EPA BRIEFING: IERL/CINCINNATI

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BACKGROUND

Industry in the United States purchases about 27 quads* annually, approximately 40% of total national energy usage (see Table 1, Col. 6). This energy is used for chemical processing, raising steam, drying, space cooling and heating, process stream heating, and miscellaneous other purposes.

In many industrial sectors energy consumption can be reduced significantly by better "housekeeping" (i.e., shutting off standby furnaces, better thermostat control, elimination of steam and heat leaks, etc.) and greater emphasis on optimization of energy usage. In addition, however, industry can be expected to introduce new industrial practices or processes either to conserve energy or to take advantage of a more readily available or less costly fuel. Such changes in industrial practices may result in changes in air, water or solid waste discharges. The EPA is interested in identifying the pollution loads of such new energy-conserving industrial practices or processes and in determining where additional research, development, or demonstration is needed to characterize and control the effluent streams.

In the first phase of this study we identified manufacturing industry sectors that have a potential for change, emphasizing those changes which have an environmental/energy impact. We focused on identifying changes in the primary production processes which have clearly defined pollution consequences. In selecting those to be included in this study, we have considered the needs and limitations of the EPA as discussed more completely in the Industry Priority Report. Specifically, energy conservation has been defined broadly to include, in addition to process changes, conservation of energy or energy form (gas, oil, coal)

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*1 quad = 10^{15} Btu

AVAILABILITY OF REPORTS FROM EPA PROJECT ON ENVIRONMENTAL

ASSESSMENT OF ENERGY-CONSERVING INDUSTRIAL PROCESS OPTIONS

Copies of reports from a major industrial environmental assessment are available upon request for specific volumes from the address given at the lower right hand corner of this sheet.

The full title of this EPA study, individual volume titles, and report numbers are as follows:

"Environmental Considerations of Selected Energy Conserving Manufacturing Process Options" - Interagency Energy-Environment Research and Development Report, U.S. Environmental Protection Agency, December 1976:

Volume I. Industry Summary Report. EPA-600/7-76-034a.

Volume II. Industry Priority Report, EPA-600/7-76-034b.

Volume III. Iron and Steel Industry Report. EPA-600/7-76-034c.

Volume IV. Petroleum Refining Industry Report. EPA-600/7-76-034d.

Volume V. Pulp and Paper Industry Report. EPA-600/7-76-034e.

Volume VI. Olefins Industry Report. EPA-600/7-76-034f.

Volume VII. Ammonia Industry Report. EPA-600/7-76-034g.

Volume VIII. Alumina/Aluminum Industry Report. EPA-600/7-76-034h.

Volume IX. Textile Industry Report. EPA-600/7-76-034i.

Volume X. Cement Industry Report. EPA-600/7-76-034j.

Volume XI. Glass Industry Report. EPA-600/7-76-034k.

Volume XII. Chlor-Alkali Industry Report. EPA-600/7-76-0341.

Volume XIII. Elemental Phosphorus and Phosphoric Acid Industry Report. EPA-600/7-76-034m.

Volume XIV. Primary Copper Industry. EPA-600/7-76-034n.

Volume XV. Fertilizer Industry Report. EAP-600/7-76-034o.

Copies should also be available for sale from the Superintendent of Documents, Government Printing Office and from the National Technical Information Service.

Power Technology and Conservation Branch
Energy Systems Environmental Control Division
Industrial Environmental Research Laboratory
U. S. Environmental Protection Agency
Cincinnati, Ohio 45268
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TABLE 1

DISTRIBUTION OF ENERGY CONSUMPTION BY SECTOR (1971)

Sector	Purchased Fuels 10^{12} Btu	%	Purchased Fuels Plus Electricity* Valued on Thermal Basis 10^{12} Btu	%	Purchased Fuels Plus Electricity Valued on Fossil Fuel Basis** 10^{12} Btu	%
Industrial						
-Manufacturing	14,329	20.8	16,085	27.9	19.732	28.8
-Non-Manufacturing	5,965	8.6	6,538	11.7	7,728	11.3
Total Industrial	20,294	29.4	22,623	39.6	27.460	40.1
Household/Commercial	14,281	20.7	17,441	30.6	24,006	35.0
Transportation	16,971	24.6	16,989	29.8	17,026	24.9
Electrical Generation	17,443	25.3	-	-	-	-
Total	68,989†	100.0	57,053	100.0	68,492†	100.0

* Purchased electricity valued at its thermal equivalence of 3,412 Btu/kWh and allocated to consuming sectors.

