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CONSERVATION and PEAK POWER - COST and DEMAND



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# CONSERVATION AND PEAK POWER — COST AND DEMAND*

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*Work done under the auspices of the U. S. Energy Research and Development Administration.

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## 1. INTRODUCTION

In this paper we discuss some of the historic areas of growth in electricity demand, compare their benefits with the cost of new power plants, and find that few of them can be economically justified. We conclude that with an aggressive State conservation program very few new power plants of any type will be needed, and that planned hydro plus geothermal plants will satisfy demand for 10-20 years.

### 1.1 Present Supply and Demand

California does not need nuclear energy to satisfy today's demand for electricity. As shown in Table I, we needed an installed capacity in 1974 of about 35,000 megawatts (MW) and already had 37,500 MW of non-nuclear capacity, plus 500 MW of nuclear capacity.

TABLE 1. Demand and supply - electric peak power.

| | 1974 Actual[a] (MW) | 1984 Projections (MW) | 1974-84 Annual Growth |
|---|---|---|---|
| 1. Peak demand (sum of individual, utility peaks) | 29,356 | | --- |
| 2. Peak coincident demand (96% of line 1.) | 28,000 | 31,500 (our projection[b]) | 1.2% |
| 3. Needed installed capacity (125% of line 2.) | 35,000 | 39,500[b] | 1.2% |
| 4. Hydro and geothermal capacity[c] | 9,400 | 15,500[a] | --- |
| 5. Total non-nuclear capacity (includes line 4) | 37,500[a] | 52,000[a] | 3% |
| 6. Nuclear capacity | 500[a] | 9,000[a] | --- |

[a]Source: P.U.C., Report on 10-Year Forecasts of Electric Utilities' Loads and Resources, General Order 131, Section 2, May 1975, Table 1.

[b]See Goldstein-Rosenfeld, LBL-3274 (1975).

[c]1974 Hydro: 9000 MW; 1974 Geothermal: 400.

## 2. PROJECTIONS

The reason, then, that the utilities are planning construction of new units is to satisfy *projected* increases in demand for electricity. Their projections are based on historical growth patterns, which were established during periods of rapid population growth and declining electricity prices. This historical record also includes the replacement of efficient uses of natural gas for heating hot water, cooking, and home heating by electricity, which is more expensive and less efficient. Thus extrapolation of historic patterns will give projections that involve high growth rates, but which are inappropriate to periods of rising prices and energy awareness.

### 2.1 Difficulties with Projections When Energy-Awareness is Changing

Not only are the projected needs based on oversimplified extrapolations, but none of the forecasts contains an explicit enumeration of what uses the growth in electric energy will serve. The reason for this may be such that an enumeration would clearly show that the growth in electricity use comes about either by the expansion of uneconomic uses of electricity, uses for which there are cheaper and better substitutes, or by the continued erosion of efficiency.

*An example: Automobile fuel economy.* To illustrate the decreasing efficiency of energy-using apparatus, we show the average miles per gallon of U.S. cars in Fig. 1. Although cars do not use electricity, this figure is typical of the changes in efficiency of many electric appliances. It shows that fuel economy declined steadily from 1967 to 1974, continuing a 30-year trend. Any statistical projection of gasoline use would incorporate this continuing loss of efficiency into its estimates of future gasoline needs.

However, in response to "energy awareness", i.e. higher prices and fear of shortages, and as a result of technological innovation, the average mileage per gallon of U.S. cars rose dramatically in 1975 and 1976, with present cars getting 27% better fuel economy than 1974 cars. We doubt that any economic forecasting method could have predicted this dramatic reduction in the energy demand of cars, nor would it have forecast that 1975 consumption of gasoline would be less than in 1973.

*The efficiency of electric motors could also suddenly rise.* Table II shows the declining efficiency of electric motors since 1940. These motors are used to power refrigerators, air conditioners, ventilation fans, etc., in homes and commercial buildings. This decline can be reversed by state efficiency standards; and is already being reversed by some manufacturers' new equipment. Projections of electricity demand based on historical experience would extend these historic losses in efficiency into the future, and would be unable to account for increases in energy-efficiency. Such increases are clearly feasible; they only entail improving new equipment to the levels of 1940 technology.

TABLE II. Efficiency of quarter horsepower electric motors.[a]

| | Efficiency (%) |
|---|---|
| 1940 Wagner Electric Heavy Duty | 71 |
| 1975 Wagner Electric Heavy Duty | 58 |
| 1975 Wagner Electric Standard | 54 |
| 1975 Wagner Electric Economy | 49 |
| 1975 Home Refrigerator[b] | 40 |
| 1975 Sears Fans and Blowers[c] | 30 |

[a]Jonathan Allen, Environment 16 No. 8, 36 (1974).
[b]M. de Cachard, Div. de Transferts Thermiques, Centre d'Energie Nucleaire, BP 85, Grenoble, France.
[c]Sears Catalog, Spring/Summer 1975, page 859.

*End-use projections.* A more accurate method of prediction is to look at each end-use of electricity, evaluate the possibilities of growth in consumption and of "conservation" in each use, and then to project future demand for electricity as the sum of demands for each end use.

