

Energy and the

by Norman Brooks

The woes of the electric utility industry make daily reading in the nation's press. The power companies have not been able to supply all the electricity the public demands during certain critical periods—as for example during heat waves, when air-conditioners, refrigerators, and electric fans add heavier power loads. The result is *more frequent blackouts and brownouts* (voltage reductions) as the power companies struggle to keep the load within the limits of generating capacity.

The utilities have faced an array of difficult and coincidental problems trying to keep up with the ever increasing demand. There have been long delays in delivery and installation of nuclear-generating units, following the unusually large orders for nuclear equipment in 1966 and 1967 which swamped that new section of the power-generating equipment industry. In some new large conventional units, operational failures have occurred unexpectedly. Power companies have found that shut-downs for maintenance have been more difficult to schedule because high peaks of demand now occur both in winter and summer.

Fuel delivery has suddenly become a problem for the utilities. For air pollution control, they must use low-sulphur coal, but the supply is inadequate. New mine safety regulations have curtailed some mining operations, and caused defaults in some coal supply contracts. Even railroad coal cars are becoming scarce, and some utilities are having to purchase their own cars to be assured of deliveries. Because of attractive prices, more coal is being *exported to Japan*. Whereas utilities used to have several months' coal supply on hand, they now have just a few weeks' supply and sometimes only a few days' advance supply. Fuel oil has also been in short supply because of oil import restrictions, and the tanker shortage caused by closure of the Suez Canal and the interruption of the Trans-Arabian pipeline.

Concern about the environment has caused a tightening of air and water quality standards for power plant discharges. Currently there are arguments about the adequacy of radiation standards for nuclear plants. For those who must plan capital expenditures and their repayment for decades into the future, the fluidity of environmental requirements presents a difficult planning problem.

Power-plant siting is an even more urgent problem of the industry. Conservationists and the power industry have had many lively confrontations over siting of plants and transmission lines in the last few years. In general, these controversies have not contributed to recent power shortages because the lead time between final site selection



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Environment

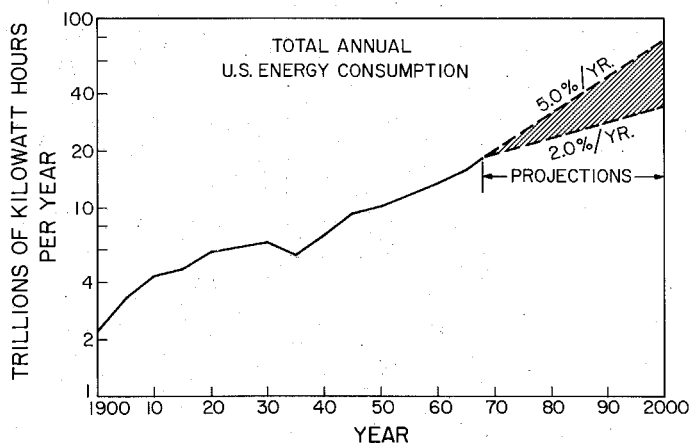
and on-line operation is often five years or more; but a few years hence we shall be able to say that power shortages were caused by arguments over power-plant sites.

Energy Consumption

Electric power is of course just one part of society's total energy usage. Not only is fuel burned to generate electricity at central power stations, but it is also used directly for heating buildings, for transportation, and in industry.

The total energy consumption in the United States in 1968 was 17.8 trillion kilowatt-hours—equivalent to a continuous average use of 10,000 watts per person. In 1900 it was 2.2 trillion kilowatt-hours—an overall average growth in the intervening years of 3.1 percent per year (compounded). But in the period 1935 to 1968, the rate was 3.6 percent per year, and in the most recent four years, 1964-68, the rate of growth was 4.9 percent per year. A growth rate of 5 percent per year in the future would lead to an energy consumption of 76 trillion kilowatt-hours in the year 2000—over four times the present yearly usage. If the growth rate were only 2 percent per year, the figure for 2000 A.D. would be less than half as much—34 trillion kilowatt-hours. The important point is that the growth rate, when compounded over many years, has an enormous leverage on how our resources and environment are going to be affected.

