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Three Scenarios for Electric and Hybrid Vehicle Commercialization

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THREE SCENARIOS FOR ELECTRIC AND HYBRID VEHICLE COMMERCIALIZATION

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ABSTRACT

Three electric and hybrid vehicle (EHV) market-penetration scenarios are developed for 1995, 2000, 2005, and 2010. The first scenario is intended to maximize the substitution of electricity for gasoline in the 101 metropolitan areas of the U.S. that are nonattainment areas for ozone; by 2010, 12 million EHVS are projected to be operating in those areas. The second scenario focuses on the nine metropolitan areas with the worst ozone problems and projects six million electric vehicles in the nine areas by 2010. The third scenario, like the first, projects 12 million EHVs in operation by 2010 but distributes the vehicles to all metropolitan statistical areas. The vehicles are distributed to the metropolitan areas as a function of area population and off-peak marginal cost of electricity for the local power pool. The scenarios contain several different EHV cars, vans, and trucks (differences include battery type, a.c. or d.c. drive, and hybrid or straight electric mode). Daily electricity consumption is calculated for each metropolitan area for the country by scenario year.

1 INTRODUCTION

Two scenarios for market penetration by alternative-fuel vehicles are being developed as part of the U.S. Department of Energy's ongoing assessment of the costs and benefits of developing a flexible- and alternative-fuel transportation system in the U.S. The three fuels with the most potential to be used as neat or neat-neat fuels and to be introduced in the 1990s are methanol, compressed natural gas (CNG), and electricity. Prior studies in the U.S. Department of Energy (DOE) assessment have indicated the most likely vehicle markets for each of these fuels.¹⁻⁵ For example, second cars in multicar households have been identified as a likely market for battery-powered vehicles. The scenarios under development draw from these studies to estimate potential penetration by each alternative-fuel vehicle in each scenario, given two distinctly different scenario objectives. This paper describes electric and hybrid vehicle (EHV) penetration in the two scenarios, as well as in a third scenario that is not constrained to the specifics of the DOE study. (This third scenario is described in Sec. 4 of this document.)

The first scenario, the “energy security” scenario, focuses on the potential energy security benefits of displacing a significant amount of oil. Alternative-fuel vehicles, including methanol vehicles, CNG vehicles, and EHVS, are introduced in sufficient numbers to displace a total of one million barrels of petroleum per day. This displacement level could affect world oil prices significantly. The vehicles are generally expected to be dual-fuel (i.e., able to operate on either an alternative fuel or conventional fuels), which allows their distribution and use throughout the U.S. EHVs are considered most likely to penetrate the market in areas that can also take advantage of their significant vehicle emission-reduction benefits. Thus, in this scenario, they are assumed to be introduced into the 101 metropolitan regions -- CMSAs, MSAS not in CMSAs, and some counties (mainly in Maine and Kentucky) -- that are nonattainment areas for ozone. This scenario is also referred to as the “101-city” scenario.

The second scenario, the “environmental” scenario, is motivated solely by environmental concerns. Alternative-fuel vehicles, including EVS, are assumed to be required in the nine metropolitan regions with the worst ozone air-quality problems (as in the President’s proposed Clean Air Act Amendments of June 1989) or preferentially marketed in these areas. The nine metropolitan regions comprise the Hartford CMSA, New York CMSA, Baltimore MSA, Philadelphia CMSA, Chicago CMSA, Milwaukee CMSA, Houston CMSA, Los Angeles CMSA, and San Diego MSA. This scenario is also called the “nine-cities” scenario. The vehicles are assumed to be dedicated (as opposed to dual-fuel) vehicles in order to maximize their environmental benefit. The schedule for introduction is based on the assumption that the rate of alternative-fuel vehicle introduction is essentially consistent with that proposed in the President’s program: 0.5 million “clean fuel” vehicles in 1995, 0.75 million in 1996, and 1.0 million each year thereafter through 2004. Sales of at least 1.0 million “clean fuel” vehicles per year are expected to continue in subsequent years.

“An MSA (metropolitan statistical area) is a geographical area that includes the named city and economically connected counties in one or more adjacent states. CMSAS (C for consolidated) include all adjacent MSAs.

2 TOTAL MARKET PENETRATION

Hamilton analyzed potential markets for EHVS in a study he conducted for the DOE assessment.¹ He concluded that, on the basis of the performance and recharging requirements of EHVS, 45% of all light-duty vehicles (LDVS) could be EHV's, if cost were not a consideration. EHVS could be used by fleets made up of vehicles with range requirements no greater than 80 miles, assuming the vehicles are parked overnight on company premises. Moreover, EHVS may be used by households with off-street parking and (for EVS only) households with a conventionally fueled vehicle (CV) available for long trips.

Given this sizeable potential market and assuming that EHVS are economically competitive with CVS and/or that policies are in place to foster or require the use of EHVS, EHV market penetration by 2010 is expected to be constrained largely by the rate at which vehicle (mainly battery) production facilities can be built and put into operation. The emergence of volume EHV manufacturing will take time. In his report, Hamilton developed a scenario for EHV production through 2000. This scenario, reproduced in modified form in Table 1, constitutes a hypothetical schedule for completing the development and demonstration of projected EHV technology and for establishing the facilities required to produce these EHVS in volume (e.g., new battery plants, powertrain factories, and vehicle assembly lines). Here, Hamilton's scenario has been adapted to form the basis of the energy security and environmental EHV market-penetration scenarios.

The major modifications made to Hamilton's scenario were as follows: we assumed that production will start four years later than Hamilton assumed; we extended production six years, to 2010; and we added a longer-range "advanced battery" electric car. Currently announced plans for EV production in the next few years are more modest than Hamilton's projections, and there are no announced plans for the production of HVS. For these reasons, we delayed the time frame of Hamilton's projections by four years. Modest EV production expected in the next few years will have little impact by 1995. Hamilton's projections were also extended to the year 2010, because that year is the focal point of the estimates of market penetration for all three alternative-fuel vehicles.

The most important factor determining the EHV production scenarios is how quickly battery technology evolves from the current lead-acid battery to more advanced batteries. The assumptions regarding rate of battery introduction are important because the more advanced batteries allow for greater vehicle range. Greater range makes the EV more acceptable to the market and increases its utilization. Hamilton's original scenario assumed the introduction of nickel-iron batteries by 1990. This was optimistic, and we have revised the projected schedule to assume production by 1995. Hamilton's scenario did not include production of more advanced batteries than the nickel-iron. In both the energy security and the environmental scenarios, a more advanced battery (with a range of as much as 200 mi) is assumed to be introduced in the 2000-plus time frame.

TABLE 1 Hamilton's Scenario for Production of Electric and Hybrid Vehicles (thousands of vehicles sales)

Year	Electric							
	Direct Current		Alternating Current Ni-Fe			Hybrid (alternating current Ni-Fe)		
	I%/Acid, Van	Ni-Fe, Van	Van	Truck	Car	Van	Truck	Car
1988	0.1							
1989	1							
1990	1	0.1						
1991	1	1						
1992		1.0	1					
1993		1.0	50					
1994			50	100		1		
1995			50	100	100	10		
1996			50	100	100	100		
1997			50	100	100	100	100	
1998			50	100	100	100	100	100
1999			50	100	100	100	100	200
2000			50	100	100	100	100	400

No assumption about the specific battery type was made because a variety of battery types may be able to achieve this range.

A production-constrained schedule, incorporating all the above modifications to Hamilton's scenario, was first developed for the energy security scenario. In this scenario, specified in Table A.1 in the appendix, nearly 12 million EHVS will be in operation in the year 2010. Six million will be EVS, half of which will be powered by nickel-iron batteries and half by advanced batteries, and another six million will be HVS. The same six million EVS are assumed to be in operation by 2010 in the environmental scenario, although their production schedule is slightly different than that of the energy security scenario (see appendix, Table A.2). Both scenarios include the assumption that total production increases each year to 2010. Sales of EVS level off by 2010 in the energy security scenario, but an increase in total EHV sales occurs because of the increase in

HV sales. EV sales in the environmental scenario are “smoothed” in order to maintain the assumption of increased total production each year.

The number of EHVS in these scenarios is small relative to the potential vehicle applications Hamilton projects could be converted. to EHVS: 93 million in 2000. Even limiting penetration to the nine worst ozone nonattainment areas, it appears that sufficient markets exist so that the EHV market penetration projected here will not be constrained by a total market limit. The nine areas contain approximately 22% of the U.S. population and can be assumed to account for approximately the same proportion of total vehicles.

3 REGIONAL MARKET PENETRATION

The national totals derived in Sec. 2 are distributed regionally in the scenarios. It is assumed that, all other things being equal, the price of off-peak electricity will determine the number of EHVS per capita in each metropolitan area. Given appropriate load-management rates or devices, EHVS are expected to be recharged during the evening hours ("off-peak"). Most off-peak power is generated by coal and nuclear power plants, since these units have the lowest marginal costs (operating, maintenance, and fuel costs). In general, nuclear plants have much lower marginal costs than coal plants. Distributing the EHVS using off-peak marginal costs thus means distributing relatively more EHVS to those areas with nuclear power, in turn, would assist with the achievement of the environmental goal of reduced urban ozone.

Table A.3 in the appendix presents, for each of the 101 ozone nonattainment areas, its local utility, the power pool in which the utility participates, and the lowest and highest off-peak marginal costs of the power pool and marginal plant's fuel types. The nine metropolitan regions of the environmental scenario are a subset of the 101 metropolitan regions. Current marginal costs may not be valid by 2010, especially for cities with a significant number of EHVS charging at night. However, current costs are used in this analysis because of the lack of estimates of future marginal costs in these areas.

