COMBUSTION AND HEAT EFFICIENCY; Boiler of the Future

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Let us take a cursory look at the Electric Utility Industry.

During the next generation, approximately 80% of the electricity used in the United States will be generated from the fossil fuels - oil, gas, and coal. Coastal utilities use most of the oil.

Our cursory view of fossil fuel costs now can begin with Table A.

TABLE A

TYPICAL COSTS PER ONE MILLION BTUs

Year	Oil	Gas	Coal
1960	$0.33	$0.50	$0.40
1970	0.30		
1973	0.54		
1974	1.89		
1977	2.12		
1979	3.25		
3/81	5.25	4.00	2.00
Change since 1960	+1490%	+700%	+400%

An industry whose raw material costs have increased 15 times in 20 years has undergone a revolutionary change. An industry (utility) whose physical plant was built during this period, and which can only burn oil, has few options. It can raise rates, build new generating plants, ... and raise rates. Therefore, we have seen the costs of 1,000KWH rise from $25 to over $100 in some areas, during the last 20 years.

It is not our intention to consider here the societal impacts of these changes.

Alternate fuels, and increased efficiency of use of fossil fuels are sources of relief from these cost increases.

ALTERNATE FUELS:

The U.S. is relatively sufficient in coal and natural gas. Use of domestic fuels offers obvious advantages over imported oil. Domestic fuels are often estimated as 25% or more advantage to our economy, compared with imported fuel, at the same price per 1mm Btu.

Conversion of boilers can be both costly and (in some cases) counterproductive. Boilers designed for oil firing only can rarely be converted to burn coal. They may be modified to burn gas, or perhaps, coal-oil mixtures (COM).

Generally, boilers designed for coal firing may be converted to either gas or oil firing.

DOMESTIC FOSSIL AND NUCLEAR FUELS:

Partial Governmental Deregulation has uncovered, or will reveal, domestic fossil fuels beyond present proven reserves. The information in Table B. is probably conservative as an estimate for the period of time domestic resources may supply domestic needs, with oil supplemented by imports. Also the "mix" will change with time. The more abundantly available energy sources will increase in relative importance.

TABLE B

ESTIMATE OF TIME DOMESTIC FUEL RESOURCES WILL SUFFICE

Fuel (Energy Source	"Sufficient" Time Period	Remarks
Oil	50 Years	Oil Shales & Tar Sands are a plus
Natural Gas	100 Years	Deep gas will extend
Coal	500 Years	Lignites will extend
Uranium (Fission)	100 Years	Extended by "BREEDERS" to
Uranium-Plutonium	500 Years	Or more
Deuterium-Tritium (Fusion)	100 Years	Or more
D-D Fusion	"Infinite-Forever"	10 Sq. mi., eq., all fossil fuels

If we follow conventional INDUSTRIALIZED nations' views of Science and Technology, some important conclusions may be drawn:

(1) Conservation and efficient utilization of our natural resources will become increasingly imperative. This will require research and development of "Best Available Technology" (BAT). Corollary is the need for industrial "Modernization" to utilize BAT. A current example is found in Japan and Germany, where industry has been rebuilt since 1946, thereby giving these countries some competitive and other advantages.

(2) Coal, and Lignites, are the more abundant of the fossil fuels.

"Convenience" fuels, e.g., pipeline, and "synthesis" gases will be among the products from coal. Increasingly, oil, coal and natural gas will be used as chemical raw materials, in addition to their use as fuel.

(3) Nuclear fuel (energy) offers to society an opportunity to become semi-independent of fossil fuels. BAT is available in fission of uranium and plutonium. The useful life of BAT will be extended considerably by development of BAT for handling, storage, separation, and utilization of spent fuel, and of by-products. A new Technology for these purposes will evolve and many uses will be developed for products.

The safety of this new industry is questioned by many. Fears of misuse and mishandling are expressed by many. However, the history of fission development is without parallel, in the degree of safety, compared with that of any other major indusrial development.

(4) Use of nuclear fusion may be the answer to man's energy problem. When deuterium-deuterium fusion technology is developed to provide electricity, a new era will begin. It appears safe to predict this beginning before the 21st. century.