I am not a "futurist" because I do not think we must plan for whatever the demands may be; on the contrary, it will be necessary for society to *control* this growth rate



Historic growth of U.S. annual energy consumption with a high and a low projection to the year 2000.

to keep energy use and its environmental effects within tolerable limits.

The primary sources of the energy were, for 1968:

Crude petroleum	40.7%
Natural gas	32.1
Coal	21.9
Natural gas liquids	3.8
Hydroelectric generation	1.3
Nuclear energy	0.2
Total (17.8x10 ¹² kwh)	100.0%

Fossil fuels accounted for 98.5 percent of the total, while nuclear energy was only 0.2 percent. The nuclear fraction will grow very rapidly in the near future as it displaces fossil fuels in production of electricity. Hydroelectric power is also a very small percentage and will probably continue to stay small because most of the feasible hydro sites have already been built. It should be noted that hydropower is the only energy source which uses the current energy budget of the earth rather than energy stored from some other geologic age. There are other small sources of energy—wood, refuse, geothermal heat—which do not usually appear in the statistical summaries, but the amount for the U.S. is probably only a few tenths of one percent of the total. Direct beneficial use of solar energy (agriculture, drying, heating, etc.) cannot be computed; the amounts mentioned here refer only to man-made energy-distribution systems.

Electric Power

Of the total energy consumed in 1968, only 8.0 percent—1.43 trillion kilowatt-hours—was converted to electric power. However, an additional 14 percent of the total was discharged as waste heat by the thermal power stations, operating at an average efficiency of 33 percent.

that the growth rate has on problems of power-plant siting. How many sites will *really* be needed in the future?

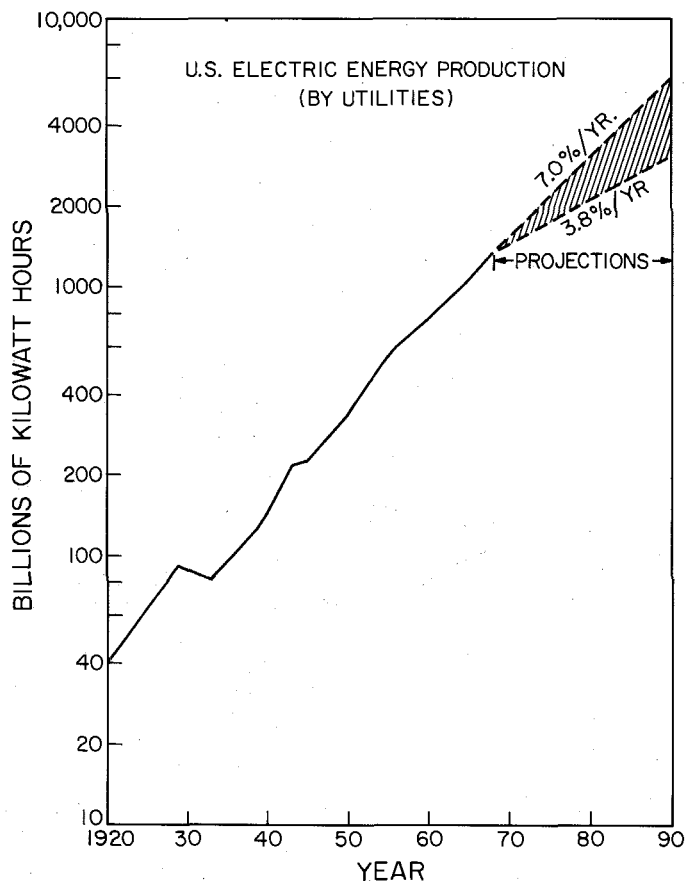
The electrical energy produced by utilities in 1968 came from the following primary sources:

Coal	51.7%
Gas	22.9
Oil	7.8
Nuclear	0.9
Hydro	16.7
Total (1.33×10^{12} kwh)	100.0%

By contrast, hydropower accounted for 36 percent in 1945. In the future, as in the past few years, the vast majority of the new installations will be thermal power, with nuclear power becoming a rapidly increasing part. Although practically all the feasible conventional hydro-power sites have been developed, large pumped-storage plants for peaking are being built and will be sought increasingly in the future to allow higher load factors at thermal plants by pumping water up for storage during off-peak hours.

