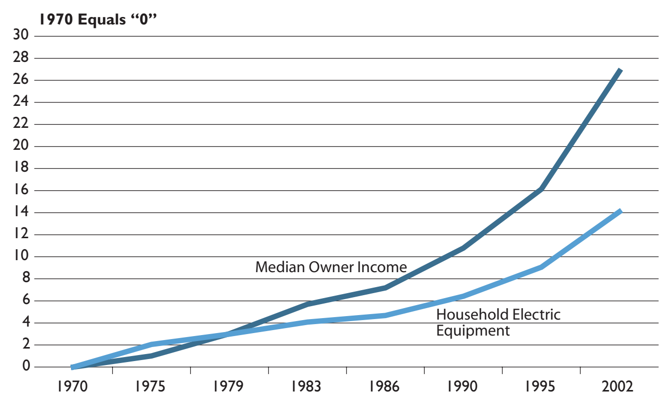
Figure 16: Household Electric Equipment Concentration
Portland MSA

	1990	% Units with:	2002	% Units with:	AAGR 1990-2002	% Growth Over 12 Years	Change in Concentration 1990-2002
Housing Units	615,600		809,300		2.3%	7.0%	
Electric Heat	278,600	45.3%	385,000	47.6%	2.7%	38.2%	2.3%
Electric Cooking	565,700	91.9%	688,700	85.1%	1.7%	21.7%	-6.8%
Refrigerator	606,300	98.5%	800,100	98.9%	2.3%	32.0%	0.4%
Dishwasher	417,600	67.8%	641,800	79.3%	3.6%	53.7%	11.5%
Washing Machine	457,500	74.3%	657,000	81.2%	3.1%	43.6%	6.9%
Clothes Dryer	452,000	73.4%	656,600	81.1%	3.2%	45.3%	7.7%
Central Air	76,800	12.5%	232,400	28.7%	9.7%	202.6%	16.2%
Room Unit	92,900	15.1%	121,600	15.0%	2.3%	30.9%	-0.1%

Source: Ibid.

Lake City, both of which have experienced a much slower growth rate in air conditioning. However, when compared to income growth over the same period, it is clear that Portland's addition of electrical products is similar to Salt Lake City and Denver, in that it is directly tied to the growth of median homeowner income over the same period as Figure 17 shows. When placed in the context

Figure 17: Income Growth Compared to Household Electric Equipment Acquisition
Portland MSA

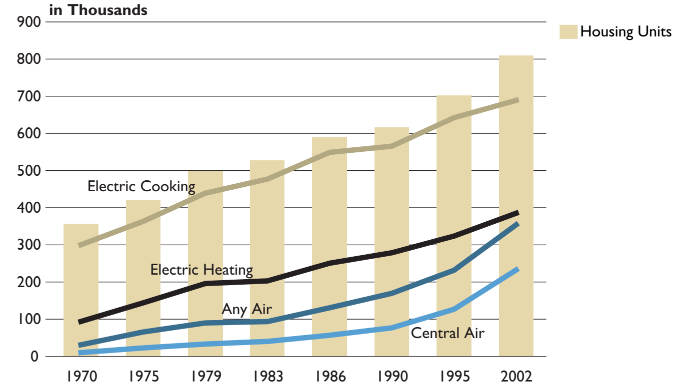


Source: Ibid.

of income rather than temperature, it is not surprising that the number of central air conditioning systems in Portland has increased at an AAGR of 7.8%, while its AAGR in housing units was only 2.7% during the same period. Portland had the fastest growing median homeowner income of any MSA studied. This also explains the rapid growth in its accumulation of other "luxury" items as observed above.

Given that Portland's growth rate in acquisition of electric equipment is so strong, it is interesting to note that while electricity used for cooking and heating grew at rates comparable to Denver and Salt Lake City, its growth in terms of central air conditioning was extreme by comparison. Central air conditioning increased by a factor of nine in the last 30 years in Portland, while it doubled in Salt Lake City and tripled in Denver as shown by comparing Figures 10, 14, and 18.

Figure 18: Drivers of Household Electricity Demand
Number of Units, Portland MSA



Source: Ibid.

