SECTION I

CURRENT AND PROJECTED ENERGY NEEDS IN THE BAY AREA

Richard Stouffer, Tom Volken

Introduction

Historically, energy use in the Bay Area has been steadily increasing. These needs have been met through the utilization of several sources. What direction these trends take in the future is the main focus of this opening section.

Our first objective will be to review current and projected population levels for the Bay Area, since these are of primary importance in determining energy demand. Next we will examine the current pattern of energy use--how much energy we are using, where it comes from, and who the end users are. This is important not only in viewing the current situation, but also in studying future consumption patterns, since any change in energy demand will involve changes in the systems employed to meet current needs. Finally we will discuss future energy demand projections, and the assumptions involved in their determination.

Population and Projections

In attempting to project future energy use in the Bay Area, it is necessary to consider the expected population growth. Population projections for the region have been calculated by several agencies or groups: Department of Finance (DOF), State Energy Commission (SEC), Pacific Gas and Electric (PG&E), Association of Bay Area Governments (ABAG), and Stanford Research Institute (SRI). These agencies or groups apply various demographic and economic assumptions to a present or baseline population figure in order to obtain figures for future population levels.

Population projections for the Bay Area have been made for ten, fifteen, and twenty year intervals. The fifteen year period which we have decided to use, from 1975 (baseline) to 1990 (projected), was sufficient to probe the future while still maintaining a relevance to the immediate state of affairs.

The 1990 projections by the above groups were all within 2% of each other. After comparing these figures we decided to use ABAG's Series III projections, which were the most recent figures available for our study. Table 1 summarizes ABAG's Series III projections for 1990 and the assumptions on which these projections are based.

ABAG projects both high (Case I) and low (Case II) population levels on the basis of different assumptions about fertility, mortality, and net (in)migration.

Fertility--All projections surveyed used varying fertility rates. They ranged from a high of 2.8 (DOF)[5] to a low of a 1.5 (ABAG-Series III).[2] However, over the fifteen year period this rate is expected to show a gradual decline.

Mortality--The death rates for the Bay Area and California have not varied appreciably in the past two decades. The age-specific mortality rates are therefore assumed to improve slightly with a negligible effect on future populations projection figures.

Migration--Net (in)migration has varied up to 85% since 1960 (SRI).[7] In 1960 net (in)migration was at a high of 357,000, and in 1970 was at a low of 16,000. This trend is expected to level off and possibly rise over the next fifteen years. We assumed a net (in)migration of 20,000 per year.

The ABAG Series III projections are based on a 1975 Bay Area population of 4,829,151 and a state population of 21,215,000. The projected population for the Bay Area in 1990 is 5,621,941 and for the state is 25,025,000. The regional figure shows an overall 12% increase in the fifteen year period.

Population projections are not an exact science and should not be considered as concrete values for future population levels. The figures presented are not predictions of things to come, but rather are calculations of what would occur if the basic assumptions of the respective projections series are valid. The numbers are only as accurate as the assumptions underlying them.

It is also necessary to state the obvious, that the projections assume no catastrophic developments, no wars, no famine, earthquakes, etc. Although implicit in all projections is an assumption of changing technology, it is very likely that a collapse in the expected supply of energy would significantly change the distribution of the population from that which is projected. The restrictions resulting from the energy shortage of 1973-1974 are not yet sufficiently clear to speculate on their effects. It is entirely possible that severe shortages of energy will discourage the spread of population and encourage greater concentration of population, but within the scope of this study, such speculation is probably premature.

Present Energy Demand in the Bay Area

Determining the amount of energy that each source provides to the Bay Area is a difficult, if not impossible, task. Little data is available for the Bay Area region. Electricity generated from many sources in Northern California is fed into a statewide network, and therefore serves an area much larger than the Bay Area. Figures for the use of petroleum products in the Bay Area as a unit or by county are also scarce, for no agency is at present responsible for compiling these figures.

Table 2 summarizes energy consumption in the Bay Area in 1975. Discrepancies in available data are noted below.