By *conservation*, we mean both the improvement of efficiency of energy use and economy of operation. For most electrical devices, a change that saves energy will also save money; we consider only those changes that will do both. It is also possible to save energy by changes in habits; however, we have not considered such effects here.

## 2.2 Future Supply and Demand

We recently estimated <Goldstein,75> that if the new State Energy Resources Conservation and Development Commission adopts vigorous, cost-effective conservation measures, California's growth in electric energy demand could be held to 1.2% annually. As shown in Table I, this would result in a 1984 peak coincident demand of 31,500 MW, which could be supplied by an installed capacity of 39,500 MW (assuming a reserve margin of 20% capacity). Note that this is only 2,000 MW above present non-nuclear capacity, and over 10,000 MW less than the non-nuclear capacity planned for 1984.

In Fig. 2, the peak demands and planned capacities of Table I have been plotted (assuming constant load factors). Our provisional forecast is seen to fall dramatically below either the 1975 PUC forecast or the non-nuclear "umbrella" corresponding to line 4 of Table I. We conclude that planned non-nuclear plants satisfy reasonable electric demand with a large margin of safety, and that many of the planned non-nuclear plants will be postponed or cancelled.

# 3. CONSERVATION

## 3.1 Costs of New Electric Power

Although there is some question about whether new nuclear plants have lower or higher total cost than new fossil-fired plants, there is no question that new plants will produce electricity that is much more expensive than present electricity. The average price of electricity to California customers is about 3¢[*] per KWhr; this price includes generation, transmission, distribution, and administrative costs. Nuclear electricity has a wide range of estimated costs, from about 2½¢ per KWhr to over 4½¢ per KWhr at the power plant. (Southern California Edison has stated in its testimony that expected costs are 4 to 4½¢ per KWhr.)[+] The range in nuclear costs is due to uncertainty about operational reliability of nuclear plants and to runaway inflation in plant construction costs (over 30% per year for the last five years).

The estimated cost of *constructing* a nuclear power plant ordered in 1975 is estimated at $1135 per "nominal" kilowatt <Reichle,75>. However, the availability of large nuclear plants is currently running around 65% <Comey,74,75>, so the cost of an available kilowatt of peak output is about $1750. After correcting for 10% transmission losses, and adding the cost of transmission lines, nuclear power demand then costs in excess of $2000 per peak kilowatt, or $2 a watt. This number refers to capital costs only; operating costs are not included.

At these prices the cost of saving a watt by more efficient design of energy using devices is much lower than the cost of supplying that watt by nuclear reactors, or even by fossil fuel.[‡] New coal plants are also very expensive; about $900 a kilowatt for construction (including sulfur control devices). In addition, the fuel cost of coal is higher than it is for nuclear reactors, and oil is even more expensive. Thus the state would be better off encouraging investments in conservation rather than in new supply.

There are as many ways to save electricity as there are to use it. In many cases, present efficiencies are so low that reductions of energy demand by 50% and more are possible without raising costs to the consumer.

## 3.2 Conservation Options

Saving peak power is even easier than saving energy, since there are two methods of accomplishment:

- To reduce power demand at all times (e.g., by raising efficiency), or
- To shift demand away from the utilities' peak period.

For example, if we improve the motor of a refrigerator, and put thicker insulation in the walls, we can decrease its power consumption by 60%. If we add a timer, we can have it work harder off-peak at night, and freeze an extra cubic foot of ice; then during peak times, it can shut off entirely and coast on the stored ice.

Table III lists some ways to save peak power in residential and commercial buildings. The first two entries (Water Heater and Range) refer to reversing an unfortunate trend in which the consumer, fearing that natural gas is running out (and not reassured by any State policy that reserves natural gas for those small items for which it is best suited), is switching to expensive electric heat for hot water and cooking.

TABLE III. Some examples of peak power savings

| Conservation Measures | Unit Peak Demand: Present to possible (watts) | Unit Peak Demand: Utility capital savings at $1 watt[e] | Annual Calif. unit sales[a] 1972-74 | California peak savings after 10 yrs (MW) | | 1975 Calif. peak demand[c] (MW) |
|---|---|---|---|---|---|---|
| **I. Residential** | | | | | | |
| Water Heater: Use natural gas | 500 → 0 | $ 500 | 100,000 | 500 | 925 | 300 |
| Range: Switch half to gas | 500 → 0 | 500 | ½ × 170,000 | 425 | | 1600 |
| Refrigerators: | | | | | | |
| Option 1. Choose best available | 188 → 115 | 73 | 540,000 | 400 | | |
| Option 2. Redesign (LBL) | 188 → 75 | 113 | 540,000 | 600 | 600 | 1100 |
| Option 3. Thermal storage | 188 → 0 | 188 | 540,000 | 1000 | | |
| Central Air Conditioners | | | | | | |
| Optimize house and A/C efficiency | 4000 → 1100 | 2900 | 60,000[b] | 1750 | | |
| (Effect of 1975 insulation standards) | (4000 → 2000) | (2 000) | 60,000 | (1200) | 2200 | 4500 |
| Room air conditioners EER 7 → 10 | 1500 → 1050 | 450 | 100,000 | 450 | | |
| | Total of Residential Examples | | | | 3725 | 7500[d] |
| **II. Commercial** | | | | | | |
| Electric Motors (50% efficiency → 70%) | | | | 2000 | | 7000 |
| Lighting (daylight 1/5 of area) | | | | 1000 | | 4000 |
| Fresh air (15 → 7.5 cfm/person × 4 million people) | | | | 150 | | 350 |
| | Total of Commercial Examples | | | 3150 | | 11,350 |

[a]Based on estimated three year average sales per household for the Pacific Region in *Merchandising Week 1975 Statistical and Marketing Report*, p. 53.

