3. ELECTRICAL POWER GENERATION AND POWER PLANT SITING

Technological advances and economic and ecological pressures have markedly changed power plant design, siting, and, in the process, environmental impacts. Selection of plant design and siting often involves competing factors such as reliability, efficiency, impact on air and water, fuel availability, and costs per kilowatt-hour. Optimal trade-offs typically involve case-by-case scrutiny -- there is no blanket prescription since each environment and each service area is different.

A. Electrical Generation in Maryland -- Trends for the Coming Decade

The combined capacity of Maryland's major electric (producing 90 Mw or more) power plants is 7,878 Mw (as of June 1975). In addition, 527 Mw is supplied to Baltimore Gas and Electric Company during peak demand from the Keystone and Conemaugh minemouth plants in Pennsylvania. Approximately another 700 Mw is supplied to Potomac Edison's and Delmarva Power's Maryland consumers from these utilities' generating sites in Pennsylvania. Conowingo Power Company exports about 400 Mw to Philadelphia Electric's Pennsylvania customers (1). Exchanges of power are made routinely among PJM grid members on an economic dispatch basis -- with the direction of flow (imports or exports) depending on station operating status and system load (see Chapter 2 of this Report).

The generating capacity projected for 1985 is 12,203 Mw, according to Maryland's Ten-Year Plan (Exhibit B). An additional 2,282 Mw is anticipated to be at Maryland's disposal from generating plants in Pennsylvania (2).

The locations of operating plants and proposed sites for which land has actually been acquired are shown in Figure 3.1*: the attached Table gives gross characteristics of each station. The Potomac River is within Maryland, and, for this reason, such plants as Possum Point are also shown. In the designation of fuel burned, when a mixture of coal and oil is

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*Operating parameters and cumulative environmental effects of air and water emissions from the plants identified in Figure 3.1 are tabulated and compared in subsequent sections of this Report.

used, the larger component of the slurry is listed first (i.e., coal/oil or oil/coal). The coal/oil ratio can change: Morgantown, for instance, can use from 100% coal to a mixture of 75% oil and 25% coal. The primary energy sources for Maryland's installed generating capacity are 83% fossil fuel, 11% nuclear, and 6% hydroelectric.

The hydroelectric unit designated in Figure 3.1 as "PEPCO-J" is a proposed pumped storage site rather than a conventional dam site. Its intended purpose is to add peaking capabilities to the utilities' proposed nuclear plants.

Duty cycles given in the Figure as "base," "load following," and "peaking" refer, respectively, to generation which is continuous, is continuous for 12 hours or more per day, or is in service for about two hours in a 12-hour period. Duty cycles are determined by such factors as load distribution among units, need for operating reserve, and daily and seasonal demand profiles (cf. Figure 2.1) (3). Larger, newer stations tend to be base plants because economy of scale and cycle efficiency make for favorable kilowatt-per-dollar operating ratios. Nuclear plants are run in a base mode because they are currently the least costly per kwhr, and are not readily cycled between high and low output. Gas turbines are intended primarily for peaking service, reserve capacity, and for on-site restart power for large steam-electric stations. Relatively low thermodynamic efficiency (20-22%) and fueling with expensive light oil causes gas turbines to be run sparingly.

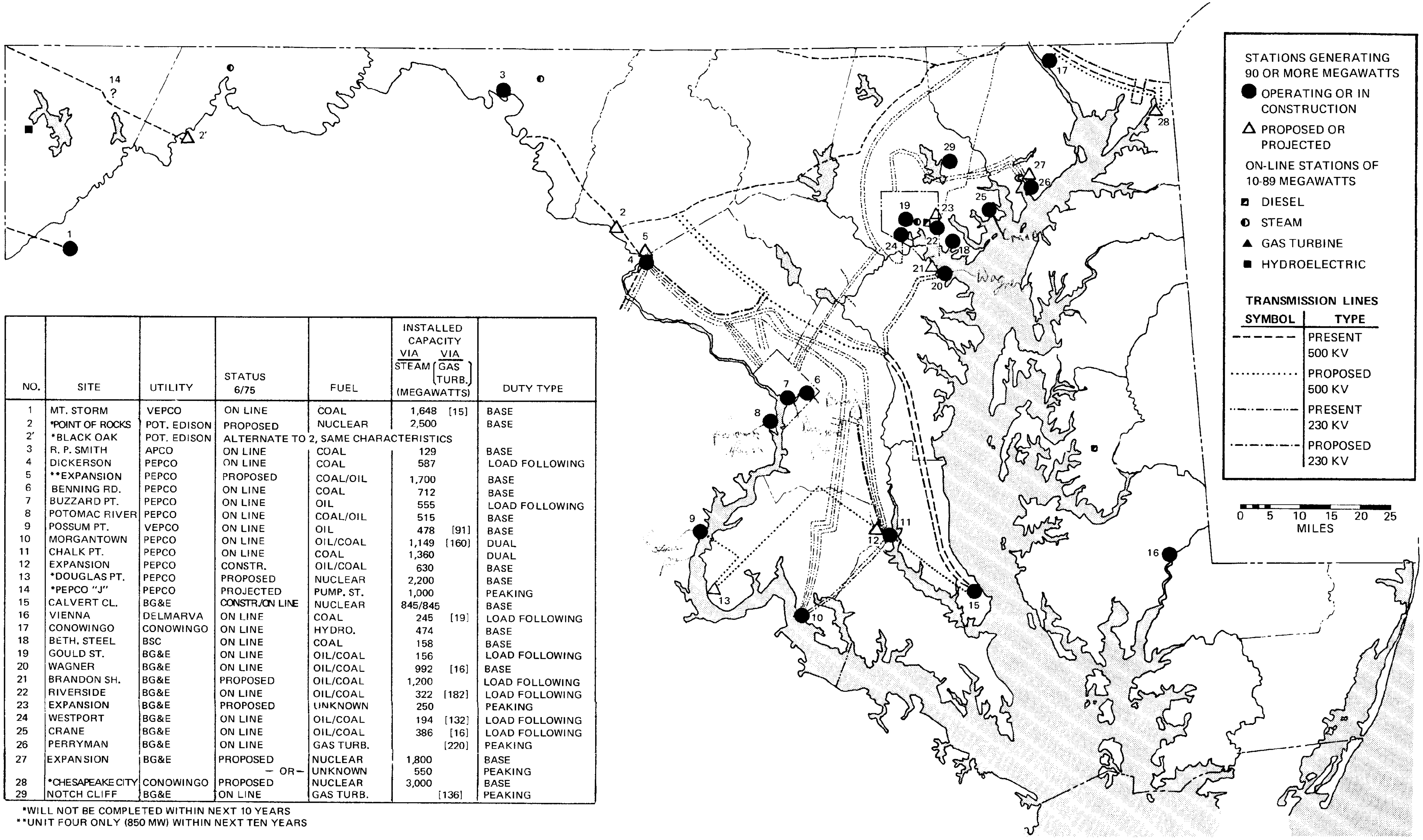
None of the plants shown in Figure 3.1 runs continuously at its full rating. Morgantown has the highest utilization factor (the annual average power output as a fraction of plant power rating), 0.77, while the average for all other Maryland plants is approximately 0.52 (4).

Between the operating and proposed nuclear plants in the State, all currently marketed nuclear designs are represented: Calvert Cliffs has pressurized water reactors (PWR); Douglas Point is planned to have boiling water reactors (BWR); and high temperature gas-cooled reactors have been proposed for the Chesapeake City (Canal) site.

Larger generating plants in Maryland (cf. Figure 3.2 (d)) offer greater thermodynamic efficiency (cf. Table 3.1 and Figure 3.4), and automation enables approximately the same number of personnel to operate a large unit as a small one. Also, capital costs/Mw for a large unit are lower: for example, the costs of a single 1,300-Mw unit are 3-6% less than for two 650-Mw units (12). By 1985, more than 50% of Maryland's generation will be provided by plants larger than 1,000 Mw.

In the past, Maryland has conformed to the practice of satisfying an area's electric demand by siting generation in that area. Older plants such as Gould Street and Westport in Baltimore

FIGURE 3.1



NO.	SITE	UTILITY	STATUS 6/75	FUEL	INSTALLED CAPACITY VIA STEAM [VIA GAS TURB.] (MEGAWATTS)	DUTY TYPE
1	MT. STORM	VEPCO	ON LINE	COAL	1,648 [15]	BASE
2	*POINT OF ROCKS	POT. EDISON	PROPOSED	NUCLEAR	2,500	BASE
2'	*BLACK OAK	POT. EDISON	ALTERNATE TO 2, SAME CHARACTERISTICS			
3	R. P. SMITH	APCO	ON LINE	COAL	129	BASE
4	DICKERSON	PEPCO	ON LINE	COAL	587	LOAD FOLLOWING
5	**EXPANSION	PEPCO	PROPOSED	COAL/OIL	1,700	BASE
6	BENNING RD.	PEPCO	ON LINE	COAL	712	BASE
7	BUZZARD PT.	PEPCO	ON LINE	OIL	555	LOAD FOLLOWING
8	POTOMAC RIVER	PEPCO	ON LINE	COAL/OIL	515	BASE
9	POSSUM PT.	VEPCO	ON LINE	OIL	478 [91]	BASE
10	MORGANTOWN	PEPCO	ON LINE	OIL/COAL	1,149 [160]	DUAL
11	CHALK PT.	PEPCO	ON LINE	COAL	1,360	DUAL
12	EXPANSION	PEPCO	CONSTR.	OIL/COAL	630	BASE
13	*DOUGLAS PT.	PEPCO	PROPOSED	NUCLEAR	2,200	BASE
14	*PEPCO "J"	PEPCO	PROJECTED	PUMP. ST.	1,000	PEAKING
15	CALVERT CL.	BG&E	CONSTR./ON LINE	NUCLEAR	845/845	BASE
16	VIENNA	DELMARVA	ON LINE	COAL	245 [19]	LOAD FOLLOWING
17	CONOWINGO	CONOWINGO	ON LINE	HYDRO.	474	BASE
18	BETH. STEEL	BSC	ON LINE	COAL	158	BASE
19	GOULD ST.	BG&E	ON LINE	OIL/COAL	156	LOAD FOLLOWING
20	WAGNER	BG&E	ON LINE	OIL/COAL	992 [16]	BASE
21	BRANDON SH.	BG&E	PROPOSED	OIL/COAL	1,200	LOAD FOLLOWING
22	RIVERSIDE	BG&E	ON LINE	OIL/COAL	322 [182]	LOAD FOLLOWING
23	EXPANSION	BG&E	PROPOSED	UNKNOWN	250	PEAKING
24	WESTPORT	BG&E	ON LINE	OIL/COAL	194 [132]	LOAD FOLLOWING
25	CRANE	BG&E	ON LINE	OIL/COAL	386 [16]	LOAD FOLLOWING
26	PERRYMAN	BG&E	ON LINE	GAS TURB.	[220]	PEAKING
27	EXPANSION	BG&E	PROPOSED	NUCLEAR	1,800	BASE
			— OR —	UNKNOWN	550	PEAKING
28	*CHESAPEAKE CITY	CONOWINGO	PROPOSED	NUCLEAR	3,000	BASE
29	NOTCH CLIFF	BG&E	ON LINE	GAS TURB.	[136]	PEAKING

*WILL NOT BE COMPLETED WITHIN NEXT 10 YEARS
**UNIT FOUR ONLY (850 MW) WITHIN NEXT TEN YEARS

and Buzzard Point and Benning Road in Washington were built within the metropolitan areas they serve.

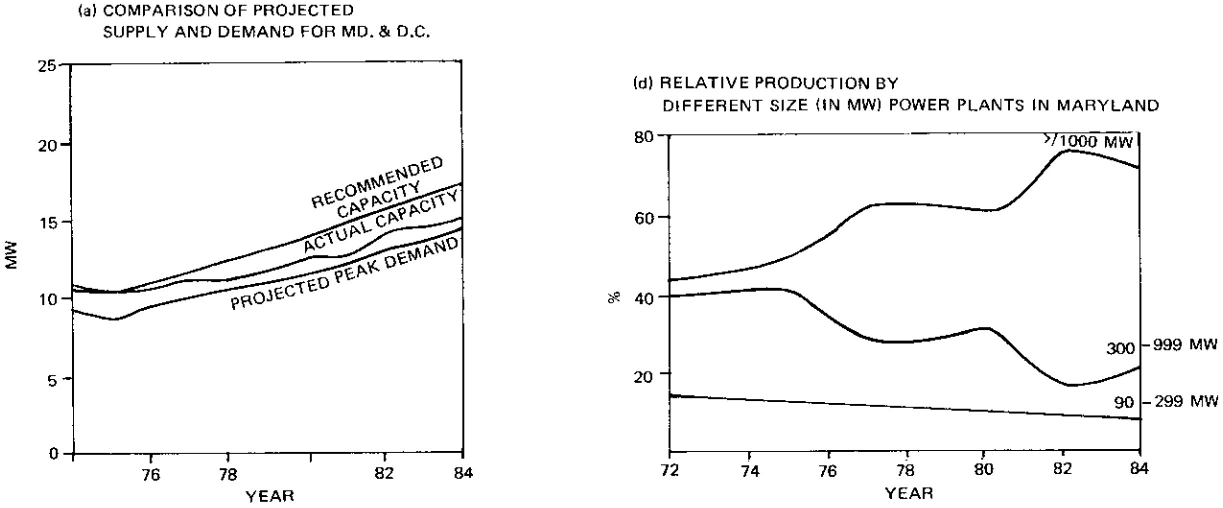
However, the introduction of high-voltage transmission lines (tensions of 230 kv and above) has had a profound influence on power plant siting and operation. (Maryland's corridors for high-voltage lines are included in Figure 3.1.) By cutting transmission losses and right-of-way needs (cf. Table 6.7), these lines make it feasible to site major generating plants at considerable distances from load centers. Rural sites are attractive for large plants because low population densities make for low ambient pollution levels (leaving air quality margins for plant pollution dispersal) -- cf. Chapter 4, sites are still available, transportation congestion is less, and sites with abundant condenser cooling water can be found (5).

Trends toward rural siting and larger generating units are clearly seen in Figures 3.2 (c) and 3.2 (d). Figure 3.2 (c) depicts the shift toward rural siting, and indicates it will be accentuated in the next decade. Of the 4,325 Mw of new generation projected for Maryland through 1984 (1), 54% will be generated at distances of 20 miles or more from metropolitan areas. If Douglas Point comes on-line in 1985-1987, this figure will jump to nearly 70%. Brandon Shores, Riverside, and Perryman are the only sites within 20 miles of metropolitan areas where additional generating units may be operating by 1985.

Another profound influence of high-voltage transmission lines is their making it technologically possible to form power grids among neighboring states to increase the reliability and reduce costs of electric power, as explained in Chapter 2.