Though some electricity is consumed by the transportation sector (BART, S.F. Municipal Railway), these amounts are negligible in comparison with petroleum usage, and have therefore been excluded. Also, petroleum

ASSUMPTION	A.B.A.G.
Fertility	Base Case Level I = 1.8 II = 1.5
Migration	I = 35,000/yr II = 10,000/yr both figures showing yearly decline. Bay Area
Mortality	I & II assume a slight decrease over a 15 year period
1975 Baseline figures for Bay Area	4,829,151
Projected 1990 population	I = 5,621,941 II = 5,283,702

Source: ABAG Series III, 1977

Base Case I - high assumptions
Base Case II - low assumptions

Table 1. ABAG population projections and assumptions

figures for transportation reported by the Bay Area Air Pollution Control District[3] are notably lower than those reported by the Stanford Research Institute.[8] Specifically, the BAAPCD gives the 1975 figure of 311.7×10^{12} Btu for transportation use, while SRI figures are 426.7×10^{12} Btu for 1971, and a projected 519.9×10^{12} for 1975. Also, BAAPCD reports no petroleum usage in the residential and commercial sector for 1975, while Behrin and Cooper (in California Energy Outlook, 1976)[4] report statewide petroleum usage in these sectors totalling 87×10^{12} Btu for 1973. This doesn't necessarily present a contradiction, yet to assume that all petroleum consumption in these sectors occurred outside the Bay Area is unlikely. We therefore point out that the consumption levels noted in Table 2 are minimum values, while actual usage, due to higher petroleum consumption, is probably greater than the levels indicated.

Trends in Energy Supply

As stated earlier, there exists a lack of reliable data on energy supply in the Bay Area. Only when we shift our focus to a larger area, the state of California, can we obtain more complete information on the

		amount	% of total
Transportation			
	electricity	---	
	gas	---	
	petroleum	311.7	
	total	311.7	28.6%
Commercial			
	electricity	40.3	
	gas	54.0	
	petroleum	---	
	total	94.3	8.6%
Industrial			
	electricity	25.3	
	gas	185.9	
	petroleum	115.7	
	total	327.1	30.0%
Residential			
	electricity	31.5	
	gas	184.8	
	petroleum	---	
	total	216.3	19.8%
Other (agriculture, government, miscellaneous)			
	electricity	9.0	
	gas	90.2	
	petroleum	42.0	
	total	141.2	12.9%
Total		1090.6	100.0%

Figures for electricity and gas are from Quarterly Fuel and Energy Summary, California ERCDC, 1976.[6]
Petroleum figures are from Emissions Inventory Summary Report, BAAPCD, 1976.[3]

Table 2. Bay Area Energy Use in 1975 (10^{12} Btu).

amounts of energy that each source supplies. Naturally, the relative importance of each source with respect to California may vary from its relative value in the Bay Area. Nonetheless, the Bay Area represents a considerable portion of California, and similar types of sources are utilized. Therefore, regarding the relative importance of each source to the total energy supply, we assume a fair degree of similarity between California and Bay Area patterns.

Table 3 lists present and projected trends of supply for California. Worthy of note are the percentage declines shown for fossil fuels. Despite this, actual amounts used show a marked increase, contrary to warnings of dwindling supplies and rising prices. Similarly, we see increases in all other supplies with coal and solar rapidly becoming more significant sources. Reasons for these trends are included in the underlying assumptions, fundamental to any such projections. The following assumptions are those made by Behrin and Cooper (California Energy Outlook, 1976) in preparing Table III. In some cases we felt they required a brief comment which we have included along with the assumptions.

	1973	1985	2000
petroleum (excluding exports)	3119 (55.2%)	3976 (54.7%)	4933 (45.3%)
natural gas	2187 (38.7%)	2396 (33.0%)	3786 (34.8%)
hydroelectric	122 (2.2%)	122 (1.7%)	190 (1.7%)
nuclear	28 (0.5%)	175 (2.4%)	388 (3.6%)
geothermal	7 (0.1%)	54 (0.7%)	126 (1.2%)
coal	48 (0.8%)	125 (1.7%)	642 (5.9%)
solar	--	15 (0.2%)	180 (1.7%)
electricty imports			
hydroelectric	42 (0.7%)		
coal	87 (1.5%)	338 (4.7%)	560 (5.1%)
nuclear	9 (0.2%)		
unnamed		64 (0.9%)	86 (0.8%)
Total	5649	7265	10891

Source: Behrin and Cooper, California Energy Outlook, 1976.[4]

Table 3. Trends in Energy Supply for California (10^{12} Btu).