Tables A.4 and A.5 in the appendix list the distributions of EHVS to the 101 cities and EVS to the nine cities, respectively (i.e, the regional market penetration scenarios). The distribution from the production scenarios to the cities in each year is linearly proportioned as follows:

$$N_{mt} = \text{POP}_m \times \text{MCF}_m \times \text{MF}_t$$

where:

- N_{mt} = the number of EVS or EHVS in metropolitan area m and year t ;
- POP_m = the 1987 population of metropolitan area m ;
- MCF_m = the marginal cost factor for metropolitan area m 's utility, calculated as the ratio of the average off-peak marginal cost for all utilities represented in the table divided by the average off-peak marginal cost of the utility serving m ; and
- MF_t = the mapping factor, which for year t maps the national EHV fleet onto each POP_m .

The factor MCF_m is proportional to the inverse of the local utility's off-peak marginal cost, so a lower marginal cost means proportionally more EHVs. The utility's off-peak marginal cost is the average of the 1988 high and low values listed in Table A.3. Neither urban population nor utility marginal costs are forecast for future years in the scenarios. The implied assumption, because these two parameters are used as scaling factors, is that the values of these factors will change but that they will remain proportionally the

same relative to each other (i.e., utility marginal costs will all change in proportion to each other, as will urban populations).

Table A.6 in the appendix presents estimates of weekday electricity consumption by EHVS for both the energy security and the environmental scenarios. The estimate of daily electricity use by EHVS of each battery type is based on Hamilton's analysis of daily travel and EHV recharge requirements. The energy security scenario is projected to use approximately 250 GWh per average weekday, while the environmental scenario is projected to use nearly 120 GWh per weekday. Because fleet vehicles are operated more on weekdays, electricity use on an average day [weekday and weekend included] would be lower, 220 GWh/d and 112 GWh/d, respectively. In the energy security scenario, EHVS will displace approximately 280,000 barrels of petroleum per day (bbl/d), and in the environmental scenario they will displace 160,000 bbl/d.

Tables A.4 and A.5 present the total electricity demand by city to charge these vehicles. The power required from one utility by 2000 can be substantial, particularly in the nine-city environmental scenario. However, it is expected that the power will be provided by the power pool.

4 THE ALL-CITY SCENARIO

A third scenario developed in the course of the present study is based on the assumptions of the 101-city (energy-security) scenario, except that all CMSAS and all MSAS not in CMSAs are used. This "all-city" scenario was developed because many cities in the Southeast and in the upper tiers of states west of the Great Lakes are attainment areas for ozone; thus, they are not in the 101-city scenario and are not EHV markets. The several counties included in the 101-city scenario that are not MSAS are not in this all-city scenario. The net change in number of "cities" between the two scenarios is 46.

The total 1978 population in the 101-city scenario is 135 million, while for the all-city scenario it is 162 million; thus, no large difference in EHV penetration exists for the cities in both scenarios. The main difference between the two scenarios is that the EHVS are distributed over somewhat different sets of cities (see Table A.7 in the appendix). Since both scenarios have the same number and mix of EHVS in each year, total electricity consumption is the same in each year.

5 CONCLUSIONS

One may ask whether the scenarios developed here are reasonable. Figures 1 and 2 show EHV sales and fleets by year for both the energy security and the environmental scenarios (and the distribution of EVs to the nine cities of the environmental scenario). One test for reasonableness is to compare these scenarios with the introduction of new automotive product lines in the recent past. The now quite popular minivan may furnish a good comparison.

As Table 2 shows, about 150,000 minivans were sold in 1984. In four years, that number increased to 850,000. In 1999, in both scenarios, more than 150,000 EHV/ EVs are projected to be sold. Over the next four years, EHV sales are projected to be slower than the minivan sales: 545,000 by 2003 in the 101-city scenario and 270,000 in the nine-city scenario. Thus, the production scenarios shown here are realizable by the automotive industry, if sufficient economic incentives exist.

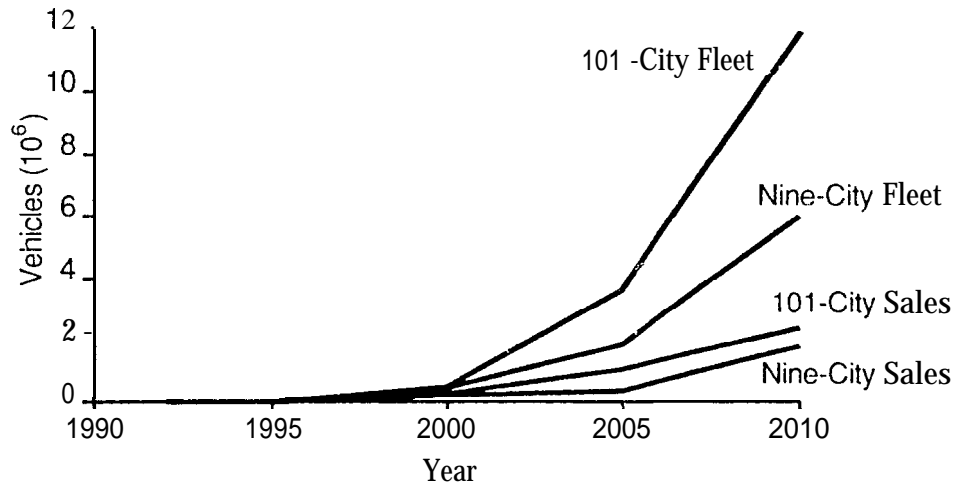


FIGURE 1 101-City and Nine-City Electric and Hybrid Vehicle Fleet and Sales

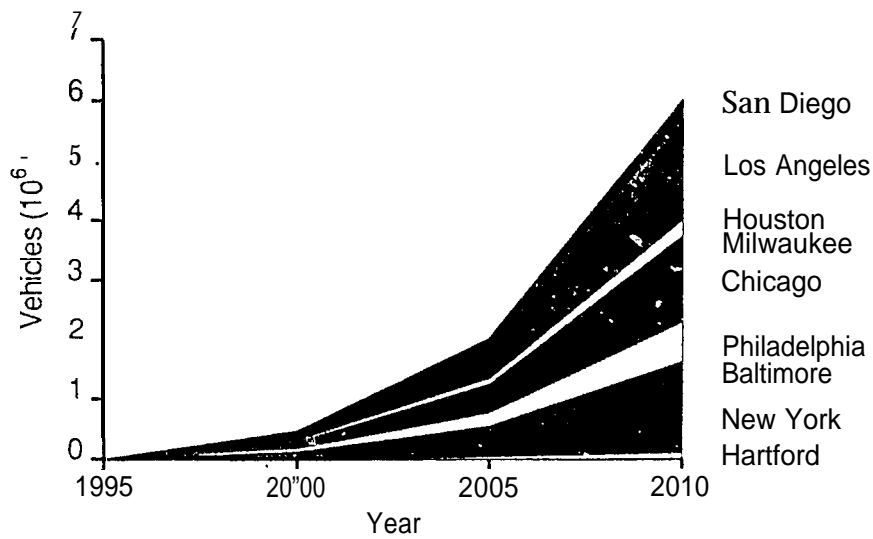


FIGURE 2 Electric Vehicle Fleet Distribution by the Nine Cities

TABLE 2 Comparison of Projected Electric and Hybrid Vehicle Sales with Recent Minivan Sales (thousands of vehicles)

Minivans		Electric and Hybrid Vehicles		
		Year	Sales	
Year	Sales	Year	101-City	Nine'-City"
1984	147	1999	151	175
1985	341	2000	260	200
1980	543	2(X)1	350	250
1987	628	2002	450	250
1988	851	2003	545	270

"EVs only.

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TABLE A.1 101-City Electric and Hybrid Vehicle Sales and Fleet

Year	Thousands of EHVS										EHV Fleet Total	
	EV (d.c.)		EV (a.c.)			HV			EV Car, Adv. Batt	Net New EHVS		
	Pb-A, Van	NiFe, Van	NiFe, Van	NiFe, Truck	NiFe, Car	NiFe, Van	NiFe, Truck	NiFe, Car				
1992	0.1										0.1	0.1
1993	1										1	1.1
1994	1										1	2.1
1995	1	0.1									1.1	3.2
1996	1	1									2	5.2
1997		10	1								11	16.2
1998		10	50								60	76.2
1999			50	100		1					151	227.2
2000			50	100	100	10					260	487.2
2001	-0.5		50	100	100	100					345.5	836.7
2002	-0.5		50	100	100	100	100				449.5	1286.2
2003	-0.5	-5	50	100	100	100	100	100			544.5	1830.7
2004	-0.5	-5	50	100	200	100	100	200			744.5	2575.2
	-0.5	-5	50	100	200	100	100	400	100		1044.5	3619.7
2006	-0.5	-5	50	50	200	100	100	400	200		1094.5	4714.2
2007	-0.5	-1.1	0	0	200	100	100	400	400		1198.4	5912.6
2008	-0.3		-50	-50	400	100	200	600	600		1799.7	7712.3
2009	-0.3		-50	-100	400	200	200	699	800		2049.7	9762
2010			-50	-200	200	200	200	800	1000		2150	11912
Total	0	0	301	400	2200	1211	1201	3500	3100		11912	

TABLE A.2 Nine-City Electric Vehicle Sales and Fleet

Year	Thousands of EVS							
	EV (d.c.)		EV (a.c.)			EV Car, Adv. Batt	Net New EVS	EV Fleet Total
	Pb-A, Van	NiFe, Van	NiFe, Van	NiFe, Truck	NiFe, Car			
1992	0.1						0.1	0.1
1993	1						1	1.1
1994	1						1	2.1
1995	1	0.1					1.1	3.2
1996	1	1					2	5.2
1997		10	1				11	16.2
1998		10	50				60	76.2
1999			50	75	50		175	251.2
2000			50	100	50		200	451.2
2001	-0.5		50	100	100		249.5	700.7
2002	-0.5		50	100	100		249.5	950.2
2003	-0.5	-5	50	100	125		269.5	1219.7
2004	-0.5	-5	50	125	125		294.5	1514.2
2005	-0.5	-5	50	75	125	100	344.5	1858.7
2006	-0.5	-5	50	75	125	150	394.5	2253.2
2007	-0.5	-1.1	0	0	200	250	448.4	2701.6
2008	-0.3		-50	-50	300	500	699.7	3-401.3
2009	-0.3		-50	-100	400	800	1049.7	4451
2010			-50	-200	500	1300	1550	6001
Total	0	0	301	400	2200	3100	6001	