Gross electrical generating capacity (not allowing for shutdowns for maintenance and repairs) is just a very few years ahead of the peak load. At the present growth rate the peak-load forecast for 1990 is over 1,000 gigawatts (or 1,000,000 megawatts) compared to the 1968 peak of 243 gigawatts.

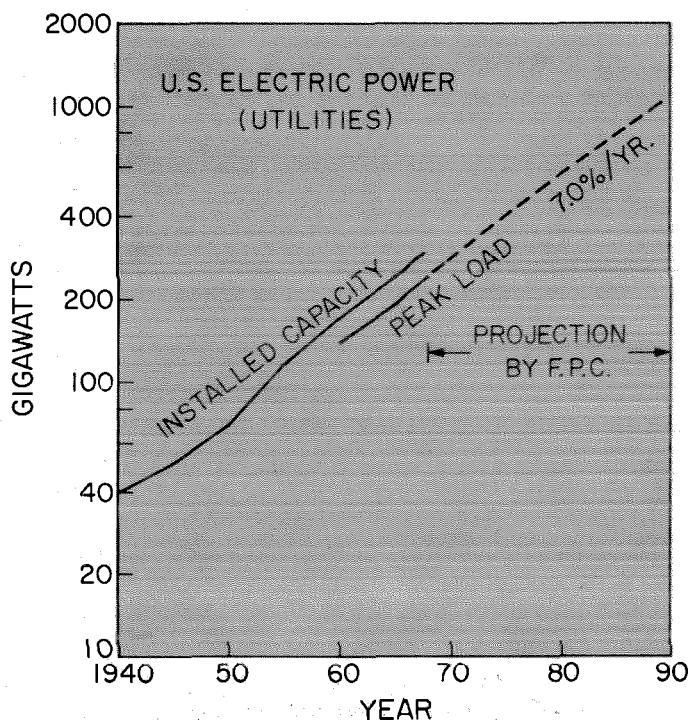
At thermal power plants the maximum size of a *single* generating unit has increased from 200 megawatts in 1950 to 1,300 megawatts at present (or the equivalent of the



Growth of electrical energy production by utilities from 1920 to 1968, with range of projections to 1990.

Hence 22 percent of the total energy supply was used to run the electric power systems.

Electric power production by utilities was 1.33 trillion kwh—a growth of 9 percent over the preceding year. (The small remainder—0.10 trillion kwh—was produced by industry for in-plant use.) For the period 1920-68, the average growth rate was 7.5 percent per year—or doubling every 9.5 years. If the demand continues to grow at 7 percent per year, the production by utilities will have to increase over fourfold by 1990 to 5.9 trillion kwh. Even a much lower projection of only 3.8 percent growth per year leads to 3.0 trillion kwh. The difference between these two projections for 1990 is more than twice the current production, which illustrates the enormous impact



Historic growth of installed capacity and peak load, with projection by the Federal Power Commission.

entire generating capacity at Hoover Dam). The largest power plants may have several of these huge units; for example, Brown's Ferry, TVA, 3,400 mw (under construction); and Point Conception, S. California Edison Co., 6,600 mw (being planned). Still larger size units are not anticipated because there are few further economies of scale to be realized and because an extremely large generating unit can be a disadvantage because its breakdown takes out too large a fraction of a given system capacity.

California

The power problems of the State of California have recently been summarized by the Resources Agency, which projects growth at 8 percent per year until 1990, at which time the demand will have increased fivefold over 1969. Per capita demand is predicted to rise from 1.17 to 4.0 kilowatts (about 6 percent per year compounded), while population growth is projected at 2 percent per year. Considering the current difficulties of finding acceptable sites, it seems almost impossible to believe that siting for over 90,000 megawatts additional can be accomplished in 21 years. Furthermore, it is hard to believe that we really need three to four times as much power per person—and can afford it.

I suspect that predictions of future power demands have often been self-fulfilling prophecies. If a power company decides to build large new generating stations to meet "projected" needs, it urgently requires that the new demand be realized on schedule in order to make a return on the company's capital investments, and it will conduct the necessary advertising and promotional campaigns to achieve the expected growth in business.

