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TAWES STATE OFFICE BUILDING
ANNAPOLIS 21401

January 7, 1976

The Honorable Marvin Mandel
Governor
State House
Annapolis, Maryland 21401

Dear Governor Mandel:

The first Cumulative Environmental Impact Report prepared pursuant to the Maryland Power Plant Siting Act is forwarded. The Report colligates the results of the studies of the Power Plant Siting Program with respect to the cumulative impact of power plants on Maryland's environment.

Major environmental policy considerations suggested in the Report are that the State should abstain from moratoriums on nuclear power plants, that the practice of dilution pumping needs to be examined, and that any blanket prohibitions against once-through cooling pursuant to Federal initiative must be avoided. Considerations related to air quality underscore the continuing efforts of the Bureau of Air Quality to balance the costs and benefits of air quality regulation.

In addition to technical considerations, several observations based on the first three years experience of the Power Plant Siting Program may be of interest. Close interaction between local scientists and administrators is essential for responsible environmental decisions. The State should have the responsibility for the environmental evaluations with the applicant developing engineering design and cost data. And finally, differences between plant designs and site environments preclude generic approaches to siting and require comprehensive site-specific field investigations.

Sincerely yours,

James B. Coulter

James B. Coulter
Secretary

JBC:pa
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The Hon. Robert L. Sullivan, Jr.
The Hon. Vladimir A. Wahbe
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POWER PLANT
CUMULATIVE ENVIRONMENTAL
IMPACT REPORT

SEPTEMBER 1975

Maryland Department of Natural Resources

Comments and requests for additional copies should be addressed to Editor, Cumulative Environmental Impact Report, Power Plant Siting Program, Maryland Department of Natural Resources, Tawes State Office Building, Annapolis, Maryland 21401.

FOREWORD

This first bienniel report on the cumulative environmental impact of electrical power plants in Maryland treats present and future impact of: (1) changes in electrical consumption and demand; (2) trends in electrical generation and power plant siting; (3) the consequences of airborne and aquatic pollution; (4) environmental aspects of nuclear power plants; and (5) social and economic considerations relating to power plant construction and operations in Maryland. It incorporates a discussion of electrical demand forecasting, prepared by the Department of State Planning. Appended is the 1975 Ten-Year Plan issued by the Public Service Commission.

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I. INTRODUCTION

Maryland and other states are engaged in a three-part quest: provide adequate electric energy at reasonable cost; improve environmental quality; and husband natural resources. This Report describes how these (sometimes conflicting) objectives are being pursued, and ventures some prognoses for Statewide trends.

The Maryland Power Plant Siting Program is an agency charged with evaluation of all aspects of environmental effects, including cumulative impacts and Statewide trends in electricity cost and availability. PPSP performs this function within the framework of its site acquisition, site evaluation, research and monitoring activities. By accumulating information on the actual environmental stress of existing power plants, the Program can formulate models to predict the consequences of proposed power plants. This, in turn, permits sound and orderly identification, evaluation and acquisition of environmentally acceptable sites for future plants.

SUMMARY OF FINDINGS
(by Chapter)

CHAPTER 2 - ELECTRICAL DEMAND AND CONSUMPTION IN MARYLAND

The Arab oil embargo of October, 1973 within 12 months raised oil and coal prices approximately 250% and 290%, respectively Passed along to the consumers, these increases boosted the cost of electricity by 50-70%. Ensuing consumer conservation practices constricted the rate of growth of residential electrical consumption from a historic (1962-1972 average) 10.3%/yr to a negative rate of growth from 1973-1974. Overall electricity sales in Maryland, reflecting both residential conservation and a business slump, fell from a growth rate of 9.8%/yr (1962-1972) to -1.77% during 1973-1974. Peak demand in 1974 was 13% less than projections made by utilities at the beginning of the year.

Based on the reduced demand, utilities have revised downwards, from 9.4% to 5.9%/yr, their estimates of annual peak load growth for the next decade. Since new generation is geared primarily to meeting peak loads, projections for required new generating capacity over the next decade have also declined -- from 9.2%/yr to 4.1%/yr. A total of 5680 Mw of new generation has been delayed two to five years, and 5500 Mw of formerly planned new generation (mostly nuclear) has been deferred indefinitely. Delays in new construction are unlikely to affect electric power availability in the near future, but a resurgence of consumption by the industrial and manufacturing sector could cause power deficiencies by the end of the decade, especially if industry were to purchase proportionally more electricity for power in response to scarcity and increasing cost of fossil fuels. On the other hand, generating capacity which is built in excess of demand produces no revenues but does increase the construction debt-servicing cost per kwhr to the consumer.

Maryland utilities have been able to use the PJM grid as a market for excess baseload generating capacity in the past, but can no longer do so since the whole PJM (Pennsylvania, New Jersey, Delaware, Washington, D.C., Maryland) service area has been subject to similar economic and conservation trends. However, if consumption rises quickly enough to outstrip the capacity of both Maryland and the grid, utilities might replace delayed nuclear capacity with fossil fuel units that can be built more cheaply and more quickly. The penalty for such stop-gap remedying would be about 11 million barrels of oil/yr or 3 million tons of coal/yr to equal the generation of a 1000-Mwe nuclear plant.

CHAPTER 3 - ELECTRICAL POWER GENERATION AND POWER PLANT SITING

Maryland's aggregate power generating capacity (plants larger than 90 Mw) is presently 7878 Mw. The average annual utilization factor of these plants is 0.52. An additional 1227 Mw is available from Pennsylvania during demand peaks. In-State generating capacity projected by the Maryland Public Service Commission for 1985 will be 12,204 Mw. An additional 2282 Mw peaking capacity is anticipated from power plants in Pennsylvania by 1985.

Fossil fuels supply the prime energy for 83% of Maryland's generation, with nuclear and hydroelectric power accounting for 11% and 6% of the generation, respectively. By 1987, when Douglas Point Unit #2 is projected to go on-line, about 72% of Maryland's generation will be powered by fossil fuels, and about 25% and 3% will be powered by nuclear and hydroelectric energy, respectively. Scarcity and rapidly escalating costs for fossil fuels are seen as compelling arguments for more nuclear power: the average cost of fuel oil rose to $1.85/million BTU in April, 1975, while the current selling price of nuclear fuel ($26/lb) is equivalent to 52¢/million BTU.

