Energy Use and Water Supply in Florida: 1975, 1985 and 2000

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Abstract: The purpose of this study is to help public agencies in Florida concerned with water resource planning to better analyze the role of energy requirements in water supply. First, we have estimated direct energy use for freshwater supply for five use categories under current (1975) conditions. This is the only estimate of its kind for Florida. Second, we have made projections of water use by category (public supply, irrigation supply, rural-domestic use, industrial self-supplied use, and freshwater supply for thermoelectric power generation) for 1985 and 2000. From these water-use projections we have developed probable energy-use requirements for water supply needs under several sets of assumptions. These projections appear to bound a credible set of outcomes. The results suggest that the role of energy in water supply is large but that the growth in water use approaching 60 percent from 1975 to 2000 will not seriously add to the state's demand for energy.

I. Introduction

Energy use and water supply are both problem areas in Florida. Energy costs tend to be high in Florida and Florida's per capita use of energy is high compared to the rest of the nation in the residential and transportation sectors. The growth of water use in Florida has been well-documented. With continued population growth, what are the implications for future water use and for the direct energy requirements to supply the needed water? The rationale for a study of this kind is clearly evident.

This paper has two parts: (1) development of energy use and freshwater supply for five use categories (public supply, irrigation supply, rural-domestic use, industrial self-supply and freshwater supply for thermoelectric power generation) for 1975 and (2) provision of a set of water and energy use projections for 1985 and 2000.

It should be clear at the outset that we are concerned with water supply *per se* and not water resource management in general. For example, we do not discuss the energy requirements of flood control projects or

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nonpoint pollution abatement. In addition we deal only with direct energy requirements of water supply and do not include indirect energy involved in the production of water supply. This means that we do not count energy use in manufacturing or fabricating structures, pumps, chemicals, fertilizers and all the other inputs.

II. Water and Energy Use for 1975

Table 1 shows estimates of freshwater use in Florida developed by the U.S. Geological Survey from 1950 to 1975 with preliminary estimates for 1980. In 1975, freshwater use totaled 7,749,000 acre-feet or 6,918 mgd. The withdrawals were almost evenly split between surface and groundwater. Not shown is saline water use of 12,880,000 acre-feet, withdrawn mainly for cooling in electric power generation.

It can be seen that irrigation is by far the largest user of freshwater at 41 percent of the total for 1975 and 1980. The efficiency of irrigation use in Florida is about 65 percent, which means in 1975 about 19 inches per acre was withdrawn for an average net application of about 12 inches per acre irrigated. As Table 1, shows, irrigation use has increased dramatically since 1960, an increase of 335 percent. By contrast the population of the state rose 71 percent in the 1960-75 period and public water use rose 116 percent. Industrial self-supplied use is leveling off and is believed to have actually declined in 1980 because of pressures on water quality of discharge which have forced more recycling and conservation of industrial water use. Nonmetropolitan population is stimulating the growth of rural-domestic use. In recent years the installation of cooling ponds and cooling towers has reduced the amount of make-up water in electric power production.

Table 2 shows that estimated primary energy use for freshwater supplied in 1975 in Florida totaled 29.170 X 10^{12} BTU. Public supply and irrigation supply dominate as energy consumers. Rural-domestic is by far the smallest energy consumer.

Table 3 compares the relative importance of energy use for the five use categories. Public supply is clearly the most energy-intensive use--17 percent of freshwater use and 42 percent of the energy consumed for water supply. The energy requirements for pumping groundwater, treatment before use and distribution to users averages 585 kwhrs per acre-foot. In addition, 51 percent of the water is returned to the system as wastewater with conveyance and treatment (secondary) requirements of 672 kwhrs per acre-foot. These requirements per acre-foot dwarf energy requirements for other uses. If AWT is required for urban wastewater in the future, the energy requirements for treatment of wastewater could almost double. The energy use for irrigation is large primarily because of pumping volume and because about 50 percent of use is in sprinkler irrigation with an average total dynamic head of 250 feet. These estimates of energy use for Florida irrigation water are about double those made earlier by the U.S. Department of Agriculture.

