FUTURE NEEDS AND THE IMPACT ON THE WATER AND WASTE EQUIPMENT MANUFACTURING INDUSTRY DUE TO THE USE OF SYNTHETIC FUELS

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Probably the most important needs of the water pollution control equipment industry are coal conversion wastewater characterizations which can be used more specifically for the design of chemical and/or biological waste treatment systems. These should include analyses which differentiate between organics which are readily biodegradable, as indicated by BOD_5 analysis, slowly biodegradable compounds which report as BOD_{20} and COD or TOC determinations which would indicate by difference the approximate concentration of nonbiodegradable organic compounds.

Total Kjeldahl nitrogen determinations would also be important for consideration of nitrification—and possibly denitrification of plant effluents in the waste treatment plant designs. Whenever possible, cell yield coefficients and endogenous rate coefficients should be determined so that food/microorganism ratios and sludge ages can be correlated for activated sludge aeration basin design calculations. Treatability factors for contact media unit design would also be helpful for evaluation purposes.

If laboratory facilities are available at pilot plant installations, biological treatability tests, including nitrification, should be made. Denitrification studies would also have long-range benefits. There are many cyclic organics and metal salts which may interfere with nitrification or denitrification and it may be necessary to pretreat to remove metal salts, or to feed powdered activated carbon into the biosystems to adsorb organics which could interfere with the biological processes.

The DuPont Waste Treatment Plant at their Chambers Works in New Jersey and the API study recently made at the Texaco plant, Port Arthur, Texas, have demonstrated the benefits of powdered activated carbon in activated sludge systems treating organic chemical wastes and petroleum-petrochemical wastes. This may also be true of coal gasification and liquefaction wastewaters.

The evaluation of biosystem plant design must take into consideration the potentially toxic effect of high concentrations of chemicals resulting from spills or upsets in the plant operations. The recovery time of a biosystem can be long—so this is an important operational consideration.

The need for surge and also backup treatment units must be evaluated for each system being considered. Before going into final design, pilot plant tests under the worst conditions which can be anticipated may indicate a preferred waste treatment process.

Biological sludge disposal can be an important factor. Excess biological sludge production varies appreciably. With 30-day sludge age and temperature of 10° C-30° C, it will range from 0.3 to 0.4[1] lbs of sludge being produced per lb. of BOD removed. The biosludge can only be concentrated to about 3 percent to 4 percent without filtration—so the volume is appreciable.

It would be to ERDA's advantage to investigate:

- Anaerobic treatment of strong wastes
- Aerobic treatment using contract media and activated sludge
  - With atmospheric oxygen
  - With pure oxygen
- Wet air oxidation of strong wastes
- Backup facilities required to handle upsets.
  - This should include granular activated carbon and reverse osmosis as polishing operations.

Characterizations of inorganic wastes are also important. Segregation of inorganic wastes can simplify treatment and save money. Most heavy metals in cationic form will precipitate to very low residual concentration as hydroxides or sulfides. Chemical treatment will release and allow precipitation of metal complexes, at least when treating waste solutions from boiler-cleaning operations.

Cooling tower blow-down can be minimized by appropriate makeup water of sidestream treatment. In many cases, the silica concentration of the cooling water determines required blow-down. It would help to have complete mineral analysis of the raw waters and knowledge of the planned cycles of concentration for optimizing the design of cooling systems to reduce blow-down.

Spent ion exchange regenerants in boiler blow-down should be kept out of the wastestreams which require biological treatment. The systems can be designed for partial recovery of ion exchange regenerants and rinse waters, thereby reducing the wastewater effluent volume.

As gasification and liquefaction processes become more refined, evaluations of water and waste treatment methods under comparable conditions will help in selecting the most cost effective methods based upon capital cost and energy requirements. They will also provide reasonable assurance of reliable operations under the varying wastewater characteristics from gasification or liquefaction plant operations which are inevitable.