If the growth rate could be cut in half—to 4 percent per year—the positive impact would be enormous. The projected peak demand in 1990 would be only 52,000 megawatts—63,000 megawatts less than the State's projection. This would still allow a 2 percent per year increase in demand per person. If this reduction in growth rate could be accomplished, the reduction in capital costs for power plants and transmission lines would be about \$20 billion dollars in 21 years—and not only do the capital costs keep going up, but so also do the intangible damages to the environment.

Even if we could survive the expansion to the year 1990, how many more doublings every 8 to 10 years can we stand? We do not need further research to prove that the environment remains finite. Its capacity to absorb wastes never doubles—it just remains fixed. Can we realistically expect technology to solve the environmental problems and side effects of energy usage?

Why does electric power get so much emphasis when it accounts for only 22 percent of all the energy consumption? It is because the power plants are such concentrated energy centers that the power plant surroundings are

HISTORIC ELECTRIC POWER DEMAND FOR STATE OF CALIFORNIA

Year	Peak Power Demand (megawatts)	Population (thousands)	Ratio: kw per capita
1940	2,300	6,907	0.33
1950	5,300	10,586	0.50
1960	11,500	15,717	0.73
1965	17,400	18,207	0.96
1969	22,800	19,476	1.17

HISTORIC GROWTH RATES (State of California)

Years	Peak Power Demand	Population	Ratio: kw per capita
1940-50	8.7%/yr	4.3%/yr	4.4%/yr
1950-60	8.0	4.1	3.9
1960-65	8.6	3.0	5.6
1965-69	7.0	1.7	5.3

subject to more intense environmental effects than other places where energy conversion and usage is more diffuse—as in our homes, businesses, and automobiles. There is a tendency to replace small-scale combustion of fuels—in furnaces, stoves, automobiles—with electricity. In other words, instead of distributing so much fuel to individual users, we burn the fuel at a central power station, and distribute electricity instead. This is an environmental trade-off, for while you relieve the problems at one place where electricity is substituted for fuel, you add to the problems of siting enough power plants and controlling their emissions. Electricity is also a great help in solving other environmental problems too—such as building and running sewage treatment plants. Thus in the long run does the strategy for locating, building, and operating central power stations assume critical importance.

The Waste Heat Problem

There are many adverse environmental effects associated with electric power generation. One set of problems is associated with the mining, processing, and transporting of fuels to the power plants; another set arises from the combustion of fossil fuels and disposal of ashes and residuals extracted from the flue gases (for air pollution control); more problems arise from the transportation, processing, and disposal of spent nuclear fuel elements; another major problem is the dispersal of waste heat; and finally there are a multitude of land use and aesthetic questions associated with power plants and transmission lines. The problem of waste heat should be considered in detail because of its fundamental nature.

At every thermal power plant a very substantial amount of waste heat is rejected—by means of cooling water systems—into the surrounding environment. Both fossil fuel and nuclear plants operate on a steam cycle which converts part of the heat from a hot source (the furnace or the reactor) into work (electric power), and the remaining

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heat is discharged into a cool sink (the power-plant environs). Typical thermal efficiencies of new plants are as follows:

	Thermal Efficiency	Waste heat per unit electrical output
Conventional (fossil fuel)	35-40%	1.5-1.8
Nuclear	30-35%	1.8-2.3

By the laws of thermodynamics, higher efficiencies in a steam cycle can only be achieved by operating at higher steam temperatures and pressures. Efficiencies of nuclear-powered steam plants will probably catch up to conventional steam plants in another decade, as operating experience will permit using higher temperatures in the steam cycle. But limitations on materials and safety will prevent any dramatic improvements above 40 percent for the presently used steam cycle. Any possible replacement of the steam cycle by more direct means of electrochemical conversion for *large* central generating stations is at least two decades away as the technology does not exist today. Also, direct conversion of nuclear energy to electricity without use of the steam cycle is not likely very soon; the future use of fusion energy will still probably be coupled with a steam cycle.