** Purchased electricity valued at an approximate fossil fuel equivalence of 10,500 Btu/kWh and allocated to consuming sectors.

† Totals would be equivalent if all electric energy were generated from fossil fuels at a rate of 10,500 Btu/kWh.

Source: FEA, Project Independence, Blueprint, Vol. 3, November 1974, and Arthur D. Little, Inc. estimates.

by a process or feedstock change. Natural gas has been considered as having the highest energy form value followed in descending order by oil, electric power, and coal. Thus, a switch from gas to electric power would be considered energy conservation because electric power could be generated from coal, existing in abundant reserves in the United States in comparison to natural gas. Moreover, pollution control methods resulting in energy conservation have also been included within the scope of this study. Finally, emphasis has been placed on process changes with near-term rather than long-term potential within the 15-year span of time of this study.

Industries were eliminated from further consideration within this assignment if the only changes that could be envisioned were:

- energy conservation as a result of better policing or "housekeeping,"
- better waste heat utilization,
- fuel switching in steam raising,
- power generation or production of synthetic fuels.

After discussions with the EPA Project Officer and his advisors, 13 industry sectors were selected for inclusion in this study as shown in Table 2. These 13 industries or industry segments account for about two-thirds of the energy used in the manufacturing indsutries (Table 2). In consultations with the EPA Project Officer and his advisors from EPA, FEA, NBS, and other agencies, several hundred manufacturing processes or process options were screened and some 80 were selected for in-depth analysis (see Table 3). The results of the study are summarized in fifteen (15) reports prepared for EPA (an Industry Priority Report, 13 Industry Assessment Reports, and an overall Summary Report). Highlights of this study are given below.

TABLE 2

SUMMARY OF 1971 ENERGY PURCHASED IN SELECTED INDUSTRY SECTORS

	Industry Sector	10^{15} Btu/Yr	SIC Code In Which Industry Found
1.	Blast furnaces and steel mills	3.49 (1)	3312
2.	Petroleum refining	2.96 (2)	2911
3.	Paper and allied products	1.59	26
4.	Olefins	0.984 (3)	2818
5.	Ammonia	0.63 (4)	287
6.	Aluminum	0.59	3334
7.	Textiles	0.54	22
8.	Cement	0.52	3241
9.	Glass	0.31	3211, 3221, 3229
10.	Alkalies and chlorine	0.24	2812
11.	Phosphorus and phosphoric acid production	0.12 (5)	2819
12.	Primary copper	0.081	3331
13.	Fertilizers (excluding ammonia)	0.078	287

(1) Estimate for 1967 reported by FEA Project Independence Blueprint, p. 6-2, USGPO, November 1974.

(2) Includes captive consumption of energy from process byproducts (FEA Project Independence Blueprint)

(3) Olefins only, includes energy of feedstocks: ADL estimates

(4) Ammonia feedstock energy included: ADL estimates

(5) ADL estimates

Source: 1972 Census of Manufactures, FEA Project Independence Blueprint, USGPO, November 1974, and ADL estimates.