Deuterium is almost infinitely available from sea water. Electricity from this source may be considered available indefinitely, OR FOREVER. Ten (10) square miles of coastal sea water will yield energy equivalent to all the fossil fuels on the earth's surface.

EXISTING AND FUTURE OIL-FIRED ELECTRIC UTILITIES:

Combustion efficiency and heat transfer (use) efficiency to mechanical and electrical energy are major areas of interest to the industry.

Figure I shows typical data for fossil-fired boiler-turbine generator. Comparisons are shown of heat losses for conventional plants and for "Co-generation" units.

Note the major heat losses to stack gases and to condenser cooling water. Some improvement may be seen in turbine and generation design, but it is anticipated that improvements will be in low percentages of the fuel heat load, unless radical breakthroughs are made.

Loss to condenser cooling water can be improved. One method is practiced in Europe and the U.S. whereby turbine extraction steam (or condensate) is used to heat (and cool) municipalities. This is in the direction of "Co-generation." Capital costs are pertinent. Similarly, steam may be efficiently used for process purposes.

Stack heat losses can be improved. This loss is intertwined with combustion controls, boiler designs, corrosion controls, and environmental considerations.

To establish perspective, a 500MW generation plant might burn 10,000,000 bbl of oil annually. Current fuel costs would exceed $300,000,000 per year.

A 1% improvement in fuel (heat) efficiency would amount to over $3,000,000.00.