The siting trend in Maryland power plants over the last several years has been towards large, rural plants. Of the 4325 Mw of new generation projected for Maryland by 1985, 54% will be sited at distances greater than 20 miles or more from metropolitan areas. If the proposed Douglas Point plant comes on-line in 1985-1987, the percentage of new generation sited further than 20 miles from metropolitan areas will approach 70%. Larger generating plants offer greater thermodynamic efficiency without a corresponding increase in environmental stress. By 1985, more than 50% of Maryland's generation will be provided by plants larger than 1000 Mw.

Thermodynamic efficiencies (at bus bar) of Maryland's fossil fuel power plants range from 28.8% (Vienna) to 38.9% (Wagner), with older plants being the less efficient. Design efficiency of the Calvert Cliffs nuclear plant is approximately 30%. Efficiencies of steam-electric plants are approaching a technological plateau, with further improvement contingent on development of bottoming or topping cycles. Pollution abatement equipment penalizes efficiency: stack-gas scrubbers and wet cooling towers cut efficiency by 5-10%. To compensate for derating of this magnitude requires an additional 128,000 to 256,000 tons of coal/yr for a typical 1000-Mw plant. Stack-gas scrubbers generate large volumes of solid wastes. For instance, 18,000 tons/day of sludge would be produced by a lime-limestone scrubber on an 1800-Mw plant burning 3.5%-5% sulfur coal. The 90%-efficient Mag-Ox scrubber used on 100 Mw of Dickerson Unit 3 during 1974 produces less solid waste per Mw, but its operation saps 7% of the boiler input energy. PEPCO engineers feel that the scrubber has demonstrated satisfactory feasibility, but advise that the expense of installing the scrubbers on all Dickerson units could reach $170 million to $200 million by 1982.

Alternatives to fueling with increasingly scarce and expensive oil are: increased use of coal, nuclear power, and combustible solid waste. Maryland has 854,900,000 tons of recoverable coal. This is equivalent to seven times more coal than needed to supply all Maryland's fossil fuel plants through the year 2000. Exploitation of these reserves would require a major expansion of Maryland's coal mining operations. Increased use of high-sulfur native coals (3.5%-4%) would entail retrofitted boilers with stack-gas scrubbers in order to comply with Federal and State Air Quality Standards. Electric power generated by nuclear fuel is about 25% cheaper than that from fossil fuel: a 2.5 mill/kwhr differential translates into a savings of $34,000-$50,000/day for each 1000 Mwe of operating nuclear generating capacity, enough to more than offset the higher capital costs of nuclear power plants ($800/kw vs. $600/kw for fossil fuel plants). A trash-to-fuel plant such as the "Landgard" plant in Baltimore can produce enough power plant fuel (either combustible gases or shredded solid waste) to save at least 1000 ton/day of coal.

CHAPTER 4 - AIRBORNE EMISSIONS

Power plants emitted approximately 66% of the SO_2, 30% of the NO_x, and 46% of the particulates discharged into Maryland's air during 1974. Maryland air quality controls, enacted to comply with the Federal Clean Air Act Amendments of 1970, have brought about a 50% reduction in power plant emissions since 1970.

Ground-level concentrations of sulfur oxides are within the Federal and State ambient standards designed to protect human health and welfare. Investigations of the health effects of chronic exposure to ambient levels of pollutants have yielded a complex, and often contradictory, body of data on the dose-response relationships. North and Merkhofer and Takacs report a causative link between particulate sulfates (oxidation products of SO_2 combined with tiny dust particles) and a number of adverse health effects. Neuberger and Radford, based on an extensive literature review, have recommended relaxing State "serious" standards for some air pollutants. Data from the Community Health and Environmental Surveillance System (CHESS) has led to estimates that 10% of the cases of chronic bronchitis, 10% of the acute morbidity in patients with chronic respiratory disease, and 10% of the annual asthma attacks in (a nationwide average of) polluted areas are induced by sulfur oxide exposure.

Sulfate concentrations in parts of Maryland distant from power plants occasionally approach 9.0 $\mu g/m^3$, a value some experts have associated with adverse health effects. Accompanying SO_2 concentrations at such times tend to be at the trace levels expected in rural areas. This anomalous pattern of sulfates and SO_2 has prompted speculation that SO_2 plumes of large point sources such as power plants are being oxidized during their travel many miles downwind. At this time the relation between power plant SO_2 emissions and ambient sulfate concentrations is not understood in a quantitative way. Information on how SO_2 evolves in the atmosphere is therefore a prerequisite for a more reliable estimate of the cumulative health impact of Maryland power plants.

A computer-modeled simulation of the population's exposure to power plant SO_2 indicates that the average Marylander is exposed, on an annual average, to 4-8 ppb of SO_2 as a result of power plant operations. Ambient Air Quality Standards now in force specify an annual average SO_2 upper limit of 27 ppb. It can be inferred from Bureau of Air Quality Control data that mean annual NO_2 and non-sulfate particulate doses received by Maryland residents from power plants in 1974 were approximately 0.006 ppm and 28 $\mu g/m^3$, respectively. Both of these concentrations are below those which available evidence links to adverse impact to public health.

One estimate places the cost of materials and aesthetic damage due to Maryland's power plant SO_2 emissions in the vicinity of $42 million. No agricultural damage due to power plant emissions has been documented in Maryland. The possibility of crop damage due to salt drift from brackish-water, natural draft cooling towers at Chalk Point is currently being investigated.

Substitution of low-sulfur oil for the coal used formerly has approximately halved the SO_2 emissions of local power plants. However, the BAQC monitoring network has not detected a reduction in ground-level sulfur oxide concentrations during this period. It is plausible that numerous small SO_2 sources, close to the monitoring stations, may have masked the effects of power plant abatement: monitoring instruments cannot usually pinpoint the origin of pollutants measured in a complex urban environment. For this reason, mathematical models of stack plume behavior 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.

The uncertain supply and escalating costs of low-sulfur fuels has prompted computer modeling to investigate the changes in air quality that would result if (1) Baltimore power plants were allowed to burn 2% S coal instead of 1% S oil, and if (2) Maryland power plants were allowed to burn fuels that meet Federal Air Quality Standards instead of the more stringent Maryland Standards. Either strategy is computed to double the power plant contribution to Baltimore's peak annual SO_2 ground-level concentrations. Pending more definitive dose-response data, it is not known if such a doubling would significantly impact public health and welfare.