TABLE 3

PROCESSES SELECTED FOR DETAILED ANALYSIS

Industry Sector	Process Selected	Baseline Process	Product
Alumina and primary aluminum	Nitric acid leaching process	Bayer	Alumina
	Hydrochloric acid leaching process	Bayer	Alumina
	Toth alumina process	Bayer	Alumina
	Alcoa chloride electrolysis process	Hall-Heroult	Aluminum
	Application of titanium diboride cathodes to the existing Hall-Heroult cells	Hall-Heroult	Aluminum
	Toth Alumina with Alcoa Chloride process	Bayer with Hall Heroult	Aluminum
Ammonia	Ammonia via coal gasification	Ammonia via natural gas	Ammonia
	Ammonia via heavy oil gasification	Ammonia via natural gas	Ammonia
Cement	Flash calciner	Natural gas or oil fired long kiln	Portland cement
	Fluid-bed cement process	Natural gas or oil fired long kiln	Portland cement
	Suspension preheater	Natural gas or oil fired long kiln	Portland cement
	Conversion to coal from oil & natural gas(a)	Natural gas or oil fired long kiln	Portland cement
Chloralkali	Dimensionally stable anodes-conventional	Graphite anode diaphragm cell	Chlorine-caustic soda
	Dimensionally stable anodes-expandable	Graphite anode diaphragm cell	Chlorine-caustic soda
	Dimensionally stable anodes-polymer membrane	Graphite anode diaphragm cell	Chlorine-caustic soda
	Dimensionally stable anodes-ion exchange membrane	Graphite anode diaphragm cell	Chlorine-caustic soda
	Modern mercury cell	Graphite anode diaphragm cell	Chlorine-caustic soda
Fertilizers	Nitric acid with catalytic reduction for NO_x	Nitric acid with no NO_x abatement	Nitric acid
	Nitric acid with molecular sieve for NO_x	Nitric acid with no NO_x abatement	Nitric acid
	Nitric acid with Grande Paroisse for NO_x	Nitric acid with no NO_x abatement	Nitric acid
	Nitric acid with CDL/Vitok for NO_x	Nitric acid with no NO_x abatement	Nitric acid
	Nitric acid with Masar for NO_x	Nitric acid with no NO_x abatement	Nitric acid
	Fuel oil firing of fertilizer dryers where emissions are controlled by bag filters	Natural gas fired dryers	Mixed fertilizers
Glass	Coal gasification & glassmaking	Natural gas fired furnace with cold charge(b)	Glass (soda-lime)
	Direct coal firing	Natural gas fired furnace with cold charge(b)	Glass (soda-lime)
	Electric melting	Natural gas fired furnace with cold charge(b)	Glass (soda-lime)
	Coal, hot gas generation & glassmaking	Natural gas fired furnace with cold charge(b)	Glass (soda-lime)
	Batch preheating & glassmaking	Natural gas fired furnace with cold charge(b)	Glass (soda-lime)
Iron and steel	CO collection from BOP	Combustion of offgases	Steel
	Direct reduction-electric furnace	Coke oven, blast furnace, BOP	Steel
	External desulfurization of blast furnace hot metal	Desulfurization in blast furnace	Blast furnace hot metal
	Dry quenching of coke	Wet quenching	Quenched coke
Olefins	Naphtha coil cracking	Ethane-propane coil cracking	Ethylene
	Gas oil coil cracking	Ethane-propane coil cracking	Ethylene

TABLE Cont'd

PROCESSES SELECTED FOR DETAILED ANALYSIS

Industry Sector	Process Selected	Baseline Process	Product
Paper and Allied Products	Alkaline-oxygen pulping	Conventional kraft	Slush pulp
	Rapson effluent-free kraft process	Conventional kraft	Slush pulp
	Deinking of waste news as a substitute for mechanical pulping	Refiner mechanical pulp (RMP)	Slush pulp
	Thermo-mechanical pulping (TMP)	Refiner mechanical pulp (RMP)	Slush pulp
Petroleum Refining	Direct combustion of asphalt in heaters/boilers	Regional cluster model for 1985 product mix	Refinery products
	Asphalt conversion by hydrocracking (H-OIL)	Regional cluster model for 1985 product mix	Refinery products
	Asphalt conversion by flexicoking	Regional cluster model for 1985 product mix	Refinery products
	Internal power generation using asphalt	Regional cluster model for 1985 product mix	Refinery products
	Hydrogen generation by partial oxidation	Regional cluster model for 1985 product mix	Refinery products
Phosphorus	Chemical cleanup of wet-process phosphoric acid	Electrothermal phosphoric acid	Detergent grade phosphoric acid
	Solvent extraction process for wet-process phosphoric acid	Electrothermal phosphoric acid	Detergent grade phosphoric acid
	"Strong acid" systems for wet-process phosphoric acid via "strong acid" process	Conventional wet-process phosphoric acid	Detergent grade phosphoric acid
Primary Copper	Outokumpu flash smelting	Reverb./converter	Blister copper
	Noranda process	Reverb./converter	Blister copper
	Mitsubishi process	Reverb./converter	Blister copper
	Oxygen use in flash smelting	No oxygen use in flash smelting	Blister copper
	Metal recovery from slags by flotation	metal recovery in electric furnace.	Refined copper
	Arbiter process	Reverb./converter/electrolytic refining	Refined copper
Textile	Integrated knit fabric mill using advanced aqueous processing(c)	Knit fabric mill using current aqueous processing	Knit fabrics
	Integrated knit fabric mill using solvent processing(c)	Knit fabric mill using current aqueous processing	Knit fabrics
	Integrated woven fabric mill using advanced aqueous processing(d)	Woven fabric mill using current aqueous processing	Woven fabrics