TABLE A.3 101-City Utility, Power Pool, Marginal Off-Peak Cost, and Marginal Off-Peak Plant Type

Metropolitan Area	utility	NERC Code	Pool #	Annual Off-Peak Marginal Cost of Electricity			
				Law		High	
				mils/kWh	Type Of Generation [†]	mils/kWh	Type of Generation*
Anderson, S.C., (Clemson, S.C.)	Duke Power Co.	SERC	19	7.534	(1)	7.687	(1)
Atlanta, Ga.	Georgia Power Co.	SERC	17	18.631	(2)	18.631	(2)
Birmingham, Ala.	Alabama Power Co.	SERC	17	18.631	(2)	18.631	(2)
Charlotte-Gastonia-Rock Hill, N.C.	Duke Power Co.	SERC	19	7.534	(1)	7.534	(1)
Columbia, S.C.	South Carolina Elec. & Gas Co.	SERC	19	7.534	(1)	7.534	(1)
Edmonson County, Ky. (Bowling Green)	Bowling Green, City of	SERC	18	7.586	(1)	7.586	(1)
Fayetteville, N.C.	Fayetteville, City of	SERC	19	7.534	(1)	7.534	(1)
Greensboro-Winston Salem-High Point, N.C.	Duke Power Co.	SERC	19	7.534	(1)	7.534	(1)
Greenville-Spartenburg, S.C.	Duke Power Co.	SERC	19	7.534	(1)	7.534	(1)
Huntsville, Ala.	Huntsville, City of	SERC	18	7.886	(1)	7.586	(1)
Jacksonville, Fla.	Jacks. nville, City of	SERC	19	7.534	(1)	7.534	(1)
Knoxville, Term.	Knoxville, City of	SERC	18	7.886	(1)	7.5%	(1)
Livingston County, Ky. (Paducah)	Pad.cab, City of	SERC	18	7.886	(1)	7.9%	(1)
Lexington-Fayette, Ky	Kentucky Utilities Co.	ECAR	32	16.185	(2)	16.185	(2)
Louisville, Ky.-Ind.	Louisville Gas & Electric Co.	ECAR	32	16.185	(2)	16.185	(2)
Memphis, Term.-Ark.-Miss	Memphis, City of	SERC	18	7.586	(1)	7.586	(1)
Miami CMSA	Florida Power & Light Co.	SERC	16	22.919	(2)	23.74	(2)
Montgomery, Ala.	Alabama Power Co.	SERC	17	18.631	(2)	18.631	(2)
Nashville, Term.	Nashville, City of	SERC	18	7.586	(1)	7.5a6	(1)
Owensboro, Ky. (adj. Hancock County)	Owensboro, City of	ECA R	32	16.185	(2)	16.185	(2)
Raleigh-Durham, N.C.	Carolina Power & Light Co.	SERC	19	7.534	(1)	7.534	(1)
Tampa-St. Petersburg-Clearwater, Fla.	Tampa Electric Co.	SERC	16	22.919	(2)	23.74	(2)
Canton, Ohio	Ohio Power Co.	ECAR	1	18.687	(2)	18.687	(2)
Chicago CMSA	Commonwealth Edison Co.	MAIN	8	7.709	(1)	7.709	(1)
Cincinnati CMSA	Cincinnati Gas & Electric Co.	ECAR	31	19.666	(2)	19.666	(2)
Cleveland CMSA	Cleveland Elec. illuminating Co.	ECAR	2	15.53	(2)	15.53	(2)
Columbus, Ohio	Columbus Southern Power Co.	ECAR	1	18.687	(2)	18.687	(2)
Dayton-Springfield, Ohio	Dayton Power & Light Co.	ECAR	31	19.666	(2)	19.666	(2)
Detroit CMSA	Det roi t Edison Co.	ECA R	4	20.259	(2)	20.259	(2)
Grand Rapids, Mich.	Consumers Power Co.	ECA R	4	20.259	(2)	20.259	(2)
Indianapolis, Ind.	Indianapolis Power & Light Co.	ECA R	33	16.17	(2)	16.17	(2)
Kewaunee County, Wis.	Wisconsin Public service Co.	MAIN	11	17.995	(2)	17.995	(2)
Lafayette-West Lafayette, Ind.	Public Service Co. of Indiana	ECAR	33	16.17	(2)	16.17	(2)
Milwaukee CMSA	Wisconsin Electric Power Co.	MAIN	11	17.995	(2)	17.995	(2)
Muskegon, Mich.	Consumers Power Co.	ECAR	4	20.259	(2)	20.259	(2)
Sheboygan, Wis.	Wisconsin Power & light Co.	MAIN	11	17.995	(2)	17.995	(2)
South Bend-Mishawaka, Ind.	Indiana Michigan Power	ECAR	1	18.687	(2)	18.687	(2)
Toledo, Ohio	Toledo Edison Co.	ECAR	2	15.53	(2)	15.53	(2)
Youngstown, Ohio-Penn. (inc. Sharon, Penn.)	Ohio Edison Co.	ECAR	2	15.53	(2)	15.53	(2)
Baton Rouge, La.	Gulf States Utilities Co.	SPP	20	18.679	(3)	18.679	(3)
Beaumont-Port Arthur, Texas	Gulf States Utilities Co.	SPP	20	18.679	(3)	18.679	(3)

TABLE A.3 (Cent'd)

Metropolitan Area	utility	NERC Code	Pool #	Annual Off-Peak Marginal Cost of Electricity			
				Low		High	
				mils/kWh	Type of Generation ¹	mils/kWh	Type of Generation ¹
Boston CMSA	Boston Edison Co.	NPcc	14	7.62	(1)	20.7	(2)
Hancock County, Maine (Acadia Nat. Park)	Bangor Hydro-Electric Co.	NPcc	14	7.62	(1)	20.7	(2)
Hartford CMSA	Connecticut Light & Power Co.	NPCC	14	7.62	(1)	20.7	(2)
Knox County, Maine	Central Maine Power Co.	NPcc	14	7.62	(1)	20.7	(2)
Lincoln County, Maine	Central Maine Power Co.	NPcc	14	7.62	(1)	20.7	(2)
Lewiston-Auburn, Maine	Central Maine Power Co.	NPcc	14	7.62	(1)	20.7	(2)
Manchester, N.H.	Public Ser. Co. of New Hampshire	NPcc	14	7.62	(1)	20.7	(2)
Portland, Maine	Central Maine Power Co.	NPcc	14	7.62	(1)	20.7	(2)
Portsmouth-Dover-Roch., N. H.-Maine	Public Ser. Co. of New Hampshire	NPcc	14	7.62	(1)	20.7	(2)
Providence CMSA	Narragansett Electric Co.	NPCC	14	7.62	(1)	20.7	(2)
Springfield, Mass.	Western Massachusetts Elec. Co.	NPCC	14	7.62	(1)	20.7	(2)
Waldo County, Maine	Central Maine Power Co.	NPcc	14	7.62	(1)	20.7	(2)
Worcester, Mass.	Massachusetts Electric co.	NPcc	14	7.62	(1)	10.7	(2)
Albany-Schenectady-Troy, N.Y.	Niagara Mohawk Power Co.	NPcc	15	15.061	(2)	21.074	(2)
Atlantic City, N.J.	Atlantic City Electric Co.	MAAC	7	7.556	(1)	15.061	(2)
Buffalo CMSA	Niagara Mohawk Power Co.	NPCC	15	15.061	(2)	21.074	(2)
Essex County, N.Y. (Whiteface Mtn.)	Niagara Mohawk Power Co.	NPcc	15	15.061	(2)	21.074	(2)
Jefferson County, N.Y.	Niagara Mohawk Power Co.	NPcc	15	15.061	(2)	21.074	(2)
New York CMSA	Consolidated Edison Co. of N.Y.	NPCC	15	15.061	(2)	21.074	(2)
Poughkeepsie, N.Y.	Central Hudson Gas & Elec. Corp.	NPCC	15	15.061	(2)	21.074	(2)
Allentown-Bethlehem, Penn	Pennsylvania Power & Light Co.	MAAC	7	7.556	(1)	15.061	(2)
Altoona, Penn.	Pennsylvania Electric Co.	MAcc	7	7.556	(1)	15.061	(2)
Baltimore, Md.	Baltimore Gas & Electric Co.	MAAC	7	7.556	(1)	15.061	(2)
Charleston, W.Va.	Appalachian Power Co.	ECAR	1	18.687	(2)	18.687	(2)
Erie, Penn.	Pennsylvania Electric Co.	MAAC	7	7.556	(1)	15.061	(2)
Greenbrier County, W.Va.	West Virginia Power	ECAR	10r3	16.095	(2)	18.687	(2)
Harrisburg-Lebanon-Carlisle, Penn.	Pennsylvania Power & Light Co.	MAAC	7	7.556	(1)	15.061	(2)
Huntington-Ashland, W.Va.-Ky.-Ohio	Appalachian Power Co.	ECAR	1	18.687	(2)	18.687	(2)
Johnstown, Penn.	Pennsylvania Electric Co.	MAAC	7	7.556	(1)	15.061	(2)
Lancaster, Penn.	Pennsylvania Power & Light Co.	MAAC	7	7.556	(1)	15.061	(2)
Norfolk-Va. Beach-Newport News, Va.	Virginia Power	SERC	19	7.534	(1)	7.687	(1)
Parkersburg-Marietta, W.Va.-Ohio	Monongahela Power Co.	ECAR	3	16.095	(2)	16.095	(2)
Philadelphia CMSA	Philadelphia Electric Co.	MAAC	7	7.556	(1)	15.061	(2)
Pittsburgh CMSA	Duquesne Light Co.	ECAR	2	15.53	(2)	15.53	(2)
Reading, Penn.	Metropolitan Edison Co.	MAAC	7	7.556	(1)	15.061	(2)
Richmond-Petersburg, Va.	Virginia Power	ECAR	19	7.534	(1)	7.687	(1)
Scranton-Wilkes-Barre, Penn.	Pennsylvania Power & Light Co.	MAAC	7	7.556	(1)	15.061	(2)
Sussex County, Del.	Seaford, City of	MAAC	7	7.556	(1)	15.061	(2)
Washington, D.C.-Md.-Va.	Potomac Electric Power Co.	MAAC	7	7.556	(1)	15.061	(2)
York, Penn.	Metropolitan Edison Co.	MAAC	7	7.556	(1)	15.061	(2)