If Maryland Air Emission Controls for Power Plants remain in effect through 1984, i.e., new plants are compelled to burn fuels meeting EPA New Source Requirements, and existing plants do not increase the sulfur content of their fuels, generating capacity will increase by 51% while SO_2, NO_x, and particulate emissions will rise only 10%, 27%, and 12%, respectively. If economic exigencies dictate higher-sulfur fuels, then emission control equipment will be needed to maintain currently acceptable emission rates. A Mag-Ox scrubber on 100 Mw of Dickerson Unit 3 demonstrated feasibility during 1974, but full-scale installation would be expensive -- \$118-\$139/kw. NO_x reductions of 48% for oil combustion and 37% for coal combustion have been achieved by (1) low-excess air firing, (2) staged combustion, and (3) flue-gas recirculation. Capital costs of abatement range from 50¢/kw for staged combustion to \$6.00/kw for flue-gas recirculation on existing units. Intermittent control system technology relies on tall stacks to reduce ground-level pollutant concentrations without necessarily reducing emissions. These techniques are permitted only as an interim measure while a utility proceeds to implement an emission limitation plan. The required use of either low-sulfur fuels or emission controls at Maryland power plants will increase electricity costs despite the moderating effect of the Calvert Cliffs nuclear power plant. Decisions molding the cumulative impact of air emissions over the next ten years will depend on which benefits are perceived to be greater: the economic advantages of cheaper, abundant high-sulfur fuels, or the environmental benefits (still to be determined) of emission abatement.

CHAPTER 5 - AQUATIC EFFECTS

The Chesapeake Bay and its tributaries support Maryland's $19.3million (in 1974) commercial fishing industry and provides unique recreational opportunities. It also supplies cooling water for most of the State's power plants. Prospects of new and larger plants using this estuary have heightened concern over possible cumulative impact on the yield of important fish and shellfish.

Most proposed and existing generating capacity in the State is situated on waters whose salinity is less than 5 ppt. Similar salinities are the spawning, nursery and feeding habitats for a number of estuarine (e.g., spot, seatrout, menhaden) and anadromous (e.g., alewives, shad, striped bass) species. Commercially important shellfish attain harvestable concentrations in waters more saline than 5 ppt. Producing bars, therefore, tend to be remote from power plants.

Power plants can cause aquatic impact in several ways: (1) by entraining fish eggs, larvae or prey organisms into a cooling system where they are subjected to thermal, mechanical and chemical stresses; (2) by impinging adult and juvenile fish and crabs on intake screens; and (3) by discharging heat and chemicals into receiving waters.

For Maryland power plants, thermal stress to entrained biota appears to be a relatively minor impact on important fisheries. Mechanical stress (from pumps) causes mortality to a large fraction of entrained fish larvae. Chlorine, used as a biocide, can cause mortality among several types of entrained plankton, depending on concentration used. Phytoplankton reproduce rapidly and are widespread in the Bay: any local phytoplankton depletions caused by power plants are soon compensated for.

Blue crabs and juvenile fish are particularly susceptible to impingement. The hard-bodied crab is little affected by encounters with screening; but schools of juvenile fish, especially those whose swimming ability is impaired by low water temperatures or low dissolved oxygen, have been involved in kills. Intake embayments accumulate juvenile fish, raising the potential for impingement kills. Intake designs which discourage fish congregation are being tested in Maryland and elsewhere.

No deleterious affects of thermal discharges have been documented in Maryland. Augmentation pumping, the practice of diluting effluents prior to discharge, appears to be counterproductive because it exposes more biota to stress.

Morgantown power plant during warm weather chlorinates to a discharge level of from 0 to 0.5 ppm. Shellfish larvae, zooplankton (microscopic animals), and adult spot (finfish) in the laboratory have been impaired by steady exposure to chlorine residuals in this range. No chlorine-related mortality was found by monitoring at the plant, a finding not in contradiction with the laboratory data because natural waters dilute and react with the chlorine. Maryland water quality regulations limit the discharge of chlorine total residuals to 0.5 ppm in tidal waters. Regulations recently promulgated by EPA will further limit chlorine discharges to an average concentration of 0.2 ppm after 1 July 1977. Wholly or partially effective alternatives to chlorine for biofouling control are installed on some Maryland plants. Mechanical cleaning (Amertap) is used at Morgantown and Calvert Cliffs. Bromine chloride, a shorter-lived biocide, is being investigated by utility and PPSP scientists.

The Conowingo Dam on the Susquehanna had several substantial fish kills in the mid-1960's. Schools of spawning anadromous fish were killed during spring runs by a depletion of dissolved oxygen when fish concentrated below the dam at times when the turbines were shut off. These kills were eliminated by modifying plant operations to allow sufficient water flow (a minimum of 5000 cfs) through the dam continuously during spawning season.

The most direct way power plants could have regionally significant impact in Maryland would be to chronically destroy a substantial fraction of a fish population's eggs or larvae. A recent study predicted that Possum Point would entrain a maximum of about 2% of striped bass larvae spawned each year in the Potomac. The Vienna plant is located on a striped bass spawning ground in the Nanticoke River. Cooling towers have been installed on newer units to minimize withdrawals. At this time there is insufficient data to estimate this plant's impact on striped bass populations of the Bay. Calvert Cliffs is on a segment of the Bay not used for spawning or as a nursery ground by any species of commercial or recreational importance. Historical data indicate that Chalk Point will have an inconsequential impact on spawning in the Patuxent. Ongoing investigations will quantify the impact of impingement and chlorination. The five Baltimore power plants, Wagner, Gould Street, Westport, Riverside, and Crane straddle no spawning grounds of consequence. Industrialization has closed the area to shellfishing. The freshwater steam-electric plants, R. P. Smith, Dickerson and Potomac River use waters heavily stressed by natural or sewage-related factors, and are not now supporting productive fisheries.

New plants proposed for operation by 1985 should add little to the cumulative impact of the State's power generation. Brandon Shores will be equipped with cooling towers,and will withdraw from Wagner's discharge canal. The Dickerson and Chalk Point expansions will both have cooling towers.