(a) Forms part of baseline technology
(b) Side port-regenerative furnace
(c) 100% polyester fiber
(d) 50/50 polyester cotton fiber mix

METHODOLOGY

In order to properly assess the impact of these processes, an analysis was made of both the currently practiced technology and the alternative technology that may be implemented in new facilities or rebuilt plants within a time frame of about the next 15 years. Where processes could be retrofited we attempted to identify such situations. To the extent possible we attempted to start with similar raw materials to make similar end products. For both baseline and new technology, three main factors entered into the assessment:

- identification of the pollutants,
- development of capital and operating costs for both production and pollution control aspects, and
- determination of energy used in baseline and alternative technology for both production and pollution control.

Judgments were then made about economic viability and likelihood of implementation of the alternative process. Finally research areas were identified.

Since most processes in the heavy industrial chemicals and metal industries take anywhere from five to twenty years from initial inception to commercialization, it is clear that few if any of the processes being considered for implementation have been developed in the United States as a result of a concern with high cost energy. "Energy-conserving technology" when it is being applied now in the United States has been developed largely abroad, mainly in Europe or Japan. Examples that can be cited are collection of carbon monoxide gas from basic oxygen furnaces (developments by Japanese and French companies), suspension preheaters in the cement industry (German and Japanese developments), and flash smelting in the copper industry (Finnish development).

MAJOR ISSUES RELATED TO INDUSTRIAL PROCESS CHANGES

In examining the 80 processes considered here in depth a wide diversity of process changes were considered. Some of the process changes could have upstream or downstream impacts. For example substitution of electric furnaces for gas-fired furnaces would generally lessen process pollution problems but increase emissions at the electric power generating site. A number of processes were identified as having potentially smaller pollution control costs while at the same time reducing energy requirements. Some examples are shown in Tables 4A-E. Table 4F gives an overall picture of the relationship between energy conservation and pollution control costs for all the new process technologies studied. In addition some problems/ impacts extend across several industries and are discussed below.

1. Availa ility of Petroleum-Based Feedstocks and Coal Gasification

Major concerns faced in the United States today are:

- The capital availability problem
- Assuring continuing supplies of a given energy form such as natural gas for fuel or feedstock.

For example in the glass industry natural gas is in short supply, and many of the glass companies have been looking at coal gasification processes. Such coal gasification processes tend to be capital intensive and are thus not particularly interesting from an investment/economic viewpoint. Moreover a gasified coal would effectively increase the price of fuel to about $3 per million Btu compared to the regulated prices of about $.60 to $1.00 per million Btu that were being paid by industry in early 1975. Similarly increased concern is being expressed about the use of natural gas in the manufacture of ammonia and attention is being given to making ammonia from heavier feedstocks or from coal. As another example, injection of natural gas into blast furnaces is no longer being actively considered as a viable option for new facilities and increased consideration is being given to injection of liquid fuels, possibly slurried with coal, or direct coal (steam coal) injection. Considering the price of regulated gas at below $1 per million Btu, all such coal based options tend to be more expensive, but are being actively considered and even implemented by industry because of concerns with natural gas availability. Thus in industry we expect more oil and coal use in place of natural gas as a fuel as well as feedstock substitute.

TABLE 4A

EXAMPLE OF ENERGY CONSERVING PROCESS TECHNOLOGY
HAVING POTENTIALLY SMALLER POLLUTION CONTROL COSTS

- Aluminum
  - – Alcoa Chloride*
  - – Hall-Heroult/Refractory Metal Cathodes*
  - – Clay Chlorination with Alcoa Chloride*
- Copper (> 85% Sulfur Recovery)
  - – Noranda Smelting Process*
  - – Flash Smelting*
  - – Mitsubishi*
- Copper
  - – Slag Flotation*
  - – Use of Oxygen*