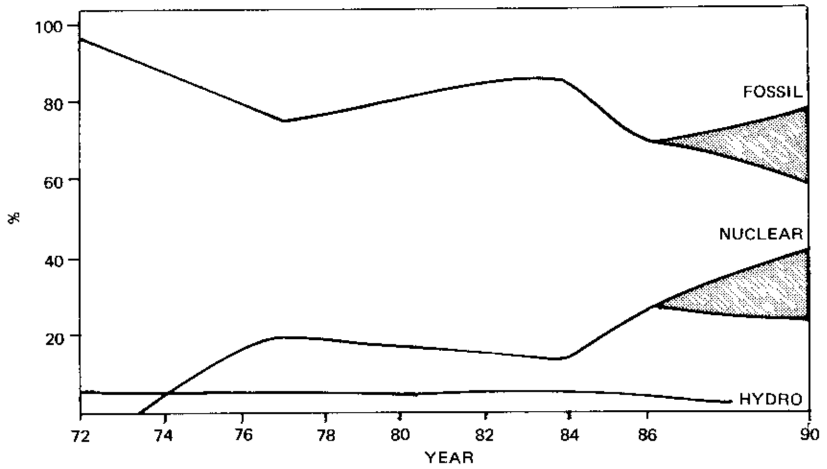
Maryland's projected generation is profiled by type in Figure 3.2 (b). Shaded areas represent situations where selection of nuclear or fossil fuel is still pending. Factors thwarting nuclear development are a history of costly licensing delays (9), e.g. short service lifetimes of first-generation valves and fuel rod densification problems in some of the larger reactors, and a record of forced outages due to component malfunctions. From 1960 to 1972, the national availability (portion of time during a given period the plant is actually available for use) of fossil fuel units 600 Mw and larger averaged 73% (10). Nuclear plant availability during the same period was 68-70% (10). Scarcity and rapidly escalating costs for fossil fuels are emerging as competing arguments for more nuclear power. The average cost of fuel oil almost tripled between September 1973 and April 1975 (36, 37) (75¢/million BTU versus $1.85/million BTU). Although nuclear fuel costs have doubled in the last year due to the increased cost of enrichment, the current selling price of $26/lb (40) is equivalent to only 52¢/million BTU. Even the $40/lb cost projected for 1980 (40) would raise the cost to no more than 80¢/million BTU.

FIGURE 3.2

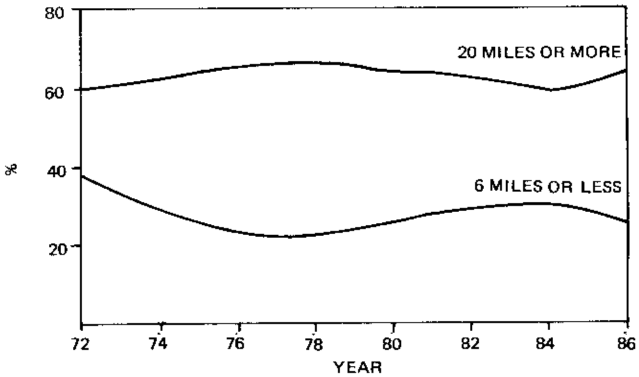

(a) COMPARISON OF PROJECTED SUPPLY AND DEMAND FOR MD. & D.C.

(d) RELATIVE PRODUCTION BY DIFFERENT SIZE (IN MW) POWER PLANTS IN MARYLAND

(b) RELATIVE ELECTRICAL PRODUCTION IN MARYLAND USING DIFFERENT ENERGY SOURCES



(c) DISTANCE FROM MARYLAND PLANT TO METROPOLITAN BALTIMORE OR WASHINGTON



SOURCE: 1975 TEN-YEAR PLAN, PUBLIC SERVICE COMMISSION OF MARYLAND

TABLE 3.1

FUEL CONSUMED IN 1974 BY MARYLAND POWER PLANTS

Generating Station (Utility)	Plant Efficiency[a] (%)	Coal Consumption (1,000 Tons/Year)	Heat Capacity of Coal (BTU/Lb.)	Oil Consumption (1,000 bbls/Year)	Heat Capacity of Oil (BTU/Gal.)
Morgantown (PEPCO)	37.0	680.5	11,578	7,732	148,851
H. A. Wagner (BG&E)	38.9	652	12,849	6,300	146,090
Chalk Pt. (PEPCO)	35.0	1,128	11,652	274.6	147,933
Dickerson (PEPCO)	36.0	1,460	11,120	--	--
Crane (BG&E)	35.9	--	--	3,806	145,381
Riverside (BG&E)	33.2	--	--	2,670	146,327
Vienna (Delmarva)	28.8	--	--	2,157	146,000
Westport (BG&E)	31.6	--	--	1,179	146,231
Gould St. (BG&E)	31.6	--	--	1,036	146,329
R. P. Smith (APSCO)	31.6	279.5	10,973	--	--
Mt. Storm (VEPCO)	NA	2,627	11,298	--	--
Benning Rd. (PEPCO)	NA	299	12,576	2,786	146,427
Potomac R. (PEPCO)	NA	953	11,855	--	--
Possum Pt. (VEPCO)	NA	--	--	5,034	148,584
Buzzard Pt. (PEPCO)	NA	--	--	728	145,678

Source: Maryland Utility Companies, Federal Power Commission Form 67 Reports for year ending December 31, 1974.

[a] Refers to steam-electric generation; for peaking gas turbines, efficiencies are approximately 20-22%.

B. Environmental Effects of the Trend

Larger plants do not aggravate the most pressing environmental problems and, in fact, pose less stress than the generating equivalent in smaller plants. Having better thermodynamic efficiency, the larger plants reject less heat (per kwhr) to receiving waters and entrain fewer organisms. Similarly, a single large plant with a tall stack provides better dilution of air pollutants than two smaller plants with lower stacks (12) (cf. Figure 4.9). Pollution control devices are more easily and cheaply fitted to large centralized installations than two separate smaller ones.

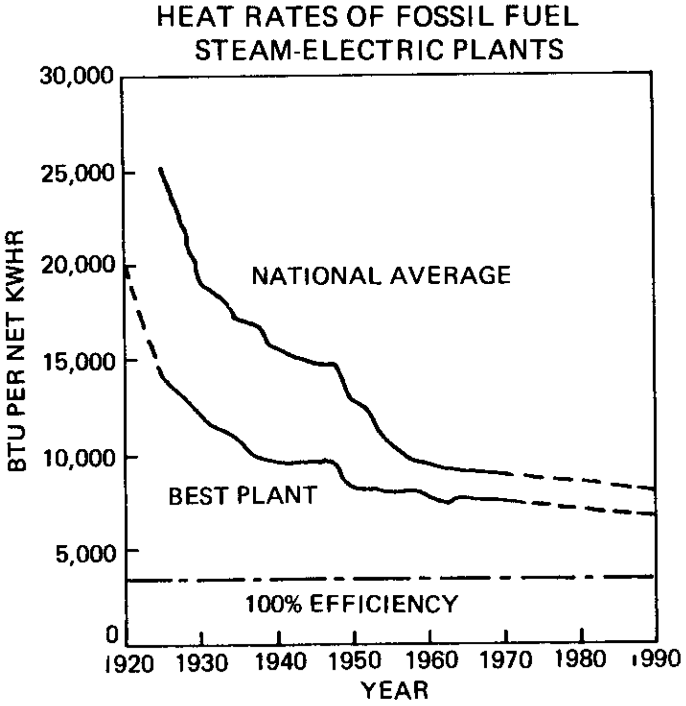
Site and transmission corridor size and visual impacts do not increase in direct proportion to a plant's capacity. A 2,000-Mw generating station requires a powerhouse only about one and one-third times longer in each dimension than the powerhouse for a 500-Mw plant.

State Emission Standards (Table 4.8) permit higher plant emissions in some rural areas because the background due to other emitters is lower than in urban areas -- thus, the power plant contribution can be higher than in more populous areas without violating air quality standards. A rurally located plant is more likely to conflict with active fish spawning areas than one located in an urban area (e.g. Baltimore Harbor), but this potential problem can be overcome by identification of spawning populations and migrations during detailed site evaluation (see Section E of this Chapter). Morgantown, for instance, is situated between two habitat-use salinities. The aesthetic impact of rural siting is more difficult to quantify: there are fewer viewers, but the development of a large tract in previously primal surroundings is more noticeable than in an urban area. This aspect, and that of the impact of power plant construction and operation on rural socioeconomics, are treated in Chapter 7 of this Report.

C. Efficiency of Energy Generation

The overall efficiencies and annual (1974) fuel consumption of plants in and around Maryland are given in Table 3.1. Close to 6.8 million tons of coal and 34 million bbls of oil are consumed by these area plants. Efficiencies range from 38.9% (Wagner, one of the newer plants) to 28.8% (Vienna, the majority of whose units are more than 30 years old). The decades-long improvement of efficiency was, in fact, one of the factors which historically held down the comparative cost of electricity. However, as the "bottoming-out" of Figure 3.3 indicates, the steam cycle is approaching its development limit, and further advances in efficiency will be small.

FIGURE 3.3

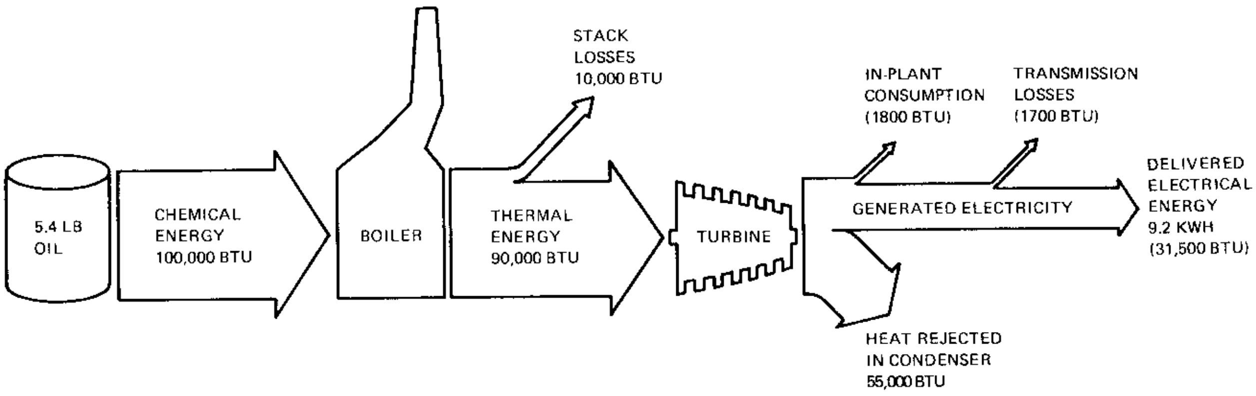


SOURCE: REFERENCE (3)

Figure 3.4 illustrates energy flow through a typical fossil fuel plant (35% conversion efficiency to electricity). Strength of materials decreases with temperature, and, as a protective measure, nuclear plants are run cooler than fossil units -- and consequently have somewhat lesser thermodynamic efficiencies (typically 30%) (14-16).

FIGURE 3.4

ENERGY CONVERSION IN A TYPICAL FOSSIL FUELED POWER PLANT



D. The Dilemma of Pollution Abatement and Energy/Economic Considerations

Pollution abatement has a non-trivial energy cost. The power to operate the pumps and fans for the wet cooling towers of a 500-Mw plant requires on the order of 5 Mw (17). The energy requirement for chemical water pollution control (evaporation, vacuum filtration, ion-exchange) has been estimated to be 0.022 Mw (17). The energy drain for pumps and reheating for stack-gas scrubbers has been estimated at 4-8% of plant power output (18). Equipment to control air and water pollution in total, then, can reduce plant efficiency by 5-10%. For a 1,000-Mw coal-fired plant, this translates into the burning of 128,000 to 256,000 tons of coal/yr (based on a 35% plant efficiency and a heat content of 25 million BTU/ton coal) to compensate for lost efficiency.

Besides the predictable costs of additional fuel and capital costs, industry is reluctant to adopt green technologies like stack-gas scrubbers because of reliability problems and difficulties in disposing of the large volume of sludge some scrubbers generate. For example, an 1,800-Mw plant burning 3.5-5% sulfur coal with a limestone scrubber produces 18,000 tons of sludge/day (19).

The 1974 cost of a lime-limestone scrubber system for an 1,800-Mw plant was estimated at $85 million, $47/kw, exclusive of sludge disposal costs (19). PEPCO estimates the cost of a Mag-Ox scrubber, similar to the one being tested at Dickerson Unit 3, at $118-$139/kw (see Chapter 4 of this Report).

Approximate 1974 costs for satisfying various combinations of air and water standards are shown in Table 3.2. The matrix looks at differential costs for a hypothetical 1,000-Mw fossil fuel unit, 35% efficient, having a 75% duty factor, and 500-ft stacks. In order to meet both primary and secondary State and national air quality standards (Table 4.7), coal of approximately 2% sulfur content is needed. To compensate for the 12% lower heat content of this cleaner fuel (11,440 BTU/lb as opposed to 13,000 BTU/lb for 3.5% sulfur fuel), an additional 340,000 tons of coal would have to be burned annually. The more stringent Maryland standards could also be met by installing flue-gas desulfurization with a capital outlay of $60-$130 million and similar energy losses, but using a 3.5% sulfur coal (as available from Western Maryland fields).

E. Regulation of Power Plant Siting and Operations in Maryland

The Maryland Power Plant Siting Program (PPSP) is an agency charged with evaluation of all aspects of environmental

TABLE 3.2

ANNUAL DIFFERENTIAL COSTS ASSOCIATED WITH GENERATION FOR A 10,000 KWHR FAMILY[a]
(1,000-Mw fossil plant, 35% efficiency, 500 ft stacks)

Air (Objective)	3.5% Coal	Scrubber[b] with 3.5% coal	2.8% Oil	2.0% Coal oil	1.0% Oil	Scrubber[b] with 2.0% fuel and re-heat	0.5% Oil	1.0% Coal
	Meet annual nat'l primary & secondary & Md. primary standards:	Meet all nat'l & Md. primary & secondary standards	Meet nat'l annual primary & secondary standards:	Meet all Md. & nat'l primary & secondary standards	Meet all Md. primary & secondary standards	Meet all nat'l and Md. primary & secondary standards	Meet all Md. secondary standards	Meet all Md. primary & secondary standards
	Could violate Md. annual secondary standards		Could violate Md. annual secondary standards					
Water (Objective)								
Once-through (Adequate to prevent significant aquatic damage)	-$84	-$61 to -$45	-$11	0	$34	$23 to $39	$62	$132
Wet tower (Zero heat discharge)	-$64	-$41 to -$25	$9	$20	$54	$43 to $59	$82	$152
Dry tower (Zero discharge) [range of cost estimates shown]	-$44 to -$24	-$21 to +$15	$29 to $49	$40 to $60	$74 to $94	$63 to $99	$102 to $122	$172 to $192

For 500-kv transmission, add $30/year if undergrounding is used.

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[a] Costs relative to generation using once-through cooling and 2%-sulfur fuels.

[b] Presumes no substantial down-time; range of cost estimates is shown.