TABLE A.3 (Cent'd)

Metropolitan Area	Utility	NERC Code	Pool #	Annual Off-Peak Marginal Cost of Electricity			
				Low		High	
				mils/kWh	Type of Generation ^a	mils/kWh	Type of Generation ^a
Dallas CMSA	Texas Utilities Electric Co.	ERCOT	5-6	14.588	(2)	19.179	(c)
El Paso, Texas	El Paso Electric Co.	WSCC(Az-NM)	26	7.369	(1)	10.426	(3)
Houston CMSA	Houston fighting & Power Co.	ERCOT	5-6	14.588	(C)	19.179	(2)
Lake Charles, La.	Gulf States Utilities Co.	SPP	20	18.679	(3)	18.679	(3)
Tulsa, Okla.	Public Service Co. of Oklahoma	SPP	21	18.631	(2)	18.631	(2)
Kansas City, Mo.-Ks.	Kansas City Power & Light Co.	SPP	22	15.969	(3)	15.969	(3)
St. Louis, Mo.-Ill.	Union Electric Co.	MAIN	9-10	16.967	(2)	16.967	(2)
Salt Lake City-Ogden, Utah	Utah Power & Light Co.	WSCC(RMPP)	28	12.405	(3)	13.222	(3)
Bakersfield, Calif.	Pacific Gas & Electric Co.	WSCC(Ca-SNv)	27	7.38	(4)	12.302	(2)
Fresno, Calif.	Pacific Gas & Electric Co.	WSCC(Ca-SNv)	27	7.38	(4)	12.302	(2)
Los Angeles CMSA	Los Angeles, City of	WSCC(Ca-SNv)	27	7.38	(4)	12.302	(2)
Modesto, Calif.	Modesto Irrigation District	WSCC(Ca-SNv)	27	7.39	(4)	12.302	(2)
Phoenix, Ariz.	Arizona Public Service Co.	WSCC(Az-NM)	26	7.569	(1)	10.426	(3)
Sacramento, Calif.	Sacramento Mun. Utility Dist.	WSCC(Ca-SNv)	27	7.38	(4)	12.302	(2)
San Diego, Calif.	San Diego Gas & Electric Co.	WSCC(Ca-SNv)	27	7.38	(4)	12.302	(2)
San Francisco, Calif.	Pacific Gas & Electric Co.	WSCC(Ca-SNv)	27	7.38	(4)	12.302	(2)
Santa Barbara-Santa Maria-Lompoc, Calif.	Southern California Edison	WSCC(Ca-SNv)	17	7.38	(4)	12.302	(2)
Stockton, Calif.	Pacific Gas & Electric Co.	WSCC(Ca-SNv)	27	7.38	(4)	12.302	(2)
Visalia-Tulare-Porterville, Calif.	Southern California Edison	WSCC(Ca-SNv)	27	7.39	(4)	12.302	(2)
Portland CMSA	Portland General Electric Co.	WSCC(NWPP)	25	9.735	(G)	13.879	(3)

^aGeneration Codes: 1 = Nuclear, 2 = Bituminous Lignite, 3 = Subbituminous Anthracite, and 4 = Geothermal

TABLE A.4101-City Electric Vehicle Distribution and Electricity Use

Metropolitan Area	Off-Peak Marginal Cost (mils/kWh)		1987 Population (10 ⁶)	Marginal Cost Factor	Fleet Totals by Year (thousands of EVs)				Daily Energy Requirement by Year (GWh/d)			
	Low	High			1995	2000	2005	2010	1995	2000	2005	2010
Boston CMSA	7.62	20.7	4.093	0.971	0.085	12.949	96.204	316.833	0.0012	0.3291	2.3575	6.7492
Hancock County, Maine	7.62	20.7	0.044	0.971	0.001	0.139	1.034	3.406	0.0070	0.0033	0.0253	0.0726
Hartford CMSA	7.62	20.7	1.057	0.971	0.022	3.344	24.844	81.821	0.0003	0.0798	0.6088	1.7429
Knox County, Maine	7.62	20.7	0.035	0.971	0.001	0.111	0.823	2.709	0.0000	0.0026	0.0202	0.0577
Lincoln County, Maine	7.62	20.7	0.028	0.971	0.001	0.089	0.658	2.167	0.0000	0.0221	0.0161	0.0462
Lewiston-Auburn, Maine	7.62	20.7	0.04	0.971	0.001	0.127	0.940	3.096	0.0000	0.0030	0.0230	0.0660
Manchester, N.H.	7.62	20.7	0.0972	0.971	0.002	0.308	2.285	7.524	0.0000	0.0073	0.0560	0.1803
Portland, Maine	7.62	20.7	0.0627	0.971	0.001	0.198	1.474	4.854	0.0000	0.0047	0.0361	0.1034
Portsmouth-Dover-Roch., N.H.-Maine	7.62	20.7	0.026	0.971	0.001	0.082	0.611	2.013	0.0000	0.0020	0.0150	0.0429
Providence CMSA	7.62	20.7	1.119	0.971	0.023	3.537	26.278	86.543	0.0003	0.0844	0.6439	1.8435
Springfield, Mass.	7.62	20.7	0.517	0.971	0.011	1.636	12.152	40.020	0.0001	0.0390	0.2978	0.8525
Waldo County, Maine	7.62	20.7	0.0301	0.971	0.001	0.095	0.707	2.330	0.0000	0.0023	0.0173	0.0496
Worcester, Mass.	7.62	20.7	0.41	0.971	0.009	1.297	9.637	31.737	0.0001	0.0310	0.2361	0.6761
Albany-Schenect.-Troy, N.Y.	15.061	21.074	0.846	0.761	0.014	2.098	15.584	51.324	0.0002	0.0501	0.3829	1.0933
Atlantic City, N.J.	7.556	15.061	0.303	1.216	0.008	1.200	8.918	29.369	0.0001	0.0287	0.2185	0.6256
Buffalo CMSA	15.061	21.074	1.175	0.761	0.019	2.913	21.645	71.284	0.0003	0.0695	0.5304	1.5185
Essex County, N.Y. (Whiteface Mtn.)	15.061	21.074	0.0363	0.761	0.001	0.090	0.669	2.202	0.0000	0.0021	0.0164	0.0469
Jefferson County, N.Y.	15.061	21.074	0.0906	0.761	0.001	0.225	1.669	5.496	0.0000	0.0054	0.0409	0.1171
New York CMSA	15.061	21.074	18.054	0.761	0.294	44.763	332.574	1095.284	0.0040	1.0685	8.1497	23.3317
Poughkeepsie, N.Y.	15.061	21.074	0.258	0.761	0.004	0.640	4.753	15.652	0.0001	0.0153	0.1165	0.3334
Allentown-Bethlehem, Penn	7.556	15.061	0.666	1.216	0.017	2.638	19.601	64.554	0.0002	0.0530	0.4803	1.3751
Altoona, Penn.	7.556	15.061	0.104	1.216	0.003	0.412	3.061	10.080	0.0000	0.0098	0.0750	0.2151
Baltimore, Md.	7.556	15.061	2.303	1.216	0.060	9.123	67.780	223.224	0.0008	0.2178	1.6609	4.851
Charleston, W.Va.	18.687	18.687	0.261	0.736	0.004	0.626	4.649	15.309	0.0001	0.0149	0.1139	0.3261
Eric, Penn.	7.556	15.061	0.279	1.216	0.007	1.105	8.211	27.043	0.0001	0.0264	0.2012	0.5761
Greenbrier Co., W.Va	16.095	18.687	0.0384	0.791	0.001	0.099	0.735	2.420	0.0000	0.0024	0.0180	0.0516

TABLE A.4 (Cent'd)