*Btu Saving as Well as Energy Form Saving

TABLE 4B

EXAMPLE OF ENERGY CONSERVING PROCESS TECHNOLOGY HAVING POTENTIALLY SMALLER POLLUTION CONTROL COSTS

- Cement
  - Suspension Preheater*
  - Flash Calciner*
- Glass
  - Preheating/Batch Agglomeration*
  - Coal

*Btu Saving as Well as Energy Form Saving

TABLE 4C

EXAMPLE OF ENERGY CONSERVING PROCESS TECHNOLOGY HAVING POTENTIALLY SMALLER POLLUTION CONTROL COSTS

- Chloralkali: Dimensionally Stable Anodes
  - Standard Membrane*
  - Stabilized Asbestos*
  - Microporous Membrane*
  - Ion Exchange Membrane*
- Iron and Steel
  - Collection of CO Gases from Basic Oxygen Process*
  - External Desulfurization of Blast Furnace Pig Iron*
  - Direct Reduction*
  - Dry Quenching of Coke*

*Btu Saving as Well as Energy Form Saving

TABLE 4D

EXAMPLE OF ENERGY CONSERVING PROCESS TECHNOLOGY HAVING POTENTIALLY SMALLER POLLUTION CONTROL COSTS

- Phosphoric Acid (Detergent Grade)
  - Cleanup of Wet Acid by Neutralization/ Precipitation*
  - Solvent Extraction*
- Phosphoric Acid via Strong Acid Process*
- Pulp and Paper
  - Rapson Effluent Free Process*
  - Alkaline – Oxygen Process*

*Btu Saving as Well as Energy Form Saving

TABLE 4E

EXAMPLE OF ENERGY CONSERVING PROCESS TECHNOLOGY HAVING POTENTIALLY SMALLER POLLUTION CONTROL COSTS

- Textiles – Knit Fabrics
  - Advanced Aqueous Process*
  - Solvent Processing*
- Textile– Woven
  - Advanced Aqueous*
- Nitric Acid (NO_x Control
  - Molecular Sieve*
  - Grand Paroisse*
  - CDL/Vitok*
  - Masar*

* *Btu Saving as Well as Energy Form Saving*

TABLE 4F

DISTRIBUTION OF NEW PROCESS TECHNOLOGIES

Energy Conservation Potential		Increase In Control Costs	No Change	More Than 5% Savings
	More Than 5% Savings	12	6	24
	No Change	2	2	3
	Increased Energy Use	3	0	2

Savings in Pollution Control Costs

2. NO_x/SO_2 Emissions

a. Coal use: With increased use of coal, one can expect higher NO_x emissions from reverberatory furnaces in the copper industry, cement kilns, etc. In addition sulfur emissions can be expected to increase because of sulfur found in coal but not in pipeline quality natural gas. Generally, the use of coal increases NO_x emissions compared to firing with natural gas or fossil fuels, mainly because 1) coal generally requires larger amounts of excess air to achieve complete combustion and 2) nitrogenous compounds in coal are apparently easily oxidized to NO_x.

b. Oxygen Use: Another area in which NO_x emissions are of concern is in the increased use of oxygen which has received considerable attention. Generally oxygen use tends to conserve fuel use because flame temperatures are somewhat raised which increases the efficiency of the furnace. For example, when oxygen was introduced into the open-hearth steelmaking furnaces the throughput rates increase by as much as 50%. Such use of oxygen is now being considered in the iron and steel industry, in the glass industry and in nearly all industries now using fossil fuels in furnaces. The increase in the flame temperature would tend to raise NO_x levels. Holding NO_x levels constant would demand better control of the air fuel combustion ratios in bringing them closer to stoichiometric.

Thus both coal use and oxygen use can be expected to increase NO_x emissions.

3. Preheating

With energy costs escalating, increased emphasis is being given to preheating. Preheating can be accomplished in a variety of vessels or types of vessels such as static beds, moving beds, fluid bed devices, gas liquid heat exchangers, gas-gas heat exchangers, etc. All of these processes or procedures have the commonality of extracting waste heat from product streams or providing process heat at lower temperatures. Major environmental problems with solid preheating are dusting, incomplete combustion of volatiles, and potential for fugitive emissions.

