1-1-1986

The Coming Boom in Computer Loads

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Recommended Citation
Oliver S. Yu, R. Squitieri, and C. Roach. "The Coming Boom in Computer Loads" *Public Utilities Fortnightly* (1986): 30-34.

Public Utilities (ISSN 0033-3808)

FORTNIGHTLY

The magazine presenting information and views on major policy issues affecting utilities.

DECEMBER 25, 1986
VOLUME 118, NUMBER 13

SEASON'S GREETINGS

ARTICLES

11 Reflections on the Regulatory Process
An interview with Branko Terzic
Recently resigned Wisconsin Public Service Commissioner Branko Terzic comments on strengths and weaknesses of utility regulation at the state level.

15 Managing Information in a Prudence Investigation
By Lawrence H. Berul
Examines objectives and essential components of information management systems needed by utilities in connection with regulatory investigations of prudence in major construction projects.

21 A Decision Support System for New Technologies
By Dale M. Keith
Describes the design and use of a microcomputer-based utility financial operation modeling system in investment decision making.

26 Forecasting with a Personal Computer: Choices and Implementation
By Kenneth P. Ballard
Outlines issues confronting new users of personal computers in utility forecasting, and suggested solutions.

30 The Coming Boom in Computer Loads
By Ray Squitieri, Oliver Yu, and Craig Roach
Focuses on the potential for new and expanded electricity markets represented by a growing use of computers generally.

4 Pages with the Editor

DEPARTMENTS

35 Washington and the Utilities
A report on proceedings at the 1986 annual convention of the National Association of Regulatory Utility Commissioners, which was held in Phoenix.

39 Financial News and Comment
Burkhardt and Niemann: Effects of federal government actions on gas industry financial performance.

45 The March of Events

47 Progress of Regulation
Trends and Topics: Cost-based rates for intrastate natural gas transportation service.

53 Industrial Progress

6	Out of the Mailbag	9	Utilities Calendar	65	Index to Advertisers
8	Remarkable Remarks	60	Professional Directory	66	Selected Utility Rate Filings

Cover: Montana's Glacier National Park. (Photo by courtesy of PacificCorp — Brian Peterson, photographer.)

The Coming Boom in Computer Loads

By RAY SQUITIERI, OLIVER YU, and CRAIG ROACH

The impression is widespread among electric utility managers that computers do not represent a significant new market or potential for increase in customer load. This article highlights the experience of two electric utilities and summarizes the results of one comprehensive study conducted by the authors which lead to a contrary conclusion: Computers and other electric equipment already consume more electricity than electric steel furnaces, nationally, and there is every reason to expect continued growth in this kind of electric consumption.

If you were to tell the average utility chief executive officer that computers are his next growth market, he might counter with the argument that a microcomputer uses no more electricity than a 100-watt light bulb, and that there are not enough micros (or mainframes and minis) to add much to utility loads. Although widely held, this view may be wrong. Already, computers and their electronic brethren consume as much electricity as electric steel furnaces and their growth shows no signs of slowing.

The computer revolution has already arrived, and utilities, whether they know it or not, are active participants. For instance, Northeast Utilities reports that 20 per cent of electricity use in a typical new office building in its service territory goes to computers. And a transmission and distribution planner at Public Service Electric and Gas Company (New Jersey) reports that his group has been constantly surprised at the larger than expected service requirements for new office buildings, the result of increasing computer loads.

Despite the large computer loads served by many utilities, existing end-use studies have paid little attention to computers, commonly relegating them to the "miscellaneous" category, along with electric cookstoves and elevators. We believe that computers already constitute an important end use, that computer loads will continue to grow rapidly, and that they deserve greater attention from utility planners and other energy analysts.

Background: Commercial Sector Growth

Because most of the growth in computer loads has been taking place in the commercial or service sector, a closer examination of this sector provides valuable insights on the development of computer loads. (Through-

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out the article we will use "computers," or "computers and other electronic devices," to refer to computers, point-of-sale terminals, automatic teller machines, et cetera, and other devices in this class.)

