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An Electric Southeast

Implications for Water Resource Planning

Growth in population, production, and income in the Southeastern U.S. is directly translated into growth in energy consumption. As a result, the environmental effects of fuel extraction, its conversion into other forms of energy, and the distribution and utilization of those forms has increased. Among the many dimensions of energy environmental linkages in the Southeast that must be explored is the relationship between electrical power production and the quantity and quality of the water resources. Presented here are two aspects of water use and energy. One is an overall view of energy consumption and the implications for water resource planning in the Southeast. The other specifically addresses the potential for the increased use of hydroelectric power at a small scale in North Carolina. Both present relevant information for the water resource planner.

Excerpts from "Electricity, Air Quality, and Water Resources in the Southeast", updated from a 1978 paper by David H. Moreau.

The majority of the existing power plants in the Southeast have nuclear or fossil fuel sources (see Table 1). Water consumption rates are extremely large for nuclear and fossil fuel plants. Consequently, the greatest amount of water resources will be utilized by the aforementioned energy sources.

Water resource implications of electricity generation are of several dimensions, including: (1) the use of water for dissipating large quantities of heat, (2) contamination by chemicals contained in steam condensate and other waters from periodic cleaning of boilers and flue-gas scrubbers, and (3) water requirements for operation of flue-gas scrubbers and water pollution resulting from those units. All of these effects are important but the most significant and the one of primary concern is the evaporative loss of water from wet cooling towers.

WE MUST EXPLORE THE RELATIONSHIP BETWEEN POWER PRODUCTION AND THE QUANTITY/QUALITY OF WATER

While there is some variability in those losses from one cooling technology to another and from one place to another in the Southeast, most of the estimated losses for the region fall within a range of 9 to 12 cubic feet of water per million BTU. With these evaporative loss rates, heat rejection rates of 5000 BTU/per kilowatt hour (kwhr) for fossil fuel plants and 7250 BTU/kwhr for nuclear plants, and with an annual capacity factor of 75 percent, plants with a rated output of 1000MW would have consumptive uses as follows:

Table 1
EXISTING INVENTORY OF ELECTRICAL GENERATING CAPACITY IN THE SOUTHEAST

Energy Source	Nameplate Capacity, MW	Percent of Total
Hydro	13,217	9
Nuclear	19,023	14
Coal	71,804	52
Natural Gas	6,783	5
Oil	27,405	20
TOTAL	138,432	100

SOURCE: Inventory of Power Plants in the United States, Department of Energy, December 1982.

Table 2
CONSUMPTIVE WATER USE IN COOLING

Type of Plant	Consumptive Use for Cooling, MGD
fossil fuel	6 - 8
nuclear	9 - 12

At an annual demand of 10,000 kwhr/person in the Southeast and the above heat rejection

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and evaporative loss rates, the consumptive use of water per capita for electricity generation is in the range of 9.2-12.3 gallons per capita per day (gpcd) for fossil fuel plants and 13.3-17.8 gpcd for nuclear plants.

To put these quantities of water consumption into another perspective, consider that cities in the Southeast with moderate levels of water-intensive industries withdraw water at a rate of 150 gpcd. Since approximately 80 percent of that water is returned to streams, the consumptive use is approximately 30 gpcd. Thus, a consumptive use of one million gallons per day (1 MGD) for power plants is equivalent to the consumptive use of an urban population of 33,300 persons, and it is equivalent to the withdrawal rate of an urban population of approximately 6700 persons.