Thus, the waste heat problem will be with us for a substantial period of time, and technological change in power generation cannot be expected to solve the problem for us. But there is another more fundamental waste heat problem arising from consumption of electricity. Practically all uses of electricity ultimately lead to conversion of the energy back to heat; it occurs directly for electric space heating, electric stoves, electric furnaces and the like, and indirectly for lighting, transportation, power tools, and so on. (To be sure, a small amount of energy is locked up in increased potential energy—mechanical or chemical—and some electromagnetic radiation—light and radio—escapes to space, but these are estimated to be only a very few percent of society's total consumption of electrical energy.) Thus, we may think of a power plant of 40 percent efficiency as releasing 60 percent of the heat in a concentrated dose at the power plant site and the other 40 percent over the points of use, primarily the urban areas.

If by some miracle all power plants could be made 100 percent efficient, the total heat release would be cut back to about 35 percent of what it is now. But if the power demand keeps doubling every ten years, the gain in

efficiency would be all used up in just 15 years of continued growth. This illustrates that any technological breakthrough in environmental control is equivalent to a one-time gain of time which can be wiped out by unchecked growth in production.

The waste heat from electricity is but part of the total waste heat released by all forms of energy use by society. The density of heat released in urban areas has already increased atmospheric temperatures significantly. Ultimately the excess heat is diffused in the atmosphere and radiated to space. On a *local* basis the total waste heat released is substantial (for example about 5 percent of solar radiation in the City of Los Angeles), but on a *global* basis it is still very small (less than 0.01 percent of insolation at the surface).

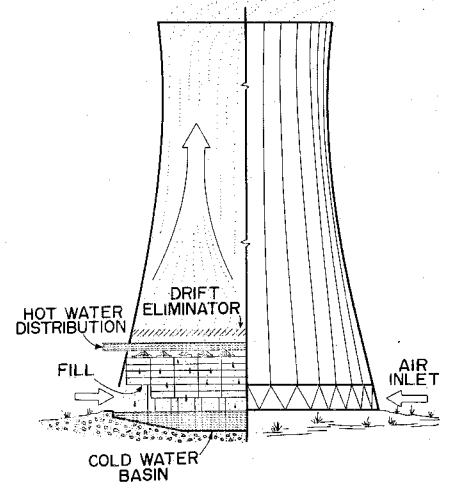
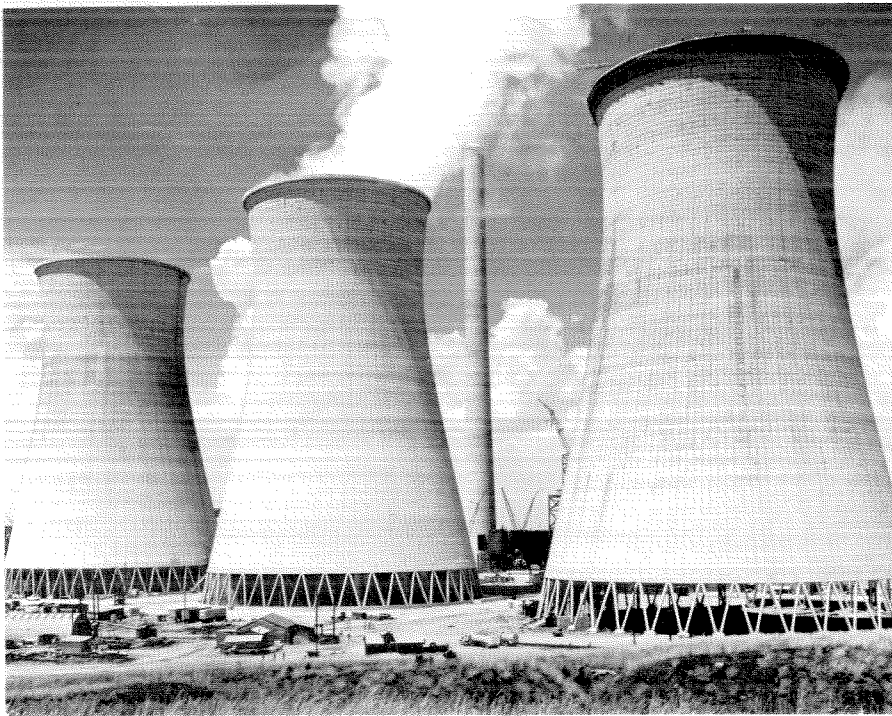
In fact, heat as a pollutant has a unique characteristic. Because of the basic laws of thermodynamics there is no treatment as such; any efforts to concentrate it (by heat pumps) simply require more mechanical energy, which means more waste heat is generated at the power plants. Other types of environmental pollution can be alleviated by various processes, which usually consume power and ultimately produce waste heat. *Thus, heat is an ultimate residual of society's activities.*