Source: Reference 22

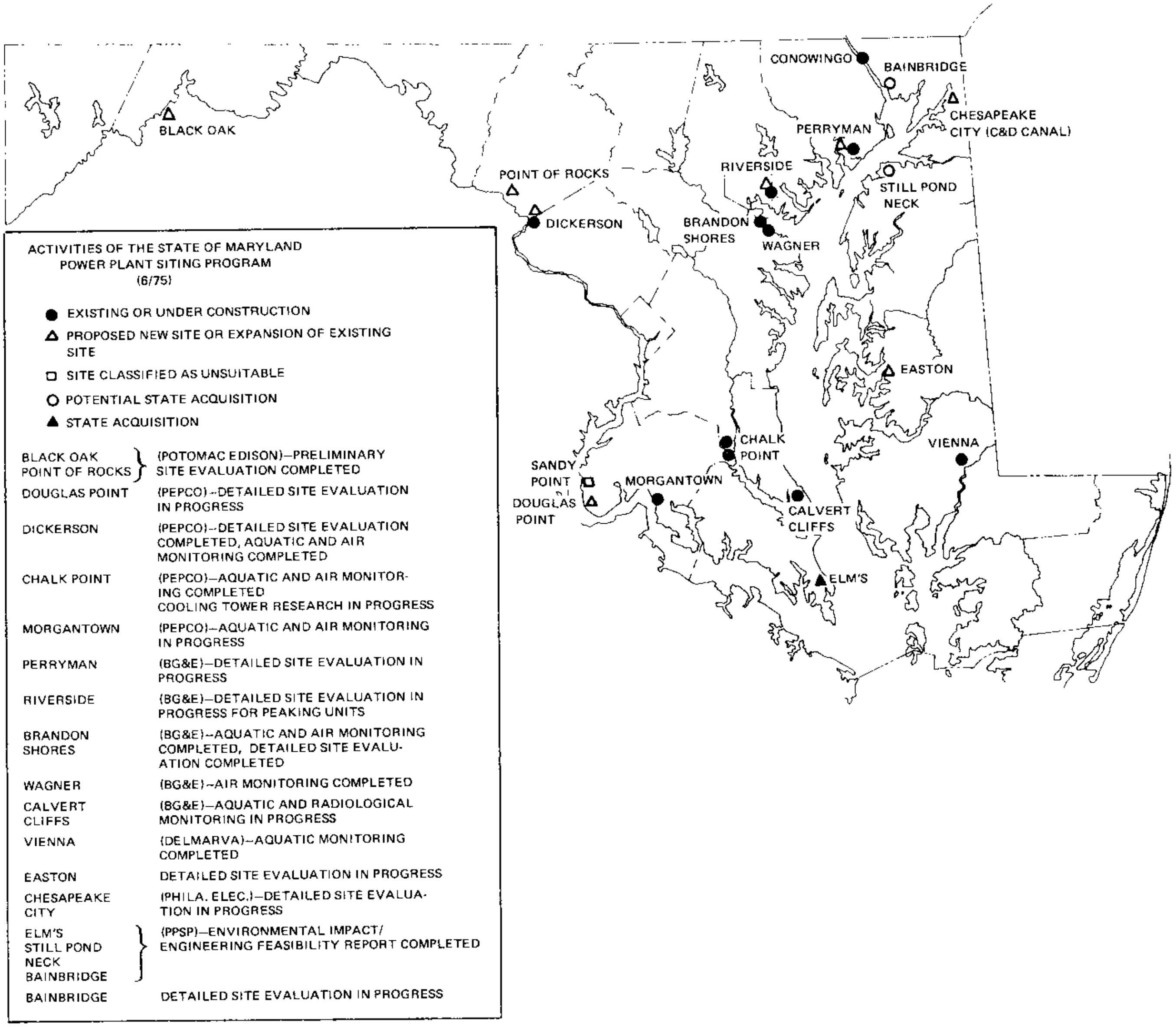
effects -- including cumulative effects and Statewide trends (Article 66C of the Annotated Code of Maryland). All utility applications for new generating plants are scrutinized in detail -- including PPSP-directed field studies of local weather, biota, land use, noise levels, and analyses and modeling to determine expected environmental, social, and economic effects of construction and operation of the proposed plant. The PPSP then makes recommendations to the State's Public Service Commission, which, along with testimony taken at public hearings, are considered in making a decision to grant a Certificate of Public Convenience and Necessity, with or without special conditions attached. Detailed site evaluation reports, conducted under PPSP direction, are listed under Reference 41. All PPSP operations are supported by the revolving Maryland Environmental Trust Fund which derives revenues through a surcharge of 0.21 mills/kwhr on electricity generated in the State. Figure 3.5 summarizes some of the activities of the Maryland PPSP.

Some of the questions addressed during site evaluation are:

1. Availability and quality of groundwater and surface water;
2. Resident and transient aquatic populations;
3. Site hydrology;
4. Site meteorology;
5. Dredging impact and spoil disposal;
6. Radiological emissions (nuclear plant);
7. Air pollutant emissions and control (fossil fuel plant);
8. Noise emissions;
9. Cooling tower plume impact;
10. Impact on aquatic populations from impingement, entrainment, and chemical and thermal effluents;
11. Alternative plant designs and operating procedures;
12. Electrical effects from high-voltage transmission lines.

In addition to evaluating specific proposed sites, the PPSP has three other activities: <u>site acquisition</u>, <u>monitoring</u>,

FIGURE 3.5



ACTIVITIES OF THE STATE OF MARYLAND
POWER PLANT SITING PROGRAM
(6/75)

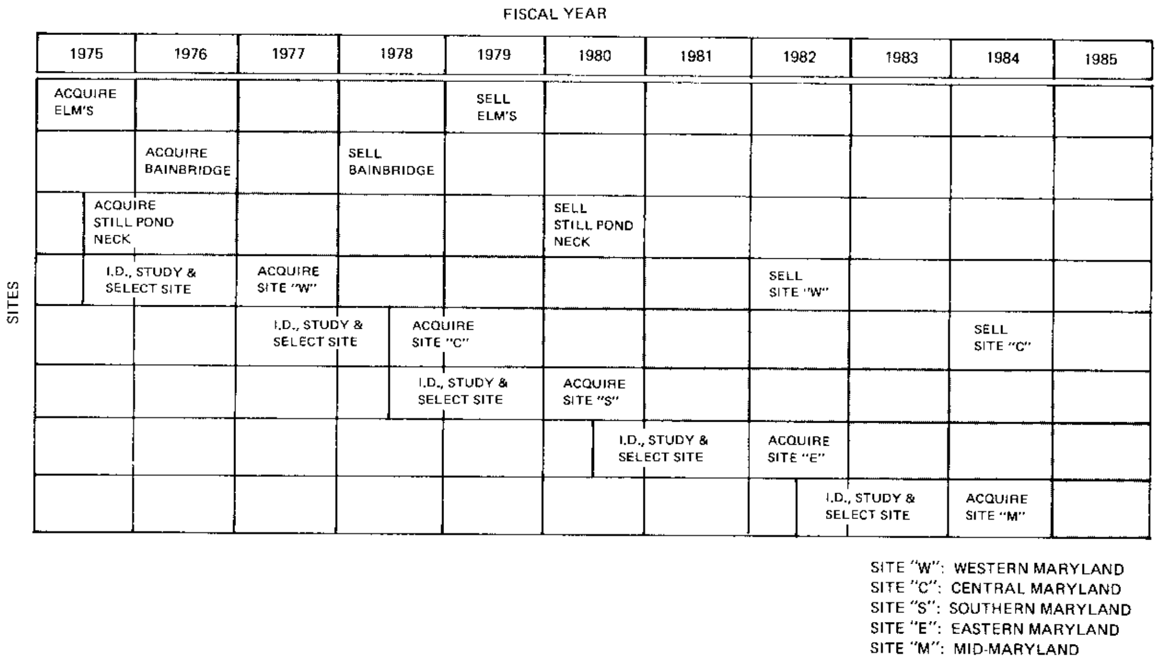
- ● EXISTING OR UNDER CONSTRUCTION
- △ PROPOSED NEW SITE OR EXPANSION OF EXISTING SITE
- □ SITE CLASSIFIED AS UNSUITABLE
- ○ POTENTIAL STATE ACQUISITION
- ▲ STATE ACQUISITION

BLACK OAK POINT OF ROCKS	(POTOMAC EDISON)—PRELIMINARY SITE EVALUATION COMPLETED
DOUGLAS POINT	(PEPCO)–DETAILED SITE EVALUATION IN PROGRESS
DICKERSON	(PEPCO)–DETAILED SITE EVALUATION COMPLETED, AQUATIC AND AIR MONITORING COMPLETED
CHALK POINT	(PEPCO)—AQUATIC AND AIR MONITORING COMPLETED COOLING TOWER RESEARCH IN PROGRESS
MORGANTOWN	(PEPCO)—AQUATIC AND AIR MONITORING IN PROGRESS
PERRYMAN	(BG&E)—DETAILED SITE EVALUATION IN PROGRESS
RIVERSIDE	(BG&E)—DETAILED SITE EVALUATION IN PROGRESS FOR PEAKING UNITS
BRANDON SHORES	(BG&E)–AQUATIC AND AIR MONITORING COMPLETED, DETAILED SITE EVALUATION COMPLETED
WAGNER	(BG&E)–AIR MONITORING COMPLETED
CALVERT CLIFFS	(BG&E)—AQUATIC AND RADIOLOGICAL MONITORING IN PROGRESS
VIENNA	(DELMARVA)–AQUATIC MONITORING COMPLETED
EASTON	DETAILED SITE EVALUATION IN PROGRESS
CHESAPEAKE CITY	(PHILA. ELEC.)—DETAILED SITE EVALUATION IN PROGRESS
ELM'S STILL POND NECK BAINBRIDGE	(PPSP)—ENVIRONMENTAL IMPACT/ ENGINEERING FEASIBILITY REPORT COMPLETED
BAINBRIDGE	DETAILED SITE EVALUATION IN PROGRESS

and research. The State is required to purchase sites which, in turn, can be purchased by a utility if its own proposed site has been judged unsuitable. The site acquisition program makes surveys to identify parcels of land that appear suitable for power plant sites. A preliminary evaluation (42) is made of the site to determine its merit for further consideration. In-depth investigation of the engineering feasibility and predicted environmental impact of constructing and operating a power plant at the site (41) are made subsequently, at the time a utility applies to buy the site and identifies initial engineering plans. A minimum of four and a maximum of eight sites comprise the land bank inventory, distributed so that there is at least one reasonably suitable alternative within reach of each major utility (i.e. ones generating more than 1,000 Mwe). So far, the Elm's property (cf. Figure 3.6) has been acquired in this way, and the PPSP is now seeking authority to acquire the Bainbridge site.

FIGURE 3.6

POWER PLANT SITE ACQUISITION



The purpose of monitoring existing plants is to gain a better quantitative understanding of their impact (both site-specific and collective) -- and, in turn, to upgrade the reliability of predictive models (43). Research seeks improved methods for carrying out biological, socioeconomic, and ecological impact assessments and projections (44).

F. Alternative Energy Resources to Scarce Fossil Fuels

The increases in oil prices since October 1973 (see Chapter 2 of this Report) and recent warnings by the National Academy of Sciences that the U. S. could deplete its oil and natural gas deposits in as little as 25 years (23) have made it imperative that alternate fuels be found for future power plants.

Technological substitutes for conventional energy sources, such as coal gasification, oil shale recovery, coal-to-oil conversion and solar energy are in the research-and-development stage and will not be of commercial significance (in the U.S.) prior to 1985 (24).

Coal is the only domestic fossil fuel in good supply, but its fuller utilization for power generation hinges on finding better ways to avoid particulate and sulfur emissions. A report prepared by the Governor's Science Advisory Council (27) recommends that processes be sought to render Maryland's substantial coal reserves acceptable for use in power plants. Maryland has 854,900,000 tons of recoverable coal in Allegany and Garrett Counties (28) -- seven times more than enough to fuel all of Maryland's current and proposed fossil fuel plants through the year 2000. Because Maryland coal is high in sulfur content (3.5-4%), plants burning it would need retrofitting with stack-gas scrubbers to meet Federal and State air quality standards. Expansion of the coal mining industry in Maryland poses ecological, transportation, and labor cost problems (28, 29) -- which must be balanced against easing some fossil fuel supply problems.

American uranium oxide (U_3O_8) reserves were recently estimated at 727,000 tons recoverable at \$8.00/lb, 1,340,000 tons recoverable at \$10/lb, and 1,520,000 tons recoverable at \$25/lb (25). This would support 1.5 million Mw of nuclear power by the year 2000 (10). A Project Independence survey (26) found that power generated by nuclear plants is now about 25% cheaper nationwide than from baseload fossil plants. Locally, PEPCO reported that its (August 1975) cost of electricity purchased from the Calvert Cliffs nuclear plant was 13.59 mills/kwhr versus a cost of 15.94 mills/kwhr from its baseload fossil fuel plants (38). A differential of 2.5 mills/kwhr scales up to \$34,000 to \$50,000 per day for a 1,000-Mw operation (26) -- enough to offset the higher capital costs of nuclear power plants (See Chapter 2 of this Report).

Another way of relieving pressure on conventional fuels is to use solid wastes as a portion of a boiler's feed. Extensive use of solid waste for power generation could reduce U.S. electric utilities' oil requirements by as much as 175 million bbl/yr (30), at savings of \$1.7 billion. More than half of the 10,000 tons/day of solid waste produced in Maryland (31) is combustible, with an average energy content of about 10 million BTU/ton. Burning one-half of the combustible solid wastes could replace about 1,000 ton/day of coal.

Baltimore is the site for a "Landgard" demonstration plant. One thousand tons/day of solid waste are shredded and fed to an oil-fired, refractory-lined rotary kiln. Organic material in the waste is converted to combustible gases and carbon: gases are burned on-site to generate steam, which will be piped through an existing utility-owned distribution system to heat and air-condition downtown buildings. Gases generated in this way are clean enough when burned in a utility boiler along with coal or oil to comply with Maryland emission guidelines for NO_x, SO_x and particulates (32). (However, a recent report (21) has raised the question of a potential problem of heavy metal discharges from refuse reclamation plants.) The net cost of operation is approximately $4.91/ton of incoming waste, including capital recovery. Once capital costs are amortized (39), this should drop to $1.19/ton, exclusive of collection costs. This compares to current disposal costs of $5.00/ton in the Baltimore metropolitan area, exclusive of collection costs (33). It is noteworthy that this latter cost is due to rise shortly, since several landfill sites are closing (45).

Another type of solid waste disposal has been used by the Union Electric Company in St. Louis on an experimental basis since 1972. Up to 10% of a boiler's fuel is shredded household waste from which non-combustibles have been removed. Based on experience with the pilot operation, plans are now underway to build an 8,000-ton/day facility that, by 1977, will treat all the solid wastes collected in the metropolitan St. Louis area. The SO_2 and NO_x emissions from the trash portion of the fuel are both less than for a comparable amount of coal. This $70 million waste recovery project is expected to save about 1 million ton/yr of coal (34).

Thus, the most solid prospects for relieving the fuel pinch, while easing, or at least not aggravating, environmental impact are:

(1) Nuclear power;

(2) Use of solid waste in power plant boilers;

(3) Cleaning and using local coal.

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4. AIRBORNE EMISSIONS

The cumulative environmental impact of power plant air emissions involves many factors: the type and quantity of the emissions; the portion of the pollutant plume that reaches ground; and, the effect of the ground-level concentrations of these pollutants on human health and welfare. Decisions on projected changes in power plant fueling must weigh any social costs of allowing higher pollutant levels against economic and energy cost and costs of continued or tighter control. At present, assessments of this kind must be made with less than firm knowledge of the health effects of low pollution levels normally experienced in areas complying with Air Quality Standards.

A. Sources and Types of Emissions

Airborne wastes from power plant combustion include sulfur oxides (SO_2, SO_3, sulfates, and sulfuric acid mist), nitrogen oxides (NO, NO_2), particulates, hydrocarbons, carbon monoxide, and traces of organic compounds such as aldehydes. The rate of pollution release depends on fuel composition and burn rate, type of boiler firing, and the efficiency of pollution control devices. Table 4.1 lists the consumption, type, and sulfur content of fuels used in 1974 by the area's major power plants.

Particulates originate as suspended fly ash and from condensation of volatile stack wastes. Predominant composition is non-combustible fuel residues (silicates, metal salts, sodium chloride) and incompletely-burned organic material. Approximate emission rates (cf. Table 4.1) are computed as the product of fuel weight, fuel ash content, unit precipitator efficiency, and, in the case of coal, the ratio of fly ash (80%) to bottom ash (collected at the base of the boiler).