Table 3
EQUIVALENT URBAN POPULATION IN THOUSANDS CORRESPONDING TO FOSSIL FUEL AND NUCLEAR PLANT WATER DEMANDS

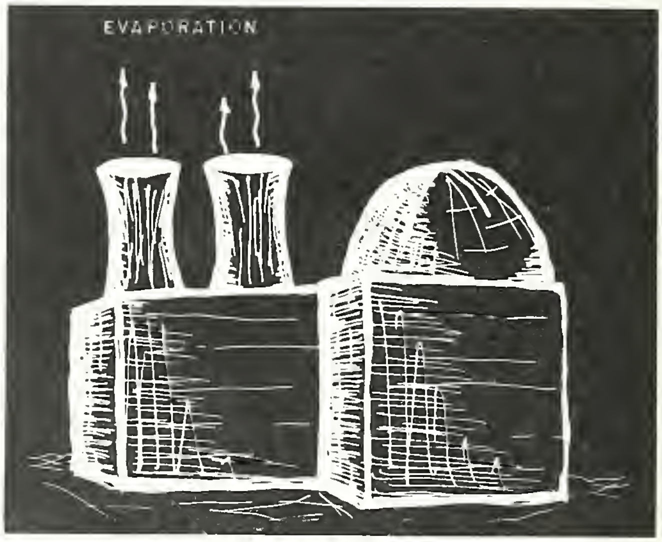
Type of Plant	Consumptive Use	Withdrawal Rates
1000MW fossil fuel	200-267	40-53
1000MW nuclear	300-400	60-80

With the projected addition of nearly 42,000MW capacity (42 percent nuclear and 48 percent fossil) over the next decade (DOE, 1982), the evaporative losses from power plants in the Southeast are equivalent to satisfying the consumptive losses of an urban population increase of 10-13 million persons. Those losses are equivalent to the withdrawal rates of an urban population of 2-2.5 million. These increases must be superimposed on increasing demands from other sectors of the region's economy.

Although the Southeast has an abundant supply of water relative to other regions of the U.S., the location of that supply relative to urban and power plant demands and the rapidly growing magnitude of those demands will soon dictate the use of water planning and management techniques that are much more complex than those in use today.

THIS ERA OF MEETING NEEDS FROM ABUNDANT LOCAL SOURCES IS DRAWING TO A CLOSE IN MANY PARTS OF THE REGION

There are 65 Standard Metropolitan Statistical Areas (SMSAs) in the Southeast; 13 are in Florida, but of the remaining 52, only eight are located on coastlines. Local imbalances between supply and demand are emerging in the vicinity of those metropolitan areas along the Washington-Atlanta-Birmingham corridor because most of the SMSA's along that route are located near the headwaters of streams which that route intersects. Within those areas there are emerging strongly competitive demands for high quality public water supplies, specifically for recreational uses, hydroelectric power, cooling water for fossil and nuclear powered electricity, and for maintenance of ample in-stream flows to protect water quality.



In the past, water demands have been satisfied by locally available resources with little concern for the quantity of water used. This era of meeting needs from abundant local sources, however, is drawing to a close in many parts of the region. This is evidenced by public concerns over proposed interbasin transfers to provide future water supplies for Atlanta, Greensboro, and Norfolk.

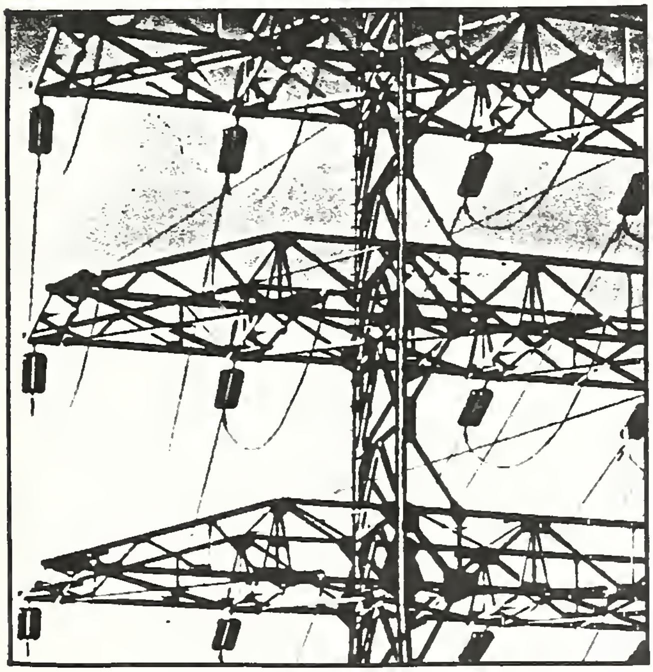
Implications for Water Resources Planning

Water resource planning in the Southeast today reflects the relative simplicity with which the resource has been managed in the past. It is highly decentralized; with electric utilities, municipalities, and state and Federal agencies having separate jurisdiction over water quality protection, river basin development, and small watershed management. As competition among water users for a diverse set of uses continues to increase, and as the interdependencies among those users become more intensive, the decentralized planning and management processes must also be modified. Such arguments are well-known and have led to the formulation of guidelines for comprehensive water resource planning.