Metropolitan Area	Off-Peak Marginal Cost (mils/kWh)		1987 Population (10 ⁶)	Marginal cost Factor	Fleet Totals by Year (thousands of EVs)				Daily Energy Requirement by Year (GWh/d)			
	Low	High			1995	2000	2005	2010	1995	2000	2005	2010
Harrisburg-Leb.-Car., Penn.	7.556	15.061	0.584	1.216	0.015	2.313	17.188	56.606	0.0002	0.0552	0.4212	1.2058
Huntington-Ashland, W. Va.-Ky.-Ohio	18.687	18.687	0.323	0.736	0.005	0.774	5.753	18.946	0.0001	0.0185	0.1410	0.4036
Johnstown, Penn.	7.556	15.061	0.252	1.216	0.007	0.998	7.417	24.426	0.0001	0.0238	0.1817	0.5203
Lancaster, Penn.	7.556	15.061	0.404	1.216	0.011	1.600	11.890	39.159	0.0001	0.0382	0.2914	0.8342
Norfolk-Virginia Beach- Newport News, Va.	7.534	7.687	1.346	1.806	0.052	7.923	58.863	193.858	0.0007	0.1891	1.4424	4.12%
Portsmouth-Marietta, W. V.-Ohio	16.095	16.095	0.0385	0.854	0.001	0.107	0.796	2.622	0.0000	0.0026	0.0195	0.0559
Philadelphia CMSA	7.556	15.061	5.891	1.216	0.153	23.336	173.379	570.999	0.0021	0.5570	4.2486	12.1634
Pittsburgh CMSA	15.53	15.53	2.296	0.885	0.043	6.623	49.205	162.051	0.0006	0.1581	1.2058	3.4520
Reading, Penn.	7.556	15.061	0.324	1.216	0.008	1.283	9.536	31.404	0.0001	0.0306	0.2337	0.6633
Richmond-Petersburg, Va.	7.534	7.687	0.825	1.806	0.032	4.856	36.079	118.821	0.0004	0.1159	0.8841	2.5311
Scranton-Wilkes-Barre, Penn.	7.556	15.061	0.731	1.216	0.019	2.896	21.514	70.854	0.0003	0.0691	0.5272	1.5093
Sussex County, Del.	7.556	15.061	0.11	1.216	0.003	0.436	3.237	10.662	0.0000	0.0104	0.0793	0.2271
Washington, D.C.-Md.-Va.	7.556	15.061	3.646	1.216	0.095	14.443	107.306	353.397	0.0013	0.3448	2.6295	7.5281
York, Penn.	7.5%	15.061	0.404	1.216	0.011	1.600	11.890	39.159	0.0001	0.0382	0.2914	0.8342
Anderson, S.C.	7.534	7.687	0.0287	1.806	0.001	0.169	1.255	4.134	0.0000	0.0040	0.03418	0.0881
Atlanta, Ga.	18.631	18.631	2.657	0.738	0.042	6.389	47.464	156.317	0.0006	0.1525	1.1631	3.3299
Birmingham, Ala.	18.631	18.631	0.917	0.738	0.014	2.205	16.381	53.949	0.0002	0.0526	0.4014	1.1492
Charlotte-Gastonia- Rock Hill, N.C.	7.534	7.534	1.091	1.825	0.043	6.487	48.196	158.727	0.0006	0.1548	1.1810	3.3812
Columbia, S.C.	7.534	7.534	0.451	1.825	0.018	2.682	19.923	65.615	0.0002	0.0640	0.4882	1.3977
Edmondson County, Ky. (Bowling Green)	7.586	7.586	0.0108	1.812	0.000	0.064	0.474	1.564	0.0000	0.0015	0.0116	0.0332
Fayetteville, N.C.	7.534	7.534	0.259	1.825	0.010	1.540	11.442	37.681	0.0001	0.0368	0.2804	0.8027
Greensboro-Winston Salem- High Point, N.C.	7.534	7.534	0.916	1.825	0.036	5.447	40.465	133.267	0.0005	0.1300	0.9916	2.8388

TABLE A.4 (Cent'd)

Metropolitan Area	Off-Peak Marginal Cost (mils/kWh)		1987 Population (lt-la)	Marginal Cost Factor	Fleet Totals by Year (thousands of EVS)				Daily Energy Requirement by Year (GWh/d)			
	Low	High			1995	2000	2005	2010	1995	2000	2005	2010
Greenville-Spartenburg, S.C.	7.534	7.534	0.612	1.825	0.024	3.639	27.036	89.038	0.0303	0.0869	0.6625	1.8967
Huntsville, Ala.	7.586	7.586	0.163	1.812	0.006	0.963	7.151	23.552	0.0001	0.0230	0.1752	0s017
Jacksonville, Fla.	7.534	7.534	0.878	1.825	0.034	5.221	38.787	127.738	0.0005	0.1246	0.9505	2.7211
Knoxville, Tenn.	7.586	7.586	0.594	1.812	0.023	3.508	26.061	85.827	0.0003	0.0837	0.6386	1.8283
Livingston Co., Ky. (Paducah)	7.586	7.586	0.009	1.812	<i>0.030</i>	0.053	0.395	1.300	<i>0.0000</i>	0.0013	0.0097	0.0277
Lexington-Fayette, Ky.	16.185	16.185	0.342	0.849	<i>0.006</i>	0.947	7.033	23.161	0.0001	0.0226	0.1723	0.4934
Louisville, Ky.-Ind.	16.185	16.185	0.967	0.849	0.018	2.676	19.885	65.489	0.0002	0.0639	0.4873	1.3950
Memphis, Tenn.-Ark.-Miss.	7.586	7.586	0.972	1.812	<i>0.038</i>	5.740	42.645	140.444	0.0005	0.1370	11-1450	2.9917
Miami CMSA	22.919	23.74	2.954	0.589	0.037	5.672	42.142	138.789	0.0005	0.1354	1.0327	2.9565
Montgomery, Ala.	18.631	18.631	0.297	0.738	0.005	0.714	5.306	17.473	0.0001	0.0170	0.1300	0.3722
Nashville, Tenn.	7.586	7.586	0.956	1.812	0.037	5.645	41.943	138.133	0.0005	0.1348	1.0278	2.9425
Owensboro, Ky. (adj. Hancock County)	16.185	16.185	0.02	0.849	0.000	0.055	0.411	1.354	0.0000	0.0013	0.0101	0.0289
Raleigh-Durham, N.C.	7.534	7.534	0.665	1.825	0.026	3.954	29377	96.749	0.0004	0.0944	0.7t 99	2.0609
Tampa-St. Petersburg- Clearwater, Fla.	22.919	23.74	1.965	0.589	<i>0.025</i>	3.773	28.033	92.323	0.0003	0.0901	0.6869	1.9667
Canton, Ohio	18.687	t 8.687	0.397	0.736	<i>0.006</i>	0.952	7.071	23.286	0.0001	0.0227	0.1733	0.4960
Chicago CMSA	7.709	7.709	8.147	1.783	0.311	47342	351.732	1158.380	0.0042	1.1301	86192	24.6758
Cincinnati CMSA	19.666	19.666	1.715	(1.699	0.026	3.907	29.024	95.587	0.0004	0.0933	0.7112	2.0362
Cleveland CMSA	15.53	15.53	2.767	0.885	0.052	7.982	59.299	195.294	0.0007	0.1905	1.4531	4.1601
Columbus, Ohio	18.687	18.687	t.32	0.736	0.021	3.164	23.510	77.426	0.0003	0.0755	0.5761	1.6493
Dayton-Springfield, Ohio	19.666	19.666	0.939	0.699	0.014	2,139	15.891	52336	0.0002	0.0511	03894	1.1149
Detroit CMSA	20.259	20.259	4.629	0.679	0.067	10.236	76.047	250.4X3	0.0009	0.2443	1.8635	5335 t
Grand Rapids, Mich.	20.259	20.259	0.657	0.679	<i>0.010</i>	1.453	10.793	35.547	0.0001	0.0347	0.2645	0.7572
Indianapolis, Ind.	16.17	16.17	1.229	0.850	0.022	3.405	25.296	83.309	0.0003	0.0813	0.6199	1.7747
Kewaunee County, Wis.	17.995	17.995	0.02	0.764	0.000	0.050	0370	1.218	0.0000	0.0012	0.0091	0.02641
Lafayette-West Lafayette, Ind.	16.17	16.17	0.0442	0.850	0s301	0.122	0.910	2.996	0.0000	0.0029	0.0223	0.0638

TABLE A.4 (Cent'd)

Metropolitan Area	Off-Peak Marginal Cost (mils/kWh)		1987 Population (10 ⁶)	Marginal Cost Factor	Fleet Totals by Year (thousands of EVs)				Daily Energy Requirement by Year (GWh/d)			
	Lrrw	High			1995	2000	2005	2010	1995	2000	2005	2010
Milwaukee CMSA	17.995	17.995	1.562	0.764	0.026	3.888	28.890	95.144	0.0003	0.0928	0.7079	2.0268
Muskegon, Mich.	20.259	20.259	0.0398	0.679	0.001	0.088	0.654	2.153	0.0009	0.0021	0.0160	0.0459
Sheboygan, Wis.	17.995	17.995	0.0474	0.764	0.001	0.118	0.877	2.887	0.000	0.0328	0.0215	0.0615
South Bend-Mishawaka, Ind.	18.687	18.687	0.107	0.736	0.002	0.257	1.906	6.276	0.0000	0.0061	0.0467	0.1337
Toledo, Ohio	15.53	15.53	0.611	0.885	0.012	1.762	13.094	43.124	0.0002	0.0421	0.3209	0.9186
Youngstown, Ohio-Penn. (inc. Sharon, Penn.)	15.53	15.53	0.503	0.885	0.010	1.451	10.780	35.502	0.0001	0.0346	0.2642	0.7563
Baton Rouge, La.	18.679	18.679	0.538	0.736	0.008	1.290	9.586	31.570	0.0001	0.0308	0.2349	0.6725
Beaumont-Port Arthur, Texas	18.679	18.679	0.371	0.736	0.006	0.890	6.610	21.771	0.0001	0.0212	0.1620	0.4638
Dallas CMSA	14.588	19.179	3.727	0.814	0.065	9.889	73.470	241.963	0.0009	0.2360	1.8004	5.1543
El Paso, Texas	7.569	10.426	0.573	1.528	0.019	2.853	21.196	69.805	0.0003	0.0681	0.5194	1.4870
Houston CMSA	14.588	19.179	3.626	0.814	0.063	9.621	71.479	235.406	0.0009	0.2297	1.7516	5.0146
Lake Charles, La.	18.679	18.679	0.0734	0.736	0.001	0.176	1.308	43.07	0.0000	0.0042	0.0320	0.0918
Tulsa, Okla.	18.631	18.631	0.733	0.738	0.012	1.762	13.094	43.124	0.0002	0.0421	0.3209	0.9186
Kansas City, Mo.-Kans.	15.969	15.969	1.546	0.861	0.028	4.337	32.221	106.117	0.0004	0.1035	0.7896	2.2605
St. Louis, Mo.-Ill.	16.967	16.967	2.458	0.810	0.043	6.490	48.216	151.770	0.0006	0.1549	1.1815	3.3626
Salt Lake City-Ogden, Utah	12.405	13.222	1.055	1.073	0.024	3.688	27.403	90.248	0.0003	0.0880	0.6715	1.9225
Bakersfield, Calif.	7.38	12.302	0.505	1.397	0.015	2.299	17.079	56.248	0.0002	0.0549	0.4185	1.1982
Fresno, Calif.	7.3a	12302	0.597	1.397	0.018	2.718	20.191	66.495	0.0002	0.0649	0.4948	1.4165
Los Angeles CMSA	7.3a	12302	13.471	1.397	0.403	61321	455.589	1500.417	0.0055	1.4637	11.1642	31.9618
Modesto, Calif.	7.38	12302	0.327	1.397	0.010	1.489	11.059	36.422	0.0001	0.0355	0.2710	0.7759
Phoenix, Ariz.	7.569	10.426	1.0%	1.528	0.064	9.758	72501	238.773	0.0009	0.2329	1.7766	5.0863
Sacramento, Calif.	7.38	12302	1.336	1.397	0.040	6.082	45.184	148.805	0.0005	0.1452	1.1072	3.1698
San Diego, Calif.	7.38	12302	2.286	1.397	0.068	10.406	77.312	254.618	0.0009	0.2484	1.8945	5.4239
San Francisco, Calif.	7.38	12.302	5.953	1.397	0.178	27.098	201330	663.053	0.0024	0.6468	4.9336	14.1243
Santa Barbara-Santa Maria-Lompoc, Calif.	7.38	12302	0.341	1.397	0.010	1.552	11.533	37.981	0.0001	0.0371	0.2826	0.8091
Stockton, Calif.	7.38	12302	0.443	1.397	0.013	2.017	14.982	49.342	0.0002	0.0481	0.3671	1.0511