Table 4 shows that our estimates place primary energy requirements for all freshwater use for 1975 at only 1.46 percent of total energy use in the State of Florida. Contrary to some estimates for other states,

Table 1.—Population and estimated freshwater use in Florida, 1950-1980[1]

	1950	1960	1970	1975	1980[3]
Population (in thousands)	2,771	4,951	6,789	8,485	9,740
Water withdrawn (acre-feet in thousands)					
Public	190	594	990	1,283	1,524
Rural domestic	62	123	218	298	347
Industrial self-supplied	[2]	[2]	1,038	1,053	875
Irrigation	495	739	2,351	3,212	3,357
Electric power generation (freshwater)	[2]	[2]	1,863	1,902	2,082
Total freshwater use	[2]	4,211	6,460	7,749	8,185

[1]The basic information was derived from S.D. Leach, Source, Use and Disposition of Water in Florida, 1975, U.S. Geological Survey, Water Resources Investigation 78-18, Tallahassee, Florida, April, 1978, pp. 36-37. We have converted figures given in mgd to acre-feet. 1 mgd = 1,120.15 acre-feet per year. Most of the numbers are rounded off. 1 acre-foot = 325,850 gallons.

[2]The data are not available.

[3]Preliminary figures received from S.D. Leach, U.S. Geological Survey, Tallahassee, Florida.

Table 2.—Estimated energy use for all freshwater supplied in Florida, 1975

Use	Estimated direct energy use[1] (X 10^{12} BTU)	Estimated primary energy use (X 10^{12} BTU)
a. Public supply	3.998	12.299
b. Irrigation		
1. Sloggett[2]	8.998	10.761
2. Nebraska Performance Standard	(6.352)	(7.834)
c. Industrial (self-supplied)	0.839	2.583
d. Rural domestic	0.305	0.939
e. Thermoelectric		
1. Freshwater only	0.844	2.596
2. Saline water only	(6.822)	(20.988)
Total	14.706[3]	29.170[3]

[1]Conversion of kwhr to BTU: Direct energy 1 kwhr = 3,414 BTU
Primary energy 1 kwhr = 10,500 BTU

[2]Sloggett's fuel requirements appear more representative of field performance in Florida. Irrigation is the only use where electricity is not the dominant fuel source.

[3]We count the energy use for freshwater only in our total because the emphasis is on energy use for freshwater supply. For other purposes the large amount of energy used to pump saline water for cooling in thermoelectric power generation would be included.

this is a relatively small burden. For example, Roberts (1979) estimated that use of electrical energy in California for 1972 for water supply alone was 7 percent of total electricity used (with large amounts of energy use not counted). We estimate that only 0.7 percent of total electricity consumed in Florida was used in water supply for all uses in 1975. In Michigan in 1979, public supplies consumed only 2 percent of the electricity and 0.5 percent of the natural gas (Lystra et al.).

Table 3.—Relative importance of freshwater use and energy use by use type in Florida, 1975

Type of use	Percent of total water use	Percent of estimated primary energy use for water supply
Public supply	16.6	42.1
Rural domestic	3.8	3.2
Industrial (self-supplied)	13.6	8.8
Irrigation	41.5	36.9
Electric power generation (freshwater only)	24.54	8.9

Total freshwater use = 7,749,000 acre-feet or 6,918 mgd.
Total primary energy use = 29.170 X 10^{12} BTU for water supply.

Table 4.—Energy use for freshwater supply in Florida in relation to total energy use, 1975

	X 10^{12} BTU
Estimated energy use for freshwater supply (primary energy)	29.17
Total energy consumption[1]	1,997.00
Distribution by end use:	
a. Residential	496.70
b. Commercial	345.20
c. Industrial	411.70
d. Transportation	743,30
	1,997.00
Energy consumption for water supply as percent of total energy consumption	$\frac{29.17}{1997}$ = 1.46 percent

[1]Source for Florida energy consumption estimates is Neil G. Sipe, "Energy Consumption Patterns for Florida: 1960-1980," The Florida Outlook, First Quarter, March, 1981, Bureau of Economic and Business Research, University of Florida, Gainesville, Florida, pp. 85-95. Florida energy-consumption figures are in terms of primary energy.

III. Water and Energy Projection 1985 and 2000

Table 5 presents the results of our baseline projections for 1985 and 2000 for freshwater use and for primary energy use for water supply. We expect the primary determinant of freshwater use in the future will be the growth in population. The baseline energy projection was based upon energy requirements per acre-foot remaining the same as in 1975. We then computed the results of four scenarios involving different assumptions about population growth, use of freshwater for electric power generation, treatment levels for urban wastewater and performance standards and sprinkler irrigation for irrigated agriculture. These four scenarios are also listed in Table 5. It can be seen that irrigation, public supply and thermoelectric power all appear to be sensitive to changes in assumptions about energy use.