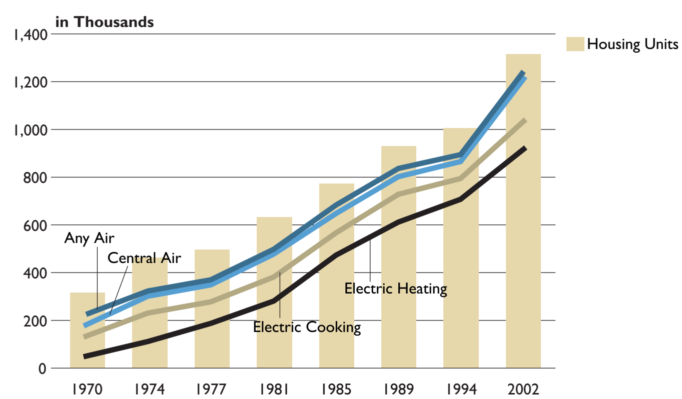
PHOENIX

Washington County was the fastest growing area in Utah according to the 2000 Census. Growth was concentrated in the area around St. George. Mindful of the vast differences in climate between the Wasatch Front and St. George, Utah Foundation chose to evaluate the changing trends in electricity use in Phoenix since it is the only MSA included in the Annual Survey of Households with a climate similar to St. George. In both metro areas the average high temperature in July is over 100 degrees (101 for Phoenix and 103 for St. George). Additionally, both areas have an average temperature of 86 degrees, and an average low temperature of 70 degrees during July.

Phoenix exhibited a trend that was not seen in any of the other MSAs studied. Because of its consistently high temperatures throughout the year, its market for air conditioners was saturated by 1970, as shown in Figure 19. Consequently, the number of households can explain almost all increases in central air- conditioning, with the exception of a small blip in the 1980s as people switched from room units to central air. Additionally, Phoenix is the only MSA studied where more households utilize air conditioning over any other use.

The climate in Phoenix makes air conditioning more of a necessity than a luxury. Because of this, households in Phoenix acquired three

Figure 19: Drivers of Household Electricity Demand
Number of Units, Phoenix MSA



Source: Ibid.

Figure 20: Household Electric Equipment Concentration
Phoenix MSA

	1989	% Units with:	2002	% Units with:	AAGR 1989-2002	% Growth Over 13 Years	Change in Concentration 1989-2002
Housing Units	929,900		1,316,400		2.7%	41.6%	
Electric Heat	611,700		917,500		3.2%	50.0%	3.9%
Electric Cooking	728,100		1,034,300		2.7%	42.1%	0.3%
Refrigerator	913,200	98.2%	1,301,400	98.9%	2.8%	42.5%	0.7%
Dishwasher	619,200	66.6%	1,008,800	76.6%	3.8%	62.9%	10.0%
Washing Machine	628,500	67.6%	1,052,200	79.9%	4.0%	67.4%	12.3%
Clothes Dryer	570,400	61.3%	1,017,300	77.3%	4.6%	78.3%	15.9%
Central Air	801,800	86.2%	1,211,800	92.1%	3.2%	51.1%	5.8%
Room Unit	34,700	3.7%	31,100	2.4%	-0.8%	-10.4%	-1.4%

Source: Ibid.

items rapidly during the 1990s: clothes dryers (15.8%), washing machines (12.3%), and dishwashers (10%) as detailed in Figure 20. The fastest growing use of electricity in the Phoenix MSA was the use of electricity as the primary heat source. This is perhaps the strongest indication that electricity consumption growth is almost wholly dependent on income growth – once needs have been met, luxury items are acquired.

COMPARING THE METROPOLITAN AREAS

The following figures offer various comparisons of the aforementioned MSAs. Due to size differentials between the MSAs, most of the charts are based on percentage growth in order to ease comparison. While this is a well-accepted approach to homogenizing data, peak load in the grid is based on raw numbers, rather than comparisons. Therefore, these charts offer only a means for comparing the growth of various elements in the MSAs and should not be interpreted as a percentage contribution to peak load. An important note on the Denver data used in this section— Denver's last Census Housing Survey was in 1995. So in order to have a relevant comparison of all the MSAs over the 32 years from 1970 to 2002, it was necessary to estimate Denver's data for the time period from 1998-2002. All estimates are simply based on average annual growth for the 25 years prior. Therefore, the data for the 1998-2002 time period may understate the growth of housing units and air conditioning use in Denver, since the area, like Salt Lake City, experienced strong growth during this time period.