Of domestic (California) oil, 82.1 billion barrels have been discovered, of which 16.4 billion barrels (20%) have been produced.[4] Technological advances may allow producers to raise the recovery rate to 35%, which would yield an additional 12.3 billion barrels. Also included are an estimated 69.4 billion barrels yet to be discovered, 21.7 onshore and 44.7 offshore. At assumed recovery rates of 30% for offshore oil and 35% for onshore oil, production of an additional 21.9 billion barrels is predicted.[4] However, several obstacles could inhibit this level of production. True, rising oil prices provide stimulus for further exploration and advanced recovery technology. Nonetheless, the attainability of these higher recovery rates has not yet been proven.

Neither have these high levels of undiscovered reserves. Furthermore, a continued moratorium on offshore drilling could severely curtail projected supplies.

Presently, only about 22% of natural gas is met by domestic supplies.[4] Of these, about 23.5 trillion cubic feet of associated gas (produced in conjunction with oil) remain to be produced. Non-associated reserves are estimated at 22.3 trillion cubic feet. Again, these projections rest largely on undiscovered reserves and remain uncertain. Associated gas is subject to the same limitations as oil production, particularly offshore reserves. In any case, California will still depend largely on out of state natural gas reserves.

Petroleum projections assume an offshore production increase of 8% per year through the year 2000, moderate by comparison with a 19% figure cited by the National Petroleum Council, yet indefinite in light of projected undiscovered reserves and injunctions against offshore drilling. Onshore production will probably decline at about 2% per year. Finally, the Elk Hills Reserve is expected to produce 160,000 barrels per day, increasing to 300,000 barrels per day by 1979. By 1982, about half of the recoverable reserves are expected to be gone, causing a 12% per year decline in production through the end of the century. Domestic natural gas production should remain relatively constant through the year 2000 due to the stimulus for exploration and production drilling provided by the expected rising costs of intrastate gas supplies.

Very large factors in anticipated supplies are Alaskan oil and gas. Due to California's large refinery capacity, the delivery of 1.2 million barrels per day of North Slope oil until the end of the century is assumed. However, the actual destination of these supplies has not yet been determined. Japan has also been considered as a possible recipient of much of the Alaskan crude supply. Therefore, this projection remains quite indefinite.

Delivery of Alaskan gas involves even greater speculation. The one billion cubic feet per day expected to reach California by 1985 would have to come either by a trans-Canada pipeline or by LNG tankers. Canada has already voiced opposition to pipeline proposals, and environmental and health hazards associated with LNG supertanker accident risks raise serious questions about the reliability of these supplies. Until transport problems are solved, Alaskan gas cannot be regarded as a dependable source.

Solar heating and cooling of buildings is rapidly becoming an economically attractive alternative to the use of gas and electricity. Behrin and Cooper[4] estimate that by 1980, about 1% of California's new housing construction is expected to be built with supplemental solar heating and cooling units which could provide approximately 70% of the heating and cooling load. By 2000, an estimated 20% of new construction will use solar energy, an annual increase of about 16%. This will probably not have as great a potential for the Bay Area as for areas of Southern California. Nonetheless, its contribution could be significant in the residential and commercial sectors.

In the electricity-generating sector, Behrin and Cooper compare estimates of future demand with estimates of output from each electricity-generating source. The excess demand they assumed to be met by petroleum fuels.

Nuclear energy projections include a contribution of 20 GWe by the year 2000 through the utilization of an estimated 20 nuclear plants in California. Presently three plants are on line with a combined rating of 1.4 GWe, while the construction of four more is in progress. This would bring the combined rating to 5.9 GWe. However, due to increasing opposition to nuclear risks, the long lead time necessary between the start of

construction and actual operation, and the fact that existing plants seldom operate at their full capacity, the above projection might never be realized, at least not before 2000. Another fact that might hinder nuclear output is the sharply increasing cost of fuels. Furthermore, utility companies are becoming more discouraged by the increasing costs, construction and licensing difficulties, and the mounting political opposition to installing nuclear plants, and may decide to curtail severely their plans for operating 20 nuclear plants by 2000.