CHAPTER 6 - RADIOLOGICAL

The era of nuclear power in Maryland has just been initiated with the start-up of the first of two 845-Mw units at Calvert Cliffs. The second unit is scheduled to go on-line in 1977. Recent construction budget cuts by Baltimore Gas and Electric Company and PEPCO due to lack of available capital, coupled with a downward trend of demand curves, have delayed planned start-up dates of Calvert Cliffs Unit 2 and Douglas Point.

Nuclear Regulatory Commission (formerly Atomic Energy Commission) criteria for nuclear power plant sites require an "exclusion zone" and a "low population zone". NRC policy presently favors sites with these distances not less than 0.4 and 2.0 miles, respectively. NRC is also developing a technique to account for population distributions out to distances of 30 miles or more by computing a "site population factor" (SPF). The SPF uses an approximation of meteorological dispersion with distance to determine the significance of the populations at each distance from a plant. The NRC has specified a preference for new sites with SPF's not exceeding 0.500 (equivalent to a uniform population density of 500 persons/square mile) at all radii within 30 miles. Nuclear plant siting is also constrained by such factors as proximity to airports, military reservations, chemical industry operations, geological faults,and availability of cooling water supply.

The most recent AEC estimates (1973) have predicted radioactive releases from Calvert Cliffs that are about one-third of the 1969 estimates reported by the Governor's Task Force on Nuclear Power Plants.

Starting with the pessimistic assumption that the most exposed member of the public could receive a radiation dose of 10 mrem/yr (more than is expected from Calvert Cliffs, for example), one concludes that the additional risk of cancer to such a maximally exposed individual would be two in a million per year of exposure. By way of comparison, the actuarial level of risk for cancer from other causes is 1,520 in a million each year. The additional risk of genetic defect in any descendants of such an exposed individual would be 0.4-10 in one million as opposed to the normal risk of 60,000 in one million.

The average whole-body dose of radiation received by Maryland residents from natural sources (cosmic rays, naturally occurring terrestrial isotopes) is about 100 mrem/person/yr. The estimated average annual dose delivered by Calvert Cliffs to the population within a 50-mile radius of the site amounts to 1/11,500,000 of natural background. The dose increment to the population within 50 miles of the proposed Douglas Point plant is estimated at 1/400,000 of natural background.

SUMMARY OF FINDINGS - CHAPTER 6

When the radiation doses which are predicted to be delivered to the public by all nuclear power plants in and near Maryland are totaled over the next ten year period, the calculated public health effects to Maryland citizens come to 0.1 deaths from cancer, 0.1 cases of genetic dominant disease, and 0.2 cases of chromosomal and recessive diseases. For perspective, it is noted that, over the next ten years, Maryland's population is expected to experience 60,000 deaths due to cancer, 70,000 cases of genetic dominant disease, and 200,000 cases of other chromosomal and genetic anomalies and diseases, all due to causes unrelated to nuclear power.

An AEC Reactor Safety Study has appraised the likelihood of a core melt-down accident as 1 in 17,000 per reactor per year, or 1 in 170 years/100 reactors. Consequences of the most likely core-melt accident are less than one fatality, less than one injury, less than one latent fatality, four thyroid nodules, less than one case of genetic defects, and $100,000 property damage. The consequences of the most serious core-melt accident with a probability great enough to significantly contribute to overall risk are considerably higher than the most likely core-melt accident -- 2,300 fatalities, 5,600 injuries, 3,200 latent fatalities, 84,000 thyroid nodules, 3,200 genetic defects, and $6 billion worth of property damage. The probability of such a catastrophic accident is estimated to be 1 in one billion years of reactor operation.

CHAPTER 7 - SOCIAL AND ECONOMIC CONSIDERATIONS

Total land area in Maryland dedicated to existing and proposed generation and transmission is approximately 53,000 acres or 0.8% of the State's total land area. Including the seven plant sites that PPSP plans to acquire over the next ten years (1,000 acres each), the total land area dedicated to power generation by 1985 will be 0.9% of Maryland's land area.

Cases of satisfactory dual public-utility land use of plant sites and transmission rights-of-way have been characterized by early and full cooperation between residents and the utility involved.

A coal-burning plant such as Dickerson (1700 Mw) must dispose of 128-160 truck-loads of ash per day (depending on power demand.) Nuclear plants require infrequent shipments for refueling and waste disposal.

Local benefits associated with the construction and operation of a power plant are primarily economic. Sales of goods and services to plant workers and contractors during construction stimulate the surrounding economy. The increased tax revenues to a county once a plant begins operations allows local government to improve services and undertake new projects. When Calvert Cliffs is fully operational, it is estimated that Calvert County will receive $12 to $14 million in utility revenues annually, equivalent to twice the County's 1974 budget. Calvert County is planning for major capital improvements in the areas of health care, recreational and municipal buildings, and several civic projects.

Peak employment for construction of a 2000-Mw nuclear plant is about 2,600 workers. Approximately 200 permanent workers are needed to operate such a plant. A 2000-Mw fossil fuel plant will involve about 1,200-1,400 construction workers, followed by perhaps 350 permanent employees.

Visual impact of high-voltage transmission lines can be reduced by underground installation, modified structural design, and consideration of terrain or other landscape features. The mild terrain in the most populous portions of the State is not well suited to visual screening. Underground installation reduces the power-carrying capacity of a high-voltage line. Lower carrying capacity can be overcome by using multiple lines to handle the same power -- but this involves clearing wide corridors and disposal of additional spoils. Undergrounding is also expensive: for equal load-carrying, the cost ratio of underground-to-overhead transmission lines ranges from 3:1 to 15:1.

Between 1971 and 1974, the number of pole miles of 230-kv and 500-kv lines in Maryland increased 259% and 127%, respectively. Pole miles of 115-kv and 138-kv lines remained nearly constant during this time. Increased use of high voltage transmission lines is likely as the trend continues to site large plants far from load centers.

With proper precautions, groundwater for boiler or reactor feedwater makeup can be withdrawn without lowering water tables or decreasing the artesian head in aquifers supplying residential needs. Calvert Cliffs draws water from a deep aquifer and monitors the water table in an observation well to ensure that shallower aquifers are not drawn down. Public Service Commission Certificates for power plants incorporate groundwater appropriations permits which reflect recommendations by the Maryland Water Resources Administration.