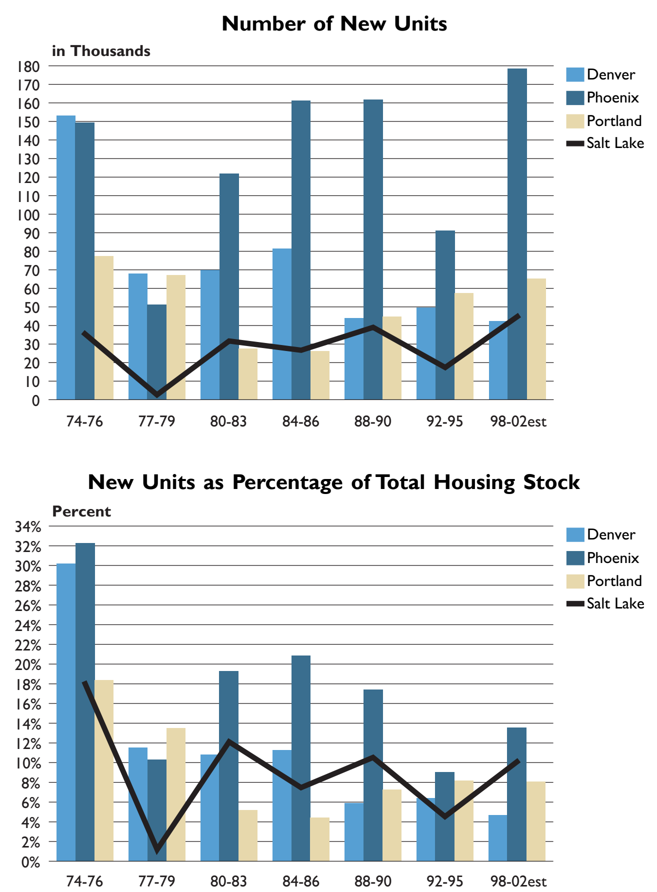
Perhaps the most important comparison to be made among the various cities is in the number and percentage of new housing units added over the time period studied. Of the four MSAs in this report, Salt Lake added the fewest number of units (197,589 between 1970 and 1998) when the last housing survey of the area was performed. This compares to 366,000 in Portland, almost 1 million in Phoenix and an estimated 508,617 in Denver.

Salt Lake again has the smallest number of total housing units in each MSA (440,000) relative to the 809,300 in Portland, 1.3 million in Phoenix, and the estimated 926,566 in Denver. This means that 44.5% of Salt Lake's existing housing stock was built after 1970. Surprisingly, Salt Lake has the oldest homes of any of the MSAs studied. Portland is a close second with 45.2% of its housing stock built after 1970. Units built after 1970 comprise 54.9% of Denver's housing stock, and Phoenix is the "youngest" city, with almost 70% of its stock dating to 1970 or newer. Figure 21 shows the number of new housing units in each MSA, and the percentage they comprise of the housing stock for each period within the 32 years of data.

This has implications for electrical usage and efficiency. Older housing stock, as was stated earlier is the most likely not to have been built with central air conditioning and therefore in need of retrofitting. While the retrofitted air conditioning units are more efficient than what was available on the market prior to 1970, other features of older housing units, such as insulation and windows, make them less efficient users of air conditioners. Additionally, unless a homeowner updates all of the wiring within the house, older homes are generally more inefficient in their use of electricity regardless of what appliances the homeowner has.