Table 5.—Water and energy projections: Effects of alternative assumptions

	1985		2000	
	Primary energy use (X 10^{12} BTU)	Water use (X 10^3 AF)	Primary energy use (X 10^{12} BTU)	Water use (X 10^3 AF)
Baseline projection	36.430	9,620	46.065	12,194
Scenario 1 - Population				
Low estimate	34.840	9,217	40.567	10,732
High estimate	37.448	9,907	48.849	12,923
Scenario 2 - Thermoelectric				
No new use of freshwater by thermoelectric plants	34.709	8,568	42,366	9,693
A doubling of the freshwater use by new thermoelectric plants	40.344	10,673	58.159	15,386
Scenario 3 - Public supply				
Tertiary treatment of all public wastewater	41.223	9,620	52,480	12,194
Tertiary treatment of 50 percent of public wastewater	38.827	9,620	49.273	12,194
Scenario 4 - Irrigation				
Nebraska Performance Standard	33.241	9,620	43.578	12,914
60/40 (Sloggett)	38.256	9,620	48.152	12,194

In public supplies, development of some newer supplies will require going to well fields at greater distances and more investment in reverse osmosis plants. There is no doubt that some of these new supplies developed will have higher energy requirements. However, these higher energy requirements will still raise total energy use for water supply by a relatively small amount because the new supplies involved will not be a large percentage of the more typical lower energy alternatives already in use.

The major variable that will raise energy requirements in the future rather dramatically is the trend toward tertiary treatment of public wastewater. For example, the move to tertiary treatment at 1,000 kwhrs per acre-foot across the board instead of 500 kwhrs for secondary treatment public wastewater in 1975 could raise energy requirements for public supplies by almost 20 percent. This, in turn, could raise energy costs for all water supply in 2000 by about 10 percent.

Perhaps the most uncertain of all of our energy-use estimates for 1985 and 2000 is the amount of energy required to pump freshwater for thermoelectric power generation. We have assumed that the ratio of freshwater to saline water used will remain at 12 percent. Although we have some confidence in our estimates of electric power demands for 1985 and 2000, we have less confidence about the 12 percent freshwater ratio. If, for example, coastal regulatory authorities refuse to permit much new power generation in the coastal zone, this figure could change. Even though the energy requirements per acre-foot are low, the volumes of cooling water involved are so large that the energy-use estimates could change considerably either up or down. As it is, we project that energy use for electric power generation (freshwater only) will be 38 percent of total energy use for water supply in 2000. The margin for error here is large; hence the uncertainty of our total estimate even though the other individual components may be fairly reasonable.

We also estimated total energy consumption in the State of Florida for all uses. Our best guess is that energy use for water supply as a percentage of total state energy use in 2000 will range from a high of 1.85 percent to a low of 1.29 percent compared to 1.46 percent in 1975. These percentages are based on the range of alternatives presented in Table 5. It does not appear that the growth of water use from 1975 to 2000 will cause energy use for water supply to become a major energy consumer relative to other energy uses in the state.

IV. Limitations

This paper does not provide estimates of how much is spent on energy and water in relation to total expenditures for goods and services. And, because we deal only with direct energy, we do not know the total energy used for water supply. Although we recognize the importance of the total energy approach, the difficulties of estimating indirect energy components make the task of estimation most difficult.

It is also important to remember that we have not studied in detail the costs of new supplies and the comparison of these costs to supplies now being used. When costs of new supplies are high it is always a wise policy to conserve on existing supplies and to reallocate them to high-value uses before plunging ahead on new water-supply investments. It is our impression that there is now a great deal of waste in the energy used to supply freshwater in Florida. It is probably also the case that present allocations of water supplies among uses are not as efficient as they should be.

References

1. Lystra, Donald W., et al. (1981), "Energy Conservation Opportunities in Municipal and Wastewater Plans," JAWWA, Vol. 73, No. 4, pp. 170-177.
2. Roberts, Edwin B. (1979), "Energy Requirements for Water Supply and Use in California," in California Water Planning and Policy (Englebert, ed.), Water Resources Center, University of California, Davis, California.