By nearly any measure, the commercial sector[1] has grown faster in the last three decades than either the residential or industrial sectors. Commercial floor space has grown faster than residential floor space; commercial output has grown faster than industrial output (4.6 per cent per year versus 3.6 per cent per year since 1960); and commercial electricity consumption has grown faster than either residential or industrial electricity consumption (6.8 per cent per year commercial, 6 per cent per year residential, 3.8 per cent per year industrial).

The commercial sector has been uniquely successful in generating new jobs. From 1970 to 1985, net U. S. nonfarm employment grew by 26.8 million jobs, 95 per cent of which were in the commercial sector, with 5 per cent in mining and construction, and none at all in manufacturing. Within the commercial sector, services contributed 39 per cent of the new jobs, wholesale and retail trade 30 per cent, federal, state, and local government 14 per cent, and smaller subsectors the remaining 12 per cent. Between 1985 and 2000, this pattern is expected to continue. Data Resources, Inc., for example, forecasts 21.8 million new nonfarm jobs. Wholesale and retail trade should account for 25 per cent, services for 24 per cent, and government 18 per cent. Manufacturing is projected to add only 2 per cent, mining and construction only 4 per cent.[2]

The rapid rise in service sector employment has driven up computer use, because the commercial sector is more computer-intensive than the manufacturing sector. Further, the fastest service sector growth has occurred in business-related services. For example, from 1977 to 1982, business-related services claimed the top six spots in the large and fast growing subsectors (over $10 billion in 1982 sales; more than 100 per cent growth). This is important because it is exactly these business-related services that are most likely to use computers.[3]

Historically, most growth in commercial sector electricity sales has come from new uses. Many of today's important uses began as small new loads, and computers may be the latest example. Figure 2 traces the growth of commercial sector kilowatt-hour (kwh) sales from 1920 to 1985, by end use. For example, air conditioning was a small load when introduced in the 1940s, grew significantly in the 1950s, and now consumes 36 per cent of all commercial-sector electricity.[4]

We have shown that the commercial sector has been the biggest contributor to kwh sales growth, and that new uses within the commercial sector have accounted for the largest portion of this growth. Next we consider two studies of energy use in office buildings, and one projection of possible growth from computers and other electronic devices.

Park Plaza Building

This 26-story one million square feet glass facade office tower, finished in 1980, was the subject of a four-year Department of Energy-funded study. Now headquarters for Public Service Electric and Gas, the Park Plaza Building is typical of large office buildings designed in the mid-1970s for energy efficiency. To record

[1]By the commercial or service sector, we mean economic activity outside the industrial sector (manufacturing, mining, construction, agriculture). Within the commercial sector, "services" refer to personal, business, health, legal, educational, and social services, plus lodging.

[2]"Data Resources Long-term Review," Data Resources, Inc., winter 1985-86, p. 93.

[3]"The (Business) Service Economy," by Courtney Slater, *American Demographics*, April, 1985.

[4]"Electricity Use in the U. S. Commercial Sector 1960-2000," by Ray Squitieri, Electric Power Research Institute, mimeo, November, 1985.

Figure 1

Electricity Sales

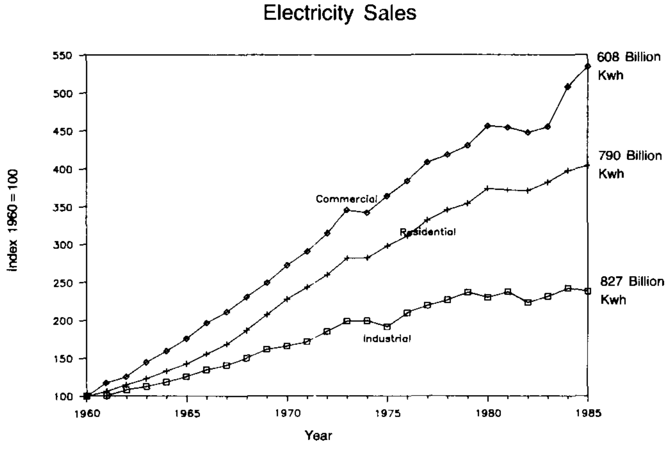
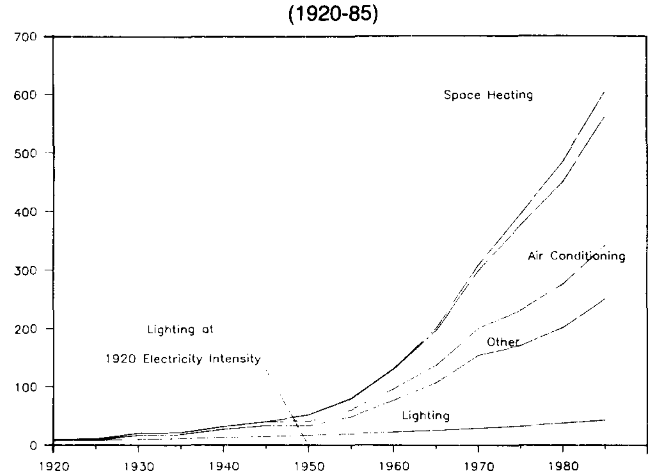