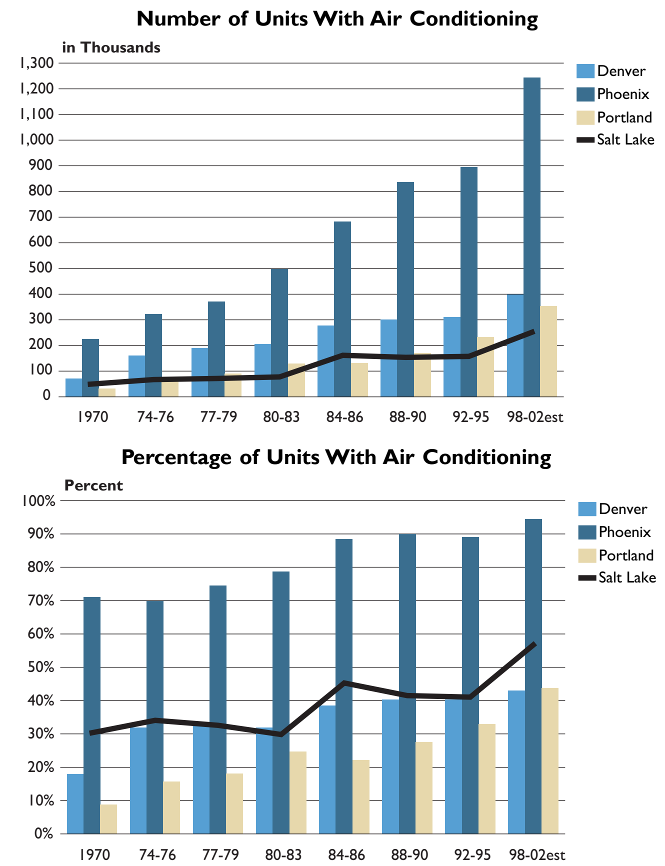
Focusing solely on the air conditioning question, the overall number of housing units with air conditioning in Salt Lake has grown from 49,500 in 1970 to 251,800 in 1998. As the first chart in Figure 22 shows, the growth in the number of air conditioners in Salt Lake remained relatively flat from 1970 to 1983, saw a sharp up-tick between 1984 and 1986, leveled off again, and then began to climb after 1998.

Figure 21: New Housing Units by MSA



Source: Ibid.

Figure 22: Housing Units With Air Conditioning by MSA



Source: Ibid.

This is consistent with Denver, the MSA with the climate most similar to Salt Lake's. Portland also experienced an upswing in the number of air conditioners from 1998-2002. However, the growth in air conditioners in Portland started in 1984-86 and has continued steadily since then. The second chart in Figure 22 compares the percentage of households with air conditioning in each MSA. Again, Denver and Salt Lake look remarkably similar except for the time period between 1998-2002. But remember , Denver's percentage is estimated for that time period. It may be the case that the percentage of households with air conditioning grew more rapidly than estimated, and therefore looks more like Salt Lake's than shown here.

While overall use of air conditioners is important to analyze for the effects on today's electricity consumption, future electricity usage will be determined by the amenities offered by builders of new homes. Therefore, it is important to compare percentage of new units with air conditioning over time. Are a greater percentage of new homes being built today with air conditioning than those built in the 1970s? If so, are these new homes being outfitted with central air or room units? While the answers to these questions may seem obvious, the magnitude is critical when planning for future electricity consumption. As Figure 23 shows, in 1998, 83.3% or 37,300 new units built in Salt Lake City had air conditioning. Of these 37,300 new units, 33,500 were central air systems. This is Salt Lake's largest percentage during the time period analyzed. The time period of 1977-79 saw 73.1% of the new units built with air conditioning. Keep in mind, this percentage could be somewhat deceptive since only 2,600 new housing units were built during that time; therefore it is an anomaly in the series. Excluding that period, the percentage of new units in Salt Lake with air conditioning has been growing rapidly since 1984, more rapidly than Denver and Portland.

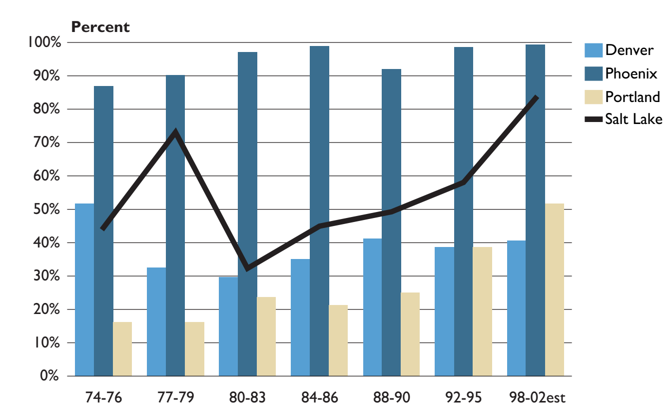
So what does this mean? As was state earlier, the drivers behind growth in air conditioning seem to be a combination of growing affluence and population growth in general. During the 1990s, the combination of these factors converged in Salt Lake City. The economy boomed and the area experienced considerable in-migration. In addition, the area has seen higher temperatures during a drought cycle that began in the middle of the decade. Denver has experienced similar growth in these drivers, but for some reason, air conditioning use, as a percentage, has remained lower. The analysis of affluence offered earlier and graphed in Figures 12, 15, and 17 provides at least part of the answer, but further study into the values and attitudes, as well as electricity pricing systems, in Denver and Salt Lake would provide greater insight.