And now, for a discussion of the projected impact of the synthetic fuels industry on the water pollution control equipment industry. The production of synthetic fuels will have an impact. However, it appears at this time that any major effects of coal conversions will not be felt until the mid-1980's or later. Current coal conversion processes are directed toward pilot plant or demonstration plant testing. Apparently this will continue until about 1980. According to ERDA's F'78 Fossil Energy Research Program[1], there are ten coal liquefaction, five pyrolysis, eight high Btu coal gasification, and nine low Btu coal gasification projects budgeted for further tests. ERDA's budget projects an increase from about $350 million in F'77 to $448 million in F'78 to maintain the coal program. $53 million in expenditures are projected for demonstration plants in F'77—and only $50 million, in F'78.

The Fossil Energy Coal Program has five categories of projects:

1. Laboratory bench-scale
2. Process development units
3. Pilot plants
4. Demonstration plants
5. Commercial demonstration plants

The only two which will involve significant expenditures for liquid waste treatment are:

- Demonstration plants operating a single modular unit using commercial sized components to demonstrate and validate economic environmental and production parameters;
- Commercial demonstration plants to establish actual economic factors and environmental feasibility. These will be three to five times the capacity of demonstration plants by combining modular production units.

The larger installations projected include the H Coal Direct Hydrogenation Process Pilot Plant at Ashland Synthetic Fuels, Catlettsburg, Kentucky. This plant has a coal input of 600 TPD. It is in the procurement and construction stage and operation is projected through the third quarter of F'80.

The Solvent Refined Coal Liquefaction Process, budgeted at $16 million in F'78 includes a pilot plant with a capacity of 50 TPD coal at Pittsburgh and Midway Coal Mining, Ft. Lewis, Washington.

The Donor Solvent Liquefaction Process budget is scheduled for $30.3 million in F'78. Exxon Research and Engineering, Baytown, Texas, will operate a process development unit through the third quarter of F'81. A pilot plant is scheduled for design and construction over a 2.5-year program in operation from F'80 through three quarters of F'81.

The major budgets for High Btu Gasification Processes are:

Bi-Gas - 120 TPD coal pilot plant, Bituminous Coal Research, Homer City, Pennsylvania. Pilot plant operation scheduled through third quarter F'79.

Synthane - 75 TPD coal pilot plant, Pittsburgh Energy Research Center, Pittsburgh, Pennsylvania. Operation scheduled through middle of F'79.

Hy-Gas - 80 TPD pilot plant, Institute of Gas Technology, Chicago, Illinois. Project evaluation by end of F'79.

CO_2

Acceptor - 40 TPD coal pilot plant, Consolidation Coal/Conoco Coal Development, Rapid City, South Dakota. Project evaluation by end of F'79.

The major budgets for Low Btu Gasification Projects are:

Lurgi combined cycle test facility for Commonwealth Edison at Pekin, Illinois, capacity 480 TPD coal. The plant is to operate through F'82.

Hydrogen from coal facility, capacity 200 TPD coal is projected to operate from F'81 for about three years.

Combustion Engineering, Windsor, Connecticut, has a 120 TPD atmospheric entrained bed gasification unit in operation. It is scheduled for evaluation in F'79.

R. Antonsen[2], Assistant Program Director, Division of Major Facility Program Management of the ERDA, has reported that:

> "Two pipeline gas projects are in the conceptual design phase. It is estimated that an evaluation of the two projects will be made in about June 1978. The estimated input of one of the projects is 3800 TPD of coal.
>
> The other project involves a conceptual design of a pipeline gas plant using the IGT Hy-Gas Process. This is projected to use 7500 TPD of coal.
>
> A fuel gas project under consideration plans to use 2800 TPD of coal. Another involves 2270 TPD of coal.
>
> An atmospheric fluidized bed combustion unit is planned using 1600 TPD of coal.
>
> A solvent-refined coal project is projected using 600 TPD of coal."