The preponderence of NO_x emitted is due to reactions between air's normal constituents (O_2, N_2) at elevated temperatures. Emission rates are sensitive to flame temperature, amount of excess air entering the boiler, and duty cycle (cf. Table 4.2). The NO_2 emissions for coal-fired plants listed in Table 4.1 were scaled from a factor of 20 lb NO_x/ton coal, an empirical value for tangential firing. NO_x for oil-fired plants was calculated using the value in Table 4.2. A small fraction of the NO_x is a decomposition product of fossil fuels.

TABLE 4.1

SOME POWER PLANT FEATURES INFLUENCING THE EMISSION AND DISPERSION OF AIRBORNE POLLUTANTS[a]

Station (Utility)[b]	Bin No.	Age (years) in 1975	Stack Height (feet)	$T_{exhaust}$ at 100% load (°F)	Scrubbers for SO_2	Avg.[c] Efficiency of Electrostatic Precipitators (%)	Annual Coal Fueling (1000 tons)	Avg. Sulfur Content (%)	Avg. Ash Content (%)	Annual Oil Fueling (1000 bbls)	Avg. Sulfur Content (%)
R. P. Smith (APSCO)	1	52	132	350	No	97.5	279.5	1.08	17.3	0	
	3	52	132	350	No						
	5	48	132	350	No						
	7	39	132	350	No	99.7					
	9	28	187	350	No						
	11	18	200	395	No						
C. P. Crane (BG&E)	1	14	353	340	No	58	0			3,806	0.91
	2	12	353	330	No						
Gould Street (BG&E)	1	49	238	430	No	56.1	0			1,036	0.9
	2	49	238	430	No						
	3	23	238	305	No						
Riverside (BG&E)	1	33	216	347	No	43	0			2,670	1.0
	2	31	216	347	No						
	3	27	216	317	No	70.7					
	4	24	216	306	No						
	5	22	216	306	No	28					
H. A. Wagner (BG&E)	1	19	287	278	No	75	652	0.9	10	6,300	1.0
	2	16	287	278	No	75.4					
	3	9	346	294,	No	98.5					
	4	3	350	600							
Westport (BG&E)	1	35	220	335	No	40	0			1,179	0.9
	2	35			No	50					
	3	34	220	382	No	93					
	4	25	220	357	No	89					
Vienna (Delmarva)	1	8	133	435	No	NA	0			2,157	1.01
	3	34	133	490	No						
	4	30	133	400	No						
	5	28	133	375	No						
	6	26	133	350	No						
	7	24	133	390	No						
	8	4	160	626	No						
Benning (PEPCO)	1	51	241	380	No	93	298.9	0.8	11.6	2,786	0.9
	3	51			No						
	5	48			No						
	7	48			No						
	2	51	241	380	No						
	4	51			No						
	6	48			No						
	8	48			No						
Benning (PEPCO)	9	46	241	380	No	See bottom of opposite column.					
	11	46			No						
	13	46			No						
	15	46			No						
	10	46	241	380	No						
	12	46			No						
	14	46			No						
	16	46			No						
	21	57	192	500	No						
	23	57			No						
	22	57	192	500	No						
	24	57			No						
	25	28	177	292	No						
	26	23	177	310	No						
	27	7	241	650	No						
	28	3									
Buzzard Point (PEPCO)	1	42	178	376	No	90	0			728	0.96
	2	41			No						
	3	35	178	350	No						
	4	34			No						
	5	32	178	350	No						
	6	30			No						
Chalk Point (PEPCO)	1	11	400	244	No	95	1127.8	1.84	15.29	274.6	1.61
	2	10	400	244	No	97					
Dickerson (PEPCO)	1	16	400	247	No	86	1459.5	2.04	17.3	0	
	2	15			No[d]	90					
	3	12	400	247	Yes	92					
Morgantown (PEPCO)	1	5	700	250	No	82	680.5	1.94	17.57	7732	1.73
	2	4	700	250	No	82					
Potomac River (PEPCO)	1	26	161	330	No	97	952.5	0.92	13.97	37	
	2	25	161	330	No						
	3	21	161	252	No						
	4	19	161	252	No						
	5	18	161	252	No						
Mt. Storm (VEPCO)	1	10	350	285	No	99	2627	2.1	19.2	0	-
	2	9	350	285	No	99					
	3	2	570	285							
Possum Point (VEPCO)	1	27	175	354	No	72	0	-	-	5034	2.26
	2	24	175	295	No						
	3	20	176	262	No						
	4	13	175	258	No						

Source: "Steam-Electric Plant Air and Water Quality Control Data for the Year Ended December 31, 1974 as reported to the FPC.

[b] APSCO = Allegheny Power Service Corporation; BE&E = Baltimore Gas and Electric Company; Delmarva = Delmarva Power and Light Company; PEPCO = Potomac Electric Power Company; VEPCO = Virginia Electric and Power Company.

[c] Estimated at Annual Operating Factor.

[d] Scrubber operating on Dickerson Unit 3~25% of 1974.

TABLE 4.2

AIR POLLUTION EMISSION FACTORS FOR TYPICAL POWER PLANTS

Pollutant	Coal lb/ton fuel[1]	Oil lb/1,000 gallons[1]
Sulfur Oxides	38 S[2]	157 S[2]
Hydrocarbons	0.3	2
Nitrogen Oxides	18-55[3]	105

Source: Reference 1

[1] 1,000 gallons of residual oil equals approximately 4.0 tons. A plant producing 1,000 megawatts and operating at 35% overall efficiency requires approximately 372 tons of coal or 65,000 gallons of oil per hour.

[2] A=ash content of fuel, in percent; S=sulfur content of fuel, in percent.

[3] Depending on type of firing.

Table 4.2 gives factors which can be used to approximate the emissions from plants in Maryland and surrounding areas. Emission factors for SO_2 assume that 95% of the sulfur in coal and 98% of the sulfur in oil is converted to SO_2 (the remainder is retained in the boiler ash). The tabulated stack heights and exhaust temperatures, together with the given emission rates, can be used to model approximate ground-level concentrations of the pollutants which are initially lofted several hundred feet at the plant.

A State-wide inventory of various emission sources is shown in Table 4.3. In terms of cumulative airshed burdening, power plants are the source of a minor portion of our NO_x, less than half the particulates, and perhaps two-thirds of the SO_x. (The inventory is inclusive of D. C., Virginia, and West Virginia plants near enough to impact Maryland air quality.)

Pollutants emitted by a power plant emerge from stacks hundreds of feet tall, and rise additionally due to the buoyancy of heated exhaust flow. Atmospheric turbulence and dispersion eventually brings the plume down to ground, several hundred-to-several thousand yards downwind of the plant. While aloft, interactions can occur between various pollutants, atmospheric oxygen, ozone, dust and sunlight. By the time it touches down, the plume's reactive components may have undergone a complex evolution. Impact of the layer of air breathed, therefore, depends on the kind and quantity of emitted pollutants, meteorological conditions, and the presence or absence of other pollutants within or outside the plume.

TABLE 4.3

STATEWIDE TOTAL EMISSIONS INVENTORY
(1974)

	Heating	Power Plants	Mobile Sources	Process	Refuse	Total
Particulate						
Tons/yr	12,223	47,454	17,566	21,960	4,304	103,507
% of Total	11.8	45.8	17.0	21.2	4.2	
Sulfur Oxides						
Tons/yr	62,177	248,796	18,129	45,532	817	375,456
% of Total	16.6	66.3	4.8	12.1	0.2	
Hydrocarbons						
Tons/yr	3,212	2,136	198,096	77,409	1,085	281,938
% of Total	1.1	0.8	70.3	27.5	0.4	
Nitrogen Oxides						
Tons/yr	47,353	102,925	154,221	39,553	963	342,939
% of Total	13.7	29.8	44.7	11.5	0.3	
Carbon Monoxide						
Tons/yr	9,941	3,905	1,374,495	112,230	3,764	1,504,335
% of Total	0.6	0.3	91.4	7.5	0.2	

Source: Bureau of Air Quality Control, March 15, 1975

MARYLAND AREA POWER PLANT EMISSION INVENTORY (tons)

	BG&E Plants	PEPCO Md. Plants	PEPCO D. C. Plants	VEPCO Plants		R. P. Smith	Vienna
				Mt. Storm	Possom Pt.		
SO_2	60,188	162,462	32,370	110,300	39,200	5,300	7,183
NO_x	44,461	47,000	15,832	23,600	11,100	2,500	4,756
Part.	3,478	43,400	5,315	1,000	200	250	200

TOTAL POWER PLANT EMISSIONS FOR MARYLAND AREA (tons)

SO_2	NO_x	Particulates
417,003	149,249	53,843

Source: Utilities and FPC form 67 reports for 1974

B. Effects of Emissions on Human Health

Numerous investigations have sought to document the health effects of exposure to air pollutants at concentrations normally encountered at ground level. Figure 4.1 relates regimes of SO2 concentrations to various emission sources and receptor effects. Noteworthy is the factor of 100-1,000 disparity between SO2 levels causing readily detectable human response and those attributable to typical power plant operation. It is this disparity that makes it difficult to quantify how power generation impacts on public health, i.e. from industrial experience, one knows what symptoms to expect from short exposures to very high concentrations (accidents). Determining effects of a lifetime's exposure to the low pollution concentrations normally encountered is an altogether different problem. Experts do not agree on "threshold values" of pollutants -- i.e. levels below which a continuous exposure will produce no ill effects.

Development of dose-response relationships for chronic exposures is based on epidemiological studies, wherein statistical comparisons are made of public health indicators (e.g. sick days, chronic respiratory hospital admissions, etc.) in communities alike in all respects except air quality. Clearcut results are thwarted by: (1) difficulty in matching populations; (2) ambiguities in dose differences; and (3) the subtle effects of covarient stresses (occupational exposure, general health, smoking habits, nutritional history).

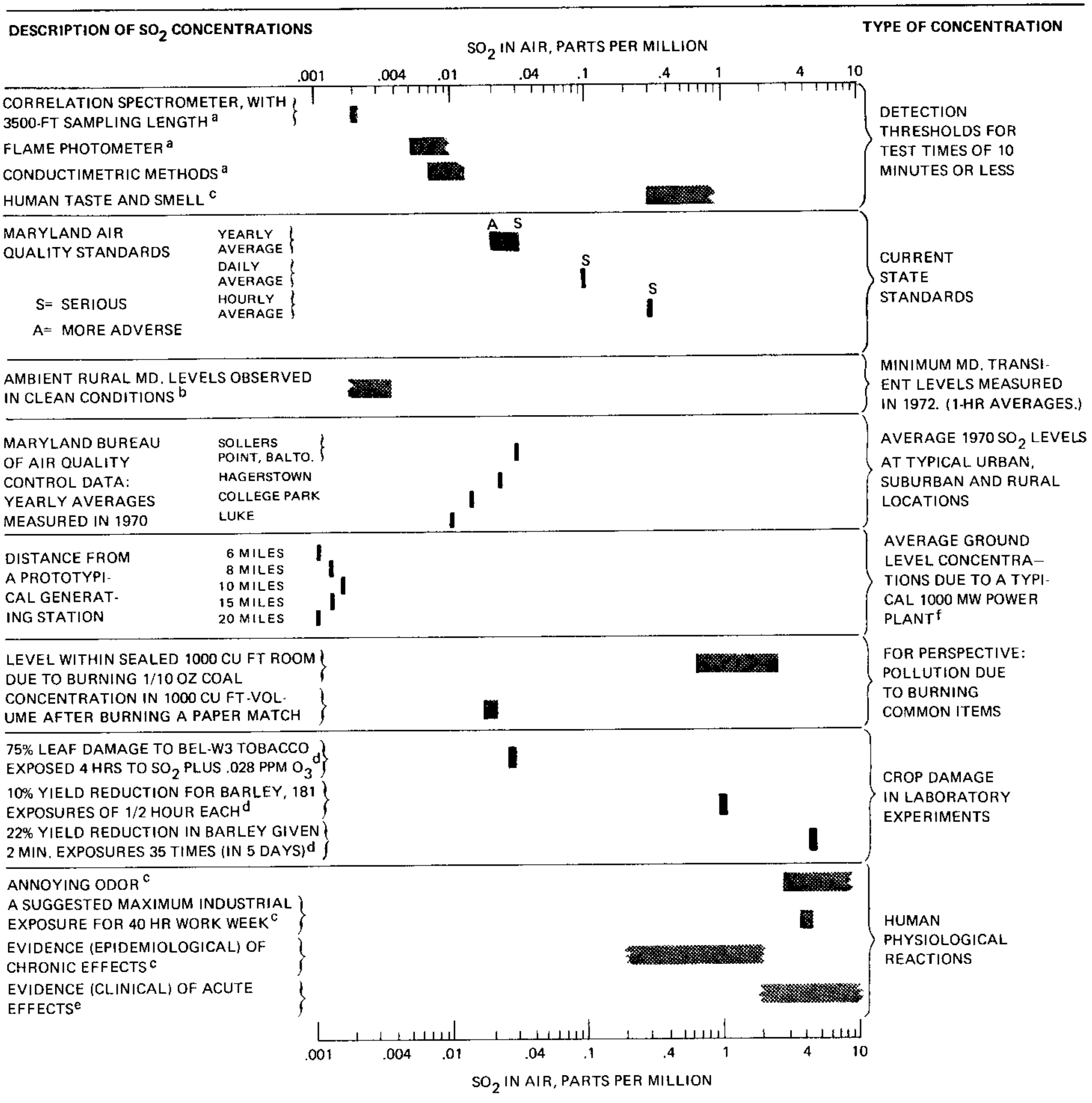
Inferring chronic implications of low-level doses from the acute effects of high concentration doses has been impeded by uncertainty over whether physiological reactions like shallow breathing are wholly, or only partly, reversible. Scientific consensus on the body of dose-response literature, summarized in Tables 4.4, 4.5, and 4.6, has led to Federal and State Air Quality Standards (Table 4.7). These contain "safety factors" as a hedge against estimated uncertainty in data and are felt to protect even the most sensitive segments of the population. Maryland standards are more stringent than the Federal, an option allowed under Federal law.

Emission Standards are promulgated as a means of bringing about compliance with Air Quality Standards by regulating pollution at its source. Table 4.8 gives the standards applicable to Maryland power plants.

Epidemiological data used to set the standards have been challenged on several counts (9-11). It has been argued that some of the studies failed to screen for the effects of other pollutants besides the one being tested, or for possible synergistic effects of combinations of pollutants (9). Inadequate accounting for other simultaneous stresses or lack

FIGURE 4.1

RELATIONSHIPS AMONG VARIOUS SULFUR DIOXIDE CONCENTRATIONS



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[a] Source: Reference (2).

[b] Source: Reference (3).

[c] Source: Reference (4), (5), (6).

[d] Source: Reference (8), (12).

[e] Sources: References (7), (12).

[f] Computed from the AQDM model, assuming as typical the following plant and meteorological conditions:

Stack height	= 500 feet.	Exit temperature	= 250° F
Inventory	= 180 tons of SO_2 per day	Atmospheric stability	= Class D
Exit velocity	= 80 feet per second	Average wind speed	= 7-10 knots.
Stack diameter	= 18 feet.	Wind direction	= uniform; i.e., circular frequency rose.