Solid preheating generally has the environmental advantage of reducing NO_x emissions per ton of product because less energy is being supplied by high temperature combustion. In addition capital investments for preheaters tend to be modest in comparison with the total plant. Since many preheaters can be retrofitted to existing facilities the impact on energy use can be felt in a shorter time frame than other options requiring completely new plant facilities entailing high investments. Thus increased NO_x emissions from coal and oxygen use can be somewhat ameliorated by application of preheaters

In conclusion major process changes prompted by a desire to conserve energy that are being considered involve increased use of coal due to shortage of natural gas and increased use of oxygen and use of preheaters for energy conservation.

Overall because of concerns on capital availability and risks entailed in application of new process technology, we expect the pace of process change to be slower than in the 1950's and 1960's, with industry making every attempt to get as much production as possible out of existing plants before starting construction of new facilities.

ENVIRONMENTAL FINDINGS

In the course of this study involving thirteen basic industries, a number of energy conserving processes were identified as having potentially smaller pollution problems than currently practiced technology.* Examples include such options as the Rapson effluent free process in pulp manufacture and the Alcoa aluminum process. However, in the majority of options examined the types of pollutants will not change significantly because the energy conserving manufacturing processes involved over the next 10 to 15 years will utilize essentially the same raw materials to produce essentially the same products. Moreover, the quantities of pollutants emitted from these processes and the energy sources used will generally increase. More stringent regulations on emissions will increase simultaneously the amounts of concentrated pollutants that must be prevented from entering the environment and the amounts of energy and resources used in removing pollutants. In particular, the replacement of natural gas and oil with coal will mean a concomitant increase in:

- The amounts of gaseous pollutants such as sulfur oxides and nitrogen oxides, and

- the amounts of sludges containing toxic and hazardous substances such as heavy metals coming from the energy supply sources.

Furthermore, in switching from gas to oil to coal increased environmental impact can be expected in obtaining the fuel, for example, strip mining, tailings disposal and in disposal of residuals as sludges, etc. In short, the single most important cause of increased environmental impact will come from changing fuel forms/feedstocks and not as a result of introducing new, energy conserving processes.

ENVIRONMENTAL RESEARCH AREAS

With a few exceptions, pollution control technology is available today to meet probable emission standards over the next five to ten years. (Exceptions such as for fine particulate control are noted below.)

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*See Table 4.

However, research and development efforts are needed to establish more cost effective pollution control technologies especially in reducing capital investment requirements and operating costs. In particular, it is necessary to establish the effectiveness of pollution control technologies in each industry sector by demonstration projects in order to provide a firm basis for establishing practicable and achievable emission standards. These research and development needs must focus on demonstrating:

- effectiveness of removal of designated pollutants,
- cross-media effects, and
- health and ecological impact of pollutants where removal may be either beyond the capabilities of existing technologies or unacceptable in socio-economic terms.

Consequently, establishing the technical and economic capabilities of pollution control systems through research and development must be done in consonance with the ecological and health aspects of pollution emissions. If maximum utilization of R&D funds are to be made, it is apparent that priorities of allocation must be established on a broader base than merely improving the capabilities of technology, i.e., consideration must be given to the need for reducing emissions from an ecological and health viewpoint, the cross-media impacts and the socio-economic effects.

Specific areas for research and development efforts in the particular industries of major concern are as follows.

1. Air Pollution Control Technology

With regard to air emissions in the new process technologies investigated, we have identified the following to be deserving of R&D attention:

- Improving fine particulate removal technology. This would include those particulates resulting from metallic smokes and sublimed substances such as mercury, arsenic, zinc, etc. For example this problem can be found in glass furnaces where compounds are sublimed and volatilized. Similarly direct firing of coal or hot gas generation from coal for use in furnaces or kilns can involve volatilizing of the trace metals found in coal. Other industry sectors examined that face these kinds of fine particulate removal problems are aluminum, ammonia, cement, copper, fertilizer, iron and steel, petroleum refining, phospherus, and pulp and paper.

- Collection or control of fugitive emissions from process equipment. The collection and removal of emissions from equipment at points other than associated with process requirements (so-called fugitive emissions) such as from high temperature processes like preheaters for cement kilns or external desulfurization of blast furnace hot metal can be expected to become of increasing importance. Besides the cement and iron and steel industries, fugitive emission problems will be found in the aluminum, ammonia, copper and fertilizer industries.