The impact of electrical energy generation on water resources is growing at such a rate that the decentralized process by which electric utilities and other users of water independently plan for their needs is no longer adequate if either energy or water resources are to be used most beneficially. Consider the case of multiple purpose energy systems in comparison with single purpose electricity generating systems which presently prevail in the Southeast. Multiple purpose energy systems include a variety of technologies such as utilization of waste heat from existing power plants, industrial cogeneration of process steam and electricity with or without the sale of excess electricity to utilities, and district heating-electricity generation for institutional, commercial, or residential complexes.

Such schemes can result in overall energy efficiencies of up to 75 percent in selected applications, a substantial improvement over present limits of approximately 40 percent in single purpose power plant. Cooling systems can be entirely eliminated from such systems, and as a corollary to improved energy efficiency, pollution from fossil fuel combustion is reduced.

The water resource will be significantly impacted by 1990 when the consumption loss from evaporative cooling of new plants is projected to fall in the range of 700 to 1000 MGD by 1990. While this demand, associated with plants that have already been sited, can be met, it hastens the day for more careful development and allocation of water resources in the region. Competitive demands for cooling water, public water supplies, recreational demands, in-stream uses, and other uses of inland streams are growing at a rate that will soon exhaust locally available resources. Because of these impacts there is a need for more centralized planning for water resources with increased attention to the role of cooling water for electric power production. This would meet the dual objective of expanding availability of water and increasing the efficiency with which both water and fuels are used.



In his paper, Moreau reviews a few of the impacts of electric power generation on water resources and he presents evidence supporting a stronger attention to existing and alternative energy technologies in water resource planning. Hydroelectric power, accounting for nine percent of the existing Southeastern power plants in 1982, is a viable energy alternative not discussed in Moreau's paper.

Harvard Ayers has recently published a paper that specifically addresses the use of hydroelectric power as a small scale alternative for power generation in North Carolina.

Excerpts from "The Potential for Small and Micro-Hydro Electric Power in North Carolina" by Harvard G. Ayers (1983, Carolina Environmental Affairs Conference)

North Carolina currently has about 250 moderate to large dams on its streams. In 1980, the Piedmont Crescent Energy Project under the direction of Thom Gunter carried out a contract for the North Carolina Department of Commerce, Energy Division intended to provide an inventory of existing small-scale hydropower sites in the state. Sources such as the N.C. Dam Safety files and the U.S. Army Corps of Engineers as well as individual site owners were consulted, resulting in a list of 222 dams resulted.

In 1981, the N.C. Energy Division contracted with Appalachian State University (ASU) to encourage further development of hydropower in the state. Project activities included encouraging commercialization of feasible sites by offering financial and technical assistance, and site visits to 102 of the dams.

Summary of Dam Inventory

A grand total of 246 dams were studied by the ASU contract. Below is a list of the numbers of dams for each status:

Table 1
NUMBER OF DAMS BY STATUS CATEGORY

Category	Number of Dams
A Presently Producing Power	45
B Formerly Produced Power	64
C Never Produced Power	94
D Breached or Destroyed	22
E Status Not Available	19
F Under Construction	2
	246

The study covered a 24 county, 10,000 square mile area that included essentially all of the significant topographic relief in the state. Elevations of this area ranged from 2000 feet to over 6000 feet above mean sea level. Some counties had vast elevation differences and others very little.