[b]Based on 40% of an estimated 150,000 new housing units constructed annually in California with central air conditioning.

[c]Based on RAND energy use data and rough estimate of number of hours of annual operation.

[d]Total residential peak demand is about 10,000 MW, so our list is about 3/4 complete.

[e]$1/watt is a weighted average of about 50¢ for peaking plants, $0.50-1.00 for fossil plants, or $2 for nuclear plants adjusted for availability.

Consider first the home *water heater*. A gas water heater supplying 50 gallons a day of 140°F water, requires 270 therms of gas per year, at a cost to the consumer of $40. A similar sized electric water heater consumes 4400 KWhr annually, which costs the consumer $105 at P.G. & E.'s *lowest* residential block rate, 2.4¢/KWhr. Rates in southern California are higher.

A water heater draws power all year long, averaging 500 watts, even during peak times. Hence a new electric water heater commits the utility to invest in 500 watts of new nuclear power availability, at $2 per watt, or $1000. This huge investment to supply a single home water heater is not paid directly by the purchaser of the heater; it is rather, distributed among all the utility customers in the form of higher rates, even for poor people who heat most of their hot water with gas.

At present, roughly 100,000 electric water heaters are sold in California each year. If the state acted to prevent their installation (where alternate fuel is available), we could save about 50 MW of new electricity demand each year. After ten years, the state would require 500 MW less electricity than it would if present trends were allowed to continue (Table III, column 4).

Similarly for *electric ranges and ovens*, listed on line 2 of Table III. An electric range uses about 1000 KWhr annually; estimating conservatively that this is distributed over 2000 hours, which include the peak period (noon to 6 pm in summer), the range, like the electric water heater, averages 500 watts and forces the utilities to invest $1000. As shown in Table III, a State policy to switch half of new electric range sales to gas would prevent the need for about 425 MW of capacity by 1985.

The use of electricity for *space heating* is also uneconomic. At present the heating season is off-peak for most California utilities, so that no new electrical plants of any variety are required for electric heating. However, if enough electric heat were installed to shift the peak to winter, then its continued installation would be prohibitively expensive. A home heat pump uses about 7 KW; the capital cost of 7 KW of nuclear power is $14,000, clearly an excessive expenditure for heating one house. Needless to say, electric resistance heating is even worse.

Actually, any use of electric space heat for houses is uneconomic for the consumer, even at present rates. Gas heat costs $2.50 per million

Btu's delivered (MBtu) as useful heat in the P.G.& E. area, while the same amount of electric resistance heat costs $7.00.

If electricity is used to supply these end uses, rates will increase dramatically, but if State policy directed toward conservation is instituted, then electricity needs and costs will not rise as rapidly; thus a slowdown on new power plant construction would have positive economic effects. Such a program would even have indirect beneficial consequences for the economy since investment in conservation produces more jobs than investment in electricity generation (see Table V).

In addition to the savings in heating appliances, there are large savings possible in increasing the efficiency of appliances that continue to use electricity. *Refrigerators* use about 6% of California's electrical energy and their energy consumption has been growing rapidly in recent years. Currently one finds a range of about 2 to 1 in the energy consumption of most classes of refrigerators of equal size and with identical features. Simply choosing the right model within each size-and-feature class can save the state about 40 MW of new capacity needs each year. In addition, considerable improvement is possible over even the most efficient refrigerators presently being sold. As shown in Table III, an energy-saving refrigerator would use about 60% less energy than an average one; this could result in an additional savings of about 20 MW of new capacity each year. In all, the improvement of refrigerators, after ten years, can eliminate the need for 1000 MW of generating capacity at average availability of 65% for nuclear (or slightly higher for fossil).

Present *air conditioners* also exhibit an almost 2 to 1 range in energy consumption for a given size, while evaporative coolers use less than one fourth as much electricity for the same output, and are satisfactory in many parts of the state. Table III shows that the new insulation standards for homes will automatically save 1200 MW of air conditioning power after ten years; efficiency improvements can increase this savings to 2200 MW.

After 10 years, Residential Conservation Measures listed in Table III add up to a decrease of 50% of present residential demand. But during ten years the growth in number of households will be less than 30%, so a net decrease in residential peak demand might well occur.

*Commercial buildings* – most operators of large buildings have found that they can cut energy and peak power consumption by about 35% with better management and with only those investments whose payback time is less than three years. Thus lighting levels, which have been demanding as much as 5 watts per square foot of new buildings are being cut back to 2 watts per square foot, with little or no discomfort. This measure is so well accepted that it is not even mentioned as a "conservation measure" in Table III; we do, however, list the following:

*More efficient electric motors* will save about 20% of the electric energy and power used in office buildings. The state need merely require efficient motors. Moreover, since a motor will often outlast the appliance or equipment it drives, the state should require motors with standard mounting brackets, so that they can be easily salvaged and reused.