TABLE 4.4

SOME EFFECTS OF SULFUR DIOXIDE (SO_2) ON HUMAN HEALTH AND WELFARE

Concern	Concentration (ppm)	Duration or averaging time	Effect	Comments
Human health	0.052	24 hour mean	Increased mortality may occur when particulates exceed 6 cohs* soiling index.	Literature from several countries indicates that the main health problems posed by sulfur oxides are related to irritation of the respiratory system. Dose-response curves, based on 1 hour exposures, have been established for some laboratory animals. In laboratory animals and man, sulfuric acid mist and particulate sulfates when present increase the irritant potency of a given SO_2 concentration. The association between long-term exposures to ambient levels of SO_2 and disease incidence rates is conservatively appraised to be intermediate in reliability.
	0.25	24 hour mean	Increased death and illness rate may occur when smoke concentration is more than 750 $\mu g/m^3$.	
	0.21	24 hour mean	Patients with chronic lung disease may have worsened symptoms if smoke concentrations exceed 300 $\mu g/m^3$.	
	0.19	24 hour mean	Increased mortality may occur if high particulate levels are present.	
	0.11 -0.19	24 hour mean	Increased hospital admissions for older persons with respiratory diseases.	
	0.037-0.092	Annual mean	When accompanied by smoke concentrations greater than 185 $\mu g/m^3$, increased frequency of lung and respiratory disease may occur.	
	0.046	Annual mean	When accompanied by smoke concentrations greater than 100 $\mu g/m^3$, increased respiratory disease may occur in school children.	
Damage to vegetation	0.05 -0.25	4 hours	Moderate to severe injury to sensitive plants when O_3 and NO are also present.	Different species, varieties and even individuals vary in tolerance to SO_2. Over 300 species have been studied. Alfalfa is one of the most sensitive species and is commonly used as a reference.
	0.03	Annual mean	Chronic damage and excessive leaf drop may occur.	
	0.03	8 hours	Some trees and shrubs show damage.	
Effect on materials	0.12	Ambient mean	Corrosion rates for steel panels may be accelerated by 50%.	Sulfur oxides contribute to damage of many kinds of electrical equipment—including transmission lines. Field observations substantiated in laboratory.
	0.09	Annual mean	Some dyed fabrics fade.	
Effect on visibility	0.10	Ambient mean	With 50% humidity and the presence of comparable particulate concentrations, visibility may be reduced to 5 miles.	Aside from aesthetic considerations, operation of airports can be significantly slowed.

*cohs—coefficient of haze: that quantity of particulate material which produces an optical density of 0.01 when measured by light transmission at 400 millimicrons and when compared to the transmission of dust-free filter paper taken as 100%

Source: Reference 12

TABLE 4.5

SOME EFFECTS OF NITROGEN DIOXIDE (NO_2) POLLUTION

Concern		Concentration (ppm)	Duration	Dose[a] (ppm sec)	Effect	Comment
Human health[b]	Acute effects due to short-term exposures	0.12	———	———	Olfactory threshold	———
		5	10 min	3,000	Measurable increase in airway resistance.	Transient response.
		15-50	2 hours	108,000-360,000	Tissue changes in lungs, heart, liver and kidney of monkeys.	Degree of damage proportional to concentration.
		90	30 min	162,000	Pulmonary edema found 18 hours after exposure—accompanied by a 50% reduction in normal vital capacity.	Accidental occupational exposure.
	Effects due to long-term exposures	0.062-0.109 daily means	Continuous	37,000-66,000 per week	Increased incidence of serious respiratory disease in family groups found during a 6-month study.	Mean level of suspended particulate nitrates during the study was at least 3.8 $\mu g/m^3$.
		0.063-0.083	Continuous	38,000-50,000 per week	Frequency of acute bronchitis was increased among infants and school children observed in a 6-month study.	Mean level of suspended particulate nitrates during the study was at least 2.6 $\mu g/m^3$.
		5	6-24 hr/day for 3-12 mos.	9,720,000-158,000,000	Toxilogical changes in mice resembling those associated with human emphysema	Enhanced susceptibility to K. pneumoniae was noted in mice exposed continuously to this NO_2 level for 3 months.
Damage to vegetation		0.25	Continuous for 8 mos.	5,200,000	Leaf abscission and decreased yield for naval oranges.	Exposure of beans to nitric oxide (NO) concentrations of 10 ppm and 4 ppm reduced apparent photosynthesis by 50-70% and 10%, respectively.
		0.50	Continuous for 35 days	1,512,000	Leaf abscission and chlorosis on citrus trees.	
		1.0	1 day	86,000	Overt leaf injury to NO_2—sensitive plants.	
Other Effects	Photochemical oxidant (OX) production	0.04-0.16	———	———	Maximum daily one-hour average OX concentration of 0.1 ppm can be associated with these NO_2 levels in the presence of 0.3-1.4 ppm of nonmethane hydrocarbon (6-9 a.m. sunlight).	Pertains to formation of photochemical smog.
	Stress corrosion	0.066-0.088 of NO_x	Continuous	———	Nitrogen oxide reaction products have contributed to corrosion and failure of electrical components.	Problem observed in 2 cities during 1965. Average particulate nitrate levels were 3.0-3.4 $\mu g/m^3$.

Source: Reference (13).

[a] The concentration-time of exposure product determines nonlethal morbidity effects of NO_2 in toxonomic studies.

[b] There is no evidence showing adverse health effects due to nitric oxide (NO) at ambient concentrations.

TABLE 4.6
SOME EFFECTS OF AIRBORNE PARTICULATES

Concern	Particulate concentration ($\mu g/m^3$)	Accompanying SO_2	Duration or averaging time	Effect	Comment
Human Health	750	>715 $\mu g/m^3$	24 hour mean	Excess deaths and increase in illness may occur.	Analyses of numerous epidemiological studies clearly indicate an association between air pollution, as measured by particulate matter accompanied by sulfur dioxide, and health effects of varying severity. This association is most firm for the short-term air pollution episodes. To show small percentage changes in deaths or increases in hospital admissions associated with coincident higher levels of air pollutants requires extremely large populations. In small cities, these changes are difficult to detect statistically and are most easily demonstrated in major urban areas. For the large urban communities which are routinely exposed to relatively high levels of pollution, sound statistical analysis can show with confidence the small changes in daily mortality which are associated with fluctuation in pollution concentrations. Such analysis has thus far been attempted only in London and in New York.
	300	>630 $\mu g/m^3$	24 hour mean	Chronic bronchitis patients likely to have a worsening of symptoms.	
	200	>250 $\mu g/m^3$	24 hour mean	Increased absence of industrial workers due to illness.	
	100-130	>120 $\mu g/m^3$	Annual mean	Children likely to experience increased incidence of some respiratory diseases.	
	80-100	Sulfation rate >30 mg/cm^2-mo.	Annual geometric mean	Increased death rates for persons older than 50 years is likely.	
Visibility	100-150	————	————	Where large smoke turbidity factors persist, in middle and high latitudes, sunlight may be reduced by 1/3 in summer and 2/3 in winter.	
	150	————	————	For particles predominantly in the 0.2μ to 1.0μ size range, and relative humidity less than 70%, visibility can be reduced to as little as 5 miles.	
Materials	60-180	Some	Annual geometric mean	In presence of SO_2 and moisture, accelerated corrosion of zinc and steel may occur.	

Source: Reference (14).

TABLE 4.7

FEDERAL AND MARYLAND STATE AIR QUALITY STANDARDS

	(To be attained by 5/31/77) National				(To be attained by 1982) State				Suggested*	
	Primary		Secondary		Serious		More Adverse			
	$\mu g/m^3$	ppm	$\mu g/m^3$	ppm	$\mu g/m^3$	ppm	$\mu g/m^3$	ppm	$\mu g/m^3$	ppm
Sulfur Oxides										
Annual Arithmetic Mean	80	0.03			79	0.03	60	0.023	79	0.03
24-hr Maximum[b]	365	0.14			262	0.10			262	0.10
3-hr Maximum[b]			1,300	0.5						
1-hr Maximum[c]					920	0.35			920	0.35
Particulate Matter										
Suspended										
Annual Arithmetic Mean	75[a]		60[a]		75		65		75	
24-hr Maximum[b]	260		150		160		140		160	
Settleable										
Annual Arithmetic Average mg/cm²/month					0.5		0.35			
Monthly Maximum					1.0		0.7			
Carbon Monoxide										
8-hr Maximum[b], mg/m³	10	9	10	9	10	9	10	9	10	9
1-hr Maximum[b], mg/m³	40	35	40	35	40	35	40	35	50	44
Hydrocarbons (non-methane)		(carbon)		(carbon)		(carbon)		(carbon)		
3-hr (6-9AM) Maximum[b]	160	0.24	160	0.24	160	0.24	160	0.24		
Nitrogen Dioxide										
Annual Arithmetic Mean	100	0.05	100	0.05	100	0.05	100	0.05	200	0.10
Photochemical Oxidants		(ozone)		(ozone)		(ozone)		(ozone)		(ozone)
1-hr Maximum[b]	160	0.08	160	0.08	160	0.08	160	0.08	120	0.06

[a] Annual geometric mean

[b] Not to be exceeded more than once per year

[c] Not to be exceeded more than once per month

*Suggested by Neuberger and Radford (10)

Primary Standards are to protect human health;
Secondary Standards are to protect human welfare.

TABLE 4.8
SOME MARYLAND AIR EMISSION STANDARDS[a] FOR FOSSIL FUEL GENERATING STATIONS

Fuel Type	Effective Date of Standard	Maximum Allowable Particulate Emissions g/SCFD	Maximum Allowable Emissions; Shell-Bacharach Smoke Spot Test Number	Required Collection Efficiency of Dust Collector	Sulfur Content[c] of Fuel for Plants with Inputs Greater Than Than 10^8 BTU/hr	Visible Emissions,[b] Except for Water in Uncombined Form
Residual oil; existing and modified installations	7/1/70				Areas III-IV: 1% or less	Areas III, IV: most prohibited; Areas I, II, V, VI: less than No. 2 Ringelmann
	10/1/72	0.02	4	70% or more		
	7/1/75				Areas I-II-V-VI: 2% or less	
	7/1/80				Areas III-IV: 1/2% or less	
Residual oil; new burners	7/1/70				Areas III-IV: 1% or less	All areas: no visible emissions
	2/21/71	0.01	4	80% or more		
	7/1/75				Areas I-II-V-VI: 2% or less	
	7/1/80				Areas III-IV: 1/2% or less	
Solid fuel: all installations	7/1/75				Areas I-II-V-VI: 3.5 lb SO_2 per 10^6 BTU (2.15% S)	New plants, all areas: no visible emissions. Existing plants in III and IV: most emissions prohibited. Other areas: less than No. 2 on Ringelmann scale.
	9/29/70 3/24/70				Areas III-IV: 1% or less	
	10/1/72	0.03	No requirement	90% or more		

[a] For stations generating 23 or more megawatts

[b] In all areas, emissions not darker than No. 2 on the Ringelmann Smoke Chart are allowed for four minutes in any 60 minute period during start-up and maintenance.

[c] If stack gas desulfurization or other means are used to control emissions, higher sulfur content fuels may be used.

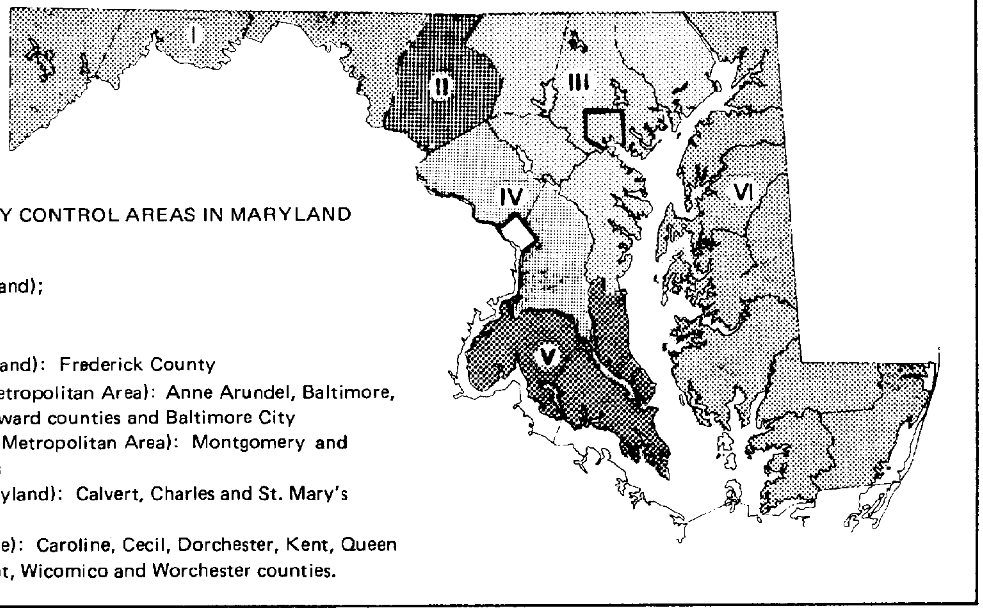
Source: "Rules and Regulations Governing the Control of Air Pollution in the State of Maryland," Maryland State Department of Health and Mental Hygiene, 1974–1975.

ENVIRONMENTAL PROTECTION AGENCY REGULATIONS ON STANDARDS FOR NEW FOSSIL-FUEL STEAM GENERATORS
(Effective June 14, 1974)

	(lb/10^6 BTU input)		
	Particulates	Sulfur Dioxide*	Nitrogen Oxides*
Solid Fuels	0.10 lb	1.2 lb	0.70 lb
Liquid Fuels	0.10 lb	0.8 lb	0.30 lb

*Where different fossil fuels are burned simultaneously in any combination, the applicable standards for sulfur dioxide and nitrogen oxides are determined by proration formulae as given in Reference 15

Source: Reference 15



THE SIX QUALITY CONTROL AREAS IN MARYLAND

AREA I (Western Maryland); Allegany, Garret and Washington counties
AREA II (Central Maryland): Frederick County
AREA III (Baltimore Metropolitan Area): Anne Arundel, Baltimore, Carroll, Harford and Howard counties and Baltimore City
AREA IV: (Washington Metropolitan Area): Montgomery and Prince George's counties
AREA V (Southern Maryland): Calvert, Charles and St. Mary's counties
AREA VI (Eastern Shore): Caroline, Cecil, Dorchester, Kent, Queen Anne's, Somerset, Talbot, Wicomico and Worchester counties.

of reliable air quality data has been cited in other instances (9). Experienced researchers have reached different, and sometimes contradictory, conclusions.

Neuberger and Radford (10), for example, assessed thresholds and safety factors for several common pollutants. To protect public health, they recommend as limits:

carbon monoxide (8-hr average) - 11 mg/m^3;

SO_2 (annual arithmetic mean) - 100 μg/m^3
(one-hr maximum) - 2,155 μg/m^3;

suspended particulates
(annual arithmetic mean) - 150 μg/m^3;

NO_2 (annual arithmetic mean) - 1,000 μg/m^3; and

formaldehyde (one-hr maximum) - 12 μg/m^3,

and suggest amending the State's "serious" Standards along the lines shown in Table 4.7.

Takacs (11) developed a statistical technique to segregate effects of mixed pollutants, socioeconomic differences and climatic factors. Applying this to the analysis of mortality rates for whole city populations, he concludes that "there are no safe threshold air pollutant concentration levels" -- with emphasis on NO_2 and particulate sulfates --, a view incompatible with the Neuberger and Radford (10) findings.

Another evaluation is given by the Assembly of Life Sciences of the National Research Council (9). Recent research indicates that although SO_2 is itself unlikely to promote excess morbidity or mortality (even at continuous exposures up to 80 μg/m^3), natural oxidation products of SO_2 (sulfuric acid and suspended particulate sulfates) may actually be responsible for the adverse health effects attributed to air pollution. This group estimates that suspended sulfates make up more than 10-25% of the small particulates likely to reach the lungs. Extrapolating from recent Community Health and Environmental Surveillance System (CHESS) data, they estimate that 10% of the cases of chronic bronchitis, 10% of the acute morbidity in patients with chronic respiratory disease, and 10% of the annual total of asthma attacks in polluted areas are induced by sulfur oxide exposure.