- Better definition of the environmental, health, and ecological impacts of gaseous emissions (such as SO_x, NO_x, CO, HF, Cl_2, NH_3) and metallic smokes with respect to obtaining more quanticative knowledge for establishing appropriate emission regulations. Examples of gaseous emissions are the transient CO emissions from collecting offgases from the Basic Oxygen Process in steelmaking, NO_x emissions from nitric acid plants, and ammonia emissions from aeration of scrubbing liquors found in the fertilizer mixing industry, metallic smokes from molten metal transfers and volatile impurities in iron and steel and copper are examples. Other new technologies facing these type of emission problems are found in the following industry sectors; aluminum, ammonia, cement, chlor-alkali, glass, petroleum refining, and pulp and paper industries.

- Better definition of the environmental, ecological, and health impacts of compounds that have high smog forming characteristics and/or have toxic effects. Examples can be found in the use of volatile organic solvents in some new textile technology (solvent processing), or emissions from coke ovens. The major industries where this is a problem is aluminum, iron and steel, olefins, petroleum refining, and textiles.

- Improvements in odor control. Examples where this has been a problem is the sulfur emissions (e.g., H_2S, mercaptans, etc.) as found in petroleum refining and pulp and paper.

- Improved instrumentation for rapid monitoring and recording of airborne emissions. The major needs for such instrumentation are (1) to provide a rapid indication of the effectiveness of control and (2) provide records for regulatory agencies. Industries where the improved instrumentation is especially needed are alumina, copper, glass, iron and steel and pulp and paper.

2. Water Pollution Control Technology

With regard to water pollution control in new technology investigated in this study, we have identified the following as deserving consideration for additional research and development.

- Better definition of the environmental, health, and ecological impact of substances which cannot be removed by Best Available Technology Economically Achievable (BATEA). This will include principally metals and organic compounds that have long biological half-lives or toxic effects. Examples in the major industries include wet scrubbing liquors in the aluminum and petroleum refining industries. Another example is hydrometallurgical technology involving dissolved trace metals such as leaching copper ores/concentrates. Other major industries where this is a problem is ammonia, iron and steel, phosphorus, and pulp and paper.

- Improvements in suspended solids removal from treated wastewaters. This is a problem found particularly in the pulp and paper industry (biological flocs), the "phossy-water" problem found in the manufacture of phosphoric acid, and the slimes generated in mining phosphate rock.

- Identification of refractory organic compounds and improvement of removal technologies. Such problems can be potentially found in textiles, manufacture of phosphoric acid, or extraction of alumina where such organic compounds may be generated as a result of solvents used or as a result of high temperature synthesis (e.g. Alcoa process).

- Improved instrumentation for rapid monitoring and recording of waterborne pollutants. Examples are found in the iron and steel industry where temporary upsets or transient conditions may cause large amounts of pollutants to enter the control systems, e.g., such as cyanide emissions from external desulfurization or zinc or other tramp elements from electric arc furnaces.

3. Solid Waste Disposal

As the quantities of pollutants emitted to the air and water environment are decreased, there is usually a concomitant increase in solid waste or sludges. These must either be destroyed, or disposed of in a manner which presents further dissemination into the environment. The following areas have been identified as deserving R&D attention.

- Technical demonstration of adequate landfill disposal techniques. Aluminum (extraction of alumina which can produce 1 to 2 tons of dry solids per ton of alumina), cement (leachable alkali metal dusts), iron and steel (basic oxygen furnace and electric furnace dusts containing tramp elements like lead and zinc), petroleum refining (disposal of sulfur and/or its compounds from desulfurizing operations or stack gas scrubbing) and phosphoric acid processes involving disposal of calcium sulfate or calcium chloride.

- Demonstration of thermal destruction technologies. The thermal destruction of residues and tars from some of the new olefin technology may be the best overall method of handling such wastes. Other examples can be found in the aluminum and petroleum refining sectors.

- Additional research into the methods of categorization, regulation and research into legal methodologies for controlling the disposal of solid wastes. Examples can be cited in the manufacture of ammonia from coal involving disposal of mine wastes and coal residues from gasifying facilities or the disposal of kaolin clay wastes in the manufacture of alumina via acid leaching processes. Other examples can be found in the cement, copper, fertilizers, glass, iron and steel, olefins, petroleum refining and manufacture of phosphoric acid.