TABLE A.4 (Cent'd)

Metropolitan Area	Off-Peak Marginal Cost (mils/kWh)		1987 Population (10 ³)	Marginal Cost Factor	Fleet Totals by Year (thousands of EVs)				Daily Energy Requirement by Year (GWh/d)			
	Low	High			1995	2000	2005	2010	1995	2000	2005	2010
Visalia-Tulare-Porterville, Calif.	7.38	12302	0.292	1.397	0.009	1329	9.875	32.523	0.0001	0.0317	0.2420	0.6928
Portland CMSA	9.735	13.879	1.383	1.164	0.034	5.247	38.985	128.391	0.(XX)5	0.1253	0.9553	2.7350
Total					3.200	487.200	3619.701	11921.0	0.0437	11.6296	88.7004	253.9400
Target					3.2	487.2	3619.7	11921.0	0.0437	11.62%	88.7004	253.9400
Map Factor					0.0214	3.25836	24.20829	79.7265				

TABLE A.5 Nine-City Electric and Hybrid Vehicle Distribution and Electricity Use

Metropolitan Area	Off-Peak Marginal Cost (mils/kWh)		1987 Population (10 ⁶)	Marginal cost Factor	Fleet Totals by Year (thousands of EVs)				Daily Energy Requirement by Year (GWh/d)			
	Low	High			1995	2000	2005	2010	1995	2000	2005	2010
Hartford CMSA	7.62	20.7	1.06	0.92	0.05	7.48	31.56	94.29	0.0007	0.1668	0.6642	1.8387
New York CMSA	15.061	21.074	18.1	0.72	0.67	100.13	422.37	1261.84	0.0392	2.2318	8.8886	24.6069
Baltimore, Md.	7.556	15.061	2.3	1.15	0.14	20.33	85.75	256.18	0.0019	0.4531	1.8046	4.9957
Philadelphia CMSA	7.556	15.061	5.89	1.15	0.35	5206	219.60	656.05	0.0048	1.1603	4.6213	12.7934
Chicago CMSA	7.709	7.709	8.15	1.69	0.71	105.67	445.73	1331.63	0.0097	2.3552	9.3802	25.9678
Milwaukee CMSA	17.995	17.995	1.56	0.72	0.06	8.66	36.55	109.19	0.0008	0.1931	0.7692	2.1294
Houston CMSA	14.588	19.179	3.63	0.77	0.14	21.49	90.65	270.81	0.0020	0.4790	1.9076	5.2810
Los Angeles CMSA	7.38	12.302	13.5	1.32	0.92	137.11	578.38	1727.90	0.0126	3.0561	12.1716	33.6954
San Diego, Calif.	7.38	12.302	2.29	1.32	0.16	23.26	98.11	293.10	0.0021	0.5184	2.0647	5.7157
Total					3.20	476.20	2008.70	6001.00	0.0437	10.6137	42.2720	117.0240
Target					3.2	476.2	2008.7	6001	0.0437	10.6137	42.2720	117.0240
Map Factor					0.0516	7.6811	32.4003	96.7961				

TABLE A.6 Daily Electricity Requirements

Scenario	Basis and Units	EV (d.c.)		EV (a.c.)			HV			EV Car, Adv. Batt.	Total EHv Fleet
		Pb-A, Van	Ni Fe, Van	Ni Fe, Van	Ni Fe, Truck	Ni Fe, Car	Ni Fe, Van	Ni Fe, Truck	Ni Fe, Car		
Nine-City	Per Vehicle* (kWh/d)	13.3	24.4	24.4	24.4	20.9				17.4	
	Fleet by Year (MWh/d)										
	1995	41.23	2.44	0	0	0				0	43.67
	2000	54.53	514.84	3,684.4	4,270	2,090				0	10,613.8
	2005	21.28	148.84	9,784.4	16,470	14,107.5				1,740	42,272
2010	0	0	7344.4	9,760	45,980				53,940	117,024	
101-City	Per Vehicle* (kWh/d)	13.3	24.4	24.4	24.4	20.9	36.9	36.9	13.7	17.4	
	Fleet by Year (MWh/d)										
	1995	41.23	2.44	0	0	0	0	0	0	0	43.67
	2000	54.53	514.84	3,684.4	4,860	2,090	405.9	0	0	0	11,629.7
	2005	21.28	148.84	9,784.4	17,080	16,720	18,855.9	14,760	9,590	1,740	88,700.4
2010	0	0	7,344.4	9,760	45,980	44,685.9	44,280	47,950	53,940	253,940	

* From Hamilton, Table 3.2.

TABLE A.2 All-City Electric Vehicle Distribution and Electricity Use

Metropolitan Area	Off-Peak Marginal Cost (mils/kWh)		1987 Population (10 ⁶)	Marginal Cost Factor	Fleet Totals by Year (thousands of EVs)				Daily Energy Requirement by Year (GWh/d)			
	Low	High			1995	2000	2005	2010	1995	2000	2005	2010
Albany-Schenectady-Troy, N.Y.	15.061	21.074	0.846	0.803	0.012	1.796	13.345	43.951	0.0002	1.0429	0.3270	0.9362
Albuquerque, N.M.	18.631	18.631	0.486	0.779	0.007	1.001	7.434	24.485	0.0001	0.0239	0.1822	0.5216
Allentown-Allentown, Penn.	7.556	15.061	0.666	1.283	0.015	2.259	16.785	55.279	0.0002	0.0539	0.4113	1.1776
Appleton-Oshkosh-Neenah, Wis.	17.995	17.995	0.309	0.806	0.004	0.659	4.894	16.118	0.0001	0.0157	0.1199	0.3433
Atlanta, Ga.	18.631	18.631	2.657	0.779	0.036	5.471	40.645	133.860	0.0005	0.1306	0.9960	2.8515
Atlantic City, N.J.	7.5	15.061	0.303	1.283	0.007	1.028	7.636	25.150	0.0001	0.0245	0.1871	0.5357
Bakersfield, Calif.	7.3H	12.302	0.505	1.475	0.013	1.969	14.625	48.167	0.0002	0.0470	0.3584	1.0260
Baltimore, Md.	7.556	15.061	2.303	1.283	0.051	7.813	58.041	191.154	0.0007	0.1865	1.4223	4.0719
Baton Rouge, La.	18.679	18.679	0.538	0.777	0.007	1.105	8.209	27.035	0.0001	0.0264	0.2012	0.5759
Beaumont-Port Arthur, Texas	18.679	18.679	0.371	0.777	0.005	0.762	5.661	18.643	0.0001	0.0182	0.1387	0.3971
Binghamton, N.Y.	15.061	21.074	0.26	0.803	0.004	0.552	4.101	13.807	0.0000	0.0132	0.1005	0.2877
Birmingham, Ala.	18.631	18.631	0.917	0.779	0.012	1.888	14.027	46.198	0.0002	0.0451	0.3437	0.9841
Boston CMSA	7.62	20.7	4.093	1.025	0.073	11.089	82.381	271.314	0.0010	0.2647	2.0188	5.7795
Brownsville-Harlingen, Texas	14.888	19.179	0.264	0.860	0.004	0.600	4.4	14.677	0.0001	0.0143	0.1092	0.3126
Buffalo CMSA	15.061	21.074	1.175	0.803	0.016	2.495	18.535	61.043	0.0002	0.05%	0.4542	1.3003
Canton, Ohio	18.687	18.687	0.397	0.777	0.005	0.815	6.055	19.941	0.0001	0.0195	0.1484	0.4248
Charleston, S.C.	7.534	7.534	0.502	1.926	0.017	2.556	18.9%	62.542	0.0002	0.0610	0.4654	1.3323
Charleston, W.Va.	18.687	18.687	0.261	0.777	0.004	0.536	3.981	13.110	0.0000	0.0128	0.0975	0.2793
Charlotte-Gastonia-Rock Hill, N.C.	7.534	7.534	1.09	1.926	0.036	5.550	41.733	135.798	0.0005	0.1325	1.0104	2.8928
Chattanooga, Tenn.	7.534	7.534	0.432	1.926	0.014	2.200	16.342	53.821	0.0002	0.0525	0.4005	1.1465
Chicago CMSA	7.709	7.709	8.147	1.883	0.266	40.544	301.194	991.959	0.0036	0.9%	7.3808	21.1305
Cincinnati CMSA	19.666	19.666	1.715	0.738	0.022	3.346	24.854	81.854	0.0003	0.0799	0.6091	1.7436
Cleveland CMSA	15.53	15.53	2.767	0.934	0.045	6.835	50.779	167.237	0.0006	0.1631	1.2444	3.5624
Colorado Springs, Colo.	12.405	13.222	0.39	1.133	0.008	1.168	8.674	28.9%	0.0001	0.0279	0.2126	0.6086
Columbia, S.C.	7.534	7.534	0.451	1.926	0.015	2.297	17.061	56.188	0.0002	0.0548	0.4181	1.19%