Another assessment of sulfur oxide health effects is advanced by North and Merkhofer (9). These authors contend that oxidation products of SO_2 (suspended sulfates) pose the major health threat of air pollution, and present dose-response relationships (Table 4.9) to this effect. In 1972, EPA reported

TABLE 4.9

"BEST JUDGMENT" DOSE-RESPONSE FUNCTIONS[a]

Adverse Health Effect	Best Judgment Exposure Duration	Threshold Function Threshold ($\mu g/m^3$)	Slope[b]
Increased Daily Mortality	24 Hours or Longer	25	.252
Aggravation of Heart and Lung Disease	24 Hours or Longer	9	1.41
Aggravation of Asthma	24 Hours or Longer	6	3.35
Excess Lower Respiratory Disease in Children	Up to 10 Years	13	7.69
Excess Risk For Chronic Resp. Disease in Adults[c]	Up to 10 Years	12	11.1

[a] These dose response relationships were developed in an unpublished study for the U. S. Environmental Protection Agency. The "best judgment threshold functions" represent subjective approximations to data, not precise mathematical fits. The studies upon which the estimates were based are as follows: Mortality; Lindeberg (1968), Martin and Bradley (1960), Lawther (1963), Glasser and Greenburg (1965), Brasser et al. (1967), Watanabe and Kaneko (1971), Nose and Nose (1970), Buechley et al. (1973). Aggravation of heart and lung disease; Carnow et al. (1970), Goldberg et al. (1974). Aggravation of asthma; French, Sugita et al. (1970), Finklea et al. (1974a), Finklea et al. (1974c). Excess lower respiratory disease in children; Nelson et al. (1974), Finklea et al. (1974b), Douglas and Waller (1966), Lunn et al. (1967), Love et al. (1974), Hammer (1974). Excess chronic respiratory disease; Burn and Pemberton (1974), Goldberg et al. (1974), House et al. (1973), Hayes et al. (1974), Yashizo (1968), House (1974), Galke and House (1974a), Galke and House (1974b).

[b] Change in percent excess over base rate for population, per $\mu g/m^3$ change in suspended sulfate level.

[c] For chronic respiratory disease, difficulties with available data necessitated the unit of measurement to be excess risk rather than direct incidence of illness. Actually, in its originally calculated form, separate dose response functions were assessed for cigarette smokers and nonsmokers. The function described in the table is a weighted linear average based upon the average prevalence of cigarette smoking in the adult population at risk.

Source: Reference 9

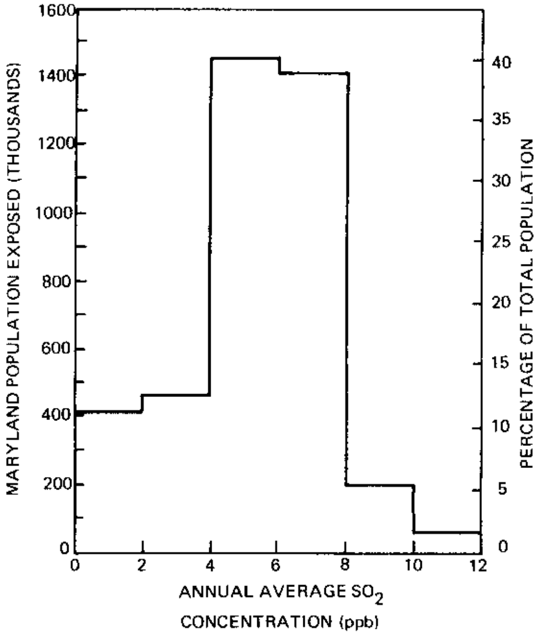
annual sulfate levels in Maryland exceeding 13.0 $\mu g/m^3$ in some urban locales and reaching 9.0 $\mu g/m^3$ in some rural areas (34), significant dose levels according to Table 4.9.

It has been proposed that rural sulfate levels are due to power plant SO_2 plumes being oxidized as they disperse downwind (16). At this time, however, the role of power plant emissions (SO_2) and ambient sulfate concentrations is not understood in a quantitative way. A better knowledge of SO_2 evolution in the atmosphere is therefore an outstanding prerequisite to determining the cumulative health impact of Maryland power plants.

The approximate annual exposure of Maryland's population to SO_2 of power plant origin can be computed by folding together dispersion modeling, annual weather data, and demographic information. The histogram, Figure 4.2, shows the Maryland and D. C. population segments exposed to various average SO_2 levels as a result of power plant operations in 1971. The majority of the population is exposed on an annual average to 4-8 ppb SO_2 of power plant origin: this is low with respect to the doses causing adverse health effects (cf. Table 4.4). Further work on atmospheric chemistry is needed before similar population/dose histograms can be made for particulate sulfates.

FIGURE 4.2

MARYLAND & D.C. POPULATION EXPOSED IN 1971 TO VARIOUS ANNUAL MEAN SO_2 CONCENTRATIONS DUE TO POWER PLANT OPERATIONS: COMPUTATIONS ARE BASED ON THE AIR QUALITY DISPLAY MODEL*



*SOURCES: (AQDM modeling—Martin Marietta Laboratories; emission inventories—PEPCO, BG&E; demographic data—DSP). Mean predicted level of population exposure is 5.2 ppb.

The potential for sulfuric acid mist formation in the Dickerson plant's co-mingling of SO_2 and cooling tower water vapor has recently been evaluated -- with the conclusion that there will be no significant acid formed so long as particulate control is adequate (17).

The annual average public exposure to NO_x and particulates emitted by power plants can be estimated in an analogous way. In 1974, the mean average annual NO_2 dose received (from all sources) by Maryland residents was about 36 $\mu g/m^3$ (18). Ascribing 30% of this to power plants (Table 4.3) yields approximately 11 $\mu g/m3$ or 0.006 ppm, a level lower than any associated with adverse health effects (10, Table 4.5). In a similar vein, mean average annual non-sulfate particulate dose (from all sources) was about 63$\mu g/m^3$ (18). Partitioning this on the basis of Table 4.3, 46%, or 28 $\mu g/m^3$, can be approximately associated with power plants. This level, as well as the total 63 $\mu g/m^3$, has not been implicated in adverse effects (10, Table 4.6).

C. Material and Social Effects of Power Plant Emissions

Severe air pollution can damage agricultural products in ways described by Tables 4.4, 4.5, and 4.6. The likelihood of such damage to Maryland crops is remote because the air quality of the State is within the protective limits set by Maryland Air Quality Standards (19) (cf. Table 4.7).

The State is investigating the possibility of grazing land/milk damage from the combined fluoride releases of the large coal-fired Dickerson plant (there is an average of about 0.1 wt% fluoride in coal) and a nearby aluminum plant. The scrubber that will be installed on the new Dickerson units will remove 80% of the fluorides from the stack gas. With this control it is anticipated that the maximum 24-hr gaseous fluoride concentration due to the plant will be 0.117 ppb, well below the State standards of 2 ppb.

Chances for drift from the Chalk Point brackish-water hyperbolic cooling tower, causing undesirable salt-buildup, are presently being studied. Table 4.10 lists the value of crops raised within a six-mile radius of the cooling tower. Estimated salt deposition rates as a function of distance from the plant are shown in Figure 4.3 for both Chalk Point and the proposed Brandon Shores plant. It is not anticipated that deposition rates from the Chalk Point tower will be troublesome beyond the plant property. However, at full load, the Brandon Shores towers will deposit an estimated 200 lb/acre/yr of salt near Stony Beach. Information on how salt affects soil and vegetation is sketchy: up to 500 lb/acre/yr has little impact on some lands, while only a few lb/acre/yr deposited directly on foliage of some sensitive crops (e.g. tobacco) can reduce their market value (18). To directly document the local effects of salt deposition, experimental crop plots (Table 4.10) are being grown at various distances from the Chalk Point tower (20).

TABLE 4.10

CROP PRODUCTION IN COUNTIES SURROUNDING THE
CHALK POINT COOLING TOWER

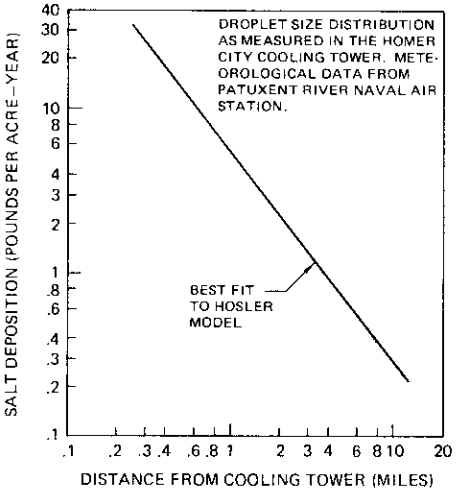
Crop	Production	Value	Approximate Portion of County Within Six Mile Radius of Chalk Point
Calvert County			25%
Tobacco	4,623,000 lb	$3,906,435	
Corn	496,000 bu	$1,205,280	
Soybeans	17,000 bu	91,800	
Charles County			10%
Tobacco	6,228,000 lb	$5,262,660	
Corn	694,000 bu	1,686,420	
Soybeans	125,000 bu	675,000	
Prince George's County			less than 10%
Tobacco	4,121,000 lb	$3,482,245	
Corn	489,000 bu	1,188,270	
Soybeans	55,000 bu	297,000	

Source: Office of Crop Reporting, University of Maryland, College Park, 1973 Statistics

North and Merkhofer (9) prepared cost estimates of materials and aesthetic damage due to power plant SO_2 emissions in the Northeastern U. S. Their results can be roughly scaled to Maryland by assuming (1) that most damage occurs in urban areas (1970 population of three million (21), (2) that material damage is proportional to population density, (3) that only power plants within the State contribute to ambient SO_2, and (4) that ground-level SO_2 can be traced to various classes of sources according to emission rates. In this simplified approach, 66% of calculated annual costs of material and aesthetic damage due to SO_2, or about $42 million, is laid to power plant operations. This example is cited to illustrate the scale of possible cumulative economic impact of power plant emissions: the approximations used are too loose to constitute a definitive evaluation.

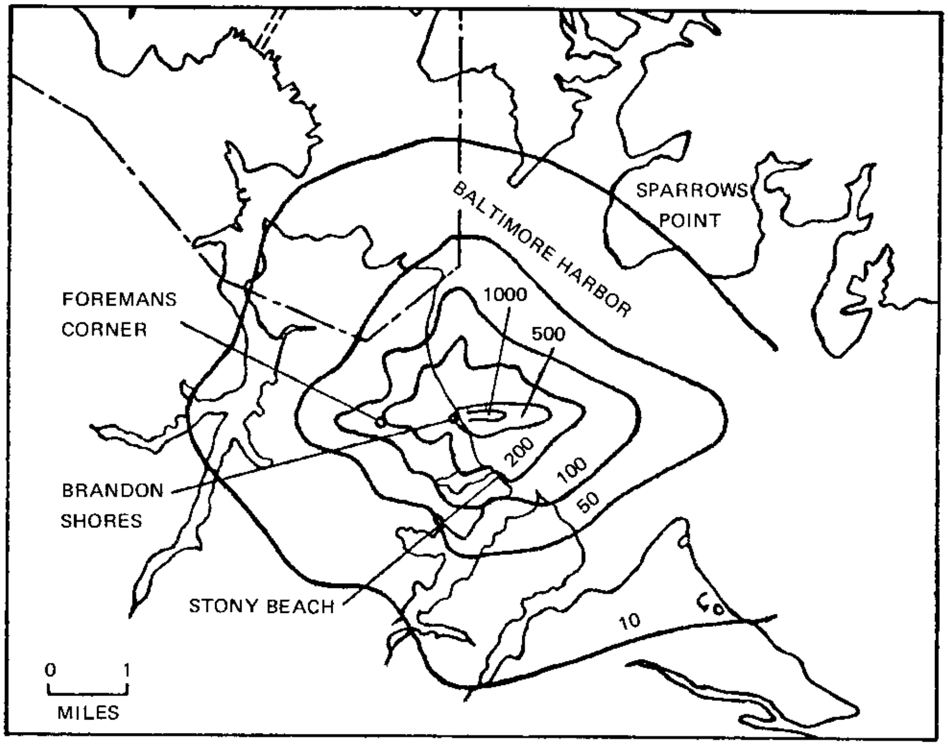
FIGURE 4.3

APPROXIMATE SALT DEPOSITION RATES
PREDICTED FOR
CHALK POINT COOLING TOWER*



*SOURCE: REFERENCE (22).

ESTIMATED ANNUAL SALT DEPOSITION (LB/ACRE/YEAR) FROM
THE PROPOSED BRANDON SHORES COOLING TOWERS



SOURCE: REFERENCE 23

D. Trends in Power Plant Fueling and Projected Impact on Air Quality

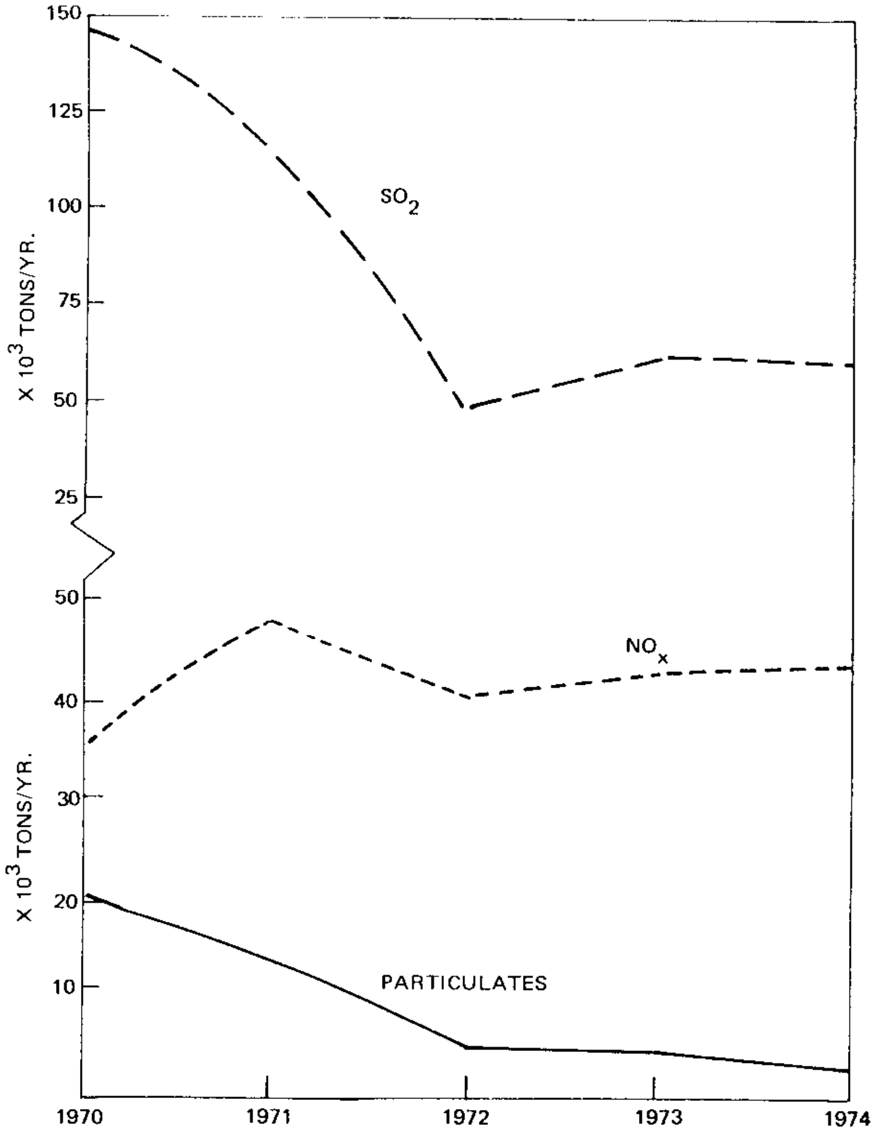
The cumulative impact of air pollution from Maryland power plants is on the downswing, use of emission controls and cleaner fuels having reduced State-wide emissions by 50% from their 1970 levels. Between 1968 and 1970, Maryland utilities spent $32.4 million for air pollution control, primarily on electrostatic precipitators. Another $8-$96 million may be spent -- $8 million to convert Chalk Point and Dickerson from coal to oil or $96 million to add stack gas desulfurization to Chalk Point, Dickerson, and Morgantown (24, 25).