*Daylighting* — simply switching off lamps within 10 feet of a window in commercial buildings in California will save about 1000 MW. Our group has been experimenting with better sorts of windows, venetian blinds, ceilings, and switches to achieve such daylighting effectively.

Since it is not cloudy in California on summer afternoons when we have our peak power demand, it seems cost-effective to switch off 2 watts per square foot in 500 million square feet (1/5) of our nonresidential space. As mentioned, the peak power savings is 1000 MW. The necessary taller windows and reflective venetian blinds cost very little, and the photocell switches should pay for themselves in a year or so out of energy savings.

*Fresh air* — the new state and national codes for nonresidential buildings recommend 7.5 cubic feet per minute of fresh air per person, but current practice is to supply roughly twice that much. This wastes energy in the winter, and requires peak power for air conditioning this excess air in the summer. Table III shows that merely by encouraging building managers to conform to the new standards we can save 150 MW at no capital expense whatsoever.

This concludes our list of explicit conservation measures in non-residential buildings — they add up to about 30% of present peak commercial demand, over and above the 35% (for better management) that we quoted earlier. Peak power demands per square foot could then be reduced to $0.7 \times 0.65$, or about 50% of their current value, yet commercial floor space in 1984 will have risen by only about 35%. So it appears that we need expect little increase in peak power demand from the commercial sector.

Finally, note that even though Table III is incomplete, it is long enough to add to a savings of > 6000 MW, which is the total contribution to peak power of all 9000 MW of nuclear plants scheduled for the next 10 years.

*Industry* – we have no "industry" entry in Table III, even though it accounts for about one third of California's peak power demand. We assume that industry is technically sophisticated enough to respond rationally to rising power and energy costs, and particularly to anticipated peak power pricing. For industry we feel that the usual concept of elasticity between demand and price is fairly well understood, and needs no special attention from us. We foresee that this elasticity will hold peak demand nearly constant for the next few years.

### 3.3 Total Energy Systems, Co-Generation of Electricity

On a life cycle basis, it is now becoming cheaper for the owner of a large building to install his own total energy system than it is to purchase commercial power. The total energy system can be powered by diesel engines and perhaps by the combustion of solid waste and even some solar energy. Most of the "waste" heat from the diesel is recoverable. We shall now discuss why we estimate that up to 30% of the power demand of new commercial buildings will never be felt by the utilities.

We present in Table IV partial results of a study of total energy vs purchased power for a one million square foot hospital designed for Travis Air Force Base. Life cycle costs were calculated assuming a 9% interest rate and an inflation rate of 7.5% for fuel, supplies, and labor. Twenty one configurations were studied, and diesel-electric came out best. Table IV compares 25-year life-cycle costs only for utility power vs diesel electric, which turns out more favorable by 15% in dollars and 43% in energy.

TABLE IV. Relative costs of purchased electricity vs a diesel-powered total energy plant for the 1 million $ft^2$ New Generation Military Hospital planned for Travis Air Force Base, CA. The maximum demands are: Electricity, 7.5 MW; Cooling, 3800 tons; Heating, 80 MBtu/hr. (Source: Consultants Computation Bureau, 594 Howard Street, San Francisco, CA 94105.)

| | POWER | |
|---|---|---|
| | Purchased | Diesel electric |
| First cost ($ million) | 5.7 | 7.8 |
| Life cycle costs ($ million) | 34.1 | 29.6 |
| Life cycle fuel ($10^{12}$ Btu) | 550 | 312 |
| Life cycle fuel (%) | 100% | 57% |

The rate of installation of total energy plants in the U.S. is still tiny – about 100 MW each year, in the form of about 50 plants, averaging 2 MW each, in buildings of 100,000 $ft^2$ or larger. But it seems likely that total energy plants will "take off" and even "take over" if the nuclear initiative provokes fear of electricity shortage. Our colleague, Fred Dubin, has been studying peak-power saving on Long Island. His estimate is that 10% of the total Long Island peak power demand (30% of commercial demand) comes from buildings large enough to benefit from total energy. Accordingly it seems reasonable to assume that about 30% of new commercial power demand in California too could switch away from utility purchased power.

*Co-generation* – a total energy system becomes even more economical if the local utility will collaborate, i.e., buy as well as sell power at reasonable rates. A challenge for the state is to formulate incentives or rules for cooperation (rather than the present hostility) between utilities and total energy plants for industry as well as buildings. One possibility is simply to permit the utility to enter the total energy business.

# 4. ENERGY USE, ECONOMIC GROWTH, AND JOBS

## 4.1 Economic Growth

Despite the fact that saving energy and peak power also saves money, both for the consumer and for the state as a whole, a belief still prevails that a growing economy requires increasing use of energy, and that cutbacks in energy use will lead to economic stagnation.

To support such an argument, one would have to demonstrate that the use of greater amounts of energy is associated with higher levels of economic activity. Figure 3 shows a plot of national income per capita vs energy use per capita for several developed countries. If energy use were inflexibly linked to income, we would expect to see all the points lying along a straight line. What actually occurs is a great deal of scatter: Some countries can achieve the same level of income as others with much less energy use. The figure shows that the U.S. uses about twice as much energy per capita as the three most developed European economies, without achieving substantially higher per capita income.