RECOMMENDATIONS

1. The State should avoid imposing a moratorium on building nuclear power plants. Evidence does not support the view that public health risks from nuclear power are greater than from other types of power generation.

2. The practice of dilution (bypass) pumping should be critically reviewed, as it appears to be ecologically counterproductive. Tradeoffs between cooling water withdrawal rates and cross-condenser temperature rise should be reevaluated in light of recent bioassays.

3. A revolving fund should be created within the Maryland Environmental Trust Fund to provide loans to local governments for providing services for the large influx of workers during power plant construction. (Repayment to the fund by counties would be made after the plant begins operations and is paying taxes to the county.)

4. The State should refrain from blanket prohibitions against once-through cooling: the type of cooling system best suited to a specific ecosystem can be determined only by extensive on-site study.

TABLE 1.1
SOME USEFUL CONVERSION FACTORS

Variable	English Measure		Metric Measure
Liquid Measure:	1 gallon (gal)	=	3.79 liters (ℓ)
	1 cubic foot (ft^3) or 7.48 gallons (gal)	=	28.4 liters (ℓ)
Flow:	1 cubic foot per second (cfs)	=	28.4 liters per second (l/sec) or 0.646 million gallons per day (MGD)
Concentration:			
1 part per million (ppm) by weight, in water	0.0028 ounces per cubic yard (oz/yd^3)	=	1.00 grams per cubic meter (gm/m^3)
1 part per billion (ppb) by volume, in air	$\frac{205}{\text{molecular weight*}}$ $\frac{\text{Pounds}}{\text{cubic mile}}$	=	$\frac{22.4}{\text{molecular wt.*}}$ x concentration in micrograms per cubic meter ($\mu g/m^3$)
Energy:	3413 mean British thermal units (BTU)	=	1.0 kilowatt hour (kwhr)
Power:	1.34 horsepower (h.p.) or 0.95 mean British thermal units per sec	=	1.0 kilowatt (kw)
Area:	1 square mile (mi^2) or 640 acres	=	2.59 square kilometers (km^2)
Temperature:	$\frac{(^{o}F-32)}{1.8}$	=	^{o}C
Temperature Change:	1.8 F^{o}	=	1.0 C^{o}
Distance:	3,281 feet (ft) 0.621 miles (mi)	=	1 kilometer (km)
Weight:	1 pound (lb)	=	0.45 kilogram (kg)

*Selected molecular weights: Nitric oxide (NO) 30.0; Nitrogen dioxide (NO_2) 46.0; Ozone (O_3) 48.0; Sulfur dioxide (SO_2) 64.1; Sulfur trioxide (SO_3) 80.1.

2. ELECTRICAL DEMAND AND CONSUMPTION IN MARYLAND

Public utilities are legally required to meet customers' power needs (demand). The instantaneous demand for electricity changes over the course of a day and is modulated by the seasons. Generating capacity must equal peak instantaneous demand. The lead time to build a new plant makes it necessary for demand needs to be projected ten years ahead. The basis for such predictions are historic patterns of electrical consumption, population and income-growth projections, trends in housing patterns, saturation levels of major appliances, industrial growth, availability and cost of competing fuels, and economic activity indicators. Escalating fuel costs and deliberate efforts at energy and fuel conservation cast some doubt on the reliability of pre-1973 patterns as the principal means for anticipating the kind and amount of future electrical needs.

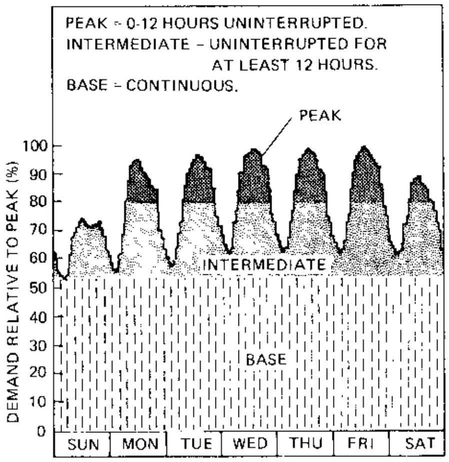
A. Definitions and Background

Electrical generating capacity is measured in megawatts (Mw) or kilowatts (kw) (units of power) and gives the design maximum of electrical power available from a generating plant. Electrical consumption is expressed in kilowatt-hours (kwhr) or megawatt-hours (Mwhr) (units of energy). Electrical demand is the average power required by the consumer during the peak hour.

An electrical generating system has some components designed to meet continuous (base) demand, and others intended to accomodate demand surges (peaks). PEPCO's 1973 peak load, for instance, was 3680 Mw, while its total sales were 14.4 million Mwhr -- which, if distributed evenly over the entire year (8760 hours), would equal an annual average demand of only 1644 Mw (about 45% of peak demand) (1). In order to meet peak demand, utilities must provide some capacity which may be rather infrequently used. A low-duty cycle increases construction debt-servicing per unit of energy sold.

FIGURE 2.1

WEEKLY LOAD CURVE FOR A SAMPLE UTILITY WITH 10,000-MEGAWATT PEAK GENERATION



SOURCE: REFERENCE 3.

Figure 2.1 illustrates a weekly load curve of the kind going into planning for new generating capacity. Reserve capacity of 20% greater than annual peak demand is recommended by the regional power grid. This reserve provides a buffer in case of shutdowns, or erratic demand peaks (2). At the end of 1973, for instance, PEPCO's net generating capacity (including D. C. plants) exceeded peak load by about 22% (1).

B. Historical Patterns of Growth in Energy Demand and Consumption in Maryland

Until recently, Maryland's demand for power underwent a decades-long period of growth. Table 2.1 shows the exponential growth rate of Maryland's sales of electric energy through 1972. Residential sales, about one-third of the total, were the fastest growing segment of total sales, averaging 10.3%/yr while total consumption increased an average of 9.7%/yr. This growth was spurred by the relative cheapness of electric power, increases in population and personal income, the introduction of energy-intensive appliances such as air conditioners, and industrial growth. Cheap electricity was possible because of cheap fuel. In September 1973, the average cost of 1.5 - 2% sulfur coal to Maryland utilities was about 45¢/million BTU or 0.5¢/kwhr (6). Average oil cost to Maryland power plants was about 72¢/million BTU or 0.77¢/kwhr (7). In this period, electricity sold for 3.1¢/kwhr to households and 1.6 - 1.7¢/kwhr to industrial customers (15) (cf. Table 2.2).