TABLE A.7 (Cent'd)

Metropolitan Area	Off-Peak Marginal Cost (mils/kWh)		1987 Population (10 ⁶)	Marginal Cost Factor	Fleet Totals by Year (thousands d EVS)				Daily Energy Requirement by Year (GWh/d)			
	Low	High			1995	2000	2005	2010	1995	2000	2005	2010
Columbus, Ohio	18.687	18.687	1.32	0.777	0.018	2.710	20.132	66302	0.0002	0.0647	0.4933	1.4124
Corpus Christi, Texas	14.588	19.179	036	0.860	0005	0.818	6.077	20.014	0.0001	0.0195	0.1489	0.4263
Dallas CMSA	14.588	19.179	3.727	0.860	0.0%	8.469	62.913	207.200	0.0008	0.2021	1.5417	4.4137
Davenport-Rock Island-Moline, Iowa-Ill.	12.87	13.5	0.367	1.101	0.007	1.068	7.933	26.126	0.0001	0.0255	0.1944	0.5565
Dnyton-Springfield, Ohirr	19.666	19.666	0.939	0.738	0.012	1.832	13.608	44.817	0.0002	0.0437	0.3335	0.9547
Daytona Beach, Fla.	18.687	1 8.687	0332	0.777	0.004	0.682	5.063	16.676	0.0001	0.0163	0.1241	0.3552
Denver-Boulder CMSA	12.405	13.222	1.861	1.133	0.037	5.572	41.393	136.324	0.0005	0.1330	1.0143	2.9040
Des Moines, Iowa	12.87	13.5	0.385	1.101	0.007	1.120	8322	27.408	0.0001	0.0267	0.2039	0.5838
Detroit CMSA	20.259	20.259	4.629	0.716	0.058	8.766	65.120	214.468	0.0008	0.2092	1.5958	4.5686
El Paso, Texas	7.569	10.426	0.573	1.613	0.016	2.443	18.150	59.776	0.0002	0.0583	0.4448	1.2733
Eric, Penn.	7.556	15.061	0.279	1.283	0.006	0.947	7.031	23.158	0.0001	0.0226	0.1723	0.4933
Eugene-Springfield, Ore.	9.735	13.(179	0.265	1.229	0.006	0.861	6.397	21.067	0.0001	0.0206	0.1568	0.4488
Evansville, Ind.-Ky.	16.17	16.17	0.281	0.898	0.004	0.667	4.953	16.311	0.0001	0.0159	0.1214	0.3475
Fayetteville, N.C.	7.534	7.534	0.259	1.926	0.009	1.319	9.798	32.268	0.0001	0.0315	0.2401	0.6874
Flint, Mich.	20.259	20.259	0.435	0.716	0.005	0.824	6.120	20.154	0.0001	0.0197	0.1500	0.4293
Fort Myers-Cirpc Coral, Fla.	22.919	23.74	0.295	0.622	0.003	0.485	3.604	11.869	0.0000	0.0116	0.0883	0.2528
Fort Wayne, Ind.	18.687	18.687	0364	0.777	0.005	0.747	5.551	18.283	0.0001	0.0178	0.1360	0.3895
Fresno, Calif.	738	12302	0-597	1.475	0.015	2.327	17.289	56.942	0.0002	0.0555	0.4237	1.2130
Grand Rapids, Mich.	20.259	20.259	0.657	0.716	0.008	1.244	9.243	30.440	0.0001	0.0297	0.2265	0.6484
Greensboro-Winston Salem-High Point, N.C.	7534	7.534	0.916	1.926	0.031	4.664	34.651	114.121	0.0004	0.1113	0.8491	2.4310
Greenville-Spartenburg, S.C.	7534	7.534	0.612	1.926	0.020	3.116	23.151	76.246	0.0003	0.0744	0.5673	1.6242
Harrisburg-Lebanon-Carlisle, Penn.	7.556	15.061	0.584	1.283	0.013	1.981	14.718	48.473	0.0002	0.0473	0.3607	1.0326
Hartford CMSA	7.62	20.7	1.056	1.725	0.019	2.861	21.254	69.999	0.0003	0.0683	0.5208	1.4911
Houston CMSA	14.538	19.179	3.626	0.860	0.054	8.239	61.209	201.585	0.0007	0.1967	1.4999	4.2941

TABLE A.7 (Cent'd)

Metropolitan Area	Off-Peak Marginal Cost (mils/kWh)		1987 Population (10 ⁶)	Marginal Cost Factor	Fleet Totals by Year (thousands of EVs)				Daily Energy Requirement by Year (GWh/d)			
	Low	High			1995	2000	2005	2010	1995	2000	2005	2010
Huntington-Ashland, W.Va.-Ky.-Ohio	18.687	18.687	0.323	0.777	0.004	0.663	4.926	16.22	0.0001	0.0158	0.1207	0.3456
Indianapolis, Ind.	16.17	16.17	1.229	0.898	0.019	2.916	21.661	71.340	0.0003	0.0696	0.5308	1.5197
Jackson, Miss.	18.679	18.679	0.396	0.777	0.005	0.813	6.042	19.899	0.0001	0.0194	0.1481	0.4239
Jacksonville, Fla.	7.534	7.534	0.878	1.926	0.029	4.471	33.214	109.386	0.0004	0.1067	0.8139	2.3301
Johnson City-Kingsport-Bristol, Tenn.-Va.	7.586	7.586	0.443	1.913	0.015	2.240	16.643	54.813	0.0002	0.0535	0.4078	1.1676
Johnstown, Penn.	7.556	15.061	0.252	1.283	0.006	0.855	6.351	20,917	0.0001	0.0204	0.1556	0.4456
Kansas City, Mo.-Kans.	15.969	15.969	1.546	0.909	0.024	3.714	27.592	90.871	0.0003	0.0886	0.6761	1.9357
Knoxville, Tenn.	7.586	7.586	0.594	1.913	0.020	3.004	22.316	73.497	0.0003	0.0717	0.5469	1.5656
Lakeland-Winter Haven, Fla.	7.534	7.534	0.387	1.926	0.013	1.971	14.640	48.215	0.0002	0.0470	0.3587	1.0271
Lancaster, Penn.	7.556	15.061	0.404	1.283	0.009	1.371	10.182	33.533	0.0001	0.0327	0.2495	0.7143
Las Vegas, Nev.	13.549	33.904	0.6	0.612	0.006	0.970	7.207	23.736	0.0001	0.0232	0.1766	0.5056
Lexington-Fayette, Ky.	16.185	16.185	0.342	0.897	0.005	0.811	6.022	19.834	0.0001	0.0193	0.1476	0.4225
Little Rock-N. Little Rock, Ark.	14.588	19.179	0.512	0.860	0.008	1.163	8.643	28.464	0.0001	0.0278	0.2118	0.6063
Los Angeles CMSA	7.38	12.302	13.471	1.475	0.345	52.516	390.128	1284.856	0.0047	1.2534	9.902	27.3698
Louisville, Ky.-Ind.	16.185	16.185	0.967	0.897	0.015	2.292	17.028	56.080	0.0002	0.0547	0.4173	1.1946
Macon-Warner Robbins, Ga.	18.631	18.631	0.28	0.779	0.004	0.577	4.283	14.106	0.0001	0.0138	0.1050	0.3005
Madison, Wis.	17.995	17.995	0.347	0.806	0.005	0.740	5.496	18.100	0.0001	0.0177	0.1347	0.3856
McAllen-Edinburg-Mission, Texas	14.588	14.588	0.379	0.995	0.007	0.997	7.404	24.386	0.0001	0.0238	0.1814	0.5195
Melbourne-Titusville-Palm Bay, Fla.	22.519	23.74	0.375	0.622	0.004	0.617	4.581	15.088	0.0001	0.0147	0.1123	0.3214
Memphis, Tenn.-Ark.-Miss.	7.586	7.586	0.972	1.913	0.032	4.916	36.517	120.267	0.0004	0.1173	0.8949	2.5619
Miami CMSA	22919	23.74	2.954	0.622	0.032	4.858	36087	118.850	0.0004	0.1159	0.8843	2.5317
Milwaukee CMSA	17.995	17.995	1.562	0.806	0.022	3.330	24.739	81.475	0.0003	0.0795	0.6062	1.7356
Minneapolis-St. Paul, Minn.	12.87	13.5	2.336	1.101	0.045	6.797	50.494	166.298	0.0006	0.1622	1.2374	3.5424
Mobile, Ala.	18.631	18.631	0.483	0.779	0.007	0.995	7.389	24.334	0.0001	0.0237	0.1811	0.5183

TABLE A.7 (Cent'd)