With projected shortages of many energy supplies, coal is expected to play a much larger part in the California energy picture. Presently, 2.6 GWe of out-of-state coal-fired electrical generation capacity is imported to Southern California. By 1985, this figure is assumed to reach 6.3 GWe, and by 2000, 10.0 GWe. Also anticipated is that by 2000, the out-of-state figure will be matched by in-state production from coal. Except in critical air basins, coal-fired plants using modern technology can meet present federal and state ambient air quality standards. However, more stringent air quality standards could limit this projection. Presumably most coal would come to California from western coal fields by rail. By 2000, California would require 3,200 train loads per year, clearly a burden on present lines.

Hydroelectric power is assumed to grow at the rate of 2% per year, due to the limited number of potential sites. By 2000, all potential sites will have been developed.

Geothermal energy in California is now generated at the Geysers in Sonoma Country, a source quite relevant to Bay Area needs. By 2000, output is expected to reach 5 GWe, with Southern California output reaching 2 GWe by the turn of the century.

Electricity imports will probably grow at a rate of 2% per year, exclusive of coal. Gas, due to its limited availability, will soon be used only minimally in electricity generation. All other demand for electricity is assumed to be met by oil, with a rise in expected fuel use from 459×10^{12} Btu in 1973 to 853×10^{12} Btu in 1985. Afterward, a rise in production from geothermal, nuclear, and coal sources should displace some of the oil used for generation, lowering oil requirements to 433×10^{12} Btu by 2000.

Demand Assumptions

Table 4 shows the projected energy demand by sector for California. The underlying assumptions on which they are based are again those of Behrin and Cooper.

The demand for petroleum comes mainly from the transportation and industrial sectors. Highway transportation projections are based on the number of vehicles per driver, the number of drivers (constant at 62% of the population), per capita demand for fuel, miles driven per vehicle, and average miles per gallon (12 mpg in 1975, 23 mpg in 1985, and 25 mpg in 2000). The demand projections are 13.2 billion gallons of fuel for 1975, and 17.4 billion gallons for 2000. For non-highway transportation, aviation demand is assumed to rise at 3% per year, with a 2% annual growth rate for all other transportation users.

Industrial demand for oil is correlated with the real value added to raw materials in manufacturing. Figures for industrial oil demand are (in thousands of barrels/day oil equivalent), 283 in 1973, 386 in 1985, and 581 in 2000.

Electricity demand is projected by customer class for nine regions of the state, and takes into account the average price of electricity, population, per capita income, and the price of gas. The averages (in GWh/yr) are:

	1975	1985	2000
Residential	50,665	85,462	152,504
Commercial	56,561	90,017	151,055
Industrial	51,074	66,382	76,782

Additional electricity demand is predicted for the transportation sector assuming the use of urban electric vehicles by the year 2000, which would require 12 x 10^{12} Btu/year. An added 1 x 10^{12} Btu/year is approximated for mass transit systems.

Gas consumption is estimated for the residential, commercial, and industrial sectors. Residential demand is related to per capita gas consumption in the residential sector, the price of gas, and per capita income. Commercial gas consumption predictions are based on the past relationship to residential demand. For the industrial sector, projections are derived from the relationship between the manufacturing value added to industrial gas consumption and the industrial price of gas. The projections are (in thousands of barrels/day oil equivalent):

	1975	1985	2000
Residential	332	423	633
Commercial	120	194	430
Industrial	298	399	637

Comparisons with Other Energy Projections

Projections contained in California Energy Outlook are moderate in comparison with projections by the Stanford Research Institute[7] and the Rand Corporation's Medium Case projections.[1] The SRI report was published in 1973 before the major increases in energy prices, consequently projections are quite high. The Rand Medium Case assumes a very high degree of conservation on the demand side. Overall projections for average annual

	1973	1975**	1985	2000
Transportation	1990 40.5%	2019 39.7%	2172 33.8%	3056 31.3%
Commercial	428 8.7%	473 9.3%	783 12.2%	1297 13.3%
Industrial	1304 26.6%	1414 27.8%	2118 33.0%	3207 32.8%
Residential	848 17.3%	905 17.8%	1253 19.5%	2102 21.5%
Other*	341 6.9%	276 5.4%	95 1.5%	97 1.0%
Total	4911	5087	6421	9759

Source: California Energy Outlook, 1976

* The decline in this sector is due to the reassignment of many uses to different sectors. For example, the inclusion of agricultural energy use in the industrial sector.