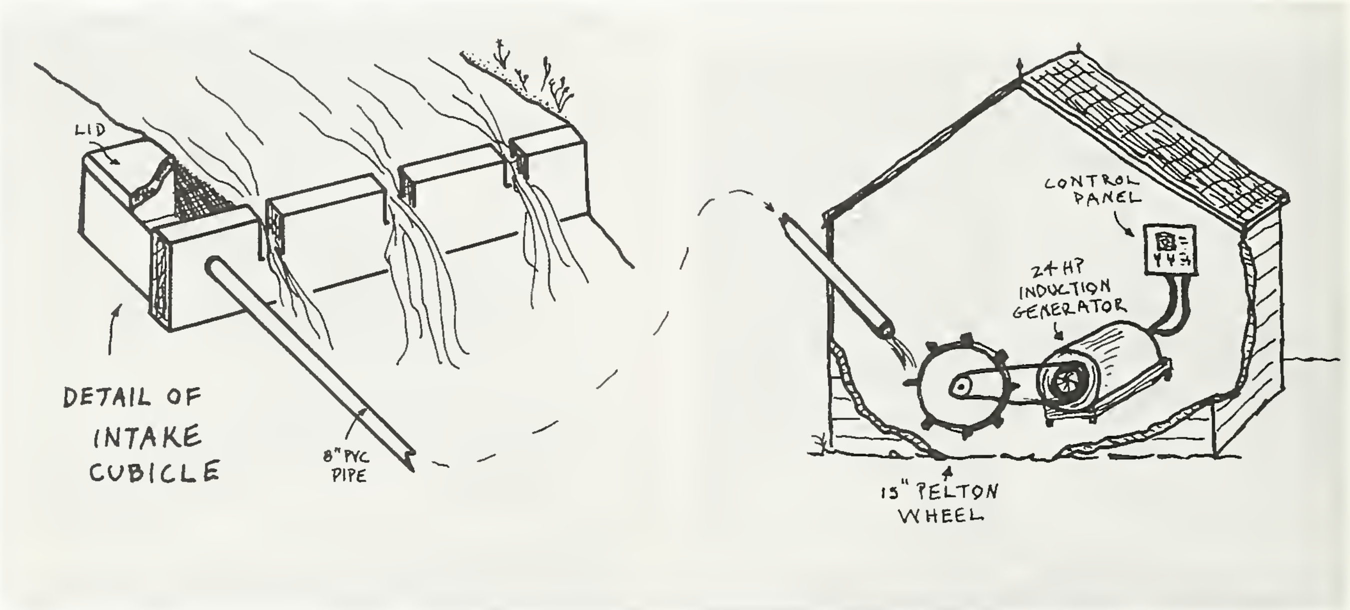
A great variety of stream flows per unit area was also found. High flows were fairly well correlated with high elevations, a phenomenon well-known to hydrologists. Variation of as much as three to four times was found with lower flows generally being reported in the northeastern part of the study area and higher flows in the southwest. Because the greater topographic relief as well as the greater stream flows are found in the southwest mountains, that area has by far the heaviest concentration of sites with good power potential.

The 10,000 square mile study area is dissected by about 7,500 miles of major streams. A methodology was developed for determining the micro-hydro production potential of all streams within the area. The methodology was designed to enable consistent, site specific estimates to be made of the maximum feasible production potential throughout the study region, based upon the best available hydrologic and topographic data.

Results of Assessment Study

Based on the methodology described in the study, 1,592 feasible sites (5-200 KW) were identified for the 24 counties in the study area. The average annual production potential of these sites is 28,075 kilowatts. Another thirteen sites with potentials of over 200 KW had 7,147 KW potential. This works out to an average production of about 308,000,000 KWH assuming no mechanical or other system malfunctions. Allowing for some downtime, about 250,000,000 KWH might be expected if all these sites were developed.

The micro-hydro sites were not evenly distributed throughout the study area. Five counties in the southwestern part of the study area accounted for about 56% of the potential sites for the 24 county area. One county, Rutherford, had only one feasible site. Table 2 lists numbers of sites and average KW potential for the 24 counties.



Micro-hydro demonstration schematic, including plan view of intake structure.