Metropolitan Area	Off-Peak Marginal Cost (mils/kWh)		1987 Population (10 ⁶)	Marginal Cost Factor	Fleet Totals by Year (thousands of EVs)				Daily Energy Requirement by Year (GWh/d)			
	Low	High			1995	2000	2005	2010	1995	2000	2005	2010
Modesto, Cal if.	7.38	12.302	0.327	1.475	0008	1.275	9.470	31.189	(1.0001	0.0304	0.2321	0.6644
Montgomery, Ala.	18.631	18.631	0.297	0.779	0.004	0.612	4.543	14.963	0.0001	0.0146	0.1113	0.3187
Muskegon, Mich.	20.259	20.259	0.0398	0.716	0.000		0.560	1.844	0.0000	0.0018	0.0137	0.0393
New Haven-Meriden, Conn.	7.62	20.7	0.519	1.025	0.009	1.406	10.446	34.403	0.0001	0.0336	0.2560	0.7328
New London-Norwich, Conn.-R.I.	7.62	20.7	0.259	1.025	0.005	0.702	5.213	17.168	0.0001	0.0167	0.1277	0.3657
New Orleans, La.	18.679	18.679	1.321	0.777	0.018	2.713	20.156	66.381	0.0002	0.0648	0.4939	1.4140
New York CMSA	15.061	21.074	18.054	0.803	0.252	38.336	284.788	937.927	0.0034	0.9150	6.9788	19.9796
Norfolk-Virginia Beach- Newport News, Va.	7.534	7.687	1.346	1.907	0.045	6.785	50.406	166.07	0.0006	0.1619	1.2352	3.5362
Oklahoma City, Okla	18.631	18.631	0.975	0.779	0.013	2.008	14.915	49.120	0.0002	0.009	0.3655	1.0464
Omaha, Neb.-Iowa	12.87	13.5	0.616	1.101	0.012	1.792	13.315	43.853	0.0002	0.0428	0.3263	0.9341
Orlando, Fla.	22.919	23.74	0.935	0.622	0.010	1.538	11.422	37.618	0.0001	0.0%7	0.2799	0.8013
Pensacola, Fla.	22.919	23.74	0.344	0.622	0.004	0.566	4.202	13.840	0.0001	0.0135	0.1030	0.2948
Peoria, Ill.	16.967	16.967	0.339	0.855	0.005	0.767	5.694	18.754	(1.0001	0.0183	0.1395	0.3995
Philadelphia CMSA	7.556	15.061	5.89	1.283	0.131	19.982	148.442	488.882	0.0018	0.4769	3.6376	10.4141
Phoenix, Ariz	7.569	10.426	1.0	1.613	0.055	8.357	62.084	204.469	0.0007	0.1995	1.5214	4.3556
Pittsburgh CMSA	15.53	15.53	2.296	0.934	0.037	5.672	42.135	138.770	0.0005	0.1354	1.0325	2.9560
Portland CMSA	9.735	13.879	1.383	1.229	0.020	4.494	33.383	109.945	0.0004	0.1073	0.8181	2.3420
Poughkeepsie, N.Y.	15.061	21.074	0.253	0.803	0.004	0.548	4.070	13.403	0.0000	0.0131	0.0997	0.2855
Providence CMSA	7.62	20.7	1.118	1.025	0.020	3.029	22.502	74.109	0.0003	0.0723	0.5514	1.5787
Raleigh-Durham, N.C.	7.534	7.534	0.665	1.926	0.022	3.386	25.156	82.849	0.0003	0.0808	0.6165	1.7648
Reading, Penn.	7.556	15.061	0.324	1.283	0.007	1.099	8.166	26.893	0.0001	0.0262	0.2001	0.5729
Richmond-Petersburg, Va.	7.534	7.6x7	0.825	1.907	0.027	4.159	30.895	101.750	0.0004	0.0993	0.7571	2.1675
Rochester, N.Y.	15.061	21.074	0.979	0.803	0.014	2.079	15.443	50.860	0.0002	0.0496	0.3784	1.0834
Rockford, Ill.	7.709	7.709	0.281	1.883	0.009	1.398	10.389	34.214	0.0001	0.0334	0.2546	0.7288
Sacramento, Calif.	7.38	12.302	1.336	1.475	0.034	5.208	38.691	127.427	0.0005	0.1243	0.9481	2.7144

TABLE A.7 (Cont'd)

Metropolitan Area	Off-Peak Marginal Cost (mils/kWh)		1987 Population (10 ⁶)	Marginal Cost Factor	Fleet Totals by Year (thousands Of EVs)				Daily Energy Requirement by Year (GWh/d)			
	Low	High			1995	2000	2005	2010	1995	2000	2005	2010
Saginaw-Bay C@-Midland, Mich.	2(3.259	20.259	t)-404	0.716	0.005	0.765	5.683	18.718	0.0001	0.0183	0.1393	03987
St. Louis, Mo.-Ill.	12.405	13.222	2.458	1.133	0.048	7359	54.671	180.056	0.0007	0.1757	1.3397	3.8355
Salem, Ore.	10.163	13..549	0.266	1.224	0.006	0.861	6394	21.059	0.0001	0.0205	0.1567	0.4486
Salinas-Seaside-Monterey, Calif.	738	12302	0343	1.475	0.009	1.337	9.933	32.715	0.0001	0.0319	0.2434	0.6969
Salt Lake City-Ogden, Utah	12.302	13.222	1.055	1.137	0.021	3.171	23860	77.594	0.0003	0.0757	0.5773	1.6529
San Antonio, Texas	14.5813	19.179	1.307	0.860	0.020	2.970	22.063	72.662	0.0003	0.0709	0.5407	1.5478
San Diego, Calif.	7.38	12.302	2.286	1.475	0.059	8.912	66.204	218.037	0.0008	0.2127	1.6223	4.6446
San Francisco, Calif.	7.3n	12302	5.95	1.475	0.152	23.196	172.316	567.507	0.0021	0.5536	4.2226	12.0889
Santa Barbara-Santa Maria-Lompoc, Calif.	7.38	12.302	ft341	1.475	0.009	1.379	9.876	32.524	0.0001	0.0317	0.2420	0.6928
Sarasota, Fla.	22.919	23.74	0.256	0.622	0.003	0.421	3.127	10.300	0.0000	0.0100	0.0766	0.2194
Scranton-Wilkes-fktrrc, Penn	7.556	15.061	0.731	1.283	0.016	2.480	18.423	60.675	0.0002	0.0592	0.4515	1.2925
Seattle CMSA	10.163	13.549	2341	1.224	0.050	7.575	56.274	185.335	0.0007	0.1808	1.3790	3.9480
Shreveport, La.	18.679	18.679	0364	0.777	0.005	0.748	5.554	in.291	0.0001	0.0178	0.1361	0.3896
Spokane, Wash.	10.163	13.549	0.355	1.224	0.008	1.149	8.534	28.105	0.0001	0.0274	0.2091	0.5987
Springfield, Mass.	7.62	20.7	0.517	1.025	0.009	1.401	10.406	34.271	0.0001	0.0334	0.2550	0.7300
Stockton, Calif.	738	12.242	0.443	1.475	0.011	1.727	12.830	42.253	0.0002	0.0412	03144	0.9001
Syracuse, N.Y.	15.061	21.074	0.443	0.803	0.006	0.941	6.988	23.014	0.0001	0.0225	0.1712	0.4902
Tampa-St. Petersburg-Clearwater, Fla.	22.919	23.74	1.965	0.622	0.021	3.231	24.005	79.059	0.0003	0.0771	0.5883	1.6841
Toledo, Ohio	15.53	15.53	0.611	0.934	0.010	1.509	11.213	36.929	0.0002	0.0360	0.2748	0.7866
Tucson, Ariz.	7.569	10.426	0.619	1.613	0.017	2.639	19.607	64.575	0.0002	0.0630	0.4805	13756
Tulsa, Okla.	18.631	18.631	0.733	0.779	0.010	1.509	11.213	36.929	0.0001	0.0360	0.2748	0.7866
Utica-Rome, N.Y.	15.061	21.074	0314	0.803	0.004	0.667	4.953	16.313	0.0001	0.0159	0.1214	03475
Visalia-Tulare-Porterville, Calif.	738	12302	0.292	1.475	0.007	1.138	8.456	27.851	0.0001	0.0272	0.2072	0.5933

TABLE A.7 (Cent'd)

Metropolitan Arm	Off-Peak Marginal Coat (mils/kWh)		1987 Population (10 ⁶)	Marginal Cost Factor	Fleet Totals by Year (thousands of EVS)				Daily Energy Requirement by Year (GWh/d)			
	Low	High			1995	2000	2005	2010	1995	2000	2005	2010
Washington, D.C.-Md.-Va.	7556	15.061	3.646	1.283	0.081	12.369	91.888	302.626	0.0011	0.2952	2.2517	6.4465
West Palm Beach-Boca Raton- Delray Beach, Fla.	22.919	23.74	0.79	0.622	0.009	1.299	9.651	31.785	0.0001	0.0310	0.2365	0.6771
Wichita, Kans.	15.969	15.969	0.47s	0.909	0.007	1.141	8.477	27.920	0.0001	0.0277	0.2077	0.5947
Worcester, Mass.	7.62	20.7	0.41	1.025	0.007	1.111	8.252	27.178	11.0001	0.0265	0.2022	0.5789
York, Penn.	7.556	15.061	0.404	1.283	0.009	1.371	10.182	33.533	0.0001	0.0327	0.2495	0.7143
Youngstown-Warren, Ohio	15.53	15.53	0.503	0.934	0.008	1.243	9.231	34.401	0.0001	0.0297	0.2262	0.6476
Total					3.200	487.2	3619.7	11921.0	0.0437	11.6296	88.7(D4	253.9400
Target					3.2	487.2	3619.7	11921	0.0437	11.6296	88.7004-	253.9400
Map Factor					0.01736	2.6435	19.638	64.6762				