** Interpolated from 1973 and 1985 figures, based on average annual growth rate for each sector during the 12 year period, so that state figures could be compared with 1975 Bay Area Figures.

Table 4. Projected Use of Energy for California (10^{12} Btu)

energy growth rates were 3.4% for SRI, 2.3% for California Energy Outlook, and 0.8% for the Rand Medium Case. These projected trends not only indicate the wide range of possible results, but also give a good indication of the potential impact of conservation (Rand's projections for the year 2000 are about 50% of the level of usage predicted by SRI, and about 67% of thelevel projected in California Energy Outlook). Hopefully we will be able to realize these lower levels of energy demand through wise and frugal use of energy resources.

Implications for the Bay Area

Table 5 shows our demand projections for the Bay Area. In projecting these future needs we compared present use of energy within each sector in the Bay Area with present use of energy in the same sector in California, and applied that percentage of state consumption to future projections for California. For example, Bay Area commercial energy use is currently 94.3×10^{12} Btu, or 19.9% of the 473×10^{12} Btu consumed by the commercial sector statewide. This percentage is then applied to state figures for 1985 and 2000. In other words we assume that Bay Area demand trends will parallel California demand trends. Admittedly, these trends are bound to vary in the future. However,our concern here is to present an approximate figure for the amount of energy that we in the Bay Area will need in the near future, as later sections of this study will discuss conventional and alternative ways to modify and meet this demand.

Population Projections

Perhaps the most important factor in estimating future consumption is the projected population. ABAG's Series III projected state figure of 25,025,000 for 1990 correlates well with the projected levels of 23,360,000 for 1985 and 26,500,000 for 2000 used by Behrin and Cooper in California Energy Outlook. Therefore we feel that our extrapolations of future Bay Area energy demand from statewide demand levels projected by Behrin and Cooper are valid for the Bay Area with respect to population.

Conclusions

Projection figures for population and energy demand are not easily derived due to their dependence upon a multitude of variables. These estimates, however, indicate the development of particular trends. This is where the "projection" really gains its relevance. After surveying the present and projected population levels, it has been found that the San Francisco Bay Area (nine counties) can expect an estimated 12% rise in popula-

	1985		2000	
Transportation	335	25.2%	472	23.3%
Commercial	156	11.7%	259	12.8%
Industrial	490	36.9%	742	36.6%
Residential	299	22.5%	502	24.8%
Other	49	3.7%	50	2.5%
Total	1329		2025	

Table 5. Projected Use of Energy for the Bay Area (10^{12} Btu)

tion, resulting in the approximate addition of 800,000 people to the region. This, coupled with current trends in energy use, clearly indicates a substantial increase in future energy demand. The once rumored "energy crisis" is no longer a topic for discussion, but rather a cause for immediate action. How well we deal with this crisis will depend upon the combined advances in conservation, technology, alternative sources, and new reforms in energy policy.

References Cited

1. Ahern, W., R. Doctor, W. Harris, A. Lipson, D. Morris, and R. Nehring, 1975, Energy Alternatives to California: Paths to the Future: Rand Corporation, Rept. R-1793/1-CSA/RF.

2. Association of Bay Area Governments, 1977, Provisional Series 3 Projections: Population, Housing, Employment, and Land Uses, San Francisco Bay Region: Berkeley, Calif., pp. 7-12.

3. Bay Area Air Pollution Control District, 1976, Emissions Inventory Summary Report: San Francisco, BAAPCD, p. 7.

4. Behrin E., and cooper, R.L., 1976 rev., California Energy Outlook: Livermore, California Lawrence Livermore Laboratory.

5. California Dept. of Finance, 1974, Population Projections for California Counties, 1975-2020: alternative series D-100, E-0, D-150, C-150--Report 74 P-2: Sacramento, Calif., DOF, pp. 7-12.

6. California Energy Resources Conservation and Development Commission, 1976, Quarterly Fuel and Energy Summary, vol. 2, nos. 1 & 2: Sacramento, Calif., ERCDC, pp. 14-20.

7. Stanford Research Institute, 1973, Meeting California's Energy Requirements, 1975-2000: Menlo Park, Calif., SRI.

8. Stanford Research Institute, 1973, Transportation Use of Energy in the Bay Area: Menlo Park, California, SRI, p. 14.