Table 2
NUMBER OF FEASIBLE SITES AND AVERAGE
PRODUCTION CAPACITY BY COUNTY

County	Sites	Average KW
Alleghany	5	44.7
Ashe	3	124.4
Avery	36	606.6
Buncombe	80	1226.0
Burke	12	280.1
Caldwell	17	352.3
Cherokee	95	1224.0
Cherokee Reservation	53	970.0
Clay	107	1335.0
Graham	156	3063.0
Haywood	216	3694.0
Henderson	42	594.0
Jackson	202	4914.0
Macon	193	4871.0
McDowell	18	288.0
Madison	52	581.0
Mitchell	14	324.6
Polk	22	1347.0
Rutherford	1	74.6
Transylvania	141	6763.0
Surry	4	79.2
Swain	65	1098.0

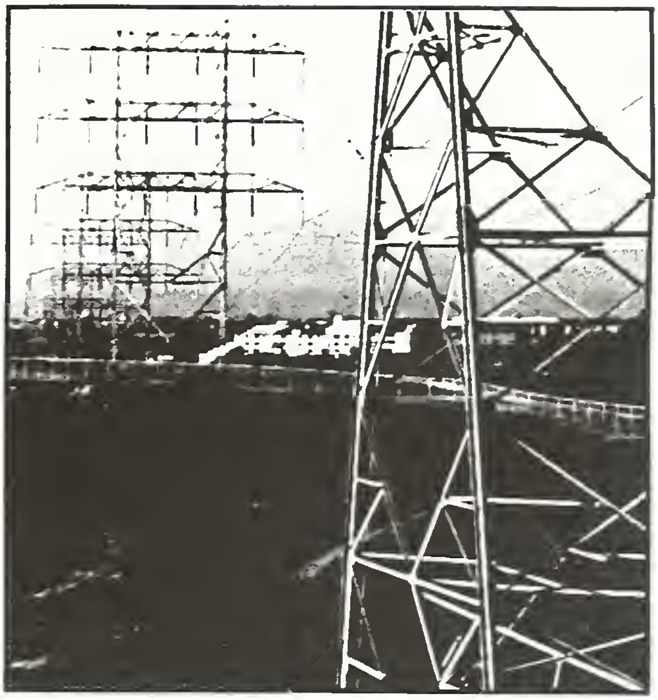
Environmental Concerns

The subject of the environmental effects of both small and micro-hydro power were given separate billing because of the importance assigned to environmental protection by those involved with the projects. Hydro projects at existing dams and at sites which can develop significant head from the natural stream gradient can be developed with a minimum of environmental degradation. Micro-hydro power projects cause significantly less environmental damage than do conventional power sources such as fossil fuels and nuclear power.

For existing dams, assuming that the environmental damage caused by impoundment has already occurred, the largest single environmental problem is that of reducing natural stream flows to facilitate power production. With dams which use their reservoir to store water for peak demand production, this problem is especially acute. While water is being stored, the stream is deprived of normal flow. Such deprivation is obviously most damaging immediately below the dam where lower tributaries have not had a chance to add to the flow.

MICRO-HYDRO POWER PROJECTS CAUSE
SIGNIFICANTLY LESS DAMAGE..........

For natural gradient, or pipe-the-pressure systems, the water needed to produce power is kept from the stream only over the pipeline distance. While fish migration is usually not a significant factor on streams steep enough to be feasible for pipe-the-pressure systems, care must still be taken to protect aquatic life over the often lengthy pipelines.



Conclusions

Moreau presents some important points with regard to water resource planning for the Southeast. As growth in the Southeast continues at a high rate, there also exists an increased demand for energy production. Consequently, more water will be consumed by power plants using evaporative cooling techniques in energy production. Competition for water will increase, thus centralized planning can play a key role in the proper allocation of existing water resources.

In contrast to Moreau's paper, the study presented by Ayers indicates that many counties in North Carolina have a high potential for micro-hydro power generation. The environmental impacts from micro-hydro power are much less than the impacts from conventional power plants. Unfortunately, the potential micro-hydro sites are fairly decentralized and only can be viable as a supplement to the larger power plants. With increasing demands, hydro power can possibly fill the gap in need for additional energy, but with reduced impacts on the environment.

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