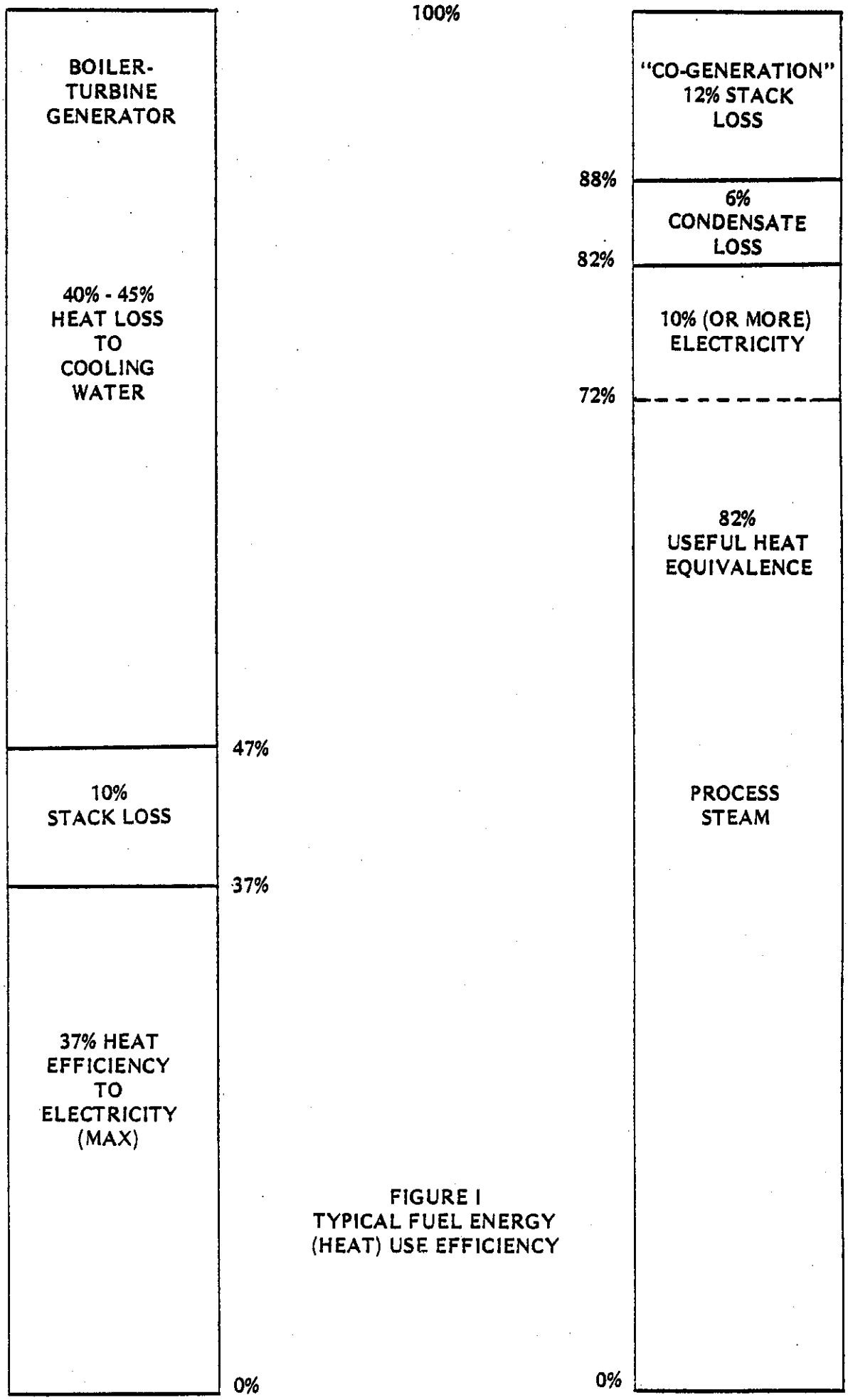

FIGURE I
TYPICAL FUEL ENERGY
(HEAT) USE EFFICIENCY

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Figure II shows graphical data pertinent to combustion controls, and sulfur compounds. Note that control of excess oxygen to below 0.7% (≈3.5% excess air) results in improved combustion efficiency.

Low excess oxygen also MINIMIZES conversion of SO_2 to SO_3. Additives and ash are carried over by gases to the cold end of the boiler. There it neutralizes condensed sulfuric acid, and MINIMIZES corrosion, even when stack gas temperature is below the sulfuric acid dew point.

This allows a boiler to be operated at lower stack gas temperature. A "rule-of-thumb" is that 40°F. is equivalent to 1% fuel (heat) efficiency.

Depending on age and design, high pressure boilers normally operate at 280 to 400°F. stack gas temperature.

It is possible to install air heaters with which to reduce stack gases to about 120°F. If applied to a unit presently operating at 280°F., this would increase heat efficiency (280-120)/40 = 4%. In our 500MW example this would save $12,000,000 per year.

A problem is the cost of condensing heat exchangers of adequate size and corrosion resistance; and the maintenance costs of same.