TABLE 2.1

ELECTRIC ENERGY SALES IN MARYLAND (1962-1974)

(billions of kwh sold)

Year	Maryland		
	Residential	Non-Residential	Total
1962	3.145	6.879	10.024
1963	3.425	7.491	10.916
1964	3.789	8.307	12.096
1965	4.227	9.081	13.308
1966	4.792	10.220	15.012
1967	5.196	11.209	16.405
1968	5.990	12.268	18.258
1969	6.700	13.497	20.197
1970	7.483	15.004	22.487
1971	7.919	16.311	24.230
1972	8.406	17.005	25.411
1973	9.33	18.27	27.60
1974	9.20	17.91	(prelim.) 27.10
Average Annual Growth Rate 1962-1972	10.30%	9.3%	9.7%
Average Annual Growth Rate 1973-1974	-1.39%	-1.97%	-1.77%

Source: Reference 4 and Annual Reports of Maryland Utilities to the Maryland Public Service Commission for year ending December 31, 1974.

With the regional demand peak occurring in the summer (due to air conditioning), space heating appeared in the 1960's to be a means of distributing electrical load more evenly over the year. Table 2.4 shows that the demand

TABLE 2.2

TYPICAL MONTHLY ELECTRIC BILLS (500 kwhr)[a]
1972-1974

Utility	1972 Charge/ 500 kwhr	¢/kwhr	Dec. 1974 Charges (Basic Rate)	¢/kwhr	% Change in Basic Rate 1972-1974	Fuel Adjustment Charge ¢/kwhr	Total Charge 500 kwhr Dec. 1974	% Change in Total Bill 1972-1974
BG&E	$15.30	3.1	$18.00	3.6	16.13	1.35	$22.05	44.12
PEPCO	10.35	2.07	15.50	3.1	49.76	1.38	21.63	109.0
Potomac Edison	10.63	2.13	13.93	2.78	31.0	0.789	17.88	68.20
Delmarva	13.19	2.64	19.22	3.8	45.72	1.54	26.92	104.1
Chestertown	13.27	2.65	18.20	3.64	37.15	1.17	24.06	81.31
Easton	14.83	2.97	15.74	3.1	6.0	1.36	22.54	52.0
Conowingo	9.92	1.98	16.86	3.37	70.0	0.708[b]	20.40	205.65
Hagerstown	10.63	2.13	13.01	2.6	22.40	0.60	16.68	56.91
Southern Md.	11.22	2.24	11.46	2.29	2.14	1.25	17.71	57.84

[a] Excluding Sales Tax
[b] Purchased power charge from Philadelphia Electric Co.

Source: Reference 7 and various utilities

TABLE 2.3

APPROXIMATE WATTAGE RATING AND ESTIMATED ANNUAL KILOWATT-HOUR CONSUMPTION OF ELECTRICAL APPLIANCES UNDER NORMAL USE

Appliance	Average Wattage	Estimated KWH Consumed Annually
Air Conditioner (window)	566	1,389
Bed Covering	177	147
Broiler	1,436	100
Clock	2	17
Clothes Dryer	4,856	993
Coffee Maker	894	106
Deep Fat Fryer	1,448	83
Dehumidifier	257	377
Dishwasher	1,201	363
Fan (attic)	370	291
Fan (furnace)	292	394
Fan (window)	200	170
Floor Polisher	305	15
Food Blender	386	15
Food Freezer (15 cu ft)	341	1,195
Food Freezer (Frostless 15 cu ft)	440	1,761
Food Mixer	127	13
Food Waste Disposer	445	30
Frying Pan	1,196	186
Hair Dryer	381	14
Heat Lamp (infrared)	250	13
Heat Pump (space heating)	11,848	16,003
Heater (radiant)	1,322	176
Heating Pad	65	10
Hot Plate	1,257	90
Humidifier	117	163
Iron (hand)	1,088	144
Oil Burner or Stoker	266	410
Oven, Microwave	1,500	300
Oven, Self-cleaning	4,800	1,146
Radio	71	86
Radio-Phonograph	109	109
Range	8,200	1,175
Refrigerator (12 cu ft)	241	728
Refrigerator (Frostless 12 cu ft)	321	1,217
Refrigerator-Freezer (14 cu ft)	326	1,137
Refrigerator-Freezer (Frostless 14 cu ft)	615	1,829
Roaster	1,333	205
Sewing Machine	75	11
Shaver	14	18
Sun Lamp	279	16
Television (B&W)	237	362
Television (Color)	332	502
Toaster	1,146	39
Tooth Brush	7	5
Vacuum Cleaner	630	46
Waffle Iron	1,116	22
Washing Machine (Automatic)[a]	512	103
Water Heater (Standard)	2,475	4,219
Water Heater (Quick Recovery)	4,474	4,811
Water Pump	460	231

[a] Does not include hot water heating

Source: Reference 3 and Maryland Energy Policy Office, 1972

TABLE 2.4

INCREASE IN NEW RESIDENTIAL UNITS USING ELECTRIC SPACE HEATING (1971 - 1974)

	Total Dwelling Units Md. & D.C.	No. of New Units Constructed	No. of New Units With Electric Heat	% New Units With Electric Heat
1971	1,398,773	31,142	4,191	13.5
1972	1,436,427	37,654	7,583	20.1
1973	1,472,488	36,061	10,195	30.56

Source: Reference 30

BY UTILITY

	Total No. Residential Customers			Total No. Electrically Heated Units			% Units with Electric Heat[b]			% New Units With Electric Heat	
	1972	1973	1974	1972	1973	1974	1972	1973	1974	1973	1974
BG&E	633,000	653,000	660,000	15,422	18,784	20,498[a]	2.4	2.9	3.1	16.75	24.5
PEPCO (Md. & D.C.)	391,288[a]	396,794[a]	401,634[a]	7102	8,484	11,614[a]	1.8	2.1	2.9	25.0	64.6
Delmarva		56,516[a]	59,979[a]		12,879[a]	16,068[a]		22.8	26.79		92.0
Pot. Ed.	197,000	201,900	206,000	26,700	32,848	36,900 (est.)	13.6	16.2	18.0	100.0	100.0
Southern Elec. Coop.			43,473			3,477			8.0		