Figure 2

Commercial Sector Electricity Use (1920-85)



detailed load data, the study team equipped the building with 360 sensors, measuring temperature, hot and chilled water flow, air flow, and electricity consumption every ten minutes. With triple the number of sensors ordinarily required for building control, the Park Plaza was, during the two years of data collection, one of the most heavily instrumented buildings in the United States.[5]

The study yielded the following striking conclusions:

- Computers consumed, directly or indirectly, about half of all energy used in the building. Of the total, direct computer load accounted for about one-third, with lighting, cooling, and other indirect loads the other two-thirds.
- During the last year of the data collection (mid-1982 to mid-1983), energy consumption increased at 12-14 per cent per month, mostly from newly installed microcomputers and word processors. This preceded the biggest increases in microcomputer sales.

The designers aimed for an energy budget of 55,000 British thermal units per square foot per year (Btu/sqft/yr), without giving much thought to computers. After a year of fine tuning, the building load, not including computers, had leveled off below the target, at 46,000 Btu/sqft/yr. Computers, however, added another 46,000 Btu/sqft/yr. The study team concluded that late-1970s efforts to conserve energy through improvements in building design and operation are now being more than offset by ever-growing electricity consumption from computers.

The study team has also reported wiring requirements for new office buildings in New York city, confirming the trend found in the Park Plaza study.[6]

Banks in New York city require 12 watts per square foot because their traders must watch exchanges in several cities at one time. Thus, each desk may have three, four, or five monitors all on at once.

Wiring Requirements for New Office Buildings, New York City

New Office	1980	5 W/sqft
New Office	1985	6
New Office (estimated)	1990	10
New York City Banks	1985	12
Computer Centers	1985	20

Northeast Utilities

This 1985 study analyzed 181 office buildings in the Northeast Utilities service territory completed in 1981 or later.[7] Office buildings form the largest class of commercial customers for NU; the buildings covered in the survey represented a cross section of the office building subsector: business and social services, government, finance, insurance, and real estate.

The project included five steps. First, the contractor selected buildings to be surveyed — generating a list of buildings, screening the list, and choosing from the screened list using statistical sampling techniques in order to ensure a representative sample. Second, the contractor conducted a detailed on-site survey of each of the 181 buildings in the sample, recording building characteristics and energy consumption data. Third, the buildings were grouped into ten types based on size, type of heating and air conditioning, and presence of a mainframe computer. Fourth, the contractor simulated building end uses with a computer model, validating the results with actual billing data. Fifth, the contractor generated end use and load profiles from the sample results.

The NU study showed, again, surprising growth in computer loads.

- NU found that new office buildings consumed more electricity per square foot despite being more energy efficient; i.e., using less total energy per square foot. Newer buildings were found to be tighter than existing ones, with better roofs, better walls, and better insulation. Newer buildings even used 15 per cent less electricity for lighting. Nonetheless, newer buildings on balance used 20 per cent more electricity, due largely to increasing computer loads, and associated air conditioning.
- For one category of large office buildings, the presence of a mainframe computer increased electricity consumption by 85 per cent. This agrees more or less with results of the Park Plaza study, above.