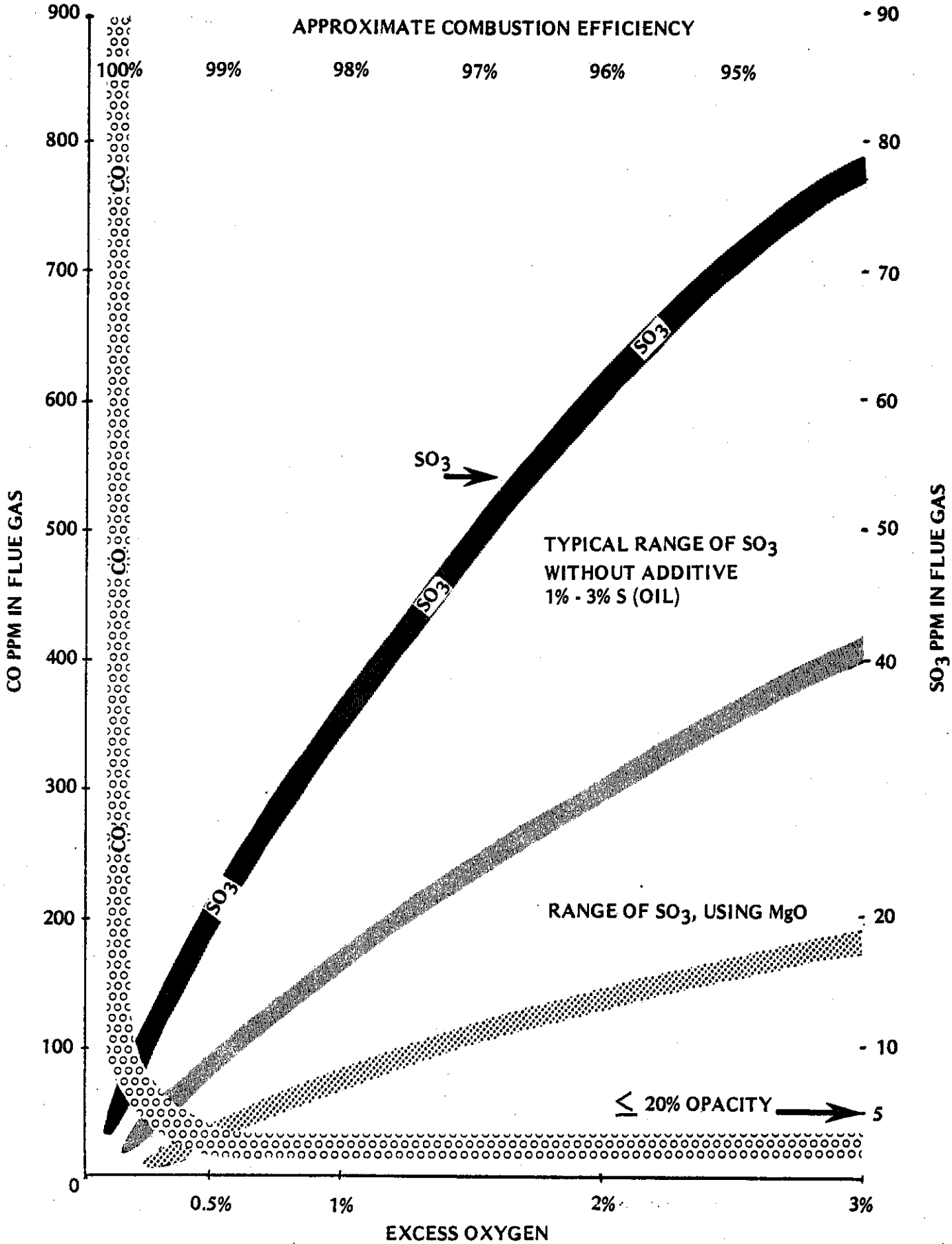

FIGURE II
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FLUE GAS SCRUBBING; PARTICULATES AND SULFUR:

Electrostatic Precipitators (ESP) may be used to remove particulate matter from stack EMISSIONS. ESPs are characteristically high maintenance items. If low sulfur coal yields high electrical resistivity flue gases, the ionic strength of the gases may be increased by adding chemicals.

When both particulates and sulfur compounds must be removed, scrubbers are used. Depending on the degree of removal of sulfur compounds and particulates required, fabric bag houses may follow the scrubbers.

The principal chemical reactions are neutralization of SO_2 and SO_3 by alkali metals, usually under oxidizing conditions. When lime (CaO) is used, the principal compound formed is gypsum, hydrated calcium sulfate. It is usually removed as a wet sludge.

One or more process designs use the alkali metals from lignite fuel as the principal scrubbing agent. The product may be removed dry from the system.

The latter type scrubber may permit design of a closed water system, with the discharge of all solid wastes as scrubber product. Cooling tower discharge may be used to make up scrubber fluids.

A closed water system also MINIMIZES water usuage.

Most scrubbers limit the efficiency of air heat exchange, and therefore, heat efficiency. If a scrubber-baghouse is operated in range of 500 or 600°F., with about a 50°F. drop in temperature, then lower cost condensing heat exchangers might increase heat efficiency more than the 4% shown in our previous example.

MAGNETOHYDRODYNAMICS

This is an intriguing power generation theory, and developing technology. Pilot work has been done on direct (current) generation from the plasma (ions) of combustion. We trust this will be followed by CONVENTIONAL (Steam) generation, using hot gases. Theoretically, it is possible to double the heat efficiency to electricity.

The operation must cope with slag formed from fuel ash.

It is our understanding, there is "Cooperative" research and development between the Soviet Union and the United States.

"THE BOILER OF THE FUTURE"

1. Will be more fuel (heat) efficient

   Estimate of potential improvement:

   a) Design of turbine generators - 1 to 2%
   b) Low oxygen burners, combustion control - 1 to 3%
   c) Lowered stack gas temperatures - 3 to 8%
   d) Condenser design and "Co-generation" via "Co-generation." - Up to 100%

2. Will be a "good" industrial resident or neighbor. Water and air pollution will be minimized.

3. Will be gradually phased out, by use of fossil fuels for chemical purposes; and by development of nuclear generation.

It is a pleasure to share these thoughts with you. I hope some of you will be stimulated to work toward BAT, and share with your fellowman the profits which will accrue.