It is significant that several contractors had submitted proposals for demonstration plants in 1976. However, as of July 1977, these proposals were still being evaluated.

ERDA's Office of Commercial Applications advised that any projects which require financial assistance from the Federal government would need funds voted by Congress after review and approval by the Department of Energy. There apparently are not commercial size gasification or liquefaction projects that are being prepared for presentation to Congress for funding in F'78. It would appear that unless projects are funded by industry, the processes currently being publicized will have to go through the demonstration plant stage with ERDA assistance before full-scale plants are considered.

Pilot plant or demonstration plants in the 400 to 600 TPD coal capacity range would probably have commercial scale water and waste treatment plants. The others would be more or less in the pilot waste treatment category. It therefore does not seem likely that the United States will be far beyond the commercial demonstration plant stage before 1985 unless an international crisis or the need for a major project to stimulate the U.S. economy, or a program to reduce an unfavorable trade balance through and accelerated synthetic fuel program, changes the priorities.

But, if we ignore the question of "when," the following provides some indication of the potential long-range impact of the water and waste treatment needs of coal gasification and liquefaction plants.

C. F. Braun made a comprehensive study which is detailed in the Interim Report, "Factored Estimates for Western Coal Commercial Concepts"[3], prepared for ERDA and the American Gas Association. This report was published in October 1976. These plants were evaluated on a comparable basis, with coal consumptions of approximately 8 million tons/year per plant, each with a capacity to produce about 250 million cubic feet/day of synthetic gas.

Coal gasification plants use considerable water. Table 1[4] lists the estimated water requirements for a Lurgi Process plant processing 21,800 TPD of coal. Based upon 5100 gpm input, 79.8 percent of the water is consumed in proccess or is lost by evaporation. The makeup water requirements of the six processes vary as shown on Table 2. Note that the estimated raw water usage of the six systems range from about 114,000 to 203,000 GPH.

Table 3 shows the estimated water treatment costs, ranging from $285,000 to $580,000, to clarify or lime-soften the makeup water. Granular media filtration and

TABLE 1

WATER REQUIREMENTS AND DISPOSITION OF A LURGI COAL GASIFICATION PLANT PROCESSING 21,800 TPD OF COAL

	GPM	%
PROCESS CONSUMPTION		
TO SUPPLY HYDROGEN	1,120	
PRODUCED AS METHANATION BYPRODUCT	-600	
NET CONSUMPTION	520	10.2
RETURN TO ATMOSPHERE		
EVAPORATION:		
FROM RAW WATER PONDS	420	
FROM COOLING TOWER	1,760	
FROM QUENCHING HOT ASH	150	
FROM PELLETIZING SULFUR	250	
FROM WETTING OF MINE ROADS	730	
	3,310	
VIA STACK GASES(1):		
FROM STEAM BLOWING OF BOILER TUBES	200	
FROM STACK GAS SO_2 SCRUBBERS	40	
TOTAL RETURN TO ATMOSPHERE	3,350	69.6
DISPOSAL TO MINE RECLAMATION		
IN WATER TREATING SLUDGES	100	
IN WETTED BOILER ASH	30	
IN WETTED GASIFIER ASH	300	
TOTAL DISPOSAL TO MINE	430	8.4
OTHERS		
RETAINED IN SLURRY POND	20	
MISCELLANEOUS MINE USES	580	
TOTAL OTHERS	600	11.8
GRAND TOTAL	5,100	100.0

(1) DOES NOT INCLUDE WATER DERIVED FROM BURNING OF BOILER FUEL

TABLE 2

PROCESS	RAW WATER GPH
IGT STEAM OXYGEN HY-GAS	114,000
IGT STEAM IRON HY-GAS	203,000
CONOCO CO_2 ACCEPTOR	136,000
BCR BI-GAS	129,000
PERC SYNTHANE	150,000
LURGI	146,000

demineralization equipment was estimated to range from $709,000 to $2,450,000. Adding the estimated costs for deaeration equipment, sodium exchange for low pressure boilers and ion exchange equipment for condensate polishing, the estimated equipment cost ranged from $1,742,000 to $3,335,580. The estimated installed costs ranged from $3.5 to $6.7 million.