There is even less of a fixed link between electricity usage and income. Figure 4 shows a plot of national income per capita vs electrical energy used per capita. Some countries use more electricity than the U.S. while having lower national income; other countries achieve almost as high income as the U.S. with lower electricity use. It should be noted that of all the countries using over 5 MWhrs of electricity per person, only the United States has less than 60% of its electrical capacity in hydroelectric facilities.

## 4.2 Jobs

Another belief is that even if we do not need more energy for a growing economy, we need it to solve our unemployment problems. However, Table V shows the consequences of spending one dollar on various consumer items. This table was developed using input-output economics, so it includes not only the employment produced in supplying a consumer item, but also all the indirect employment in producing the equipment necessary to manufacture the consumer item. A dollar spent on electricity produces fewer jobs than almost any other option. One particularly interesting comparison is between electricity (line 1) and appliances (line 4). This comparison suggests that a dollar spent in improving the energy-efficiency of an appliance produces about twice as many jobs as the same dollar spent on extra electricity to operate an inefficient one.

## 5. CONCLUSIONS

The net effect of a state-mandated electricity conservation and peak reduction program would thus be to slow the growth rate of consumption to the point that existing facilities, plus planned additions to hydro and geothermal capacity, would be sufficient to meet the state's needs until at least 1995. This scenario of state sponsored conservation could result in cost savings to consumers, no sacrifice in well-being, greater employment and lower electric rates than a scenario of rapid construction of nuclear plants.

## 6. ACKNOWLEDGMENT

We are indebted to Dr. Robert D. Clear for sharing with us his data and ideas, particularly on appliances.

TABLE V. Energy and labor intensities of the largest (dollarwise) personal consumption activities for 1971. Source: Hannon and Puleo, Center for Advanced Computation, University of Illinois, 1974.

| Personal Consumption Expenditure Sector Description | Energy Intensity Btu/$ | Labor Intensity (Jobs/$1000) |
|---|---|---|
| Electricity | 502,473 | 0.04363 |
| Gasoline and oil | 480,672 | 0.07296 |
| Cleaning preparations | 78,120 | 0.07332 |
| Kitchen and household appliances | 58,724 | 0.09551 |
| New and used cars | 55,603 | 0.07754 |
| Other durable house furniture | 45,593 | 0.08948 |
| Food purchases | 41,100 | 0.08528 |
| Furniture | 36,664 | 0.09176 |
| Women and children's clothing | 33,065 | 0.10008 |
| Meals and beverages | 32,398 | 0.08756 |
| Men and boys clothing | 31,442 | 0.09845 |
| Religious and welfare activity | 27,791 | 0.08636 |
| Privately controlled hospitals | 26,121 | 0.17189 |
| Automobile repair and maintenance | 23,544 | 0.04839 |
| Financial interests except insurance co. | 21,520 | 0.07845 |
| Tobacco products | 19,818 | 0.05854 |
| Telephone and telegraph | 19,043 | 0.05493 |
| Tenant occupancy non-farm dwelling | 18,324 | 0.03502 |
| Physicians | 10,271 | 0.03258 |
| Owner occupancy non-farm dwelling | 8,250 | 0.01676 |
| Average, including energy purchases | 70,000 | 0.08000 |
| Average, non-energy purchases only | 52,000[a] | -- |

[a]1967 figure. The corresponding 1967 figure for average including energy was 80,000 Btu/$. Source (1967 figures), R. Herendeen, private communcations.

## FOOTNOTES AND REFERENCES

David D. Comey (1974, 1975). "On Cooking Curves" and "Points vs Trends" in The Bulletin of the Atomic Scientists, Vol. XXXI, No. 8 (October 1975) pp. 38-45; and "Will Idle Capacity Kill Nuclear Power", Ibid. Vol. XXX, No. 9 (November 1974) pp. 23-28. The cumulative weighted average capacity factor for U.S. nuclear power plants larger than 400 MW is 54.7%. The average availability factor, which is defined as the percent of the total time in a given period that the plant is operating, was 69% in 1973, and 59% in 1974. However, this factor overstates the plants' availability to produce full power at the peak.

D. B. Goldstein and A. H. Rosenfeld (1975). "Projecting an Energy Efficient California", Lawrence Berkeley Laboratory Report No. LBL-3274.

Leonard Reichle (1975). "The Economics of Nuclear Power", presented by Ebasco Services Inc. to the New York Society of Security Analysts, August 27, 1975. The capital cost for construction alone is $1005 per kilowatt, while the capital cost for the initial core fuel is $123, for a total investment of $1128 per kilowatt. The New York Times (October 5, 1975) quotes Mr. Reichle that the cost of building a nuclear reactor is $1135 per kilowatt.

*3¢ per KWhr is a rough estimate of average electricity price to California users, based on the following average prices per KWhr sold by the major utilities (as derived from California Public Utilities Commission staff economic studies):

| | |
|---|---|
| Pacific Gas & Electric | 2.6¢ |
| Southern California Edison | 3.3¢ |
| San Diego Gas & Electric | 4.0¢ |

†These estimates exclude transmission losses and the cost of the rest of the utility's operation.