Source: Reference 8

[a] Utility figures

[b] Includes conversions

TABLE 2.5

PERCENTAGE OF HOMES WITH MAJOR ELECTRIC APPLIANCES IN SELECTED AREAS (1970-1974)

	Charles Co.	Prince Georges	Mont-gomery	Balto. Co.	Balto. City	Maryland		Prince Georges Montgomery Co. 1974	BG&E Service Area 1974[b]
						1960	1970		
Water Heat	40.6	14.0	12.5	10.7	4.2	13.2	17.1	15%	14%
Cooking	41.7	27.4	40.3	25.2	5.2	22.9	29.2		30%
Washing Machine	75.9	63.2	74.9	81.3	62.0	75.3	71.6		
Clothes Dryer	39.9	33.1	45.1	24.7	7.2	10.3	28.6		30%
Freezer	39.1	25.7	31.5	27.3	12.8	16.7	26.7		
Air Cond.	42.1	75.7	79.8	57.1	33.2	14.9	50.6		30% (central A/C)
Dishwasher	17.1	36.5	59.5	30.7	9.1	--	26.7		

Source: Reference 14

[a] M. Milsted - PEPCO
[b] W. Miller - BG&E

associated with increasing use of electric heating has helped level the seasonal imbalance, but has never equaled the peak summer load. This is because the percentage of Maryland homes having electric air conditioning is greater than the percentage with electric heat. For instance, only 5% of PEPCO's Maryland customers were in all-electric homes in 1974 (9), but over 50% of the dwelling units in PEPCO's Maryland service area had electric central air conditioning (10). Similarly, 4% of BG&E's residential customers had electric heating in 1974, while 30% had electric central air conditioning (11).

Saturation percentages for appliances other than electric heat are shown by county in Table 2.5 for 1960, 1970, and 1974. Inter-county differences are due to:

(1) Type of residence -- Homes in counties with a large percentage of apartments (e.g. Prince George's) have proportionally fewer major home appliances than those in counties which have a high percentage of single family homes (e.g. Montgomery);

(2) Income levels -- In general, areas with low median family income (13) (e.g. Baltimore City) tend to have fewer electrical appliances;

(3) Availability of alternative fuels -- An absence of natural gas service promotes use of electric appliances. For instance, homes in Charles County have no access to natural gas, and consequently, a large percentage of electric appliances is found there. More recently, Washington Gas Light Company instituted a moratorium on natural gas service to all new (after October 1973) residences in the PEPCO service area. This prompted installation of electric heating and appliances in a large percentage of new dwelling units in PEPCO's service area. BG&E has instituted a similar moratorium on units completed after February 1, 1975, but the low cost of natural gas to the residential user prior to the cutoff (the equivalent of about 0.8¢/kwhr in December 1973 -- Ref. 15) is one factor behind the low percentage of electric appliances in BG&E's service area.

Maryland's average annual residential electrical consumption and annual percentage increase in consumption are listed in Table 2.6. Suburban homes tend to be larger and more lavishly equipped than their urban counterparts, and are thus heavier consumers. Farms are large consumers, commonly having 200-ampere service. All-electric homes use up to five and one-half times the electricity of homes using other fuels for heating, cooking, or water heating (See Table 2.6).

TABLE 2.6

AVERAGE ANNUAL RESIDENTIAL ELECTRICITY CONSUMPTION PER HOUSEHOLD (1974)

Community	Ann.kwhr	Ann. kwhr all-electric homes	Rate of Annual Increase 1966-1971 (%/yr)	Rate of Ann. Increase 1971-1974 (%/yr)
Baltimore City	4219	21,600	6.8	2.6
Baltimore County	6960		6.9	0.3
District of Col.	5492	29,898	6.6	1.5
Montgomery County	10,110		7.5	0.7
Eastern Shore	5959	13,858		
Charles & St. Mary's Counties	9600	14,500 (farms)		

Source: Reference 7 and various utilities.

Another historical spur to electrical consumption were the consistent growth in real personal income (6.1%/yr from 1959-1969, 5%/yr from 1969-1973 -- Ref. 16), and steady population growth: from 1960-1970, Maryland's population increased by 26.5% (from 3,100,680 to 3,922,399), or 2.38%/yr. At 10.3%/yr, residential use of electricity outpaced the sum of income growth and population growth. The rate of electrical consumption by industry in Maryland also increased -- from 5 billion kwhr purchased in 1966 to 6.8 billion kwhr in 1971, or a rate of about 6.5%/yr (4, 18, 19).

In the past, a sound way of projecting future energy needs was to merely extrapolate historical growth trends. Using this kind of extrapolation, Maryland utilities in 1972 projected a 9.4% annual increase in peak load in the 1973-1982 period (5): this compares closely with the actual 1972 growth rate quoted above. Exhibit A, "Electrical Power Consumption in Maryland and in the United States", prepared by the Electrical Energy Forecasting Unit, Maryland Department of State Planning, outlines the factors entering into current forecasts of electrical energy demand.

C. Current Trends in Electrical Demand and Consumption in Maryland

The October 1973 oil embargo and subsequent jump in fuel prices has had a profound effect on Maryland's energy use. In September 1974, the delivered costs of oil and low-sulfur coal rose to $1.797/million BTU and $1.427/million BTU, increases of 250% and 291%, respectively. Fuel adjustment charges passed a portion of these increased fuel costs along to the customer. Table 2.2 shows December 1974 fuel adjustment charges made by various Maryland utilities and the percentage of consumer costs (1972-1974) this represented.

Increased price, a business slump, and conservation efforts caused Maryland's peak 1974 demand to sag 13% below earlier projections (26). Total 1974 electricity sales were about 27 billion kwhr, equivalent to an average annual <u>decrease</u> of -1.77% over 1973, as compared to average annual <u>increases</u> of 9.7% from 1962-1972 (cf. Table 2.1) (19). For PEPCO, this translated to kwhr sales and peak demand being 7.7% and 5% lower, respectively, than in the preceding year. BG&E's electricity sales in 1974 declined by 2.4% in the same period.