It has been predicted that two SNG coal-based plants will be in operation and producing 0.16×10^{15} Btu per year by 1985[5]. Another forecast indicates 0.4×10^{15} Btu per year, which would indicate the need for five plants, each processing 8 million tons of coal/year. If we assume that the water treatment equipment for these plants would be purchased in 1981 or 1982, the estimated cost of the water treatment equipment in 1977 dollars would be in the range from $3.5 to $6.7 million for two plants and $8.5 to $17 million for five plants.

Table 4 compares the costs of waste treatment equipment and auxiliaries for the six processes studied by Braun. The estimated cost of equipment for chemical coagulation, flotation to remove tars and oils and staged activated sludge treatment, together with aerobic digestion, thickening and vacuum filtration of waste sludge would range from about $2.6 to $5.3 million per plant. With pumps and tanks added, the estimates range from about $3 to $6.1 million. Estimated installed costs assume that the civil works would be about 80 percent of the total costs—or in the range from $15.3 to $30.5 million.

The estimates are all based upon the use of western coal. The type of coal used would have a significant effect upon the wastewater analyses as shown in Table 5[6]. However, as there are many other variables which would influence the cost of waste treatment plants at the time when they are considered for final design, any closer estimates would have to be made on a case by case basis, using the latest technologies for coal conversion and for waste treatment.

It is assumed that on a comparable coal tonnage basis, the wastewater from coal liquefaction processes would have about the same pollution load as the coal gasification projects and that the treatment costs would be in the same order of magnitude. The estimation of either two or five plants by 1985 would have a moderate impact. However, the water and waste treatment equipment manufacturing industry should be operating at a high level in the early 1980's because of equipment expenditures for compliance with the EPA's BAT standards which are scheduled to go into effect in 1983. As the present guidelines will probably be supplemented by additional standards for compliance with the Toxic Substances Control Act, the impact of an additional $6 million to $30 million in waste treatment equipment and appurtenances for coal conversion plants would not be significant.

TABLE 3

WATER TREATMENT

	IGT STEAM OXYGEN HYGAS	IGT STEAM IRON HYGAS	CONOCO CO_2 ACCEPTOR	BCR BIGAS	PERC SYNTHANE	LURGI
DRY COAL TO PROCESS TONS/HR	568	742	699	578	929	632
RAW WATER GAL/HR	114,000	203,000	136,000	129,000	150,000	146,000
LIME SOFTENING - CLARIFICATION	$ 285,000	580,000	330,000	350,000	345,000	435,000
FILTERS AND DEMINERALIZERS	980,000	2,450,000	1,470,000	1,310,000	790,000	900,000
DEAERATORS	212,000	295,000	185,000	330,000	420,000	255,000
SODIUM EXCHANGERS	105,000	340,000	--	290,000	340,000	510,000
CONDENSATE POLISHERS	160,000	250,000	220,000	350,000	--	--
TOTAL	$1,742,000	3,335,580	2,205,000	2,630,000	1,895,000	2,100,000
ESTIMATED INSTALLED COSTS	$3,500,000	6,700,000	4,400,000	5,300,000	3,800,000	4,200,000

TABLE 4

WASTEWATER TREATMENT

	IGT STEAM OXYGEN HYGAS	IGT STEAM IRON HYGAS	CONOCO CO_2 ACCEPTOR	BCR BIGAS	PERC SYNTHANE	LURGI
DRY COAL TO PROCESS TONS/HR	568	742	699	578	929	632
RAW WATER GAL/HR	114,000	203,000	136,000	129,000	150,000	146,000
ORGANICS REMOVED BY BIOLOGICAL TREATMENT LBS/HR	6,600	8,000	--	--	5,100	1,200
EQUIPMENT	$ 3,992,000	5,311,000			3,305,000	2,631,000
TANKS	382,000	507,000			285,000	288,000
PUMPS	150,000	283,000			146,000	150,000
TOTAL	$ 4,524,000	6,101,000			3,736,000	3,069,000
ESTIMATED INSTALLED COST	$22,620,000	30,505,000			18,680,000	15,345,000
WASTEWATER EVAPORATORS	$ 5,800,000	15,000,000	6,400,000	9,800,000	8,100,000	8,800,000