‡One can actually choose a range of costs for peak power from about 50¢ a watt for inefficient fossil peaking-plants through $1.00 a watt for modern base-load fossil-fuel to about $2.00 a watt for nuclear. Which figure is relevant depends on one's opinions about which plants will be built, and on whether the end use in question is basically peak- or base-load. We have chosen $2.00 a watt because it allows us to compare first costs of appliances directly with first costs of new supply. If the lower-first-cost power plants are built, then more attention must be paid to operating costs.

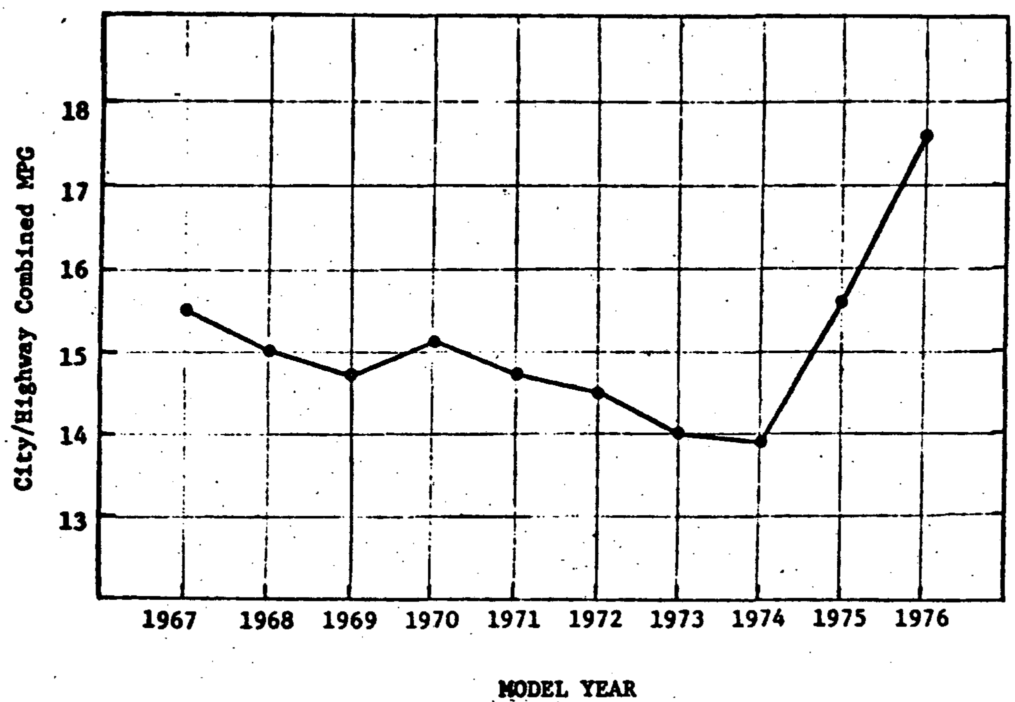


Fig. 1. Sales-weighted fuel economy trends — 1967 to 1976. (From T. C. Austin, R. B. Michael, and G. R. Service, *Passenger Car Fuel Economy Trends Through 1976*, S.A.E. Automobile Engineering Meeting, Detroit, Michigan (October 13-17, 1975), S.A.E. Publication 750957.)