Such decreases in demand have left Maryland utilities holding higher-than-expected reserve margins. For example, PEPCO, projecting a 21.7% reserve margin for 1975 (26), was, in fact, carrying a 44% reserve margin by 1975 (20). At the end of 1974, BG&E had a reserve margin of about 28% over its 1974 peak load.

Decreases in peak demand growth projected for various regions of the State for the 1975-1984 period are shown in Attachment No. 4 to the 1975 Ten-Year Plan (Exhibit B). Estimated peak loads have decreased in all areas of the State. Peak demand is now estimated to double in 12.1 years instead of the 7.7 years estimated in the 1973 Ten-Year Plan.

D. Effects of Decreasing Electrical Demand and Comsumption Growth in Maryland

Utilities response to the slackening in demand is shown in Attachment No. 4, Exhibit B. This revises downwards the projected rates of adding generating capacity. Completion dates for new units are being deferred and construction budgets trimmed. Estimates of Statewide generating capacity available in 1983 decreased 18% from those predicted in the 1974 Ten-Year Plan.

Current estimates call for Maryland and D. C. generating capacity to double in 17.2 years, as compared to the 7.9 years estimated in the 1973 Ten-Year Plan.

PEPCO has cut back its 1974-1977 capital budget program by $354 million, primarily by retarding completion of Douglas Point nuclear plant (21), and delaying Dickerson #4 and Chalk Point #4. BG&E has cut its 1975 construction budget by $275 million, delaying the start-up of Calvert Cliffs Unit 2 and two fossil-fuel units at Brandon Shores. The Philadelphia Electric Company has postponed from 1975-1984 the possible start of construction of a new generating station at the Canal Site. Potomac Edison has frozen plans for a nuclear plant at Point of Rocks. In all, 5680 Mw of new generation has been postponed from two to five years, and plans for 5500 Mw of generation, most of it likely to be from nuclear power, have been delayed indefinitely. Figure 3.2(a) shows the 1975-1984 projected growth in peak demand, generation capacity, and reserve margin.

These delays in construction should have no immediate impact on the availability of electric power in Maryland and could temporarily moderate utility rates since there will be lesser debt-servicing needs. Long-term trends, such as decreased population growth (now 1.68%/yr, down from 2.38%/yr during 1960-1970 -- Ref. 22), further escalation in fossil fuel costs, proposed tax incentives for improving home insulation (23), and inflation should continue to exert a dampening effect on residential demand.

Industrial energy conservation efforts, especially in the steel industry (24), and the apparent reduced rate of industrial growth have likewise deflated demand forecasts.

The Mid-Atlantic Area Coordinating Council (PJM grid) (25) confirms Maryland utility projections of reduced demand growth. The Council predicts that customer electricity usage patterns will continue to decrease from former levels, and cites the following factors:

1. Limited supply and high cost of money will restrict and delay residential and commercial construction; and

2. Inadequate and costly fuel supplies will encourage further conservation.

Possible modifications to utility rate structures now being considered by the Maryland Public Service Commission, may further modify the way electricity is used. Proposed changes include discount pricing for consumers who decrease their electricity consumption and higher rates for electricity used during daily and seasonal peak demand periods.

E. Uncertainties in Demand Projections

The factors shaping the use of electricity do not all lend themselves to reliable prediction. In 1971, for example, industry and manufacturing in Maryland purchased fuel with an energy content of 138.5 trillion BTU. Over 70% of this was oil and natural gas (17). At a conversion rate of 3413 BTU/kwhr, and assuming a 30% generating efficiency at the industrial plant, i.e. $(138.5 \times 10^{12}$ BTU $\times 0.3)/3413$, industry generated 12.2 billion kwhr from these fuels. If natural gas and oil were to become unavailable, unreliable or too costly, some industries would buy electricity in lieu of burning fuels themselves. For instance, assume that one-half of the 12.2 billion kwhr mentioned above were purchased from the utilities over the next 10 years. The incremental electrical demand in 1984 would be at least 685 Mw (6 billion kwhr/8760 hr.). With an annual growth rate of 2% (a little over one-half of the 1972 Obers projections for Maryland manufacturing -- Ref. 16), total increased industry demand would be 822 Mw (685 Mw compounded at 2% over 10 years). This additional 822 Mw would leave the system with a scant 7% capacity reserve instead of the 20% recommended. Other scenarios lead to wider or narrower reserve margins: this example simply demonstrates some of the inherent uncertainties in demand projection.

F. Effects of Inaccuracy in Electrical Demand Projections

The penalties for widescale underestimating of electrical demand would be brownouts. As a hedge against this, utilities formed power pools such as the Mid-Atlantic Area Coordinating Council (PJM grid). This grid has provided Maryland with electrical power when there have been deficits in available generating capacity, and has been a market for electricity when there was an excess baseload generating capacity. Sales to and from the grid members do not provide complete buffering from large chronic surpluses or deficits in generating capacity in a member service area. For instance, in 1972, PEPCO sold 5 million kwhr of electricity to other grid members (1). In 1974, with a larger system capacity and capacity reserve, its sales to the grid amounted to only 3.6 million kwhr (28)-- the grid could not absorb all of PEPCO's excess baseload generating capacity due to grid-wide economic and conservation pressures.

Some economists argue (21) that because cutbacks in utility construction budgets have hit nuclear plant construction the hardest, sudden upsurges in demand might be met by replacing projected nuclear capacity with a fossil fuel unit cheaper and quicker to build ($600/kw and 8 years to build a fossil fuel plant versus $800/kw and 10 years for a nuclear plant -- Ref. 27). In terms of scarce fossil fuel, the penalty for such stop-gap remedying of underestimating demand is about 11 million barrels of oil/yr or 3 million tons of coal/yr, either of which would be needed to equal the generation of a 1000-Mwe nuclear plant.

Overestimating electricity demand, and subsequent construction of excess generating capacity, leads to customers having to stand the debt-servicing costs of idle equipment. For instance, the burden of a 44% capacity reserve in 1975 (due to the unforeseen decline in demand) is cited by PEPCO in its recent rate increase request (20).

G. Conclusions

As a result of recent declines in electrical demand, tight money markets, and licensing difficulties, the construction of several new nuclear plants has been postponed or delayed indefinitely. A rapid surge in consumer demand might favor construction of fossil fuel plants instead of nuclear. In the long term, this would aggravate the State's dependence on outside energy sources, and compound pollution problems.

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