Productivity Pull Scenario

Electricity is the chosen fuel for today's office productivity tools. Two of the present writers conducted a recent EPRI study that asked how much the demand for electricity would be pulled along by the aggressive pursuit of improved office productivity — just as consumption of fossil fuels was pulled along by new, more productive, industrial processes earlier in the century.[8] This study was not intended as a forecast, but rather as one possible view of the future. After selecting several commercial subsectors, the authors identified in each one an important new device or process that uses electricity. For example, corporate headquarters for manufacturing

[5] *Design and Operational Energy Studies in a New High-rise Office Building*, Tishman Research Corporation, DOE/CS/20271-1 to 20271-5, Springfield, Virginia, National Technical Information Service, 1983-84.

[6] Barry Donaldson, Tishman Research Corporation, personal communication, February, 1986.

[7] "New Commercial Office Building End-use Energy Survey," Synergic Resources Corporation, Berlin, Connecticut; Northeast Utilities Service Company, mimeo, September, 1985.

[8] "Office Productivity Tools for the Information Economy: Possible Effects on Electricity Consumption," by Craig Roach, EPRI, mimeo, April, 1985.

firms constitute a subsector, engineering design is an activity, and the activity uses computers for design and analysis. Six subsectors were chosen:

- Education: teachers and students use microcomputers to teach and to study, often in new ways.
- Retail: shops install point-of-sale (POS) terminals tied to minicomputers; POS systems automate record keeping and inventory management, and may allow electronic payments by customers.
- Finance: banks and bank-like businesses implement electronic funds transfer systems, using large computerized data centers.
- Health Services: hospitals and clinics use microcomputers to automate their laboratories, pharmacies, intensive care units, and medical imaging.
- Manufacturing Headquarters: corporate staff use mainframe, mini- and microcomputers for planning, analysis, financial control, and electronic communication.
- Infrastructure: improving office productivity will require electricity-using equipment outside of office buildings, such as expanded telephone switching, and personal computers in homes.
- Building Services: operators of large office buildings install electronic equipment to offer centralized computer and telecommunication services to their tenants.

Various assumptions went into this study. In making these assumptions the authors tried not to overstate the case for vigorous growth. Their objective was a high-growth (optimistic) scenario, but based on plausible assumptions.

The results presented here refer to the early 1990s. As Table 1 shows, computers can add substantially to electricity sales. In this scenario, new electronic equipment (installed after 1982) adds 152 billion kwh per year by the early 1990s. Most recent forecasts project about the same growth in commercial kwh sales, without considering computers (2 per cent per year growth, 550 billion kwh in 1984). These conventional forecasts assume that sales growth comes from increases in employment and floor space, with its associated cooling and lighting loads. But the scenario presented here demonstrates that electronic devices could add more to electricity growth than the conventional sources combined.

Table 1

Connected Load and Annual Energy Required by New Information Technologies, Early 1990s

Sector	Connected Load (Gw)	Annual Energy (Billion Kwh)	Per Cent Of Total Connected Load	Per Cent Of Total Annual Energy
Manufacturing	3.1	8.9	10	7
Education	8.5	13.3	27	11
Retail	3.5	27.0	11	22
Finance	3.1	24.6	10	20
Health	0.9	5.8	3	5
Building Services	4.2	33.1	13	27
Infrastructure	8.1	11.1	26	9
Total	31.4	123.8	100	100

Table 2

Connected Load and Annual Energy Required By New Technologies

Technology	Connected Load (Gw)	Annual Energy (Billion Kwh)	Per Cent Of Total Connected Load	Per Cent Of Total Annual Energy
Computers				
Microcomputers	16.6	20.7	53	17
Minicomputers	4.3	33.8	14	27
Mainframes	4.2	33.3	13	27
Subtotal	25.1	87.9		
POS Terminals	0.2	1.1	1	1
Telecommunications	2.1	16.8	7	14
All Other	3.9	18.1	12	15
Total	31.4	123.8	100	100

Building services makes the biggest contribution to kwh sales (33 billion kwh), followed by retail sales (27 billion kwh), then finance, education, infrastructure, manufacturing headquarters, and health services.