Cooling Water Discharge

The waste heat rejected from power plants is unusually concentrated compared to the overall release of heat by society. For example, at the proposed 6600-megawatt nuclear power station at Point Conception on the California coast, the waste heat will be 13,000 mw (thermal) or equivalent to insolation on about 70 square kilometers of the ocean (assuming 100 percent load factor at the power plant, and insolation at 400 langley/day = 193 mw/ki²).

Thermal power plants use cooling water to transfer heat from the condensers (on the low-pressure side of the turbines) to the environment. Once-through systems, which are the least expensive, take water from the environment and return it about 10° to 15°C hotter. Fresh water sources have been frequently used in the past, but with stringent thermal requirements (such as not more than 3°C rise), there are few remaining opportunities to use once-through fresh water cooling for new major plants of several thousand megawatts. Most rivers simply do not have enough flow to provide sufficient dilution during critical summer months, and those that do (like the Tennessee) are already being used extensively for cooling.

Lakes and reservoirs can be good heat sinks, but the currents are often too small to provide good advection of heat away from the plant sites. Furthermore, lake biota and water quality are particularly sensitive to thermal changes. For Lake Michigan, for example, the new rules now being proposed are so strict that new large power plants will be forced to use cooling ponds or cooling towers.



Cooling towers at TVA's Paradise Steam Plant in Kentucky are designed, as in the diagram above, to supplement the capacity of the Green River to cool the plant during the summer months. Each tower is 320 feet in diameter at the base, and 437 feet high. Power plant capacity is 2560 megawatts.

Many estuaries are also too small to take large additional heat loads, and increased temperatures aggravate water quality problems. The open ocean is still an excellent heat sink, but increased attention is needed for development of logical temperature criteria and effective diffusion structures for hot water discharge.

In once-through cooling systems the natural water environment is being used as a giant heat exchanger between the power plant and the atmosphere. Thus, in setting thermal requirements and designing cooling water outfalls, more attention should be given to the next step in the heat transfer chain. Some questions:

1. Is it desirable to minimize the temperature rise in the receiving water by wide dispersal of the heat?
2. Should the transfer of heat to the atmosphere be maximized (by keeping the temperature increment high instead of low)?
3. Should discharge be arranged to avoid complete "blockage" of a waterway with heated water?
4. Should waste heat be stored below thermoclines in lakes and oceans to avoid any direct effect on surface temperatures during the summer?

The current regulatory practice by FWQA (the Federal Water Quality Administration) and the states is the specification of maximum temperature increments in the receiving water (objective 1), but this may be contrary to desirable objectives 2 and 3. Furthermore, following objective 4 in lakes might have serious consequences for the annual regime of a lake, although temperature increment requirements are satisfied. Within the overall limits of the heat assimilation capacity, there are various

strategies for design of outfalls to control the heat distribution in the environment—such as submerged outfall diffusers for high dilution or channel outlets for surface spreading of hot water with little dilution.

It is urgent that we have a better understanding of the ecological effects of heat in each case, and find out whether it is better to disperse waste heat widely (disturb a vast region just a little) or to set aside a much smaller aquatic region to be heated significantly, allowing other regions to remain undisturbed. Millions of dollars are going to be spent for thermal pollution control for ecological objectives that are not yet defined or understood. Even when we do understand the ecology, there remains the problem of evaluating tradeoffs—how much disturbance of aquatic life should be tolerated, considering the many benefits derived from electricity?

Electric utilities understandably find it desirable to use the ocean water for once-through cooling if the load centers are near the coast. But the coastlines are strongly desired for other uses, too. In California, the public wants the shoreline reserved for recreation and its natural beauty rather than for unsightly thermal power plants. There is a limit also to how much heat the coastal ocean can assimilate, although we are apparently still far from this limit in California.