The growth of residential housing units, air conditioners, and other appliances only completes part of the picture. In order to accurately assess the growth in electricity consumption and peak loads, it is necessary to analyze the growth in the General Service category, which is comprised of commercial and industrial customers.

COMMERCIAL AND INDUSTRIAL GROWTH

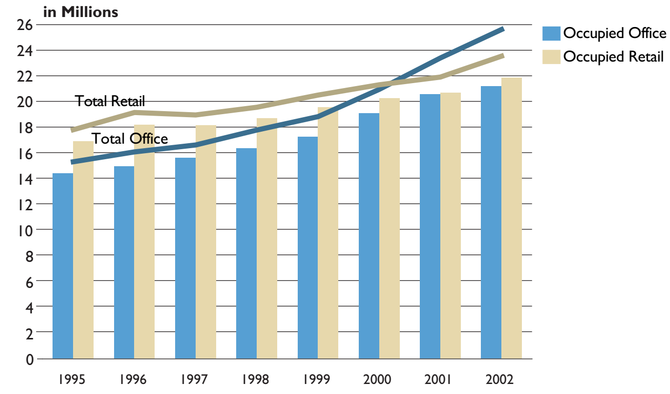
Unfortunately, there isn't a survey similar to the Census Annual Housing Survey for the commercial and industrial sectors. In fact, there is very little data available anywhere that provides information on buildings used by businesses in Utah or the Salt Lake Metropolitan Area. This section will discuss the growth seen in the overall square footage of the commercial and industrial sector compared to the growth of their base and peak electricity loads. Colliers International provided the data on the amount of square footage in Salt Lake City. These data break out commercial square footage into office and retail. Unfortunately, the time series only dates back to 1995, so any growth in these sectors during the first half of the 1990s remains unknown.

Figure 23: New Units With Air Conditioning



Source: Ibid.

Figure 24: Occupied & Total Office & Retail Square Footage
Salt Lake City



Source: Colliers International.

The data from 1995 onward tells an interesting story. While the industrial sector, primarily manufacturing and warehousing, still has the majority of square footage in Salt Lake City with approximately 97 million square feet or 66.3% of the total, the commercial sector has been growing faster, and is now a larger portion of the total than it was in 1995. The commercial sector contains two types of space— retail and office. While retail space grew from 17 million to 23 million square feet over the eight years, office space grew from 15 million to 25 million square feet during the same time. Starting in 2000, office space became a larger portion of the total inventory. Figure 24 compares office and retail space, both total and occupied space in Salt Lake City from 1995.

Electricity consumption and peak loads in the commercial sector are mainly driven by commercial building usage. Figure 25 shows the summer electricity loads of the major end-uses of commercial buildings in California. The California figure is used because there have not been any comprehensive end-use surveys conducted in Utah thus far, and because of the relative similarities of the summer climate. Also, the overall commercial load shape in California resembles the load shapes of Utah commercial loads, and so provides useful insight for Utah commercial building usage. The figure shows that the largest contributors to peak demand and overall consumption are: air conditioning, interior lighting, "other", ventilation, refrigeration, office equipment, hot water, exterior lighting, and cooking. The "other" category includes office equipment, portable fans, and task lighting. Commercial loads rapidly rise as the business day begins, shortly after 6 AM and significantly tapers as the business day ends, around 5 PM. Because air conditioning's contribution to peak loads is so substantial, commercial peak loads are dramatically higher in summer months than at other times of the year.

The industrial sector tends to have higher load factors than other sectors due to the long operating hours of industrial facilities[9] and the constant use of electrical powered machinery during the hours of operations. This means that the difference in industrial loads during coincident peak periods and other load periods is relatively small.