ENVIRONMENTAL RECAPITULATION

Thus, in each case, the direction o research programs should be viewed with the objective of attaining the maximum effectiveness for removal or controlling pollutants at the minimum economic penalty, since it is rarely possible to remove or control pollutants to present and anticipated standards without entailing at least some costs. Consequently, research programs must be examined within the framework of cost/benefits to the environment, to human health and to the economy.

Table 5 provides our perception of those areas in each industry examined where the first and second level priorities for research, development and demonstration should be placed. Tables 6A-C show summaries of these results. Examination of this table indicates to us that the first two industries into which the most effort should be placed are petroleum refining, iron and steel, pulp and paper and aluminum. A second tier includes all of the remaining industries except chlor-alkali and fertilizer mixing plants which are judged to not have significant problems requiring further RD&D efforts.

REGIONAL IMPACTS

Impacts of the new technology will be felt largely in regions where today's production facilities are located, shown for several industries in Figure 1. As can be seen by this figure regions with the heaviest concentration of industrial development, such as the Gulf region and the Great Lakes area, would be expected to experience the greatest impact.

TABLE 5

AREAS FOR RESEARCH AND DEVELOPMENT IN POLLUTION CONTROL

	Textiles	Petroleum Refining	Ol[illegible]	Ir[illegible] & S[illegible]	Gla[illegible]	Chl[illegible]	Ph[illegible]	[illegible]	[illegible]	Pulp & Paper	Cement	Alu[illegible]	Copper
Air													
Fine particulate removal technology. This would include especially those particulates resulting from metallic smokes and sublimed substances such as Mercury, arsenic, zinc, etc.		1		1	1		1	1	1	1	1	1	1
Collection or control of fugitive emissions from process equipment	1	2	2	1			2	1	1	2	2	1	1
Better definition of the environmental and biological impacts of the following emissions with respect to obtaining more quantitative knowledge for establishing emission regulations.													
a. Gases such as SOx, NOx, CO, F, Cl, NH_3		1	2	1	1	1			1	1	1	1	1
b. Metallic smokes		2	2	1	1				1		1	1	1
c. Organic compounds that have high smog characteristics or carcinogenic aspects	1	1	1	1						2		1	
Odor Control		1	2							1			
Improved instrumentation for rapid monitoring and recording of airborne emissions		2		1	1					1	2	1	1
Water													
Better definition of the environmental and biological impact of substances which cannot be removed by best available technology economically achievable. This will include, principally, metals and organic compounds that have long biological half-lines or carcinogenic effects.		1		1			1		1	1		1	1
Suspended solids removed from treated wastewaters		1		1		2	1		1	1	2	2	2
Removal of refractory organic compounds not achievable by technologies now designated as BATEA by EPA	1			1								2	
Color Removal	1	2								1			
Removal of dissolved metals		2		1	2	2	1					1	2
Improved instrumentation for rapid monitoring and recovery of waterborne pollutants	2		2	1			2		2	1			
Solid Wastes													
Demonstration of adequate landfill disposal techniques	2	1	2	1	2	2	1		2	2	1	1	2
Demonstraton of thermal destruction technologies		1	1	[illegible]						2		1	
Research into the methods of categorization, regulation and legal methodologies for controlling the disposal of solid wastes	2	1	1	1	1	2	1	1	1	2	1	1	1

(1) Denotes First Level Priority

(2) Denotes Second Level Priority

TABLE 6A

AIR POLLUTION CONTROL R&D

Research Area	Number of Industries Represented Priority Level: First	Second
• Fine Particulate	10	0
• Fugitive Emissions	6	5
• Quantifying Impacts		
– SO_x, NO_x, CO, etc.	9	1
– Metallic Smokes	6	2
– Organic Compounds	5	1
• Odor Control	2	1
• Instrumentation (Rapid Monitoring)	5	2

TABLE 6B

WATER POLLUTION CONTROL R&D

Research Area	Number of Industries Represented Priority Level	
	First	Second
○ Quantifying Impacts of Metals/Organics	7	0
○ Removal of Suspended Solids	5	4
– Refractory Organics	2	1
– Color	2	1
– Dissolved Metals	3	4
○ Instrumentation (Rapid Monitoring)	2	4

TABLE 6C

SOLID WASTE R&D

Research Area	Number of Industries Represented Priority Level First	Second
• Landfill Disposal	5	7
• Thermal Destruction	3	3
• Categorization, Regula ion, Legal Methodologies	10	3