When once-through cooling is not desirable, cooling ponds or evaporative cooling towers may be used. The use of cooling towers instead of once-through cooling systems increases the cost of electricity only about 1 to 2 percent for residential customers or 3 to 4 percent for industrial customers. But these systems also have their hydrologic

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impacts especially where water is scarce. In either case most of the heat exchange to the atmosphere in warm weather occurs by evaporation of water from the pond surface or from the cooling tower spray. For each kilowatt-hour of electricity generated, the evaporation is about 2 liters.

In the last few years large natural-draft cooling towers have come into use in the U.S. When the circulating water is sprayed downward into the rising air current, a small fraction of the water (a few percent) is lost by evaporation and by upward drift of droplets, necessitating a continuous inflow of makeup water to the system. Since such water usage is evaporative, the salts are left behind and have to be flushed out occasionally, thus degrading the quality of the remaining natural water supply. Dry (non-evaporative) cooling towers have not yet been developed for large power plants of hundreds or thousands of megawatts.

Planning for the Future—Braking the Growth Rate

The waste heat problem is not readily solved by technological change. Different outfall arrangements or siting alternatives can convert and distribute the heat in ways which minimize adverse effects, but the waste heat discharges are not *eliminated*. Gradual small improvements in thermal efficiency of power plants will give barely perceptible relief on the waste heat problem in the next few decades.

We shall continue to depend on large central power stations. One alternative, solar cells, has the advantage of using the present heat budget of the earth and circumvents the waste heat problem (like hydro power), but the huge requirements for land and material will make it impractical for generation of the large blocks of additional power to meet projected needs in the next few decades.

The “globalists” would have us believe that we are far from environmental limits on energy use because man’s energy input is small compared to the global heat budget. But they fail to allow for the fact that local and regional environmental impacts (such as in California or the northeastern U.S.) are rapidly becoming severe. Furthermore, heat dissipation is not the only problem; on all the other fronts as well (air pollution, mine debris, nuclear waste management, aesthetics), it is highly doubtful that technology can reduce the impact per unit of consumption at a continuing annual percentage rate anywhere near the current rate of growth of consumption. Each single technological improvement in environmental

control is equivalent to only a one-time gain of a few years in an exponentially growing business; in some instances the improvement due to a new control technology may be counteracted by growth even faster than the new control technology can be implemented (as may well be the case for air pollution from automobiles).

Our most powerful tool for environmental control in the next few decades is a *drastic reduction in the rate of increase of consumption*. Society must set limits on the total release of heat and all other contaminants to protect the quality of our finite environment.

A decade ago energy planners were primarily concerned with the adequacy of our fuel reserves. But now nuclear power has proved itself, and with breeder reactors probably to be in use soon, there is little concern about running out of nuclear fuel. The next step will undoubtedly be fusion reactors using deuterium derived from a huge supply in the ocean waters. The great optimism on the fuel picture is well illustrated by a promotional booklet for nuclear energy entitled “Infinite Energy” issued by the Westinghouse Company a few years ago.

The “scarcity” of the environment is now replacing the scarcity of fuel as the critical constraint in growth of the energy industry. The environment can no longer be regarded as *infinite*. One hundred years ago it must have seemed to our forebears as though there was infinite land in the United States; but the frontier days are past, and we have become adjusted to thinking of our land as a scarce and limited resource. Any freedom to use land has been reduced by government regulations like zoning. We have also of course already recognized the finiteness of fresh water supplies, and have established rights, priorities, and regulations to control their use.

Now we have passed the last frontier of the infinite environment concept. We must stop talking about meeting the demand for energy and instead devise ways to allocate a limited potential supply and to change people’s attitudes toward energy. The first step is to reduce the annual rate of increase—in a sense, to reverse the curvature of the growth curve. This does not imply an actual decrease of energy consumption but rather an attempt to level the growth curve off below some upper limit which is not too far above our current position.

Limiting the total growth of the energy usage is not a new idea, but somehow technologists always seem to concentrate just on reducing the adverse effects of each unit of usage, optimistically assuming that the overall growth will not overwhelm them. But the thought is beginning to appear in various reports. In its report “Electric Power and the Environment” (Aug. 1970), the Office of Science and Technology says:

“ . . . It may well be timely to re-examine all of the basic factors that shape the present rapid rate of energy growth in the light of our resource base and the impact of growth on the environment. We raise the issue here for further study and discussion.”