TABLE 5

BYPRODUCT WATER ANALYSIS FROM SYNTHANE GASIFICATION OF VARIOUS COALS, MG/L (EXCEPT pH)

	COKE PLANT	ILLINOIS NO. 6 COAL	WYOMING SUBBITUMINOUS COAL	ILLINOIS CHAR	NORTH DAKOTA LIGNITE	WESTERN KENTUCKY COAL	PITTSBURGH SEAM COAL
pH.............	9	8.6	8.7	7.9	9.2	8.9	9.3
SUSPENDED SOLIDS	50	600	140	24	64	55	23
PHENOL..........	2,000	2,600	6,000	200	6,600	3,700	1,700
COD.............	7,000	15,000	43,000	1,700	38,000	19,000	19,000
THIOCYANATE.....	1,000	152	23	21	22	200	188
CYANIDE.........	100	0.6	0.23	0.1	0.1	0.5	0.6
NH_3.............	5,000	[1]8,100	9,520	2,500	7,200	10,000	11,000
CHLORIDE........	-	500	-	31	-	-	-
CARBONATE.......	-	[2]6,000	-	-	-	-	-
BICARBONATE.....	-	[2]11,000	-	-	-	-	-
TOTAL SULFUR....	-	[3]1,400	-	-	-	-	-

[1]85 PERCENT FREE NH_3

[2]NOT FROM SAME ANALYSIS

[3]$S^{=}$ = 400

$SO_3^{=}$ = 300

$SO_4^{=}$ = 1,400

$S_2O_3^{=}$ = 1,000

The reference previously cited also forecasts 2.5×10^{15} Btu per year for synthetic gas produced from coal in the year 2000. If correct, there would be a need for about 31 plants each having a gas production capacity of 250 million cubic feet/day. This would have a major impact on the water and waste equipment manufacturing industry and on the entire economy because of the general stimulus it would have on industry. Each coal conversion plant in terms of 1976 dollars, was estimated by C. F. Braun to range in total cost from $0.87 to $1.28 billion.

A survey by Frost and Sullivan, Inc.[7] estimated that 20 plants would be in operation by 1990, producing 1.6 trillion cubic feet of gas/year. This is reasonably close to the 1.8 trillion cubic feet which would be the capacity of 20 plants each having capacity of 250 million cubic feet/day.

Attempting to relate projected expenditures for coal conversion plants to total sales for water and waste treatment equipment is difficult. Accurate information regarding the market for water and wastewater equipment has been virtually impossible to obtain since the Office of Business Research and Analysis of the Bureau of Domestic Commerce of the U.S. Department of Commerce discontinued maintaining summaries of water supply and wastewater disposal treatment equipment shipments. Annual reports of the major companies are consolidated and do not help very much. Published reports of expenditures or forecasts are either based upon total installed costs, including civil works, or do not indicate what is classified as equipment. In addition, the forecasts seldom indicate what dollars are used in the forecasts.

There have been predictions that equipment expenditures for water and waste treatment will be in the range between $1.5 and $2.0 billion in the 1980-1985 period. What may occur after that is highly speculative because water shortages in certain geographical areas probably will necessitate major expenditures for treatment of sewage plant effluents for industrial use. Enforcement of the zero effluent concept would also add appreciably to waste treatment equipment expenditures, so the long-range impact of coal conversion plants on the demand for water and waste treatment equipment cannot be predicted at this time.

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