The story is different with connected, noncoincident load at the customer's site. Education ranks first (8.5 gigawatts), then infrastructure (8.1 gw), building services (4.2 gw), and retail (3.5 gw). Electronic devices in retail stores show very high kwh consumption but relatively low connected load. Education and infrastructure, on the other hand, show higher connected load but much lower kwh sales. The authors assumed a high capacity factor for the electronic equipment in retail stores: the POS terminals operate all day; the minicomputer, which supports the POS terminal during the day, performs accounting chores at night. Schools, on the other hand, are expected to use mostly microcomputers. The authors assumed that students turn these off when through, giving low load factors. Infrastructure shows the same pattern, with high connected load because of a large network of machines, and relatively low kwh consumption because of low load factors.

Examining electricity sales by technology (see Table 2), we find minicomputers first (34 billion kwh), followed closely by mainframes (33 billion kwh) and micros (21 billion kwh). Minicomputers rank first because of their importance in the retail sector, and because (we assume) they operate virtually all the time.

Summary

The two utility studies represented here make it clear that computers already represent a large market for electricity. The prospective study, while not conclusive, suggests that the potential exists for rapid further growth, as much as 150 billion kwh by the early 1990s. The utility chief executive officer who argues that a microcomputer consumes no more electricity than a light bulb should remember that the hundreds of millions of light bulbs now in use consume 200 billion kwh in the commercial sector alone.

The likely boom in computer loads should come as welcome news to those utilities who have in recent years heard only the gloomy forecasts of increased conservation and a declining industrial base.

Historically Dynamic Coal Industry to Continue Changing

Despite its resemblance to a classic "mature" industry, the United States coal industry remains dynamic and may undergo significant restructuring by the end of this century. The implications for industry managers are compelling, as the changes are likely to affect coal marketing strategies and the geographical distribution of profitable and unprofitable operations. According to Scott Palm, a senior associate at Charles River Associates, Inc., the Boston-based strategy development firm, "It can be very useful for industry managers to understand how certain forces may affect their individual operations." In an address to a recent joint meeting of the West Virginia Coal Mining Institute and the Appalachian Section of the American Institute of Mining and Metallurgical Engineers, Palm outlined four trends that will alter the coal industry over the next two decades: acid rain legislation, advanced "clean coal" generating technologies, changes in the regulation of U. S. electricity generation, and increasing competition in U. S. coastal coal markets.

According to Palm, although the aggregate impacts of these events will, in many cases, offset one another, the effects on certain coal producers will be dramatic. He notes: "Acid rain legislation is likely to restrict the supply — and raise the price — of clean British thermal units from coal. Producers of low-sulfur coal in, for example, Wyoming and Montana, may initially experience a windfall when environmental legislation takes effect. However, these producers' gains are likely to decline fairly soon, as a result both of normal competitive conditions and of successful new 'clean coal' technologies such as fluidized bed combustion. As the newer technologies become widely adopted, long-distance transportation costs will make low-ash, low-sulfur coal uncompetitive with poorer quality local coals."

Due to the energy market stresses of the 1970s and legislative and regulatory pressures, electric utilities are increasingly concerned with electricity distribution rather than electricity production. As a result, the opportunity exists for coal producers to integrate forward, either through direct agreements with utilities or through cogeneration joint ventures. In effect, coal producers may in the future deliver their coal in the form of electricity. "Although the aggregate market impact of such ventures will not be great, forward integration may be an important marketing strategy for individual coal firms," says Carol Leiter, senior associate at Charles River Associates. "Coal producers not involved in such ventures would probably be excluded from future coal sales to the plants in question."

Coastal U. S. markets for coal are particularly vulnerable. Low-cost electricity imports from Canada, the development of a massive low-cost coal industry in Colombia, and continued depressed oil prices threaten coal producers serving both the East and West coasts. To compete effectively, U. S. coal producers must devise strategies to lower the costs of delivering coal or its products to U. S. coastal markets. To remain profitable, coal industry managers are well-advised to carefully evaluate these forces of change.

Copies of "Strategic Issues Facing the U. S. Coal Industry," a paper co-authored by Palm and Leiter and presented at the joint meeting of the West Virginia Coal Mining Institute and the Appalachian Section of the AIME, are available from Charles River Associates (617) 266-0500.