I would have been happier if it said, "We raise the issue for action!"

A December 1969 report on energy forecasting for OST by Battelle Northwest slipped in just a one-sentence paragraph on the growth-environment issue:

"It is even possible to envision Federal policies designed to slow the growth of energy consumption due to adverse environmental effects through rate-making policies and emphasis on increased efficiency."

It's not a question of whether it is "even possible"; it's a *necessity* to develop such policies if we want to survive this energy "explosion." It's not a case of saying the public is not ready for growth control. It's time for the technologists to say, "You must recognize the limitations of your environment and live within your environmental means."

The Elements of an Energy Policy

The federal and state governments need to develop more comprehensive and better defined energy policies and strategies, such as:

1. All forms of energy must be considered together, so that comprehensive strategies involving tradeoffs between different fuels and energy systems can be adequately evaluated.
2. It must be recognized that energy usage must ultimately be limited because of unavoidable environmental effects (such as the release of heat). The attitude of unlimited development to meet unlimited demands must be replaced by a willingness to keep energy demands within reasonable limits, considering the limitations of the environment. Heat is an inevitable residual of industrial societies.
3. The growth rates must be drastically curtailed in the near future. This will not be easy, and a carefully developed strategy would probably include many of the following features:
 - a. The consumers of electricity and fuels should be charged for all environmental costs, including both direct costs for environmental pollution costs and indirect damages to the environment. Present pricing policies simply do not imply a high enough value for the environment which must be shared by all.
 - b. Regressive rate structures should be revised, as necessary, to discourage wasteful usage of energy by large users who often enjoy preferential rates.
 - c. Stopping advertising and promotional programs, especially by electric utilities.
 - d. Establishment of taxes to increase the cost of energy use to discourage excessive usage.
 - e. Establishment of adequate licensing procedures and priorities for large new users of electricity or other energy sources. In some circumstances permits for use of energy should be denied where the environment cannot tolerate such additional energy uses.
 - f. Setting limits on unit consumption of energy by automobiles, electric appliances, houses, etc.
 - g. Discourage use of electricity as a simple source of heat, unless it is necessary for air pollution control. When-

ever one unit of electrical energy is used for heating, approximately two units of waste heat must be rejected to the environment; thus, even though electricity is a "clean" source of heat to the consumer, it loads more heat altogether into the environment.

h. In urban planning, limitations must be set for the areal density of total energy release in urban areas, in order to avoid excessive climatic change.

i. The consumer must learn not to use energy wastefully or carelessly, and realize that his consumption inevitably produces some environmental degradation.

4. A vigorous program of research and development on alternative long-range energy strategies should be undertaken. In a broadly interdisciplinary way, the new Environmental Quality Laboratory at Caltech, under the direction of Lester Lees, has already started a study of these problems (see p. 11).

5. More research is needed on the individual components of environmental control (e.g., air pollution, water pollution, radioactive wastes), and power-plant-siting alternatives (e.g., underground or underwater).

6. Establish adequate organizations to manage the environment in all aspects, with the ability to make tradeoffs between different kinds of environmental effects. (Should air pollution be solved in one place at the expense of a thermal pollution problem somewhere else?)

7. Clarify environmental goals and damages especially in the fields of medicine and ecology.

8. Energy systems and environmental limitations must become a central element in regional and urban planning.

9. Adequate long-range planning is vital, as illustrated by the electric power industry. Since the time required for licensing and construction of electric power plants is often ten years, tentative site identification must be made 15 years before expected startup. The overall planning for a given utility must extend even further, say 20 years. Finally, basic policy planning for the whole energy industry must extend about 30 years into the future in order for orderly planning to proceed. It is because of this pattern that I sound the alarm for basic long-range questions of growth and other strategies rather than for any particular argument over a power-plant site.

Environmental control is the civilian counterpart of arms control. We now have the technology to do vast damage to our environment, even by the "normal" peacetime activities of society. We must accept some profound changes and restraints in our societies to control man's overall effects on the environment. The environment is definitely finite, and it simply can no longer tolerate man's unrestrained activities and new developments, whether of military or civilian nature.