Table 4.11 and Figure 4.4 show the substantial reduction in the primary power plant pollutants that has occurred since 1970. Pollution abatement strategies and the Maryland Emission Standards for Power Plants (Table 4.8) prompted switching much of Maryland's generation from coal to low-sulfur (low-ash) oil. In 1970, for instance, BG&E's boilers consumed about 89 trillion BTU in fuel, more than 86% of it coal. By 1974, when BG&E used about 114 trillion BTU, only 14% of it was coal. The average sulfur content of the coal burned by BG&E plants (mostly in urban areas) in 1970 was 2.2% (19), whereas the average sulfur content of the oil burned in 1974 was less than 1% (Table 4.1). PEPCO slightly increased its rural plant coal consumption in 1974 as oil became increasingly scarce and expensive. In 1973, coal accounted for about 56% of PEPCO's generation (26); in 1974, coal accounted for 58% of PEPCO's generation (27).

The drop in power plant emissions over the last five years has not improved the State's air quality. Monitoring stations operated throughout the State by the Division of Air Monitoring, Bureau of Air Quality Control (Figure 4.5), provide comprehensive comparison of 1972, 1973, and 1974 annual average SO_2 concentrations. The BAQC 24-hr gas bubbler data for this period indicates little, if any, change in Baltimore or Washington suburban ground-level concentrations of SO_2, despite the marked slackening in Baltimore area power plant SO_2 emissions (cf. Figure 4.4). If power plants indeed contribute anything near 66% of the ground-level SO_2, and this concentration is reduced 50%, one would expect to detect a drop in ambient SO_2. The fact that one does not may have a number of explanations: (1) low-level releases from unabated sources have enough local influence to mask any changes in power plant contributions; (2) concentrations recorded at most stations are in the 0-30 $\mu g/m^3$ range -- close enough to detection thresholds of the monitors that changes due to power plant emissions abatement do not register; (3) other categories of emitters have increased their releases at a rate high enough to compensate for the cutback by the utilities.

FIGURE 4.4

AIR EMISSIONS FROM BALTIMORE GAS AND ELECTRIC COMPANY PLANTS 1970 - 1974



YEAR	HC	NO_x	SO_x	PART.
1970	451	36,236	146,172	19,051
1971	1646	58,146	121,786	13,314
1972	894	40,815	53,089	4,643
1973	968	43,746	66,889	4,210
1974	1046	44,461	60,188	3,478

SOURCE: REFERENCE (19).

TABLE 4.11

ANNUAL AVERAGE SO_2 EMISSIONS FOR SOME LARGER POWER PLANTS IN THE MARYLAND AREA
(Tons/day)

	1970	1971	1972	1973	1974
Crane	103.9	84.31	29.5	36.0	33.7
Gould	34.0	39.3	11.5	10.5	9.2
Riverside	65.79	42.27	21.3	18.0	24.0
Wagner	133.6	134.2	65.24	107.22	89.0
Westport	50.25	27.6	11.6	6.6	10.6
Chalk Point	151.6	153.1	114.8	92.2	112.0
Dickerson	173.7	125.5	120.9	106.0	141.7[c]
Morgantown	30.3[a]	130.9	69.5[b]	165.68	189.5
TOTALS:	743.1	737.2	444.3	542.2	609.7

[a] Morgantown operations started up in 1970 and reached full capacity during 1971.

[b] Low emissions due to one turbine being out of service for several months during 1972.

[c] 90%-efficient scrubber operated about 25% of the time on boiler #3 in 1974.

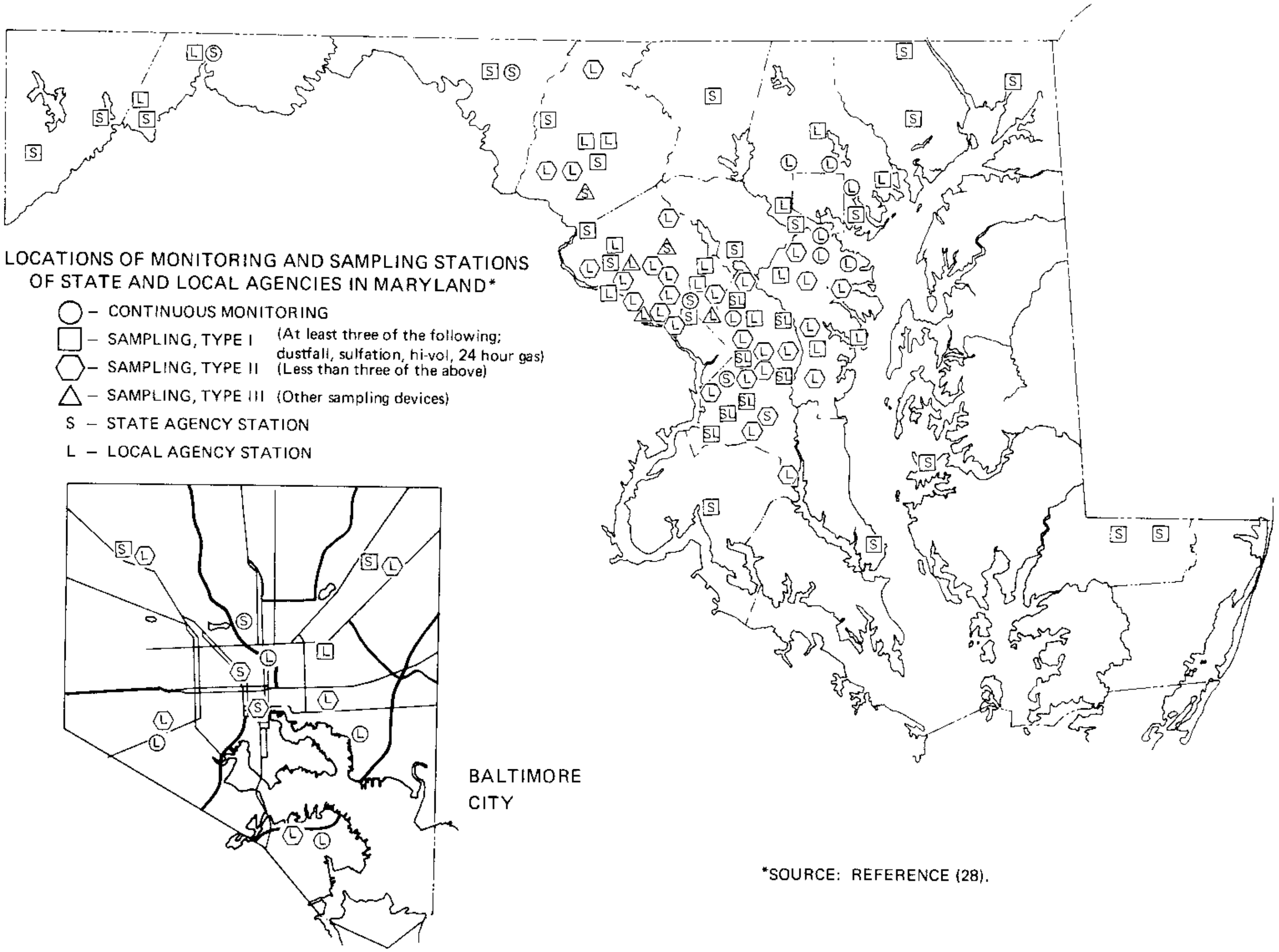
Source: Reference 19

Monitoring networks determine actual ground-level pollutant concentrations but cannot trace the source of pollution in a complex urban environment. Mathematical models of how stack plumes behave have been developed to predict how ground-level SO_2 concentrations will change as a result of changing the type or quality of a plant's fuel. In what follows, such predictions will be used to assess trends and options in power plant operations.

1. Impact of Fuel-Switching on the Baltimore Region Airshed

The unprecedented scarcity and cost of low-sulfur oil complicates the abatement program mentioned earlier. Area utilities and Federal agencies (29) must now weigh the advantages and disadvantages of switching back from oil to coal. The impact of some hypothetical fuel switches on the Baltimore airshed can be gauged by using the Gaussian plume model (30).

FIGURE 4.5



LOCATIONS OF MONITORING AND SAMPLING STATIONS OF STATE AND LOCAL AGENCIES IN MARYLAND*

○ – CONTINUOUS MONITORING
☐ – SAMPLING, TYPE I (At least three of the following; dustfall, sulfation, hi-vol, 24 hour gas)
⬡ – SAMPLING, TYPE II (Less than three of the above)
△ – SAMPLING, TYPE III (Other sampling devices)
S – STATE AGENCY STATION
L – LOCAL AGENCY STATION

*SOURCE: REFERENCE (28).

Baltimore presents a "worst case" from an air quality standpoint: the only two stations at which BAQC monitors recorded SO_2 concentrations exceeding State "adverse" levels in 1974 were Fort McHenry and Patapsco State Park, both within the City limits.

Figure 4.6 is a computer simulation of how some hypothetical fuel switches from 1% S oil to 2% S coal will alter maximum ground-level SO_2 concentrations around Baltimore (31). At 60% of total BG&E system conversion (point "D"), the maximum ground-level concentration due to power generation increases less than 25%. However, converting (the relatively small) Westport and/or Gould and/or Riverside plants (points "E" through "I") causes a sharp escalation in maximum pollution levels: conversion to coal of all three of these older plants would double the maximum ground-level SO_2 concentrations due to power generation.

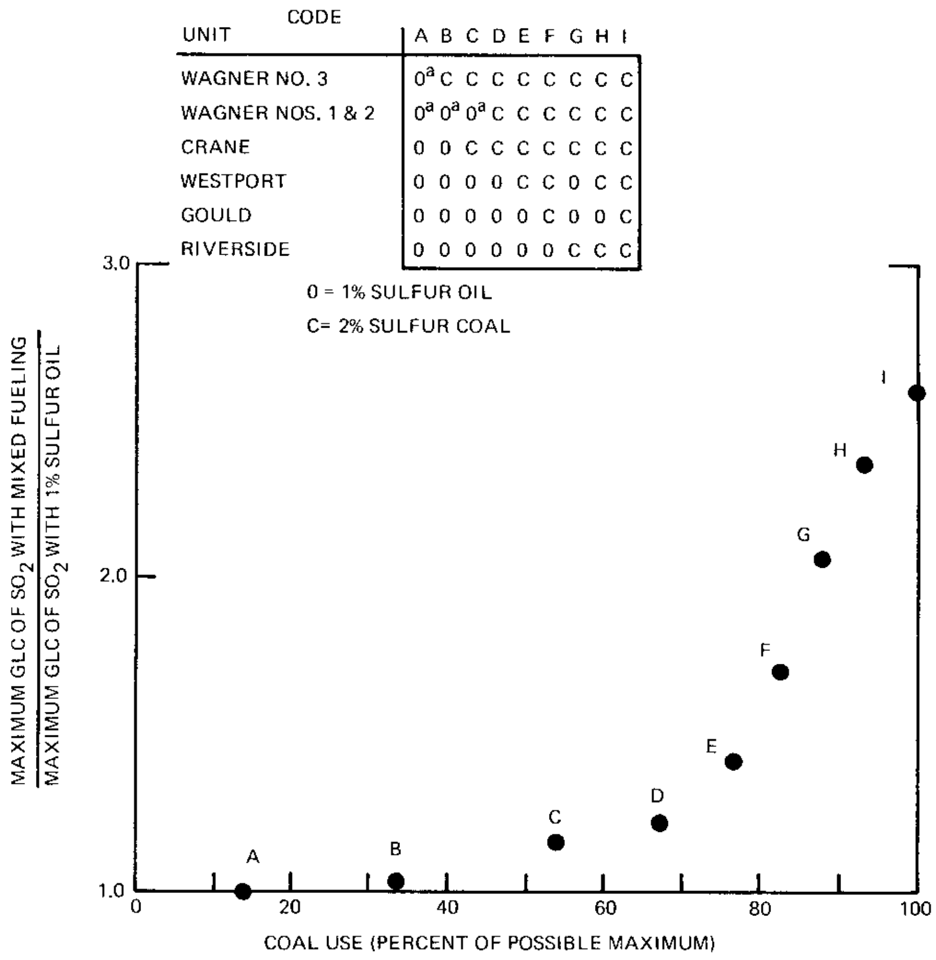
2. Impact on Air Quality of Relaxing Maryland Air Quality Standards

Towards attainment of Maryland Air Quality Standards (Table 4.7), the BAQC imposes limits on emissions from the State's power plants (Table 4.8). These Emission Standards tend to be more restrictive where (Air Quality Areas III and IV, the Baltimore Metropolitan area and the Maryland suburbs of Washington) air quality is most in need of upgrading. Plants in these areas are permitted to burn fuel with a sulfur content not higher than 1%. BG&E plants are operating under this requirement. Two PEPCO plants, Dickerson and Chalk Point, have a temporary variance allowing the burning of fuels with higher sulfur contents.

The pressures of uncertain supply and costs of low-sulfur fuels prompts modeling scenarios to quantify the air quality impact of allowing Maryland utilities to burn fuels with the maximum sulfur content which will not violate the less stringent Federal Air Quality Standards. Plants emitting SO_2 up to short-term Federal Standards would contribute 21 $\mu g/m^3$ to peak annual SO_2 ground-level concentrations, as compared to the 1974 peak (when all plants used about 1% S fuel in compliance with BAQC regulations) of 10 $\mu g/m^3$. Figure 4.7 shows isopleths of SO_2 due to Baltimore area power plants in 1974 (all plants using 1% S fuel). Figure 4.8 shows the corresponding constant-pollution contours when Baltimore area power plants emit up to the limits of Federal standards in 1974. These figures clearly illustrate that SO_2 ground-level concentrations would significantly exceed 1974 levels if plants were to emit up to Federal standards. Pending more definitive data on the health effects of ambient pollutant doses, it is unknown if these higher SO_2 levels would cause significant impact on the public health and welfare.