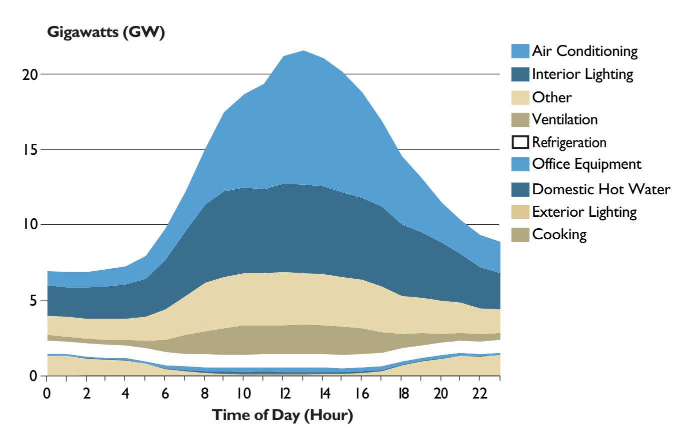
As an estimate, based on sales schedules, commercial load contribution to the summer coincident peak load is about 80-85% of the general service class load. When the average annual growth is calculated, commercial peak demand of approximately 5.7% per year outpaced commercial consumption or load growth of 4.9% per year during the 1990s. In the meantime, industrial peak load growth was similar to the sector's growth in consumption, both at around 2.5% per year.

While industrial consumption grew by the smallest percentage of the major sectors within Utah, it still grew at a higher rate than nationally. Manufacturing production grew for most of the 1990s, but it began to shrink in 1999 and continues to do so. Figure 26 compares manufacturing and transportation/warehousing employment and income to the retail sector for the Salt Lake MSA. Manufacturing and warehousing firms comprise the majority of industrial customers in Salt Lake City, while retail represents a portion of commercial customers. These indicators help show the relative importance of these sectors to the economy and how each has grown or declined in relation to the other. Retail employment surpassed manufacturing employment in 1996. It continues to grow as a portion of overall employment, while manufacturing declines. Transportation and warehousing, the other category of industrial users, has held steady since 1999, with 6.5% of the jobs in the Metro Area.

Jobs cannot be looked at alone, since manufacturing has been increasing mechanization, and as a result, the amount of electricity used. Retail, however, remains dependent on labor. The second graph in Figure 26 attempts to account for these differences by looking at the amount of income each sector brings to the Metro Area. As the graph shows, while manufacturing income has been steadily declining since 1990, it makes up a larger portion of personal income than does retail, while transportation and warehousing remained flat.

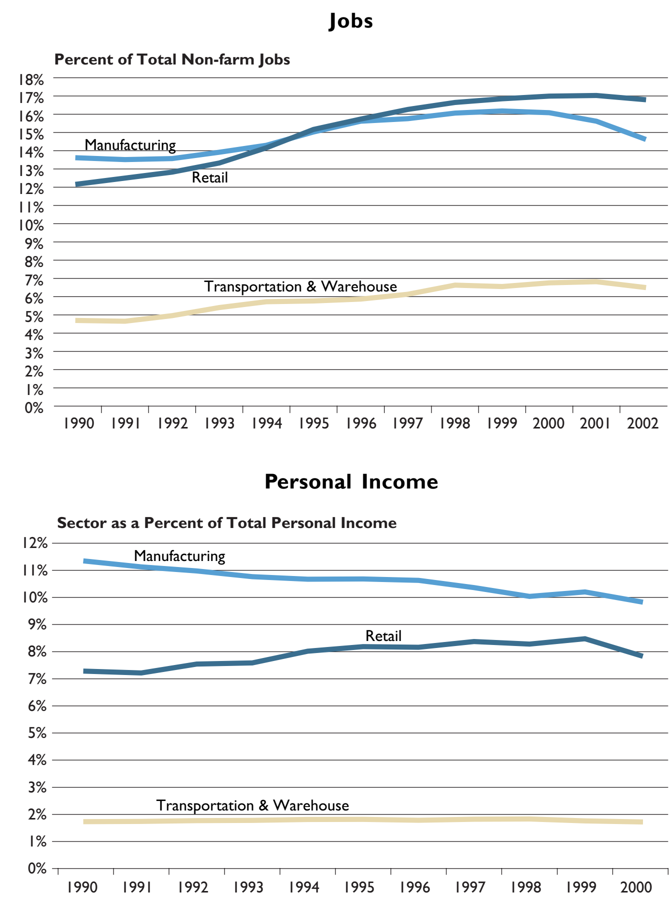
Together, all the data suggests that the commercial sector, encompassing office and retail space, has been the driver of general service peak load growth during the 1990s, while industrial customers have remained fairly constant. Since commercial air conditioning is the largest component of business' peak load usage, this is the driver behind the general service peak load spikes seen during the hottest days of the year.