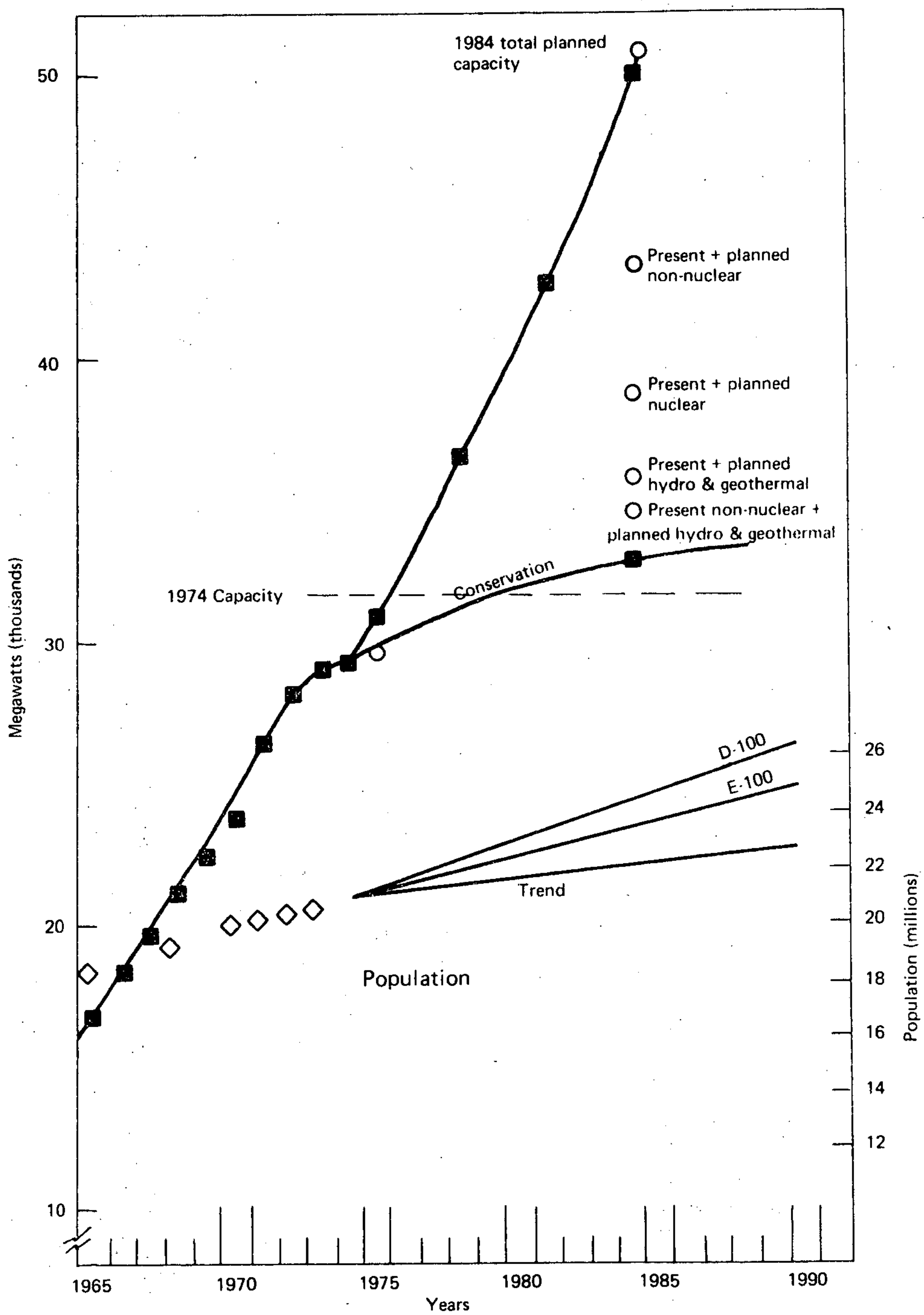


Fig. 2. Projections of California electricity comsumption with and without explicit conservation assumptions. The "conservation" projection is well below the limit of what can be supplied by planned additions to hydro plus geothermal capacity. (Pre-1970 power is estimated from energy (KWhr), and 1970 load factor. Capacities include 10% reserve margin and a 4% allowance for coincident demand.)