FIGURE 4.6

MAXIMUM CUMULATIVE ANNUAL AVG. SO_2 CONCENTRATION AS A FUNCTION OF HYPOTHETICAL FUEL SWITCHING IN THE BALTIMORE AREA*



UNIT \ CODE	A	B	C	D	E	F	G	H	I
WAGNER NO. 3	0[a]	C	C	C	C	C	C	C	C
WAGNER NOS. 1 & 2	0[a]	0[a]	0[a]	C	C	C	C	C	C
CRANE	0	0	C	C	C	C	C	C	C
WESTPORT	0	0	0	0	C	C	0	C	C
GOULD	0	0	0	0	0	C	0	0	C
RIVERSIDE	0	0	0	0	0	0	C	C	C

0 = 1% SULFUR OIL

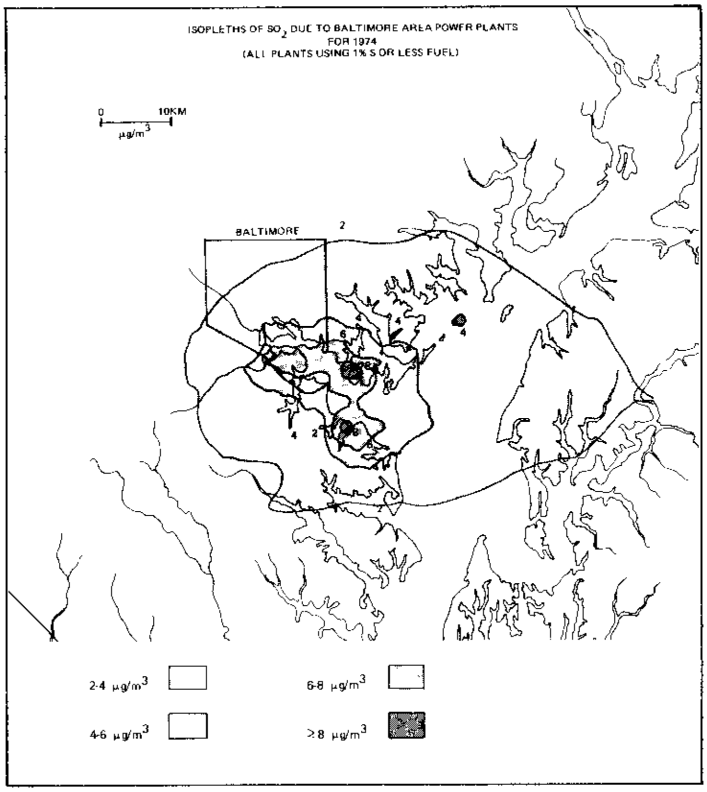
C= 2% SULFUR COAL

*Source: Reference (31).

[a] Wagner units on 1% coal.

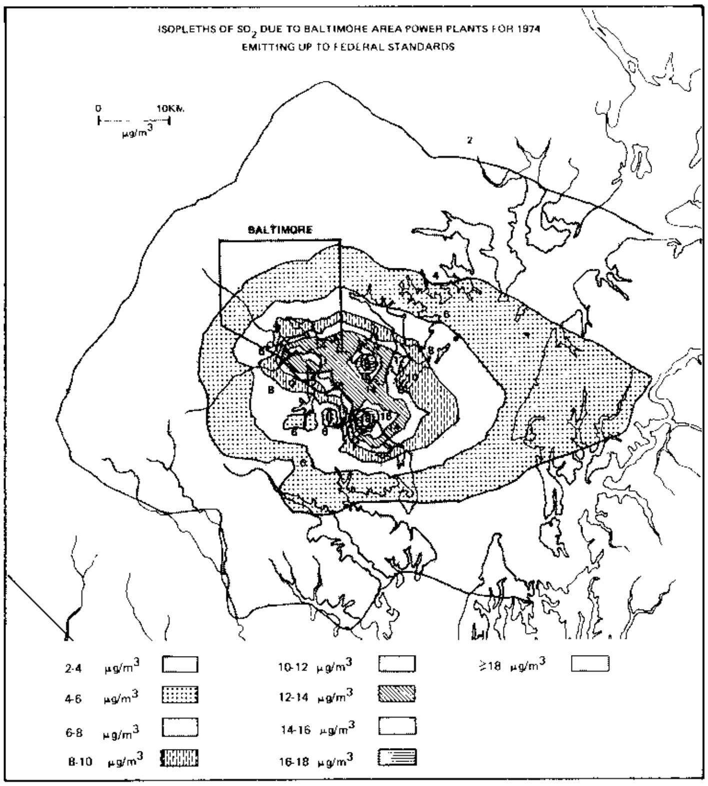
[b] ASSUMPTIONS: 1972 WIND ROSE; AQDM (PGT) MODELS; HEAT RATE EQUIVALENTS (1 TON COAL = 4.48 BBL OIL); UTILITY FACTORS (GOULD, WESTPORT = 50%, RIVERSIDE = 70%, WAGNER, CRANE = 80%); ZERO SO_2 BACKGROUND.

FIGURE 4.7



ISOPLETHS OF SO_2 DUE TO BALTIMORE AREA POWER PLANTS FOR 1974 (ALL PLANTS USING 1% S OR LESS FUEL)

FIGURE 4.8



ISOPLETHS OF SO_2 DUE TO BALTIMORE AREA POWER PLANTS FOR 1974 EMITTING UP TO FEDERAL STANDARDS

3. Estimate of Future Power Plant Emissions

Future decisions by Maryland and Federal agencies will fix the type and quality of fuel to be used in Maryland power plants in the coming decade. Table 4.12 shows the amounts of SO_2, NO_x and particulates which could be expected from Maryland plants in 1979 and 1984 under a set of plausible fueling assumptions.* Emissions by 1979 should drop somewhat as BG&E's load is increasingly carried by Calvert Cliffs. An increase in 1984 would occur when Brandon Shores comes on-line. If Douglas Point nuclear plant comes on-line in 1985-1987, it will probably absorb some of the baseload from PEPCO's older D. C. plants, rather than reduce generation from PEPCO's large three Maryland plants. A feature of this scenario is that power plant emissions will not increase as fast as generating capacity. If capacity in 1984 is 51% greater than in 1975 (including Calvert Cliffs), projected SO_2, NO_x and particulate emissions will increase by approximately 10%, 27%, and 12%, respectively. However, a decision by the State or FEA/EPA to allow higher-sulfur content fuels would change prospects considerably. For instance, if Morgantown were to switch to all-coal fueling in 1979, using coal with a 17.57% ash content and its existing 82% efficient precipitator, its particulate emissions would rise by 370%. If Wagner were to switch to all-coal fueling in 1979, using coal of 10% ash content and a 98.5% efficient precipitator, its particulate emissions would increase 10%. If protection of

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*The following assumptions were used in the estimate:

1. Fuel type, quality, consumption, and emissions for Crane, Riverside, Westport, Wagner and Gould in 1979 and 1984 are as estimated by BG&E in 1974 Federal Power Commission form 67 Reports;
2. Fuel type, quality, consumption, and emissions by Vienna and R. P. Smith in 1979 and 1984 are as estimated by Delmarva Power and Light Co. and Potomac Edison Co., respectively, in 1974 FPC form 67 Reports;
3. The scrubber on Dickerson Unit 3 is operating at 100% capacity in 1979;
4. Fuel type, quality, and consumption for Morgantown and Dickerson Units 1, 2, and 3 are identical to that used in 1974;
5. #6 fuel oil with the same sulfur and ash content as that used in 1974 at Chalk Point is used to fuel Chalk Point Unit 3;
6. A 90%-efficient SO_2 scrubber is used on Dickerson Unit 4 and operates at 100% capacity;
7. Brandon Shores Units 1 and 2 and Chalk Point Unit 4 use 0.5% S oil;
8. Brandon Shores, Dickerson Unit 4 and Chalk Point Unit 4 are operated to meet EPA New Source Performance Standards.

TABLE 4.12

ESTIMATED EMISSIONS FROM MARYLAND POWER PLANTS FOR 1979 AND 1984

1979

Plant	Oil Usage (10^3 bbl)	Coal Usage (10^3 tons)	Emissions, Tons of SO_2	NO_x	Part.	Precipitator Efficiencies %
Crane	3,058 (0.5%S)		5,040	6,750	340	
Riverside	1,017 (0.5%S)		1,680	2,240	190	
Westport	433 (0.5%S)		710	950	70	
Wagner	3,386 (0.5%S)	710 (0.9%S, 10% ash)	18,040	13,860	1,760	98.5
Gould	530 (0.5%S)		870	1,170	50	
Chalk Point (Units 1-3)	5,821 (1.61%S)	1,128 (1.84%S, 15.29% ash)	70,326	24,113	6,007	96
Dickerson (Units 1-3)		1,460 (2.04%S, 17.63% ash)	38,371	14,596	20,592	90
Morgantown	7,732 (1.73%S)	680.5 (1.94%S, 17.56% ash)	69,184	23,853	17,930	82
R. P. Smith		195.1 (1.0%S, 17.3% ash)	3,900	1,800	240	98.5
Vienna	2,157 (1.01%S)		4,700	3,100	130	
		TOTALS:	212,821	92,432	47,309	

1984

Plant	Oil Usage (10^3 bbl)	Coal Usage (10^3 tons)	Emissions, Tons of SO_2	NO_x	Part.	Comments
Crane	3,071 (0.5%S)		5,070	8,770	340	
Riverside	709 (0.5%S)		1,560	1,170	140	
Wagner	2,975 (0.5%S)	627.3 (0.9%S, 10% ash)	15,910	12,200	1,570	
Westport	270 (0.5%S)		460	620	50	
Gould	306 (0.5%S)		500	670	30	
Brandon Shores[a]	21,420 (0.5%S)		35,312	19,728	3,600	60% NO_x control required
Chalk Point (Units 1-4)[b]	5,821 (1.61%S) 5,545 (0.5%S)	1,128 (1.84%S, 15.29% ash)	79,467	29,213	6,472	60% NO_x control on Unit 4 required
Dickerson (Units 1-4)[b]		3,574 (2.04%S, 17.63% ash)	46,565	31,046	22,942	99%-eff. precipitator required on Unit 4
Morgantown	7,732 (1.73%S)	680.5 (1.94%S, 17.57% ash)	69,184	23,853	17,930	
R. P. Smith		104 (1%S, 17.3% ash)	2,100	940	130	
Vienna	2,157 (1.01%S)		3,300	2,200	90	
		1984 TOTALS:	259,426	130,410	53,294	
		1979 TOTALS:	212,821	92,432	47,309	
		1974 TOTALS:	235,133	102,925	47,454	

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[a] All units emitting at EPA New Source Performance Standards, cf. Table 4.8.

[b] Unit 4 emitting at EPA New Source Performance Standards, cf. Table 4.8.

public health and welfare precludes higher emissions, and other exigencies dictate the fuel changes, costly emission control equipment will be needed.

E. Emission Controls

Among emission controls being considered for use in Maryland are scrubbers like the one undergoing trials on 100 Mw of Dickerson Unit 3. This Mag-Ox scrubber was operational approximately 25% of the time during 1974 pilot tests. It reduced SO_2 emissions by 90% when in service. Scrubber operation, including sorbent regeneration to cut waste disposal problems (9), saps about 7% of the boiler output energy (32). PEPCO interprets the pilot operation as having demonstrated the scrubber's technical feasibility (32), but notes that full-scale operation would be expensive at a projected cost of $118-139/kw (25). However, the extremely low-sulfur fuels that new plants are permitted to use in lieu of scrubbers (EPA New Source Performance Standards - Table 4.8) are not necessarily less costly over the life of the plant.

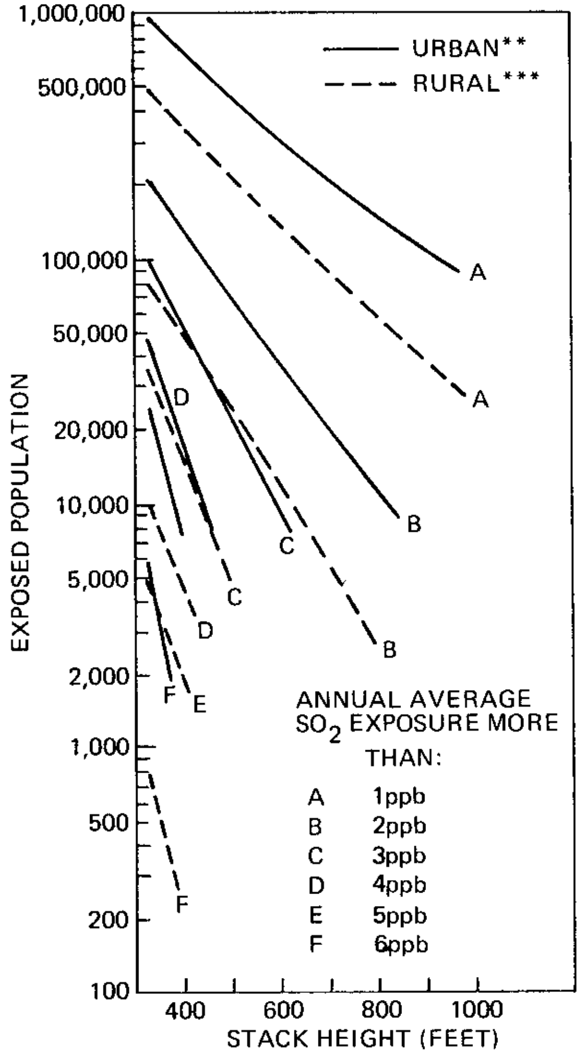
Additional technology also is needed to bring NO_x emission levels into compliance with EPA New Source Standards. Various methods of reducing NO_x include: (1) low-excess air firing; (2) staged combustion; and (3) flue-gas recirculation. Full-scale demonstration trials of these techniques have achieved reductions of NO_x of 48% for oil combustion and 37% for coal combustion. Capital costs depend strongly on specific installation size and design: $.50/kw for staged combustion to $6.00/kw for flue-gas recirculation on existing units, and up to $4.00/kw for flue-gas recirculation on new units. Boilers generally can be adapted for low-excess air firing and staged combustion without major modification (9).

Intermittent control systems (ICS) have been proposed as cheaper alternatives to stack-gas cleanup systems (9). Inherent in ICS programs is use of tall stacks to reduce ground-level pollutant concentrations (Figure 4.9). The cost of a 1,000-ft stack for a 500 Mw plant is $4 million (33) -- as opposed to approximately $50 million for a scrubber system (based on a scrubber cost of $100/kw). Tall stacks reduce ground-level pollution in the vicinity of a plant, but do not significantly reduce the amount of pollutants emitted. In fact, greater dispersal from tall stacks increases the potential for sulfate concentrations further downwind. Besides relying on tall stacks to enhance dispersion of pollutants, ICS systems reduce emissions either by switching to a lower-sulfur fuel or by passing the generating load to another plant when meteorological conditions (stagnation) are conducive to building up excessive ground-level concentrations. Federal legislation (9) requires setting emission limitations at a fixed level and temporarily permits ICS techniques only in special circumstances · for example, as a grace period during which a utility completes

FIGURE 4.9

RELATIONSHIP BETWEEN POPULATION DOSE AND STACK HEIGHTS FOR HYPOTHETICAL 1000 MW STATIONS SITED IN RURAL AND URBAN LOCATIONS

EXPOSURE TO SO_2 VERSUS STACK HEIGHT*



* COMPUTED IN THE AQDM APPROXIMATION, USING SYNOPTIC WEATHER DATA FOR 1971 FROM FRIENDSHIP AIRPORT AND POWER PLANT PARAMETERS AS FOLLOWS:

POWER:	1000 MW
STACKS:	TWO, OF 18 FOOT EXIT DIAMETER.
FUEL:	1% SULFUR CONTENT–LEADING TO EMISSION OF 180 TONS OF SO_2 PER DAY.

** POPULATION DENSITY ASSUMED TO BE UNIFORM WITHIN EACH OF THREE ZONES:

0–10 MILE RADIUS – 3000 PER SQUARE MILE
10–20 MILE RADIUS – 1500 PER SQUARE MILE
20–45 MILE RADIUS – 750 PER SQUARE MILE

***POPULATION DENSITY IS ASSUMED TO BE 500 PER SQUARE MILE EVERYWHERE construction to bring itself into compliance.

As they stand, required emission controls for new plants, and low-sulfur fueling of many existing plants, will undoubtedly push Maryland's electricity costs even higher - despite the price-moderating influence of the State's new nuclear power.

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