Figure 25: California Commercial Consumption



Source: Ernesto Orlando Lawrence Berkeley National Laboratory.

Figure 26: Salt Lake MSA by Sector



Sources: Bureau of Labor Statistics and Bureau of Economic Analysis.

CONCLUSION

During the 1990s, peak loads grew at a faster rate than overall electrical consumption in Utah. The drivers of this rapid increase in peak load seem to be economic prosperity and overall increases in the population of the state. Both residential and commercial customers are major contributors to the growth in peak loads. This is true because residential and commercial customers are more sensitive to changes in temperature than larger industrial customers. An important finding of the data reviewed in this report is that, in terms of megawatts, the growth in commercial customers' peak demands exceeds the growth in residential peak demands by a considerable amount. However, the residential sector grew from a smaller base and therefore is growing at a faster percentage rate.

More data were available to analyze the factors influencing residential demand growth than commercial. Residential customers are impacting peak loads in two ways: first by pushing the peak higher; and second, by pushing it later in the day. Using the Census Annual Survey of Housing data, it appears that air conditioning installation and retrofitting is more contingent on affluence than climatic considerations, at least in temperate areas of the West. Peak load data from 2001, during an economic downturn, provide some evidence that electricity use is curbed during times of financial difficulty. Usage was down during 2001 over 2000, despite similar temperatures. Since 2001 data look very similar to 1999, however, this causal relationship is very weak. It could be that electricity usage during the summer of 2000 was abnormally high, or that energy conservation campaigns during 2001 had their desired impact and customers voluntarily curbed their usage. More study by consumer advocates and utility providers need to be done to definitively determine the reasons for 2001's data.

This report also highlights the need to gather other critical data in order to determine the causal relationship between growing affluence and electricity usage. First would be a study similar to that performed in California, in which homes and businesses allow utility providers to meter individual appliances to determine consumption curves for residential and general service customers. Additionally, some sort of census of commercial and industrial buildings is needed to determine the quantity and quality of these spaces in Utah and the types of amenities they offer. This would be invaluable in providing more comprehensive data on usage patterns, and in determining if factors such as the move to "big box" retail have a significant impact on electricity and other infrastructure.

Finally, utility providers may consider surveying residents in areas of the country similar to communities in Utah. For example, it would be interesting to see the attitudes of residents in Denver towards electricity usage and conservation compared to those in Salt Lake City. Do Utahns value air conditioning more than their counterparts in Colorado?

All of these factors should be considered prior to any changes in electrical pricing or infrastructure. Otherwise, imbalances in generation versus transmission capabilities and/or pricing structures may occur.

ENDNOTES

[1] Definitions partially taken from Brown, R., and Koomey, J.G. (2002) "Electricity Use in California: Past Trends and Present Usage Patterns" Ernesto Orlando Lawrence Berkeley Nation Laboratory, LBNL-47992, May.

[2] Osborn and Kawann, 2001.

[3] (LBNL 49947).

[4] Ibid.

[5] "Average gap" was determined by taking typical temperature days during July 1991 and 2001, and looking at the difference between load and peak load. The "peak" was assumed to be between 3-5 PM, based on historical trends.

[6] (LBNL).

[7] Ibid.

[8] "Average-high" temperature data for the MSAs analyzed here was found at http://www.city-data.com it represents the typical high, averaged across most relevant weather stations, and correlates to the most likely time cooling will be used.

[9] Ibid.

This Research Report was written by Director of Research Janice Houston, and Research Analysts Sara Sanchez and Richard Pak. Utah Foundation thanks its advisory committee for this report, which included Richard Anderson, Gary Dodge, Dan Gimble, Judith Johnson, Doug Larson, Stan Lockhart, Doug Matsumori, and Reed Searle. Many PacifiCorp employees also provided invaluable assistance with data, for which we are grateful.