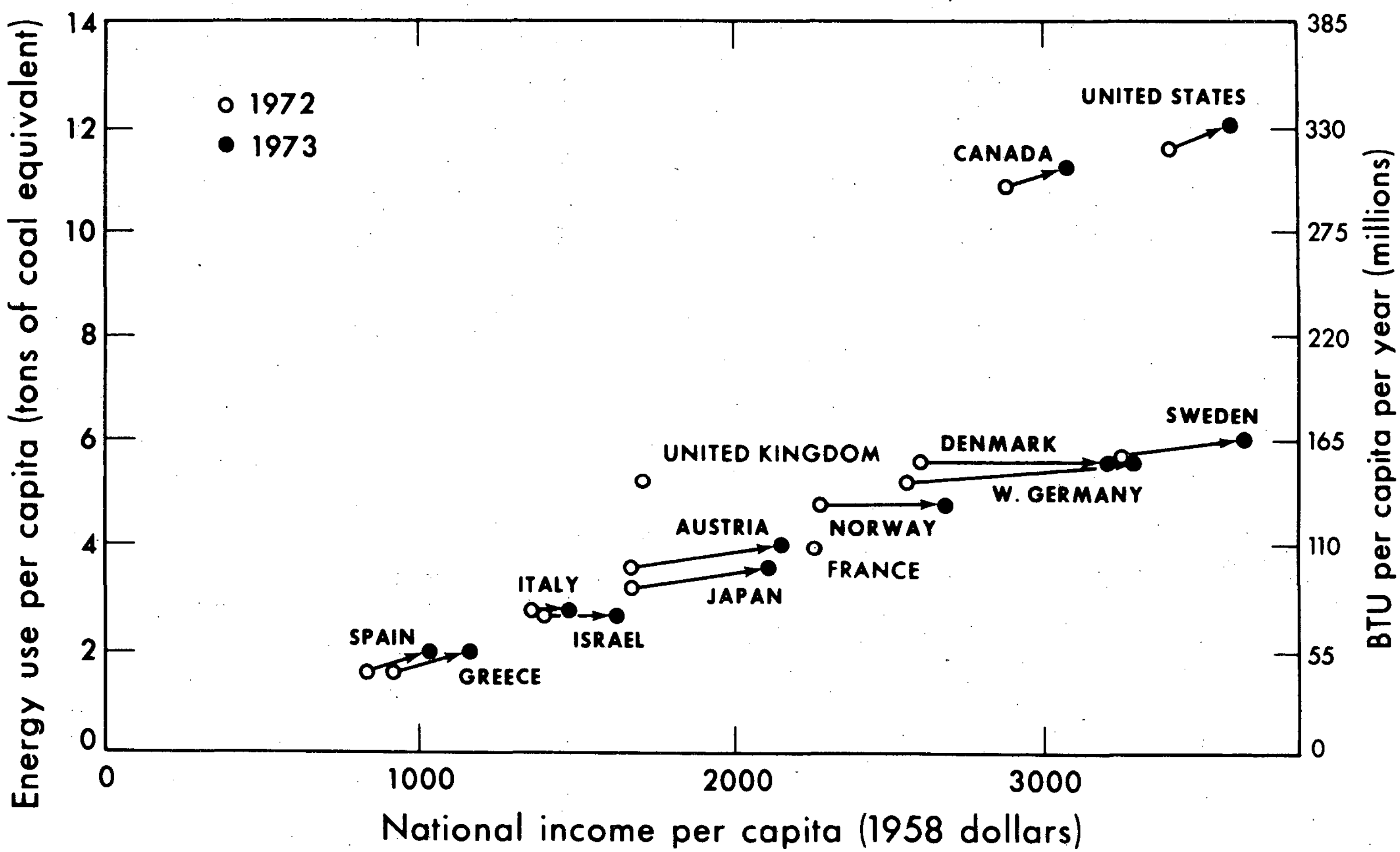


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Fig. 3. Comparison of national income per capita with total energy use per capita, 1972 and 1973, for selected countries.

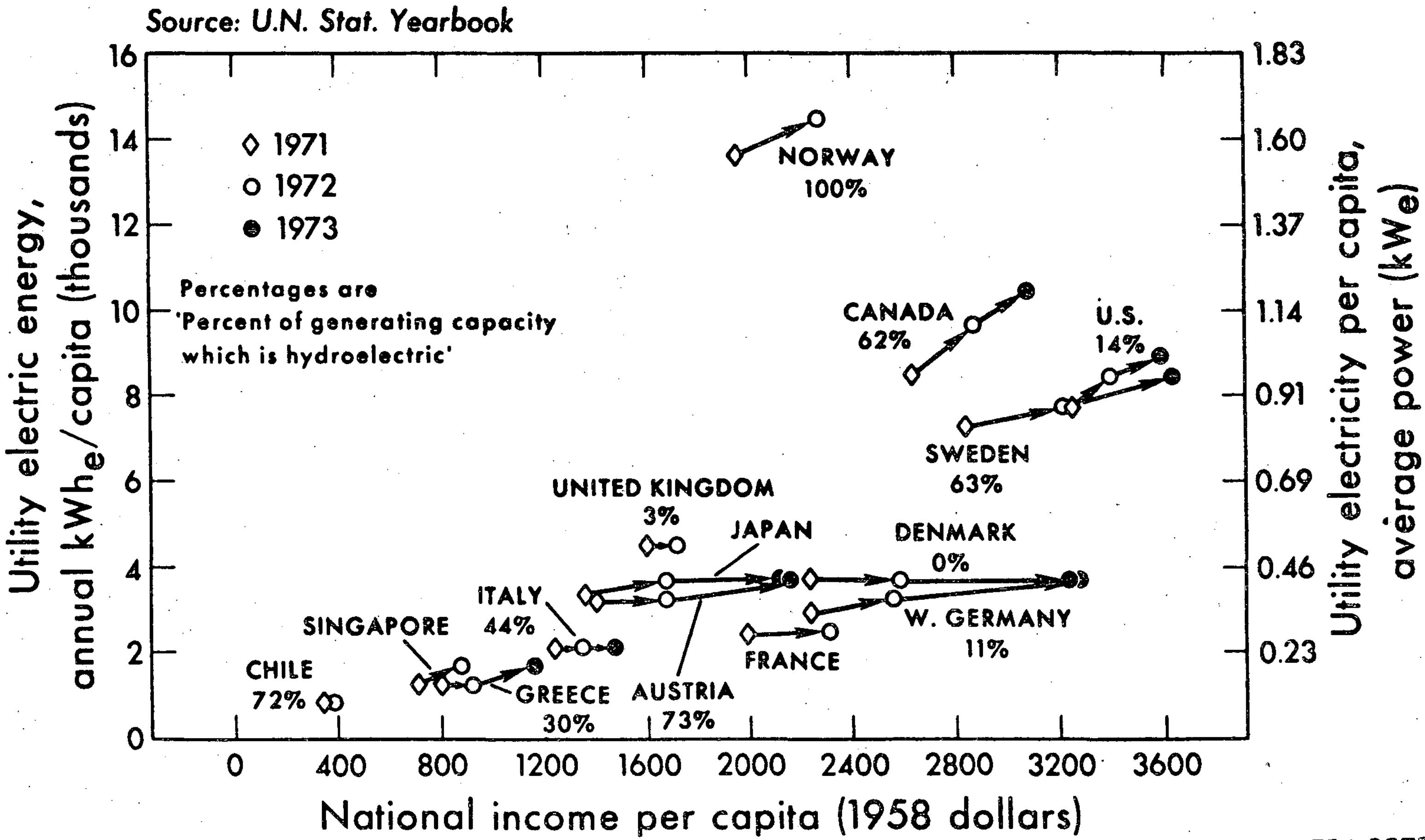


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Fig. 4. Comparison of national income per capita with public utility electricity consumption per capita, 1971 - 73, for selected countries. The percentage of hydroelectric capacity in each country's total generating capacity is noted.

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